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Radio-Electronics

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AUGUST 1988

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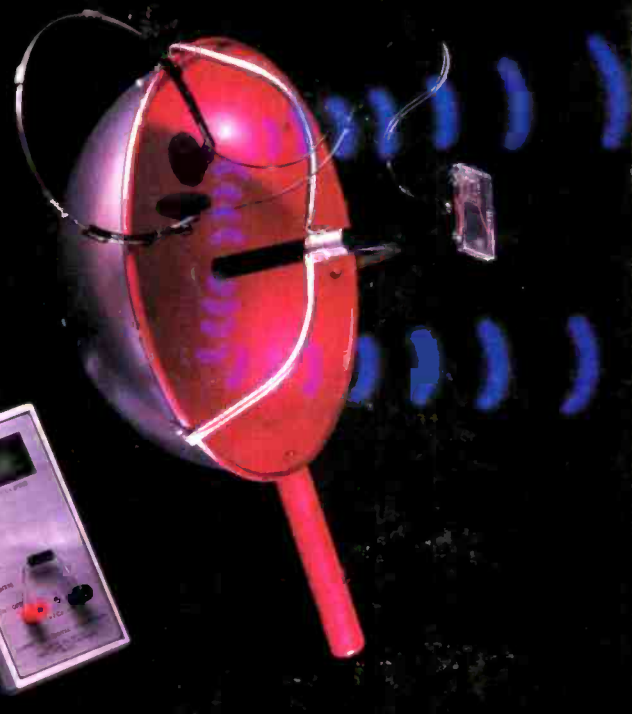

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Discover the potential. With digital storage you can freeze waveforms. Capture events invisible to nonstorage scopes. Find signals buried in noise. And build a library of reference waveforms.

Digital storage display accuracy enhances your confidence in measurements. And all you have to do is push a button for *real-time* display analysis.

Compare the 2230, 2221 and 2220 to each other—and all others. The new 2221 offers such advanced features as CRT readout and measurement cursors. For even more performance and flexibility, there's the 100 MHz, dual time base 2230 with optional battery-backed memory for saving up to 26 waveform sets. And if it's economy you want, choose the 60 MHz 2220 with many of the same features at an even lower cost.

With each scope you can capture events as narrow as 100 ns at any sweep speed thanks to Tek's proprietary peak detect mode. View events prior to or following a trigger event with pre/post trigger. Store waveforms into 4K records. Automate measurements with optional GPIB and RS-232-C interfaces. And output direct to a printer or plotter.

Tek software is available to help you make the most of the 2230, 2221 and 2220 in system configurations.

Features	2230	NEW! 2221	2220
Analog/Digital Storage BW	100 MHz	60 MHz	60 MHz
Maximum Sampling Speed	20 MS/s	20 MS/s	20 MS/s
Record Length	4K/1K (selectable)	4K	4K
Peak Detect	100 ns	100 ns	100 ns
Save Reference Memory	One, 4K Three, 1K	One, 4K	One, 4K
Vertical Resolution	8 bits 10 bits (AVG mode) 12 bits (AVG mode over the bus)	8 bits 10 bits (AVG mode)	8 bits
CRT Readout/Cursors	Yes	Yes	No
GPIB/RS-232-C Options	Yes ($750)	Yes ($500)	Yes ($500)
Battery-Backed Memory (save 26 waveform sets)	Yes (inc with GPIB/ RS-232-C)	No	No
Price	$4995	$3995	$2995

Call Tek for a free video brochure or to place an order.

Ask about free digital storage application notes and educational materials. Orders include complete documentation, manuals and 3-year warranty on labor, parts and CRT.

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August 1988

Radio-Electronics

Vol. 59 No. 8

BUILD THIS

33 MICRO-SIZED AMPLIFIER
Build a super-sensitive amplifier in a super-small package.
Frank Polimene

37 INFRARED COMMUNICATIONS SYSTEM
Put infrared technology to use in this wireless speaker system.
Rudolf F. Graf and William Sheets

45 Radio-Electronics ADVANCED CONTROL SYSTEM
Part 7. Adding a CRT controller and printer port.
Michael A. Tucker

50 L/C METER
Part 2. Construction details for the digital L/C meter.
Neil W. Heckt

TECHNOLOGY

8 READ/WRITE CD
Tandy announces the world's first erasable compact disc.
Brian C. Fenton

53 GENERAL-PURPOSE INTERFACE BUS
Part 2. GPIB accessories, plus customizing and troubleshooting.
Vaughn D. Martin

61 TESTING SEMICONDUCTORS
Part 9. More on testing TTL devices.
TJ Byers

HISTORY

57 THE EARLY DAYS OF RADIO
Better radio design with improved tubes.
Vaughn D. Martin

DEPARTMENTS

6 VIDEO NEWS
The latest happenings.
David Lachenbruch

20 EQUIPMENT REPORTS
Beckman's *HP 153* DMM.

24 COMMUNICATIONS
Personal-communications.
Herb Friedman

69 HARDWARE HACKER
Remote controls and more!
Don Lancaster

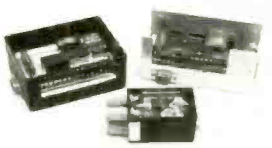
75 AUDIO UPDATE
Can you hear the difference?
Larry Klein

78 SHORTWAVE RADIO
General conditions.
Stanley Leinwoll

80 DRAWING BOARD
Planning displays.
Robert Grossblatt

COMPUTER DIGEST

RS232 CONTROL/MONITOR SYSTEM



BUILD A PAIR OF LINE-CARRIER MODEMS

CD CLASSROOM

PAGE 81

PAGE 8

AND MORE

116 Advertising and Sales Offices

116 Advertising Index

10 Ask R-E

117 Free Information Card

12 Letters

98 Market Center

23 New Books

30 New Products

66 PC Service

4 What's News

ON THE COVER

We have so many great construction projects, that we couldn't limit this month's cover to only one. First, we have a super-sensitive amplifier that uses surface-mount technology to achieve its tiny size. And we have complete details on how to build a set of wireless speakers that use infrared light instead of wires!

We also have a couple of projects that we have to finish up this month. First is an easy-to-build LC meter for your workbench. It accurately measures capacitance from 0.1 to 99,990 pF, and inductance from 0.01 to 99,990. In ComputerDigest, we tell you how to build a set of line-carrier modems for cable-free computer interfacing.

COMING NEXT MONTH

THE SEPTEMBER ISSUE IS ON SALE AUGUST 2

BUILD THE TELEGUARD-II
Prevent unauthorized out-going calls with this easy-to-build project!

QUANTUM IC's?
A new theory could change integrated circuits forever.

BUILD A WALKMAN AMPLIFIER
Use it to get big sound from your personal stereo, or as a benchtop utility amp.

COMPUTERDIGEST
Build a Biofeedback Monitor and a Hemi-Sync Generator.

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Advertising Sales Offices listed on page 116.

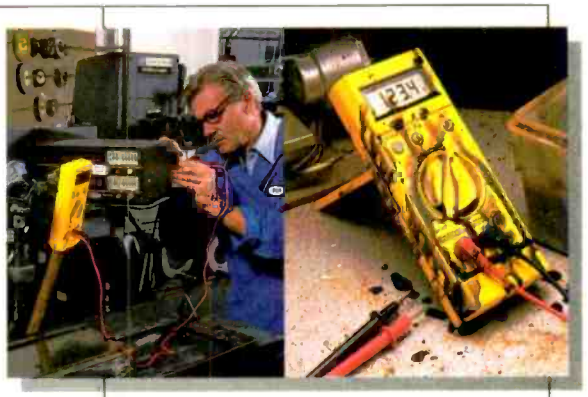
Intermittents. We Hear You.

Introducing The Heavy-Duty DMM With An Audible Readout That Lets You Keep Both Eyes On The Job.

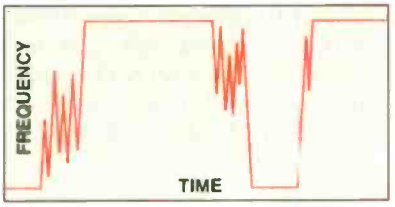
Intelligent design and solid construction make the new HD 150 Series the best DMMs in their class.

They're the latest in a distinguished line that began when Beckman Industrial pioneered heavy-duty DMMs with their distinctive yellow color. Many competitors have since imitated that color. As for imitating their performance, no one comes close.

The HD 150 Series attains new levels of excellence with a range of advanced features. They're waterproof. Drop proof. Auto-ranging. Slim-styled for one-hand comfort and convenience. With auto-off to prolong battery life. Plus 2 fuses, PTC resistor *and* MOV for unsurpassed overload protection.



Audible readout. A "sound" reason to go with the HD 150 Series. With this unique feature on the HD 153, you measure parameters by listening to a continuous variable tone. As the parameter you measure rises or falls, the tone's frequency increases or decreases, accordingly. Use it for volts, amps, or ohms. It's ideal for peaking and nulling, too.



Intermittent alert. A key application of audible readout. The HD 153 pinpoints intermittents by emitting a "crackling" sound when they're detected. The response sounds in about 1 msec—far faster than the information appears on any DMM display.

Logic function. The HD 153 detects TTL or CMOS logic pulses using standard test leads.

Easy to use. The HD 150 Series lets you read the LCD even at wide angles. With the large rotary dial you select functions with one-handed (right or left) convenience. Auto-ranging speeds you to the right range. A tilt-stand and Skyhook let you set or hang the DMM almost anywhere.

Built tough to work hard. The HD 150 Series DMMs are so tightly sealed against water and grime that they're *guaranteed for five years* against contamination. And, because they're built so tough, they're guaranteed for two years against *any* damage (except abuse). Crashes, overloads, moisture, dust...you name it. The HD 150 Series can handle it all!

Listening is believing. For a hands-on demo, see your distributor now. Learn why the HD 150 Series is the soundest DMM value you'll see. Or hear.

Key Specifications

	HD 151	HD 152	HD 153
Auto-ranging	✓	✓	✓
Range Lock		✓	✓
Audible readout			✓
Tilt Stand and Skyhook™	Optional	Optional	Included
Logic pulse detector			✓
DC voltage accuracy	0.7%	0.5%	0.25%
10A range		✓	✓
Suggested list price	$149.00	$169.00	$199.00

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WHAT'S NEWS

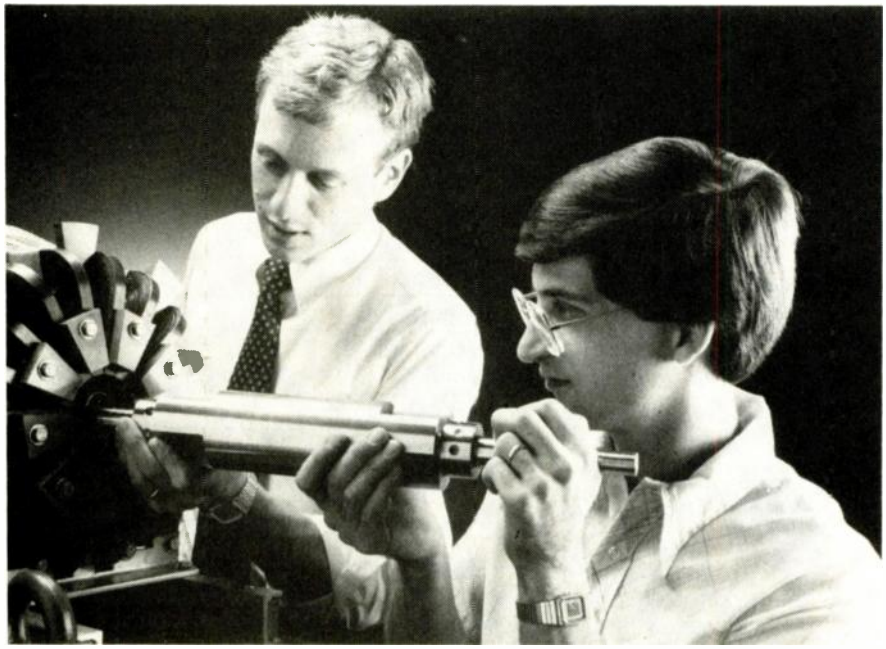
Fastest inductor motor runs up to 50,000 RPM

A number of industrial processes (such as some types of metal machining) require high speeds at fairly high power. Small motors can be built to operate at high speeds, but rotors with embedded coils or laminations have a tendency to fly apart as weight and speed is increased. Gears can often be used to increase speed, but that's only at the cost of efficiency and reliability.

Engineers at REM Technologies (Albany, NY) have announced a design using a rotor machined from a single piece of steel—there are no coils or laminations. The three rotor segments follow the rotating field set up in the armatures, in a manner similar to that of a standard induction motor.

Electric current for the new motor is supplied from an inverter that transforms the 60-Hz power to any frequency from 3 Hz to 3,000 Hz, providing variable speeds up to 50,000 RPM.

The solid rotating field will remind old radiomen of the Alexanderson alternators—used for high-power long-wave transmission before high-power electronic tubes came into use—in which a toothed disc revolved past a large number of fixed poles to produce frequencies up to 200 kHz.



REM TECHNOLOGIES' VICE-PRESIDENT OF ENGINEERING, Jim Grant (l.), and technician John Cestra, are shown inserting a rotor machined from a single piece of steel into the *H*omopolar *I*nductor *Drive* (HiDrive) motor. That rotor is the only moving part of the HiDrive motor.

Solar-to-chemical energy unties transmission snags

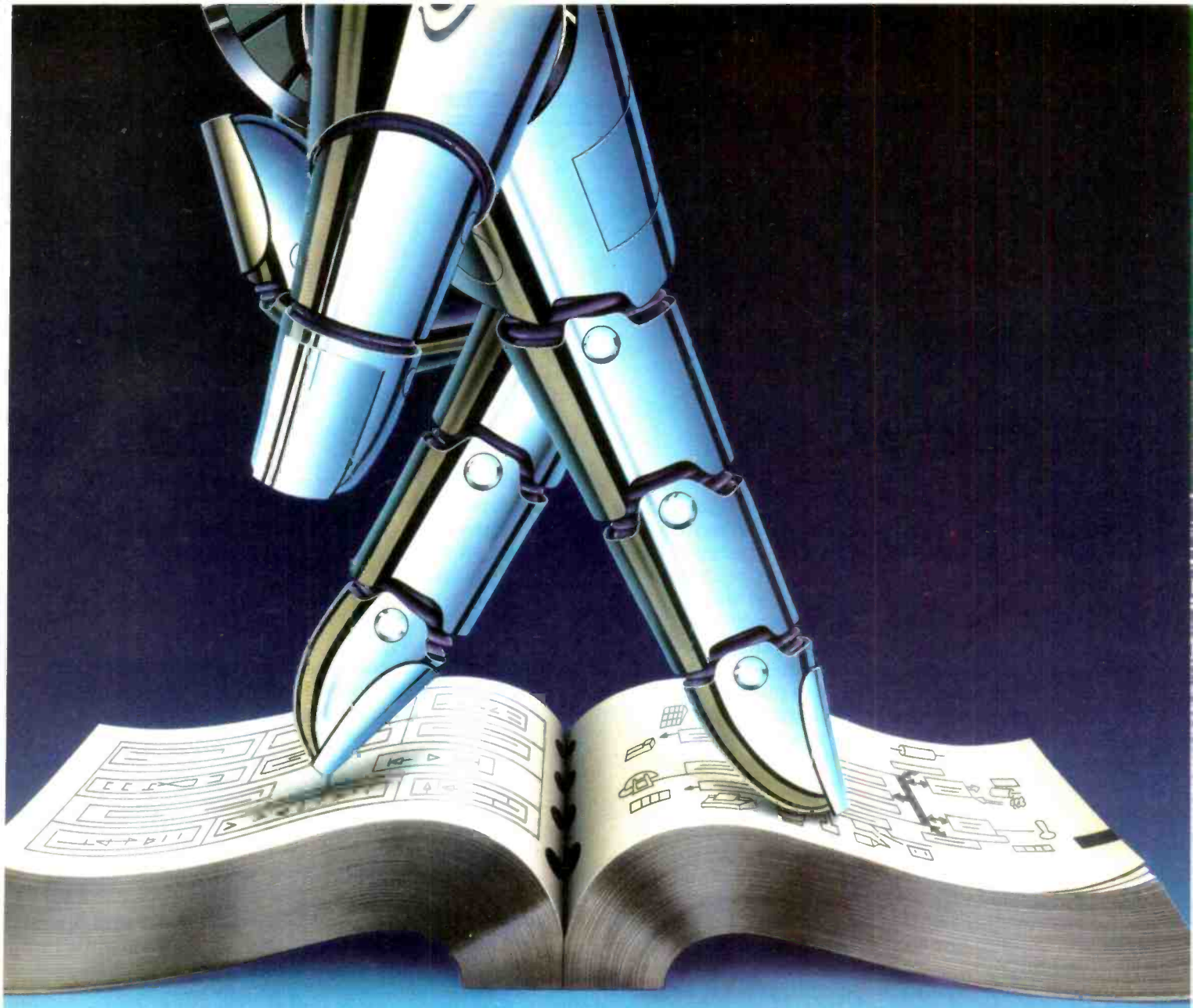
A serious problem in the use of solar energy is that the areas where it is produced most efficiently are often far from the industrial areas where it could be used effectively. Energy that is captured from the sun is readily turned into other forms of energy, such as heat, normally in the form of hot fluids—which can be used to generate electricity or for other purposes. But heat losses make long-distance transmission of hot fluids impractical.

A major goal is to eventually be able to transport solar energy long distances. The energy would be collected in solar-dish collector fields, located in a remote desert areas, and "piped" to highly industrialized areas where it could then be used immediately or stored for later use.

Sandia National Laboratories (Albuquerque, NM), has presented a new solution—the heat is used to produce a chemical change in a gas. The gas can be transmitted by pipeline over long distances and reconverted to its original state. On reconversion the gas gives up the heat it absorbed in the first conversion.

The solar receiver/chemical reactor consists of a series of vertical pipes filled with a granular catalyst through which the active fluid, a mixture of methane and carbon dioxide, flows. The pipes are surrounded by liquid sodium, which evaporates when exposed to concentrated sunlight. The sodium then condenses on the pipes, giving up its heat to the mixture within. That causes the methane to react with the carbon dioxide to form carbon monoxide and hydrogen. The new gas can then be piped to the place of use and reconverted to methane and carbon dioxide, giving up the heat it absorbed in the first conversion. The liquid sodium is recycled to the solar panels to be reheated.

Tests conducted at the Weiszman Institute in Rehovot, Israel have been highly successful, and Israeli researchers expect to be able to use the system to transport solar energy collected in the deserts in the south to industrial regions. **R-E**



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VIDEO NEWS

DAVID LACHENBRUCH,
CONTRIBUTING EDITOR

• **CD Recorder.** The surprise announcement by Tandy Corporation (owner of the Radio Shack chain and the Memorex consumer video- and audio-tape business), that it had developed a low-cost optical-disc recording system, could have a great impact on both the audio and video industries. The system, which Tandy calls THOR-CD (for Tandy High Intensity Optical Recording) is claimed to permit repeated digital recording and erasure of discs which are playable on standard CD players. Tandy says the recorder will cost less than $500 and be ready within two years.

Although the system is capable of making digital audio and computer discs, Tandy noted that video discs are among its possibilities as well. The discs, however, won't be compatible with current laserdiscs, according to Tandy officials, because THOR is a digital recording medium. The THOR video disc could become the first medium for consumer digital-video recording.

The THOR system is based in part on a process developed by Optical Data Inc., using a disc coated with a dye polymer coating, which forms bump-like deformations when exposed to a laser beam. The mark or bump, which doesn't deteriorate with repeated use, can be erased and rewritten when exposed to a laser beam of another wavelength. The system is inexpensive and can be manufactured in high volume with existing magnetic-media techniques.

• **Ho hum, HDTV.** The average person isn't particularly excited about high-definition TV, according to research conducted with the general public by Massachusetts Institute of Technology, HBO, and the Canadian Broadcasting Corporation. The MIT researchers, reporting on the opinions of 613 people who were shown HDTV and standard TV side by side in a Massachusetts shopping mall, found that HDTV "doesn't knock the socks off everyone who sees it," in the words of the study's author, Assoc. Prof. Russell Newmann. The survey results showed that HDTV's impact is much less than that of color TV as compared with black-and-white. Some of the test subjects actually preferred a standard NTSC picture to HDTV, with only 62% preferring HDTV. All three surveys showed that about 50% of subjects would pay $100 premium for an HDTV set, but only 5% would pay $500 more. Current estimates are that, if mass-produced, HDTV sets will cost between $1,500 and $3,000.

• **Hi-fi Camcorders.** FM "depth multiplex" hi-fi stereo has been available for a long time now in full-sized VHS decks and a very few VHS camcorders that are being sold, but now the principle is being extended to the miniature VHS-C system. The new system, expected to be introduced late this year, will be compatible with VHS hi-fi stereo. Because of VHS-C's small head drum, the system will use nine recording heads; four for the picture, four for sound, and one flying erase head. The 8mm-Video system provides for two sound systems; one FM-based mono system and a PCM digital-stereo version. A group of 10 major Japanese companies is now developing standards for a stereo version of the FM sound system. Sony says that they won't add analog stereo, but instead will use PCM-stereo sound on its higher-priced 8mm camcorders.

• **Surround-sound TV.** Another audio-for-video development is a test that is being conducted by NBC on the transmission of surround sound along with the MTS stereo-sound signal. No additional audio-signal paths are required other than the standard L+R and L−R, an NBC engineer explained, noting that the surround-sound information for motion pictures is matrixed into two channels. The network, he said, will "test the retrievability of surround sound under a variety of conditions," including satellite distribution, VHF and UHF transmissions, and cable systems, to determine how much degradation of the surround sound occurs. The network has already transmitted several programs with encoded surround sound. Reception requires a surround-sound decoder (an increasing number of those are being built into higher-priced TV sets) and one or two rear speakers. **R-E**

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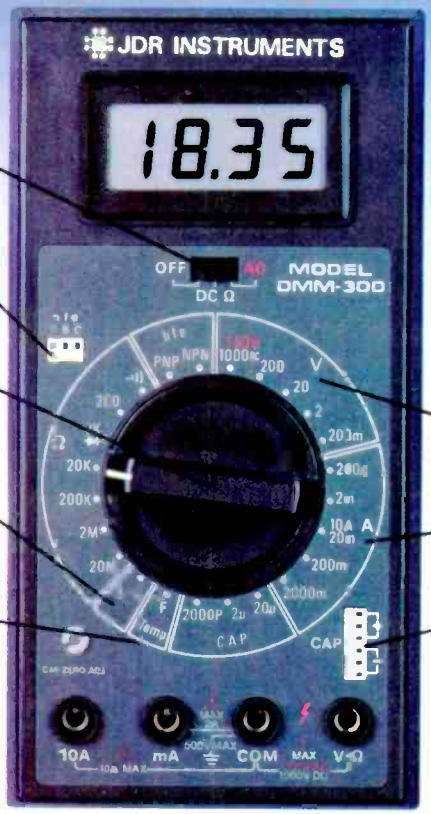

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3.5 DIGIT PROBE TYPE DMM

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- Input impedance: 11M ohm
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DMM-200 $49.95
3.5 DIGIT FULL FUNCTION DMM

Get highly accurate performance at a very affordable price. Rugged construction, 20 amp current capability and 22 ranges make it a perfect choice for serious field or bench work. Lo battery indicator and tilt-stand. Probes and 2000 hour battery included.

- Basic DC accuracy: plus or minus 0.25%
- DC voltage: 200mv–1000V, 5 ranges
- AC voltage: 200mv–750V, 5 ranges
- Resistance: 200 ohms–20M ohms, 6 ranges
- AC/DC current: 200µA–20A, 6 ranges
- Input impedance: 10M ohm
- Fully overload protected
- Approx. 7" x 3½" x 1½" Wt. 11 ozs.

MODEL 2000 $389.95
20 MHz DUAL TRACE OSCILLOSCOPE

Model 2000 makes frequency calculation and phase measurement quick and easy. The component tester aids in fast troubleshooting. Service technicians appreciate the TV Sync circuits for viewing TV-V and TV-H and accurate synchronization of the video signal, Blanking, VITS, and V/H sync pulses.

- Exceptionally bright 5" CRT
- Built-in component tester
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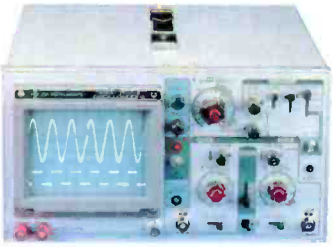

MODEL 3500 $499.95
35 MHz DUAL TRACE OSCILLOSCOPE

Wide bandwidth and exceptional 1mV/DIV sensitivity make the Model 3500 a powerful diagnostic tool for engineers or technicians at a remarkable price. Delayed triggering allows any portion of a waveform to be isolated and expanded for closer inspection. Variable Holdoff allows stable viewing of complex waveforms.

- Exceptionally bright 5" CRT
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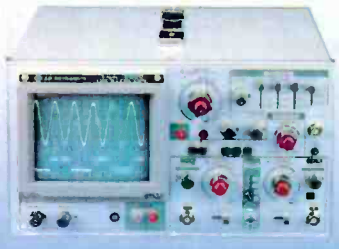
- Z axis intensity modulation
- X-Y operation • TV sync filter
- Fast 10ns rise time



DMM-100 $29.95
3.5 DIGIT POCKET SIZE DMM

Perfect for the field service technician. Shirt pocket size without compromising features or accuracy. Large, easy to read ½" LCD display. Fully overload protected for safety. 2000 hour battery life with standard 9v cell. Probes and battery included.

- Basic DC accuracy: plus/minus 0.5%
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- AC voltage: 200v–750v, 2 ranges
- Resistance: 2k ohms–2M ohms, 4 ranges
- DC current: 2mA–2A, 4 ranges
- Input impedance: 10M ohm
- Fully overload protected
- Approx. 5" x 3" x 1". Under 7 ozs.

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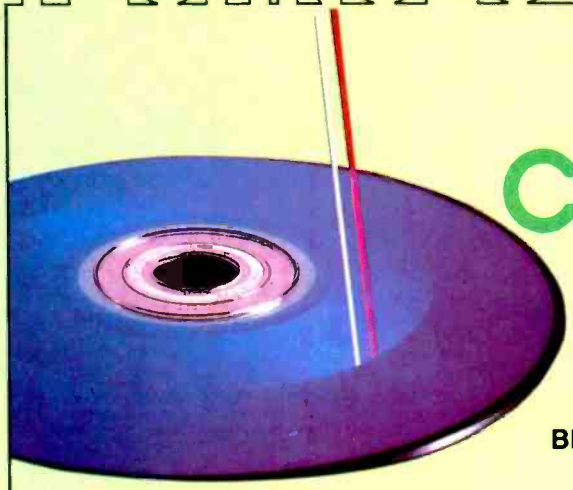


READ/WRITE COMPACT DISCS

The world's first recordable CD-compatible disc.

BRIAN C. FENTON, EDITOR

TANDY CORPORATION'S ANNOUNCEMENT of a major breakthrough in optical media generated a great deal of surprise in the electronics industry—and an almost equal amount of skepticism. Tandy claimd to have developed the technology to produce the first read/write compact disc, called THOR-CD or *T*andy *H*igh-intensity *O*ptical *R*ecordable *C*ompact *D*isc.

What makes Tandy's THOR-CD different from existing recordable optical discs is its complete compatibility with CD-audio discs. Other recordable optical media include WORM (*W*rite *O*nce, *R*ead *M*any) discs, which are becoming quite common, and erasable magneto-optical discs, which were developed last year by several Japanese firms.

Making erasable discs compatible with CD audio equipment has been difficult because of the way data are recorded—in tiny pits and lands that scatter or reflect the laser beam that is used to read the encoded data. Making the pit isn't too difficult; until now, erasing the pit has been.

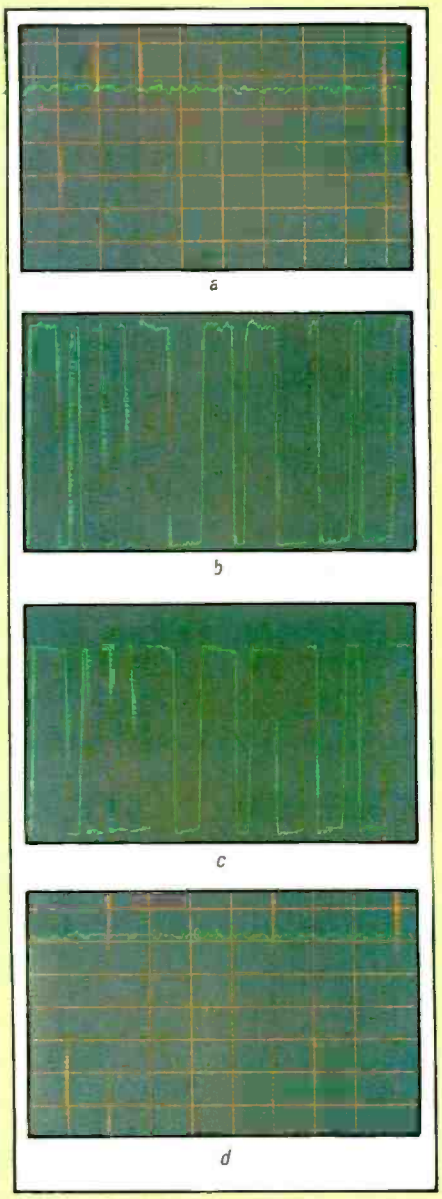
Tandy is very close-mouthed regarding any details of their technology, which is based on a process developed by Optical Data Inc. of Beaverton, Oregon. Knowing that, all we can guess is that Tandy's process uses a reflective disc coated with dye polymer layers that can be pitted by a laser beam; the pit can be removed by a laser beam of a different wavelength. The pit is permanent unless erased, and the discs are claimed to be as rugged as their pre-recorded commercial counterparts.

Tandy predicts that the technology will lead to compact-disc recorders and recordable media in about two years, at an expected starting price of around $500. The discs are expected to be priced at about $5 each. That, incidentally, is about half the expected price of blank *D*igital *A*udio *T*apes (DAT).

Recordable compact discs could have applications other than audio. However, without further technical information, it is too early to say for sure what those applications will be. Mass data storage for computer systems seems to be a likely candidate, but only if error detection and correction schemes can be made sufficiently robust.

Even then, it is uncertain whether THOR-CD data-storage devices would be accepted in the marketplace. First, no one knows how many erase cycles the discs can survive. (Tandy spokespersons have said that the discs conceivably could survive an infinite number of write cycles.) Second, access times for CD-ROM drives are slow—on the order of floppy-disk drives. That, however, is a function of the drive mechanisms, not the medium itself.

Tandy's announcement generated a healthy amount of skepticism, especially among Japanese firms who were early to experiment with erasable optical discs. One reason for that was the skimpy details that Tandy released. Another reason was the announcement's timing, at least two years before the product could be marketed. (Tandy did not have any prototype recorder to show, and played only a tape that they said was recorded from their prototype.) In the worst case, we'll know the answer in two years. **R-E**



TANDY SUPPLIED THESE OSCILLOSCOPE waveform photographs that show (*a*) the THOR-CD media before recording, and (*b*) the digital input. The waveform in (*c*) shows the same signal played back. Although differences between the waveforms in *b* and *c* can be seen, the signals look identical to a CD player. In (*d*), we see the disc after erasure.

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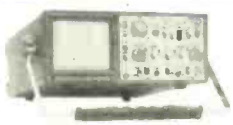

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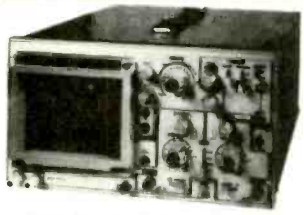

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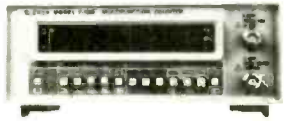

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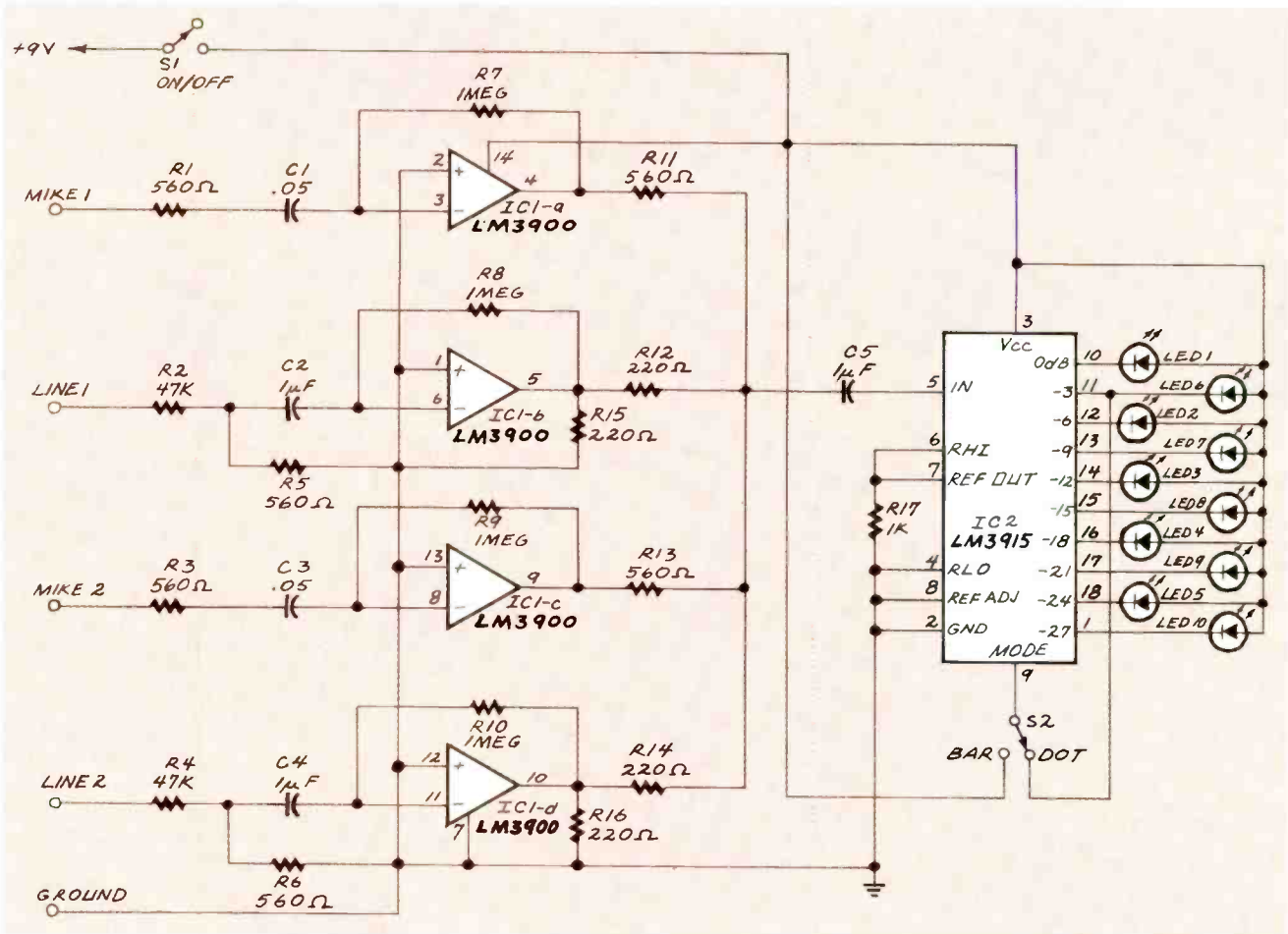

FIG. 1

LED VU METER

Is there any simple circuit I could use to have a series of LED's light in response to the volume of an incoming audio signal? The circuit should be battery powered and have a small amplifier in it to handle a variety of input signals.—J.K., Altoona, IA

If this letter looks familiar to you, it's because we ran it in May. The only problem was that we printed the wrong schematic along with our answer. We hope that we didn't confuse you too much, although some of you probably picked up on the error before we did. So, now we're going to answer the question and include the *right* schematic.

What you're really talking about building is an LED VU meter. You could put one together with discreet parts but it's a lot smarter to use an LM3915. That IC has the buffers, drivers, and precision voltage reference on board to do the job. Best of all, they're not expensive and you can probably find one at your local supplier.

A circuit that does what you ask is shown in Fig. 1. You didn't say what kind of audio signal would be used as the input, but, the circuit has both a microphone and line-level input.

You only need two of the four op-amps in the LM3900 package implement the basic circuit. You can use the extra amps to provide

more gain, more inputs, etc. As shown in Fig. 1, I've elected to use them for additional inputs, but you can change that and use them for anything else you have in mind.

Switch S2 is used to change the display from a dot to a bargraph. You can use any construction technique you want. The circuit doesn't draw much current, so a nine-volt battery will keep the circuit going for a long time.

POWER-LINE INTERFERENCE

I am plagued by interference from local power lines. Representatives of the power company have not been able to deal with the problem. The noise level is between S-9 and 20-dB over on my Yaesu *FRG-7* receiver. It appears that I'll have to add a noise blanker to the receiver. Can you or any reader help with a circuit that can handle the level of noise that I have here?—D.S., Steinbach, Man, Canada

Sometimes, public utilities are not as diligent as they should be in eliminating sources of RFI from their equipment. Sometimes the interference is caused by a loose connection on a high-tension line, a defective transformer, corona discharge, or arcing across a dirty insulator some distance away from the consumer experiencing the interference problem. In other instances, the noise may be caused by heavy electrical equipment in an industrial plant many miles from you.

In such cases, the consumer should do all that he can to pinpoint the source of the interference. If you can localize the source of interference, most power companies will quickly clear up the problem.

WHAT'S A HALF DIGIT?

The multimeter I'm planning to purchase is described as a 3½-digit instrument. I don't know what the "half digit" is all about, and local store clerks can't explain it either. Can you?—M.H., Dover, DE.

An instrument with a 3½-digit display has *four* LED or LCD readout devices. Three of those displays, counting from right to left, can display all numerals 0–9. The fourth display, the one on the left, can only display a 1. That is the "half digit." The purpose of the "half-digit" display element is to increase the full-scale value of each range by one decade. For example, the display's capacity can increase from 99.9 to 199.9. Therefore, the full-scale reading of any range will be 1.999 or multiples thereof. The circuitry involved in the single-digit display is simpler and much less expensive than the flip-flops and counters that would be required to add another full digit to the display.

To illustrate, let's connect a variable 0- to 150-volt source to a 3½-digit voltmeter and gradually increase the voltage starting from 0 volt. As the voltage is applied, the meter displays 0.001 to 0.999, 1.000 to 1.999, 2.00 to 9.99, 10.00 to 19.99, and 20.0 to 150.0 volts on the 200-volt range. Note that the "1" comes on when the display reading reaches the full-scale value of each range. **R-E**

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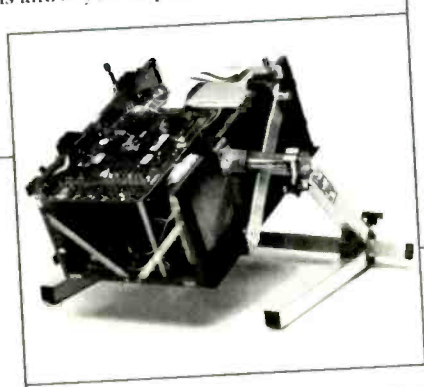

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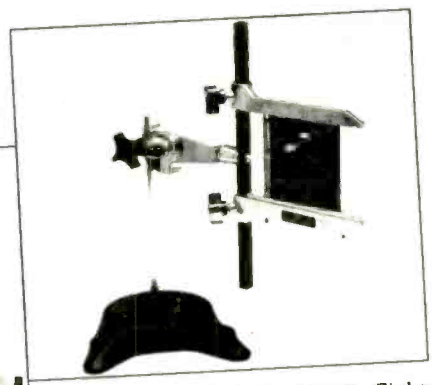

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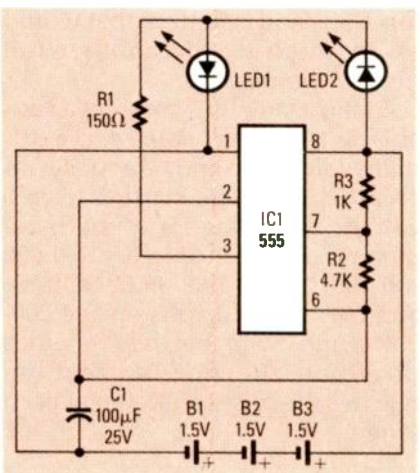

Fig. 1

DOUBLE INDEMNITY

Are our faces red! We claimed that Fig. 1 in the "Good Knight" correction that appeared in last month's "Letters" column was the correct circuit. It was actually a reprint of the incorrect *circuit that originally accompanied the article "Electronic Knighthood" in the April issue. The real correct circuit is shown above in Fig. 1. We apologize for bringing you April foolery in July.*—Editor

HEARING AIDS

I'm writing in response to J.B.C.'s letter in the May 1988 "Ask R-E" department, requesting information on a hearing aid capable of delivering more bass and having mid-frequency attenuation.

The fitting of a hearing aid is not a black-and-white decision. If a behind-the-ear model is suitable, some of the recent innovations in ear-mold and ear-hook technology could give the required frequency response. With an all-in-the-ear model, it would probably have to be achieved electronically. The wearer's specific audio goals must also be considered: Is it to boost the base response, or to improve speech understanding? Or, is speech understanding suffering because the necessary bass response is lacking? Excessive low-frequency response could result in an upward spread of masking—an undesirable condition.

Those are just a few of the many of questions necessary to render an appropriate fitting profile. The fitting of a hearing instrument is probably more important than the choice of a particular device. Without having the basic audiometric information, any decision would be inappropriate.

Finally, audiologists specialize in audiology. Otolaryngologists specialize in the medical discipline of ear, nose, and throat. The medical specialists who have also completed the necessary requisites to specialize in audiology are probably few and far between. I would recommend seeing an otolaryngologist for a medical evaluation of one's hearing impairment, and then presenting that evaluation to an audiologist *or* a hearing aid dealer for fitting. I am sure that satisfactory response from a hearing aid can be attained.

G. ALLEN BLOCH
Kent, OH

CURING CABLE-TV CONVERTER HUM

I have the same problem with the cable-TV converters used here as that described by B.B. in "Ask R-E" (**Radio-Electronics**, May 1988). It isn't a problem with the television—the hum is there, regardless of the model or age of the set. Exchanging the converter doesn't help either; it appears to be a design problem common to all the converters. And my local cable company offered no more help than did B.B.'s.

I came up with a solution to the problem, assuming the converter has a remote control. Turn the volume level of the converter to its highest level, and the TV volume to a bit higher than normal. From that point, adjust the volume level with the converter's remote control. This doesn't really *cure* the problem, but it sets the audio to a level that overrides the hum.

By the way, in the same "Ask R-E" column, Fig. 1 does not match the LED V meter circuit that is described in the text.

MELVIN ZION
St. Joseph, MO

You're absolutely correct, and we apologize for the mistake. The correct circuit drawing for the LED VU meter appears in this month's "Ask R-E."—Editor

MORE ON MACROSCRUBBER

I must disagree with R. Falcone's letter (**Radio-Electronics**, April 1988) about the "Macrovision Scrubber" (December 1987). I tried the unit on several recently released Macrovision-encoded tapes, and it removed all traces of the encoding.

However, there were a few errors in the article and in the kit. In Fig. 2, the block diagram of the DPDT switch, one of the poles should be reversed. The input to the buffer amp should be either the output of the sample and hold circuit or the clamped video. In the schematic in Fig. 3, the junction of IC7 and R17 should be connected to the +12 volt source. (The PC board is correct.)

Although the article stated that

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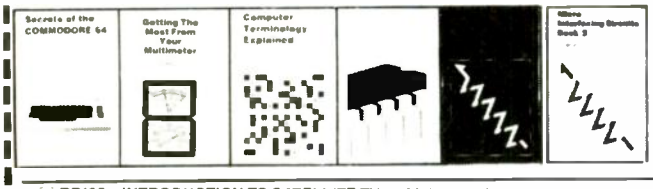

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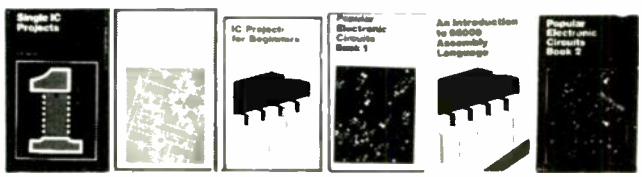

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the Macroscrubber can be left in line and powered at all times, I felt that the video signal should be routed through as few processing devices as possible. I installed a power/bypass switch.

WALTER M. SCOTT, III
Knoxville, TN

FUNCTION GENERATOR

"Build This Function Generator" (**Radio-Electronics**, May 1988) caught my eye because the discrete-components-based function generator I am presently using shows signs of impending death. Mr. Wannamaker's project appears to be a versatile, precise piece of equipment.

However, I am troubled by the grounding. The schematics show the utility ground (green wire in the cord) and the analog ground (one terminal of T-1) connected to the same point. That seems to invite unnecessary ground-loop noise and hum.

Generally, the only reason to connect the utility ground to the box is to protect personnel from an accidental shock if the 120-volt line shorts to the chassis. The power-supply secondary is connected to a ground plane, or to the chassis, to reduce stray capacitive coupling within the circuit by providing lower-impedance capacitive coupling to ground.

On a metal chassis, both grounds are usually the same. Your photographs, however, seem to show a plastic case with a metallic front panel. If the power switch and fuse holder are moved to the back panel, and the leads kept properly short, there is no danger from an electrified case except through the transformer-mounting screws. Those can be connected to the green wire, but kept separate from the analog-circuit ground.

If the project is built in a two- or three-part metal enclosure, and R30 is connected to the front panel as suggested, a noisy output may result from imperfect contact between the painted enclosure parts. That connection is in the ground circuit, bypassed only by the relatively high-impedance wires to the ground jacks.

When a plastic case is used, a

capacitive ground environment can be created by mounting grounded sheet metal on standoffs immediately adjacent to the circuit board. Better yet, a ground plane can be designed into the circuit board, to be connected to the case and to the utility ground, or not, as the designer chooses.

The second problem with the article is that you have edited out almost all of the circuit description, and much of what remains is confusing. Of course, I can puzzle out most of the circuit for myself, and Exar can provide a data sheet for the XR2206, but I have come to expect better from **Radio-Electronics**. I realize it was a long article; I wish you had opted to spread it out over two issues.

DAVID MARSHALL
El Cerrito, CA

The project, with the grounding shown, worked fine. We saw no reason to change the author's design.—Editor

CALIBRATION CORRECTIONS

The article "All About Calibration," in the June 1988 issue of **Radio-Electronics**, contains a slight error. In discussing the international standard for length, the author states that the meter has now been redefined as "a certain number of wavelengths of an orange-red line of light irradiated by atoms of krypton^{86}." That was, indeed, the *former* definition—the exact number of wavelengths being 1,650,763.73. That value, together with the definition of the second as the time for the electromagnetic radiation from a radioactive-cesium clock to make 9,192,631,770 vibrations, later led to a measured value for the speed of light in a vacuum (*c*) equal to 299,792,458 meters per second.

The measurement of *c* had become so precise that in October 1983, the General Conference on Weights and Measures decided to redefine the meter as the length of the path traveled by light in vacuum during a time interval of one 299,792,458th of a second.

In effect, then, the meter is a unit derived from this more fundamental quantity.

WM. H. LAMB, JR.
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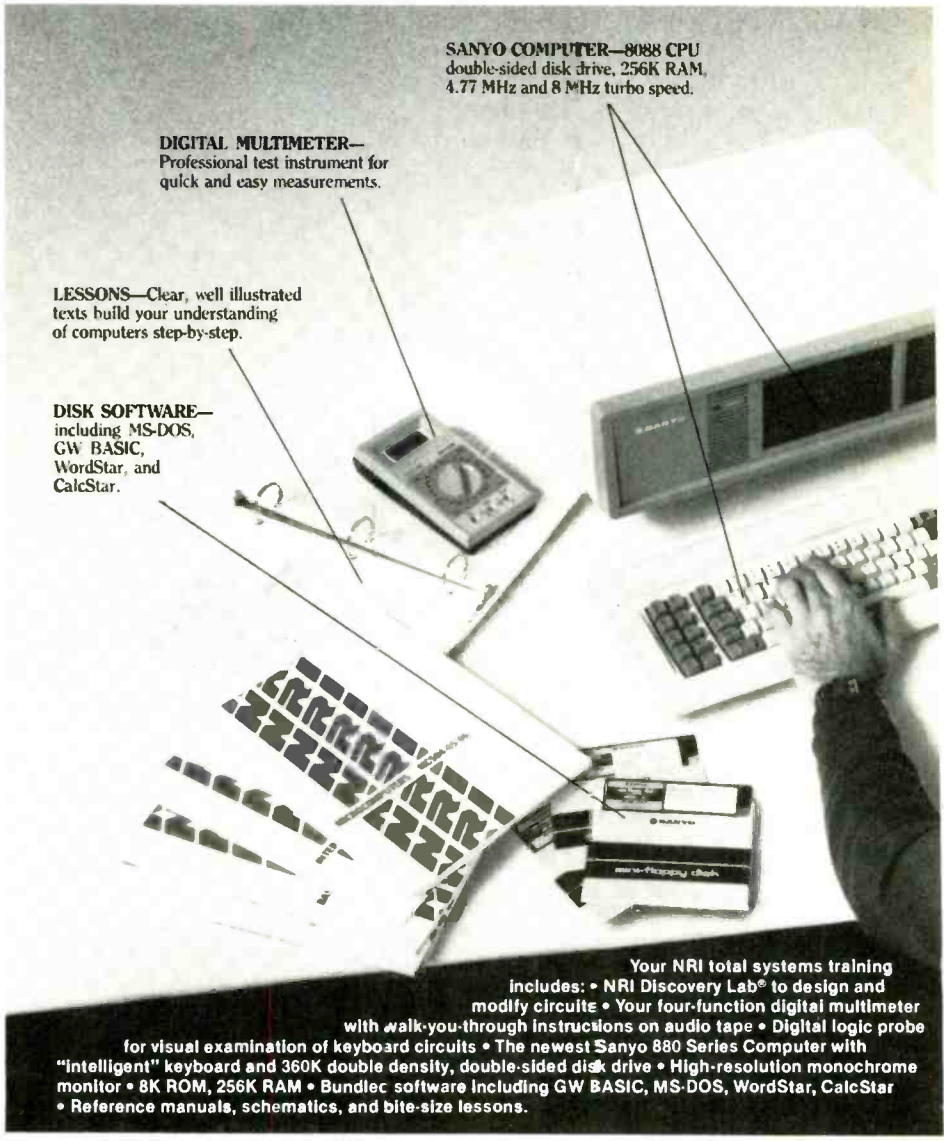

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UNLIKE PREVIOUS HEAVY-DUTY DIGITAL multi-meters (DMM's), the new-generation DMM, such as Beckman's *HD150 Series*, is not only smaller, but you don't even have to touch the meter after you set the basic function: The proper range is set automatically by a smart chip within the meter.

And you don't often have to even *look* directly at the meter. Instead, you can monitor continuous audible tones, whose pitch varies with the magnitude of the reading in proportion to the "position" of the reading within the

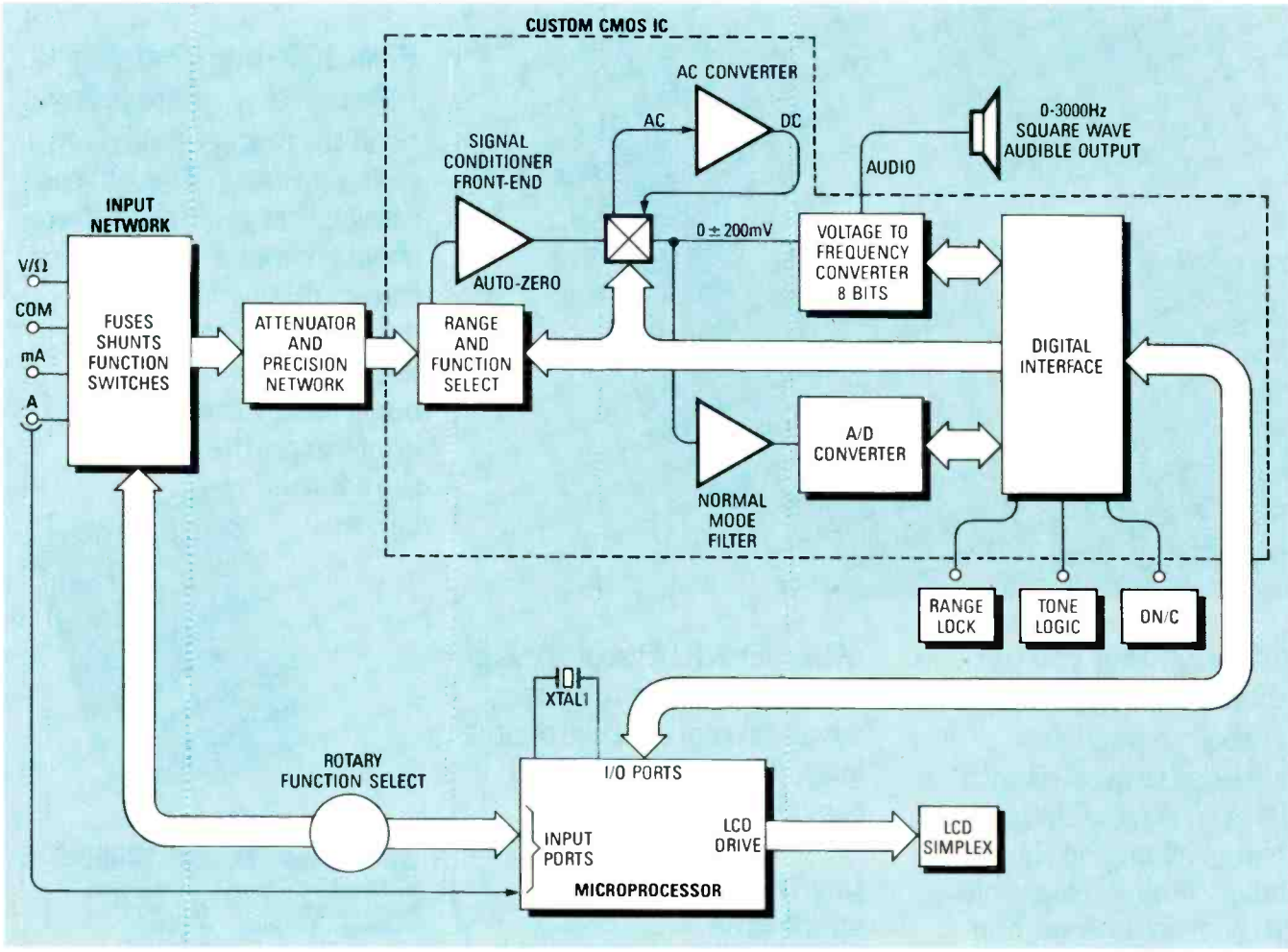

FIG. 1

range. The combination of auto-ranging and audible readout lets you keep your eyes, your hands and your mind focused on your task, rather than having to shuttle back and forth between adjusting or looking at your DMM and setting or moving test leads and making adjustments.

Keeping your attention on the test leads is also a safer way to work, but, the meter will warn you if your test leads do accidentally make contact with dangerous voltages. As the meter enters either the 200-volt or the 1000-volt range, it beeps, warning you of the presence of voltages greater than 20.

The latest technology

The new meters are designed around two powerful microchips—a custom-programmed microprocessor and a custom-designed CMOS analog-to-digital (A/D) converter. The microprocessor performs digital measurement algorithms and it also drives the LCD output.

The fast A/D circuits used in earlier auto-ranging DMM's tended to be noisy, so that several readings must be taken and averaged to assure accuracy. The averaging is done in software, and then the reading is displayed.

