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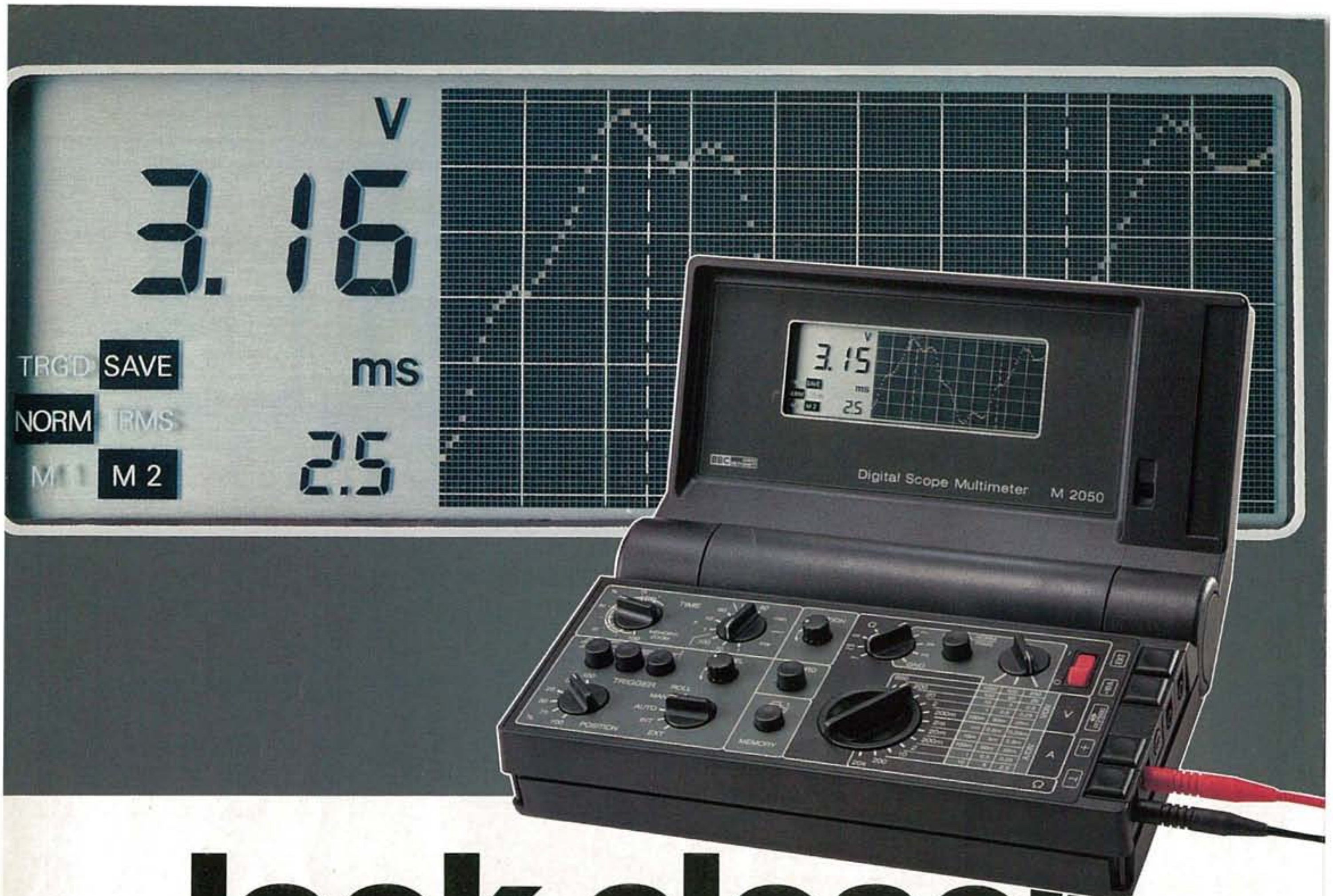

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MX3000

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NEW! Regency‡ MX3000

List price $299.95/**CE price $199.00**
6-Band, 30 Channel • No-crystal scanner
Search • Lockout • Priority • AC/DC
Bands: 30-50, 144-174, 440-512 MHz.
The *Regency* Touch MX3000 provides the ease of computer controlled, touch-entry programming in a compact-sized scanner for use at home or on the road. Enter your favorite public service frequencies by simply touching the numbered pressure pads. You'll even hear a "beep" tone that lets you know you've made contact.

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NEW! Regency® HX650

List price $119.95/**CE price $84.00**
5-Band, 6 Channel • Handheld crystal scanner
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Allow 120-240 days for delivery after receipt of order due to the high demand for this product.
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In addition to normal scanner listening, the MX7000 offers CB, VHF, and UHF TV audio, FM Broadcast, all aircraft bands (civil and military), 800 MHz communications, cellular telephone, and when connected to a printer or CRT, satellite weather pictures.