The new Beckman DMM's implement auto-ranging and A/D conversion differently. Two parallel circuits are used—one to select the range, another to take the reading. In the first circuit, a voltage-to-frequency converter selects the range. Although not accurate enough to make the actual measurement, it is very fast and is sufficiently accurate to select the range. A related benefit is that the signal can be amplified and connected to a speaker so that the user can actually hear the reading as a tone that is proportional in frequency to the magnitude of the reading. Since the audible readout operates off the very fast voltage-to-frequency converter, the tone reacts quickly to any change in the parameter being measured; it is fast enough to measure transient or intermittent signals.

Once the range is determined, a low-noise A/D circuit makes the actual measurement, measuring the parameter only once and displaying the result on a liquid-crystal display.

This two-step process is so fast that it can keep the tone varying continuously with the input, changing along with digital readouts that actually correspond to "true signal." That is, even in the auto-ranging mode, the new circuitry can sense and measure analog input in *real time*, rather than as discrete, averaged readings of events that have passed.

Reliability

From a practical viewpoint, the new DMM's also provide greater reliability. For example, *automatic shutoff,* extends the life expectancy of the batteries. Although this feature has been advertised widely in the test instrument marketplace in the past, the claim rarely meant that the device would shut itself down completely. On some DMM's having auto-shutoff, the

device just switches to a low-drain condition. The *HD150 Series*, however, will turn itself *off*—completely—after an hour of unattended operation.

Another aspect of reliability is less obvious: The *HD150 Series* is engineered to include a minimum of moving parts. Auto-ranging eliminates much of the need for mechanical switch movement and reduces the number of electrical contacts in the meter, which permits the designer to "design out" some of the potential sources of failure, such as corrosion and resistance of the contacts.

CMOS benefits

A related benefit of CMOS technology is increased DMM sensitivity and lower operating voltages; which is particularly helpful when using the meter in its resistance mode because you may be able to measure resistors in-circuit, without concern that diodes might "break over." When resistors are tested in-circuit in all but the 20 Megohm range, the test voltage output by the meter will not exceed 200 mV, which is far below the 700 mV at which diodes will switch.

Improved LCD

The *HD150*'s liquid-crystal display is *direct-drive*, meaning non-multiplexed. The more an LCD is multiplexed, the less the contrast and viewing angle. Compared with prior models, the *HD150*'s display is brighter and easier to read over a wide viewing angle, and over a wider range of ambient lighting.

Logic detection

While logic-detection capability in a DMM is not new, the ease of using it has been improved in the *HD150 Series*. For example, a separate logic probe is not needed for sensing digital signals; the meter uses its conventional probe to detect digital pulses that are typically too brief to be measured by analog detection circuits. If a data signal is present, the meter emits an audible beep (1875 Hz).

More "hands-free"

To some designers of electronic gear, high-tech means more than custom VLSI and packaging that looks like some NASA prototype. The engineering of the *HD150 Series* reflects the attitude that there's still a place for simple features that are downright handy. For example, the meters feature a *Skyhook*; a one-inch tab that folds out from back of meter at a 45° angle. Sized to fit over anything up to ¾-inch electrical conduit, the hook allows you to hang the meter virtually anywhere—on the edge of a shelf, on a pipe, on the door of an electrical panel, etc. This ingenious idea should make it even easier to work hands-free.

To round out the hands-free concept, the meters also features a tilt stand that folds out from the case, much like a stand for a picture frame. There are also anti-skid pads to prevent the meter from sliding if it's placed face-up on a surface that's not level.

Using audible readout

So, how would you work differently if you had a DMM with audible readout and auto-ranging? Well, how many times when working with TV or stereo gear do you have to adjust an amplifier circuit for peak output? Or for low noise? Using an *HD150-Series* DMM for these kinds of peaking and nulling tests, you can keep your hands—and your eyes—on the test leads and adjustments while you merely listen for the highest or lowest tone produced by the meter. (Once you select the function and attach the test leads, you shouldn't have to touch or look at the meter again.)

Another example? The time-honored diagnostic technique for tracking down intermittents is the "wiggle test." You simply flex the board or connector and try to force a failure. With a DMM connected to either side of the circuit, you can test for changes in output as you stress selected components. On a conventional analog meter, the intermittent connection shows up as a fluctuation of the needle. On a DMM, the digital readout shifts numerically up and down. The difficulty in either case, of course, is that you have to look

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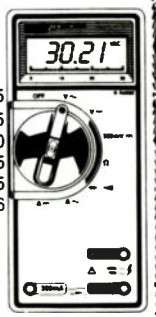

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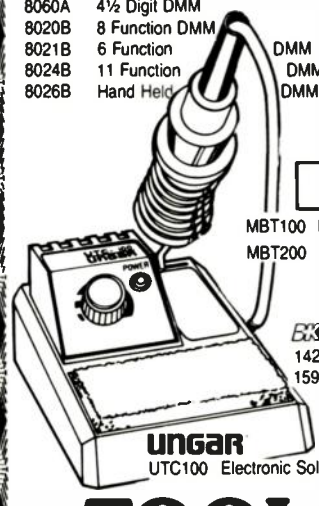

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at the meter to see this. With audible readout, however, you connect the DMM, wiggle the board or connector, and simply listen. If there's an intermittent connection, you'll hear a characteristic crackling noise as the tone breaks up. Since you don't have to look at the meter at all, you'll have a better chance of seeing exactly what you were doing when the elusive bad connection revealed itself. You can do this in volts, ohms, or amps—whichever is most convenient at that time.

The Beckman *HD150 Series* contains three models: the *HD151*, $149; the *HD152*, $169; the *HD153*, $199. (price is determined by features and tolerance.) Take note that the *Skyhook* and tilt stand are optional features of the lower cost models, while the audible readout is available only on the top-of-the-line model.

So, no matter which model you choose from the *HD150 Series*, it's going to make your testing and troubleshooting much easier, and a lot less time consuming. **R-E**

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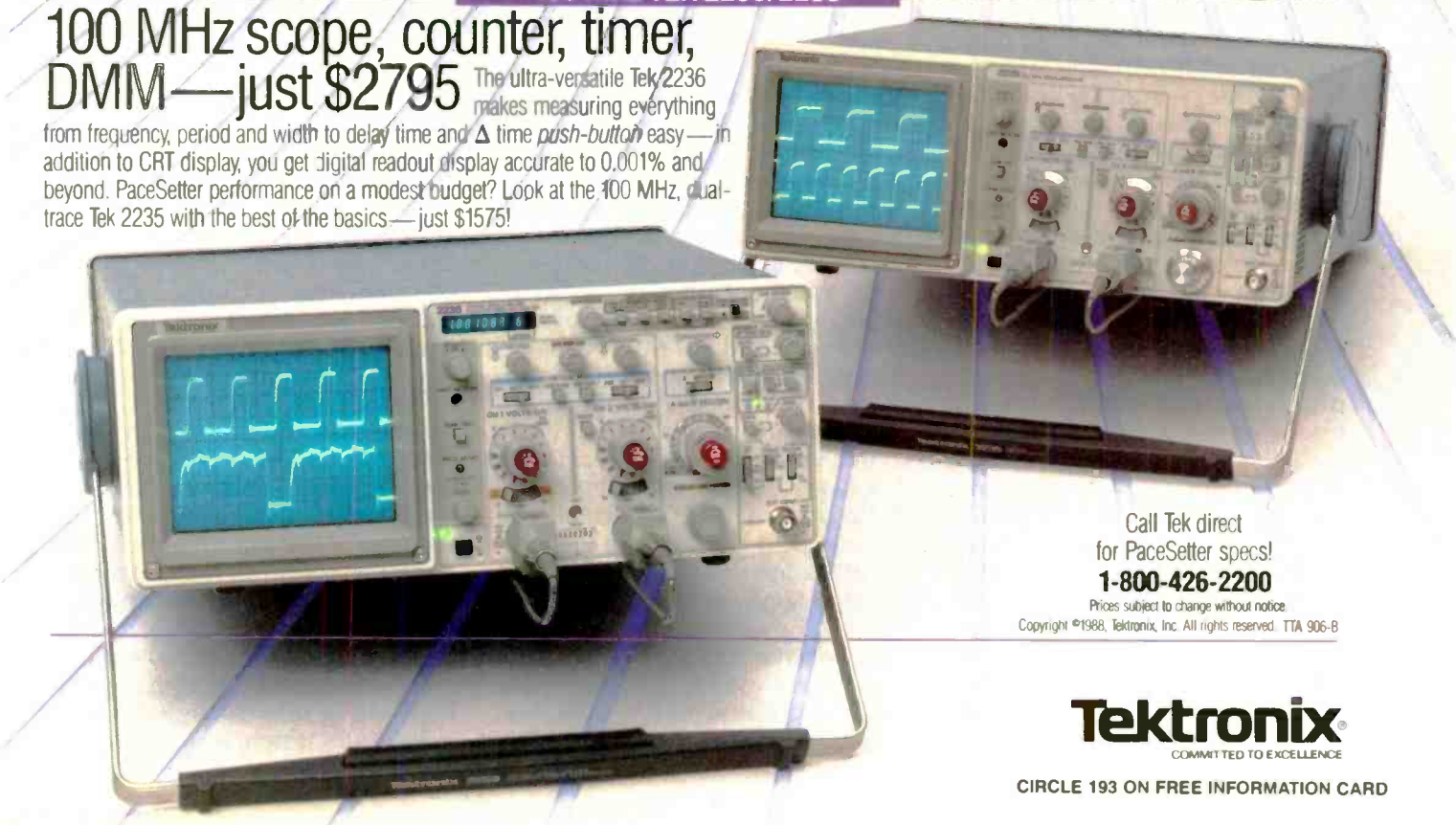

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HERB FRIEDMAN,
COMMUNICATIONS EDITOR

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AT ONE TIME WE WERE THE LEADER IN non-military and consumer communications. We made the best transmitters and receivers; and more important, most new technology originated here in the U.S.

But CB radio changed all that. While our manufacturers were using antiquated circuits, or attempting to use up their stock of existing parts, the Japanese were developing circuits and hardware that literally buried our consumer-communications industry. An example? At the time that American mechanical filters were priced at $22, Japanese CB radios were using mechanical filters of their own design that cost about $2. Similarly, while our gear was using a separate crystal for each channel, the offshore-manufactured transceivers had crystal synthesizers. Actually, the list of offshore firsts is almost endless.

The FCC, which had bobbled the ball on the CB market, then came up with what they believed was a stroke of brilliance. The FCC wanted a cellular telephone system; an idea that met with underwhelming enthusiasm because a cost-effective technology simply didn't exist. The FCC looked closely at the multi-megabuck CB market and discovered how easily multi-million sales resulted in a quick payoff of development costs; which almost immediately translated into high-tech gear at pocket-change prices. So the FCC started to make noises about moving CB to approximately 900 MHz—the approximate frequency band the FCC intended for cellular telephone service.

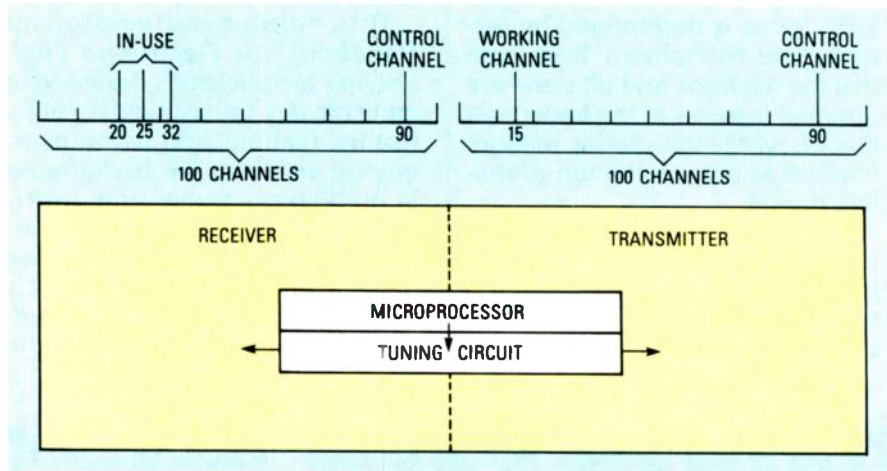

FIG. 1

The idea was that the multi-million sales potential for CB's would result in low-cost 900-MHz hardware, which could then be used for the cellular telephone system. Unfortunately, as soon as every man, women, child, and dog had two CB's, the CB market died, and with it the U.S. 900-MHz personal radio band.

Fortunately, about the time CB died there occurred tremendous developments in both microprocessors and 900-MHz RF hardware, which together made modestly-priced cellular-telephone gear possible.

But while the cost of cellular hardware can be considered upscale mass-market, the actual cost of using the system can be prohibitive for small business and general family use.

Inexpensive 900 MHz

But look what's happened. The cellular market has resulted in low-cost 900-MHz RF hardware, but what runs up the cost is a relatively high RF output and the complex microprocessor circuits needed for a cellular phone. But cut back the RF output to less than 5 watts, and strip out the microprocessor-controlled networking and what have we got? The original 900-MHz personal radio service!

Unfortunately, a 900-MHz personal radio service won't take place here but in Europe, where it will be known as PARS, an acronym for *P*rivate *A*dvanced *R*adio *S*ervice. Presently, because the range of PARS equipment will be limited to about 3 miles, the system is intended to be free from both licensing and network/system control. (However, knowing the Europeans' fear of unlicensed and/or unregulated radio communications, and their tendency to tax anything that remotely resembles a radio or TV, I would not bet the ranch on PARS being free of licensing or networking.)

The PARS system is similar to the

simplex 900-MHz Japanese *P*ersonal *R*adio *S*ervice (PRS). (*Simplex* means that both the transmitting and receiving stations are on the same channel, and only one station can speak at a time.) But unlike the Japanese PRS system, PARS is digital, right down to the modulation. That allows the system to have basic privacy from random eavesdropping, have direct ability to transmit digital data in its original format (such as from a personal computer or whatever), and to easily maintain automatic channel control to avoid the chaos that occurred on our 27-MHz Citizen's Band.

A control channel

PARS uses a control channel to keep conversations private and free from interference. Figure 1 shows how PARS works. (Keep in mind that Fig. 1 is simplified for ease of understanding.) Assume that PARS provides for 100 channels, and that channel 90 is designated as a "control" channel. In the transmit mode, each transceiver outputs on both its working channel and control-channel 90. Actually, there aren't two transmitters. Because the system is entirely digital, the transceiver can easily and almost instantaneously switch between the working and control-channel frequencies.

The receiver section sweep-tunes all 100 channels. When someone keys the transceiver, the receiver section first checks control-channel 90 for in-use channel codes being received from other users. The transceiver then switches the transmitter to an unused channel and transmits the ID code of the desired station, as well as the control-channel's digital code for the working (in-use) channel. The in-use channel code locks out all other transceivers from using that channel, while the working-channel ID code raises the desired transceiver or transceivers. For example, Fig. 1 shows channels 20, 25, and 32 in use. Their in-use data is received on channel 90, so the microprocessor locks out those channels from the transmitter. The transmitter can operate on any channel except 20, 25, 32, and 90. In Fig. 1, we show that the microprocessor has selected channel 15 for transmitting. So the transmitter outputs on channels 15 and 90: 15 containing the digitized voice; 90 containing the in-use data.

No transceiver other than the desired one(s) is activated by the digital address code or channel-15 code, nor can any other transceiver use the active channel as long as a contact is taking place.

Because PARS is a very short-range system, the same frequencies (channels) can be used throughout a geographic area. As long as the control channel does not receive an ID that a particular channel is in use, there can be no interference by other stations on the in-use channel.

Another possibility for PARS is that the receiver will not sweep-tune all channels. It may monitor only the control channel, listening for both a paging signal and the in-use signal. On receiving a paging signal the receiving station may automatically switch to the channel automatically selected by the transmitting station. **R-E**

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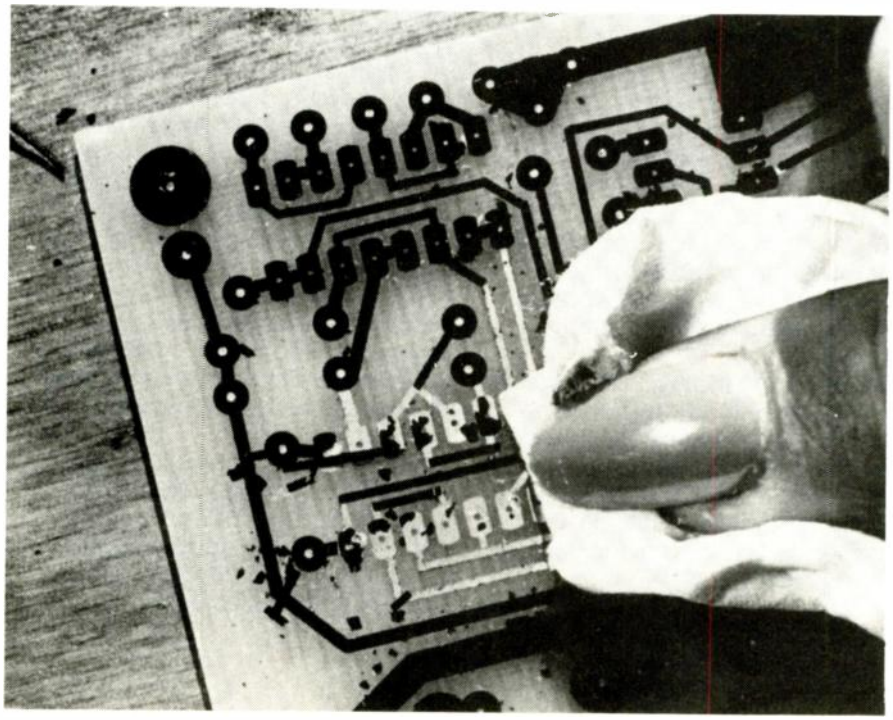

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ETCH RESISTANT PATTERNS. *Direct Etch* is a system designed to make quality printed-circuit boards without formal artwork. The set includes 69 sheets of donuts, traces, through-hole, and surface-mount patterns that transfer by pressure directly onto a copper-clad circuit board. Each pattern is also available separately as a refill set.

To make a circuit, patterns and donuts are rubbed down with a ball point or spoon burnishing tool. Connecting traces are put down by cutting to length with a drafting knife, then transferring the trace to the board. The final circuit is spray- or tank-etched in any standard etchant. The resist is removed by soaking the board in mineral spirits, then rubbing with a soft cloth.

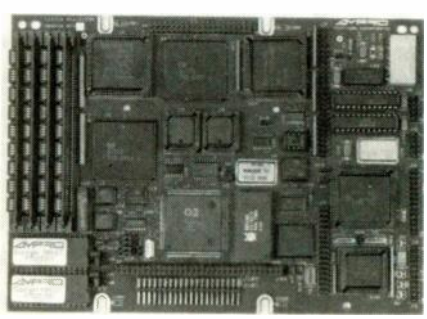
The *DE-973 Direct Etch* allows circuit designers to quickly try different layouts, and engineers and technicians can make rough prototypes where printed circuits would not normally be cost effective. *DE-973* costs $34.95. The refill sets of two sheets cost $2.00.—**The DATAK Corporation**, 3117 Paterson Plank Road, No. Bergen, NJ 07047.

TINY PC/AT-COMPATIBLE BOARD. Ampro's PC/AT-compatible *Little Board/286* packs all the functions normally contained on a motherboard and three expansion cards into 46 cubic inches of volume—the space of a half-height 5¼-inch disk drive. The board requires only 8 watts of power, operates at temperatures ranging from 0–70°C, and has an 8- or 12-MHz 80286 CPU. A *S*mall *C*omputer *S*ystem *I*nterface (SCSI) allows the connection of up to seven external devices, including hard disks, tape drives, bubble memory, CD-ROM, scanners, RAM disks, and laser printers.

Disk, serial, and parallel-port controller functions are socketed VLSI components set directly on the computer board. The optional video-controller (EGA, CGA, MDA, Hercules) can also be installed on the board. Standard PC and AT bus plug-in cards can be connected via the *Little Board/286's* bus- expansion port. Added cards can be connected on a ribbon cable, or on Ampro's optional miniature two-slot passive backplane. Another option—"StackPlane"—permits a PC bus card, up to 8 inches long, to be mounted parallel to the board without additional hardware.

Sockets on the *Little Board/286* allow on-board EPROM of up to 256K, or battery-backed RAM of up to 1M bytes, to function as an MS-DOS-compatible solid-state disk drive. MS-DOS-based applications are converted into EPROM format automatically, without the need for special programming techniques. A RAMdisk offers improved speed, reliability, and durability, as well as reduced power consumption and cost. The *Little Board/286* runs all software applications and utility packages developed for IBM's PC and PC/AT.

Other standard features include AT-compatible BIOS, a real-time clock, keyboard port for XT or AT



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keyboards, floppy-disk controller for up to two 5¼- inch or 3½-inch disk drives, two RS-232C serial ports, three counter-timers, seven DMA channels, and 16-level interrupts. Prices start at $739.00, for quantity orders.—**Ampro Computers, Inc.,** 1130 Mountain View, Alviso Road, Sunnyvale, CA 94089.

CORDLESS MOTO-TOOL. Sometimes less is more: The *Freewheeler* cordless *Moto-Tool (Model 850)* and *Moto-Tool Kit (Model 8500)* offer all the features of the original, corded rotary-power tool—plus added mobility. The *Freewheeler* can use all the attachments and accessories of the corded model.

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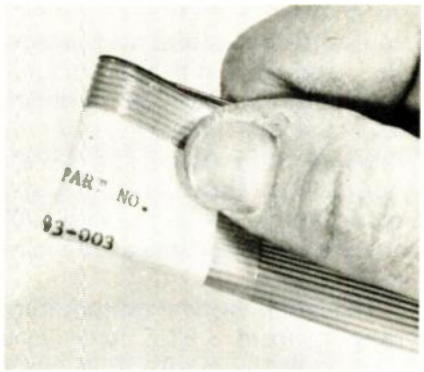
The compact *Freewheeler* is 8½-inches long with a 1¼-inch diameter; it weighs about one pound. The kit includes 30 accessories for sanding, cutting, polishing, grinding, sharpening, and drilling. Both models come with a charger unit. A keyless chuck—standard with the kit—is included with the *Model 850* as a special introductory offer.

The two-speed (15,000 and 20,000 RPM) tool uses a 6-volt high-torque motor, that is powered by five nickel-cadmium batteries. An LED indicator shows when the tool is charging. Suggested retail prices are $59.00 for *Model 850*; $79.00 for *Model 8500*.—**Dremel,** 4915 Twenty-First St., Racine, WI 53406.

RIBBON CABLE MARKER. Ribbon cable presents a difficult surface for labeling. Paper and polyester don't adhere well to its ribbing, and wrap-around labels limit its flexibility. Datak designed *Cabelabel* to solve those labeling problems.

Each label has a white write-on surface that accepts pencil, pen, typewriter, or printer ink. A clear



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vinyl cover securely seals the label to the ribbon cable, and protects the label from dirt and abrasion. An acrylic adhesive has an initially low tack that increases after the marker is in place for several hours. *Cabelabel* is flexible, so it conforms to the corrugated cable surface and stretches as the cable is bent.

The labels work at temperatures ranging from −55°C to +125°C. Sizes range from 1.8 × 0.25 inches to 1.8 × 1.8 inches, and quantities vary from 36 to 108 per set. The price, for any size, is $7.80 per set.—**The DATAK Corporation**, 3117 Paterson Plank Roac, No. Bergen, NJ 07047.

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Model 363B001 measures 18 × 13 × 4 inches and features an exterior organizer pocket for paperwork. With a removable multipocketed portfolio that snaps inside the case cover, *Model 363B004* also measures 18 × 13 × 4 inches. *Model 363B005* (18 × 13 × 5 inches) features a removable portfolio and an attached zippered pocket for a printer. All three carrying cases have diced foam interiors, and meet airline carry-on luggage requirements.

Model 363B001 is priced at $109.00, *Model 363B004* is $129.00, and *Model 353B005 is $149.00.*—**Jensen Tools Inc.**, 7815 South 46th St., Phoenix, AZ 85044. **R-E**

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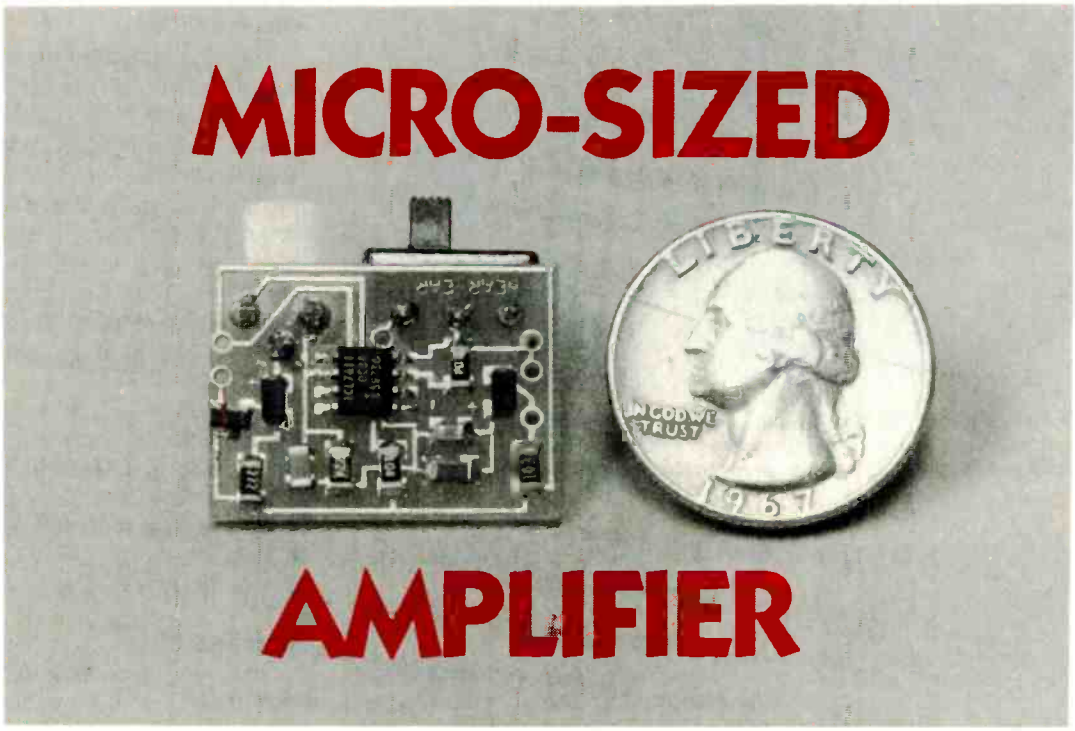
- MICHAEL CARTER is trying to find a transformer for a Zenith radio, model *7S363*, that dates back to the late 1930's or early 1940's. The transformer number is C95-526N. He can be reached at *M.A.C. Electronics, RR4, Box 110, Hutchinson, MN 55350.*



Because it uses surface-mount technology, this micro-size amplifier is not much larger than your thumbnail; but it can make your ears super-sensitive.

FRANK POLIMENE

BECAUSE THEY'RE SO TINY THAT THEY CAN be tucked directly inside the ear, high-gain micro-amplifiers add greatly to the quality of life for the hearing-impaired. For others—those who can still hear the TV without cranking up the volume so high that it can be heard down the block—micro-amps can be lots of fun, because they make possible projects that couldn't be done using conventional-size, or even miniature amplifiers.

As a general rule, commercial super-gain micro-amps are usually a component part of a larger, relatively expensive device, such as a hearing aid, a long-range Big Ear-type microphone, or a surface-microphone super-snooper device that you can use to listen through walls or to monitor your own heartbeat. However, if you'd like to experiment with a micro-amp that's so small that it can almost hide behind a quarter, you can build an SMT (*S*urface-*M*ount *T*echnology) version of the amplifier shown in Fig. 1 for under $20.

If the amplifier was assembled using standard technology it would occupy a space of approximately four square inches; but, by using surface-mount technology we will build the amplifier, including through-hole devices S1 and R6, on a ¾ × 1-inch PC board. Then we'll show you how to use the micro-amp for both a home-brewed Big-Ear type microphone and a super-snooper.

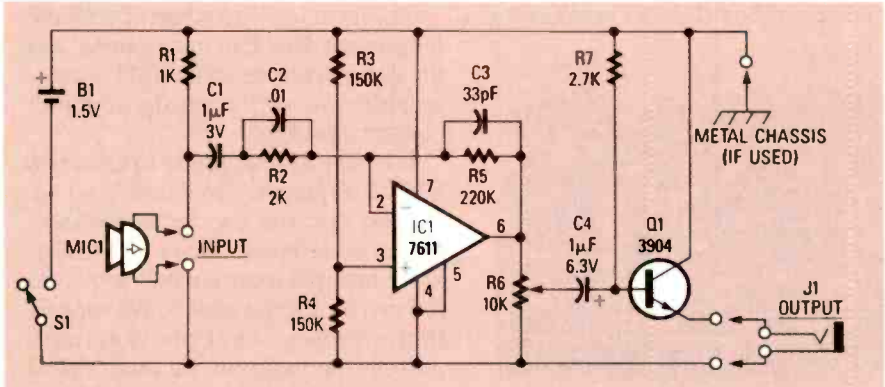


FIG. 1—THIS AMPLIFIER CAN BE BUILT using either SMD or conventional components. Even IC1 and Q1 are available in both SMD and conventional sizes.

Really small

The operational amplifier (IC1) and transistor (Q1) shown in Fig. 1, as well as all the capacitors and fixed-resistors, are available in both conventional and SMD (*S*urface-*M*ounted *D*evice) versions.

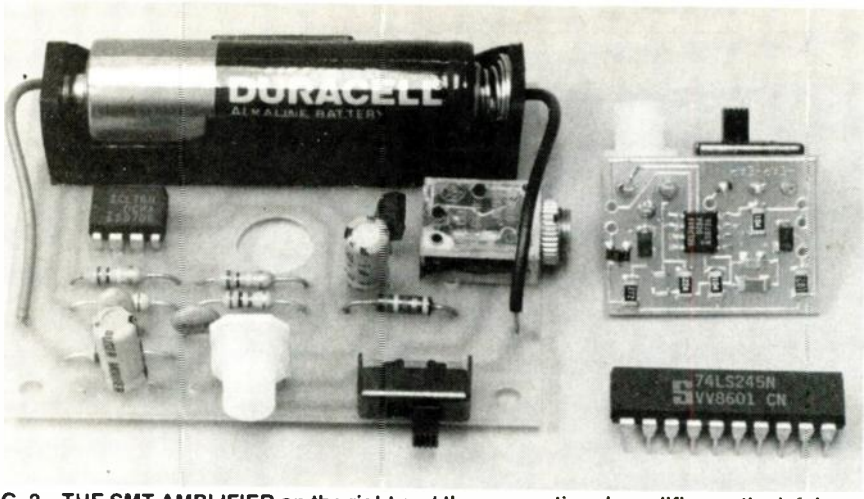


FIG. 2—THE SMT AMPLIFIER on the right and the conventional amplifier on the left have the same performance, although the conventional amp's PC board has room for a battery holder and an output jack. The 20-DIP IC also serves to illustrate the small size of the SMT amplifier.

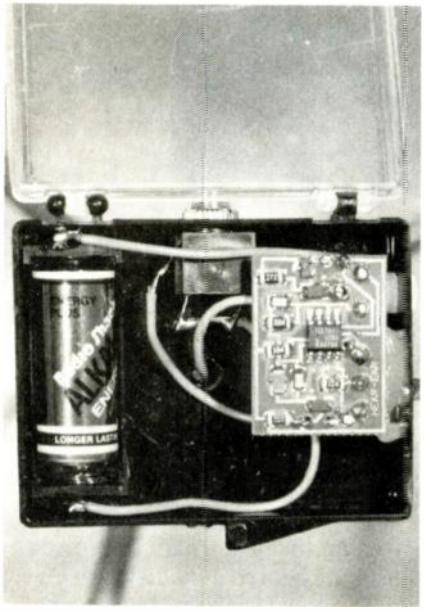


FIG. 3—THE COMPLETE SMT AMPLIFIER, including an N-battery and an earphone jack, can be assembled in a small plastic pill box.

SMD-type capacitors and resistors are called *chips*; hence, an SMD-type resistor is called a *chip resistor*.

Figure 2 shows the SMT amplifier on the right and the same circuit, made using conventional miniature components, on the left. Note that when using conventional parts, the PC board gets so large that's its easy to install the battery holder and an output jack for the headphones directly on the board. Obviously, for the SMT amplifier the battery (B1) used for the power supply and the microphone (MIC1) must be external to the amplifier. The 20-pin DIP IC, also seen in Fig. 2, shows the relationship in size between the entire SMT amplifier and a single conventional integrated circuit.

Why so small?

While most of us can understand the reasons for using surface-mount technology in commercial equipment, it's logical to ask what real value or purpose there is for the hobbyist to use SMT to build what is essentially a simple electronic circuit. First, it gives you a chance to build a practical device that could not be easily done using conventional-size components. Second, using SMT provides both acquaintance and experience with the latest manufacturing technology used in consumer and professional equipments.

The complete amplifier assembly (Fig. 3) that is used for for both the Big Ear-type microphone and the super-snooper is a good example of why a hobbyist would use SMT construction. The entire amplifier, including its battery and headphone jack, is so small it can be assembled in a plastic pill box that can be glued to the front of a Big Ear-type microphone, or carried in a shirt pocket.

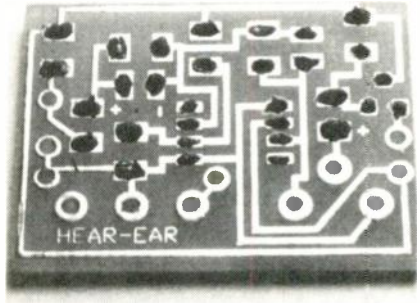


FIG. 4—DROPS OF SOLDERING PASTE are applied only to the components' soldering pads.

The amplifier

Sound detected by the electret microphone (MIC1) is fed to IC1's input through resistor R2, and capacitors C1 and C2. Resistors R2 and R5 determine the overall stage gain, while C2 partially determines the amplifier's frequency response. To ensure proper operation using a single-ended power supply, R3 and R4 simulate a null condition equal to half the power supply's voltage at IC1's non-inverting input.

The output of IC1 is transferred to emitter-follower amplifier Q1 via volume control R6. The high-Z-in/low-Z-out characteristic of the emitter-follower matches the moderately high-impedance output of IC1 to a low-impedance headphone load.

Stop and think

One note of caution on the SMT amplifier. There is a practical limit as to how small the battery can be. While N-size and larger batteries work fine, the small 1.5-volt button cells don't have sufficient ampacity (current-capacity) to provide a low-distortion output. So when figuring how you'll house the amplifier, keep in mind that the battery will be about the same size as the amplifier, or larger. Also, the battery's life depends on the type that you use. You can expect about 12–24 hours of continuous use from a small watch battery, and two months or more from a D-type Alkaline flashlight battery. Keep in mind that the distortion is a good indicator of the battery's condition: A dramatic increase in distortion means that the battery is pooped out.

Construction

The most important part of both the long-range Big Ear microphone and the super-snooper is the SMT micro-amplifier, so we'll cover the amplifier construction first.

It is almost impossible to create an SMT foil pattern "by hand," so we suggest that you use the double-size PC-board template shown in PC Service. Just make certain that you scale it down by a factor of 0.5. We suggest that a professional photographic positive or negative be used. Most copy houses and photographic dealers can use the PC Service template to prepare a negative or positive "stat."

PARTS LIST

Resistors are ⅛-watt chip-type unless otherwise noted.
R1—1000 ohms
R2—2000 ohms
R3, R4—150,000 ohms
R5—220,000 ohms
R6—10,000-ohm miniature control, Mouser ME322-9400 or equivalent
R7—2700 ohms
Capacitors are chip-type rated at least 6.3 volts.
C1, C4—1 μF
C2—0.01 μF
C3—33 pF
Semiconductors
IC1—ICL7611DCBA, operational amplifier (Intersil)
Q1—MMBC3904, PNP transistor
Other components
B1—1.5-volt battery, see text
J1—Miniature phone jack
MIC1—electret microphone, Mouser 25LM042 or equivalent
S1—SPDT, miniature switch, Mouser 10SP018 or equivalent
Miscellaneous: printed-circuit board materials, 1-oz. solder paste, 32-ohm stereo headphones, solder, etc.
Note. The following components are available from BCT Electronics, 8742 Belair Rd., Baltimore, MD 21236:
Etched and drilled printed-circuit board, $3.95; IC1, $3.95; complete kit including solder paste, $14.95. Add $1.50 postage and handling for each order. Maryland residents must add 5% sales tax.

If you don't want to go through the hassle of making the board yourself, it can be ordered from the source given in the Parts List.

Although commercial SMT printed-circuit assemblies are made using a variety of methods, most use some kind of solder mask and/or automatic adhesive dispensing, and a pick-and-place machine to put the parts on the board. But you'll have to put the parts in place one at a time by hand, so you'll have to provide a way to position the component, hold it in place, and make it ready for careful soldering.

The positioning, holding, and prefluxing is done with a special kind of solder paste that contains tiny balls of solder mixed with flux. (The mixture forms a paste that's similar in consistency to smooth peanut butter.) It is usually supplied in jars or cans, but is also available in syringe-type dispensers for precise paste delivery.

Most electronic supply stores now carry some variation of SMT solder paste as a stock item. But a note of caution: Solder paste has a relatively short shelf-life—6–12 months after it's been opened—so purchase the minimum amount possible and store it in the refrigerator when not in use.

Mix the solder paste thoroughly. Place a small amount on a piece of aluminum foil and allow it to reach room temperature. Stir the paste with a toothpick until it reaches a smooth consistency; then, as shown in Fig. 4, place small drops of the paste only on the soldering pads that will be used for the SMD's.

If in the process of applying the paste to the PC board you mess up, simply use a toothpick to move or remove the paste. If the mess is beyond control, use a tissue to mop up all the paste and start over.

Using tweezers, position an SMD over its pasted pad and gently press the SMD into the paste. The paste will hold the part in position until it's soldered. If positioning the components causes the solder paste to slop onto adjacent traces, use a toothpick to clean the area between the traces.

Soldering

Position the parts on the PC board as shown in Fig. 5. The SMD's don't have to be perfectly centered on the pads because the paste will pull them into position during the soldering process. After all the SMD's have been placed, prepare the soldering device—a hot plate that's topped with a shallow aluminum pan or a skillet—by preheating the pan or skillet with the hot plate's temperature control set to HIGH. (Solder melts at approximately 400°F.) Pick up the completed board with tweezers and place it on the pan or skillet with the board's flat side down (component side up).

It will take from 20 to 50 seconds for the solder to melt. Then remove the board quickly to prevent the components from overheating. Set the board aside to cool. Next, using a low-wattage soldering iron, install switch S1 and volume-control R6. Microphone MIC1, battery B1, and output-jack J1, are connected through wires that are hand-soldered to their respective PC-board terminals.

Finally, as shown in Fig. 3, install the amplifier, along with B1 and J1, in a small plastic pill box.

The reflector

Details for building the prototype Big Ear-type reflector are shown in Fig. 6. The reflector is an 11-inch aluminum bowl. Actually, unlike a parabolic reflector—which is really what's needed—the bowl-shaped reflector used for our prototype Big Ear-type microphone doesn't sharply focus the arriving sound into the microphone. But the back of the bowl *does* have the approximate shape of a small parabolic reflector, and the tube that supports the microphone and its amplifier housing can be positioned for optimum sound pickup—so the assembly really can function as a moderately sensitive Big Ear.

The amplifier's cabinet is cemented to the back of a 7-inch length of ½-

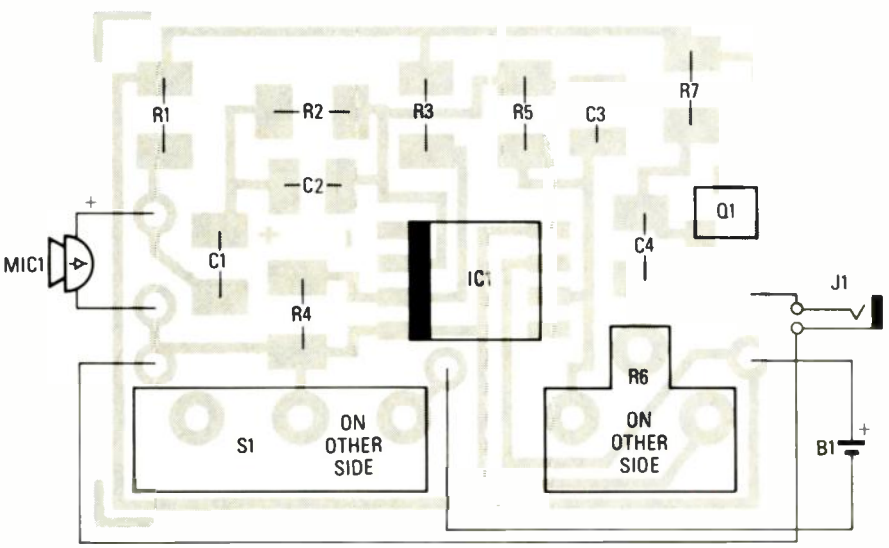


FIG. 5—THE SMT AMPLIFIER'S PARTS LAYOUT. Keep in mind that you're dealing with chip components that are all soldered in place at the same time.

inch copper tubing. Microphone element MIC1 is secured inside a ⅜-inch rubber grommet that's cemented inside the tubing with silicon rubber adhesive or hot-melt glue. The front of the microphone should be flush with the front of the grommet, which is set back about ¼-inch from the input end of the tubing. The details for the amplifier assembly and the microphone installation are illustrated in Fig. 7.

As shown in Fig. 6, the microphone assembly is supported by three bands formed from ¼-inch copper tubing. One end of each band is screwed to the bowl; the other end is soldered to a ½-inch solder-type copper coupling. The microphone's pickup is optimized by sliding the amplifier assembly back and forth in the coupling until the best sound pickup is attained. The actual Big Ear-type microphone prototype is shown in Fig. 8.

Snooping

A super-snooper's amplifier is built the same way as for the Big Ear, with the exception that the microphone is not installed in a pipe that's attached to the amplifier. Instead, using the same mounting arrangement shown in Fig. 7, install the microphone in a 1-inch length of ½-inch plastic tubing, PVC, or ABS pipe. Connect the microphone to the amplifier's input through approximately two feet of shielded cable. Since the amplifier is intended for listening to weak sounds, expect to hear considerable distortion if someone speaks directly into the microphone, or even nearby. As a general rule, use the super-snooper for monitoring weak sounds, such as your own heartbeat, and adjust volume-control R6 for the minimum usable gain.

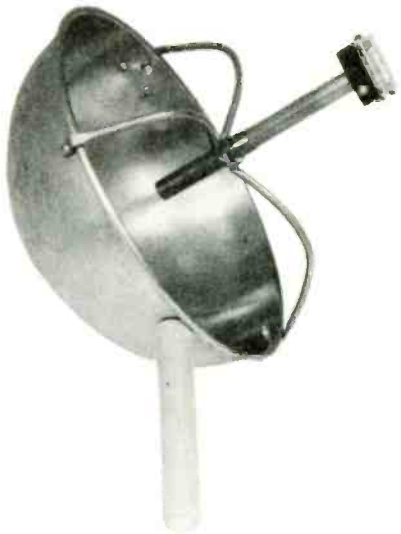


FIG. 8—THE PROTOTYPE BIG EAR-TYPE microphone. The tubing containing the microphone and the amplifier is positioned for optimum sound pickup.

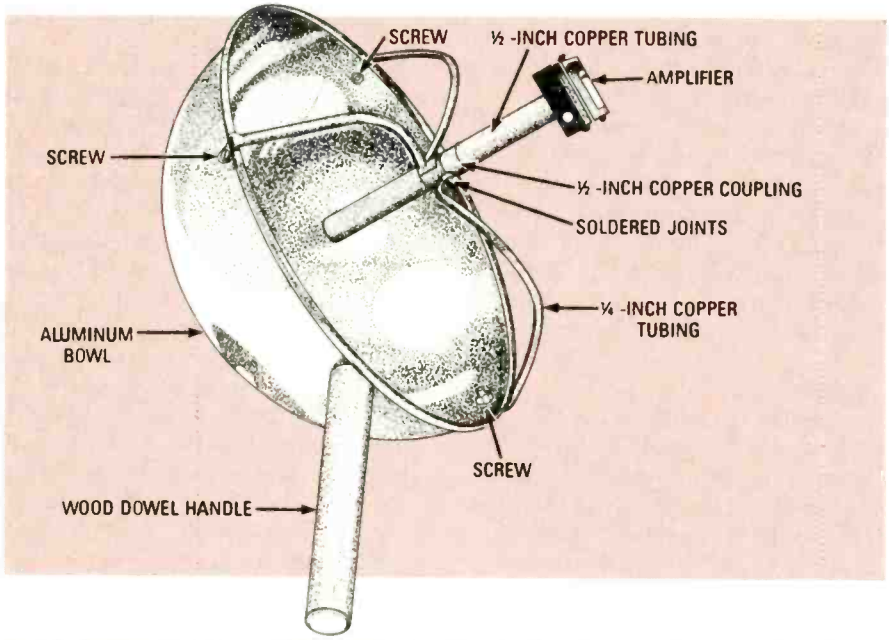


FIG. 6—THE BIG EAR-TYPE MICROPHONE'S REFLECTOR is actually an aluminum bowl, so it does not have the sensitivity of a parabolic-reflector long-range microphone.

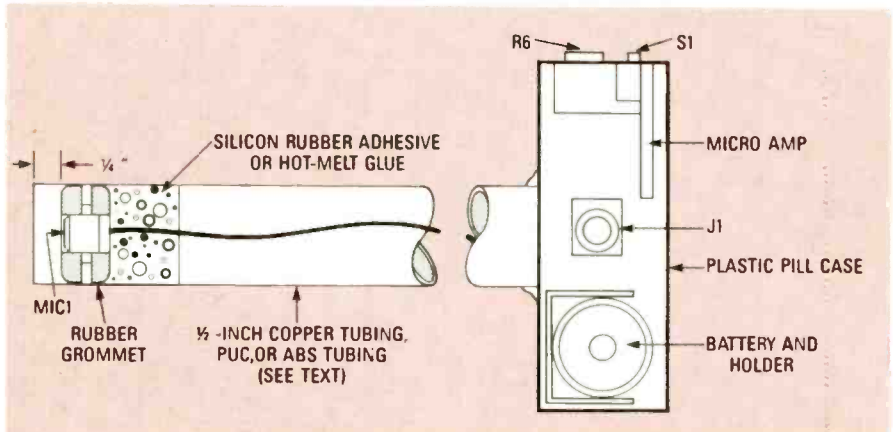


FIG. 7—THE SAME TYPE OF MICROPHONE ASSEMBLY is used for both the Big Ear-type microphone and the super-snooper. The only real difference is the length of the tubing used to hold the microphone element.

Unusual snooper

Figure 9 shows an unusual kind of snooper; one that you can wear in a crowd and no one will be the wiser. A complete circuit, including the microphone, and a power source, is built into both "headphones" of a *radio headset*; one of those listen-while-you-jog radios. Simply strip out the guts from both earpieces—taking care not to damage the headphone unit itself—and install our micro-amp, a microphone, and a button-cell. R-E

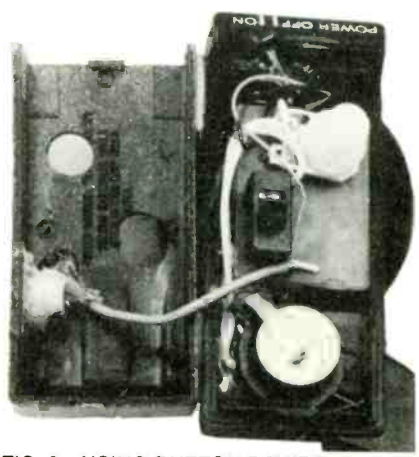
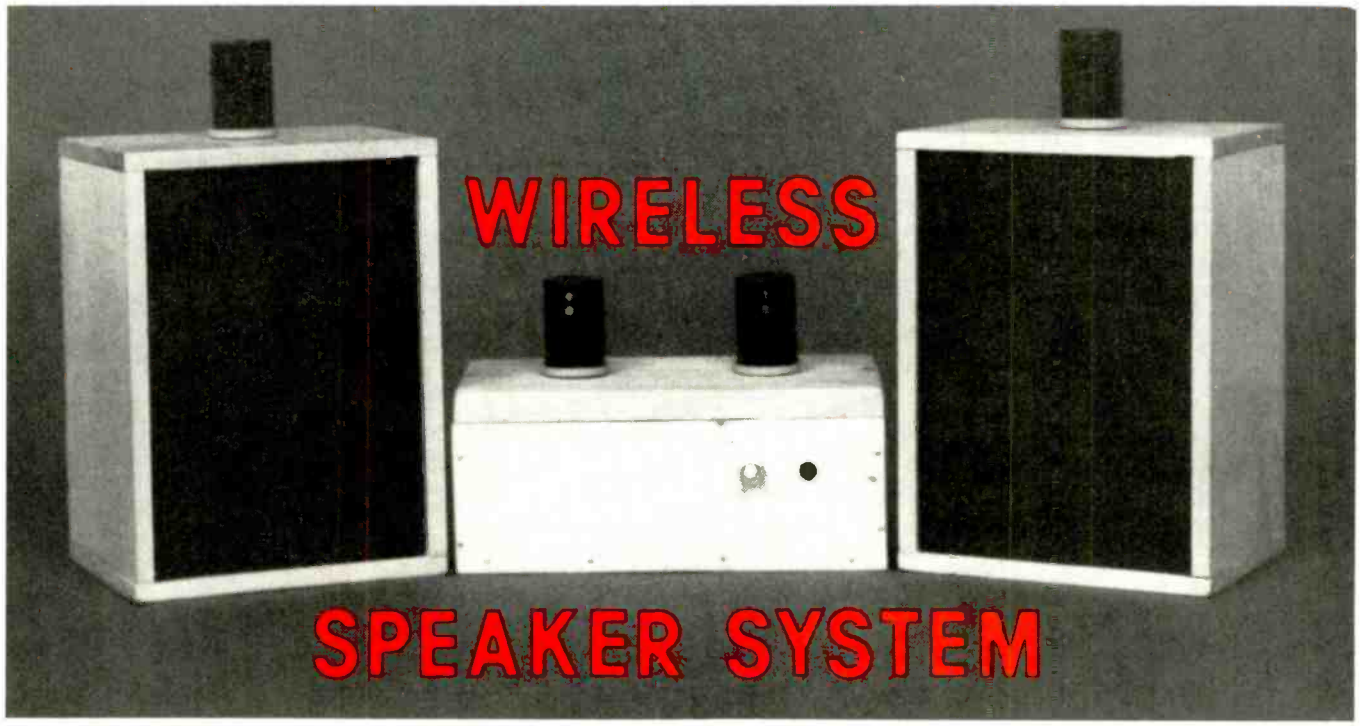


FIG. 9—USING BUTTON POWER, you can install the micro-sized amplifier in place of a headset radio.



Many modern devices make use of infrared technology for communications. In this article we'll show you how to build one of those devices—a wireless speaker system.

WILLIAM SHEETS and RUDOLF F. GRAF

FOR MANY YEARS, INFRARED TECHnology was used mainly in military and industrial applications. Those included such things as snooperscopes, night-vision equipment, thermal cameras, missile-guidance systems, and satellites. More recently, however, infrared technology has found its way into a wide variety of consumer and hobby applications. It will undoubtedly be used to a greater extent in the future.

Before we go on, it would be useful to define exactly what *I*nfra*R*ed (IR) radiation is. It can be broadly defined as any radiation lying between the low (red) end of the visible spectrum, and the upper limit of the radio spectrum. That includes the very short wavelengths from about 700 nanometers to about 1000 nanometers.

The advent of hobbyist-priced IR-LED devices and integrated circuits makes it possible for us to build control and communication devices that operate in the near-IR (around 900 nanometers) portion of the spectrum. Several applications that are suitable for IR technology are:

- Wireless links between audio equipment
- Remote controllers
- Computer-data interfaces
- Wireless intercoms
- Aids for the hearing-impaired
- Cordless headphones

In this article we are going to look at one of those applications: a wireless audio link.

IR communications

Although the IR region is free from radio interference, it is subject to interference from incandescent lamps, fluorescent lamps, stray reflections, and other sources; that is especially true of the near-infrared region.

A simple way to overcome that problem is to create a "carrier" by chopping the IR radiation at a rate of 100 kHz. The audio can then modulate the carrier by modulating the chopping rate. A receiver can then detect the IR beam as a 100-kHz FM signal. The only disadvantage is that instead of a simple audio amplifier, a high-gain FM receiver is necessary. However, with the IC's that are now available, an FM receiver is easy to build, and contains little more circuitry than a high-gain audio amplifier.

The transmitter

A schematic for a suitable IR transmitter is shown in Fig. 1-*a*. Basically, it is a voltage-controlled oscillator that drives up to four LED emitters. A line-level (1-volt p-p, maximum) audio signal is fed to J1 (an RCA jack), and appears across R1. The audio is coupled to the base of Q1, which has a voltage gain of about five. It is then coupled to pin 5 of oscillator IC1, which operates in the 30- to 250-kHz range, depending on the application. Capacitor C8 sets the oscillation-frequency range, and then the exact frequency is adjusted by R9. Values for C8 for several frequencies are shown in Fig. 1-*b*. A square wave at pin 3 of IC1 drives Q2, which in turn switches Q3 on and off. The collector current through R15 and R16 bias the IR emitters (LED1 and LED2). Up to four IR LED's can be used, depending on the output level required; depending on the number of LED's used, the value for R15 and R16 may be between 100 and 330 ohms. Our prototype, which has two LED's, uses 150 ohms for both R15 and R16.

The receiver

The schematic for a companion IR

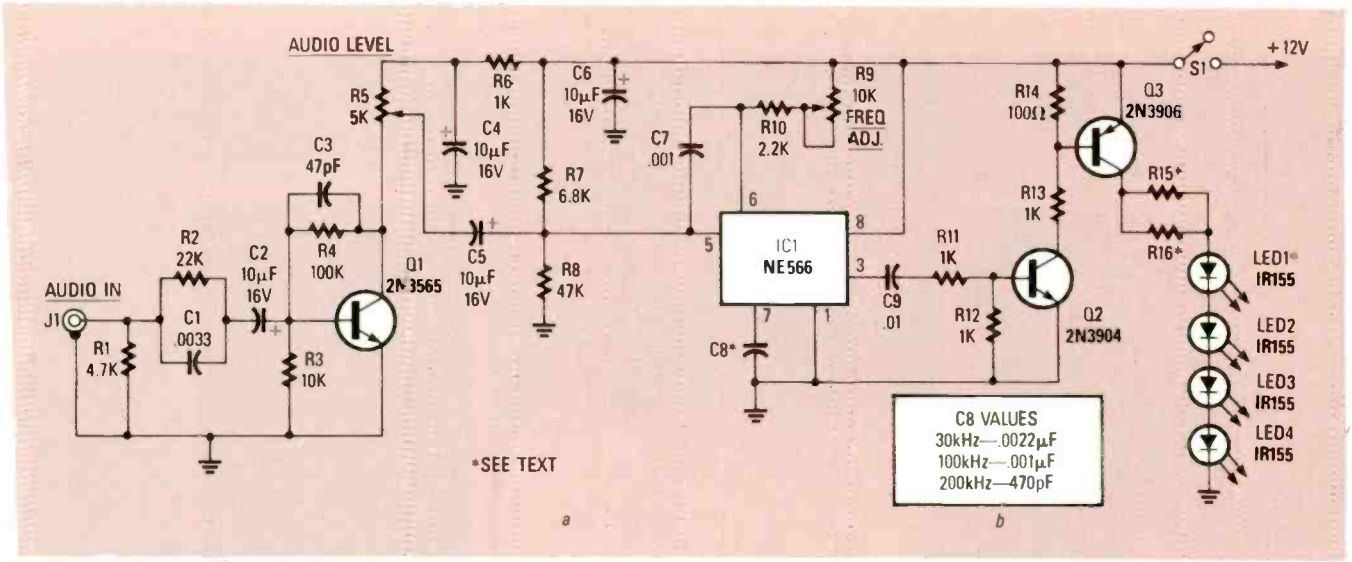
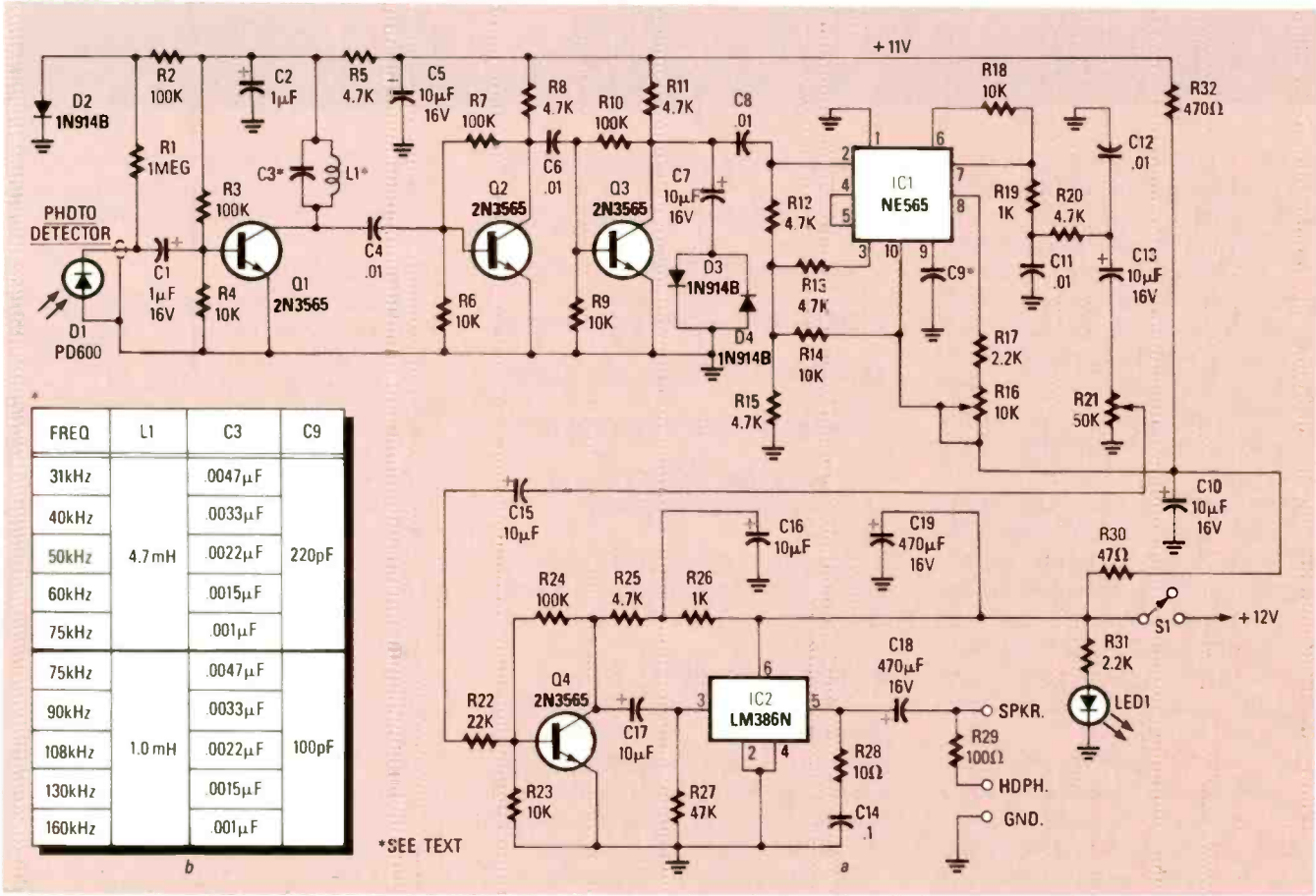


FIG. 1—THE IR TRANSMITTER (*a*) sends audio signals to the IR receiver. The chart (*b*) shows the correct values for C8 for operation over different frequency ranges.



FREQ	L1	C3	C9
31kHz	4.7mH	.0047µF	220pF
40kHz		.0033µF	
50kHz		.0022µF	
60kHz		.0015µF	
75kHz		.001µF	
75kHz	1.0mH	.0047µF	100pF
90kHz		.0033µF	
108kHz		.0022µF	
130kHz		.0015µF	
160kHz		.001µF	

FIG. 2—THE IR RECEIVER (*a*) picks up signals from the transmitter and drives the speakers. The chart (*b*) shows the values for L1, C3, and C9. Those components cause the receiver to operate on the frequency of your choice.

receiver is shown in Fig. 2-*a*; it operates as follows: Photodiode D1 is a PD600; that photodiode has a built-in infrared filter that reduces the effects of stray visible light. When infrared energy from the transmitter is detected by D1, it causes the photodiode to conduct a small reverse current. The received modulated signal is coupled to amplifier Q1. Low-frequency noise is somewhat attenuated by a tuned circuit (L1/C3) that is broadly resonant between 30 and 150 kHz; that circuit allows the desired operating frequency to be passed through. The chart in Fig. 2-*b* shows the L1, C3, and C9 values for different operating frequencies.

The signal at the collector of Q1 is coupled to Q2, which amplifies the signal and feeds Q3. The signal at the

PARTS LIST—TRANSMITTER

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

R1—4700 ohms
R2—22,000 ohms
R3—10,000 ohms
R4—100,000 ohms
R5—5000 ohms, standard trimmer potentiometer
R6, R11–R13—1,000 ohms
R7—6800 ohms
R8—47,000 ohms
R9—10,000 ohms, standard trimmer potentiometer
R10—2200 ohms
R14—100 ohms
R15, R16—150 to 300 ohms, see text

Capacitors

C1—0.0033 μF, 10%, mylar or ceramic disc
C2, C4–C6—10 μF, 16 volts, radial electrolytic
C3—47 pF, 10%, ceramic or mica
C7—0.001 μF, 20%, mylar or ceramic disc
C8—470 to 2,200 pF, mylar, mica, or npo ceramic (see text)
C9—0.01 μF, 25 volts, ceramic disc

Semiconductors

IC1—NE566 VCO
Q1—2N3565 NPN transistor
Q2—2N3904 NPN transistor
Q3—2N3906 PNP transistor
LED1, LED2—IR155 LED

Other components

J1—RCA jack
S1—SPST switch
Miscellaneous: PC board, wire, solder, etc.

PARTS LIST—RECEIVER

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

R1—1 megohm
R2, R3, R7, R10, R24—100,000 ohms
R4, R6, R9, R14, R18, R23—10,000 ohms
R5, R8, R11–R13, R15, R20, R25—4700 ohms
R16—10,000 ohms, standard trimmer potentiometer
R17, R31—2200 ohms
R19, R26—1000 ohms
R21—50,000 ohms, potentiometer
R22—22,000 ohms
R27—47,000 ohms
R28—10 ohms
R29—100 ohms
R30—47 ohms
R32—470 ohms

Capacitors

C1, C2—1 μF, 16 volts, radial electrolytic.
C3—see text
C4, C6, C8—0.01 μF, 25 volts, ceramic disc
C5, C7, C10, C13, C15–C17—10 μF, 16 volts, electrolytic
C9—see text
C11, C12—0.01 μF, 20%, mylar
C14—0.1 μF, 20%, mylar
C18, C19—470 μF, 16 volts, radial electrolytic

Semiconductors

IC1—LM565 phase-locked loop
IC2—LM386N low-voltage audio power amplifier
Q1–Q4—2N3565 NPN transistor
D1—PD600 photodiode
D2–D4—1N914 diode
LED1—Red light-emitting diode (see text)

Other components

L1—see text
S1—SPST switch
Miscellaneous: PC board, wire, solder, etc.

PARTS LIST—POWER SUPPLY

Resistors

R1, R2—47 ohms, 1 watt

Capacitors

C1—0.01 μF
C2–C4—2200 μF, 16 volts, radial electrolytic

Semiconductors

D1–D4—1N4002 diode

Other components

F1—0.5-amp fuse
S1—SPST switch
T1—12 volt, 1 amp transformer (Radio Shack 273-1365 or equivalent)
Miscellaneous: 3-prong line cord, fuse holder, perforated construction board or terminal strip

collector of Q3 is limited to 1 volt, peak-to-peak (via D3/D4), and coupled to pin 2 of IC1, an NE565 phase-locked loop. That IC consists of a phase detector and a VCO; the input to pin 2 causes the internal VCO to lock on to the input-signal frequency.

An internally generated DC voltage controls the VCO. The internal phase detector's output (pin 5) is connected to the internal VCO-control input (pin 4) via an external jumper wire. The tuning-control resistor, R16, is adjusted so that the VCO's free-running frequency is approximately the same as the signal frequency. The recovered audio signal is obtained at pin 7.

The recovered audio is first coupled to R21, the AF gain control, and then to the AF-amplifier, Q4. The gain of the Q4 stage is limited by R22 to about five, and a 0.5-volt audio signal is available at its collector. Audio from the collector of Q4 is coupled to IC2, an audio power amplifier, which can provide over ½ watt of audio to a loudspeaker. The audio is also coupled to R29, which is a limiting resistor used to avoid damaging low-impedance headphones.

The project can be powered from either a 12-volt power supply or battery pack. Eight alkaline AA-cells in series can be used if desired. An optional pilot lamp formed by R31 and LED1 should be left out for battery-powered applications to minimize power drain. So for battery applications use headphones instead of speakers to conserve power.

Figure 3 shows a schematic for a 12-volt power supply to operate the modules from the power line. It has two separate outputs, each with its own filtering.

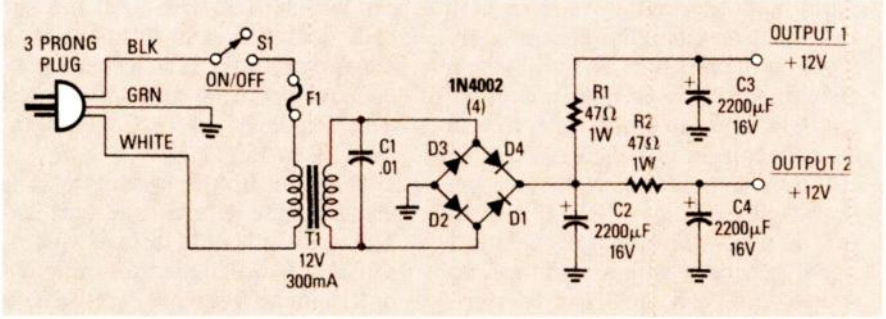


FIG. 3—USE THIS POWER SUPPLY to power your modules from the AC power lines if you want to avoid using batteries.

Construction

During construction, you should take the same precautions as you would with any high-gain circuit. The

low-level leads to the detector photodiode should be shielded cable, and try to keep them short to minimize capacitance. Be sure to use the specified transistors and capacitors to keep the noise levels low. For best results, use a physically small coil for L3 to reduce stray inductive coupling.

The LED's can be mounted on the space provided for them at the end of the PC board, or you can mount them as you see fit. We used old 35-mm film cases to mount the LED's for the transmitter and the photodiodes for the receiver. You can use an RCA jack for J1. Just attach the jack to the cabinet, and wire it to the board. Follow Fig. 4 when building the transmitter, and Fig. 5 when building the receiver.

The PC-board layouts in the PC Service can be used to make your own PC boards. However, a pre-drilled and etched set is available from the source listed in the sources box. A kit containing all PC-board-mounted parts, including the photodiode and two LED's, is also available. (We recommend using two IR-LED's for each transmitter; one will do the job, but using two will extend the range.) You can mount the components for the power supply (if used) on a terminal strip using point-to-point wiring; otherwise, perforated construction board can be used.

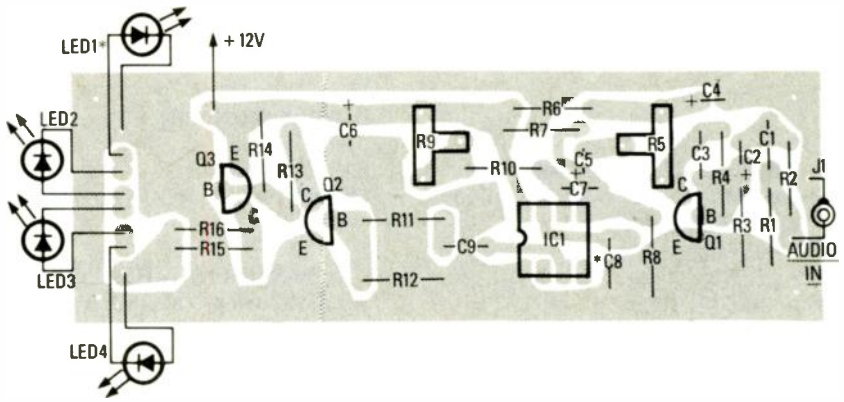


FIG. 4—USE THIS PARTS-PLACEMENT DIAGRAM to build the IR transmitter.

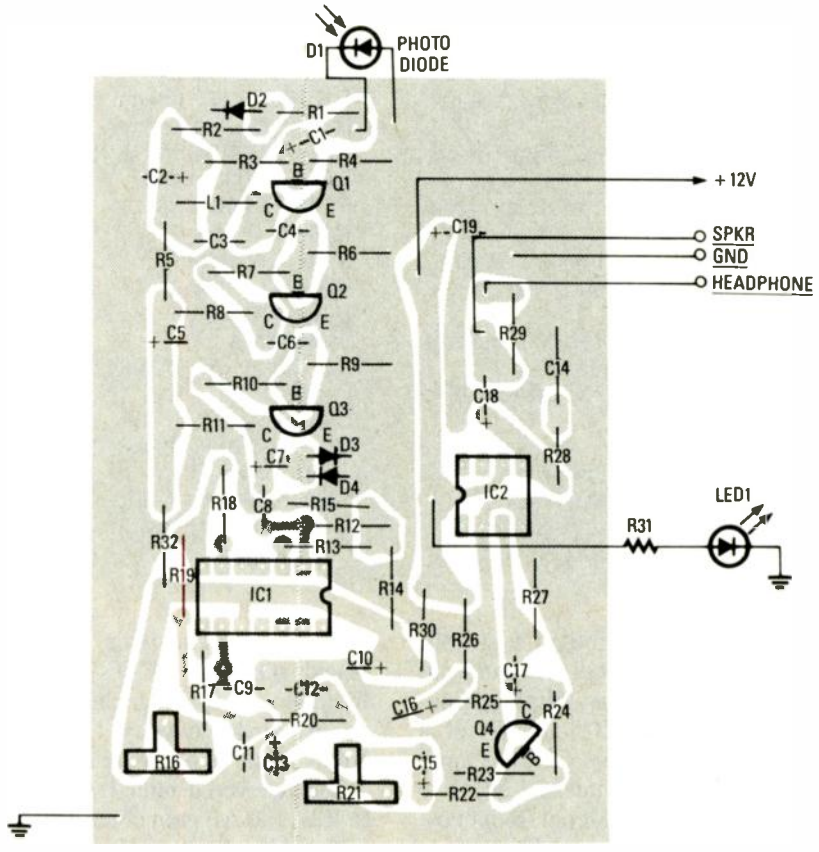


FIG. 5—THE IR RECEIVER is built using this parts-placement diagram.

Final adjustments

A frequency counter is helpful when tuning the completed modules, but is not strictly necessary. All voltage measurements are DC. Referring to Fig. 1 (the transmitter), check for about 12 volts on pin 8 of IC1. Next, check for about 6 volts on the collector of Q1, although anything between 5 and 8 volts is ok. There should be between 8 and 10 volts on pin 3 of IC1. With the LED's connected to the circuit, there should be about 6 volts on the collector of Q3.

Place an AM radio tuned to a low frequency (around 600 kHz) close to the transmitter and rotate R9. You should hear some squeals from the radio if IC1 is oscillating. Set R9 around midrange. Now, by listening for harmonics on the AM radio, you can tell the frequency of the transmitter. For example, if you hear a signal at 610 kHz, another at 720 kHz, and another at 830 kHz, the transmitter frequency is close to 110 kHz. That is because the harmonic spacing is 110 kHz, which is equal to the fundamental frequency.

To check out the receiver's operation, connect an 8-ohm speaker to the audio-output terminal. Set both R16 and R21 to about midrange, and apply power to the receiver. You will hear a rushing noise if everything's working properly. You can check for 6 volts at the collectors of Q1–Q4, and on pin 5 of IC2. You should be able to measure 11 volts at pin 10 of IC1, and about 4 volts at pin 2. If you have access to a signal generator with a calibrated attenuator, you can check the receiver's sensitivity. About 1 mV on the base of Q1 (use a 0.1 μF coupling capacitor) should cause the receiver to quiet down by about 10 dB. If the generator can be FM modulated, set it for 25-kHz deviation and adjust R16 for maximum audio. The generator frequency should be tuned to the resonant frequency of L1/C3 (generally from 50 to 150 kHz).

Next, set up the transmitter a few feet from the receiver and turn it on. The receiver should instantly quiet itself. Adjust R9 in the transmitter and/or R16 in the receiver to set them both for the same frequency. That should

be equal to the resonant frequency of L1/C3. Now, apply a 1-kHz, 0.5-volt signal to the transmitter-audio input. A 1-kHz tone should be heard at the receiver, and should cease when the IR beam is interrupted. (Note that sometimes IR radiation will penetrate visually opaque materials.)

Applications

Before discussing the various applications for the IR transmitter and receiver, it should be noted that one transmitter can send a monaural signal to one receiver; therefore two of each circuit will be necessary if a stereo-audio transmission is desired.

One application for the IR transmitter and receiver is in a wireless-speaker setup that's similar to the prototype shown in the opening of this article. It can be used in conjunction with a pocket stereo. Audio from the headphone jack can be used to feed two separate transmitters—left and right. In our prototype, two inexpensive speakers were mounted in separate wood cabinets, with a receiver module and battery pack in each. The inside of one of our prototype speakers is shown in Fig. 6. If you like, you can use speakers from a small hi-fi set; there should be plenty of room inside the cabinet to mount the receiver module, battery pack, and on/off switch.

The two audio channels in our stereo prototype operate at frequencies of 80 kHz and 140 kHz; you can use any frequencies you choose, but make them as widely spaced as possible. Frequencies from 30 to 250 kHz have been tried with good results. Just make sure that you do not operate at exactly 100 kHz because there is a powerful loran-navigation signal on that frequency and the receiver might pick it up. (That may not be a problem away from the east coast of the US.)

If you wish to install the modules in an opaque plastic housing, a visually-opaque filter that transmits IR can be made from stock red and green plexiglass sandwiched together. The plexiglass is also available from the source listed in the Source box.

Figure 7 shows the inside of our prototype stereo transmitter. Two transmitter boards have been mounted along with the power-supply components. You can build a similar cabinet or make your own design.

Figure 8 shows a mono IR transmitter. Since it's a mono unit, it can be mounted in a more compact case. The unit only requires that you build one transmitter circuit and one receiver circuit. If you're on a budget, you might prefer building a mono unit.

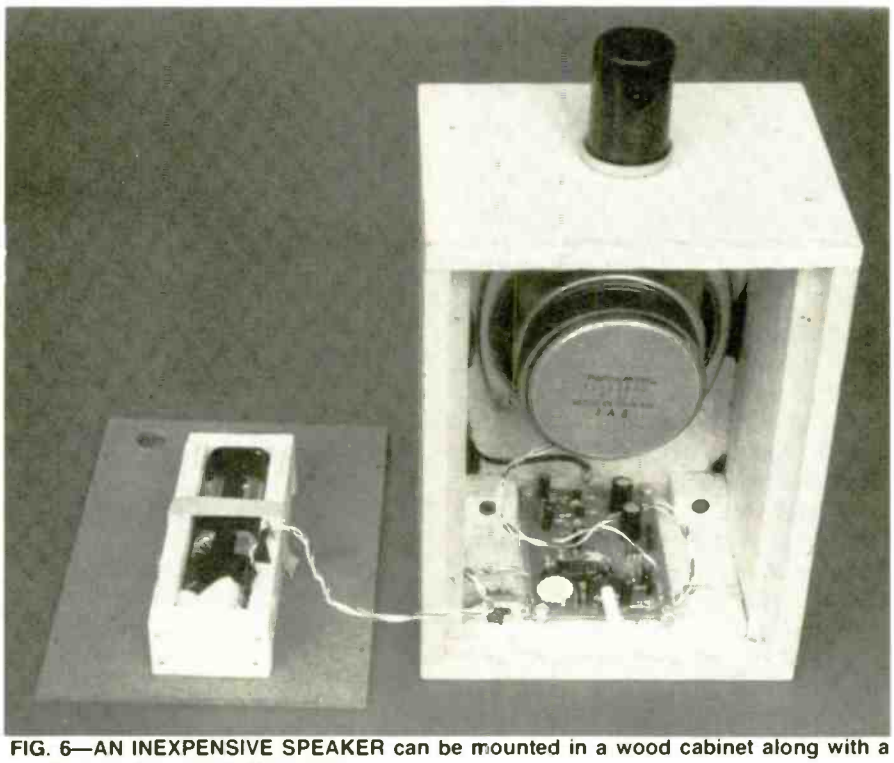


FIG. 6—AN INEXPENSIVE SPEAKER can be mounted in a wood cabinet along with a receiver module and battery pack.

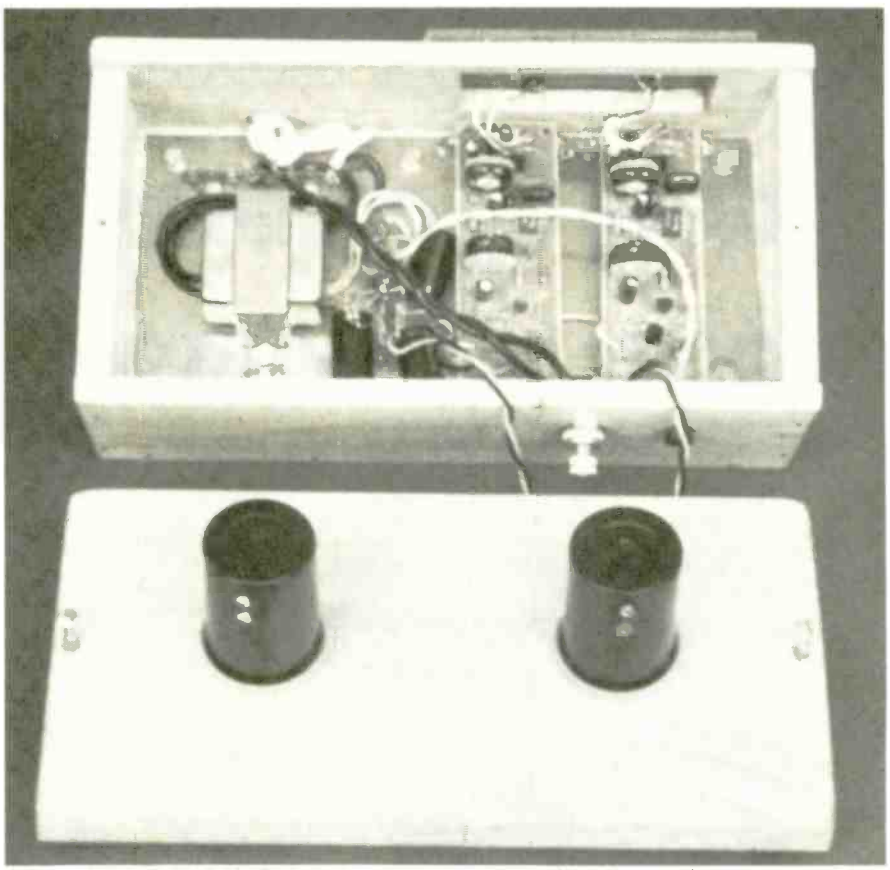


FIG. 7—MOUNT THE MODULES for the stereo transmitter in a cabinet along with the power-supply components or a battery pack if you so desire.

Another application for the IR transmitter and receiver is in a wireless-headphone setup, which can be used to watch television without disturbing others. The audio signal for

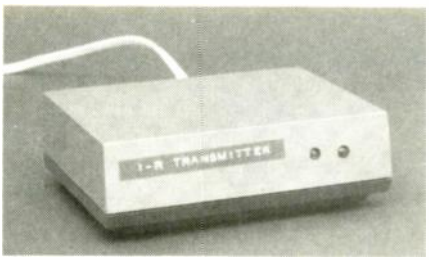


FIG. 8—A MONO TRANSMITTER can be built that will fit in a smaller cabinet.

the transmitter is obtained from the TV's speaker or earphone jack. If your television doesn't have an earphone jack, you'll have to open up the set and tap the audio directly off the speaker terminals.

WARNING: Do not open your television set if you don't know what you're doing. There are high voltages that could be hazardous to yourself, and you could damage the set itself. Do not install on any set that has any conductive path between ground and the AC powerline.

The receiver module can be mounted in a small plastic case fitted with a headphone jack. Just make sure to include R29 (for use with headphones) in the receiver's output section and connect the headphone jack to it. Headphones from a pocket stereo are excellent for use in a wireless-headphone setup because of their light weight.

Fiber optics are a good conductor of IR transmissions. A length of fiber-optic cable (with suitable terminations) can be used to connect the transmitter and receiver, and will enable you to "bend" signals around corners or through a floor to another level of your home. The setup is particularly useful for experimenting with fiber optics, and you can use your imagination to come up with the many possible applications for that unique medium.

Figure 9 illustrates an IR perimeter-security system. If no audio is used to modulate the transmitter, the receiver's audio output will be zero. When the IR beam is broken, the receiver's output will produce a noisy signal. That noise can be rectified with a diode and an RC filter; the DC level that is produced can drive a relay circuit or some other type of alarm. The IR beam is completely invisible, and path lengths of several hundred feet can be obtained using special optics. Those optics are desirable anyway because they help to keep the IR beam as narrow as possible so it is more easily broken. The specifics of the perimeter-security system are left to the experimenter.

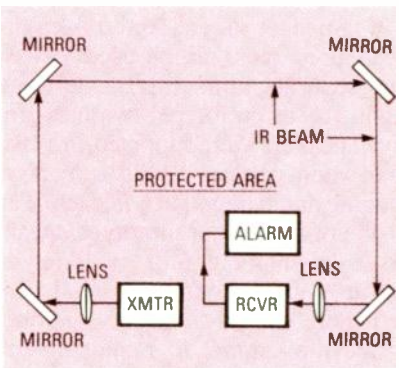


FIG. 9—THE IR MODULES can be used as a perimeter-security system for path lengths up to 1,000 feet.

You should get a range of at least 20 feet from the system, however you will find the range to be somewhat directional. If you have white ceilings, aiming the LED's at the ceiling should give you complete room coverage. If you position a magnifying lens in front of the detector, you may be able to extend the useable range to as much as 100 feet. With optics at both ends, an even greater range might be possible. **R-E**

SOURCES

The following items can be purchased from North Country Radio, P.O. Box 53, Wykagyl Station, NY 10804.

A kit of parts for one mono system consisting of the receiver and transmitter PC boards, all components that mount on the boards, including LED1, LED2, and D1 is available for $39.95 plus $2.50 for postage and handling.

A kit of parts to build two systems (for stereo) is available for $74.95 plus $2.50 for postage and handling.

Red and green plexiglass (2" × 2" × ⅛") to make an IR filter can be purchased for $12.50 plus $1.75 for postage and handling.

One receiver PC board and one transmitter PC board are available for $12.50 plus $2.50 for postage and handling.

LED1, LED2, and D1 are available for $16.95 plus $2.50 for postage and handling.

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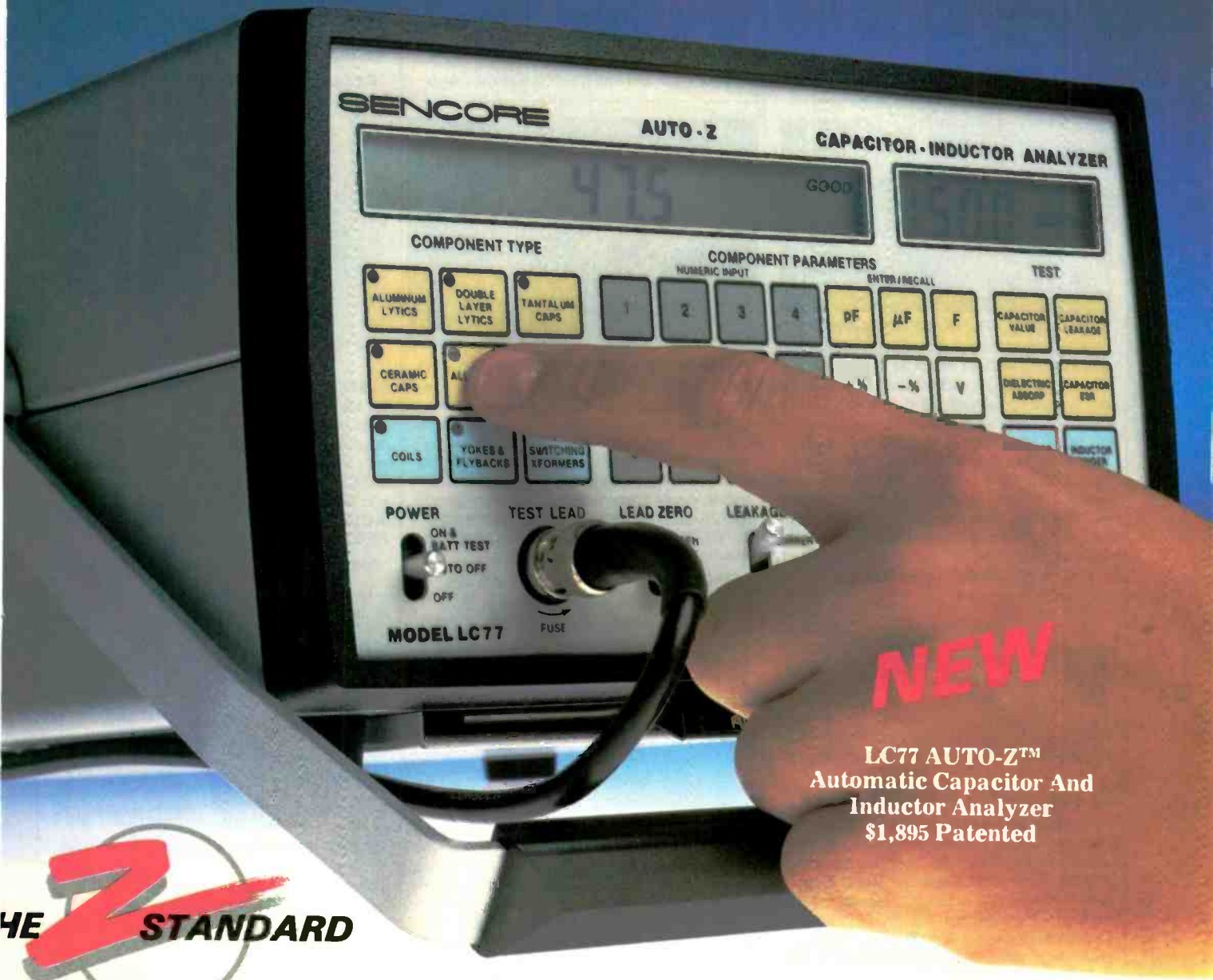

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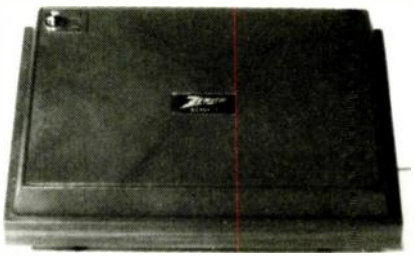
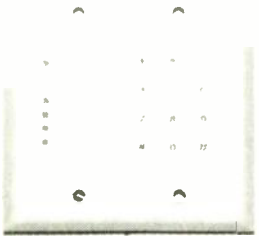


ZENITH SSAVI UHF INPUT FROM $199, ch. 3 input **$229,** reconditioned. UHF SSAVI handbook **$6.50** ppd. Used Sylvania 4040s **$169.** New N-12-VS $99, ch 2 or 3. MLD-1200s ch 2 or 3. Converters, amplifiers & accessories. Satellite systems. Professional used radar guns from **$275.** New Panasonic multi-line business telephone systems from **$1395.** Catalog **$1. AIS SATELLITE, INC., 106 N. 7th St./A, Perkasie, PA 18944. 215-453-1400.**

CIRCLE 81 ON FREE INFORMATION CARD



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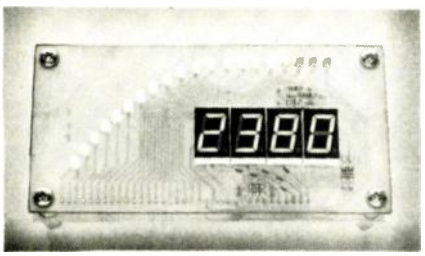
CIRCLE 203 ON FREE INFORMATION CARD



THE DIGITAL TACHOMETER MONITORS engine speed with a fast, easy to read bar/graph along with an accurate digital readout. The Digital Speedometer's dual display delivers vehicle speed with a 3-digit readout and a rapid-read analog display. Adjustable redline on both units. See R-E June & July 1987. Complete kits only **$75.00 ea.** Assembled & tested **$99.95** ea. Add 4% S/H. 90 day warranty. Contact: **DAKOTA DIGITAL, 11301 Kuhle Drive, Sioux Falls, SD 57107. (605) 332-6513. Visa/MC accepted. Dealer inquiries welcome.**

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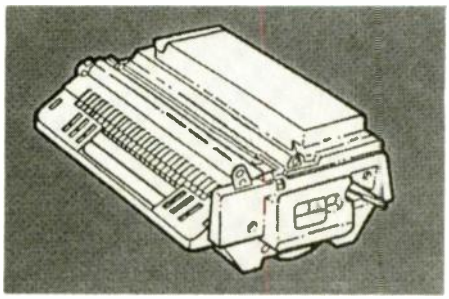

RECHARGE LASER PRINTER TONER CARTRIDGES—Earn big $$ in your spare time—All supplies and Do-It-Yourself kits with complete instructions available. Supplies cost from **$10.95** in qty and you can sell recharged toner cartridges for **$40.00** to **$55.00** each. Printers include HP LaserJet and Series II, Apple LaserWriter, QMS, etc. Canon PC-25 Copier also. **CHENESKO PRODUCTS, 21 Maple St., Centereach, NY 11720, 516-736-7977, Fax: 516-732-4650**

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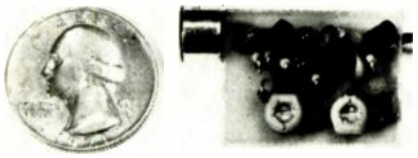

SIMPLY SNAP THE WAT-50 MINIATURE FM TRANSMITTER on top of a 9v battery and hear every sound in an entire house up to 1 mile away! Adjustable from 70-130 MHZ. Use with any FM radio. Complete kit **$29.95** + **$1.50** S + H. Free shipping on 2 or more! COD add **$4.** Call or send VISA, MC, MO. **DECO INDUSTRIES, Box 607, Bedford Hills, NY 10507. (914) 232-3878.**

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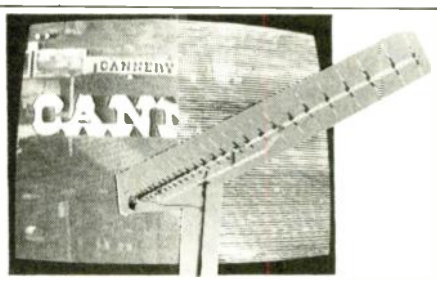
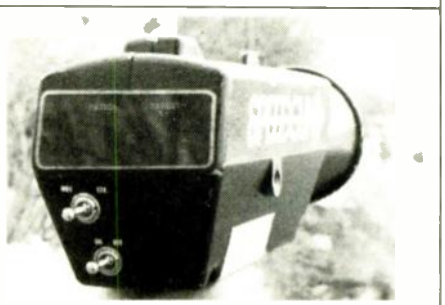
PANASONIC CABLE CONVERTERS, Wholesale and Retail. Scientific Atlanta and Pioneer Cable Converters in stock. Panasonic model 140N 68 channel converter **$79.95,** Panasonic Amplified Video Control Switch Model VCS-1 **$59.95.** Scientific Atlanta Brand new Model #8528 550MHZ 80 Channels Converter **$89.95.** Video Corrector (MACRO, COPYGUARD, DIGITAL) ENHANCER **$89.95.** We ship to Puerto Rico, Caribbean countries, & So. Amer. Write or call **BLUE STAR IND., 4712 AVE. N, Dept 105, Brooklyn, NY 11234. Phone (718) 258-9495.**

CIRCLE 85 ON FREE INFORMATION CARD



RECEIVE WEAK UHF STATIONS WITHOUT local station interference. Tunnel-vision pre-amps see only the station that you tune with no overload! Complete line of DX UHF/VHF/FM long distance reception equipment. Tunnelvision pre-amps (25DB) **$159.95,** (32DB) DX UHF preamps **$99.95,** (39DB) amp **$29.95** additional. 114 element UHF antenna **$109.95,** package **$199.95/$219.95** UPS shippable. Give channels. **DX-TELE LABS, 6601 E. Clinton St., Scottsdale, AZ. 85254, 602-998-3966**

CIRCLE 201 ON FREE INFORMATION CARD



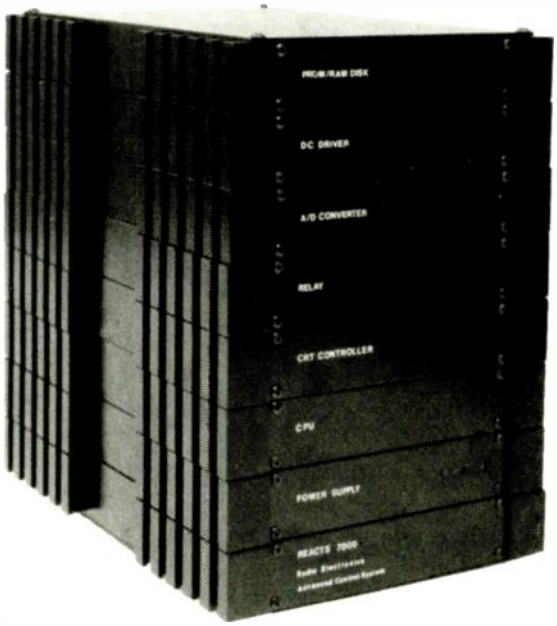
RADAR SPEED GUNS AND SYSTEMS. Professional units for clocking speeds in baseball, car & boatracing, etc., starting at **$269** used, **$350** reconditioned. Moving and stationary units available with dual displays. All units are road tested and have 30-day warranties. Catalog **$1.** Complete line of TV accessories. New Panasonic multi-line key business telephone systems from **$1395. AIS SATELLITE, INC., 106 N. 7th St./A, Perkasie, PA 18944. 215-453-1400.**

CIRCLE 185 ON FREE INFORMATION CARD

Build REACTS:

THE RADIO-ELECTRONICS ADVANCED CONTROL SYSTEM

Part 7 IN ORDER to write programs and develop practical systems using REACTS, some type of terminal is required as part of the development system. Many end-user applications also require a terminal interface for normal operation. REACTS allows you to use any one of three devices for the terminal. The first choice is that you use a standard CRT terminal. The second alternative is to use an IBM PC as a terminal, and the third choice is to build a general-purpose CRT controller/keyboard interface module using the information supplied in this article.



MICHAEL A. TUCKER

The interface has 2 microprocessors; one is a general-purpose Z-80, and the other is a special-purpose CRT controller. The design is flexible enough to allow you to create a custom terminal by simply changing the on-board PROM. An added feature on the module is a Centronics-type parallel-printer interface, for an IBM PC compatible printer.

Standard CRT terminal

Over the past decade, computer terminals have come down in price (a quality terminal can be purchased for less than $400.00). A number of different terminals have been tested and found to be satisfactory. There are also a number of used terminals on the market that can be purchased for next to nothing. Just be sure that the one you buy is compatible with a standard RS-232 interface, and try not to buy any terminal that doesn't have its technical manual.

The following parameters and their settings were used with REACTS and the Qume 101 terminal. They will give some idea where to start even if you use a different monitor.

- EMULATION—QVT101C
- PARITY—OFF
- DATA BITS—8
- STOP BITS—1
- BIT8—0
- FDX/HDX (Full or Half Duplex)—FDX
- CHAR/LINE/BLCK—CHAR
- ON LINE/LOCAL—ON LINE
- BAUD RATE—9600

Your PC as a terminal

The **Radio-Electronics** bulletin board (516-293-2283, 300/1200 baud, 8N1) contains the software necessary to convert your PC into a terminal for controlling REACTS. That software is also available on a floppy disk with a manual from the source listed elsewhere in this article. The software package from that source contains a file-transfer program on a PROM, which, in addition to making your PC act like a "dumb" terminal, allows you to use your PC disk, hard or floppy, as storage devices for your REACTS. That capability is very useful when developing software and allows you to keep your investment in the system to a minimum.

The PC-terminal software is contained in the file TERMINAL.EXE. To invoke that software, just type TERMINAL at the system's prompt. The software will automatically clear the screen. The only requirements for the software is that it must be run on an IBM PC or compatible, and REACTS be configured for a baud rate of 1200. The IBM-terminal software is designed to emulate the Televideo-912 terminal, so any software designed for the Televideo terminal should work as long as the host system is set up for 1200 baud. The relatively low baud rate is due to the speed limitations of a standard IBM PC. The REACTS will accept and transmit data at rates of at least 10 times faster than the PC when the PC is operating in an emulation mode.

The PC and its keyboard act just like a standard terminal at this point. Any operation that you would perform on a standard terminal is possible using your PC. With the PROM-based file-transfer program there is

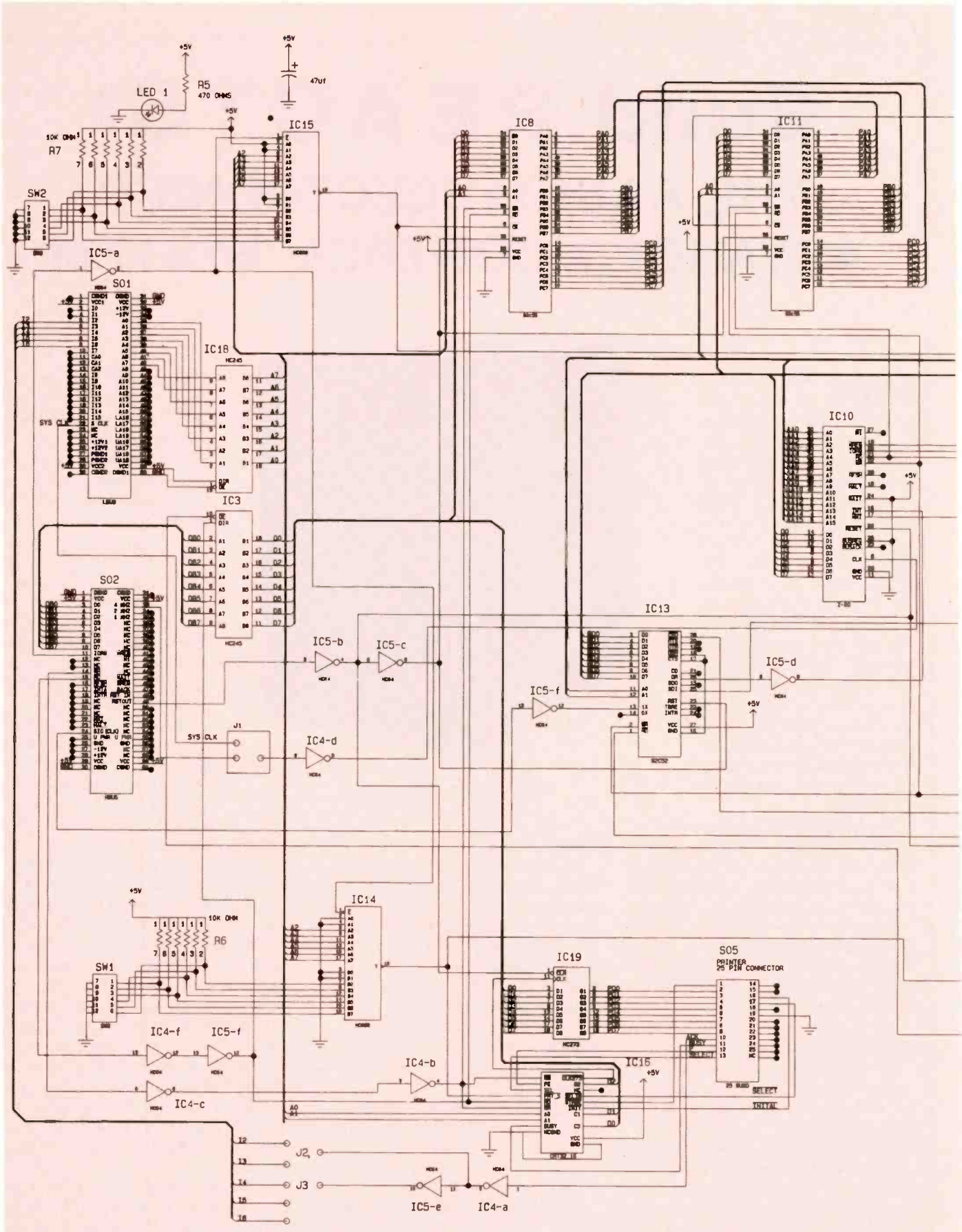
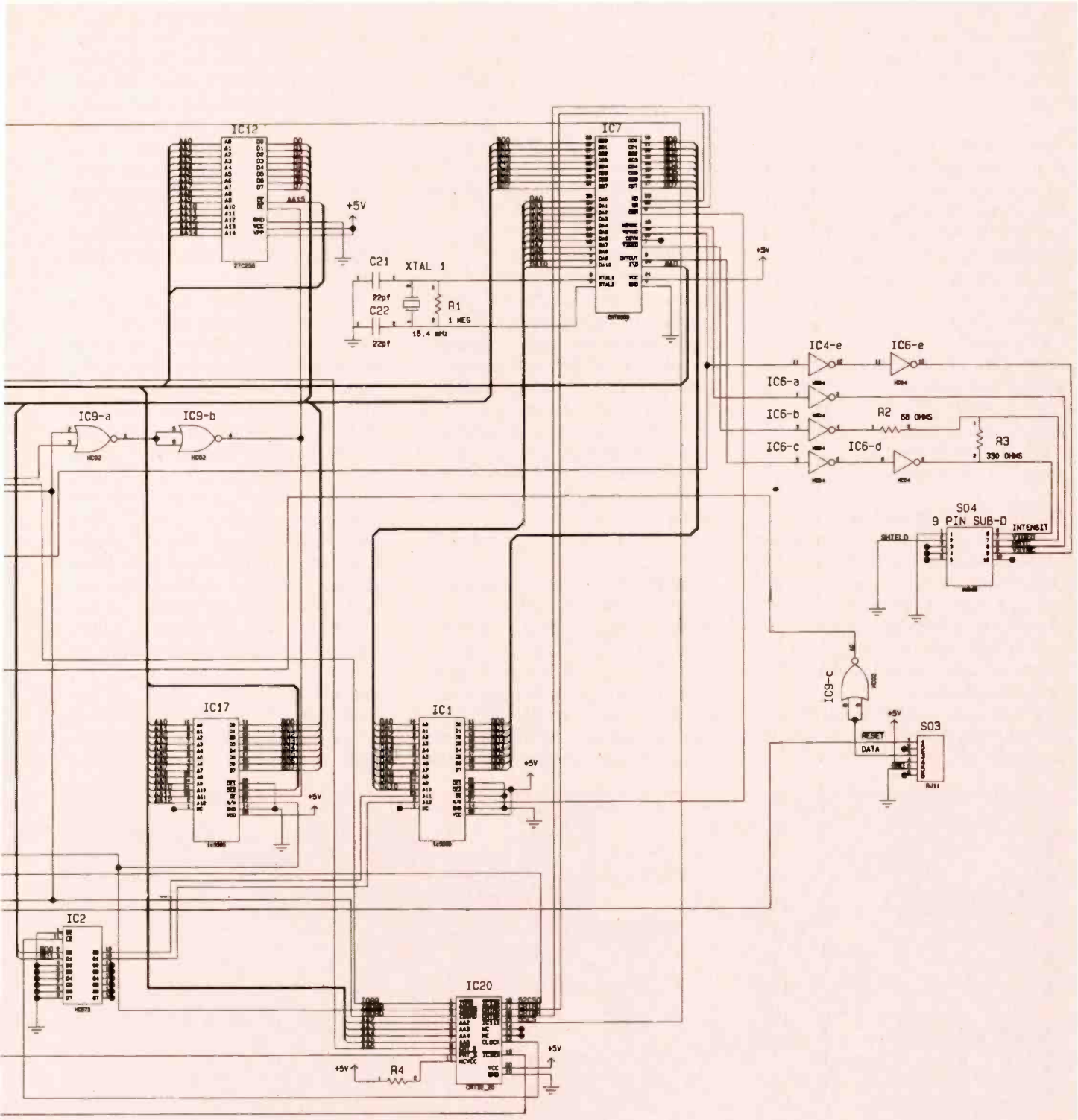


FIG. 3—THE COMPLETE SCHEMATIC for the CRT controller/keyboard interface module is shown here. The module also includes a printer port.


IC12
IC7
+5V
C21
XTAL 1
22pf
C22
R1
1 MEG
18.4 MHz
22pf
IC4-e
IC6-e
IC6-a
IC6-b
R2
56 OHMS
R3
330 OHMS
IC6-c
IC6-d
IC9-a
IC9-b
S04
9 PIN SUB-D
SHIELD
INTENSITY
IC9-c
RESET
DATA
S03
IC17
IC1
IC2
IC20
R4

the added capability of the PC's mass-storage potential; the terminal software can transfer your ASCII files from REACTS to the PC and vice versa.

The REACTS controller

In many applications it is desirable to have a terminal as part of the system. Also, the integral controller is the lowest-cost approach to the terminal problem. Additionally, many of the entrepreneur types will find it useful to develop special-purpose terminals using the REACTS and its CRT controller as the basis. Indeed, it is possible to emulate a multi-thousand dollar terminal—if you are willing to write the software. The monochrome monitor used by the controller can be any standard off-the-shelf IBM PC-compatible monitor.

Module considerations

As with all of the other modules we've discussed, this module will use two 60-pin module connectors. All bus signals pass from module to module through those connectors, which provide a good, sound connection and eliminate any external cabling between the modules.

A 32K ultra-violet erasable PROM is used to store the video controller's program. You can rewrite the software on the PROM and create your own custom terminal or emulate some other terminal. You would use REACTS itself as the development system to write the custom software. The program would then be burned onto a 32K × 8-bit PROM using the PROM-programmer option of the PROM/RAM module, covered in **Radio-Electronics**, May 1988.

System components

The block diagram in Fig. 1 shows the basic layout of the CRT/printer interface-module circuitry. The CRT-controller portion centers around an *E*nhanced *V*deo *T*erminal *L*ogic *C*ontroller (EVTLC), specifically the Standard Microsystem's CRT 9053. That integrated circuit will enable our video controller to display visual attribute features such as reverse video, intensity control, underline, and character blink. Also, the EVTLC is capable of producing limited graphics.

The EVTLC's built-in character set consists of the 96 standard ASCII characters and 32 special characters. Each ASCII character occupies an area of 9×12 screen dots. In the wide-graphics mode, the space that is normally taken up by one alphanumeric character is instead divided into six independently addressable segments. On a screen set up for 25 rows and 80 columns, the graphics mode would allow the independent addressing of twelve-thousand segments (80×25×6). In the thin graphics mode, the space that is normally taken up by one alphanumeric character is divided into four independently addressable segments layed out in a "cross-hair" fashion (see Fig. 2). The video controller will also allow a mixture of alphanumeric and graphic characters.

Two modes of screen scrolling are available: jump and smooth scrolling. The data on the monitor is moved up or down one row at the time in the jump-scroll mode, and one scan line at the time in the smooth-scroll mode. If desired, a non-scrolling status line can be enabled. The line will remain at the bottom of the screen at all times; that is, it stays stationary while the rest of the screen is scrolled. Other than non-scrolling, the status-line data can be manipulated in the same manner as the rest of the screen data.

As previously mentioned, screen attributes include reverse video (changing screen backgrounds), intensity control, character underline, and character blink. There are two modes of selecting the characters to be enhanced and the type of attributes to be used. In the first mode, called

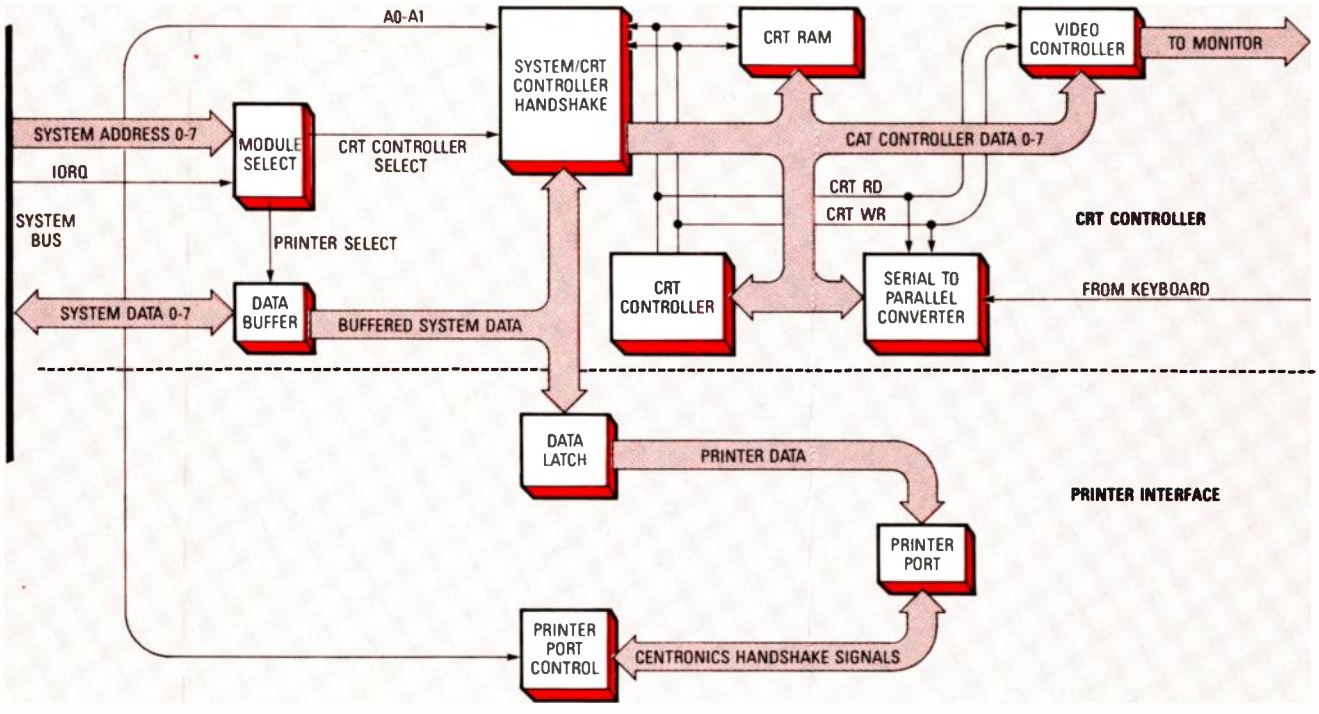


FIG. 1—THE BLOCK DIAGRAM OF CRT CONTROLLER/KEYBOARD interface module. This module allows you to interact with REACTS, and also allows REACTS to display messages on a CRT.

the 9 × 28 mode, each character to be enhanced is "tagged" with a tag bit, which is actually the most significant bit of the character byte. In that mode, only one attribute style can be enabled per screen. That is, all the "tagged" characters on any specific screen will be reverse video, intensified, underlined, or blinked. In the 9 × 56 mode, multiple attributes per screen and character are available. That is accomplished by sending an attribute byte before the character byte that will be enhanced with the desired attribute.

The fill-screen feature allows the entire screen to be filled with a given character without having to write to each display's memory address (that is ideal for quick clearing of the screen).

In addition to the EVTLC, other main components of the video controller include a Z80 microprocessor, two 8K × 8 CMOS-RAM IC's, two 82C55 programmable peripheral interfaces (PPI), an 82C52 universal asynchronous receiver/transmitter (UART), and an already mentioned 32K × 8 UVPROM.