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NEW! JIL SX-100

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Regency® HX1000

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List price $329.95/**CE price $209.00**
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Search • Lockout • Priority • Scan delay
Sidelit liquid crystal display
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JANUARY 1984 Vol. 55 No. 1

ON THE COVER

As you are probably aware, stereo broadcasts are now legal on the AM band. Because of the FCC's "let-the-market-decide" approach, there are now four systems in competition. One that is very promising is Motorola's C-QUAM (*C*ompatible *Q*uadrature *A*mplitude *M*odulation) system. We'll take a look at Motorola's MC13020 decoder IC and build a stereo converter for your radio. The story begins on page 41.

The telephone shown above is the one that the now-famous words "Mr. Watson, come here, I want you" were spoken in 1876. Our look back at the telephone begins on page 47.

COMING NEXT MONTH
On Sale January 19

- **Cable-TV descrambling**
- **Digital voltmeter modules**

And lots more!

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VIDEO ELECTRONICS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

8-mm VIDEO

While Japanese manufacturers seemingly have sent the concept of 8-mm Video back to the drawing board (**Radio-Electronics,** December 1983), Europe's biggest consumer electronics manufacturer, Philips, has demonstrated a prototype and says its version will be on the market in Europe in the fall, in a combination camera-recorder unit that will sell for $1,500-$1,600, including all taxes. The camcorder, a PAL-SECAM unit, uses metal-evaporated tape in a cassette just about the size of an audio cassette. The camera-head is detachable from the recorder, with each unit weighing about 2.4 lb., and the battery, which can operate one hour per charge, weighs about ¾ lb., giving the system a total weight of 5.5 lb. That system weight is actually almost a pound heavier than the upcoming Video Movie camcorder, which uses a VHS-C 20-minute cassette.

Philips' cassette initially will be available in 30- and 60-minute versions, but the company says that future cassettes should have the capability to store at least three hours of video. The 8-mm camcorder has an electronic viewfinder, 6:1 power zoom, on-screen date insert, LCD tape counter, and fade and pause/still controls. The soundtrack is hi-fi FM, helically scanned mono, but future models are expected to have PCM digital stereo. The pickup is a 3/4-inch Newvicon, eventually to be replaced with a CCD image sensor. In separate packages are a combination AC power supply with RF modulator and battery charger, and a tuner-timer.

Japanese manufacturers have lost much of their original enthusiasm for the 8-mm Video standard—probably because sales of the current half-inch VCR's are so much better than they anticipated. As a result, they're looking with considerable favor upon a French proposal to re-engineer the standard using a baseband recording technique that would make possible recordings that could be played back in PAL, SECAM, or NTSC.

TV SETS FOR '84

The emphasis in 1984-model color-TV sets is on the "modified component" approach—tacit admission by many manufacturers that they guessed wrong last year by taking tuners (and sometimes loudspeakers) out of the sets and charging premium prices. There has been virtually no increase in the number of "true component" models offered; the trend now is definitely toward the monitor-receiver, which can be used as a stand-alone TV set or as the basic component in a home-video system. In other words, the approach is the one chosen by RCA as opposed to that selected by Zenith last year. Even such an esoteric brand as Proton is adding self-contained systems to its component lines.

The number of monitor-receivers — probably best defined as color sets with multi-inputs and at least one set of outputs — is growing by leaps and bounds; set sizes range from 4.6 to 25 inches. The trend for 1984 is to increase the number of input jacks, and to locate at least one pair at the front of the set, so devices may be connected temporarily without pulling the receiver out of a wall rack or cabinet. RGB jacks are finally becoming popular and are being added to models that didn't sport them last year — including those by Mitsubishi, NEC, Panasonic, Proton, Sanyo, Sony, and Zenith. Along with RGB inputs, more brands are offering higher-resolution pictures for computer monitoring.

VIDEODISC GAMES

The new sensation of the video arcade could spread to the home—at least videodisc-player manufacturers hope so. The first coin-operated videodisc arcade game to be widely distributed—*Dragon's Lair* by Cinematronics—has been an overnight success. The next is likely to be *Astron Belt* by Sega Entertainment.

Dragon's Lair uses animated footage and *Astron Belt* "live" material to add new realism and action to coin games. They both use microprocessor-equipped industrial optical videodisc players made by Pioneer, which at press time was having difficulty keeping up with orders. Cinematronics thinks there's a market for 20,000 to 30,000 *Dragon's Lair* games, but must be content to ship 200 to 400 daily (about half the number ordered) because of the shortage of disc players.

All of that is being watched closely by videogame, home computer, and videodisc manufacturers. Based on past experience in the videogame business that arcades spark demand for home products, the industry is working away furiously on game systems for the home that use videodiscs. And videodisc-player manufacturers, whose products have been selling none too briskly, are joining in the effort—with fingers crossed. **R-E**

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Single Sweep	—	—	Yes
Accuracy: Vert/Horz	3%	3%	2%
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WHAT'S NEWS

Flicker-free 3-D movies with new stereo system

Various "3-D" optical systems used in videogames, movies, etc., have shown weaknesses. Those using red-green eyeglasses limit the color spectrum and often cause eyestrain. Polarizing systems render color better but produce ghosting if the viewer's head is not kept rigidly vertical.