The Z80 is the control center for the CRT controller. It manages the incoming and outgoing data between the 82C52 UART, the EVTLC, and the 82C55 PPI's. That is, it enables and/or disables the correct IC's at the correct time to maintain a smooth data flow. The Z80's clock input comes from the 8-MHz clock signal that is generated in the REACTS CPU and routed to one of the pins of the two 60-pin connectors. One of the 8K × 8 RAM chips is used by the Z80 as a scratch pad or buffer. The other provides the display memory for the EVTLC. As already mentioned, the PROM contains the video controller's control program. The 82C52 UART receives the incoming keyboard data in serial form and converts it to parallel form before transferring it to the EVTLC and/or PPI's. The PPI's act as the interface between the video controller and the CPU; that is, all data being passed between the CPU and the video controller pass through those IC's. By checking certain handshaking signals of those IC's, the CPU determines whether the video controller is ready to send data to it. Likewise, the CRT controller can determine when the CPU is sending data to it.

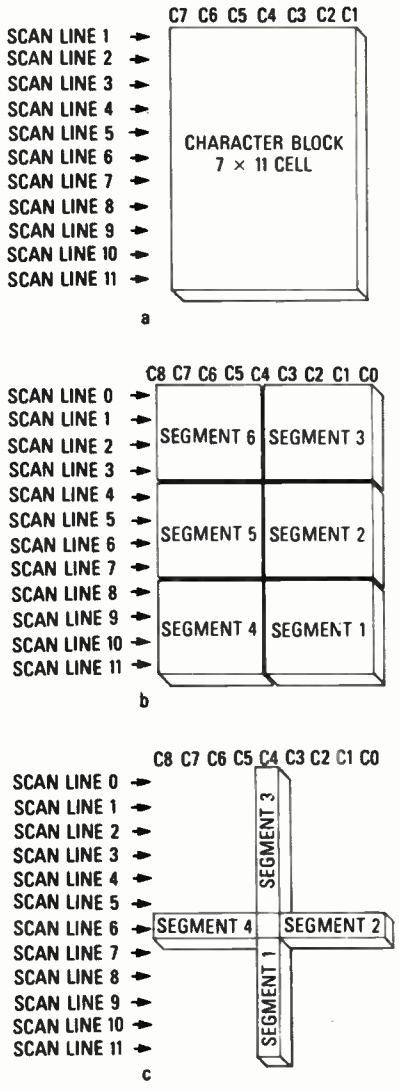


FIG. 2—The EVTLC's BUILT-IN CHARACTER SET consists of the 96 standard ASCII characters and 32 special characters. Depending on what graphics mode is being used, the screen space is divided as shown in (*a*) for the alphanumeric mode, (*b*) for the wide-graphics mode, and (*c*) for the thin-graphics mode.

Controlling the EVTLC

The EVTLC is connected to two data buses; one passes data between the Z80 and the EVTLC, and the other between the display memory and the EVTLC. That way we know that all the data we send or receive from the display memory passes through the EVTLC. The EVTLC contains several 8-bit software-programmable data registers which select the desired screen attributes, move and keep track of the screen cursor, transfer data, and select operating modes.

The EVTLC's programmable data registers are selected indirectly by the address register, which is selected when the input on the A/D pin of the EVTLC is high (see Fig. 3) and a write occurs. Data is sent to and/or read from the data registers when the input on the A/D pin is low. That is, first the desired register is selected by raising the A/D input and writing the correct register address in binary form, then the data is written to or read from the register with the A/D input lowered. When the A/D input is raised and a read is done, the status register's contents can be obtained. Bit seven of the status register is used to synchronize data transfers between the Z80 and the EVTLC. When bit seven is low, the EVTLC is busy and will not receive or send any data. Only when bit seven is high, is the EVTLC ready to send or receive data.

The data registers that are indirectly selected via the address register are: the top-of-screen address, cursor-low, cursor-high, fill-address, screen-attribute data, mode-1, mode-2, and character registers. We will give the correct address of each register and briefly discuss their functions. Unfortunately, that will have to wait unitl next month. We'll continue then with a discussion of the registers and then go on to building and programming the terminal interface. **R-E**

Sources

The following items are available from DataBlocks, Inc
579 Snowhill Road, Glenwood, GA 30428. Or call (800) 652-1336; in Georgia call (912) 568-7101

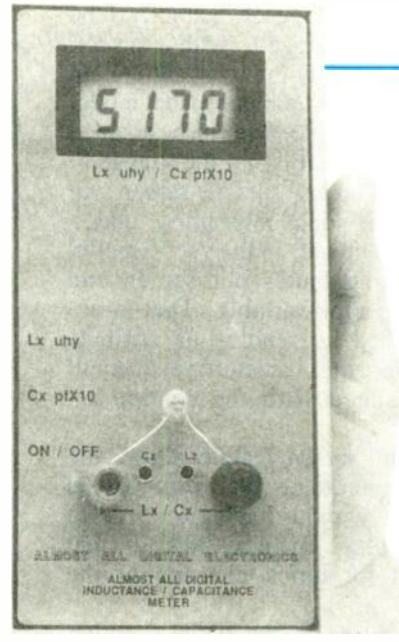
- TERM-PROM: Software to enable the use of an IBM compatible as terminal for REACTS. Includes the software on a 360K floppy disk with instructions; $18.00.
- DP-CRT/PRT: Design package of schematics and instructions; $10.00.
- PC-CRT/PRT: PC board for CRT/printer interface, includes design package; $36.00.
- CRT-PROM: A control program for the CRT controller installed on a 32K UV-erasable PROM, includes documentation; $17.00.
- REC-CRT: Complete set of parts including the PC board, IC's, connectors, and PROM; $124.00.
- Keyboard for REC CRT controller; $85.00.

Please include $5.00 postage for any order of $37.00 or less and $10.00 postage for any order over $37.00. Georgia residents must add appropriate sales tax.

BUILD THIS

LC METER

This month we show you how to build the inductance/capacitance meter, and show you how to get the most out of using it.



NEIL W. HECKT

Part 2 LAST TIME WE EXplained the theory behind the LC meter. Now we build and align the meter so that you'll have a very accurate instrument to add to your lab.

Construction

The instrument is assembled on a double-sided printed-circuit board for which templates are provided in PC Service. Alternately, a PC board having plated-through holes is available from the source given in the Parts List.

The component placement is shown in Fig. 3. Note that the four display drivers, IC8–IC11, are mounted under the liquid-crystal display (DSP1). The display must be mounted about ½ inch off the PC board if it is to be reasonably close to the front panel of the specified Pactec *HPL-9VB* cabinet. Three layers of low-profile 40 pin IC socket-halves plugged together will provide the clearance. On the other hand, both the kit and the finished unit specified in the Parts List contain some Samtec 0.56-inch sockets.

If S1, S2, and S3 are ITT's Cannon-type switches, they mount directly on the PC board. However, the switches supplied with the kit are from a different manufacturer and it is necessary to mount them off the PC board in such a manner that less than 1/32-inch of the longer leads protrude through the board on the solder side. In either case, the correct mounting so the push-button switches will fit through the holes in the cabinet is for the center line of the switch shafts to be 11/32 inch above the component side of the PC board. (Note: The switches in the kit are supplied pre-installed.)

The PC board provides for two 4-pole double-throw switches and one 2-pole double-throw switch. The extra contacts aren't used.

The LM7805 voltage regulator, IC12, lies flat on the board and must have a small piece of plastic electrical tape between it and the PC board to prevent shorting the case of the regulator to the circuit traces. Of course a standard mica insulator can also be used. Heat is not a problem as the unit draws only 17 mA.

Binding posts BP1 and BP2 are mounted in a somewhat unusual way directly to the PC board. Drill clearance holes for two 8-32 screws at the two binding-post locations shown in Fig. 3. Pass the screws through from the bottom of the board and secure ¾-inch 8-32 metal spacers at each location. When the cabinet is assembled, BP1 and BP2 are passed through the cabinet cover into the spacers, making the electrical connections and securing the cabinet.

The completed unit, with the cover removed, is shown in Fig. 4. Notice that no binding posts are shown. Instead, there are threaded spacers in the binding-post locations on the PC board. When the cover is installed the

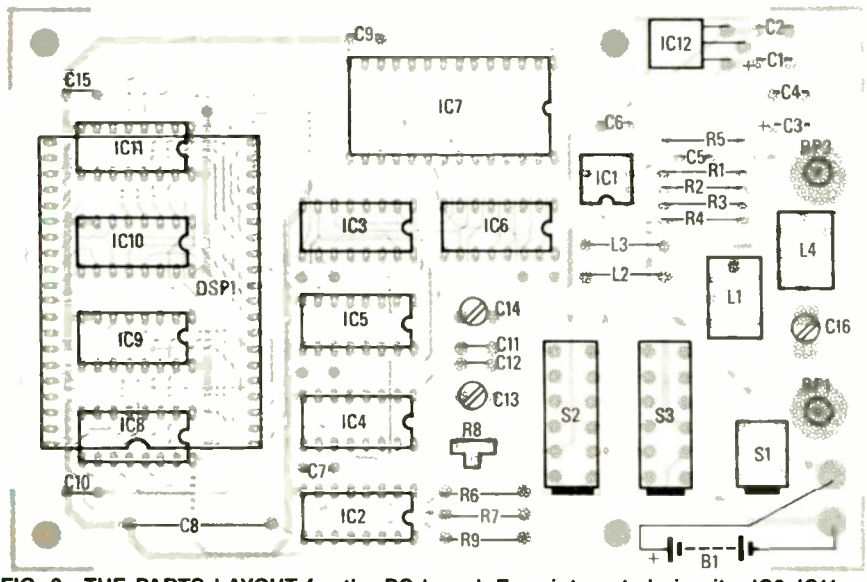


FIG. 3—THE PARTS LAYOUT for the PC board. Four integrated circuits, IC8–IC11, are located directly under the display module (DSP1). Binding posts BP1 and BP2 mount through the enclosure to spacers on the PC board.

binding posts pass through the cover and are screwed into the spacers; thereby securing the cover while providing electrical connections to the meter.

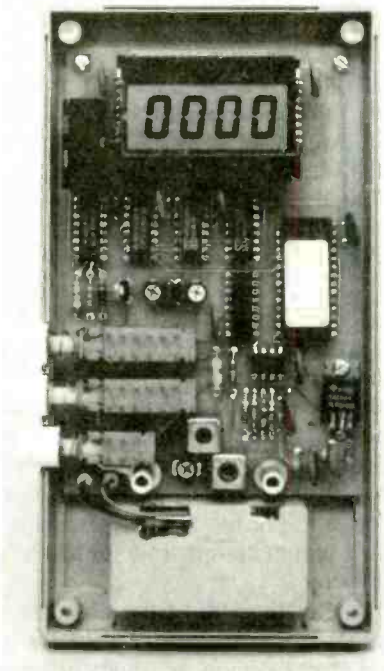


FIG. 4—THE COMPLETED METER. Five IC's are installed on the PC board directly under the display module, which is raised off the board approximately ½ inch so it will be flush with the enclosure's window. The battery is in a separate compartment that is moulded into the bottom of the enclosure.

Alignment

All that's needed to align the unit is a frequency counter and a capacitor of approximately 68,000 pF who's value is known to an accuracy of at least 1%. That capacitor is much larger than the 705-pF standard capacitor in the tank circuit, making the standard capacitor insignificant when adjusting the standard 70.5-µH inductor.

Ignore the display during the initial alignment because it might be doing some pretty wild things if the PLL is not in lock. (That particular adjustment will be made after the oscillator alignment.) Connect the frequency counter to pin 14 of IC3. The frequency at that location is the oscillator frequency/16.

First calculate the oscillator frequency when your known capacitor will be in the circuit:

$$f2 = 1/(2 \times \pi \times \sqrt{(70.5E\text{-}6 \times (C_k + 705)E\text{-}12)})/16$$

where C_K is your known capacitor in pF. (*f*2 should be about 4500 Hz.)

Connect C_K across the test jacks, depress C_X switch S3, and adjust L1 to obtain the calculated frequency ±10 Hz. Release S3 and set coarse-adjustment C13 (12–70 pF) and fine-adjustment C14 (3–10 pF) to obtain a frequency of 44,582Hz ±100 Hz. You may want to repeat the entire procedure several times because there is some interaction between the adjustment of L1 and the capacitors.

Finally, set R8 to the center of the adjustment range that produces 0000 on the display. The lock range is fairly large so the adjustment isn't critical. The center of the range will provide the best long-term stability rather than any immediate benefit.

The 9-volt battery-terminal clip cannot be installed until the PC board is installed in the cabinet because the clip cannot fit through the opening to the cabinet's battery compartment. Alternately, you can cut away part of the battery compartment's wall so the clip can then slide through into the compartment.

Final adjustment

After final assembly, the only re-

PARTS LIST

All resistors ¼-watt, 5%, unless otherwise noted.
R1, R2, R7—100,000 ohms
R3, R5—47,000 ohms
R4—1000 ohms
R6—1 Megohm
R8—25,000 ohms, trimmer potentiometer, 0.1" × .2" spacing
R9—4700 ohms

Capacitors
C1, C3—10 µF, 10 volts, tantalum
C2, C4, C5, C9, C10, C15—0.1 µF, 50 volt, ceramic disc
C6—not used
C7—1500 pF, 100 volt, Mylar
C8—2.2 µF, polystyrene (Panasonic *ECQ-1225KZ*)
C11, C12—330 pF, polystyrene or propolyne
*C13—12–70 pF, trimmer capacitor (Mouser *ME242-1270*)
*C14, C16—3–10 pF, trimmer capacitor (Mouser *ME242-2710*)

Semiconductors
IC1—LM311N
IC2—CD4046
IC3—CD4520
IC4—CD4020
IC5—CD4022
IC6—CD4040
IC7—27C256 special programmed EPROM (see ordering note below)
IC8—CD4054
IC9–IC11—CD4056
IC12—LM7805CT
†DSP1—four digit LCD display, AND *FE0202*

Inductors
*L1—39 µH, variable inductor (Toko *154ANS-T1016Z*)
*L2—33 µH (J. W. Miller *8230-56*)
*L3—0.39 µH (J. W. Miller *8230-10*)
*L4—0.33 µH, variable inductor (Toko *BTKXNS-T1047Z*)

Other components
B1—9-volt battery
*BP1, BP2—5-way binding post with 8-32 thread
*S1, S2, S3—DPDT alternate action switch (ITT Schadow *51281*)
*3—pushbuttons for S1–S3
†2—LCD sockets
*2—8-32 × ¾-inch threaded spacer with mounting hardware
*2—8-32 screws and star washers
*1—battery terminal clip !1—socket for DSP1, Samtec *ESQ-120-12-T-S*
1—enclosure, Pactec *HPL-9VB*

Note: The following parts and kits are available from Almost All Digital Electronics, 5211 117th St. SE, Bellevue, WA 98006.
A complete kit containing all components in the parts list with the exception of the EPROM, display kit, enclosure, and the PC board: $69.95. A kit of hard-to-locate parts consisting of those indicated in the parts list with the * symbol: $29.95. The programmed EPROM: $19.95. The display kit consisting of those parts indicated with a † symbol: $14.95. The enclosure, with all holes machined and a front panel decal: $19.95. The PC board with plated-through holes: $19.95
A complete semi-kit (the switches are mounted and soldered) consisting of all of the above and a "standard" capacitor for calibration: $149.95.
The completely assembled, tested, and calibrated unit: $169.95. Add $5 for shipping and handling per total order. Washington residents must add 8% sales tax.

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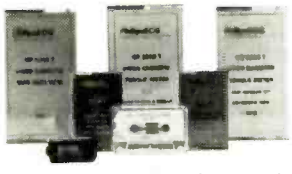

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maining operation is to adjust the zero-trimmers for the binding posts. Use a non-metallic alignment tool for the adjustments.

With nothing connected to the binding posts, depress switch S3 and adjust C16 for a 0.00 pF reading. The adjustment will be somewhat tricky because the 3–10 pF trimmer capacitor is very tiny and has only a ½-turn range.

Next, place a piece of braided solder wick (which is about as close to zero inductance as you can get) across the binding posts and depress switch S2. Adjust inductor L4 for a reading of 0.00.

Note: The C16-adjustment reading is hard to maintain because the effect of your hand's capacitance is well within the range of the instrument. Rather than habitually make the zero adjustment, or when using test leads, we suggest you measure the open circuit capacitance and/or short-circuit inductance as described above— including test leads if any, and subtract those values from the final reading. The range of the zero adjustments is too small to compensate for test leads anyway.

The offset drift of the zero adjustments is usually only ±0.01–0.02 μH, and therefore becomes insignificant (1% to 2%) when measuring components with values greater than 1 μH or 10 pF.

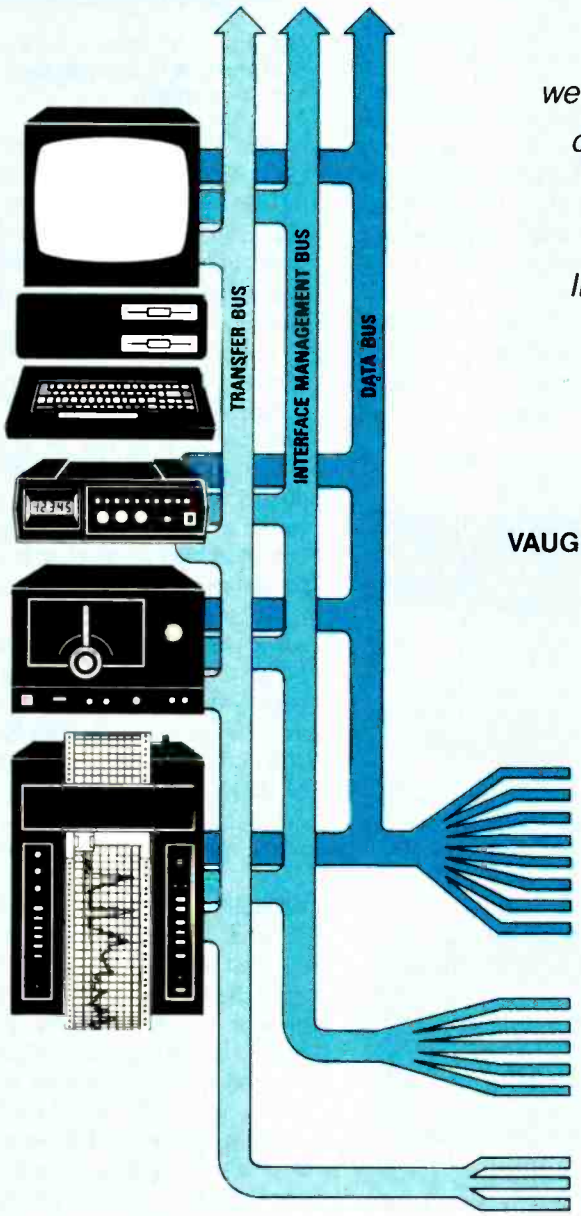
Accuracy

Using 31 inductors ranging in value from 0.1 μH to 6800 μH, and 35 capacitors ranging from 2.7 pF to 0.1 μF, the average error for inductance measurements, compared to the measurements of a 1-MHz digital *HP4275A* laboratory-type LCR bridge was 1.58%. Percentages for values below 0.1 μH lose meaning because the 0.01-μH resolution would cause a minimum percentage error of 10%, degrading to 100% at 0.01 μH.

The average error for capacitors was 0.78%. Percentages for values below 1.0 pF lose meaning because the 0.10-pF resolution would cause a minimum percentage error of 10%, degrading to 100% at 0.10 pF.

When the same components were measured on an *HP4274A* digital LCR bridge, at 100 kHz the average error between the two laboratory instruments was 10.17% for inductors and 7.12% for capacitors. **R-E**

GENERAL PURPOSE INTERFACE BUS



This month we continue our discussion on the General Purpose Interface Bus.

VAUGHN D. MARTIN

Part 2 LAST TIME WE DISCUSSED what a GPIB is. Now we'll cover such things as accessories, troubleshooting, and customizing, as well as some special systems and applications.

GPIB Accessories

Before analyzing or troubleshooting the bus, let's take a look at some hardware accessories that enhance an engineer's design capabilities with the instrument bus.

The HP *59301A* ASCII-to-Parallel Converter, Fig. 7, accepts byte-serial ASCII characters from the GPIB and converts them to parallel output. In operation, ASCII characters transmitted serially along the bus are converted to 4-bit characters. The first ASCII character that's received is interpreted as the most significant digit (MSD). A string of up to 16 characters terminated by a linefeed can be converted and placed on the output lines. (The linefeed character causes the HP *59301A* to output a print command). The HP *59301A* allows instruments controlled with either BCD or binary signals to be operated by the GPIB.

The HP *59303A* Digital-to-Analog Converter, Fig. 8, accepts a string of serial ASCII characters and converts any three consecutive input digits to an analog output voltage, which is accurate to 0.1% in 30 μs. The device is fully programmable via the GPIB, or it can be manually operated from front panel controls.

A rotary switch on the front panel makes it easy to select the three-bit group for DAC conversion. The three output modes (NORMAL, OFFSET, and PLUS/MINUS) make the DAC convenient to use directly with a variety of data-logging devices, thereby avoiding the need for auxiliary equipment to shift the zero level or the change polarity. Compatible logging devices include strip-chart recorders, X-Y plotters, and displays.

The HP *59306A* Relay Actuator, Fig. 9, has six relays that allow for control of external devices either manually from front-panel pushbuttons, or remotely from the GPIB. Relay contacts are specified to switch 24-volt DC or 115-volt AC at 0.5 A. Each relay can be programmed independently or multiple relays can be

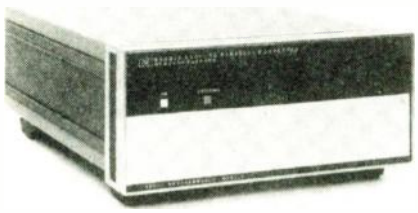


FIG. 7—THE HP *59301A* ASCII-to-parallel converter accepts byte-serial ASCII characters from the GPIB, then converts them to parallel output.

FIG. 8—THE HP *59303A* digital-to-analog converter accepts a string of serial ASCII characters, then converts any three consecutive input digits to an analog output voltage.

FIG. 9—THE HP *59306A* RELAY actuator has six relays that provide for GPIB control of external devices.

FIG. 10—THE HP *59307A* DUAL VHF switch module provides two 1P4T switches controllable by the GPIB.

switched together. Front-panel pushbuttons illuminate to indicate the state of each relay.

The HP *59307A* Dual VHF Switch, Fig. 10, provides two 1P4T switches controlled from front panel pushbuttons or remotely from the GPIB. The HP *59307A* is a DC to 500 MHz 50 ohm switch designed to maintain fast pulse transition times. The switches are independent and bidirectional for optimum use in multiplexing 50 ohm signal lines into measuring instruments or other devices.

The HP *59309A* GPIB Digital Clock, Fig. 11, displays the month, day, hour, minute, and second, and upon command will output time via the interface bus. Time can be set into the clock either by local control or by remote commands received from the GPIB.

Troubleshooting the GPIB Bus

The HP *5940IA* bus-system analyzer is shown in Fig. 12. That analyzer allows the user to see the status of all bus lines, including the actual characters on the data bus. Since that analyzer can drive all bus lines, it can completely exercise another talker, listener, or controller.

The GPIB bus analyzer may be operated at one of several speeds. The slowest speed is useful for single-stepping through a program for software debugging. At regular bus speed, the GPIB can be tested for system-related faults. The analyzer may even be operated at a variable rate, which is determined by an external clock input.

The analyzer's 32-character memory can be used to store bus characters in the Listen mode, or to output characters to the bus in the Talk

FIG. 11—THE HP *59309A* GPIB digital clock displays month, day, hour, minute, and second, and upon command will output time via the interface bus.

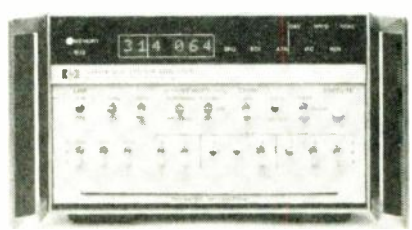


FIG. 12—THE HP *59401A* BUS-SYSTEM analyzer allows its user to see the status of all bus lines.

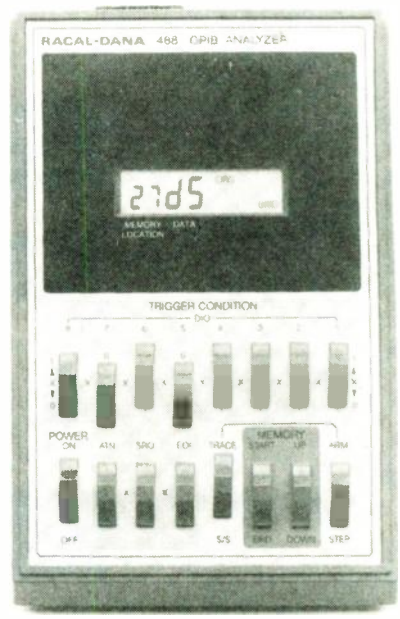


FIG. 13—THE RACAL DANA 488 GPIB BUS analyzer is portable and may also be battery-operated.

mode. When the analyzer is in the Compare mode, a stream of bus traffic can be stopped on a pre-selected character—and at that time a trigger pulse is available that is useful when analyzing transients or timing-related bus problems.

There are less expensive alternatives, if your budget cannot tolerate a bus analyzer like the HP *5940IA*. The alternatives are all nonintrusive bus analyzers, which means that they do not seize control of the bus, but rather generate control signals that command the network to be exercised in one manner or another.

Such nonintrusive bus analyzers are less elaborate and relatively inexpensive; moreover, a typical portable battery-operated GPIB bus analyzer may be quite small. The Racal Dana 488 GPIB Analyzer can fit in the palm of the hand, shown in Fig. 13. But don't let its size fool you; its analytical powers can be great.

Adapting non-GPIB

What if you cannot afford the added cost of buying your instruments with the GPIB option, or you've purchased equipment in the past before you knew about GPIB? Take heart! You need not scrap your equipment. There are GPIB translators that can make your non-GPIB instrument into a GPIB compatible if your instrument has TTL-compatible binary outputs and programmable commands. A

cost-effective way of upgrading an instrument not specifically designed for the GPIB is to use the Fluke *1120A* IEEE-488 translator shown in Fig. 14.

The Fluke *1120A* was designed specifically to get only Fluke products that are non-GPIB in design on the GPIB bus. The *1120A* connects instruments to the bus through an optional data-output unit in the instrument and a "personality card" in the *1120A*. Each personality card is individually addressable and "transparent" to other instruments. Each "personality" card corresponds to a particular Fluke instrument model and is sold as an option to that instrument or as a field-installable kit.

FIG. 14—THE FLUKE *1120A* IEEE-488 translator can up-grade an instrument not specifically designed for the GPIB.

FIG. 15—THE *HP-41* IS A combination handheld calculator and controller for the HP-IL.

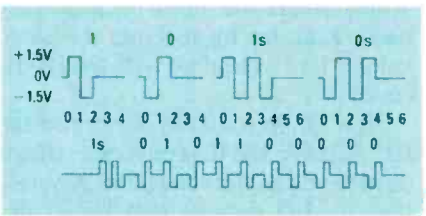


FIG. 16—THE HP-IL USES three-level codes, a logic high pulse is a +1.5 volt followed by a −1.5 volt, and the opposite is a logic low. Each transmission is 11 bits long and occurs in frames with a special encoded 1 and 0 for synchronization at the beginning of a frame. Those are designated as 1_S and 0_S respectively.

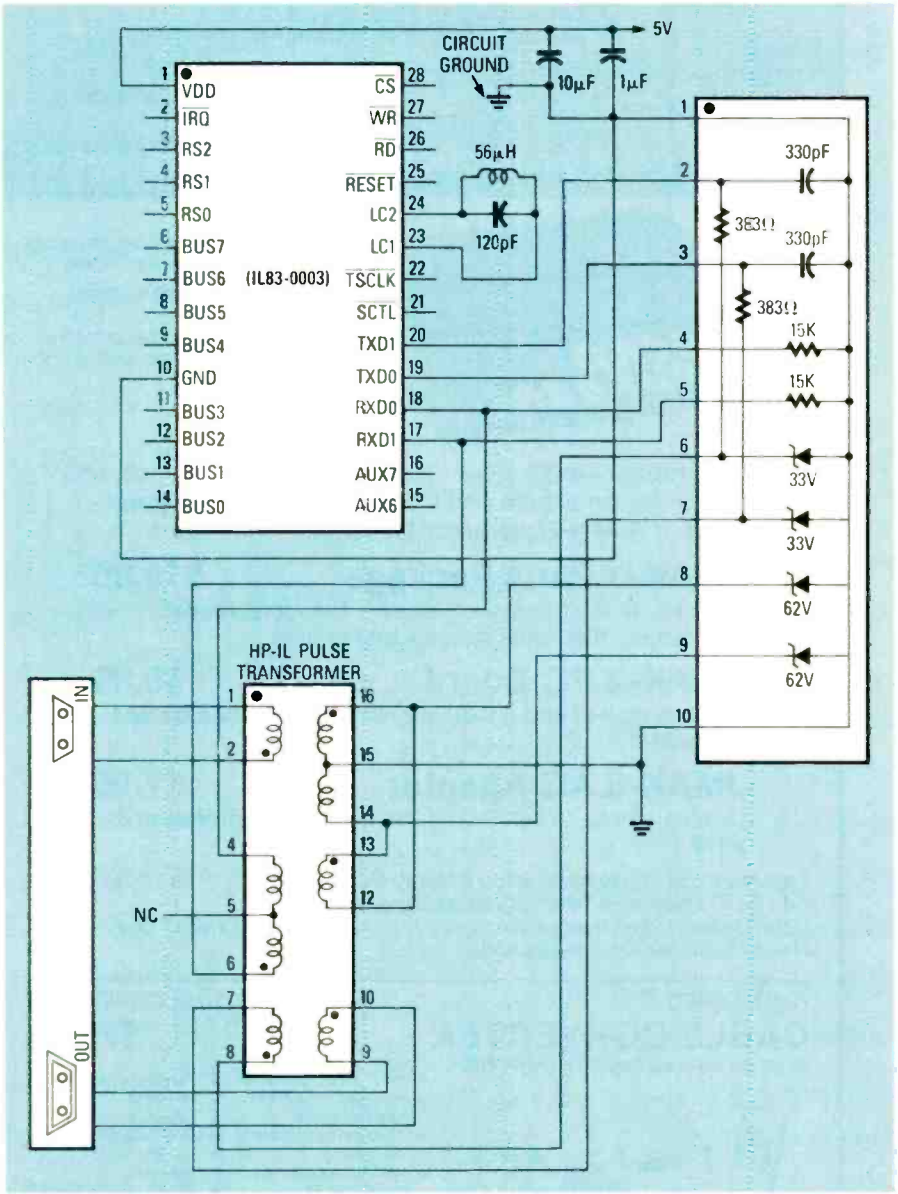


FIG. 17—PULSE TRANSFORMERS act as isolation line drivers and receivers. These transformers make it easier to generate the three voltage levels required with the HP-IL code.

A special circuit card for the Fluke *1120A* Translator converts it into a general-purpose translator between GPIB-bus systems and bit-parallel data systems. That circuit card, called an *A17-4*, handles up to 32 digital inputs and outputs; up to three *A17-4* cards will fit in a *1120A* translator.

Now that we better understand instrument buses, let's examine another convention, the HP-IL or Hewlett-Packard Interface Loop.

The HP-IL

Unlike the GPIB, the HP-IL (Hewlett Packard–Interface Loop) is just a *uni*directional transmitter of serial digital data to the next HP-IL device. Along with the data, sufficient energy is transmitted to energize the next HP-IL device in the loop. The waiting device idly rests until energized, making battery-powered portable operation a reality. Once data has been transmitted through all the HP-IL devices, it returns to the transmitter/controller and is checked for errors. That checking process simply compares the data initially transmitted with the data returned after completion of the loop.

The HP-IL *Master/slave* configuration uses the same "talker" (transmitter) and a "listener" (receiver), as discussed previously for digital-data transfer. With the HP-IL, one talker is

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designated as the controller, or master. All other devices within the loop are slaves—regardless of whether they are inherently listeners or talkers by design. It is possible, however, to operate without a controller. For example, a voltmeter (talker) could log readings onto a printer (listener). The use of multiple controllers with prioritized levels of interrupts is also possible. One Hewlett Packard controller that enjoys widespread popularity with the HP-IL is the *HP-41* handheld calculator shown in Fig. 15.

There are plug-in ports on the back of the *HP-41* for RAM's, ROM's, a card reader, a thermal printer, and a bar-code reader.

The ability of the HP-IL to poll its accessories allows the operator to enter a written message and then run the PRINT command. The HP-IL network is then searched for the first available printer upon which any English message may be printed.

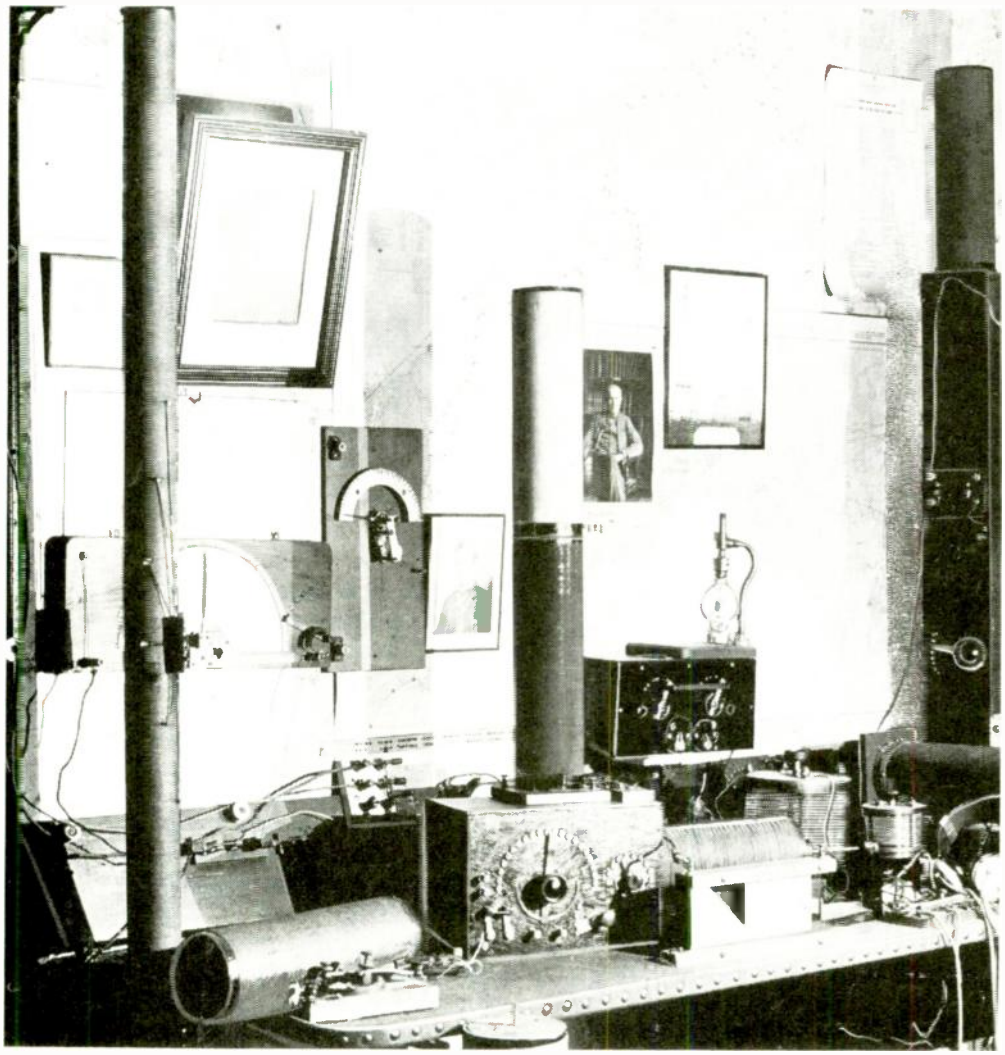
The HP-IL uses an unusual and clever three-level code method of data transmission that results in greater noise immunity, higher reliability, and less power consumption, and works as follows:

A logic-high pulse is a +1.5 V followed by a -1.5 V, the opposite is a logic low, (see Fig. 16). If a high or low pulse occurs because of electrical noise, it will be ignored because the noise pulse is not followed by a pulse of the opposite magnitude. Transmissions are each 11 bits long and occur in frames with a special encoded 1 and 0 for synchronization at the beginning of a frame, designated as 1_S and 0_S respectively. The "S" stands for *synchronization*. Five bits of the 11-bit transmission is the address of the instrument that is being used.

As shown in Fig. 17, instead of semiconductor line drivers and receivers, *pulse transformers* act as isolated line drivers and receivers. Transformers are used because they make it easier to generate the three voltage levels required with the HP-IL code.

Hewlett Packard has developed the HP *82166A* HP-IL converter, which transforms noncompatible general-purpose I/O devices into HP-IL devices. One can expect that other manufacturers will build that capability into measurement instruments rather than require the use of more costly interface devices. **R-E**

The Early Days of RADIO



MARTIN CLIFFORD

With better tubes came better radio designs.

BY THE EARLY 1920'S, RADIO DESIGN HAD progressed to the point where producing acceptable audio levels was no longer a problem and radios were being welcomed in more and more households. But with the growth of radio came the growth of radio stations. Before long there were so many radio signals, especially in urban areas, that poor selectivity no longer was merely a nuisance; it was intolerable.

At the same time, however, designers acknowledged that not everyone had the room or means to install a large, outdoor aerial system. Smaller systems, especially the indoor loops that were becoming popular in cities, could not deliver the same signal level to the receiver, so radios had to be even more sensitive to make up the difference. To solve both problems, radio designers turned to a multi-stage approach, adding sensitive and selective RF stages to their circuits. In this article we will see how their designs progressed, and eventually evolved into the circuits we use today.

Resistance-coupled RF amplifier

Early RF-stage designs were little more than barely modified audio-amplifier circuits. One early multi-stage receiver design is shown in Fig. 1. That radio used a pair of resistance-coupled RF amplifiers. Those did nothing for selectivity, but they did make receivers more sensitive. Unfor-

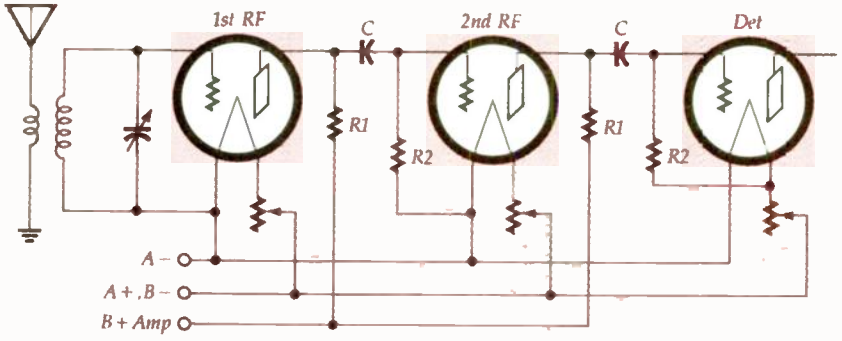


FIG. 1—RESISTANCE-COUPLED RF amplifiers made receivers more sensitive, but did nothing for selectivity.

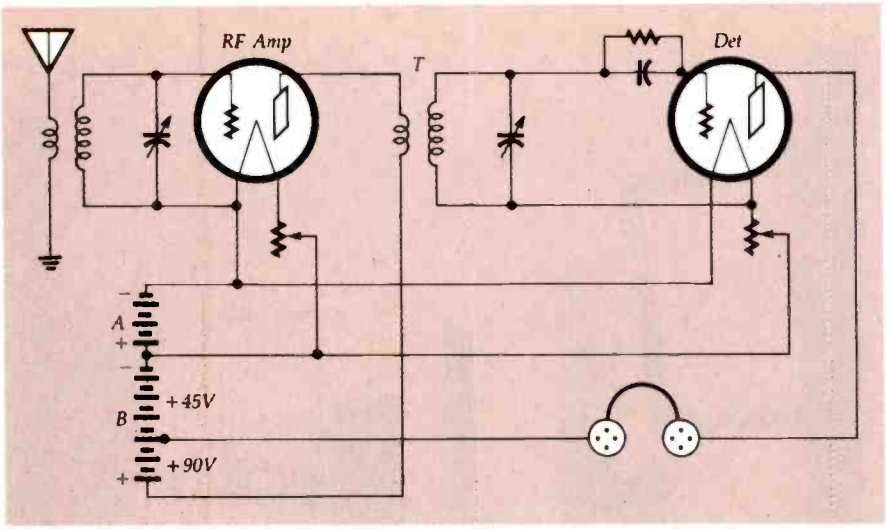


FIG. 2—THE TUNED RADIO-FREQUENCY amplifier improved selectivity by adding a tuning capacitor.

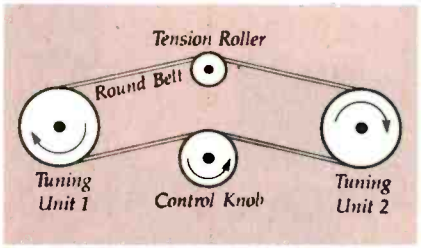


FIG. 3—TO REDUCE THE NUMBER of controls, some receivers linked the tuning capacitors via a belt drive.

tunately, the added sensitivity compounded the problem of selectivity; more signal reached the detector, but without being sorted. The resistance-coupled RF amplifier did not become popular and soon went on its way.

TRF amplifier

To improve selectivity, a second tuned circuit was added, yielding a circuit similar to the one shown in Fig. 2. The set was called a *Tuned RF* (TRF) receiver. Selectivity was slightly improved with that design; before long, receivers with a second tuned-RF stage (three tuned circuits) began to appear. With two stages, it was possible to tune the set so that the background signals from competing stations were subdued.

Both single- and two-stage TRF receivers tuned quite broadly, and the tuning capacitor settings were not too critical. However, with the two-stage design, the user had three settings to fiddle with and every time you changed stations, all three had to be readjusted.

One-dial tuning

Even though tuning wasn't critical in the TRF receiver, tuning three capacitors every time you changed stations was a tedious affair, and one that even intimidated some prospective users. To simplify the tuning procedure, various one-dial tuning schemes were tried. One technique was the pulley and drive-belt system shown in Fig. 3. Another was a rack and pinion drive system; it was not as simple as the drive-belt method and was much more expensive to implement, so it wasn't used to any extent. The problem was solved to everyone's satisfaction by mounting the tuning capacitors on a common shaft, a tuning technique that is still in use today.

The loop antenna

As was alluded to earlier, a key to the popularity and practicality of radio was the elimination of large aerial systems. In fact, the crystal set's absolute need for such an aerial was as big a factor as any other in its eventual fall from popularity.

Owners of early multi-stage vacuum-tube receivers soon discovered

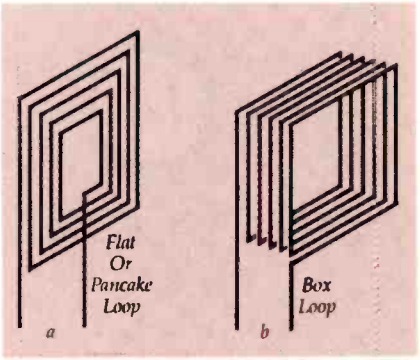


FIG. 4—TWO TYPES OF LOOP ANTENNAS. A flat or pancake type is shown in *a*, a box type is shown in *b*.

that it was possible to forsake the large outdoor designs in favor of compact indoor antennas. Some experimenters used bedsprings or window screens as the antenna; others ran large loops of wire around their baseboards or in their attics. However, a more elegant answer soon became

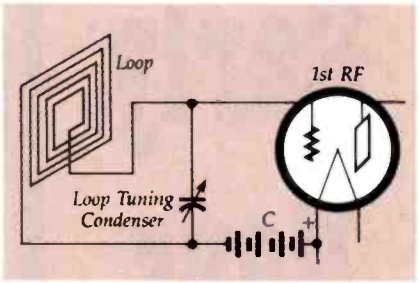


FIG 5—LOOP ANTENNAS formed part of a tuned circuit and could be tuned for a specific frequency, thereby increasing selectivity.

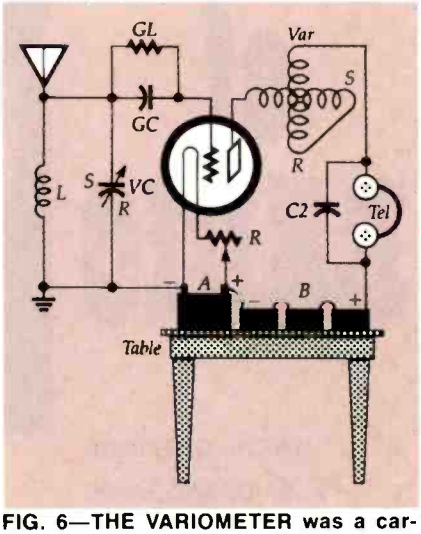


FIG. 6—THE VARIOMETER was a carryover from crystal sets.

popular—the loop antenna. Those were generally positioned on top of the receiver or nearby and were of two types: the flat or pancake loop shown in Fig. 4-*a* or the box loop shown in Fig. 4-*b*-. One advantage of the loop antenna was that it helped minimize competing signals. The loop was part of a tuned circuit (see Fig. 5) that could be tuned for resonance at a particular frequency, thereby improving selectivity. Further, the loop could be physically rotated or positioned to minimize interference. As shown in Fig. 5, a "C" battery often was used for bias, but grid leaks and grid capacitors were also used for that purpose.

Variometer tuning

While the appearance of vacuum-tube triodes spelled the end of crystal-set popularity, that end did not come overnight.

Both types of sets co-existed for many years. And many sets incorporated circuits and features from both types of receivers. For instance, some sets combined a crystal detector with a vacuum tube audio amplifier.

One crystal set component that was commonly found in tube sets was the *variometer*, which consisted of a continuously variable inductance formed by connecting two coils in series and mounting them so that one rotated within the other. The overall inductance could be varied over a wide range, with a very low minimum value. As shown in Fig. 6, the variometer was inserted in the plate circuit of the tube. Both the variometer and the variable capacitor in the grid circuit were used to tune a signal. In time, with the introduction of receivers with two and three tuned-RF stages, the variometer joined the growing heap of discarded electronics components.

The neutrodyne

It seems that every advance in receiver circuitry was accompanied by some unexpected problems; the triode

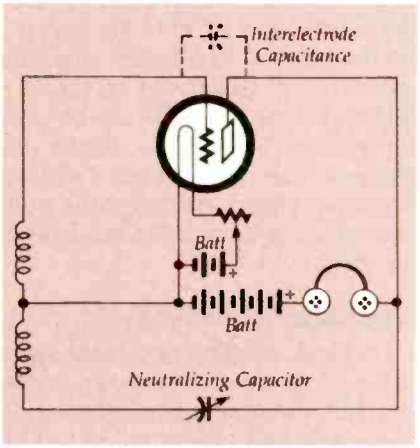


FIG. 7—A NEUTRALIZING CAPACITOR was needed to compensate for the triode's interelectrode capacitance.

and the TRF were no exception. Since the elements of the triode were made of metal, they formed a capacitor. And like all other capacitors, the *interelectode capacitance* had a reactance that varied inversely with frequency. When used as an audio amplifier, the interelectrode capacitance was not a great concern. At radio frequencies, however, it was quite definitely a concern. At those frequencies, the interelectode capacitance provided a feedback path between the receiver's input and output circuits. Since the feedback was in phase with the input, the result was oscillation, and a howling in the headphones or the speaker.

Fortunately, the problem was solved by Professor Hazeltine of the Stevens Institute in Hoboken, NJ when he developed what he called the neutrodyne principle. The capacitor shown in dashed lines in Fig. 7 indicates the feedback path provided by the tube's interelectrode capacitance. Hazeltine's technique was to use an adjustable capacitor to intentionally feed back part of the signal, but out of phase with the input. The out-of-phase feedback signal was equal to or greater than the in-phase feedback, and the two canceled out.

The introduction of the multigrid tube relegated the neutrodyne to receiver history. However, neutralization is still used today in transmitters, including those with multi-grid tubes.

Enter the tetrode

The need for receiver tube neutralization was eliminated by the introduction of the tetrode. That four-electrode tube was invented by A.W. Hull. His name for the tube was the *Pliodynatron*, which never did grip the public's imagination. But, although the name was soon forgotten, the tube remained.

In the tetrode, another grid (the "screen grid") was positioned between control grid and plate. That reduced interelectrode capacitance by putting the tube's capacitances between grid and plate in series. Instead of being from grid to plate it was from grid to screen grid and from screen grid to plate. Some early attempts

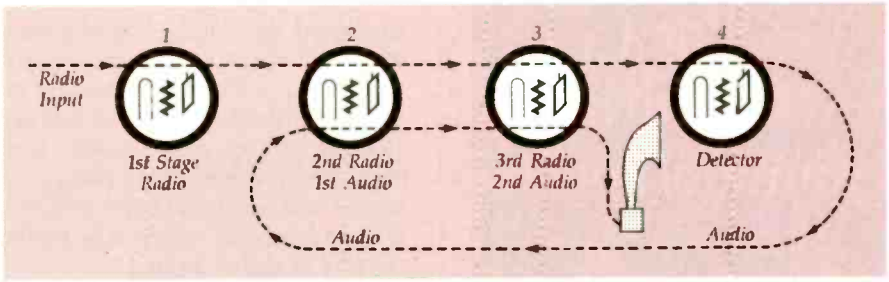


FIG. 8—IN A REFLEX RECEIVER, some tubes are called upon to do double duty.

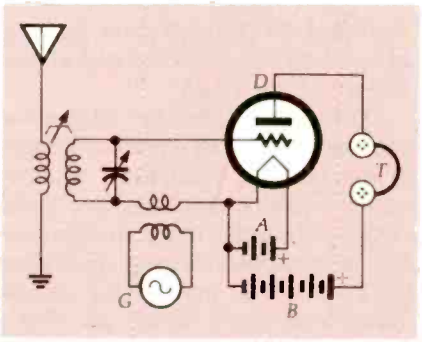


FIG. 9—IN THE HETERODYNE RECEIVER, a locally generated signal is mixed with the received signal.

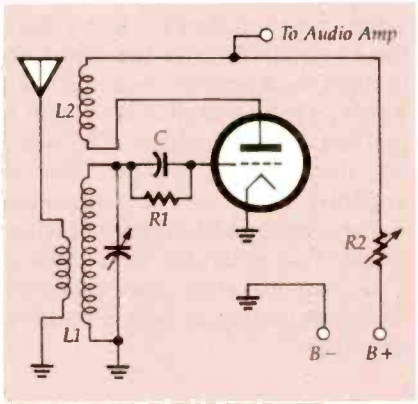


FIG. 10—ALTHOUGH LOW COST and easy to build, the regenerative receiver suffered from many drawbacks.

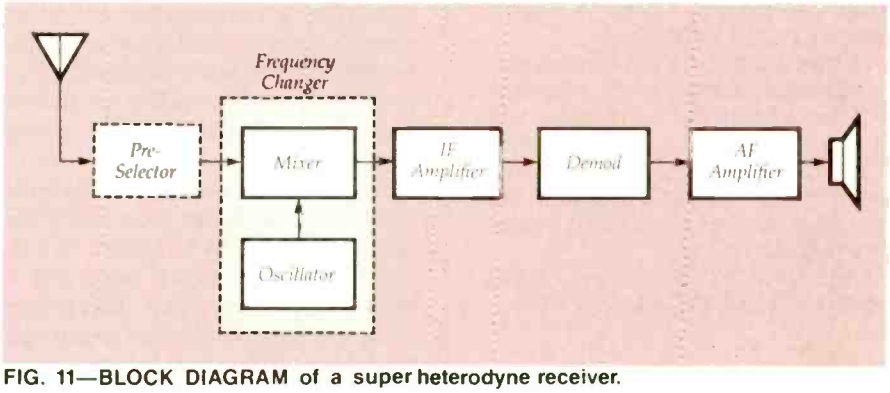


FIG. 11—BLOCK DIAGRAM of a super heterodyne receiver.

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connected the screen grid to ground which of course made it an effective shield. But it was discovered that if a positive potential was put on that new element, and was held constant, feedback would be practically zero. A capacitor was connected between screen grid and ground effectively putting the grid at signal ground.

The addition of the screen grid tube also had a second, pleasant effect. It increased the amplification factor to as much as 400, as compared to only about 10 for a triode.

During the mid 1920's, volume was still one of the most important criteria in the public's evaluation of a receiver's quality. One approach to increasing the volume without increasing the component count, and hence the cost, was to use a *reflex* circuit. There were many variations of that idea, and one popular one is shown in Fig. 8. In that circuit, the incoming signal was brought into an RF amplifier, proceeded through two more RF stages, and was then fed into a detector. From the detector the signal was brought back into the second RF amplifier, which was then also used as the first audio amplifier. The signal was then injected into the third RF amplifier, which now also functioned as the second audio stage, and whose output was delivered to a speaker. Thus, two of the four tubes did double duty, functioning as both RF and AF amplifiers.

The heterodyne receiver

Spark transmitters generated large numbers of damped waves having all kinds of harmonics. Those waves heterodyned or beat together in the receiver's detector, and therefore could be referred to as self-modulating. That property was what made it possible to hear dits and dashes using simple crystal receivers.

However, those same receivers were not suitable for receiving *C*ontinuous *W*ave (CW) signals. A CW signal is simply an RF wave that is broken up into long and short pieces using a telegraph key and is not self modulating. That problem was overcome by the invention of the heterodyne receiver by Reginald A. Fessenden in 1905. The hetrodyne circuit was the basis on which Major Edwin H. Armstrong devised the superheterodyne circuit in 1918.

As shown in Fig. 9, the principle behind the heterodyne receiver is quite simple. In it, a local signal is generated (G) and injected into the detector. There, it beats or heterodynes with the received signal, producing a number of sum and difference signals. One of those, a difference signal in the audio range, is heard in the headphones.

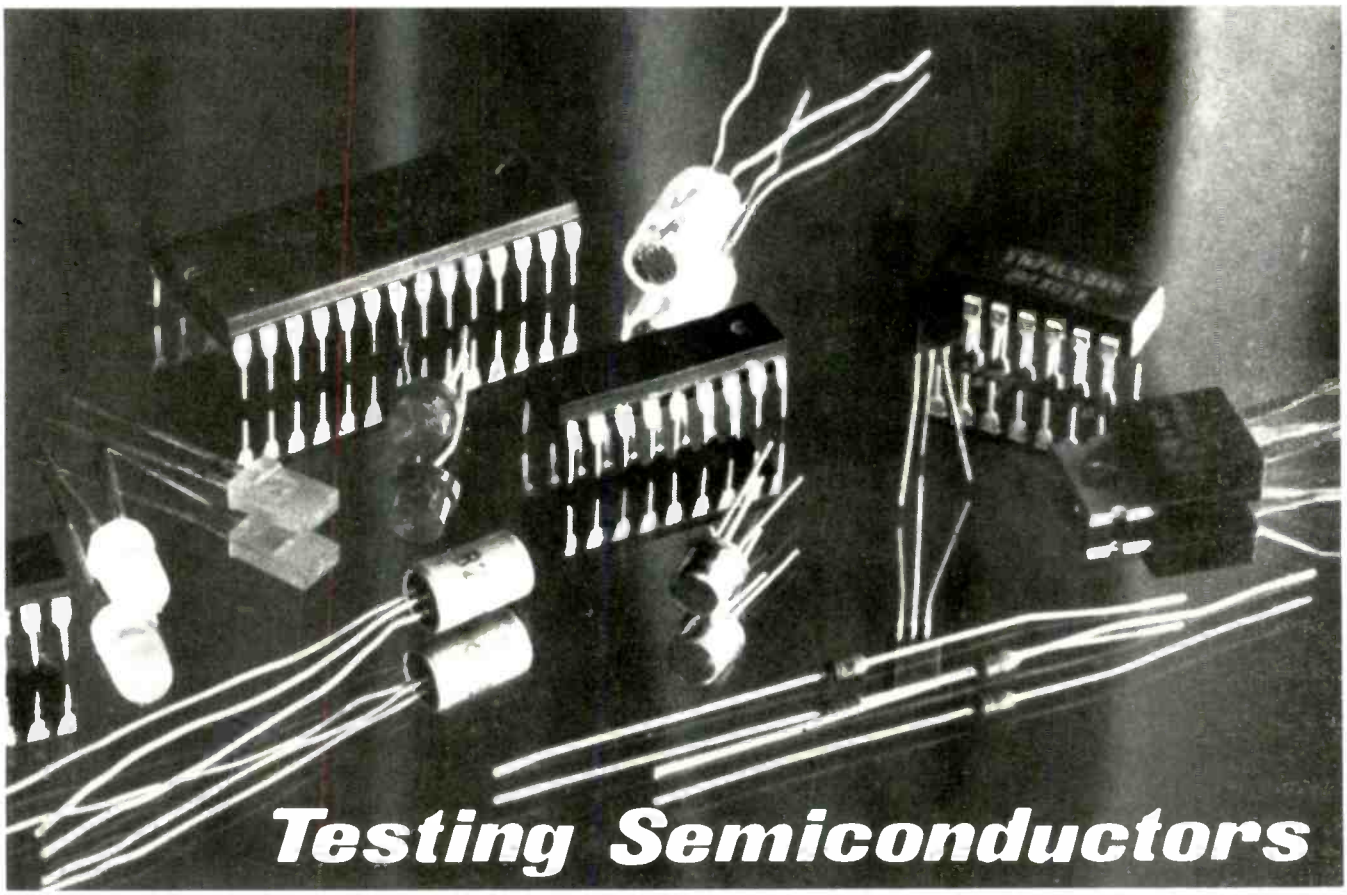
The regenerative receiver

The triode vacuum tube was full of surprises. It was initially regarded solely as an audio amplifier. Subsequently, it was learned that the same tube could be used, simultaneously, as a detector. And then it was discovered that the triode also could simultaneously function as an oscillator as well. A circuit that used one tube for all three functions was the regenerative receiver shown in Fig. 10.

In that circuit, some of the amplified signal output is fed back to the input in-phase with the incoming signal. The grid leak, R1, its shunting capacitor C1, the tuned circuit, and the filament/cathode form a diode detector, with R1 functioning as the diode's load. The amplified signal is inductively coupled from L2 into L1, a process that is allowed to continue by adjusting of R2 until the circuit is at the point of oscillation; that's the point where its sensitivity (gain) is greatest. Since the tube can be made to oscillate, that self-oscillation produces a frequency that beats with the incoming signal, resulting in an audio tone that can be heard in headphones or speaker.

The superheterodyne

A block diagram of a basic superheterodyne receiver is shown in Fig. 11. The preselector consists of one or more tuned RF stages, but in less expensive receivers it is often omitted. As in the heterodyne receiver, the incoming signal is fed to a mixer, where it beats with a signal supplied by a local oscillator. However, unlike the heterodyne receiver, the local oscillator is designed so that the difference frequency is on the order of several hundred (or more) kHz. Known as the *I*ntermediate *F*requency (IF), the difference signal is then amplified, demodulated to recover the audio signal, and then the audio is amplified again. The great advantage of the superheterodyne design was, and still is, the large amount of selectivity that can be supplied by the IF stages, which are fixed-tuned to a selected frequency. **R-E**



Testing Semiconductors

More on testing TTL devices, including low-power, high-speed, and Schottky types.

TJ BYERS

Part 9 LAST TIME WE EXamined the static (DC) characteristics of TTL gates. This month we will expand our discussion to encompass the entire family of TTL-compatible devices. That family includes five prominent members. They are standard TTL, low-power TTL (54L/74L00), high-speed TTL (54H/74H00), Schottky TTL (54S/74S00), and low-power Schottky TTL (54LS/74LS00). Each of those subfamilies within the TTL family serves to fill a specific characteristic that makes it more suitable for a given application.

Family traits

The patriarch of the family is, of course, the TTL gate. When there are no specific characteristics to fill, we often turn to TTL because it is readily available and inexpensive. TTL gates have moderate power consumption, good fan-out, and adequate operating speed for most applications.

The first two TTL subfamilies grew as a direct result of optimized TTL characteristics. The 54L/74L series capitalizes on the low-power aspects of TTL design, reducing typical gate power consumption by a factor of 10. Unfortunately, the operating speed of low-power TTL is only about ¼ that of standard TTL.

On the other hand, when emphasis is placed on speed, the price is power. A high-speed 54H/74H TTL gate can operate at up to twice the speed of standard TTL, but it consumes nearly 2½ times more power than a standard TTL gate, and 23 times more power than a 54L/74L gate.

The invention of Schottky TTL made possible devices that had both high speed and low power consumption. A standard Schottky TTL gate operates at about twice the speed of a high-speed 54H/74H TTL gate while consuming but ¾ the power.

Then a low-power version of the Schottky gate, the 54LS/74LS series, soon evolved from the original Schottky concept. That gate consumes only slightly more power than a low-power 54L/74L TTL gate while maintaining the speed characteristics of a standard TTL device.

Now the newest addition to the TTL family is a series of advanced Schottky TTL integrated circuits, designated as 54AS/74AS00 and 54ALS/74ALS00. Building on established Schottky TTL designs, those devices use improved construction techniques to enhance the speed of the already superior Schottky gate while reducing its power requirements. The specific switching speeds, as well as the typical power consumptions per gate for the entire TTL family, are listed in Table 1.

TABLE 1

Series	Propagation Delay	Power Dissipation	Frequency
54/74	10 ns	10 mW	35 MHz
54H/74H	6 ns	23 mW	50 MHz
54L/74L	33 ns	1 mW	3 MHz
54S/74S	3 ns	19 mW	125 MHz
54LS/74LS	9 ns	2 mW	45 MHz
54AS/74AS	1.7 ns	8 mW	200 MHz
54ALS/54ALS	4 ns	1.2 mW	70 MHz

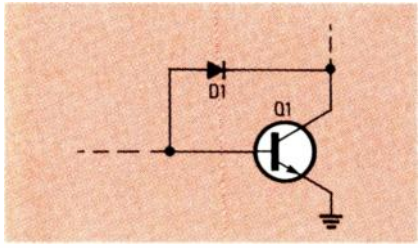


FIG. 1—IN THE BAKER CLAMP a germanium diode is placed across a transistor's base-collector junction.

Schottky TTL

Until the advent of Schottky TTL, all logic gates were pretty much the same internally, with emphasis put on certain features for speed or power. The first of the Schottky TTL devices to appear adhered to that design strategy with one important exception—they used Schottky transistors.

The Schottky transistor is what evolved from two earlier concepts: the *Baker clamp* and the *Schottky barrier-diode*.

The Baker clamp, as shown in Fig. 1, is a method of avoiding saturation in a discrete transistor. It has been established that saturated transistors take longer to switch from one state to another than do unsaturated transistors. Consequently, if the transistor can be prevented from going into saturation, the operating speed of the logic gate is improved.

The Baker clamp uses a germanium diode across the base-to-collector junction of the switching transistor to prevent saturation. The forward voltage drop of the germanium diode is 0.3 volt as compared to 0.7 volt for the base-emitter junction of a silicon transistor. When the transistor is turned on, base current drives the transistor toward saturation, decreasing the collector voltage. As the collector voltage drops, the germanium diode begins to conduct forward current, causing excess base-drive current to be diverted from the the base-emitter junction to the base-collector junction of the transistor. The result is that the transistor is held out of deep saturation, and the turn-off time is dramatically reduced.

Unfortunately, germanium does not integrate monolithically with silicon, making it impossible to use in silicon IC's. Therefore, the germanium diode must be replaced with a silicon equivalent that has a lower forward voltage drop than the base-collector junction of the transistor. A normal silicon p-n diode does not meet that requirement because its structure and forward voltage drop is identical to that of a silicon transistor. The Schottky-barrier diode, on the other hand, uses a metallic ohmic junction that gives the diode a lower forward-voltage drop, making it ideal for the application.

The Schottky diode is fabricated by depositing a metalization layer directly over the collector region, and tying it back to the base. The contact of the metal and the collector region forms a rectifying junction with a forward-voltage drop of about 0.4 volt, well below the 0.7 volt of the base-collector silicon junction. The arrangement is known as a Schottky transistor. A schematic of a typical Schottky gate is shown in Fig. 2.

Low-power Schottky TTL

The design of a low-power Schottky (LS) device varies somewhat from a traditional TTL design in that the input logic transistor does not have multiple emitters. Instead, Schottky barrier diodes are attached to the base of the input transistor, with each diode representing an input. A schematic of a typical low-power Schottky gate is shown in Fig. 3.

When a high is applied to either input of the gate, transistor Q1 receives base current from the 18K base resistor, which forces that transistor into conduction. When that happens, Q5 begins conducting, and as a result, Q4 is turned off, giving the gate a logic low output.

When a low signal is applied to either input of the device, the signal diverts some of Q1's base current through the input diode or diodes. Because the voltage drop across the Schottky-diode input is less than the base-emitter voltage (V_{BE}) of input transistor Q1, the transistor shuts off, causing the collector voltage to go high. That forces Q5 off and Q4 on, producing a high output signal.

That arrangement is essentially a modern version of DTL (*D*iode-*T*ransistor *L*ogic), a logic design that preceded TTL. Compared to the classic multi-emitter TTL structure, the low-power Schottky design is faster and dissipates less power.

All inputs are provided with Schottky clamping diodes, as shown in Fig. 3. Those diodes conduct when the input signal to the device goes negative, which limits undershoot and helps to control ringing.

The low-power Schottky series is functionally equivalent to standard

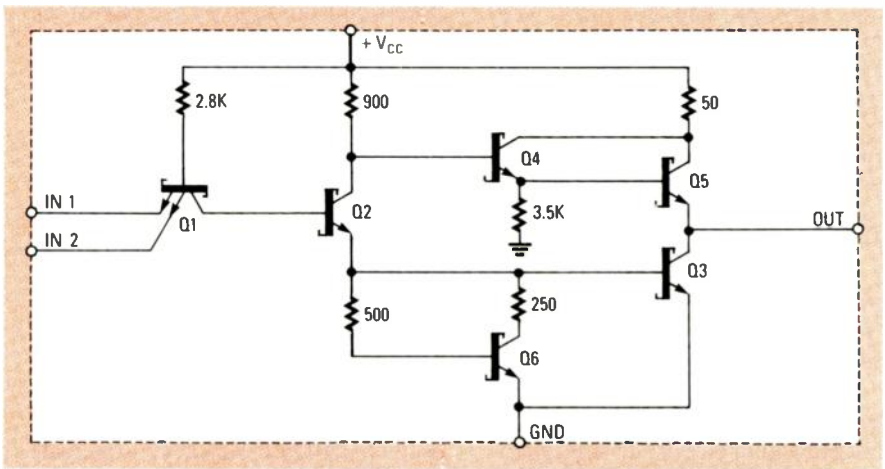


FIG. 2—A SCHOTTKY TTL GATE uses Schottky transistors, which have junctions having a lower voltage drop than that of standard silicon transistors.

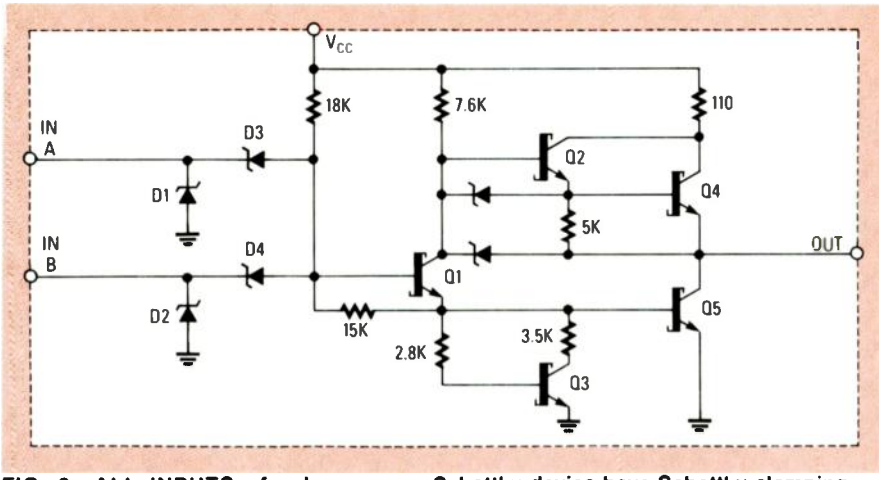


FIG. 3—ALL INPUTS of a low-power Schottky device have Schottky clamping diodes to control ringing.

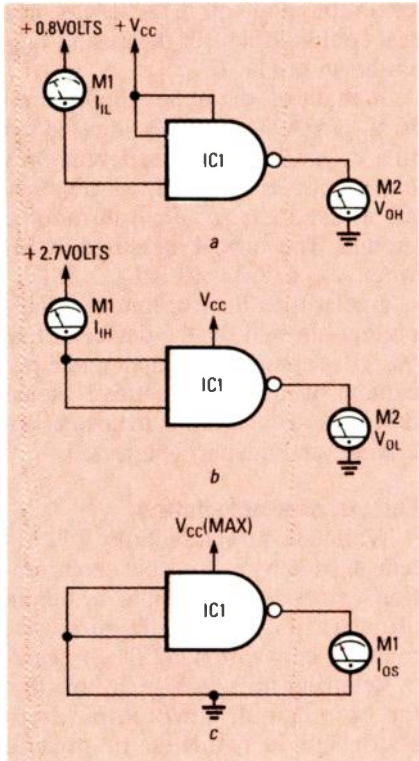


FIG. 4—STATIC INPUT AND OUTPUT parameters of standard, high-speed, and low-power TTL devices can be done using these circuits. The circuit in *a* tests I_{IL} and V_{OH}, the one in *b* tests for I_{IH} and V_{OL}, and the one in *c* tests for I_{OS}.

TTL, even in switching speed, but consumes typically one-fifth as much power. It's no wonder that it is the most popular TTL-type device.

Family feuds

It is quite possible to use more than one of the TTL subfamilies in a single system. An example might be where a high-frequency input signal is to be divided down to a lower frequency. There we might use a Schottky TTL in the front end of the divider chain, and standard TTL once the frequency has been scaled down.

But you must be very careful when mixing TTL logic. There is a wide variation in static parameters among the various TTL subfamilies.

Testing the static input and output characteristics of standard, low-power, and high-speed TTL devices can be done as described last time. Figure 4 shows a quick summary of the test circuits that are used and Table 2 shows typical results for each subfamily. Note that the test configurations are for negative (NAND, NOR) logic. To test positive logic devices (AND, OR), change the input levels accordingly.

Testing Schottky TTL

When testing 54S/74S00 TTL logic, remember that other than the use of Schottky-clamped transistors, the circuit configuration is basically the same as that of the other TTL families already discussed, and the device compares favorably with high-speed TTL. The only parameter that is different is the V_{OL} output voltage, which is typically 0.4 volt rather than 0.1 volt. Since that is still well below the maximum V_{IL} for a standard TTL gate, the 54S/74S series is fully compatible with other TTL logic.

With static testing of low-power Schottky and advanced Schottky TTL devices, what we have is an altogether different matter. Because of the modified input-circuit design, the input gates of those devices varies considerably from the norm.

Input characteristics

In general, most low-power and advanced Schottky input parameters can be measured using the techniques we explored last time; those include I_{IL}, I_{IH}, V_{IL}, and V_{IH}. The results of those measurements, though, are somewhat different.

Typically you will find that the input currents are considerably less than that of standard TTL. Typical values for I_{IH} and I_{IL} are 20 μA and 0.4 mA, respectively, as compared to 40 μA and 1.6 mA for TTL devices. That means that a standard 10-unit TTL driver can drive twice as many low-power Schottky gates as standard TTL gates.

Input voltages, on the other hand, tend to run a little lower because of the presence of the Schottky diodes. Where a TTL gate might trigger from high to low with a 1.4-volt input, the Schottky input may have to be reduced to 1.1 volts before a logic transition takes place. Since both values are well above the 0.8-volt maximum for V_{IL}, there is no significant difference in performance.

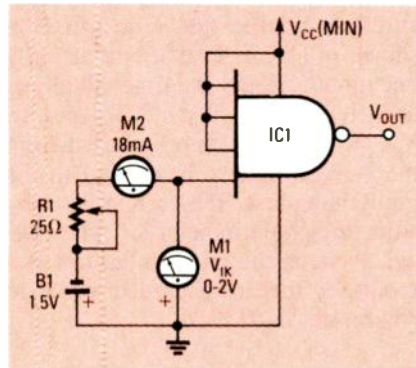


FIG. 5—THE INTEGRITY OF THE INPUT clamping diode can be tested using this setup.

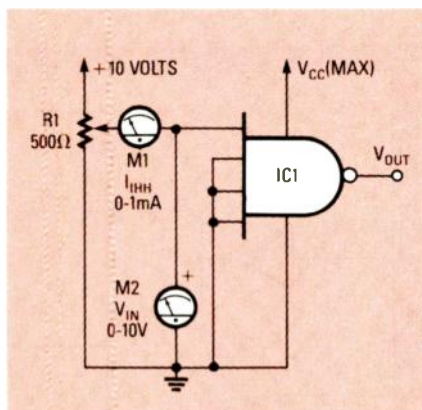


FIG. 6—INPUT BREAKDOWN VOLTAGE can be determined by applying 7 volts to an input and measuring the resulting input leakage current under worst-case power-supply conditions.

Measuring V_{IK}(MAX)

There is one test performed on low-power Schottky devices that is not performed on any other type of TTL logic. It a test for V_{IK}(MAX), the most negative voltage at an input when 18 mA is forced out of that terminal. That parameter guarantees the integrity of the Schottky input diode that is placed across the logic input and ground. Those diodes are normally reverse-biased and are there only to suppress transient currents.

Looking at Fig. 3, we see that as the input voltage to input A approaches ground, increasing amounts of current flow through D3 until it reaches I_{IL}. Beyond that point, the input voltage starts swinging negative, as would be the case if the input signal suffered from ringing. That effectively places ground at a positive voltage and the logic input at a negative voltage, forcing diode D1 into forward conduction. The input voltage is now clamped at the forward voltage drop of D1, which effectively dampens any ringing that may be present on the input signal.

The V_{IK}(MAX) parameter is measured using the test configuration shown in Fig. 5. In that circuit, only one input is tested at a time; all others are tied high. With V_{CC} set to V_{CC}(MIN), a −18-mA current from the 1½-volt battery is applied to the input under test. The current is set by adjusting potentiometer R1. The voltage between the input under test and ground is then measured in order to determine V_{IK}(MAX).

Breakdown voltage

Another consequence of using Schottky diodes for the logic input is an increase in the input breakdown voltage. The typical input breakdown voltage of a low-power Schottky gate is 15 volts or more.

However, testing for breakdown voltage is critical. Unlike the multi-emitter input of a standard TTL gate, which can sustain short periods of overload, the base-emitter junction of a Schottky transistor is small and can easily be over stressed by a transient caused by spikes on the input signal.

Two tests are used to measure input breakdown voltage. The simpler involves applying a voltage to the input and noting whether the device fails or not. That is commonly referred to as destructive testing because it renders the part useless.

More frequently, the gate input is subjected to an additional high-level input voltage and a leakage-current measurement is taken. Because there is a linear relationship between breakdown voltage and leakage current, the breakdown voltage of the input can be extrapolated by comparing the measured leakage current to already established guidelines.

The leakage measurement, which is unofficially called I_{IHH}, is done by applying 7.0 volts to an input under the worst-case power-supply voltage conditions and noting the results. The test configuration for measuring I_{IHH} is shown in Fig. 6.

In that test, the power supply is set to V_{CC}(MAX) and R1 is adjusted until a V_{IN} of 7.0 volts is achieved. Only one input can be tested at a time and all unused inputs are returned to ground. The current measured by M1 when V_{IN} is 7.0 volts is I_{IHH}. If I_{IHH} is greater than the maximum leakage current allowed for the device at that V_{IN}, it is assumed the input under test cannot sustain the repetitive breakdown voltages common to normal operation, and the part is rejected.

TABLE 2

Symbol	Parameter	54/74 Series	54H/74H Series	54L/74L Series	54S/74S Series	54LS/74LS Series	54AS/74AS Series	Units
I_{OH}	Output high current	400	500	100/200	1000	400	2000	µA
I_{OL}	output low current	16	20	2/3.6	20	4/8	20	mA
V_{OH}	output high voltage	3.4	3.5	3.2	3.4	3.4	3.0	V
V_{OL}	output low voltage	0.2	0.2	0.15/0.2	0.5	0.25/0.35	0.35	V
I_{IH}	input high current	40	50	10	50	20	20	µA
I_{IHH}	input high current					100	112	µA
I_{IL}	input low current	1.6	2	0.18	2	0.36	0.4	mA
V_{IH}	input high voltage	2	2	2	2	2	2	V
V_{IL}	input low voltage	0.8	0.8	0.7	0.8	0.8	0.8	V
V_{IK}	input clamp voltage					0.65	1.5	V
I_{OS}	short circuit current	18–55	40–100	3–15	40–100	6–40	60–224	mA

Output characteristics

While low-power Schottky TTL retains the totem-pole output configuration we examined last time, the output circuitry has several features not found in conventional TTL devices.

Referring back to Fig. 3, note that the base of pull-down output transistor Q5 is returned to ground through Q3 and a pair of resistors instead of through a simple resistor. That arrangement is called a squaring network because it squares up the transfer characteristics of the logic transitions by preventing Q1 from conducting until the input voltage rises high enough to allow Q1 to supply sufficient base current to Q5 for a snappy transition.

The output pull-up circuit (Q2, Q4) is a Darlington circuit with the base of the output transistor returned to the output terminals through a 5K resistor. Compare that to the output circuit in 54H/74H and 54S/74S logic, which has its base returned to ground. The Darlington configuration con-

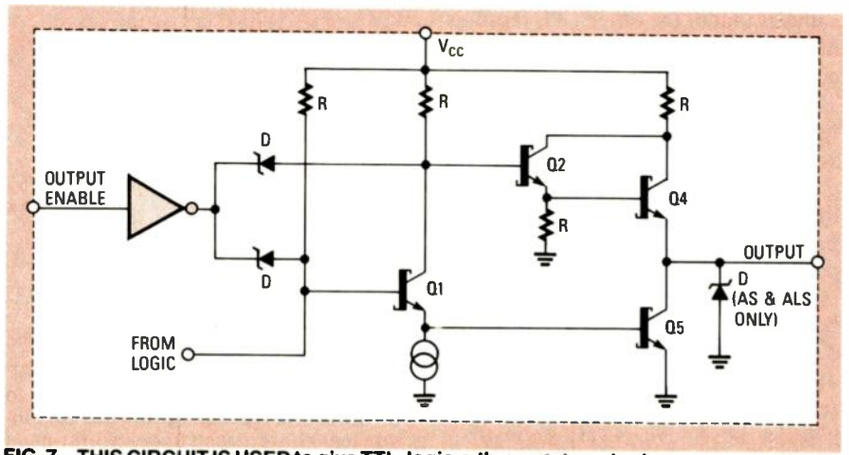


FIG. 7—THIS CIRCUIT IS USED to give TTL logic a three-state output.

sumes less power while allowing the output to pull up to one V_{BE} below V_{CC} for low values of output current. Note that 54AS/74AS and 54ALS/74ALS logic devices include a Schottky clamping diode across the output to control ringing on long signal lines.

Output characteristics I_{OL}, I_{OH}, V_{OL}, and V_{OH} are measured using the methods described last time, and are summarized in Fig. 4. Note, however, that the test parameters are changed slightly. Whereas V_{IL} is 2.4 volts for standard TTL, its value is 2.7 volts for Schottky devices. You will also find that Schottky output currents and voltages are slightly different than TTL. The differences are listed in Table 2.

Three-state output

An interesting twist was added to binary logic with the introduction of three-state logic. Conventional binary logic maintains that there are only two states for a logic device—its either on or off. Three-state logic, on the other hand, says that there may be three states: on, off, and "none" or high-impedance.

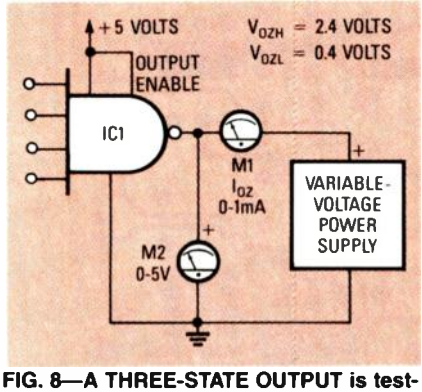


FIG. 8—A THREE-STATE OUTPUT is tested using this circuit.

In the none state, the output of the logic device is floated in a high-impedance mode. In essence, the gate is removed from the circuit without actually being physically removed.

The extra circuitry used to obtain the high-impedance output condition in three-state outputs is shown in Fig 7. When the OUTPUT ENABLE signal is high, both the phase-splitter transistor, Q1, and the Darlington pull-up pair, Q2 and Q4, are turned off. In that condition the output circuitry is nonconducting, which allows the outputs of two or more circuits to be connected together in a bus application in which only one output is to be enabled at any particular time.

Theoretically, no current flows either in or out of the output when it is in the three-state mode. Practically, some current does. Those currents are designated I_{OZH} and I_{OZL}.

I_{OZH} is the current that flows into a disabled three-state gate output with a specified high voltage applied to the output. I_{OZL} is the current that flows out of a disabled three-state gate output with a specified low voltage applied to the output. Both measurements are made using the test configuration shown in Fig. 8.

The gate is tested with the OUTPUT ENABLE pin tied high, placing the gate in the three-state mode. I_{OZH} is measured by applying 2.4 volts to the gate output, as indicated by M2, and reading the output current from M1. I_{OZL} is measured by applying 0.4 volts to the gate output and reading the output current from M1. Typical values for I_{OZH} and I_{OZL} are 20 μA and 0.4 mA, respectively. **R-E**

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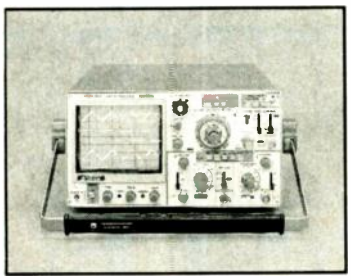

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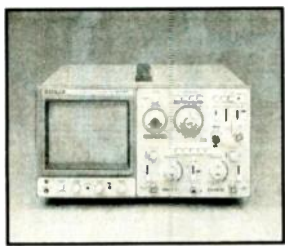

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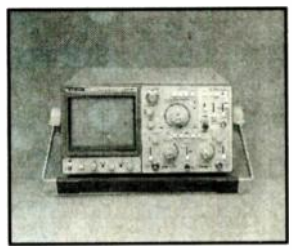

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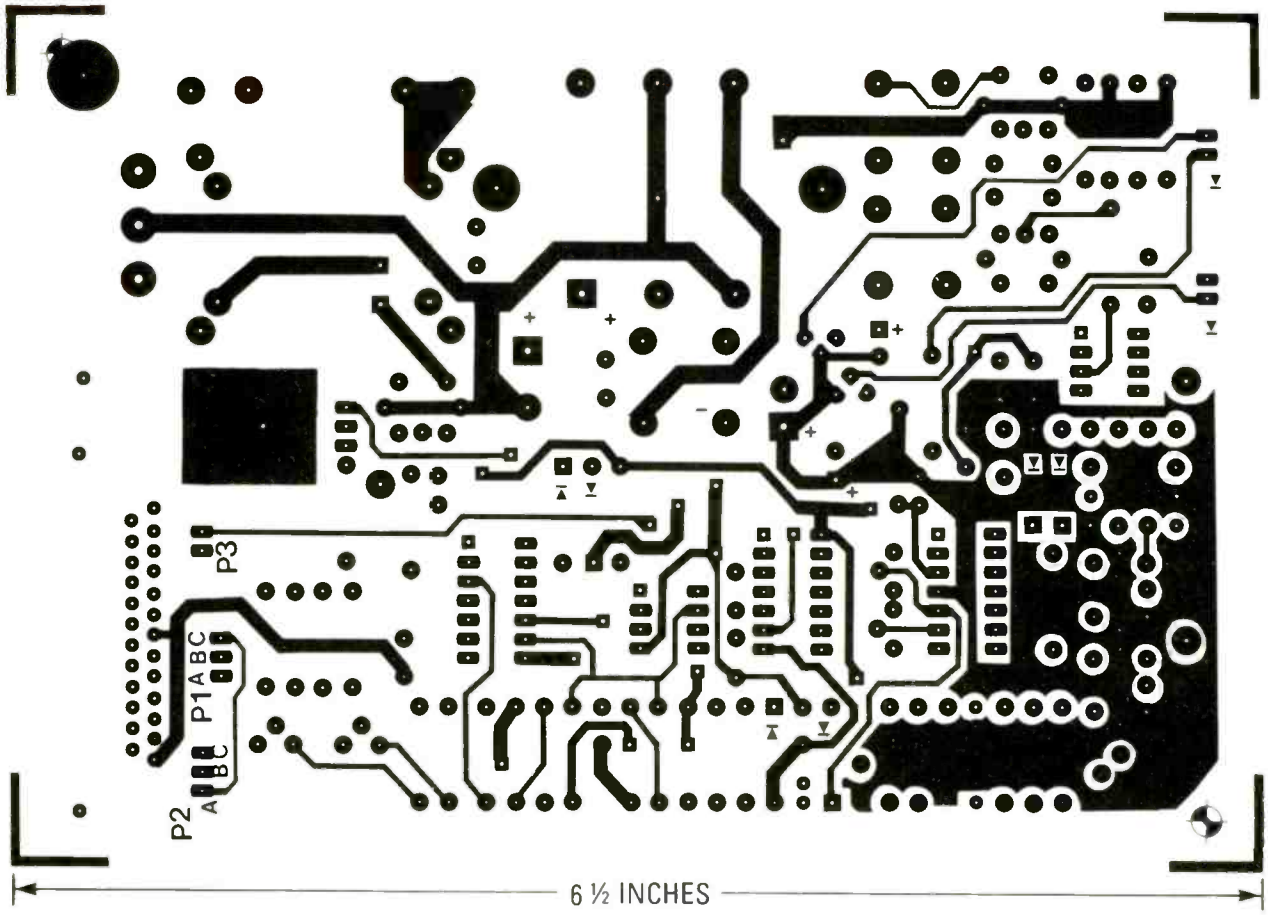
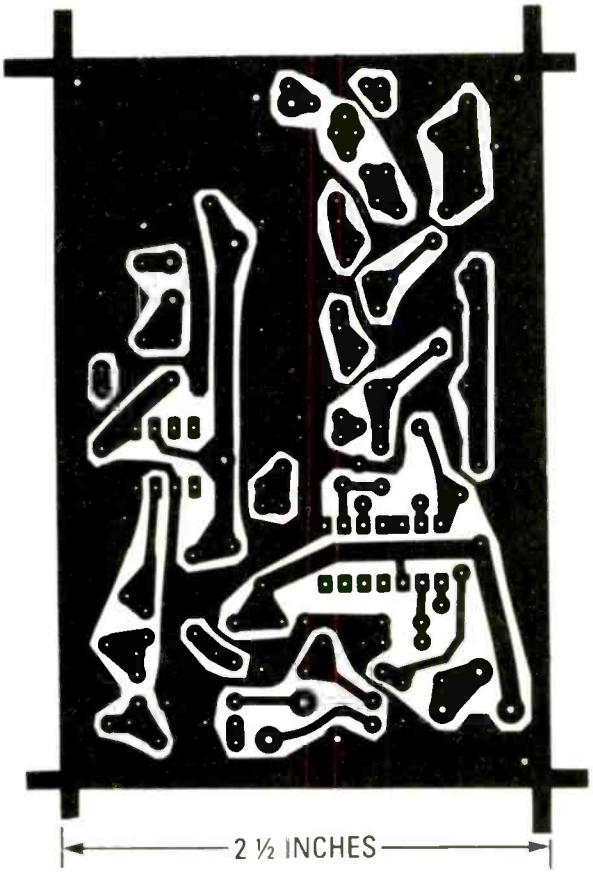
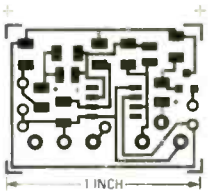
THE INFRARED TRANSMITTER board shown here is full sized.



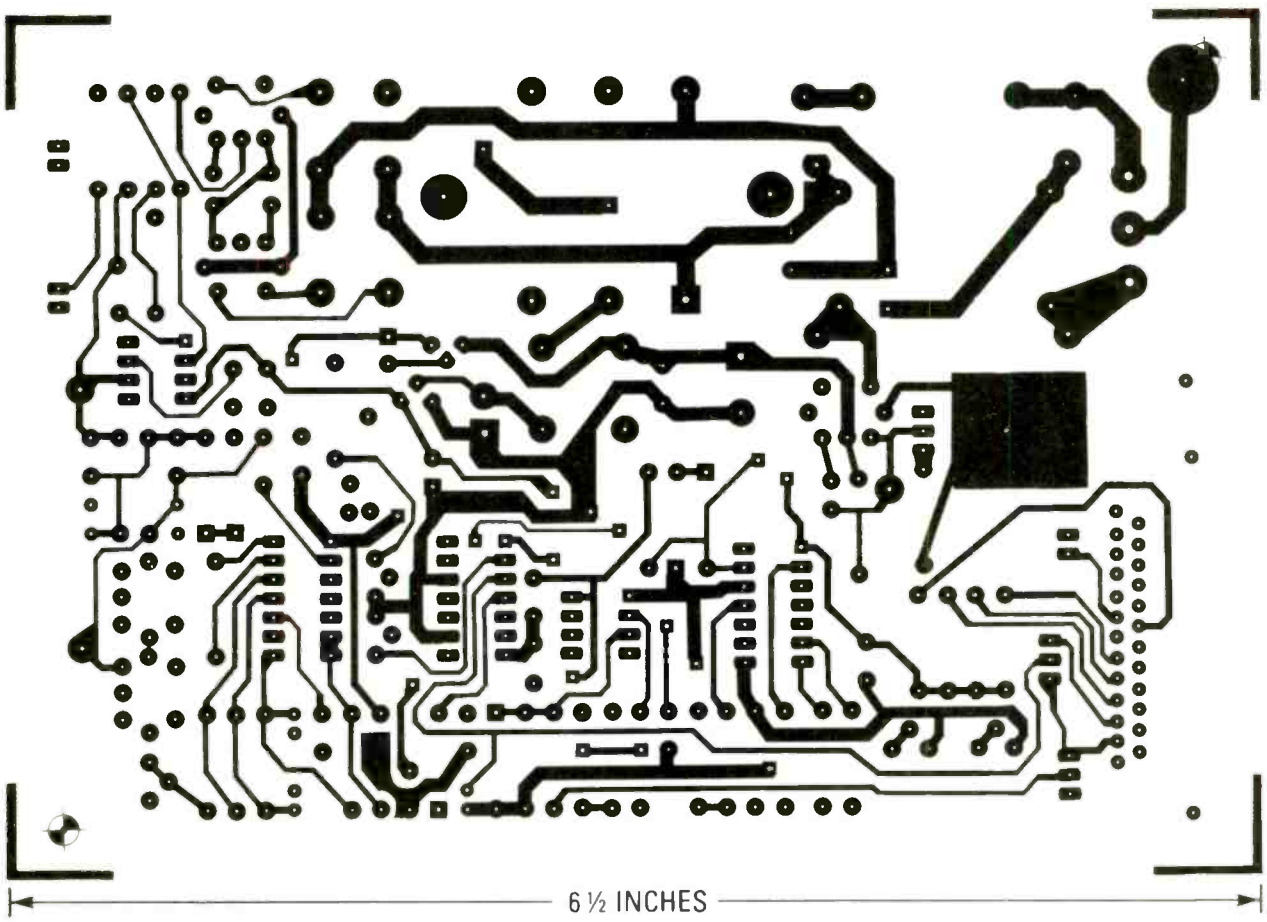
THE COMPONENT SIDE of the line carrier modem board is shown here.



THE PATTERN for the IR receiver is shown here.



THE SMT AMPLIFIER pattern is shown here at twice its actual size.



THIS IS THE SOLDER SIDE of the line carrier modem board.

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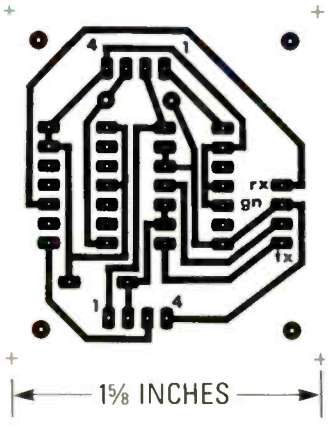
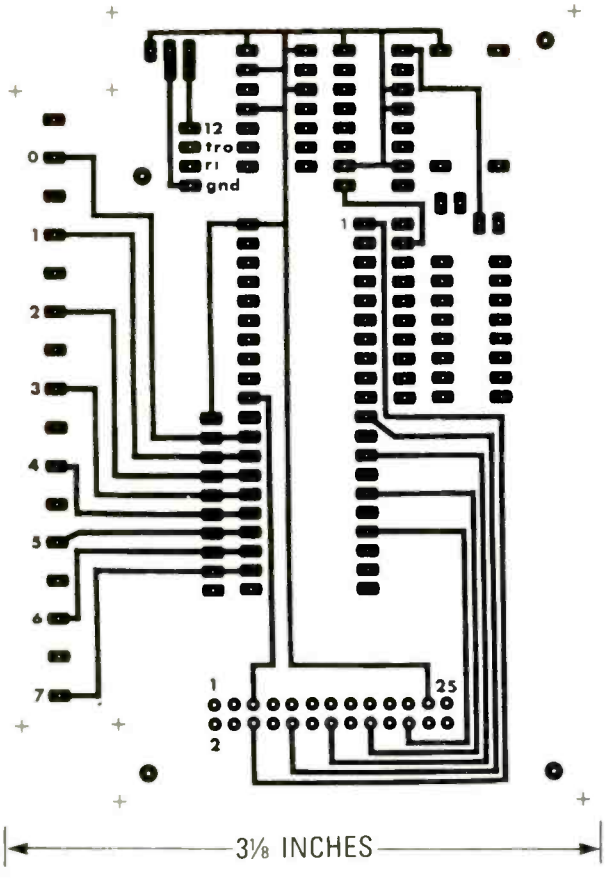
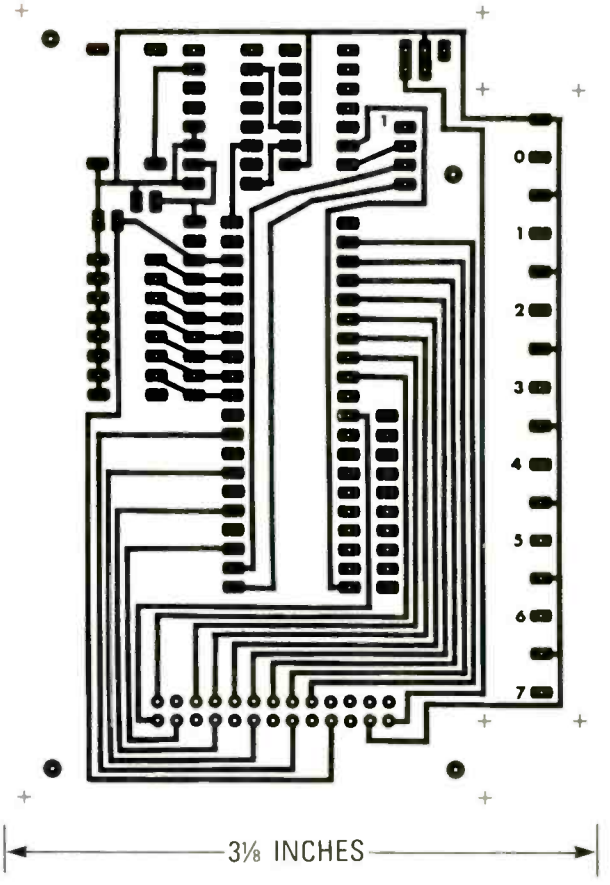


THIS IS THE COMPONENT SIDE of the RS-232 interface board.



THE SOLDER SIDE of the RS-232 node circuit board is shown here.



THE COMPONENT SIDE of the RS-232 node circuit board is shown here.

HARDWARE HACKER

Remote controls
Infrared receivers
A new A/D converter
New data book resources
Analog computer interfacing

Remote controls and a great A/D converter!

DON LANCASTER

We will start out with our usual reminder that this is your column and that you can get both technical help and off-the-wall networking by calling the Guru hisself per the "Need Help?" box. The best calling times are during weekdays, 8–5, mountain standard time.

Also as is usual, I have gathered pretty near every source mentioned here into a common "Names and Numbers" table. Several of those addresses are where you go to get more info or to follow up on any specific product.

Let us see. I have now found yet another low-cost source for those data-access arrangement telephone transformers that we looked at last month. Do check out the Tamura model *TTC-142*. They're available for under a dollar in very large quantities.

The developments in superconductivity continue at an astonishing pace. By switching to materials made of aluminum, barium, and the thallium used in rat poison, the critical temperatures have now been raised another 30 degrees to 120 Kelvin. Which is now halfway up to dry-ice temperature.

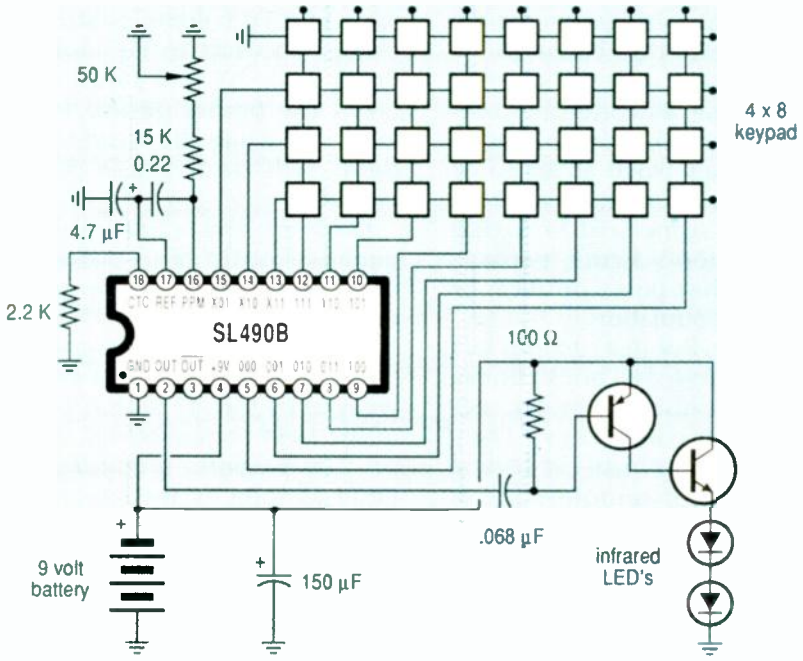


FIG. 1—A HANDHELD REMOTE-CONTROL transmitter can send up to 32 different commands. Each command outputs a repeating code of six brief light pulses.

The new materials are also much cheaper and more stable. It does remain to be seen whether their current densities will end up high enough for real-world uses.

One very good source of most superconductor info is *Science* magazine, which is published by the American Association for the Advancement of Science, and is available at most larger libraries. Those 120-K superconductors are detailed in the February 16 issue.

There's also a very interesting tutorial on tree-electron lasers in the March 4, 1988 *Science*; and the first details on what probably is the final elusive proof to Fermat's last theorem (a classic and inturiatingly subtle math problem) are found in their March 18 copy.

Onward and upward...

Remote controls

There sure is a lot of help-line interest lately in remote-control circuits. All you **Radio-Electronics** hackers are now trying to remote-control everything from HO-gauge trains through hi-fi audio, home entertainment, to commanding an amazing assortment of robotics, aides for the handicapped, on up to industrial-process controls and even full-size racing cars.

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It turns out that there is no "best" or even a "standard" way of handling any remote-control problem, nor is there one single circuit that will do all things for all people. It depends on what you are remote-controlling over what channel, how reliable the control has to be, how many others are using the same channel, the amount of security required, the available power, what types of outputs you need, etc...

The popular carriers for remote control do include tones over the phone line; fiber optics; radio links including ham and CB; sonic and ultrasonic sound; both regular and infrared light; the AC power-line RF techniques; and all of those usual computer networks and serial ASCII data channels.

Most remote controls these days are digital, and often are computer controlled. Any analog or varying signals (such as audio or the flaps on a R/C model plane) are handled by some sort of digital communication scheme, perhaps by using either pulse position or duty-cycle modulation.

At any rate, I've just run into two outstanding free data books from a pair of widely different integrated-circuit manufacturers. They should keep you busy for several years' worth of remote-control hacking.

Start out with the bright green new *Integrated Circuit Solutions for Communications* product data book from MX-COM. Those people build specialized integrated circuits for both the telephone and radio communications trade. The typical single-quantity chip prices are in the $10–25 range.

Some of their more interesting devices include the *MX204* speech scrambler, their brand new *MX403* selective calling transponder, the *MX315* tone-controlled squelch circuit, and their *MX205* digital tone-generator chip.

Then, check into that magenta *Satellite, Cable and TV Integrated Circuit Handbook* from Plessey.

There are many dozens of very interesting and low-cost circuits in that book. Once again, it will take years to fully explore all of the hacker potential of those unique chips.

As a ferinstance, we can start out with the *SL490-B* remote-control transmitter shown in Fig. 1. The intended use is for a hand-held, battery-powered infrared remote-control transmitter, as are popular with TV sets and VCR's.

The same circuit can be used with ultrasonic transducers or most any other control channel.

A total of 32 commands are available that use a five-bit pulse position modulated code. When used with infrared diodes, pulse widths of 15 microseconds are also used. The five-bit word is sent out most significant bit first.

The timing period of a digital logic "1" varies with the application, but is usually made as long as possible. Otherwise, functions such as a TV volume control may change too fast to be usable. A digital logic "0" will always be 1.5 times the timing period for the logic "1," while the word-interval delay will be 3 times the "1" period.

Each of the command sequences consist of six pulses. The first is a start pulse. The second pulse is delayed by the "1" or the "0" time of the most significant command bit. The third pulse is delayed by the "1" or the "0" time of the next command bit, and so on. The six pulse groupings continue as long as the key is held down.

Note that no current limiting is provided for the infrared-light-emitting transmitting diode or diodes. It is thus very important that your circuit layout will discharge only a small portion of the 150 microfarad capacitor charge into the output LED per pulse, and that the supply voltage to the chip itself not drop in the process.

While most any infrared LED could be used, you'll more than likely get the best results with one or two high-power, high-brightness lamps, driven by a suitable pair of high-gain, and high pulse current transistors.

The infrared output power can be increased with a mirror or else a directional reflector.

Infrared receivers and decoders

There are a number of suitable decoder chips and circuits detailed in the Plessey handbook. They vary with whether you need analog outputs for volume controls or whatever, and on whether you are in a television-receiver or a computer environment.

Figure 2 shows us an infrared preamplifier circuit that should automatically convert the received infrared pulses into some noise-free digital pulses of just the correct amplitude for further processing. A two-chip receiver is normally used, with the preamplifier receiving and cleaning up the pulses, and the separate decoder converting all the receiver code bursts into actual output commands.

The data book does include a suggested circuit layout for their *SL486* preamp. An infrared sensitive photodiode is used for the light receiver, while those capacitors provide bandpass filtering for good noise rejection.

The preamp circuit is normally placed inside a shielded case that has a plastic filter in front of it; the filter passes infrared but rejects room illumination.

This month, let's have us a double contest. Just dream up a new or unusual remote-control ap-

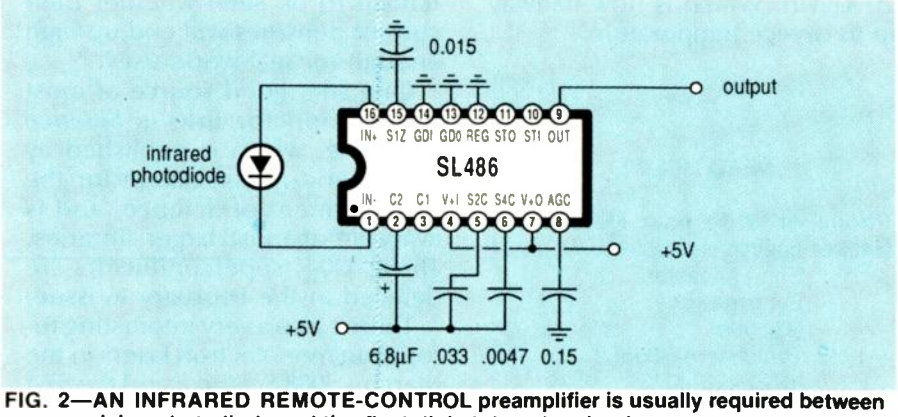

FIG. 2—AN INFRARED REMOTE-CONTROL preamplifier is usually required between your receiving photodiode and the final digital decoder circuitry.

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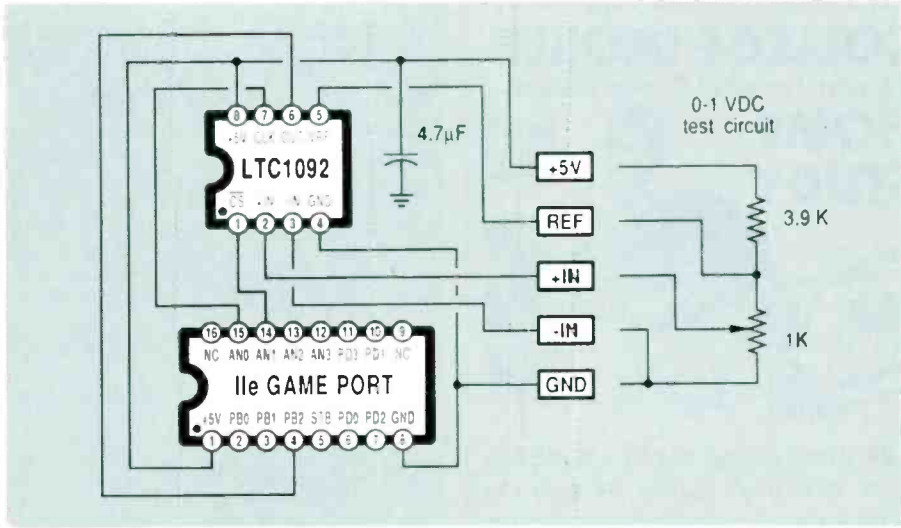

FIG. 3—THIS 10-BIT FLOATING POINT A/D CONVERTER is very easy to interface to an Apple IIe, IIgs, or any other personal computer or microprocessor.

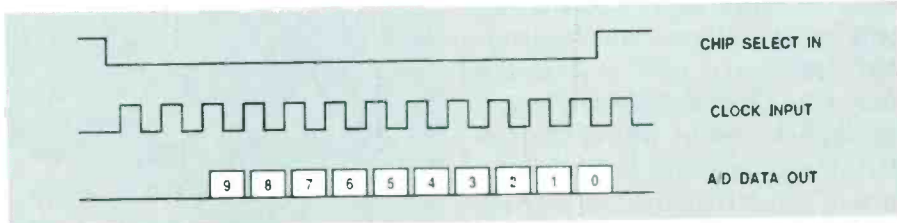

FIG. 4—TIMING WAVEFORMS USED WITH THE LTC1092. Your computer or other external timing inputs a chip select and thirteen clock pulses; the LTC1092 responds in turn with ten A/D serial data bits. The A/D conversion speed can be as fast as 45 kHz.

plication, or an off-the-wall use for the upcoming A/D converter circuit of Fig. 3. There will be the usual Incredible Secret Money Machine prizes to the best twenty entries, and an all-expense-paid (FOB Thatcher, AZ.) tinaja quest to the best entry of all.

As always, send your entries directly to me, and not to the **Radio-Electronics** offices.

Paper designs are just fine; you do not have to build or test your entry to enter.

An amazing A/D converter

There's a new analog-to-digital (A/D) converter out that I have been really impressed with. It is called the *LTC1092* and is made by Linear Technology. Cost is around $12.

The resolution is a big 10 bits, meaning that you can accurately and linearly slice an analog signal into 1024 pieces. It can run as fast as 50 kilohertz and includes its own internal sample and hold circuitry. Since the *LTC1092* is an 8-pin mini-DIP serial device, it is easy to interface to virtually any microcomputer or personal computer. And it all works off a single +5-volt power supply.

But, what I like best of all about that beast is that it uses a floating-point reference-voltage scheme. By lowering the reference voltage, you can directly handle ridiculously smaller input signals. In fact, you should now be able to run a temperature transducer or even a pressure sensor directly into this chip without needing any fancy pre-amplification or signal conditioning.

Put another way, the chip can give you a 10-bit resolution over a 16-bit dynamic range, all at a tiny fraction of the cost of a "real" 16-bit A/D converter. All of which should enormously simplify hacking just about everything from postal scales to hot-tub controllers through stream gauges and audio frequency processing.

Figure 3 shows you a test circuit I worked up that can plug directly into the game-paddle port of an Apple *IIe* or *IIgs*. All the waveforms involved are shown in Fig. 4, while the machine-language driver and Applesloth controlling program appear in Fig. 5. Finally, Fig. 6 shows a possible PC layout.

You connect the chip to +5 volts and ground through the supply

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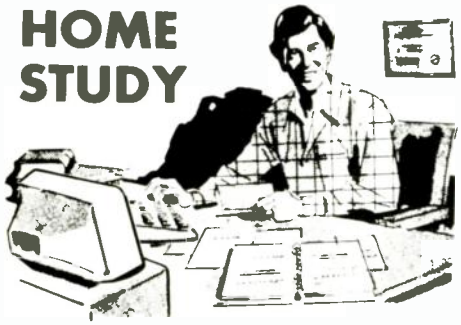

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1. To CREATE your machine language driver, get into BASIC.SYSTEM and then do a CALL -151. Then enter the following code in this order . . .

```
300:  02 02 2C 5A C0 2C 58 C0 2C 59 C0 2C 58 C0 2C 59  <cr>
310:  C0 2C 58 C0 2C 59 C0 A9 00 0E 63 C0 2A 2C 58 C0  <cr>
320:  2C 59 C0 0E 63 C0 2A 8D 01 03 2C 58 C0 2C 59 C0  <cr>
330:  0E 63 C0 2A 2C 58 C0 2C 59 C0 0E 63 C0 2A 2C 58  <cr>
340:  C0 2C 59 C0 0E 63 C0 2A 2C 58 C0 2C 59 C0 0E 63  <cr>
350:  C0 2A 2C 58 C0 2C 59 C0 0E 63 C0 2A 2C 58 C0 2C  <cr>
360:  59 C0 0E 63 C0 2A 2C 58 C0 2C 59 C0 0E 63 C0 2A  <cr>
370:  2C 58 C0 2C 59 C0 0E 63 C0 2A 8D 00 03 2C 5B C0  <cr>
380:  2C 58 C0 2C 59 C0 60                             <cr>

BSAVE DRIVER.1092.1, A$300, L$87 <cr>
```

2. To ACCESS your machine language driver, use this BASIC program . . .

```
100  PRINT CHR$(13); PRINT CHR$(04); PRINT "BLOAD DRIVER.1092.1"
200  CALL 770
300  PRINT PEEK (768) + 256 * PEEK (769)
400  GOTO 200
```

FIG. 5—THIS APPLE IIe/IIgs SOFTWARE DRIVER will let you directly interface a high-quality 10-bit A/D converter from your computer's game I/O connector.

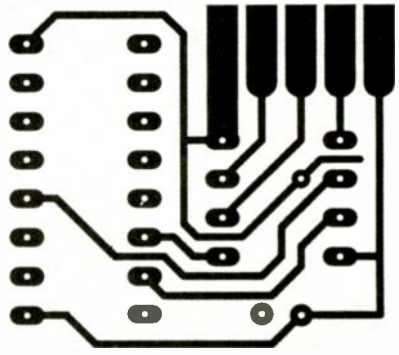

FIG. 6—ONE POSSIBLE PC LAYOUT for your converter.The ground plane on the component side is an absolute must! The view here is from the foil side.

pins. There are three pins on the input side called the + input, the − input, and the reference input. The voltage difference between the + input and the − input is compared against the reference. A zero or a negative difference gets you a zero output, while a difference equal to or greater than the reference gets you "all ones" or decimal "1023."

In between, the output number is linear with the input voltage difference. For instance, a difference of one-half the reference will get you level 512 and so on. The + input and − input impedances are very high, while the reference input will look like a 7K load.

There are three pins on the output side. The first is the chip select. Your computer or timing circuit brings it low at the start of a conversion cycle, holds it low for a complete conversion, and releases it back high again.

A second pin is called the clock. Your computer, or else an external timing circuit, delivers thirteen clock pulses during a conversion, first bringing the clock high and then returning it back low again. The clock frequency must be in the 10- to 500-kHz range.

That is a "successive approximation" type of register. Nicely, the clock-to-clock pulse spacing does not have to be constant, which greatly simplifies using software to generate clock pulses.

The analog input only has to be constant and present during the first 2½ clock cycles. That is called the acquisition time. The input reference is internally held for the remainder of the conversion interval. That can certainly eliminate the need for an external sample and hold circuit.

The *LTC1092* outputs data in the following way: One microsecond after the third clock pulse, the most significant bit (B9) is output. A microsecond after the fourth clock pulse, the next bit (B8) is output. That continues until all ten bits are output. It is up to your computer or your external interface circuit to catch those bits on the fly.

A/D controlling software

It is fastest to generate your clock pulses with add-on hardware, but the Apple *IIe* and *IIgs* can manipulate their game-port lines fast enough so that you can get over a 6-kHz conversion rate using nothing but machine-language software.

That is ridiculously faster than is needed for most hacker uses, particularly for such applications as recording temperatures.

Use of the BASIC language will, of course, slow you down bunches. One hundred or so conversions per second is typical for a simpler BASIC program.

Over on the game-paddle port, annunciator AN1 is used as the chip-select line and AN0 is used as the clock. Data is input on the PB2 line. The machine-language driver simply drops the chip-select low, outputs eleven clock pulses, and then returns the chip-select high.

Following the third through twelfth clock pulse, the received data is routed into two registers with the eight least significant binary bits ending up in location $0300, or decimal 768. The two most significant binary bits end up in location 0301, or decimal 769.

In the simple example shown, the Applesloth program will do a 10-bit binary to decimal ASCII conversion for you and display it.

Oh yes. About that jitter.

A one-bit resolution with a one-volt reference ends up less than a millivolt. If any ground currents or any other type of noise gets into

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your inputs or reference, it will be duly converted over into a 10-bit accurate result and cause your answers to bounce around a bit.

Extreme care must be used when shielding and guarding both the inputs and the reference, particularly if you are going to run with very low reference inputs. Printed-circuit boards and good shielding are a must. But that's what the black magic of analog circuit design is all about.

Yes, I have a source-code listing available on that. Let me know if you want a copy. Similarly, if you work up a driver for some other computer, send in a copy so we can share it with the others.

New tech info

Texas Instruments has a new and free *Advanced CMOS Logic Designers Handbook* out, but watch all the fine print. TI opted for non-standard chip pinouts and did some other rather bizarre things with this new high-speed logic family. They have also gone way overboard on laughingly arcane and confoundingly obtuse new logic symbols.

There's a sequence of new *The Brighter Power* booklets available from SGS-Thompson. They include chips to handle Detroit's latest buzzword—high-side drivers. The high-side driver lets you ground the other side of a lamp, coil, solenoid, valve, or whatever. Yes, high-side driver chips are smart enough to shut themselves down on a short circuit, a current overload, high temperature, etc.

Other data books this month include the new *LCA Applications Handbook* from Monolithic Memories on hacker-programmable gate arrays; a *Smart Analog* data book from Crystal Semiconductor about their telephone chips and A/D converters; and a great book on *Analog Signal Processing Integrated Circuits* from Reticon.

There's a new trade journal out called *Personal Engineering* that you may want to try and qualify for. And Alcoswitch has a fat new catalog of all sorts of switches and similar hardware available.

Turning to my own products, if you are into the fundamentals of microprocessors and microcomputers, please check out my *Micro Cookbooks*, volumes I and II. I've got two new utility packages for those of you now using PostScript-speaking laser printers—one for hacker printed-circuit layouts and a second for creating two-point perspective drawings.

And, yes, we should soon have a complete set of *Hardware Hacker* reprints available, going all of the way back and including a master names and numbers section. Write or call if you are interested.

Let's hear from you.... **R-E**

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AUDIO UPDATE

Can you hear the difference?

LARRY KLEIN,
AUDIO EDITOR

WHEN I BECAME AN AUDIOPHILE IN THE early Fifties, the general performance level of almost all audio equipment was abysmally low. In 1952, one channel of any of today's $300 stereo receivers would have represented an astonishing breakthrough in FM sensitivity, power, S/N, distortion, and frequency response. (Of course, the second channel would have been a confusing redundancy because, of course, there was no stereo program material available.)

In any case, when I bought a new component in the Fifties, I expected that it was going to sound somewhat different—and I hope, better—than the unit it was replacing. It was a time of rapid audio evolution. Quality control was improving; the Europeans were regularly producing new tubes designed specifically for audio equipment; and each new generation of phono cartridges, tweeters, and tape heads seemed to deliver another octave or so of high-frequency performance. (Today's top cassette decks have better specifications at 1⅞ inches-per-second than my old 10½-inch open-reel Concertone had at 15 inches-per-second.)

Diminishing returns

At some point in time, the audible improvements achieved by each new generation of amplifiers seemed to diminish. That's not to say that there weren't plenty of low-powered, unstable, and distorted products still available. There were, but almost all the high-powered top-of-the-line power amplifiers that I dealt with began to sound pretty much alike on casual listening—and in fact sounded identical when I later got into critical listening with an A/B switch box. Of course, the best available program material, phono cartridges, and speakers of that time, fell somewhat short of today's sonic standards. And perhaps I tended to ignore subtle sonic differences among amplifiers simply because I was so distressed by the gross audible problems of most other components. In any case, my perceptions led me to become an early member of the "all amplifiers sound alike" school of audio criticism.

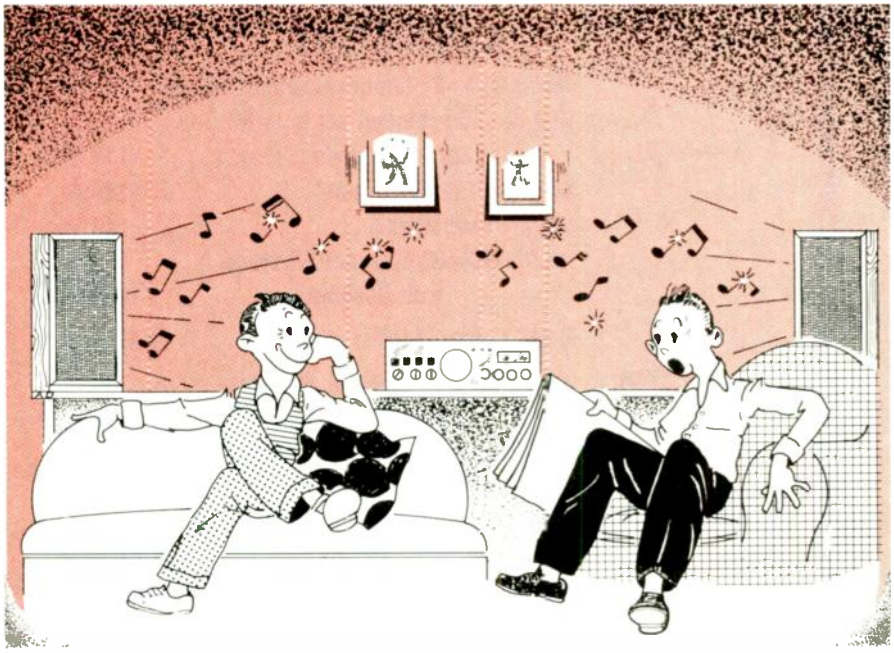

FIG. 1

I've not totally resigned from the "sound-alike" club, but my attitude has certainly been tempered by time. My position now is that there are no sonic differences among amplifiers that cannot be accounted for by non-esoteric and readily measurable factors—mostly frequency response. In my view, the esoteric varieties and sources of distortion discovered (or rediscovered and renamed) in recent years have done far more for advertising copywriters than they have for the listening quality of the products. I'm aware that the "I Love a Mystery" audiophiles believe firmly that an amplifier can measure well and—for unknown, and perhaps unknowable reasons—sound lousy; but as far as I'm concerned, that just doesn't happen when a design engineer knows what he's doing—and most design engineers are very good at their jobs.

The debate goes on

There are good psychological, psychoacoustic, and commercial reasons why the debate about amplifier sound quality continues. The essential audio-tweak challenge to the validity of lab tests is that they don't correlate very well with what critical ears hear. (Those ears—such as mine—that refuse to hear consistent differences among components are considered either uncritical, defective, or perverse.)

It is true that the EIA Amplifier Standard includes a series of lab tests that are performed using sine-wave test signals as inputs and non-inductive precision resistors as loads. Conversely, real-life listening with music and speakers involves a wide-band, constantly changing input signal and a complex reactive speaker load whose values shift wildly with frequency. Competent audio engineers certainly know that as well as anyone else, and for many years supplemented conventional sine-wave measurements with a wide variety of more dynamic real-world evaluations.

In short, there appear to be no mysterious differences in amplifier performance that are not readily subject to laboratory evaluation. When sonic differences between amplifiers do occur, they usually reflect a voltage or current inadequacy, or a simple departure from an ideal (flat) frequency response. For example, a slight rise in response above 10 kHz will cause an amplifier to sound more open, detailed, and airy, particularly with program material or speakers that fall slightly short on the high end.

The complex or very low-impedance loads presented by some speaker designs will produce small, but audible, frequency-response aberrations in the output of some amplifiers. However, those problems don't show up when either the speaker or the amplifier is measured by itself. Depending upon random conditions in a given setup, the aberration will add a subjectively desirable or an undesirable quality to the sound.

That all helps to account for the audiophile claim that certain speakers (or amplifiers) are particularly "revealing" in that they are able to disclose the flaws or positive qualities of other equipment. I strongly suspect that the special *reference* amplifiers or speakers used by some of the underground critics tend to create rather than reveal the differences between components undergoing listening evaluations. The random interaction effects would also account for the frequent disagreements among the Golden Ear critics with different "reference" equipment as to the specific audible virtues of equipment under evaluation.

To my ears, the sonic differences under discussion usually border on the trivial, meaning that they can be wiped out by the twitch of a tone-control knob. But when tone controls are considered anathema, and any sonic difference—whatever its cause—is enormously important, the ground rules of the argument be-

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come too amorphous to be resolved. I'm aware that there are many other aspects of audiophile-listening evaluations that I've not even touched on. Suffice it to say that I've read most of the discussions on the matter, pro and con; and I continue to hold to the opinion that the human ear is a marvelous instrument that along with its ability to hear minute differences also tends to create differences that don't exist. Descriptions of numerous scientifically conducted double-blind listening tests have proven to my satisfaction that trained listeners are unable to distinguish between well-designed amplifiers (although they imagine they are doing so) when their overload, amplitude, and frequency response levels are the same.

Next month I'm going to be discussing several of the test techniques that are used by a leading manufacturer in the audio industry so that they can reveal audible sonic differences between different components when they really do exist. **R-E**

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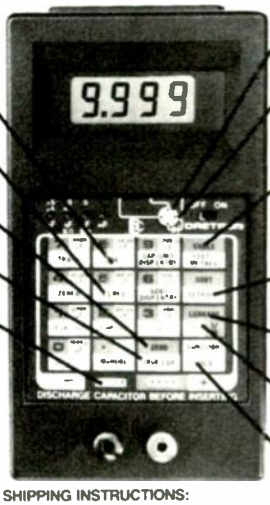

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SHORTWAVE RADIO

General conditions for July and August

STANLEY LEINWOLL,
CONTRIBUTING EDITOR

SHORTWAVE RADIO CONDITIONS WILL be good to excellent for DX in the 16- and 19-meter bands during daylight hours. The 13-meter band will be good to fair. At night, 25 and 31 meters will be best; however, nighttime DX will be possible in all bands from 49 to 19 meters.

During the summer months, but especially during July and August, a phenomenon occurs that results in some very good short-skip openings in the 10-meter amateur and the 11-meter Citizen's Band. Known as sporadic-E (or E_S), it can also result in occasional short-skip TV and FM DX, as well. Sporadic-E was explained in greater detail in the Shortwave Radio column (**Radio Electronics**, June 1988). For suburbanites who live in fringe areas, E_S can be a cause of TV interference, particularly on the lower channels (2, 3, and 4). Sporadic-E openings are at their peak during the mid to late afternoon in mid-latitudes. Broadcast-Band DX will continue to be poor because of longer periods of daylight, as well as seasonally high noise levels.

Chit-chat

Radio Canada International has received approval from its Department of Communications to construct four curtain antennas capable of operating in the 22-meter band (13.6–13.8 MHz). The antennas, which will be constructed at RCI's Sackville, New Brunswick transmitter site, will be designed to broadcast to North and South America, Europe, and Africa. Completion is scheduled for mid-1989, although 13-MHz operation may start before the construction of the permanent-curtain arrays is complete.

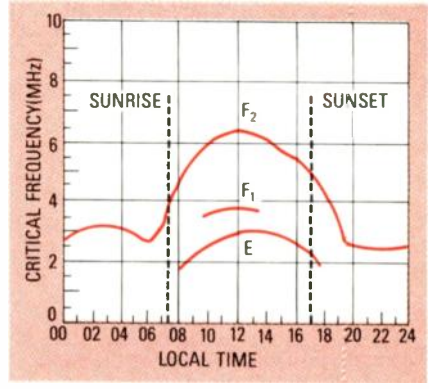

FIG. 1

The 22-meter band was not scheduled to become available for shortwave broadcasting before July 1, 1989. However, because most users of that band (using fixed, point-to-point service) have already vacated it and moved to other frequencies, many countries have begun broadcast operations in the 22-meter band. Among the countries already broadcasting in 13.6–13.8 MHz are the United States, the Federal Republic of Germany and the German Democratic Republic, the Netherlands, the Soviet Union, North and South Korea, Israel, Iraq, Czechoslovakia, and Pakistan. Others are sure to follow.

Now, let's continue our discussion on the fundamentals of shortwave radio propagation.

Ionosphere variations

Because the ionosphere is formed by radiation from the sun, it is clear that as the position of Earth with respect to the sun changes, the amount and intensity of the radiation falling on any given point above Earth's surface will change as well.

The changes that take place because of the position of Earth with respect to the sun can be divided into three categories:

1—Day to night
2—Seasonal
3—Geographical

In addition, changes in the levels of radiation from the sun also cause the ionosphere to vary. That change in radiation levels is due to sunspots, which result in:

4—Cyclical variations in the ionosphere

Day to night variations

As Earth rotates on its axis, the angle of the sun above any point on Earth is in constant flux. It is the rotation of Earth that results in our having day and night, and it also gives us fundamental changes in the ionosphere. At noontime, when the sun is at its highest point in the sky, radiation is at a maximum, and ionization in the E, F_1, and F_2 layers are at their highest levels.

The degree of ionization in those layers, and consequently the range of frequencies that they are capable of refracting, follows the angle of the sun (the zenith angle) very closely, as shown in Fig. 1.

Figure 1 shows the hourly changes in the characteristics of the E, F_1 and F_2 layers of the ionosphere. Time is plotted against the critical frequency (the highest frequency that the ionosphere will return to Earth when the signal is beamed ver-

tically). The curve is typical of conditions in the United States during the winter months.

The F_2 layer is the most highly ionized of the ionospheric layers, and it is also the only layer that remains in existence for twenty-four hours. That is due to the very high levels of ionization that take place in the F_2 layer during the day, and the relatively slow recombination rates after sunset.

As indicated in our last column, the F_2 layer is of most importance to reliable long-distance high-frequency communication. Its presence throughout the day and night is a major reason for that.

Seasonal variations

In addition to rotating about its axis, Earth also revolves around the sun, orbiting it once a year. The axis of Earth is inclined at an angle to the plane of the sun's equator. In addition, Earth travels from a point above the plane of its equator (winter solstice) to a point below the plane in summer. Moreover, the distance between Earth and the sun varies throughout the year, the sun being closest in winter and farthest away in summer. And, as a result of those complex seasonal motions, ionization in the ionosphere is constantly changing.

During the summer months, days are longer in the northern hemisphere, and ionization persists throughout much of the day. As a result, the ionosphere can propagate the higher frequencies a much greater distance during the day than at night.

However, in the summer, the intensity of ionization is not as great as in the winter, because Earth is farther away from the sun. Therefore, the range of frequencies that the ionosphere will refract in the summer is not as wide as in the winter when Earth is three million miles closer to the sun. That's why, during daylight hours in the northern hemisphere, much higher frequencies are reflected by the ionosphere in the winter than in the summer. Also, because there are more hours of darkness in the winter, there is more time for recombination to occur, so the range of nighttime winter frequencies is narrower than in the summer.

Another factor which complicates things even further is that in the northern hemisphere during the summer, heating takes place in the ionosphere, expanding the F_2 layer, further contributing to lower ionization density than in the winter.

To summarize some of the seasonal variations in the ionosphere:

- Summer—Longer days in the northern hemisphere result in longer periods during which the higher frequencies will propagate. Shorter nights result in less recombination, so the higher frequencies are still usable during hours of darkness. Heating in the ionosphere results in daytime frequencies being lower than in the winter.
- Winter—Because Earth is closer to the sun, relatively high daytime frequencies will propagate. They are usually one to two bands higher than a summer day. Because nights are much longer, recombination takes place for a longer period, so winter nighttime propagation frequencies are considerably lower than summer nighttime frequencies.

Geographical variations

The characteristics of the ionosphere also vary with latitude. That is to be expected because Earth's axis of rotation is tilted to the plane of the sun's equator (the zenith angle) and the ionization intensity varies with that angle. Geographical variations are complex, but in general we can summarize them as follows:

- Winter—In the northern hemisphere, ionization levels are highest near the equator, and decrease as the latitude increases. In the southern hemisphere, ionization levels are high at the equator, they increase near the Tropic of Capricorn (where the sun is directly overhead), and then decrease.
- Summer—In the northern hemisphere, ionization levels are high at the equator, then they increase near the Tropic of Cancer (where the sun is directly overhead), and then decrease. In the southern hemisphere, ionization is highest above the Tropic of Capricorn, and decreases with increasing latitude. R-E

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ROBERT GROSSBLATT,
CIRCUITS EDITOR

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ONE OF THE WORST, AND MOST COMmon traps you can fall into as a designer is not knowing when a job is finished. There's always that last minute brainstorm, the "one more terrific idea," that has to be worked into the final design. I can't tell you how many times that's happened to me. And even though I'm aware of the problem, it's really easy to get caught up in it.

The best way to avoid that is to know what you want to accomplish when you first sit down at the bench. A list of design goals and a set of criteria may seem silly at the onset of a design but, take it from me, you'll read them over and over as you get deeper into the project. No design is static—ideas mature and goals change. What you wind up with at the end is probably going to bear only a vague resemblance to what you originally set out to do.

The reason I'm mentioning that is because it's my way of apologizing again for changing my mind in last month's column. I had originally felt that a lot more could be learned by setting up a buffer-and-latch type arrangement for external access to the memory. When I began putting the design together, the number of chips started to pile up and before I realized it I was looking at designations like IC26! Clearly, the project was past what some people euphemistically like to refer to as "manageable size." *D*irect *M*emory *A*ccess (DMA) is a perfect way of getting in and out of our Z-80 system. It can be a little tricky, however, so let me know if you have any problems and I'll do my best to give you a hand.

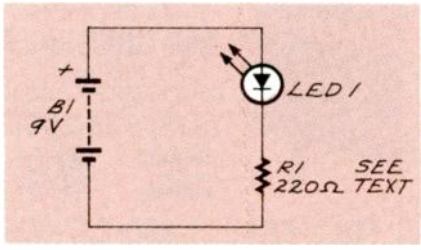


FIG. 1

But now for something completely different.

There are some things in electronics that show up no matter what kind of circuit you're designing. Just about everything from an electric toothbrush to Star Wars has to deal with the problem of how best to display data. Now, if all your circuit needs is a few LED's there's not much of a problem; but if you've got a lot of data that has to be displayed, you're going to have to give it some thought.

LED's are notoriously power hungry. Batteries can go dead really fast when you have more than a couple of LED's lit up at the same time. The standard way around that problem is to "multiplex" the display. That's a twelve

continued on page 97

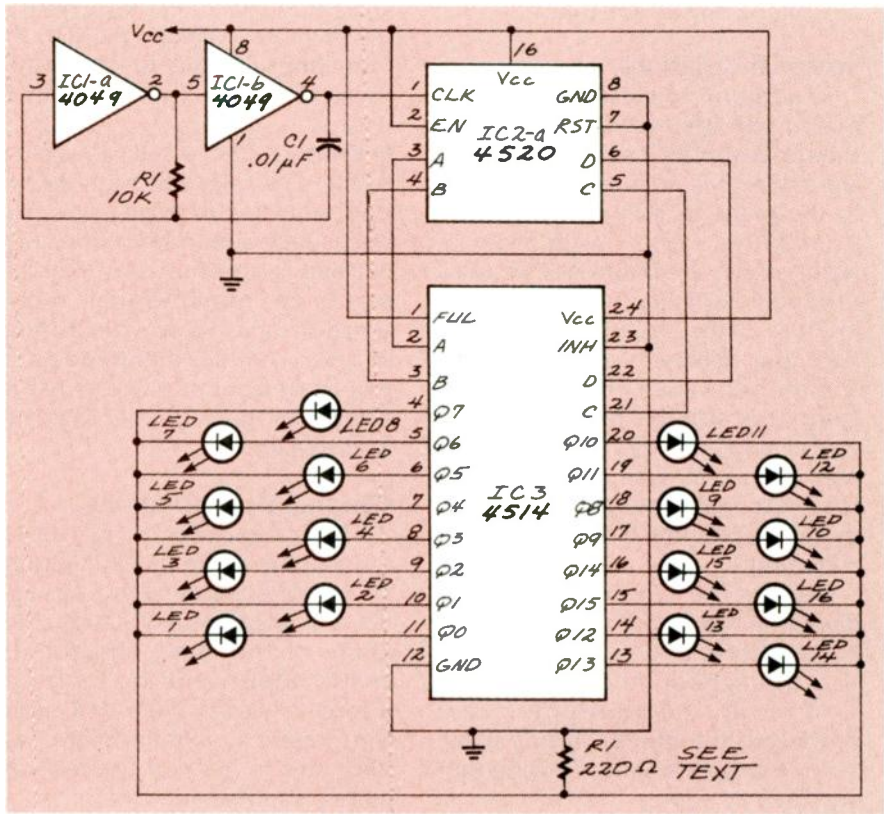


FIG. 2

VOL. 5 NO. 8 AUGUST 1988

COMPUTER DIGEST

A NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS

RS232 CONTROL/MONITOR SYSTEM

Put your serial port to work! Page 83

BUILD A PAIR OF LINE-CARRIER MODEMS

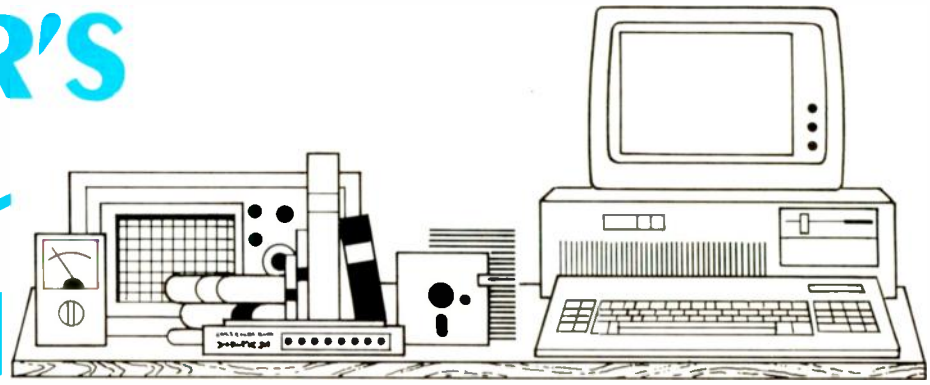
A GERNSBACK PUBLICATION

For cable-free interfacing Page 88

CD CLASSROOM

Finishing up the DRAM circuitry Page 91

EDITOR'S WORK-BENCH



Report from Atlanta

Comdex was so big this year that it spilled out of the Georgia World Congress and into the Atlanta Apparel Mart. Of course, the vast majority of what was displayed amounted to YECC: *YE*t another *C*heap *C*lone. But hidden in the back rooms, and between some of the large exhibits, were a few interesting products. We'll highlight some of the more interesting ones, and point out the overall trends.

OS/2

Microsoft's new operating system has been and will continue to be the subject of much speculation, both for its potential, and for the present lack of applications that run under it. Regardless, IBM has claimed that there will be 1000 OS/2 applications running by the end of the year.

To prove that claim, Microsoft and IBM jointly sponsored a large exhibit in which OS/2 applications were shown—sort of. In fact, most products shown were not running under the new operating system, but under DOS (or at best in the compatibility box). Meanwhile the exhibitors claimed to be just about ready to release the OS/2 versions. For example, we saw versions of WordStar 2000 and Word Perfect, various programming languages, graphics programs like Inset (reviewed here in the February 1988 issue), Designer (from Micrografx), all sorts of business applications.

IBM distributed a 400-page book (the *Operating System/2 Application Guide*) that lists OS/2 programs in thirteen categories ranging from accounting to word processing.

The problem is that very few if any of those programs are being designed to take advantage of the new features of OS/2. Rather, most are quick and dirty ports of the DOS versions. That's not all bad, because when those ports are done, at least we'll have something to run under OS/2. Meanwhile, we'll have to be patient for the sort of innovative software that the new operating system makes possible.

Removable disk drives

An increasingly popular product is the removable hard-disk drive. With one disk drive and two controllers (one in your office PC, and one at home), you could take your work home at night. In a high-security situation, you could also lock your drive up at night. For example, Plus Development Corp. (1778 McCarthy Blvd., Milpitas, CA 95035, (408) 434-6900) announced the Passport. It comes in 20- and 40-megabyte configurations, can be mounted internally or externally, and the same disk drive can be used (with different controllers) in both AT's and PS/2's.

Aristotle Industries (C7-1305 Meader Avenue, Bellingham, WA, (206) 676-4377) has a similar device, the Plato Hardpac 20, a 20-megabyte removable hard disk. Versions are available for both IBM compatibles and Macintosh computers.

Graphics boards

Resolution and speed of graphics cards continue to spiral. New boards from Paradise (99 South Hill Drive, Brisbane, CA 94005, (415) 468-7323), Video Seven (46335 Landing Parkway, Fremont, CA 94538, (415) 656-7800), and SOTA Technology (657 N. Pastoria Ave., Sunnyvale, CA 94086, (408) 245-3366) offer resolutions up to 1024 × 768, compatibility with CGA, EGA, VGA, and Hercules monochrome graphics, and 16-bit bus interfaces. The increased bus width allows graphics applications to run much faster, but limits those cards to running in AT compatibles—not XT's.

Some cards also offer special features. For example, in addition to a sixteen-bit bus interface, Video Seven's V-RAM VGA uses high-speed VRAM (Video RAM) rather than traditional DRAM to achieve even greater speeds.

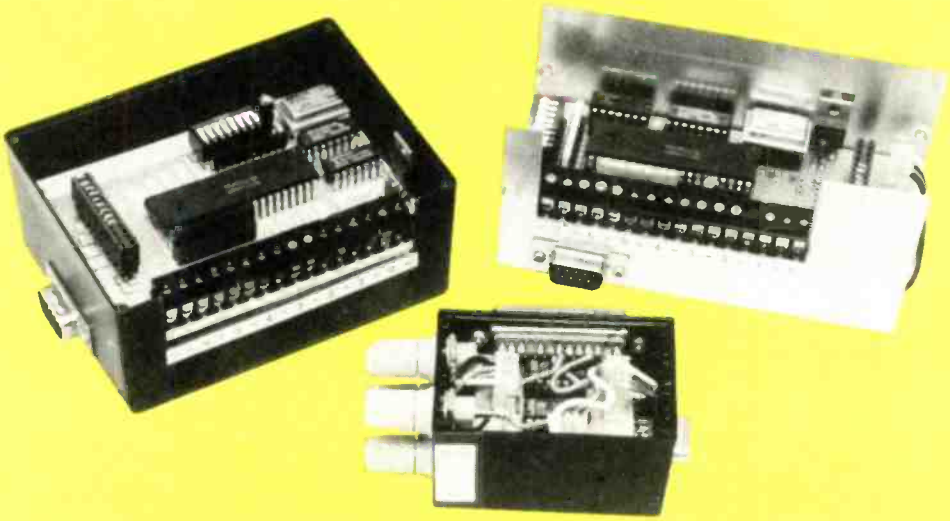
A product for those on a budget, Paradise's AutoSwitch Monochrome EGA adapter allows you to run EGA software on a standard TTL monochrome monitor. Colors are simulated by various intensity levels, and the simulation works well. Watch for reviews of those products in an upcoming issue.

Configurable motherboard

Orchid Technology (45365 Northport Loop West, Fremont, CA 94538, (415) 490-8586) privately showed a motherboard that is more than a passive backplane (like the one that Zenith sells with some models), yet less than a complete system board. The board includes sockets for one megabyte of RAM in DIP's and eight megabytes in SIMM's; shadow RAM for running the BIOS from RAM (about three times faster than from ROM); EMS support; battery-backed clock; reset switch; two eight-bit and four sixteen-bit standard expansion slots, an I/O expansion slot (that can hold a board with two serial and one parallel port), and a 32-bit slot for the CPU, which may be either an 80286 or an 80386 running at speeds ranging from 12 to 20 MHz and zero wait states.

For do-it-yourselfers like us, that could really be an exciting product. Unfortunately, however, the company will not be selling the board on a retail level, but only through VAR's (*V*alue *A*dded *R*esellers) and private-label distributors as part of a complete system. If you are a VAR or distributor, be sure to check it out.

RS-232



MONITOR/CONTROL SYSTEM

Control the environment with your PC and our simple interface.

STEVEN J. FRICKEY

PC's aren't just for word processing, spreadsheet analysis, and database management. In fact, when a PC can collect data from remote locations it can make decisions based on that data, so it becomes a powerful tool for controlling the environment. The problem is that special I/O cards might be required, and they typically cost hundreds of dollars. Also, I/O boards usually require installation within the PC, taking up yet another slot.

In this article we will describe the hardware and software of an I/O control system that can be implemented for less than $50.00, will interface to any personal computer through an RS-232 port, is modular, and has full duplex operation for both input and output.

The heart of the system is a little-known special-purpose IC made by Motorola, the MC14469. The MC14469 is an addressable asynchronous receiver/transmitter that is especially well-suited for remote data collection and control.

The control software is written in Microsoft "C" for the IBM PC and compatibles. Adapting the software to other compilers and computers should be easy.

System overview

Figure 1 shows an overview of the system. It's composed of a PC, control software, a combination RS-232 interface and power-distribution center, and one or more control nodes connected in parallel over a four-conductor bus. The conductors carry power and ground, and the transmit and receive signals.

A control node is shown in Fig. 2. Each node has a unique 7-bit address that is set via DIP-switch S1, which connects to the seven address lines (A0–A6) of IC3.

To communicate with a node, the software on the host PC must first transmit an address byte, over the common receive line (RI). Each node on the bus then compares the received address against its own address, which is set by the DIP switch. If the values match, then that node will accept the control byte that follows

The control byte is latched until a new address and control byte are received by the node. The control and address bytes are distinguished by the value of the most significant bit.

The control data may be used in conjunction with two other MC14469 control signals to direct the activity of the node. The other control signals are Valid Address Pulse (VAP), which is generated after a valid address is detected, and Command Strobe (CS), which is generated after a valid control byte, has been received.

Data transmission back to the host PC is initiated by toggling the SEND input (pin 30) from low to high. The

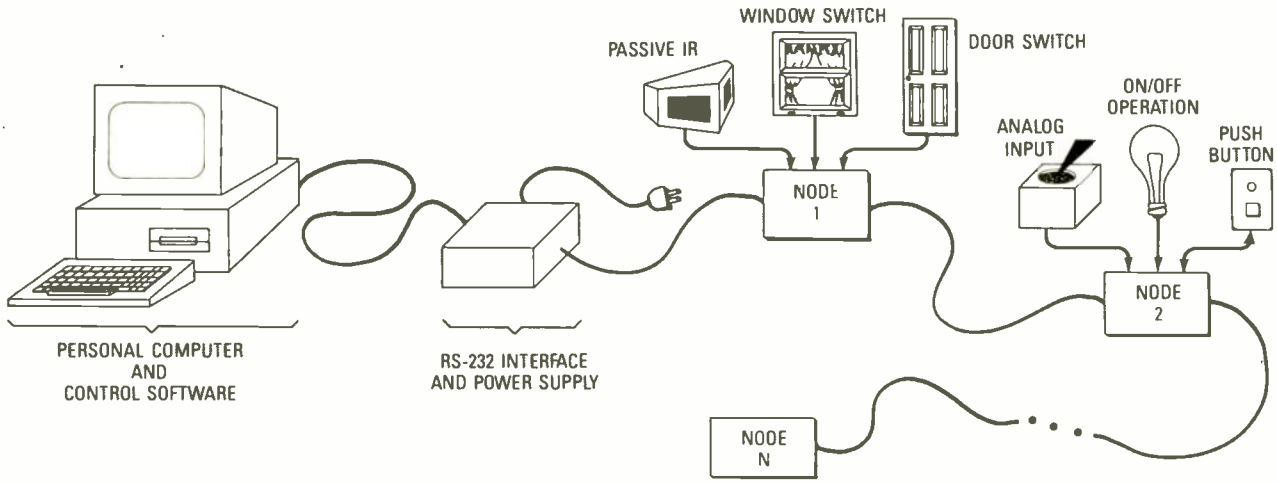


FIG. 1—THE RS-232 INTERFACE buffers communications between the host PC and all nodes.

data that is present on the sixteen input pins (ID0–ID7 and S0–S7) will be transmitted back to the host after SEND is toggled. Data is sent one byte at a time; we'll discuss the details shortly.

After receiving the data from the selected node, the host software could compare that value against the previous value from the same node, perform some action based on the comparison, and then continue on, polling the next node.

By creating an appropriate interface between external devices and any given node, the software can be tailored to a number of monitor and control situations. For example, a number of inputs could be connected to door and window switches. If one of those switches were opened before a master switch, an alarm might be sounded.

Node circuit

Connector J3 provides eight pulled-up input lines (S0–S7) that may be driven by reed switches, pushbuttons, mercury switches, tilt switches, relays, and other mechanical-switching devices. That connector also provides eight ground lines for attaching lead wires.

Connector J4 provides access to the seven output-control lines (C0–C6) of the MC14469, eight more input lines (ID0–ID7), and various control signals. To use the node in its basic configuration, jumpers should be installed across pins 9 and 10, 11 and 12, and so on, through pins 25 and 26. Later on, we'll show how J4 can be used to interface an 8-bit A/D converter to a node.

As shown in Fig. 2, the four-conductor bus runs straight through each node from J1 to J2. One line is for ground, another for +12-volts DC, one for the common transmit line (TRO), and another for the common receive line (RI). The overall length of the bus (from the RS-232 interface to the last node on the bus) depends on the degree of electrical noise in the operating environment. The author has successfully operated three nodes, using 20-gauge unshielded cable, at a cumulative length of 200 feet.

With a seven-bit address, the possible number of nodes in a system is 127, but that is not a practical limit. Realistically, the number of nodes is limited by the amount of current supplied by the +12-volt power source. Each node (with no expansion circuitry) draws 50 mA.

IC4, a 7805 voltage regulator, drops the +12-volt bus voltage to +5 volts for powering the logic circuitry. Because the +12-volt line is also available at J4, you can attach off-the-shelf alarm-system components, such as passive infrared detectors, buzzers, beepers, etc.; all of which typically operate at +12 volts.

The MC14469's baud-rate clock can be generated internally across pins 1 and 2, or an external clock can be fed directly to pin 1. The maximum baud rate (4800) is re-

NODE-CIRCUIT PARTS LIST

IC1—74ALS161, synchronous 4-bit counter
IC2—74ALS05, open-collector hex inverter
IC3—MC14469, addressable asynchronous receiver/transmitter
IC4—7805, 5-volt regulator
IC5—4-MHz TTL crystal oscillator
RP1, RP2—4700 ohms, 10-pin SIP
S1—8-position DIP switch.
C1—0.33 μF, 12 volts, tantalum
C2—22 μF, 25 volts, electrolytic
C3—0.1 μF, monolithic ceramic
J1—9-pin D, female
J2—9-pin D, male
J3—16-pin, PC-mount, screw terminal block
J4—26-pin dual-row header strip

RS-232 INTERFACE PARTS LIST

IC1—1488, quad RS-232 line driver
IC2—1489, quad RS-232 line receiver
R1—4700 ohms, ¼ watt, 10%
J1—25-pin D, male
J2—9-pin D, male
J3—4-pin power connector
Miscellaneous: Power supply with ±12- and +5-volt outputs, cases, interconnecting cables, etc.
Note: A double-sided PC board with plated-through holes is available for $16, the MC14469 is available for $15 (including spec sheet and application note), and a floppy with the source code is $5 from Steven J. Frickey, 3661 N. Lena, Boise, ID 83704. All orders add $2 for shipping and handling. Also, the author has also developed control software for the Amiga; contact him at the address above for more information.

stricted by the +5-volt supply. The required clock rate is 64 times the baud rate, or in this case, 307.2 kHz.

Because that's a non-standard frequency, the circuit uses a readily available 4-MHz TTL clock oscillator (IC5), a 74ALS05 (IC2) open-collector inverter, and a 74ALS161 (IC1) four-bit counter to divide the 4-MHz signal by 13, thereby providing a 307.69-kHz signal. The communications protocol is fixed at one start bit, eight data bits, an even parity bit, and one stop bit. So at 307.69 kHz, the maximum sampling time error over the entire 11 bits is 35.7 μs, well within one-half of a data bit period, which is 104 μs at 4800 baud.

A second gate on the 74ALS05 (IC2-d) inverts the serial data from IC3 and drives the common transmit line (TRO). The pull-up resistor for IC2-d is actually located in the RS-232 interface circuit (shown in Fig. 3 as R1). The open-collector outputs of all nodes are pulled up by that resistor, which makes it a wired-OR circuit.

A local reset is generated by each node at power up by an RC circuit consisting of 22-μF capacitor C2 and a 4.7K resistor inside RP1. The reset signal is also provided at J4, should your expansion circuitry require access to that signal.

The 7-bit address for each node is set on pins 4 through 10 (A0–A6) of IC3. Table 1 shows the relationship between switch settings and node numbers.

The voltage supplied to IC3 can range from 4.5–8.0 volts. At five volts, the output drive current of each pin (I_{OH}) is typically 0.35 mA, providing a fan-out capacity of 17 ALS devices. The output-high voltage (V_{OH}) is typically 5.0; the low voltage (V_{OL}) is typically 0.0. The input high voltage is typically 2.75; the input-low voltage is typically 2.25. For more information on the MC14469, consult *CMOS/NMOS Special Functions Data*, Motorola Inc., 1984, and Application Note AN806A, *Operation Of The MC14469*, Motorola Inc., 1984.

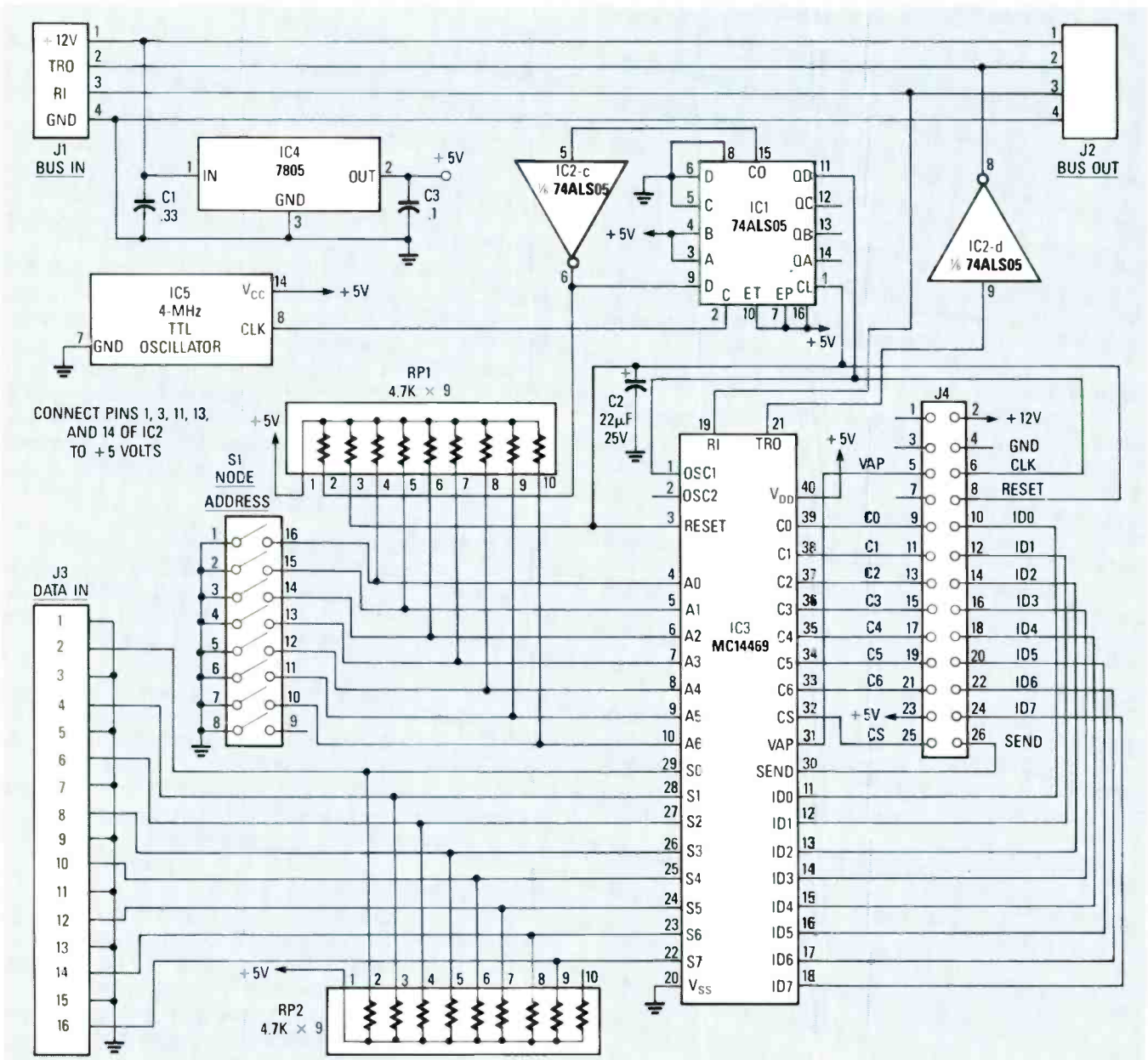


FIG. 2—THE HEART OF A NODE is the MC14469, an addressable UART. When a node is addressed, data present on pins 11–18 and 22–29 is transmitted to the host. The address is set on pins 4–10.

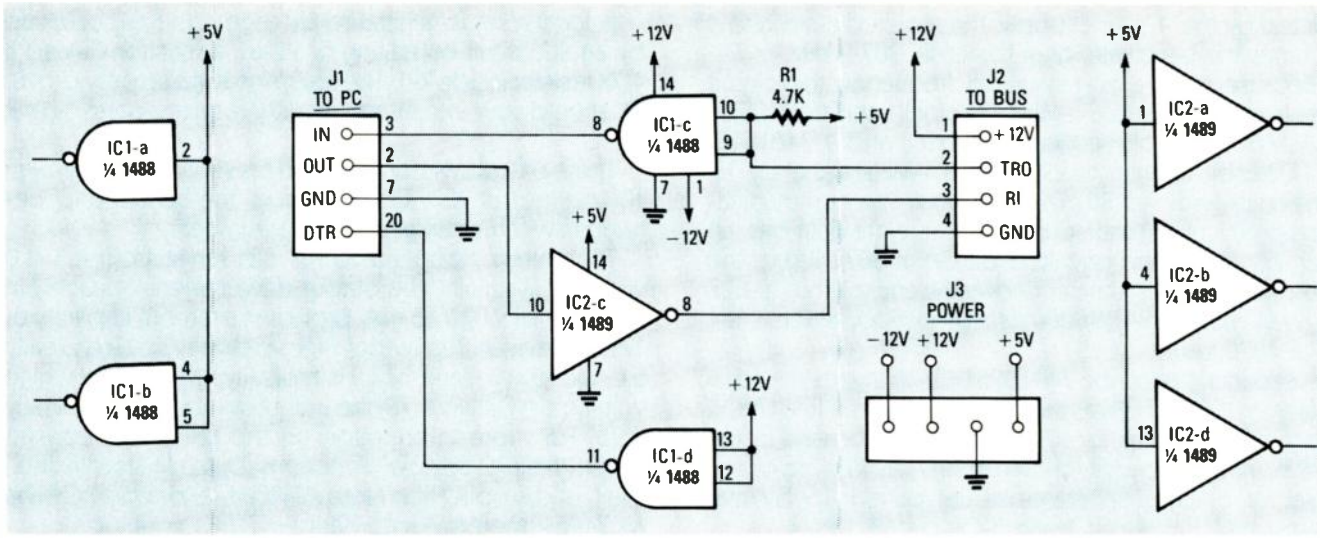


FIG. 3—THE RS-232 INTERFACE routes 12-volt power to the nodes, and buffers data between the nodes and the host PC.

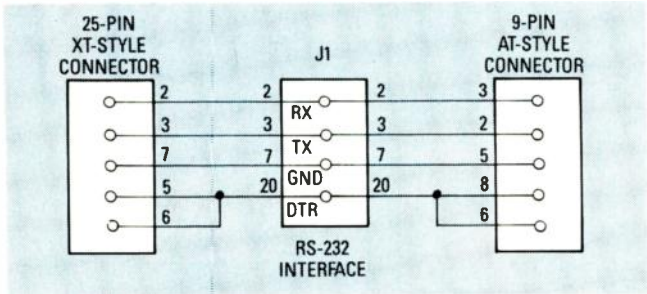


FIG. 4—CONNECT AN XT TO J1 of the RS-232 interface as shown at left, and to an AT as shown at right.

Node operation

The communication software first transmits a seven-bit address that is received simultaneously on pin 19 (RI) of all MC14469's in the system. Each node then checks the state of the most significant bit. If it's high, then the remaining seven bits are compared against the address set on A0–A6. If the values are identical, then VAP is generated on pin 31. VAP is not used in the node circuit shown in Fig. 2, but it is used internally by the MC14496 to latch a control byte on output pins 33–39 (C0–C6). Control-byte data is latched only after a valid address has been received, and it remains latched until another address byte is received.

Transmitting data back to the host PC is accomplished by toggling pin 30 (SEND) high. After receiving the SEND pulse, the MC14469 will transmit, via pin 21 (TRO), the data present on pins 11–18 (ID0–ID7), followed by the data on pins 22–29 (S7–S0). The only stipulation is that the rising edge of the SEND pulse must occur within eight bit times after the generation of either VAP or CS. At 4800 baud, eight bit times provides a maximum of 1.667 ms.

Receipt of a control byte generates a Control Strobe (CS) pulse on pin 32. In our circuit, CS is normally connected to SEND through J4. In this configuration, data will be transmitted to the host as soon as a control byte has been received.

What is the minimum interval between events that this system can detect? The time it takes to transmit and receive data from the same node twice, which works out to (1/4800) × 11 bits/byte × bytes, or about 18 ms.

Realistically, the minimum time is much longer, at least on the order of hundreds of milliseconds, because of the amount of time the software processing takes, especially when relatively slow I/O devices (disk, BIOS video routines, printer) are being accessed. Just don't try to detect more than three events per second.

TABLE 1—NODE ADDRESSES

Node	A6	A5	A4	A3	A2	A1	A0
0	H	H	H	H	H	H	H
1	H	H	H	H	H	H	L
2	H	H	H	H	H	L	H
3	H	H	H	H	H	L	L
. . .							
125	L	L	L	L	L	H	L
126	L	L	L	L	L	L	H
127	L	L	L	L	L	L	L

RS-232 interface and power supply

Figure 3 is the schematic for the RS-232 interface, which uses a 1489 (IC2) for the line receiver and a 1488 (IC1) for the line driver. Pin 2 of J2 is the common transmit line (TRO) that receives data from the open-collector output of each node, and R1 is the pull-up resistor.

Power is supplied to the system via four-pin connector J3. As stated earlier, a single node draws about 50 mA from the +12-volt supply. Low-current sources of +5 and −12 volts are also required.

Figure 4 shows the cable wiring required to connect the RS-232 interface to a 25-pin XT-style port (on the left), and to a 9-pin AT-style port (on the right).

Assembly and testing

Figures 5-*a* and 5-*b* show how to mount the components on the PC boards. The Node board, shown in Fig. 5-*a*, is a double-sided board. You can use the patterns shown in PC Service to build your own, or you can purchase the board from the source mentioned in the Parts List. The pattern for the RS-232 board is also shown in PC Service, but because it is so simple, a commercial product has not been made available.

After you assemble the system, test it using the sample

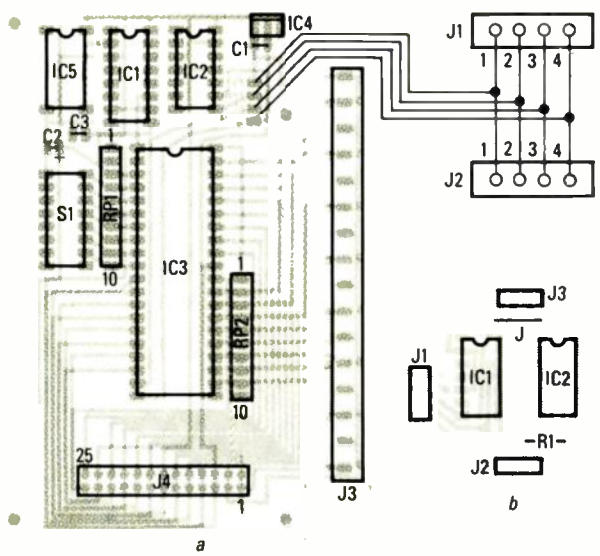


FIG. 5—MOUNT ALL COMPONENTS on the node circuit board as shown in 5-*a* and mount all components on the RS-232 circuit board as shown in 5-*b*.

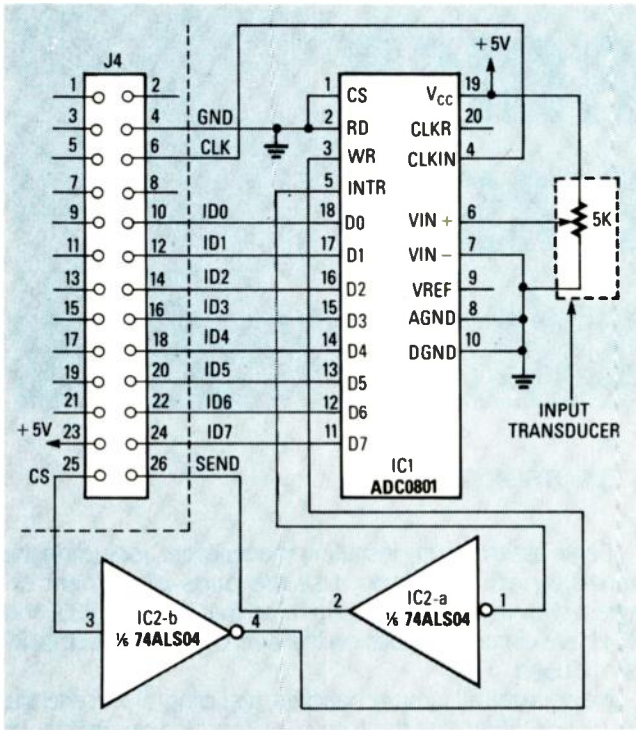


FIG. 6—THE OPTIONAL A/D CONVERTER is shown here. CS from the Node board starts the conversion process; INTR from IC1 here informs the Node that the process is complete.

program that will be discussed shortly. Apply ±12- and +5-volts DC to the RS-232 module, and connect it to your PC and to a single node configured as address 0. Then run the test program. If you receive any error messages (especially a time-out error), check your cabling carefully—the chances are that the RS-232 module hs not been connected to your PC properly.

When the software seems to be running correctly, temporarily short several of J3's even-numbered pins to ground, one at a time. Then terminate the test program according to the directions given on the screen. An ASCII text file called MONITOR.LOG should be present in your current directory. That file should contain a number of messages corresponding to the state of the input lines of J3 at startup, and it should also include messages indicating that it sensed the shorts.

A/D expansion example

Figure 6 shows how to interface an eight-bit analog-to-digital converter (the ADC0801) to a node via connector J4. The component labeled Input Transducer is shown as a 5K potentiometer, but in real life it might be a temperature sensor, a pressure sensor, etc.

In this circuit, CS initiates the analog-to-digital conversion (WR), and the end-of-conversion (INTR) pulse from the ADC initiates data transmission to the host by toggling the MC14469's SEND input.

The ADC uses the 307-kHz node clock. At that rate, a single conversion will take at most 240 µs, which is well within the 1.667-ms time limit between the CS and the SEND pulses.

The software

Because of space limitations, we are unable to print the 600-line C source listing here. However, we will give an overview of how the software works. In addition, both executable files and the full source code have been posted on the RE-BBS (516-293-2283). Download file RS232MON.ARC at 300 or 1200 baud, eight data bits, one stop bit, and no parity. (Source and executable files of an additional program that demonstrates use of the A/D converter is also included.)

The program is a simple event-logging system that continually polls a single node, logs the date, the time, and the input device(s) that changed state since the last time that node was polled. Execute it by typing the name of the program followed by the number of the serial port being used (0 = COM1, 1 = COM2, etc.).

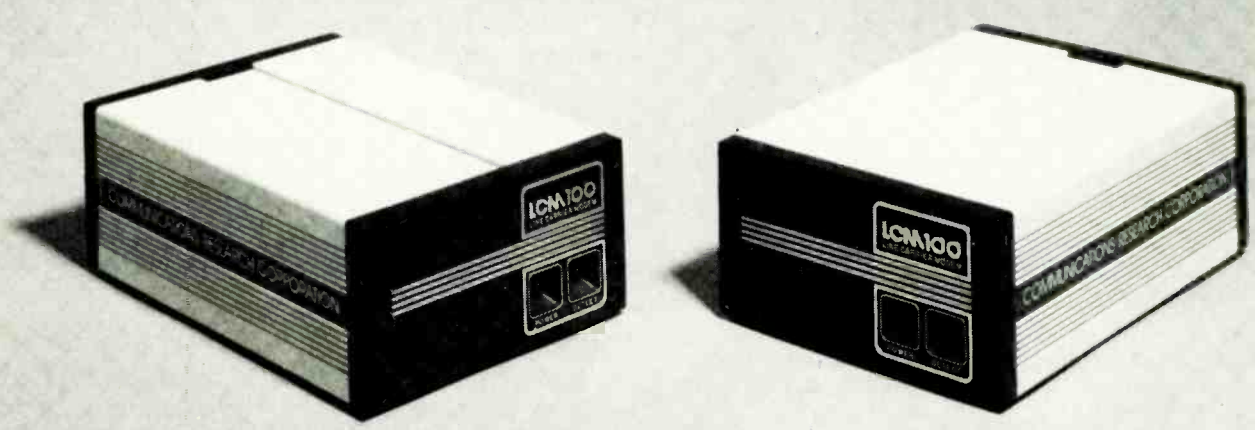
The program communicates directly with the serial port through BIOS interrupt 14h. That means the program can reconfigure the port-communications protocol, read a byte, write a byte, and check the status of the port. Several error conditions can also be determined when using the interrupt. If an error does occur during execution, the program stops and a message is displayed on the screen indicating the type of error.

In the program, each node is represented by a data structure that contains the node address, the initial value of the control byte, a mask value indicating which bit values to respond to, a copy of the last data values returned from the node, and sixteen other fields that correspond to the bit values returned from a node. The sixteen fields contain names that identify what a bit represents, what its *on* state is, and what its *off* state is.

When the program starts, each record is accessed sequentially, and the corresponding node address and control byte are sent. For each node, required functions are initialized, communications checked, and initial conditions logged in a disk file called MONITOR.LOG.

After initialization the program begins to loop, sequentially polling each node and checking the return values against the previous values from the same node. If a new value is different from a previous value, and if those particular bits that indicate a difference are not masked, then the event is logged in the log file with the date and time. Polling continues in that way until the user terminates the program by pressing a key.

BUILD A PAIR OF



LINE-CARRIER MODEMS

Build a pair of modems that communicate over the AC lines—for less than $100!

KEITH NICHOLS, CRC ELECTRONICS

Last month when we left off, we were just about finished with our circuit description. We'll continue with a brief look at the power supply circuit, and then move on to discuss the construction details.

Power supply

The LCM100's power supply, shown in Fig. 7, consists of power-transformer T2, bridge-rectifier BR1, precision-voltage-regulators IC4 and IC5, and other associated filter capacitors. Regulators IC4 and IC5 produce the ±12-volt supplies required by the various IC's. In addition, fuse F1 and MOV1, a 150-volt varistor, provide protection from short circuits and voltage surges.

Construction

The line-carrier modem system is built on two identical PC boards, one of which is designated as the LCM100-01 module and the other, the LCM100-02 module. Each circuit board contains a power-supply, a transmitter, a receiver, an output driver, an RS-232C interface, and carrier-detect circuitry. All components on the two boards except C3, C26, C29, C32, C36, R10, R27, R33, and R34 are identical.

Begin assembly by installing the resistors, including the variable potentiometers. Use the parts-placement diagram shown in Fig. 8. Keep in mind that R10, R27, R33, and R34 have different values on the two boards. Note that R9 is not used.

Next, install all jumper headers, test pins, J1, J2, and the fuse clips. Note that the fuse clips must be oriented with the indented ends away from the fuse. Connectors J1 and J2 should be secured to the board with 4-40 hardware before soldering.

The capacitors and diodes are installed next, except the electrolytic capacitors, C6 and C11. Be sure to observe the polarity of the diodes and the tantalum capacitors, C12 and C17. Again, note that capacitors C3, C26, C29, C32 and C36 have different values on the two boards.

Next, install IC1, IC2, IC3, IC6, and IC7. The use of IC sockets is recommended to minimize the possibility of damage to the IC's from excess heat. However, if you choose not to use sockets, insert the IC's carefully and solder only a few legs at a time to keep heat to a minimum. Note that pin 1 on all IC's point toward the same side of the PC board.

Transistors Q1, Q2, and Q3, varistor MOV1, and IC4 and

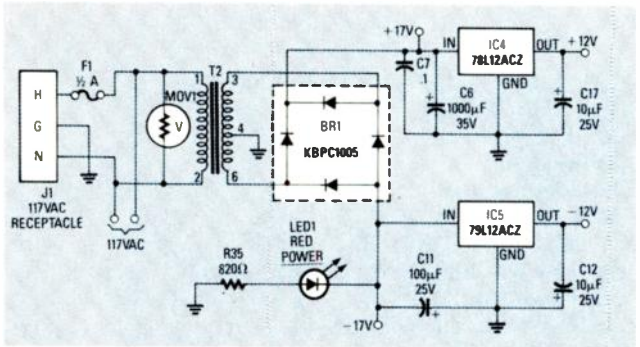


FIG. 7—THE LCM100's POWER SUPPLY. Regulators IC4 and IC5 are precision types; don't interchange them!

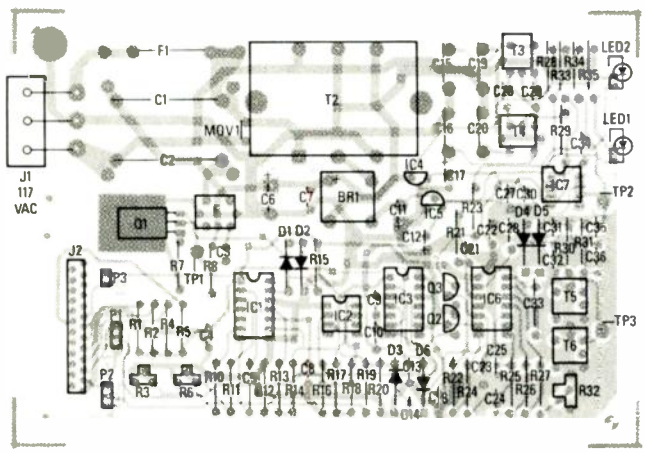


FIG. 8—INSTALL ALL COMPONENTS as shown here.

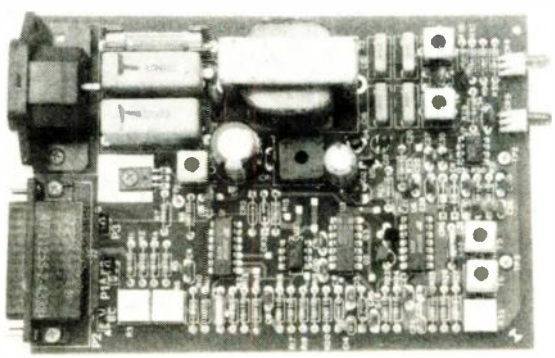


FIG. 9—THE FINAL ASSEMBLY looks like this.

IC5 are installed next. Use care not to interchange IC4 (78L12A) and IC5 (79L12A), the +12- and −12-volt regulators. Note that transistor Q1 should be secured to the PC board with a 4-40 screw and nut prior to soldering. Use extreme care not to overheat the transistors and IC's when soldering. It's a good idea to attach heat-sink clips to the individual component legs when soldering to minimize heat flow to the component.

The tunable RF coils are installed next. Note that T1 (TOKO RAN 10A6729HK) has a different part number than T3, T4, T5 and T6 (TOKO RAN 10A6729). When installing the RF coils, be sure to solder all 5 pins plus the two housing tabs to the PC board.

Next, install the power transformer (T2), bridge-rectifier BR1, electrolytic capacitors C6 and C11, and the LED's. Be sure that the correct polarity is observed when installing the electrolytic capacitors and LED's. The cathode (or flat side) of the LED's goes toward the center of the PC board. Transformer T2 must be installed with leads 1 and 2 (120 V) toward the AC receptacle (J1). Bend the mounting tabs against the board and solder them, as well as the six transformer leads, to the board. Also, be sure that bridge-rectifier BR1 is installed with the (+) lead closest to pin 2 of T2.

Last, if you used sockets for the IC's, carefully insert the IC's in their respective sockets. Be sure orientation is correct before inserting the IC's. Figure 9 shows the final assembly.

Testing and tuning

1) Begin testing by thoroughly inspecting both boards for missed or inadequate solder joints, solder bridges, etc. Because double-sided PC boards with plated-through holes are used, solder will normally flow through the holes to both sides of the board. However, if you have chosen to make your own PC boards (the patterns are shown in PC Service), be sure to solder the component leads on both sides of the board where appropriate!

Caution! Working directly with AC power is dangerous, so be careful! Before applying power to the circuit, be sure to place the board on a non-conductive surface, and do not touch any exposed leads or traces on the line-voltage side of the circuit!

2) With the assembled board on a non-conductive surface, install F1 (½ amp) in the fuse clips, then connect a three-wire power cord to receptacle J1 and apply power to the circuit. **Keep your hands away from the high-voltage components and traces on the board!** The red LED (D9) should light, indicating that power is on. The green LED may flicker momentarily; however, it should not remain lit.

3) Now connect a temporary switched jumper between the data-input pin of J2 (the DB25P connector) and one of the +12-volt sources (pin 4, 5, 6, or 20 of J2). A convenient way to do that is to use a spare DB25P male connector with an SPST switch wired across the pins to be jumpered. You might want to make a separate jumper for each board, because the data input is pin 3 on the LCM100-01 board and pin 2 on the LCM100-02 board. If you haven't already done it, install the jumpers on headers P1, P2, and P3 as follows. On the LCM100-01 board: P1, P2—A and B jumpered; P3—not jumpered. On the LCM100-02 board: P1, P2—B and C jumpered; P3—jumpered.

4) The next step is to adjust the mark and space frequencies of modulator IC1. Begin with the LCM100-01 board. Attach the input lead of a frequency counter to TP1 (the collector of Q1), and the ground lead to pin 1 or pin 7 of the DB25P jumper. With the jumper switch on, adjust R3 until the meter reads 150 kHz. That is the "space" frequency (*f1*) of the FSK modulator. Next, turn the jumper switch off and adjust R6 to get a reading of 156.5 kHz. That represents the "mark" frequency (*f2*). Switch between *f1* and *f2* several times while fine tuning R3 and R6 until both frequencies are correct.

5) The transmitter line coupler can now be tuned to the modulator's FSK band as follows: Attach a high-impedance oscilloscope probe (×10 setting) to TP1, and clip the ground lead to pin 1 or pin 7 of J2. Set the sweep time

PARTS LIST

Note: Component values in parentheses are for the LCM100-02 board; other values are for the LCM100-01 board.
All resistors are ¼-watt, 5% unless otherwise noted.
R1, R2, R4, R5, R15, R19. R28, R29—4700 ohms
R3—5000 ohms, PC-mount trimmer potentiometer
R6—200,000 ohms, PC-mount trimmer potentiometer
R7—4.2 ohms
R8—300 ohms
R9—not used
R10—17,400 ohms, 1% (24,900 ohms, 1%)
R11—360,000 ohms
R12—3900 ohms
R13—5100 ohms
R14—3000 ohms
R16, R20, R22, R30, R31—10,000 ohms
R17—150,000 ohms
R18—220,000 ohms
R21—470,000 ohms
R23, R35—820 ohms
R24—510,000 ohms
R25—100,000 ohms
R26—300,000 ohms
R27—24,900 ohms, 1% (16,200 ohms, 1%)
R32—5000 ohms, PC-mount trimmer potentiometer
R33, R34—100,000 ohms (47,000 ohms)
Capacitors
C1, C2—1 μF, 135 volts
C3—1800 pF (3900 pF)
C5—330 pF
C6—1000 μF, 35 volts, electrolytic
C4, C7–C10, C13, C18, C22, C23, C27, C30—0.1 μF, 25 volts, monolithic
C11—100 μF, 25 volts, electrolytic
C12, C17—10 μF, 25 volts, tantalum
C14, C25, C33—330 pF
C15, C16, C19, C20—0.1 μF, 135 volts
C21—3900 pF
C24—100 pF
C26, C29, C32, C36—3900 pF (1800 pF)
C28—0.01 μF, disk
C31, C35—470 pF
C34—6.8 pF
Semiconductors
BR1—50 volts, 1 amp
D1, D2, D3, D6—1N4148
D4, D5—1N4728 (3.3-volt Zener)
LED1—standard red
LED2—standard green
IC1—XR2207, FSK modulator
IC2—LM311N, op-amp
IC3—1488, RS-232 line driver
IC4—78L12ACZ, precision +12-volt regulator
IC5—79L12ACZ, precision −12-volt regulator
IC6—XR2211, FSK demodulator
IC7—LM318N, op-amp
Q1—MJE180, NPN power transistor
Q2—PN2222, NPN switching transistor
Q3—2N3906, PNP switching transistor
Other components
J1—115-volt AC receptacle J2—25-pin D connector P1, P2—3-pin header strip P3—2-pin header strip MOV1—150-volt varistor T1—RF coil, TOKO RAN10A6729HK T2—24-volts, 180 mA, PC mount (Dale PL-13-07) T3–T6—RF coil, TOKO RAN10A6729
Miscellaneous
Note: The following are available from CRC Electronics, 13547 S. E. 27th Place, Suite 3D, Bellevue, WA 98005, (206) 747-9636: Etched and drilled PC boards with plated-through holes, $24.95/pair; Partial kit (includes PC boards, all transformers, coils, jacks, and high-voltage capacitors) $49.95/pair; Complete kit excluding case and power cords, $99.00/pair; Assembled and tested PC-board assembly without cases and power cords, $119.95/pair; Complete assembled and tested system, $159.95/pair. Individual components are also available.

and amplitude controls to display a sine wave. Adjust the tuning slug of RF-transformer T1 until maximum amplitude is obtained. Now flip the DB25P jumper switch to the other position and observe the change in amplitude as the frequency changes. Adjust T1's tuning slug until the amplitudes of *f*1 and *f*2 are equal. Repeat steps 2 through 5 with the LCM100-02 board, using 100 kHz and 106.5 kHz as the *f*1 and *f*2 settings respectively.

6) The receiver-stage line couplers are similar to the one used in the transmitter except that two of them are configured in a parallel arrangement. That permits precise tuning to the mark and space frequencies individually, rather than using an average of the two. The result is greater receiver sensitivity and superior noise rejection.

Tune the receiver line couplers as follows: Attach a scope probe (× 10 setting) to TP2 (pin 6 of IC7) on the LCM100-01 board. Be sure to clip the ground lead to the signal ground, as before. Connect the power cords to both boards and plug both cords into the same 115-volt outlet box. The volts/division setting of the scope should be increased a couple of notches from where it was set for TP1. Adjust the tuning slug of T3 or T4 until an increase in amplitude of the waveform is seen on the display. Continue adjusting the slug until maximum amplitude is obtained. You may need to adjust both T3 and T4 in order to do that. When the amplitude exceeds a certain point you will see the peaks of the sine wave flatten out as the Zener diodes (D6 and D7) chop the voltage at ± 3.3 volts. Flip the DB25P jumper switch on the LCM100-02 board to shift the frequency, then readjust T3 or T4 (on the LCM100-01 board) until the maximum amplitude is seen on the scope. Now, toggle the LCM100-01 jumper switch several times while fine tuning T3 and T4 until both *f*1 and *f*2 frequencies appear to have equal amplitude on the scope display. The waveform should look like a symmetrical sine wave with flattened peaks. Repeat step 6 for the LCM100-02 board (using the DB25P jumper switch on the LCM100-01 board to shift the frequencies).

7) The next step is to align the bandpass-filter network. The procedure is the same for each board. Attach the scope probe (× 10 setting) to TP3 (the ungrounded end of T6). Adjust the tuning slug of T6 until maximum amplitude of the sine wave is displayed. Toggle the jumper switch (on the opposite board) and fine tune T6 until an equal amplitude is obtained for both frequencies. Next, adjust T5 in the same manner as T6; note that T5 affects the amplitude very little.

continued on page 96

BUILD THE PT-68K

We complete our look at the PT-68K's DRAM circuitry

We left off last month rather abruptly, before we even finished disucssing how the DRAM operates while being accessed by the CPU. As we continue, keep last month's issue at hand for Figs. 1 and 2 referenced here.

Note that timing of the DRAM circuitry is critical; most PT-68K operations involve the DRAM, so squeezing extra speed out of the circuit is important.

Now let's return to Fig 1. After the 150-ns delay, pin 8 of IC52 goes high, which makes pins 10 and 13 of IC51 both high. As a result, all inputs to IC37-c are high, so its output goes low. That signal is inverted by IC66-d, so $\overline{\text{RAS}}$ goes high again. Meanwhile, delay-line IC52 is now processing the low. After 30 ns, pin 12 of IC52 goes low, so A/B SELECT goes low. That signal also drops the clock input of IC49-a from high to low, but the flip-flop does not react because it only responds to a rising edge. So, the flip-flop stays set and continues outputting $\overline{\text{CAS}}$ and $\overline{\text{DRAM DTACK}}$.

After 150 ns, pin 8 of the delay line goes low and the DRAM circuits are ready for another memory access. Meanwhile, the 68000 also finishes its memory access; it then negates $\overline{\text{AS}}$, so IC49-a finally resets, and both $\overline{\text{CAS}}$ and $\overline{\text{DTACK}}$ go high.

DRAM operation during refresh

Now let's look at how the DRAM circuits operate during refresh. First, Fig. 1 shows the 8-MHz clock signal (CLK8) being applied to two decade counters, IC65-a and IC65-b. The two counters each divide the input frequency by 10, so the output of IC65-a is an 800-kHz signal, and the output of IC65-b is 80 kHz. The resulting REFRESH CLOCK is sent to the refresh counters, IC46-a and IC46-b, shown in Fig. 2.

As mentioned last time, refreshing a DRAM involves reading 128 rows once every two milliseconds. Although only 128 rows are needed, IC46-a and IC46-b are each divide-by-16 counters, so together they make a divide-by-256 counter. All eight outputs of the two counters are sent to the DRAM address lines through IC61, even though only seven outputs are needed. The eighth output does no harm, and may be used for possible future expansion.

The period of the 80-kHz signal is 1/80,000, or 12.5 µs, so the refresh counters complete 128 counts in 128 × 12.5 = 1600 µs = 1.6 ms, which is well within the ratings of the DRAM IC's that require refreshing at least once every two milliseconds.

Once every 12.5 µs, pin 9 of IC65-b goes high and sets IC50-b (because its D input is connected to +5 volts) to signal the DRAM circuits that it is time to do a refresh. The Q output of IC50-b goes high, so the next rising edge of MPUCLK (which might be anywhere from 8 to 16 MHz, depending on CPU speed) sets IC50-a. Its Q output also goes high, sending a high to the D input of IC49-b. The circuit now waits for two other events: For $\overline{\text{AS}}$ to go high and for MPUCLK to go low again. Then IC49-b sets, and that is what starts the refresh cycle.

Note that it was not sufficient for the 80-kHz signal to go high—the circuit waited for the correct sequence of MPUCLK and $\overline{\text{AS}}$ before actually starting the refresh. The reason is that a refresh can interfere with the 68000's normal use of DRAM unless the refresh is timed just right. The circuitry described here is designed to delay the refresh until the end of an address strobe. The idea is to try to do a quick refresh just after the 68000 has finished accessing memory and to squeeze the refresh into an unused time period.

In any case, refresh begins when IC49-b sets. That switches REFRESH from low to high, and $\overline{\text{REFRESH}}$ from high to low. As shown in Fig. 2, when REFRESH goes high it turns off

the three multiplexers (IC62, IC75, and IC88); when REFRESH goes low it enables IC61, so that the DRAM IC's receive the refresh address instead of the normal column or row address from the address bus.

Back in Fig. 1, however, the REFRESH signal is also sent to pin 1 of IC51-a. That starts the same type of memory cycle as was started by the RAM signal from the address decoder, so that the delay line receives first a high and then a low, as in normal operation. But this time there are two differences.

First, the REFRESH signal is now low, so the 30-ns output on pin 12 of delay-line IC52 cannot set IC49-a. Thus no CAS or DRAM DTACK is generated during a refresh. That means that only a row address is sent to the DRAM's, no column address. Furthermore, DTACK is not needed because the 68000 is not involved in refresh, and doesn't even want to know that refresh is occurring.

The second difference is that the 30-ns output of the delay line is also sent to pin 4 of IC35-b. Since pin 5 is already high (because REFRESH is high), pin 6 of IC35-b goes low, thereby resetting flip-flops IC50-b, IC50-a, and IC49-b. That ends the refresh cycle.

Now let's look at how the 32 DRAM IC's are actually wired. Figure 3 shows the connections to IC38. First, each 256K DRAM has nine address lines that connect to MA0 through MA8. As shown in Fig. 2, each line comes through a 33-ohm resistor, a rather unusual practice in normal digital circuits but actually quite common in memories.

Further Help

If you need further help, contact us through our BBS at 914-241-3307. If that is not possible, hardware questions can be answered by Peripheral Technology, 1480 Terrell Mill Rd. #870, Marietta GA 30067, (404) 984-0742. Software questions dealing with the HUMBUG monitor program or the SK*DOS disk operating system can be answered by Star-K Software Systems Corp., P. O. Box 209, Mt. Kisco NY 10549, (914) 241-0287.

The resistors are used primarily to reduce voltage overshoots and undershoots (above +5 volts and below 0 volts), which would otherwise exist on the address lines.

Basically the problem is caused by the fact that the address lines each go to 32 IC's. The actual wiring for those lines is quite long and complex, and therefore represents a fairly large capacitance to ground. The buffers driving those lines would normally feed rather large current surges into that wiring, which would result in overshoots and undershoots. In addition to the address lines, 33-ohm resistors are also found on the R/W and RAS lines, which also go to all 32 DRAM's, as well as the CAS lines. Only the data lines are not connected to resistors, since each data line goes to only two IC's.

The RAS signal from Fig 1, and the R/W signal (from the 68000) are also applied to each and every DRAM IC in the entire system. This means that all DRAM's accept the same

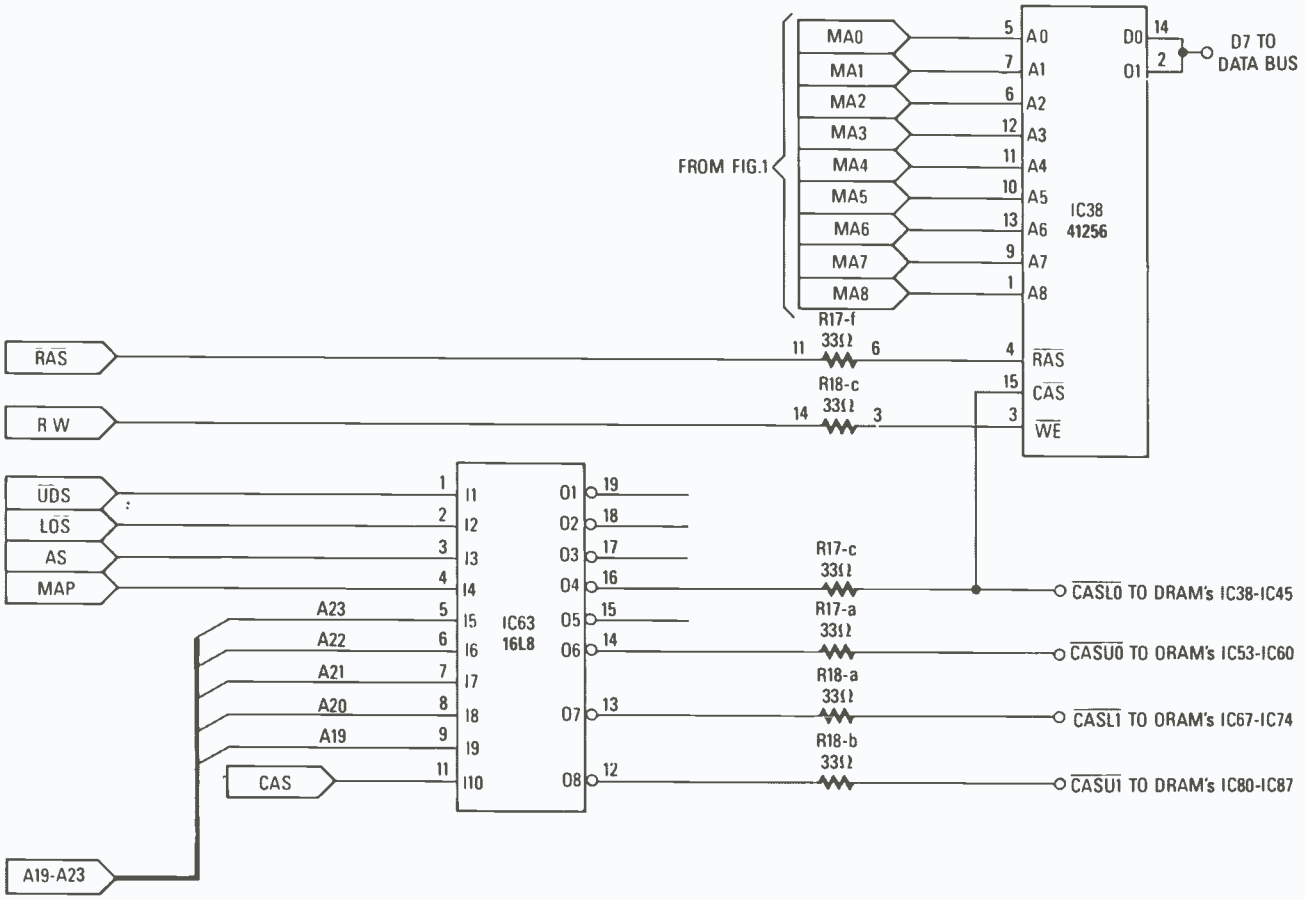


FIG. 3—SAMPLE DRAM WIRING. Corresponding address lines to each DRAM are all connected together, as are RAS and R/W; but the DATA IN, DATA OUT, and CAS lines are wired separately.

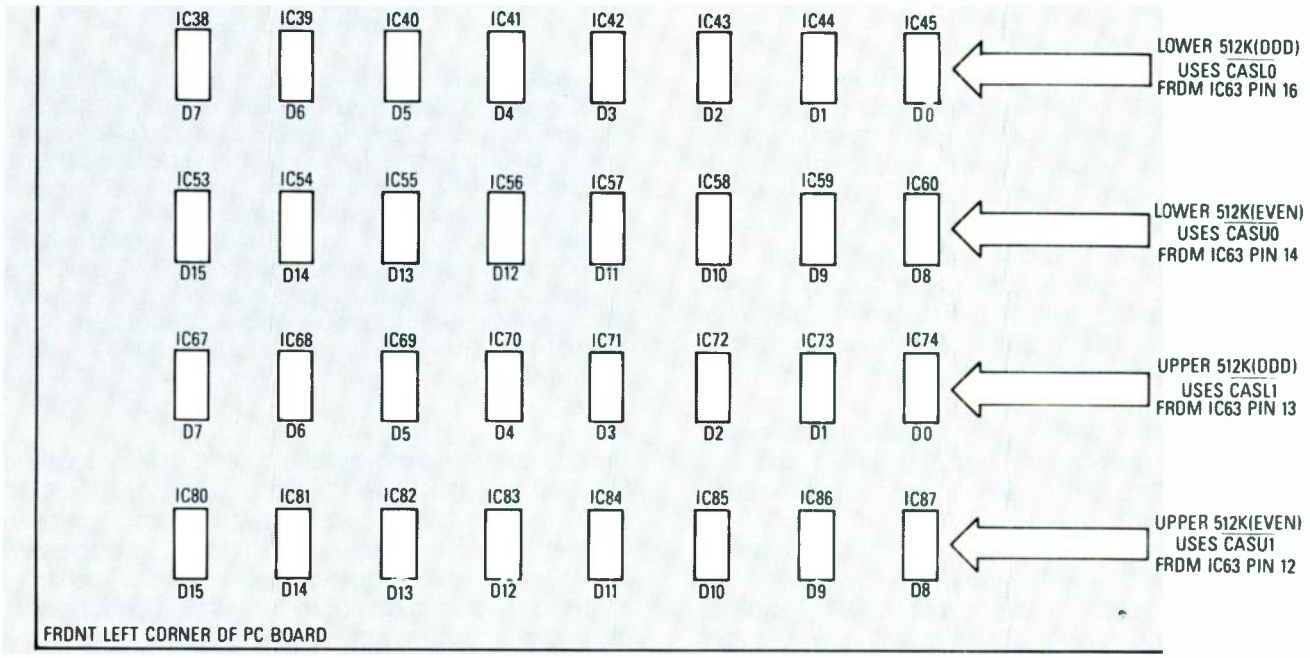


FIG. 4—DRAM ORGANIZATION on the PT-68K motherboard. Each row of IC's corresponds to the even or odd portion on one 512K bank; each column corresponds to a single data bit as shown.

row address, and also all receive R/$\overline{W}$ at the same time (although they don't actually read or write unless they also receive the $\overline{CAS}$ signal).

The $\overline{CAS}$ signal leaving Fig. 1 does not go directly to the DRAM's; instead it goes back to the address decoder (shown completely in Fig. 3 of the January issue, and shown incompletely here in Fig. 3.). $\overline{CAS}$ is used only during actual memory accesses by the 68000, not during refresh. At that time, the address decoder must decide which group of DRAM's is actually being addressed. The 32 DRAM's are divided into four groups of eight IC's:

(A) the even (or high-order) bytes of the first 512K, IC53 through IC60, which connect to $\overline{CASU0}$,

(B) the odd (or low-order) bytes of the first 512K, IC38 through IC45, which connect to $\overline{CASL0}$,

(C) the even (or high-order) bytes of the second 512K, IC80 through IC87, which connect to $\overline{CASU1}$, and

(D) the odd (or low-order) bytes of the second 512K, IC67 through IC74, which connect to $\overline{CASL1}$.

The address decoder PAL (IC63) decides which group (or groups) of DRAM's to enable, based on the status of the upper and lower data strobes ($\overline{UDS}$ and $\overline{LDS}$), and address lines A19–A23, and then passes the $\overline{CAS}$ signal to the appropriate group or groups. Note that it might send $\overline{CAS}$ to two groups of DRAM's at the same time if a 16-bit data transfer is needed from both an even and an odd byte at the same time.

Finally, within each group of eight DRAM's, each IC is connected to a different bit of the data bus so that every data transfer involves either eight or sixteen DRAM's, all writing or reading a different bit of the data bus. The DRAM's have separate DATA IN and DATA OUT pins, which are connected together, as shown in Fig. 3.

Figure 4 shows a pictorial view of the 32 DRAM's on the PC board, identifying which IC connects to which data line, and which group connects to which $\overline{CAS}$ line.

Step 19. Building the DRAM

It is now time to build the DRAM portion of the board. Begin by checking that the following components have been installed in prior steps:

IC35 (74LS00), IC37 (74LS10), IC48 (74LS08), IC51 (74LS32), and IC66 (74LS04). Each IC should be socketed. Also, C68 (33 pF), R12 (10K), and R17 and R18 (33-ohm DIP resistor packs) should be installed. In addition, if IC65 (74LS390) is not already installed, then install it now (with socket). Make sure that C68 is 33 pF, not 0.1 µF like most of the disk capacitors on the board.

Now install the following:

IC49 (74S74); IC50 (74LS74); IC52 (150-ns delay line); IC62, IC75, and IC88 (74S257); IC46 (74HCT393); IC61 (74S373). Socket all IC's except IC52, the delay line, which should be soldered directly to the board.

A 74LS393 will often work for IC46, but we have found that the 74HCT393 rejects noise better, so it is a safer choice. As for IC61, do not use a 74S373 made by TI, because we have found the circuit to be very unreliable with that brand (although a TI-brand 74S393 works just fine as IC19.) The DRAM refresh circuitry has some very critical timing, and 74S373 IC's made by TI do not seem to operate well in this circuit—we have had good luck with units made by National Semiconductor and others.

We are now ready to install more components, but much of the wiring in this area is very close, so we must take special precautions to guard against accidental short circuits. When installing the following components, install the IC sockets first, and after every group of eight or so, recheck the wiring and then turn on the computer to ensure that it still works. (Remove all loose wires or solder before turning on the power). Although that is not a foolproof check, it does help to narrow down the cause of most problems as soon as possible after they happen. If at any point the computer suddenly stops working,

recheck all new soldering and components, and look for accidental solder joints. Now install these components:

Sixteen 41256 DRAM's (with sockets), at IC38–IC45 and IC53–IC60. Use 150-ns IC's at 8- or 10-MHz clock speeds, or 120-ns IC's at 12.5 or 16 MHz. Sixteen IC's provide 512K of RAM and is the minimum number that can be installed at this time. If you wish, you may also install a second sixteen DRAM's at IC67–IC74 and IC80–IC87. Even if you install only 16 DRAM's now, install all 32 sockets to avoid having to remove the board from the cabinet later.

Next, install forty 0.1-μF disk capacitors as follows: C15–C46 are installed near pin 1 of each of the 32 DRAM sockets; C47 and C49–C54 are along the bottom edge of the board below the DRAM sockets; C56 is between IC75 and IC88.

Now let's try the memory; if it passes the following tests, you can skip ahead to Step 21 (although you may want to read Step 20 to learn some troubleshooting techniques).

Begin by moving the MAP jumper (J25) to position 1; that enables the DRAM. Now turn on the power. The speaker should beep and the normal HUMBUG prompt should appear on the screen. We're not done yet, because even if the DRAM memory were malfunctioning, the prompt could still come up, because HUMBUG uses mostly static RAM. (DRAM is used only to hold vector addresses).

To make sure the memory works we need to do some more tests. First, use the MT (memory test) command of HUMBUG to run a quick memory check. If you have installed all 32 DRAM's, then the correct command is

```
MT FROM ADDRESS 0 TO FFFFF
```

which tests one megabyte of memory from address $00000 to $FFFFF. If you have installed only 16 DRAM's, then the correct command is

```
MT FROM ADDRESS 0 TO 7FFFF
```

which checks out only the first 512K of memory. In each case, press the space bar after the zero and after the last F to tell HUMBUG that you have finished typing the address. Either way, HUMBUG should display a + sign and then its normal * prompt if the memory passes the test.

Although the MT memory test of HUMBUG is fast, it is not thorough. It merely goes through every location of memory and tries to set and reset every bit, one at a time. It then reads the bit back and tests it. But since it reads the bit back immediately after it sets it, the DRAM may seem to work even if the refresh circuitry is bad. We need a more thorough test for a more long-term memory.

There are two ways to do that. One method involves copying the HUMBUG ROM into DRAM, waiting a minute or so, and then doing a memory compare to check the two against each other. Since the HUMBUG ROM is less than 20K in size, it is not big enough to fill up all of DRAM for a thorough test. Nevertheless, we can do a rough check by typing in the following two commands:

```
MO ENTER OLD ADDRESSES: FROM F80000 TO F84000
   ENTER NEW ADDRESS: 1000
```

Now wait a minute or two, and then enter the following:

```
MC REGION 1: FROM F80000 TO F84000
   REGION 2: 1000
```

Ordering Information

Complete details were given in part one (in the October 1987 issue). To summarize: the basic kit (PT1, $200) contains all parts except power supply, case, and video terminal or personal computer to get a small system (ROM monitor, 2K RAM) up and running. The full basic system (PT-68K, $530) includes 512K of dynamic RAM, floppy-disk controller, parallel port, battery-backed clock/calendar, three PC-compatible expansion slots, SK*DOS operating system, editor, assembler, and system utilities. To order, or for more information, contact Peripheral Technology, 1480 Terrell Mill Road #870, Marietta GA 30067, (404) 984-0742.

The MO command moves the contents of ROM locations $F80000 through $F84000 down into RAM locations $1000 and up (do not store anything into locations 0 through $400, as they are used to hold vector addresses). The MC command compares the two areas of memory. If the two sets of data do not match, HUMBUG will display the addresses where a difference is found.

Another simple test is to use the FM (Fill Memory) command to fill all of memory with zeroes, and then the CS (Checksum) command to ensure that the sum of all those zeroes is itself zero. Another test is to move whatever random data is in the bottom 512K into the top 512K, and then make sure that the checksum of the bottom 512K is the same as the top 512K. You could also use ROM BASIC to POKE consecutive numbers into memory locations, and then come back later, read them back with PEEK, and check against what was stored. Later, when we boot the SK*DOS disk operating system, there will be plenty of opportunity to test the computer's memory more thoroughly.

Step 20. DRAM troubleshooting

Defective DRAM circuitry can show itself in many ways—the computer might be totally dead, or it might come to life but be unreliable, or it might appear to work but fail memory tests.

The specific troubleshooting procedures vary, depending on symptoms. The most likely symptoms that you'll encounter, and some recommended diagnoses and prescriptions for cure are as follows.

1) The computer is completely dead. Move J25 back to position 2 to disable DRAM and return to static RAM-only operation. If the computer is still dead, you probably introduced a short circuit while soldering the memory sockets.

2) The speaker beeps, but nothing appears on the screen, or only the "Please press enter" message appears on the monitor (unless you are using only a serial terminal), and at some point the HALT LED goes on. Those symptoms generally indicate that at least part of the DRAM circuitry is working; the first step is to interchange DRAM IC's, swapping each IC in an upper or even group with those in a lower or odd group. If the symptoms change then it generally indicates a defective DRAM IC. If, on the other hand, the symptoms stay the same, then the problem is probably elsewhere.

If an oscilloscope is available, place J25 in position 2,

continued on page 96

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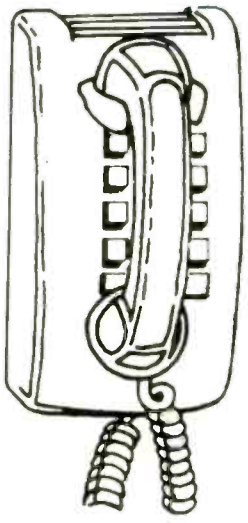

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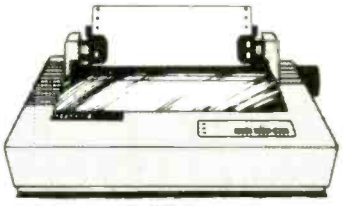

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LINE-CARRIER MODEMS

continued from page 90

8) The final tuning step is to adjust the free-running frequency of the VCO in the XR2211. The simplest way to do that is to adjust R32 while observing the green LED (D8) on the board (the opposite board, of course, must be plugged in and transmitting). Turn the adjustment screw of R32 until the green LED lights, then continue turning in the same direction until it turns off again. Set the adjustment screw of R32 halfway between the two points and mark the position of the screw slot with a pencil. Now flip the jumper switch on the opposite board to change the frequency, and repeat the previous step. You should have two pencil marks on R32 a few degrees apart. Turning the adjustment screw halfway between the two marks should result in the correct setting. Repeat that step for the other board.

8-a) A more accurate method of setting the VCO of the XR2211 is as follows: Configure a function generator to produce a 4800-Hz square wave with a voltage swing of zero to +6 volts. Use that signal to adjust your oscilloscope to display a symmetrical square wave. Next, attach the function-generator output lead to the DATA-IN pin of J2 on the LCM100-01 board. Make sure the jumper switch is in the off position. Attach the scope probe to the DATA-OUT pin of J2 on the LCM100-02 board. With the power on to both boards, adjust R32 (on the LCM100-02) until a symmetrical square wave is displayed. That indicates the correct setting of the oscillator at the "center frequency," the midpoint between the detector mark and space frequencies. The green LED will, of course, be on at that setting.

Repeat the previous step, reversing the two boards, to complete the "tuning" process. The final step is to test the modems by transmitting actual data.

9) To do so, you'll need a serial-data output source. A video terminal, in full-duplex configuration, will do nicely. A simple loop-back circuit is the easiest test. The terminal is connected to the LCM100-01 modem that is plugged into the power line. The LCM100-02 modem, with pins 2 and 3 of J2 jumpered together, is plugged in some distance away. As you type on the keyboard, the data is transmitted to the LCM100-02 modem, looped back through the jumper, and re-transmitted to the LCM100-01 modem where it appears on the terminal's screen. Depending on your terminal's configuration (DTE/DCE), you may need to transpose the two modems or switch the internal jumpers on the LCM100-01 modem board to get things working properly.

The LCM100 will successfully transmit data over distances of several hundred feet, or more, at rates up to 9600 bps. In general, the greater the distance, the lower the baud rate should be for error-free transmission. It is best to experiment with different transmission rates and distances to establish reliable operating parameters for your AC line.

The ultimate range is limited by the power company's step-down transformer and the cross-coupling between the 115 V legs of a 230-volt distribution system. You can arrange communication between the latter by attaching a fused capacitor (a 1-μF, 400-volt capacitor in series with a ½-amp fuse) between the two 115-volt legs in your electrical panel box.

BUILD THE PT-68K

continued from page 94

which disables CPU accesses to DRAM, but keeps the refresh circuits going. Now check for the following, and trace signals if any appear to be wrong:

A) An 80-kHz signal at pin 1 of IC46.

B) The frequency of each successive output from IC46 should be half of the preceding output.

For example, pin 6 should be at 40 kHz, pin 5 at 20 kHz, etc.

C) There should be thin, barely-visible (depending on the oscilloscope) negative-going pulses at pin 8 of IC49 and at pin 8 of IC66.

d) There should be thin, barely visible positive-going pulses at pins 8 and 12 of IC52.

e) IC49-a should stay set at all times, so pin 6 should always be high.

3) If the computer works, but fails a memory test, try to analyze the MT test printout to determine where in memory the problem is. For example, if errors occur in locations $80000 and above, then the problem is only in the upper 512K of memory. If the problem occurs in a small region of memory, then the problem is likely to be in a single IC.

Another way to narrow down defective DRAM problems is to use the ME command to store a number into memory at one of the locations flagged as defective by the MT test, and then read it back to see whether it was stored properly. For example, suppose the MT test indicates errors in odd locations between $4001 and $4FFF. This would indicate that an error is occurring in the odd or lower memory group in the first 512K of memory. Use the ME command to store the number $FF in location 4001, one of the defective locations. If you then read back $FB, for example, compare the bit patterns for FF (11111111) and FB (11111011). Since there is a difference in the third bit from the right (bit D2), you can then use Fig. 4 to identify the correct IC. In this case, it is IC43, since IC43 is connected to D2 in the lower 512K of memory. (Note that the bits in even locations are numbered from D15 on the left to D8 on the right, and the bits in odd locations are numbered from D7 on the left to D0 on the right.)

Although it is not possible for us to anticipate each and every problem you might have, the DRAM circuitry used in the PT-68K is simple enough that most of the people who have rushed ahead to build their kit without waiting to read this article have had no problem. If you are one of the unlucky few who do run across a glitch, just keep at it—it is solvable.

When we return

Next time we'll finish building the PT-68K by working on the floppy-disk controller, the parallel printer port, and the optional hard-disk controller port. Then the fun of *using* the computer can begin.

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DRAWING BOARD

continued from page 80

dollar word to indicate that you can take advantage of retinal persistence. If the LED's are turning on and off very quickly, it will seem like they are on continuously.

When you're dealing with LED-based displays, there are several ways to go about multiplexing them. LCD displays can be multiplexed as well, but they're much slower and don't respond well to rapid strobing. And since they basically run on flea power, there's not much of a point in multiplexing them.

To get started, let's suppose that you have sixteen LED's in your display; all of them will be on some of the time, and you're running the circuit off a 9-volt battery. If we do a bit of arithmetic, we can see what's going to happen to the battery. A fresh 9-volt battery is usually somewhere around 8 volts and a value of 220 ohms is a good ballpark figure for a current-limiting resistor. The simplest kind of circuit configuration is shown in Fig. 1. Assuming the voltage drop across each LED to be 1.7 volts, we can apply Ohm's law as follows:

$$I_{LED} = V/R$$
$$= (V_{BAT} - V_{LED})/R$$
$$= (8 - 1.7)/220$$
$$I_{LED} = 28.6 \text{ mA}$$

So if you were driving 16 LED's, you would have to supply almost half an amp—and that's a significant amount of power!

The circuit in Fig. 2 is one way of multiplexing the same 16 LED's. All we have is a simple clock driving a 4514. The outputs of the decoder are normally low and the selected output goes high. A similar chip, the 4515, has normally high outputs so you can use the circuit for LED's with a common leg tied to either ground or power, whichever you prefer.

The clock is a standard one made up of a pair of inverters driving a 4520 binary counter, which is being used to make the decoder scan across its outputs. You might consider that to be an unnecessarily complex way of doing a simple job, but the circuit is good for demonstrating the basic idea. There are lots of ways to do the same job with fewer IC's and we'll be looking at several of them later on.

The components shown for the clock cause it to oscillate at about 10 kHz. Assuming that it takes no time at all to switch between the outputs, and that the CMOS chips are using no power, you're going to be able to light all 16 LED's with even less current than the circuit in Fig. 1 uses. Even if you allow 10 mA for each of the IC's, you're still looking at only 60 mA for the entire circuit—and, for the record, there's no way those CMOS IC's are going to want 10 mA each.

The price you pay for multiplexing a display is that each of the LED's will appear to be dimmer—how much dimmer depends on a number of things. The efficiency, size, and color of the LED's are all going to have an effect on the apparent brightness; and don't forget that each LED is only on less than one sixteenth of the time.

The easiest way to boost the brightness of a multiplexed display is to drop the value of the current-limiting resistor. Unfortunately, there's no way to tell how much of an increase in brightness you're going to get as you increase the current. Each LED reacts differently. You can, however, choose a value for the current-limiting resistor that will give you the maximum allowable current through the LED—usually about 70 mA or so for the standard T-1 ¼-size LED's.

If the multiplexing frequency is high enough, you can push really huge amounts of current through the LED. Standard jumbo LED's can handle 1 amp if it's

continued on page 100

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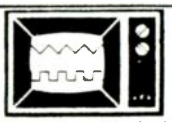

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DRAWING BOARD

continued from page 97

restricted to a 1 microsecond pulse and a .3% duty cycle! For the purposes of our test circuit (Fig. 2), don't drop R2 much below 47 ohms, because you won't get much more brightness below that—but there's a very good chance you'll send the LED up in smoke. Also, make a few calculations to be sure that you don't exceed the current-limiting resistor's power rating.

We have our clock running at about 10 kHz to make sure that there's no flickering in the display, but that's really overkill for a 16-LED display. Standard movie projectors run at 24 frames per second and provide a good illusion of continuous motion. Since they also use a 180 degree shutter, they have an effective duty cycle of 50 percent. Since our demonstration circuit keeps each LED illuminated for one complete clock cycle, the duty cycle isn't important yet; but keep it in mind.

In order to light our display at film speed, we have to use a clock with a frequency of 16 × 24 or 384 Hz. You can drop the clock to that frequency by replacing C1 with a 0.2 μF capacitor. The LED's should appear brighter and you shouldn't see them flickering. I say "shouldn't" because biology isn't as precise as electronics. Experiment with different clock frequencies on your own and see "how low you can go" while still maintaining the illusion of constant illumination. **R-E**

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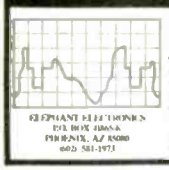

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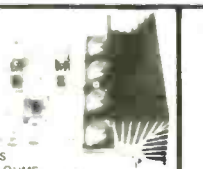

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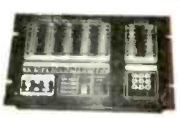

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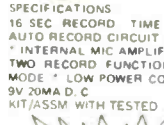

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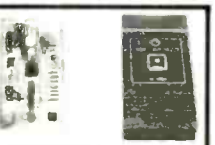
INFRARED REMOTE CONTROL UNIT TY-41 MKV △△△



It has two modes of operation "Continuous" and "on/off". It is suitable for many kinds of electrical and electronic applications whose power consumption is within 300W. Such as light control, garage door opener, TV on/off, burglar alarm and many others.

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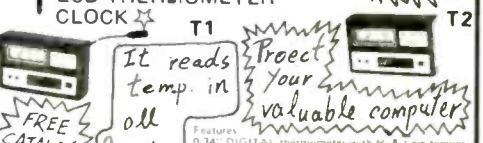

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0.34" DIGITAL thermometer with Hi & Low temperature alarm function and 12 hours clock combination
Measuring range 0°F to 160°F or 20°C to +70°C
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T2 with Fahrenheit Celsius measuring $19.80

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UPD70108-8	(8MHz) V20 Chip	$ 8.95
UPD70108-10	(10MHz) V20 Chip ~~$21.95~~	$14.95
UPD70116-8	(8MHz) V30 Chip	$11.95
UPD70116-10	(10MHz) V30 Chip ~~$24.95~~	$19.95

7400

Part No.	1-9	10+	Part No.	1-9	10+
7400	.29	.19	7485	.65	.55
7402	.29	.19	7486	.45	.35
7404	.29	.19	7489	2.95	1.95
7405	.35	.25	7490	.49	.39
7406	.39	.29	7493	.45	.35
7407	.39	.29	74121	.45	.35
7408	.35	.25	74123	.55	.45
7410	.29	.19	74125	.55	.45
7414	.49	.39	74126	.69	.59
7416	.39	.29	74143	3.95	3.85
7417	.39	.29	74150	1.35	1.25
7420	.35	.25	74154	1.35	1.25
7430	.35	.25	74156	~~1.59~~	.99
7432	.39	.29	74173	.85	.75
7438	.39	.29	74174	.59	.49
7442	.55	.45	74175	.59	.49
7445	.79	.69	74176	~~.99~~	.69
7446	.89	.79	74181	1.95	1.85
7447	.89	.79	74189	1.95	1.85
7448	2.05	1.95	74193	.79	.69
7472	.85	.79	74198	1.85	1.75
7473	.39	.29	74221	.99	.89
7474	.39	.29	74273	1.95	1.85
7475	.49	.39	74365	.65	.55
7476	.45	.35	74367	.65	.55

74LS

74LS00	.29	.19	74LS165	.75	.65
74LS02	.29	.19	74LS166	.99	.89
74LS04	.35	.25	74LS173	.59	.49
74LS05	.35	.25	74LS174	.49	.39
74LS06	1.09	.99	74LS175	.49	.39
74LS07	1.09	.99	74LS189	4.59	4.49
74LS08	.29	.19	74LS191	.59	.49
74LS10	.29	.19	74LS193	.79	.69
74LS14	.49	.39	74LS221	.69	.59
74LS27	.35	.25	74LS240	.69	.59
74LS30	.29	.19	74LS243	.69	.59
74LS32	.35	.25	74LS244	.69	.59
74LS42	.49	.39	74LS245	.89	.79
74LS47	.99	.89	74LS259	.99	.89
74LS73	.39	.29	74LS273	.89	.79
74LS74	.35	.25	74LS279	.49	.39
74LS75	.39	.29	74LS322	4.05	3.95
74LS76	.55	.45	74LS365	.49	.39
74LS85	.59	.49	74LS366	.49	.39
74LS86	.35	.25	74LS367	.49	.39
74LS90	.49	.39	74LS368	.49	.39
74LS93	.49	.39	74LS373	.79	.69
74LS123	.59	.49	74LS374	.79	.69
74LS125	.49	.39	74LS393	.89	.79
74LS138	.49	.39	74LS590	6.05	5.95
74LS139	.49	.39	74LS624	~~2.05~~	1.49
74LS154	1.09	.99	74LS629	2.95	2.85
74LS157	.45	.35	74LS640	1.09	.99
74LS158	.45	.35	74LS645	1.09	.99
74LS163	.59	.49	74LS670	1.09	.99
74LS164	.59	.49	74LS688	2.39	2.29

74S/PROMS*

74S00		.29	74S188*		1.49
74S04		.29	74S189		1.69
74S08		.35	74S196	~~2.49~~	1.49
74S10		.29	74S240		1.49
74S32		.35	74S244		1.49
74S74	~~.45~~	.25	74S253	~~.79~~	.49
74S85	~~1.79~~	1.19	74S287*		1.49
74S86		.49	74S288*		1.49
74S124	~~2.75~~	1.95	74S373		1.49
74S174		.79	74S374		1.49
74S175		.79	74S472*		2.95

74F

74F00		.29	74F139	~~.69~~	.59
74F04		.29	74F157	~~.69~~	.49
74F08		.29	74F193		2.95
74F10	~~.29~~	.25	74F240	~~.99~~	.69
74F32		.29	74F244		.99
74F74		.39	74F253	~~.89~~	.49
74F86	~~.99~~	.29	74F373		.99
74F138		.69	74F374		.99

CD—CMOS

CD4001		.19	CD4076		.59
CD4008	~~.69~~	.49	CD4081		.25
CD4011		.19	CD4082		.25
CD4013		.29	CD4093		.35
CD4016		.29	CD4094		.89
CD4017		.49	CD40103		2.49
CD4018		.59	CD40107	~~.49~~	.29
CD4020		.59	CD40109		.79
CD4024		.49	CD4510		.69
CD4027		.35	CD4511		.69
CD4030		.29	CD4520		.75
CD4040		.65	CD4522		.79
CD4049		.29	CD4538		.79
CD4050		.29	CD4541		.89
CD4051		.59	CD4543		.79
CD4052		.59	CD4553		4.95
CD4053		.59	CD4555		.79
CD4063		1.49	CD4559	~~7.95~~	4.95
CD4066		.29	CD4566	~~2.49~~	1.75
CD4067	~~1.95~~	1.49	CD4583	~~.89~~	.59
CD4069		.25	CD4584		.39
CD4070		.25	CD4585		.89
CD4071		.25	MC14411P		8.95
CD4072		.25	MC14490P		4.49

MICROPROCESSOR COMPONENTS

MISCELLANEOUS CHIPS

Part No.		Price
D765AC	~~4.95~~	3.95
WD9216	~~6.95~~	4.95
95H90	~~9.95~~	4.95

Z80, Z80A, Z80B SERIES

Z80	~~1.25~~	.99
Z80-CTC	~~1.79~~	.99
Z80-DART		4.95
Z80-PIO	~~1.79~~	.99
Z80A		1.69
Z80A-CTC		1.79
Z80A-DART		4.95
Z80A-PIO		1.69
Z80A-SIO/0		5.75
Z80B		3.49
Z80B-CTC		3.95
Z80B-PIO	~~4.29~~	3.95

6500/6800/68000 SER.

6502		2.65
65C02(CMOS)	~~8.95~~	7.75
6520		1.95
6522		3.95
6532	~~5.49~~	5.49
6551	~~4.49~~	2.95
65C802(CMOS)	~~19.95~~	15.95
6800		1.95
6802		3.95
6810		1.25
6821		1.75
6840	~~9.95~~	3.49

6500/6800/68000 Cont.

6845	~~8.95~~	2.95
6850		1.95
6852	~~1.49~~	.75
6854	~~1.49~~	1.19
MC68000L8	~~11.95~~	9.95
MC68000L10	~~13.95~~	11.95
MC68010L10	~~49.95~~	29.95
MC68020RC12B	~~169.95~~	99.95

8000 SERIES

8031		3.95
80C31		9.95
8035		1.95
8073		9.95
8080A	~~2.95~~	2.49
8085A		2.49
8086	~~5.95~~	4.95
8086-2		6.95
8087(5MHz)		129.95
8087-1(10MHz)		229.95
8087-2(8MHz)		159.95
8088	~~6.49~~	5.75
8088-2	~~8.95~~	7.75
8116		4.95
8155		2.49
8155-2		4.95
8156		3.95
8202	~~5.95~~	4.95
8203	~~9.95~~	6.95
8212		2.29
8224		2.25

8000 SERIES Cont.

8228		2.95
8237-5	~~4.95~~	4.49
8243	~~2.25~~	1.75
8250A		6.49
8250B (For IBM)		6.95
8251A		1.89
8253-5		1.95
8254		4.95
8255A-5		2.95
8259-5		2.25
8272	~~4.95~~	3.95
8279-5		2.95
8741		9.95
8742	~~29.95~~	19.95
8748 (25V)		7.95
8748H (HMOS) (21V)		9.95
8749		9.95
8751 (3.5 8MHz)		39.95
8751H (3.5 12MHz)		44.95
8755		14.95

DATA ACQUISITION

ADC0804LCN	~~3.49~~	2.79
ADC0808CCN		5.95
ADC0809CCN	~~3.95~~	3.69
ADC0816CCN	~~11.95~~	8.95
ADC1205CCJ-1		19.95
DAC0808LCN		1.95
DAC1008LCN		4.95
AY-3-1015D		4.95
AY-5-1013A		2.95

MICROPROCESSOR SALE!

Part No.		Price
8052AHBASIC	CPU w/BASIC Interprete*	$29.95
MC68008L8	32-Bit MPU (8-Bit Data Bus)	~~$16.95~~ $9.95
MC68701	8-Bit EPROM Microcomputer	$14.95
MC68705P3S	8-Bit EPROM Microcomputer	~~$14.95~~ $9.95
MC68705U3S	8-Bit EPROM Microcomputer	$10.95
80286-10	16-Bit Hi Performance MPU	$99.95
80287-8	Math Co-processor (8MHz)	$245.95
80287-10	Math Co-processor (10MHz)	$309.95
80387-16	Math Co-proc. (16MHz) GRID ARRAY	$494.95
80387-20	Math Co-proc. (20MHz) GRID ARRAY	$795.95

DYNAMIC RAMS

Part No.			Price
*4116-15	16,384 x 1	(150ns)	1.09
4128-20	131,072 x 1	(200ns) (Piggyback) ~~$25~~	2.75
*4164-100	65,536 x 1	(100ns)	4.25
*4164-120	65,536 x 1	(120ns)	3.75
*4164-150	65,536 x 1	(150ns)	3.25
*4164-200	65,536 x 1	(200ns)	2.75
*TMS4416-12	16,384 x 4	(120ns)	7.49
*41256-80	262,144 x 1	(80ns)	14.95
*41256-100	262,144 x 1	(100ns)	14.49
*41256-120	262,144 x 1	(120ns)	13.95
*41256-150	262,144 x 1	(150ns)	12.95
*50464-15	65,536 x 4	(150ns) (4464)	9.95
*511000P-10	1,048,576 x 1	(100ns) 1 Meg ~~49.95~~	39.95
*514256P-10	262,144 x 4	(100ns) 1 Meg	89.95

STATIC RAMS

*2016-12	2048 x 8	(120ns)		3.95
2018-45	2048 x 8	(45ns)	~~6.95~~	5.49
2102	1024 x 1	(350ns)		.89
2114N	1024 x 4	(450ns)		.99
2114N-2L	1024 x 4	(200ns) Low Power		1.49
21C14	1024 x 4	(200ns) (CMOS)		.49
5101	256 x 4	(450ns) CMOS		1.95
*6116P-3	2048 x 8	(150ns) CMOS		6.49
*6116LP-3	2048 x 8	(150ns) LP CMOS		6.95
*6264LP-12	8192 x 8	(120ns) LP CMOS		8.95
*6264P-15	8192 x 8	(150ns) CMOS		7.75
*6264LP-15	8192 x 8	(150ns) LP CMOS		8.75
6514	1024 x 4	(350ns) CMOS		3.49
*43256-15L	32,768 x 8	(150ns) Low Power		12.95

EPROMS

TMS2516	2048 x 8	(450ns) 25V		6.95
TMS2532	4096 x 8	(450ns) 25V	~~6.95~~	6.49
TMS2532A	4096 x 8	(450ns) 21V	~~5.95~~	4.49
TMS2564	8192 x 8	(450ns) 25V	~~7.95~~	7.95
TMS2716	2048 x 8	(450ns) 3 Voltage	~~9.95~~	6.95
1702A	256 x 8	(1µs)	~~7.95~~	4.95
2708	1024 x 8	(450ns)		4.95
2716	2048 x 8	(450ns) 25V		3.75
2716-1	2048 x 8	(350ns) 25V		4.25
27C16	2048 x 8	(450ns) 25V (CMOS)		5.49
2732	4096 x 8	(450ns) 25V		3.95
2732A-20	4096 x 8	(200ns) 21V		4.25
2732A-25	4096 x 8	(250ns) 21V		3.95
27C32	4096 x 8	(450ns) 25V (CMOS)		5.95
2764-20	8192 x 8	(200ns) 21V		4.25
2764-25	8192 x 8	(250ns) 21V		3.75
2764A-25	8192 x 8	(250ns) 12.5V		3.95
2764-45	8192 x 8	(450ns) 21V		2.95
27C64-15	8192 x 8	(150ns) 21V (CMOS)		6.49
27128-20	16,384 x 8	(200ns) 21V		6.95
27128-25	16,384 x 8	(250ns) 21V		5.95
27128A-25	16,384 x 8	(250ns) 12.5V		5.25
27C128-25	16,384 x 8	(250ns) 21V (CMOS)		6.95
27256-20	32,768 x 8	(200ns) 12.5V		6.95
27256-25	32,768 x 8	(250ns) 12.5V		5.95
27C256-25	32,768 x 8	(250ns) 12.5V (CMOS)		7.95
27512-20	65,536 x 8	(200ns) 12.5V		13.49
27512-25	65,536 x 8	(250ns) 12.5V		11.95
68764	8192 x 8	(450ns) 25V		13.95

EEPROMS

2816A-25	2048 x 8	(250ns) 5V Read/Write	5.95
2817A	2048 x 8	(350ns) 5V Read/Write	7.95
2865A	8192 x 8	(250ns) 5V Read/Write	9.95
52B13 (21V)	2048 x 8	(350ns) 5V Read Only	1.49

COMMODORE CHIPS

Part No.		Price
LAG570	~~10.95~~	9.95
WD1770	~~11.95~~	9.95
SI3052P	~~2.49~~	1.25
6502		2.65
6504A	~~1.95~~	1.19
6507	~~4.39~~	2.95
6510		9.95
6520		1.95
6522		3.95
6525	~~4.95~~	2.49
6526	~~14.95~~	12.95
6529		2.95
6532	~~6.49~~	5.49
6545-1	~~4.95~~	3.25
6551	~~4.49~~	2.95
6560		10.95
6567		19.95
6569	~~24.95~~	15.95
6572	~~8.95~~	6.95
6581 (12V)		14.95
6582 (9V)	~~14.95~~	6.95
8360		14.95
8501	~~10.95~~	8.95
8502	~~7.95~~	4.95
8563		15.95
8564	~~9.95~~	4.95
8566	~~24.95~~	15.95
8701		9.95
8721	~~14.95~~	11.95
8722	~~9.95~~	6.95
*251104-04	~~10.95~~	8.95
310654-05		9.95
318018-03	~~10.95~~	8.95
318019-03	~~10.95~~	8.95
318020-04	~~10.95~~	8.95
325302-01		10.95
325572-01		14.95
*82S100PLA**		15.95
901225-01	~~11.95~~	9.95
901226-01		11.95
901227-03		11.95
901229-05		11.95

*No specs available
**Note 82S100PLA U17 (C-64)

SPECIALS!

SMP81FY	Prec. Sample & Hold Amp	7.95
MAX232CPE	Dual RS232 Rec./Trans.	5.19
LM306P	Dual Comparator	.79
6116P-1	16K CMOS SRAM (100ns)	7.49
27128-45	128K EPROM (450ns) 21V	4.95
74LS612	Memory Mapper, Tri-State	7.95

74HC HI-SPEED CMOS

Part No.		Price	Part No.		Price
74HC00	~~.25~~	.19	74HC175	~~.69~~	.49
74HC02	~~.25~~	.19	74HC221	~~1.19~~	.89
74HC04	~~.29~~	.19	74HC240	~~.99~~	.69
74HC08	~~.29~~	.19	74HC244	~~1.~~	.69
74HC10	~~.29~~	.19	74HC245	~~1.~~	.79
74HC14	~~.49~~	.29	74HC253	~~.59~~	.39
74HC30	~~.29~~	.19	74HC259	~~.89~~	.39
74HC32	~~.29~~	.25	74HC273	~~.99~~	.69
74HC74	~~.39~~	.29	74HC373	~~.99~~	.65
74HC75	~~.39~~	.35	74HC374	~~.99~~	.65
74HC76	~~.45~~	.35	74HC595	~~1.29~~	1.09
74HC85	~~.79~~	.55	74HC688	~~.99~~	.79
74HC86	~~.39~~	.35	74HC943		8.95
74HC123	~~.89~~	.69	74HC4040	~~.99~~	.79
74HC125	~~.49~~	.39	74HC4049	~~.59~~	.39
74HC132	~~.59~~	.39	74HC4050	~~.59~~	.39
74HC138	~~.49~~	.39	74HC4060	~~.99~~	.89
74HC139	~~.49~~	.39	74HC4511	~~1.29~~	.99
74HC154	~~1.49~~	1.19	74HC4514	~~1.79~~	.99
74HC163	~~.65~~	.39	74HC4538		.89
74HC174	~~.69~~	.49	74HC4543	~~1.19~~	.89

74HCT — CMOS TTL

74HCT00	~~.29~~	.17	74HCT139	~~.59~~	.35
74HCT02	~~.29~~	.17	74HCT157	~~.59~~	.19
74HCT04	~~.29~~	.17	74HCT174	~~.69~~	.35
74HCT08	~~.29~~	.17	74HCT175	~~.69~~	.39
74HCT10	~~.29~~	.17	74HCT240	~~.99~~	.89
74HCT32	~~.29~~	.21	74HCT244	~~.99~~	.39
74HCT74	~~.49~~	.25	74HCT245	~~1.19~~	.79
74HCT86	~~.49~~	.19	74HCT373	~~1.19~~	.55
74HCT138	~~.59~~	.35	74HCT374	~~1.19~~	.49

74C—CMOS

74C00		.29	74C174		.79
74C02		.29	74C175		.79
74C04		.29	74C221		1.79
74C08		.35	74C240	~~1.79~~	.69
74C10	~~.35~~	.19	74C244		1.79
74C14		.59	74C373		1.95
74C32		.35	74C374		1.95
74C74		.59	74C912		8.95
74C85		1.49	74C915	~~1.99~~	.99
74C86		.35	74C920	~~6.95~~	4.95
74C89	~~5.49~~	3.95	74C921	~~6.95~~	4.95
74C90		.99	74C922		3.95
74C154		2.95	74C923		3.95
74C173	~~1.05~~	.59	74C925		5.95

LINEAR

DS0026CN		1.95	LM1458N		.39
TL074CN		1.19	LM1488N		.49
TL084CN		.99	DS14C88N (CMOS)		1.19
AF100-1CN		8.95	LM1489N		.49
LM307N		.45	DS14C89N (CMOS)		1.19
LM309K		1.25	LM1496N	~~.89~~	.69
LM311N		.45	MC1648P	~~3.49~~	1.95
LM317T		.79	LM1871N		1.95
LM318N		.99	LM1872N		1.95
LM319N		1.29	LM1896N-1	~~1.49~~	.79
LM323K		3.95	ULN2003A		.79
LM324N		.39	XR2206		3.95
LM338K		4.95	XR2211		2.95
LM339N		.39	XR2243		1.95
LF347N		1.79	26LS29	~~3.95~~	2.95
LM348N		.99	26LS31		1.19
LM350T		2.95	26LS32		1.19
LF351N		.39	26LS33		1.49
LF353N		.49	LM2901N	~~.99~~	.15
LF355N		.79	LM2907N		1.29
LF356N		.89	LM2917N (8 pin)		1.95
LF357N		1.09	MC3419CL	~~6.95~~	3.95
LM358N		.49	MC3446N	~~1.69~~	.99
LM360N		2.19	MC3450P	~~1.95~~	.49
LM361N		1.79	MC3470P		1.95
LM380N-8	~~.99~~	.85	MC3471P	~~1.95~~	.75
LM386N-3		.89	MC3479P		4.79
LM387N		.99	MC3486P		1.69
LM393N		.39	MC3487P	~~1.69~~	.99
LM399H		2.95	LM3900N		.49
LF411CN		.79	LM3905N		1.19
TL497ACN	~~1.49~~	.99	LM3909N		.99
NE540H (C540H)	~~2.95~~	1.49	LM3914N		1.95
NE555V		.29	LM3916N		1.95
XRL555		.59	NE5532		.69
LM556N		.49	NE5534		.69
NE558N		.89	7805K (LM340K-5)		1.29
LM565N		.99	7812K (LM340K-12)		1.29
LM567V		.79	7815K (LM340K-15)		1.29
NE592N	~~.89~~	.69	7805T (LM340T-5)		.49
LM741CN		.29	7812T (LM340T-12)		.49
LM747CN		.59	7815T (LM340T-15)		.49
MC1350P	~~1.89~~	.89	7905K (LM320K-5)	~~1.95~~	.99
MC1372P	~~1.95~~	.99	7905T (LM320T-5)		.59
MC1377P		2.29	75477	~~.59~~	.39
MC1398P	~~8.95~~	4.95	75478	~~.89~~	.49
LM1414N	~~1.29~~	.49	MC145106P	~~2.49~~	1.95
			MC145406P		2.95

IC SOCKETS

Low Profile		Wire Wrap (Gold) Level #3	
8LP	.11	8WW	.59
14LP	.12	14WW	.65
16LP	.13	16WW	.69
24LP	.25	24WW	1.19
28LP	.27	28WW	1.39
40LP	.29	40WW	1.89

Soldertail Standard (Gold & Tin) & Header Plug Sockets Also Available

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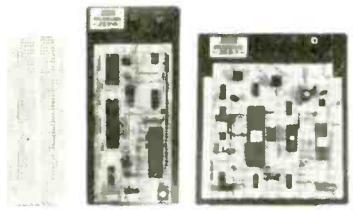
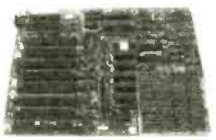


JE23 JE24 JE27

Part No.	Dim. L x W	Contact Points	Binding Posts	Price
JE20	6½ x ⅜	200	0	$ 2.29
JE21	3¼ x 2⅛	400	0	$ 4.49
JE22	6½ x 1⅜	630	0	$ 5.95
JE23	6½ x 2⅛	830	0	$ 7.49
JE24	6½ x 3⅛	1,360	2	$14.95
JE25	6½ x 4¼	1,660	3	$22.95
JE26	6⅞ x 5⅜	2,390	4	$27.95
JE27	7¼ x 7½	3,220	4	$37.95

Jameco's IBM PC/XT/AT Compatible Motherboards



JE1001

- Award BIOS ROMs included

JE1001	4.77/8MHz (PC/XT)	$ 99.95
JE1002	4.77/10MHz (PC/XT)	$119.95
JE1007	6/8/10/12MHz (AT)	$349.95

2 & 3MB Memory Expansion Cards for IBM AT and Compatibles

JE1082

JE1081	2MB of expanded or extended memory (zero-K on-board) (AT)	$119.95
JE1082	3MB of expanded or extended memory, parallel printer port, serial port and game port (zero K on-board) (AT)	$169.95

Jameco Computer Power Protection

JE1190

JE1190	Power Base	$29.95
JE1191	6-Outlet Power Strip	$11.95

IBM PC/XT/AT Compatible Keyboards

JE1016 Pictured

- Tactile touch keyswitches - Switch selectable between PC/XT or AT - Illuminated Caps Lock, Num Lock and Scroll Lock

JE1015 . . . . . $59.95

- Enhanced keyboard layout - Illuminated Num Lock, Caps Lock and Scroll Lock - Automatically switches between PC/XT or AT

JE1016 . . . . . $79.95

DATA BOOKS

400041	NSC Linear Data Book-Vol.I (87)	$14.95
400042	NSC Linear Data Book-Vol.II (87)	$ 9.95
400043	NSC Linear Data Book-Vol.III (87)	$ 9.95
210830	Intel Memory Handbook (87)	$17.95
230843	Intel Microsystem Hndbk. Set (87)	$24.95

Jameco's New and Improved AT Compatible Kit!

FREE! Word Processing Software! / ***Now*** with I/O Board!

IBM AT Compatible Kit

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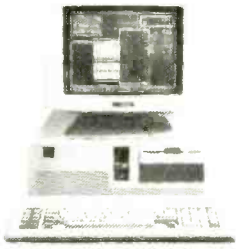
Now with FREE! QAPLUS Diagnostic Software!



JE1007	Baby AT Motherboard (Zero-K RAM — Includes Award BIOS ROMs)	$349.95
JE1015	XT/AT Style Keyboard	$ 59.95
JE1017	Baby AT Flip-Top Case	$ 69.95
JE1022	5¼" Hi-Density Disk Drive	$109.95
JE1032	200 Watt Power Supply	$ 89.95
JE1043	360K/720K/1.2M Floppy Controller Card	$ 49.95
JE1065	Input/Output Card	$59.95

Regular List $789.65

SAVE $99.70! JE1059 $519.95 (EGA Monitor and Card not included)

JE2009* IBM AT Compatible Kit. **$689.95**

JE286M JE2009 Technical Manual. $29.95

*RAM not included — Minimum RAM configuration 512K (18 Chips 41256-120, see left)

IBM COMPATIBLE DISPLAY MONITORS

12" Amber Monochrome — TTL Input, High Resolution (PC/XT/AT)

AMBER. . . . ~~$109.95~~ $99.95

14" RGB Color — CGA Compatible Amber/Green/Color Switchable, 640 x 200 Resolution (PC/XT/AT)

TTX1410. . . . . $279.95

TTX1410

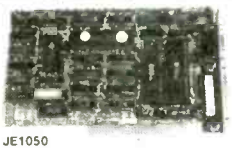
14" EGA Color - EGA/CGA Compat., 720 x 350 (max.) resolution (PC/XT/AT)

TE5154. . . . . $399.95

IBM PC/XT/AT COMPATIBLE CARDS

Graphic Display Cards

JE1059 EGA Card and Monitor $519.95



JE1050

JE1050	Mono Graphics Card w/Printer Port (PC/XT/AT)	$59.95
JE1052	Color Graphics Card w/Printer Port (PC/XT/AT)	$49.95
JE1055	EGA Card with 256K Video RAM (PC/XT/AT)	$169.95
JE1071	Multi I/O with Drive Controller and Mono Graphics (PC/XT)	$119.95

Multifunction, I/O and Expansion Cards

JE1060	I/O Card with Serial, Game, Parallel Printer Port and Real Time Clock (PC/XT)	$59.95
JE1061	RS232 Serial Half Card (PC/XT/AT)	$29.95
JE1065	I/O Card with Serial, Game and Parallel Printer Port (AT)	$59.95
JE1078	Expand to 384K (zero-K on-board) Multifunc. w/Serial, Game, Parallel Printer Port & Real Time Clock (PC/XT)	$69.95

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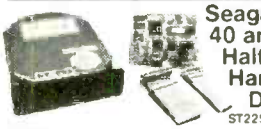
JE1040	360KB Floppy Disk Drive Controller Card (PC/XT)	$29.95
JE1041	20/40MB Hard Disk Controller Card (PC/XT)	$79.95
JE1042	30/60MB RLL Hard Disk Controller (PC/XT)	$99.95
JE1043	360K/720K/1.2MB Floppy Disk Cont. Card (PC/XT/AT)	$49.95
JE1045	360K/720K/1.2MB Floppy/Hard Disk Controller Card (AT)	$149.95

Additional Add-Ons Available!

COMPUTER PERIPHERALS

Seagate 20,30 40 and 60MB Half Height Hard Disk Drives



ST225XT (Pictured)

ST225	20MB Drive only (PC/XT/AT)	$224.95
ST225XT	20MB w/Controller (PC/XT)	$269.95
ST238	30MB Drive only (PC/XT/AT)	$249.95
ST238XT	30MB w/Controller (PC/XT)	$299.95
ST238AT	30MB w/Controller (AT)	$389.95
ST251	40MB Drive only (PC/XT/AT)	$429.95
ST251XT	40MB w/Cont. Card (PC/XT)	$469.95
ST251AT	40MB w/Controller Card (AT)	$539.95
ST277	60MB Drive only (PC/XT/AT)	$499.95
ST277AT	60MB w/Controller Card (AT)	$639.95

Jameco 5.25" PC/XT & AT Compatible Disk Drives

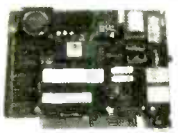
JE1022 (Pictured)

JE1020	360K Black Bzl. (PC/XT/AT)	$ 89.95
JE1021	360K Beige Bzl. (PC/XT/AT)	$ 89.95
JE1022	1.2MB Beige Bzl. (PC/XT/AT)	$109.95

Toshiba 3.5" PC/XT/AT Compatible Disk Drive

352KU 3.5" 720KB (Bezels and Installation Kit incl) (PC/XT/AT) . . . $129.95

2400/1200/300 Modems



Datatronics

- Hayes command compatible - Bell 103/212A compatible - Auto-dial/auto answer - FCC approved 1-year warranty - Includes MaxiMate Communication Software

1200H	1200/300 Baud Internal Modem	$ 69.95
2400S	2400/1200/300 Internal Modem	$139.95
1200C	1200/300 Baud External Modem	$119.95
2400E	2400/1200/300 External Modem	$179.95

Jameco Extended 80-Column Card for Apple *IIe*

- 80 Col /64K RAM - Doubles amount of data your Apple *IIe* can display as well as its memory capacity - Ideal for word processing - Complete with instructions

JE864 $39.95

ADD12 (Disk Drive II, II+, *IIe*) **$99.95**

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KD302 . . $27.95

Metex M4650:

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M4650 . . $89.95

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2114	1024x4	(450ns)	.99
2114L-2	1024x4	(200ns)(LOW POWER)	1.49
TMM2016-100	2048x8	(100ns)	1.95
HM6116-4	2048x8	(200ns)(CMOS)	1.79
HM6116-3	2048x8	(150ns)(CMOS)	1.85
HM6116LP-4	2048x8	(200ns)(CMOS)(LP)	1.85
HM6116LP-3	2048x8	(150ns)(CMOS)(LP)	1.90
HM6116LP-2	2048x8	(120ns)(CMOS)(LP)	2.45
HM6264LP-15	8192x8	(150ns)(CMOS)(LP)	3.95
HM6264LP-12	8192x8	(120ns)(CMOS)(LP)	4.49
HM43256LP-15	32768x8	(150ns)(CMOS)(LP)	12.95
HM43256LP-12	32768x8	(120ns)(CMOS)(LP)	14.95
HM43256LP-10	32768x8	(100ns)(CMOS)(LP)	19.95

DYNAMIC RAMS

4116-250	16384x1	(250ns)	.49
4116-200	16384x1	(200ns)	.89
4116-150	16384x1	(150ns)	.99
4116-120	16384x1	(120ns)	1.49
MK4332	32768x1	(200ns)	6.95
4164-150	65536x1	(150ns)	1.79
4164-120	65536x1	(120ns)	1.99
MCM6665	65536x1	(200ns)	1.95
TMS4164	65536x1	(150ns)	1.95
4164-REFRESH	65536x1	(150ns)(PIN 1 REFRESH)	2.95
TMS4416	16384x4	(150ns)	3.75
41128-150	131072x1	(150ns)	5.95
TMS4464-15	65536x4	(150ns)	4.95
41256-150	262144x1	(150ns)	3.95
41256-120	262144x1	(120ns)	4.95
41256-100	262144x1	(100ns)	5.49
HM51258-100	262144x1	(100ns)(CMOS)	6.95
1 MB-120	1048576x1	(120ns)	31.95
1 MB-100	1048576x1	(100ns)	34.95

EPROMS

2708	1024x8	(450ns)(25V)	4.95
2716	2048x8	(450ns)(25V)	3.49
2716-1	2048x8	(350ns)(25V)	3.95
TMS2532	4096x8	(450ns)(25V)	5.95
2732	4096x8	(450ns)(25V)	3.95
2732A	4096x8	(250ns)(21V)	3.95
2732A-2	4096x8	(200ns)(21V)	4.25
27C64	8192x8	(250ns)(12.5V CMOS)	4.95
2764	8192x8	(450ns)(12.5V)	3.49
2764-250	8192x8	(250ns)(12.5V)	3.69
2764-200	8192x8	(200ns)(12.5V)	4.25
MCM68766	8192x8	(350ns)(21V)(24 PIN)	15.95
27128	16384x8	(250ns)(12.5V)	4.25
27C256	32768x8	(250ns)(12.5V CMOS)	7.95
27256	32768x8	(250ns)(12.5V)	5.95
27512	65536x8	(250ns)(12.5V)	11.95
27C512	65536x8	(250ns)(12.5V CMOS)	12.95

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- 200 NS
- CMOS DESIGN FOR LOW POWER

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8031	3.95
8035	1.49
8039	1.95
8052AH BASIC	34.95
8080	2.49
8085	1.95
8086	6.49
8088	5.99
8088-2	7.95
8155	2.49
8155-2	3.95
8741	9.95
8748	7.95
8749	9.95
8755	14.95

8200

8203	14.95	8255-5	1.59
8205	3.29	8255	1.95
8212	1.49	8255-5	2.29
8216	1.49	8257	2.25
8224	2.25	8272	4.39
8228	2.25	8274	4.95
8237	9.95	8275	16.95
8237-5	4.75	8279	2.49
8243	1.95	8279-5	2.95
8250	6.95	8282	3.95
8251	1.29	8283	3.95
8251A	1.69	8284	2.25
8253	1.59	8286	3.95
8253-5	1.95	8287	3.95
8255	1.49	8288	4.95

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8087	5 MHz	$99.95
8087-2	8 MHz	$159.95
8087-1	10 MHz	$229.95
80287	6 MHz	$179.95
80287-8	8 MHz	$249.95
80287-10	10 MHz	$309.95
80387-16	16 MHz	$499.95
80387-20	20 MHz	$799.95

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74LS00

74LS00	16	74LS112	29	74LS241	69
74LS01	18	74LS122	45	74LS242	69
74LS02	17	74LS123	49	74LS243	69
74LS03	18	74LS124	2.75	74LS244	69
74LS04	16	74LS125	39	74LS245	79
74LS05	18	74LS126	39	74LS251	.49
74LS08	18	74LS132	39	74LS253	.49
74LS09	18	74LS133	49	74LS257	.39
74LS10	16	74LS136	39	74LS258	.49
74LS11	22	74LS138	39	74LS259	1.29
74LS12	22	74LS139	39	74LS260	.49
74LS13	26	74LS145	99	74LS266	.39
74LS14	39	74LS147	99	74LS273	.79
74LS15	26	74LS148	99	74LS279	.39
74LS20	17	74LS151	39	74LS280	1.98
74LS21	22	74LS153	39	74LS283	.59
74LS22	22	74LS154	1.49	74LS290	.89
74LS27	23	74LS155	59	74LS293	.89
74LS28	26	74LS156	49	74LS299	1.49
74LS30	17	74LS157	35	74LS322	3.95
74LS32	18	74LS158	29	74LS323	2.49
74LS33	28	74LS160	49	74LS365	.39
74LS37	26	74LS161	39	74LS367	.39
74LS38	26	74LS162	49	74LS368	.39
74LS42	39	74LS163	39	74LS373	.79
74LS47	75	74LS164	49	74LS374	.79
74LS48	85	74LS165	65	74LS375	.95
74LS51	17	74LS166	95	74LS377	.79
74LS73	29	74LS169	95	74LS390	1.19
74LS74	24	74LS173	49	74LS393	.79
74LS75	29	74LS174	39	74LS541	1.49
74LS76	29	74LS175	39	74LS624	1.95
74LS83	49	74LS191	49	74LS640	.99
74LS85	49	74LS192	69	74LS645	.99
74LS86	22	74LS193	69	74LS670	89
74LS90	39	74LS194	69	74LS682	3.20
74LS92	49	74LS195	69	74LS688	2.40
74LS93	39	74LS196	59	74LS783	22.95
74LS95	49	74LS197	59	25LS2521	2.80
74LS107	34	74LS221	59	26LS31	1.95
74LS109	36	74LS240	.69	26LS32	1.95

7400

7400	19	7437	49	7490	.39
7402	19	7438	29	7493	.35
7404	19	7442	49	74121	.29
7406	29	7445	69	74123	.49
7407	29	7447	89	74125	.45
7408	24	7473	.34	74150	1.35
7410	19	7474	.33	74151	.55
7411	.25	7475	.45	74153	.55
7414	.49	7476	.35	74154	1.49
7416	.25	7483	.50	74157	.55
7417	.25	7485	.59	74159	1.65
7420	.19	7486	.35	74161	.69
7430	.19	7489	2.15	74164	.85
7432	.29			74166	1.00
7438	.29			74175	.89
7442	.49			74367	.65

LINEAR

TL071	.69	LM567	.79
TL072	1.09	NE570	2.95
TL074	1.95	NE592	.98
TL082	.99	LM723	.49
TL084	1.49	LM733	.98
LM301	.34	LM741	.29
LM309K	1.25	LM747	.69
LM311	.59	MC1330	1.69
LM311H	.89	MC1350	1.19
LM317K	3.49	LM1458	.35
LM317T	.69	LM1488	.49
LM318	1.49	LM1489	.49
LM319	1.25	LM1496	.85
LM320 see7900		ULN2003	.79
LM323K	3.49	XR2206	3.95
LM324	.34	XR2211	2.95
LM331	3.95	LM2917	1.95
LM334	1.19	CA3046	.89
LM335	1.79	CA3146	1.29
LM336	2.75	MC3373	1.29
LM338K	4.49	MC3470	1.95
LM339	.59	MC3480	8.95
LM340 see7800		MC3487	2.95
LF353	.59	LM3900	.49
LF356	.99	LM3911	2.25
LF357	.99	LM3909	.98
LM358	.59	LM3914	1.89
LM380	.89	MC4024	3.49
LM383	1.95	MC4044	3.99
LM386	.89	RC4136	1.25
LM393	.45	RC4558	.69
LM394H	5.95	LM13600	1.49
TL494	4.20	75107	1.49
TL497	3.25	75110	1.95
NE555	.29	75150	1.95
NE556	.49	75154	1.95
NE558	.79	75188	1.25
NE564	1.95	75189	1.25
LM565	.95	75451	.39
LM566	1.49	75452	.39
NE590	2.50	75477	1.29

H TO-5 CAN, K TO 3, T TO-220

6500

1.0 MHz

6502		2.25
65C02	(CMOS)	7.95
6520		1.65
6522		2.95
6526		13.95
6532		5.95
6545		2.95
6551		2.95

2.0 MHz

6502A	2.69
6520A	2.95
6522A	5.95
6532A	11.95
6545A	3.95
6551A	6.95

3.0 MHz

6502B	4.25

6800

1.0 MHz

6800	1.95
6802	2.95
6803	3.95
6809	2.95
6809E	2.95
6810	1.95
6820	2.95
6821	1.25
6840	3.95
6843	4.95
6844	6.95
6845	2.75
6847	4.75
6850	1.95
6883	22.95

2.0 MHz

68B00	2.95
68B02	3.95
68B09E	5.49
68B09	5.99
68B21	1.85
68B45	4.95
68B50	1.75
68000	9.95

Z-80

2.5 MHz

Z80-CPU	1.25

4.0 MHz

Z80A-CPU	1.29
Z80A-CTC	1.69
Z80A-DART	5.95
Z80A-DMA	5.95
Z80A-PIO	1.89
Z80A-SIO 0	5.95
Z80A-SIO 1	5.95
Z80A-SIO 2	5.95

6.0 MHz

Z80B-CPU	2.75
Z80B-CTC	4.25
Z80B-PIO	4.25
Z80B-DART	6.95
Z80B-SIO 0	12.95
Z80B-SIO 2	12.95
Z8671 ZILOG	9.95

CLOCK CIRCUITS

MM58167	9.95
MM58174	9.95
MSM5832	2.95

BIT RATE GENERATORS

MC14411	9.95
BR1941	4.95
4702	9.95
COM8116	8.95

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ICL7107	10.95
ICL7660	1.99
ICL8038	3.85
ICM7207A	5.95
ICM7208	15.95

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1791	9.95
1793	9.95
1795	12.95
1797	12.95
2791	19.95
2793	19.95
2797	29.95
8272	4.39
UPD765	4.39
MB8876	12.95
MB8877	12.95
1691	6.95
2143	6.95
9216	6.29

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AY3-1015	4.95
TR1602	3.95
2651	4.95
IM6402	3.95
IM6403	9.95
INS8250	6.95
NS16450	10.95

MISC.

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ADC0809	3.85
DAC0800	3.29
DAC0808	1.95
DAC1022	5.95
MC1408L8	1.95
8T28	1.29
8T97	.59
DP8304	2.29
9334	1.75
9368	2.85
9602	.69
ULN2003	.79
MAX232	7.95
MC3470	1.95
MC3487	2.95
AY5-3600 PRO	11.95

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V20	8 MHz	10.95
V20	10 MHz	12.95
V30	8 MHz	13.95

Replaces 8088 to speed up PC 10-40

CRYSTALS

32.768 KHz	.95
1.0 MHz	2.95
1.8432	2.95
2.0	1.95
2.4576	1.95
3.579545	1.95
4.0	1.95
5.0	1.95
5.0688	1.95
6.0	1.95
6.144	1.95
8.0	1.95
10.0	1.95
10.738635	1.95
12.0	1.95
14.31818	1.95
16.0	1.95
18.0	1.95
18.432	1.95
20.0	1.95
22.1184	1.95
24.0	1.95
32.0	1.95

OSCILLATORS

1.0MHz	5.95
1.8432	5.95
2.0	5.95
2.4576	5.95
2.5	5.95
4.0	4.95
5.0688	4.95
6.0	4.95
6.144	4.95
8.0	4.95
10.0	4.95
12.0	4.95
16.0	4.95
18.432	4.95
20.0	4.95
24.0	4.95

PALS

16L8	$2.95
16R8	$2.95
16R6	$2.95
16R4	$2.95

74F/74S

74F00	.35
74F02	.35
74F04	.35
74F08	.35
74F10	.35
74F32	.35
74F64	.55
74F74	.39
74F86	.55
74F138	.79
74F139	.79
74F253	.89
74F157	.89
74F240	1.29
74S00	.29
74S02	.29
74S04	.29
74S08	.35
74S10	.29
74S32	.35
74S74	.49
74S86	.35
74S112	.50
74S124	2.75
74S138	.79
74S153	.79
74S157	.79
74S158	.95
74S163	1.29
74S175	.79
74S195	1.49
74S240	1.49
74S241	1.49
74S244	1.49
74S280	1.95
74S287	1.69
74S288	1.69
74S299	2.95
74S373	1.69
74S374	1.69
74S471	4.95
74S571	2.95

CMOS/HIGH SPEED CMOS

4001	.19	4066	.29	74HC154	1.09
4011	.19	4069	.19	74HC157	.55
4012	.25	4070	.29	74HC244	.85
4013	.35	4081	.22	74HC245	.85
4015	.29	4093	.49	74HC273	.69
4016	.29	14411	9.95	74HC373	.69
4017	.49	14433	14.95	74HC374	.69
4018	.69	14497	6.95	74HCT00	.25
4020	.59	4503	.49	74HCT02	.25
4021	.69	4511	.69	74HCT04	.27
4023	.25	4518	.85	74HCT08	.25
4024	.49	4528	.79	74HCT32	.27
4025	.25	4538	.95	74HCT74	.45
4027	.39	4702	9.95	74HCT138	.55
4028	.65	74HC00	.21	74HCT139	.55
4040	.69	74HC02	.21	74HCT161	.79
4042	.59	74HC04	.25	74HCT240	.89
4044	.69	74HC08	.25	74HCT244	.89
4046	.69	74HC10	.25	74HCT245	.99
4047	.69	74HC14	.35	74HCT273	.99
4049	.29	74HC32	.35	74HCT373	.99
4050	.29	74HC74	.35	74HCT374	.99
4051	.69	74HC86	.45	74HCT393	.99
4052	.69	74HC138	.45	74HCT4017	1.19
4053	.69	74HC139	.45	74HCT4040	.99
4060	.69	74HC151	.59	74HCT4060	1.49

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CIRCLE 113 ON FREE INFORMATION CARD

CAPACITORS

TANTALUM

1.0µ	15V	12	1.0µ	35V	45
6.8	15V	42	2.2	35V	19
10	15V	45	4.7	35V	39
22	15V	99	10	35V	69

DISC

10µ	50V	05	.001µ	50V	05
22	50V	05	.005	50V	05
33	50V	05	.01	50V	07
47	50V	05	.05	50V	07
100	50V	.05	1	12V	10
220	50V	.05	1	50V	12

MONOLITHIC

.01µ	50V	14	1µ	50V	18
.047µ	50V	15	4.7µ	50V	25

ELECTROLYTIC

RADIAL			AXIAL		
1µ	25V	14	1µ	50V	14
4.7	50V	11	10	50V	16
10	50V	11	22	16V	14
47	35V	13	47	50V	19
100	16V	15	100	35V	19
220	35V	20	470	50V	29
470	25V	30	1000	16V	29
2200	16V	70	2200	16V	70
4700	25V	1 45	4700	16V	1 25

VOLTAGE REGULATORS

7805T	49	7812K	1.39
7808T	49	7905K	1.69
7812T	49	7912K	1 49
7815T	49	78L05	49
7905T	59	78L12	49
7908T	59	79L05	69
7912T	59	79L12	1.49
7915T	59	LM323K	4.79
7805K	1.59	LM338K	6.95

DISCRETE

1N751	.15	4N28	69
1N414825	.10	4N33	.89
1N4004	.10	4N37	1 19
1N5402	.25	MCT-2	59
KBP02	.55	MCT-6	1.29
2N2222	.25	TIL-111	99
PN2222	.10	2N3906	10
2N2907	.25	2N4401	.25
2N3055	.79	2N4402	.25
2N3904	.10	2N4403	.25
4N26	.69	2N6045	1 75
4N27	.69	TIP31	49

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$49.95

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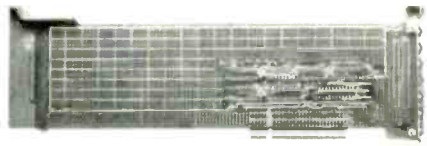
SILK SCREENED LEGENDS MOUNTING BRACKETS INCLUDED



FOR PS/2

JDF-PR32	32 BIT PROTOTYPE CARD	69.95
JDF-PR16	16 BIT CARD WITH I/O DECODING LAYOUT	49.95
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.01 µF	CERAMIC DISC	100	$5.00
.01 µF	MONOLITHIC	100	$10.00
1 µF	CERAMIC DISC	100	$6.50
1 µF	MONOLITHIC	100	$12.50

RESISTOR NETWORKS

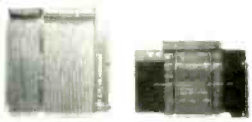
SIP	10 PIN	9 RESISTOR	.69
SIP	8 PIN	7 RESISTOR	59
DIP	16 PIN	8 RESISTOR	1.09
DIP	16 PIN	15 RESISTOR	1.09
DIP	14 PIN	7 RESISTOR	99
DIP	14 PIN	13 RESISTOR	99

SHORTING BLOCKS

5/$1.00

EXTENDER CARDS

FOR PROTOTYPE DEBUGGING AND TROUBLESHOOTING



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EXT-80286	FOR AT SYSTEM	39.95
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IDC CONNECTORS/RIBBON CABLE

DESCRIPTION	ORDER BY	CONTACTS 10	20	26	34	40	50
SOLDER HEADER	IDHxxS	82	1 29	1 68	2 20	2 58	3 24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1 35	1 76	2 31	2 72	3 39
WIREWRAP HEADER	IDHxxW	1 86	2 98	3 84	4 50	5 28	6 63
RIGHT ANGLE WIREWRAP HEADER	IDHxxWR	2 05	3 28	4 22	4 45	4 80	7 30
RIBBON HEADER SOCKET	IDSxx	.63	.89	.95	1 29	1 49	1 69
RIBBON HEADER	IDMxx	...	5 50	6 25	7 00	7 50	8 50
RIBBON EDGE CARD	IDExx	.85	1 25	1 35	1 75	2 05	2 45
10' GREY RIBBON CABLE	RCxx	1 60	3 20	4 10	5 40	6 40	7 50

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE CONNECTORS BELOW

3 VOLT LITHIUM BATTERY $1.95 HOLDER $1.49

SPECTRONICS CORPORATION EPROM ERASERS

Model	Timer	Chip Capacity	Intensity (mW Cm²)	Unit Cost
PE 14	NO	9	8,000	$89
PE 14T	YES	9	8,000	$139
PE 24T	YES	12	9,600	$189

D-SUBMINIATURE CONNECTORS

DESCRIPTION		ORDER BY	CONTACTS 9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	45	59	69	69	1 35	1.85
	FEMALE	DBxxS	49	69	75	75	1 39	2.29
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	49	69	...	79	2 27	...
	FEMALE	DBxxSR	55	75	...	85	2 49	...
WIREWRAP	MALE	DBxxPWW	1 69	2 56	...	3 89	5 60	...
	FEMALE	DBxxSWW	2 76	4 27	...	6 84	9 95	...
IDC RIBBON CABLE	MALE	IDBxxP	1 39	1 99	...	2 25	4 25	...
	FEMALE	IDBxxS	1 45	2.05	...	2 35	4 49	...
HOODS	METAL	MHOODxx	1 05	1 15	1.25	1 25	...	...
	GREY	HOODxx	.39	.39	...	.39	.69	.75

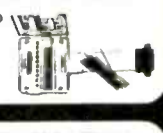
ORDERING INSTRUCTIONS
INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED xx OF THE ORDER BY PART NUMBER LISTED EXAMPLE A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB 15PR

MOUNTING HARDWARE 59¢

RS-232 BREAKOUT BOX

FOR TROUBLESHOOTING SERIAL COMMUNICATIONS

- OPEN/CLOSE INDIVIDUAL CIRCUITS
- 20 JUMPERS CROSS-CONNECT ANY TWO CIRCUITS
- 10 LEDS SHOW CIRCUIT ACTIVITY
- GENDER-BO 19.95



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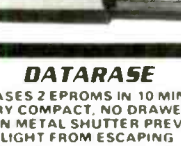

GENDER CHANGERS

FOR 25 PIN D-SUBMINIATURE CONNECTORS

GENDER-FF	FEMALE-FEMALE	7.95
GENDER-MM	MALE-MALE	7.95
GENDER-MF	MALE-FEMALE	7.95
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GENDER-JB	JUMPER BOX	8.95
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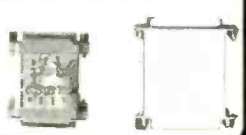

IC SOCKETS/DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 8	14	16	18	20	22	24	28	40
SOLDERTAIL SOCKETS	xxST	11	11	12	15	18	15	20	22	30
WIREWRAP SOCKETS	xxWW	59	69	69	99	1 09	1 39	1 49	1 69	99
ZIF SOCKETS	ZIFxx	...	4 95	4 95	...	5 95	...	5 95	6 95	9.95
TOOLED SOCKETS	AUGATxxST	62	79	89	1 09	1 29	1 39	1 49	1 69	2 49
TOOLED WW SOCKETS	AUGATxxWW	1 30	1 80	2 10	2 40	2 50	2.90	3 15	3 70	5.40
COMPONENT CARRIERS	ICCxx	49	59	69	99	99	99	99	1.09	1.49
DIP PLUGS (IDC)	IDPxx	95	49	59	1 29	1 49	...	85	1 49	1.59

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE CONNECTORS ABOVE

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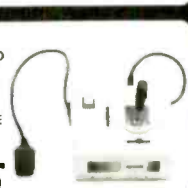

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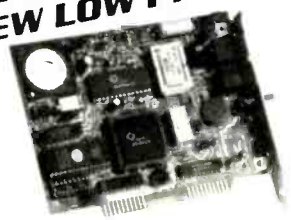

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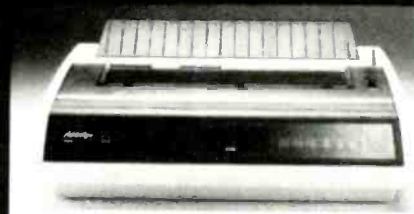
PS-200



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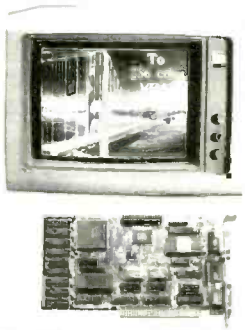

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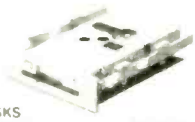

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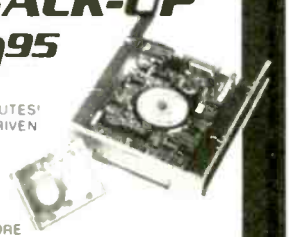

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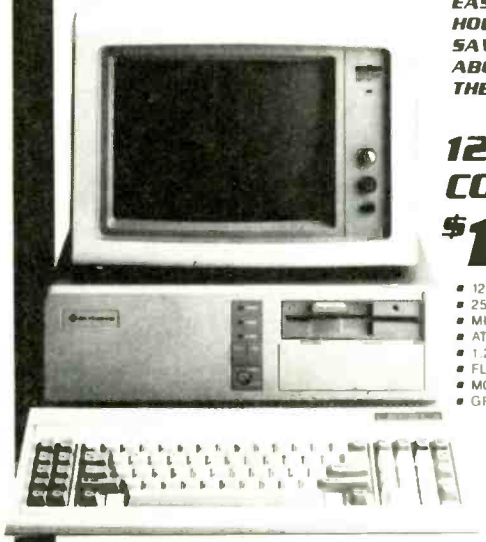

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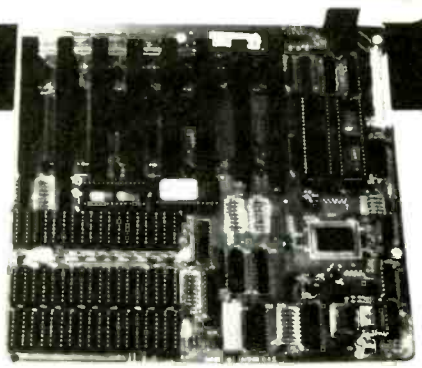

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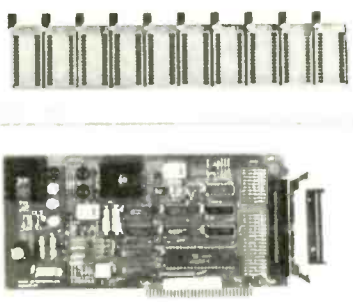

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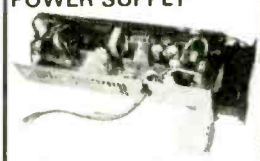

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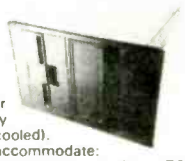

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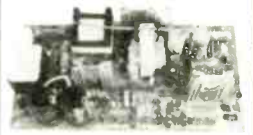

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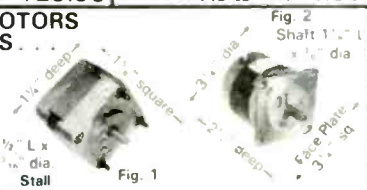

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12V @ 450Ma.
Contains 10 AA cells. Recharge rate: 45 ma. 16–18 hours.
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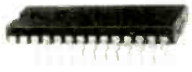

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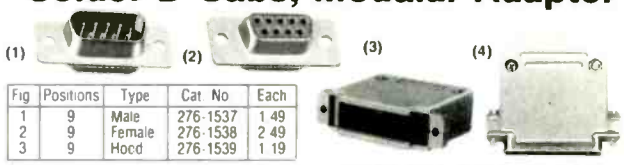

Fig	Positions	Type	Cat. No	Each
1	9	Male	276-1537	1.49
2	9	Female	276-1538	2.49
3	9	Hood	276-1539	1.19

Positions	Type	Cat. No	Each
25	Male	276-1547	1.99
25	Female	276-1548	2.99
25	Hood	276-1549	1.29

(4) RS-232 to Modular Jack Adapter. Connect computers and peripherals with inexpensive—or existing—phone wiring. Six-position. Ready for your custom hookup. **#276-1405** **2.99**

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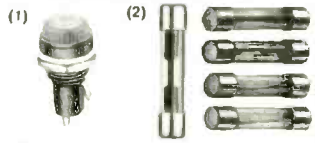

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- **High-Gain IC Design**

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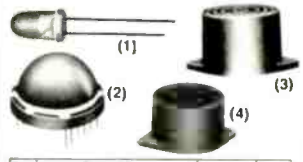
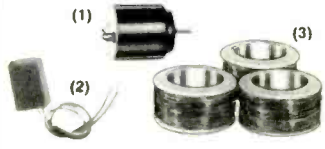


Fig	Description	Cat. No	Each
1	Super-Bright Red LED	276-066	1.19
2	Jumbo Red LED Display	276-064	3.49
3	Tri-Sound Siren	273-072	5.95
4	Electronic Chime	273-071	8.69

Hobby Bargains



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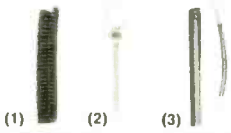

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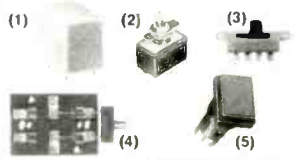

Fig	Item	Cat. No	Each
1	12VDC Relay	275-219	2.49
2	Toggle Switches (3)	275-322	2.69
3	Slide Switches (6)	275-327	1.99
4	DPDT Knife Switch	275-1537	1.29
5	Lighted Pushbutton	275-678	6.99

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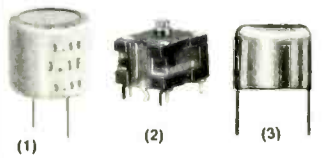

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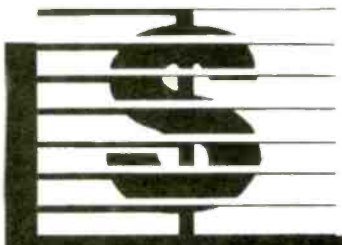

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7409N	48
7410N	43
7411N	60
7412N	60
7413N	72
7414N	1.00
7416N	60
7417N	60
7420N	43
7421N	52
7422N	60
7423N	60
7425N	60
7426N	60
7427N	60
7428N	60
7430N	43
7432N	60
7433N	60
7437N	60
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7489N	2.50
7490AN	1.00
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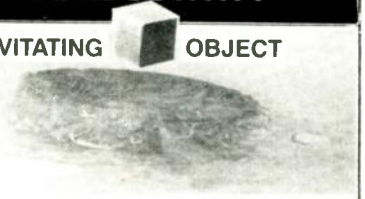

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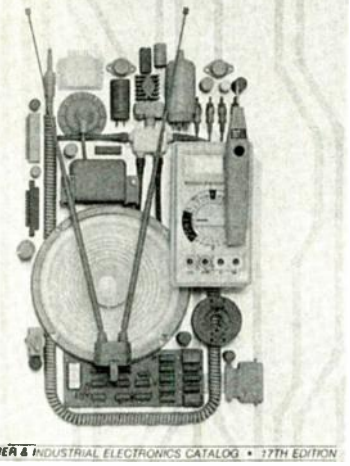

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Free Information Number		Page
81, 185	A.I.S. Satellite	44
203	ACS Supply	44
186	AMC Sales	15
—	AMCOM	100
107	All Electronics	114
—	Amazing Devices	100, 116
106	American Design Components	111
202	American Reliance	81
176	Banner Technical Books	77
98	Beckman Industrial	3
85	Blue Star Industries	44
109	C & S Sales	9
179	CEI	116
60	CIE	26
184	Chenesko Products	44
—	Command Productions	73
58	Cook's Institute	15
182	Crystek	73
201	DX Tele Labs	44
181	Daetron	77
205	Dakota Digital	44
127	Deco Industries	44
82	Digi-Key	115
204	Dynamic	95
—	Electronic Technology Today	13
121	Fluke Manufacturing	60
—	Fordham Radio	CV4
200	G.D.C. Computers	95
—	Grantham Col. of Engineering	72
86	Heath	15
65	J & W	56
59	JDR Instruments	7
113, 187	JDR Microdevices	106, 107
188, 189	JDR Microdevices	108, 109
190	JDR Microdevices	110
114	Jameco	104, 105
104	Jan Crystals	79
—	Joseph Electronics	31
183	Kelvin	74
191	Kikusui	65
87	MCM Electronics	113
53	MD Electronics	73
93	Mark V. Electronics	101
61	Microprocessors Unltd.	95
117	Mouser	77
198	Music Quest	95
—	NRI	16
—	Pacific Cable	99
196	PanaVise	11
56	Parts Express	103
68	Philips ECG	52
101	Pomona Electronics	32
—	RCA D&SP	5
78	Radio Shack	112
177, 178	Sencore	43, 14
74	Solid State Sales	102
—	Star Circuits	79
73	T S M	CV3
197	Talking Technology	95
92, 192	Tektronix	CV2, 21
193, 194	Tektronix	23, 25
66	Tools-4-U!	22
180	United Electronic Supply	76
195	WPT Publications	97
199	Z World	95

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	21	39	57	75	93	111	129	147	165	183	201	219	237	255	273
	22	40	58	76	94	112	130	148	166	184	202	220	238	256	274
	23	41	59	77	95	113	131	149	167	185	203	221	239	257	275
	24	42	60	78	96	114	132	150	168	186	204	222	240	258	276
	25	43	61	79	97	115	133	151	169	187	205	223	241	259	277
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11	29	47	65	83	101	119	137	155	173	191	209	227	245	263	281
12	30	48	66	84	102	120	138	156	174	192	210	228	246	264	282
13	31	49	67	85	103	121	139	157	175	193	211	229	247	265	283
14	32	50	68	86	104	122	140	158	176	194	212	230	248	266	284
15	33	51	69	87	105	123	141	159	177	195	213	231	249	267	285
16	34	52	70	88	106	124	142	160	178	196	214	232	250	268	286
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	22	40	58	76	94	112	130	148	166	184	202	220	238	256	274
	23	41	59	77	95	113	131	149	167	185	203	221	239	257	275
	24	42	60	78	96	114	132	150	168	186	204	222	240	258	276
	25	43	61	79	97	115	133	151	169	187	205	223	241	259	277
	26	44	62	80	98	116	134	152	170	188	206	224	242	260	278
9	27	45	63	81	99	117	135	153	171	189	207	225	243	261	279
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11	29	47	65	83	101	119	137	155	173	191	209	227	245	263	281
12	30	48	66	84	102	120	138	156	174	192	210	228	246	264	282
13	31	49	67	85	103	121	139	157	175	193	211	229	247	265	283
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15	33	51	69	87	105	123	141	159	177	195	213	231	249	267	285
16	34	52	70	88	106	124	142	160	178	196	214	232	250	268	286
17	35	53	71	89	107	125	143	161	179	197	215	233	251	269	287
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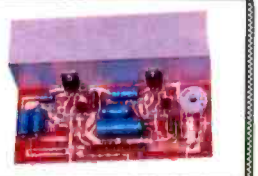

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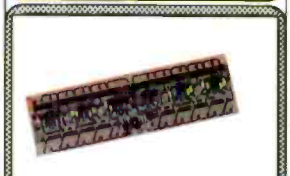
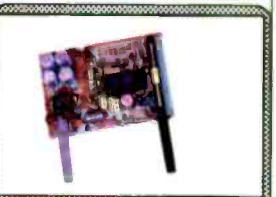


TSM 146 $33.99
STEREO 2X5 BANDS EQUALIZER , SUPPLIED WITH 10 POTENTIOMETERS, FREQUENCY RESPONSE 50HZ TO 15 KHZ,POWER SUPPLY 2 X 12V D.C./0.2A

TSM 147 $18.88
MONO 5 BANDS EQUALIZER ,SUPPLIED WITH 5 POTENTIOMETERS, FREQUENCY RESPONSE 50 HZ TO 15KHZ. POWER SUPPLY 2 X 12V D.C./0.15A.



TSM 61 $25.48
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TSM 158 $27.42
FM RECEIVER, OUTPUT 20 WATTS/8Ω POWER SUPPLY 12/16V D.C. /2A.

TSM 211 $10.00
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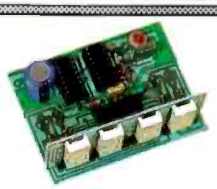
TSM 205 $35.40
FM RECEIVER, HEADPHONE STEREO OUTPUT POWER SUPPLY 9/12V D.C./0.1A



TSM 201 $26.77
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TSM 157 $40.00
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TSM 206 $10.15
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TSM 210 $10.50
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TSM 54 $13.85
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TSM 150 $82.50
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TSM 130 $26.77
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TSM 105 $15.15
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TSM 83 $38.77
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TSM 196 $19.71
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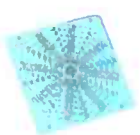

TSM 99 $130.00
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TSM 212 $17.50
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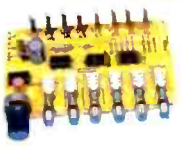
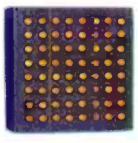


TSM 214 $20.50
8-CHANNEL CATERPILAR, SAFE LOW VOLTAGE OPERATION USING TSM 220 AND 221 SPCT., 9V D.C., 0.5 A



TSM 220 $25.30
64 LED'S SPOT FOR SAFE LIGHT MODULATION. SUPPLIED WITH BOX.

TSM 213 $16.20
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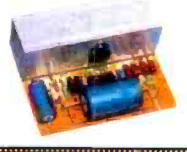
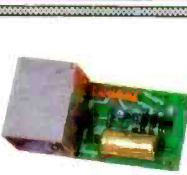
TSM 221 $17.20
25 LED'S SPOT FOR SAFE LIGHT MODULATION. SUPPLIED WITH BOX.



TSM 2 V2 $22.20
VARIABLE SOLID STATE REGULATED POWER SUPPLY 3V TO 38V/2A. TRANSFORMER IS NOT INCLUDED WITH THE KIT.



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