In a new system, originated by Stereographics Corp. of San Rafael, CA, glasses are used in which the left and right lenses are triggered alternately on and off in sync with the program source (video games, computer software, videotape, stereoscopic microscope, or video camera).

The stereoscopic program source is connected to a "black box", which decodes the image for each eye and keeps it in sync with the electro-optical shuttering glasses.

In earlier versions of the system, the glasses are connected to the black box by wire. In later systems, infrared rays or ultrasonic waves have been used experimentally.

New Tektronix shutter makes color from black and white

Tektronix announces that it plans to sell its new Liquid Crystal Color Shutter (LCCS) first demonstrated in May, 1983, on a contract basis to customers outside the company. The decision is based on a feeling that the cost-effective application of that color technology extends beyond the company's product lines.

With the new shutter, a monochrome display tube is used, preferably one whose output peaks in the red and green portions of the spectrum. It is activated in field-sequential manner, which is reminiscent of the old CBS color-television proposal.

The color shutter consists basically of a sandwich of special polarizers and Tektronix's proprietary liquid-crystal pi-cell, which acts as a switchable, red-green birefringent filter that switches between two states, the first allowing red to pass and then green. The alternate fields, viewed through the different colored polarizing filters, are integrated by the viewer's eye to produce color images. The full range of colors between red and green can be achieved through the varying intensity of the two primary colors—or in lower-cost instruments a simple three-color display (red, green, yellow) can be used.

Earlier attempts to produce a field-sequential system have not been entirely satisfactory, largely due to the long switching time of the cells available. The new Tektronix cell has a switching time between 2 and 5 milliseconds, as compared to tens of milliseconds in older types.

Cellular mobile radio approved in Pittsburgh

The first cellular mobile franchise was granted through a comparative hearing process to MCI Communications Corp. A construction permit for a system in Pittsburgh was awarded the company by an FCC judge, and MCI stated that it would begin operation as soon as it received authorization from the Pittsburgh Public Utilities Commission. "We should be operational by early 1984," said an MCI spokesman.

Cellular radio (**Radio-Electronics**, p. 41, Feb. 1982 and p. 6, July 1983) is a technology that permits "virtually unlimited" mobile and portable telephone service in an area. The FCC will allow two competitors in each market designated for cellular service.

MCI estimated that its construction costs will run over $7 million, and expects first year revenues to be nearly $1 million.

New electronic mail is faster and cheaper

MCI has introduced an electronic mail system that it claims is faster and can be as much as 90 percent cheaper than comparable time-sensitive mail services. The new service provides a variety of speeds and delivery systems, from "Instant," delivered electronically in seconds, to next-day delivery by local regular mail.

MCI Mail can be used with almost any personal computer, word processor, electronic typewriter, data terminal, Telex, or other digital communications device. The messages can be printed on laser-printed replicas of the customer's letterhead and signed with pre-registered, laser-printed signatures.

If the recipient has no terminal, the mail is routed via MCI's network to the MCI postal center nearest the recipient for laser printing and mail delivery.

There are four delivery and rate options:

Instant—from terminal to terminal via MCI's electronic mailbox, at a cost of about $1.00.

Four-hour—hard-copy delivery by courier anywhere within the metropolitan areas of 15 major cities. Cost for that service is about $25.00.

Overnight—(by noon). Delivery by courier in 20,000 continental U.S. cities. Cost, about $6.00.

MCI letter—Transmitted electronically to the nearest MCI postal center, then delivered via local mail service. Cost, about $2.00.

512-kilobit memory IC developed by IBM

An experimental version of a new computer-memory IC with a capacity of 512 Kilobits was announced by IBM this past October. The new IC is said to be the biggest single product in the history of microelectronics.

The new IC, if found to be adaptable to mass production, will be most useful in large-scale systems like IBM's 308X line, which are capable of executing up to 23 million instructions a second.

A new "square look" for RCA picture tubes

RCA announces that it is developing several new sizes of color-picture tubes that will provide squarer screens and a "new look" for future TV receivers. The new tubes will come out in 26-inch, 20-inch, 16-inch, and 14-inch, (diagonal) picture sizes.

Existing picture tubes—in 13, 15, 19, and 25-inch sizes—are so designed as to curve inward at the sides and round off the corners of the viewing screen. That reduces the sharpness in the corners of the picture. The new "full square" tube provides a more pleasing rectangular picture, with greater picture area to enhance television viewing.

The new tubes will be available for sale to TV receiver manufacturers beginning in 1984. **R-E**

Radio-Electronics

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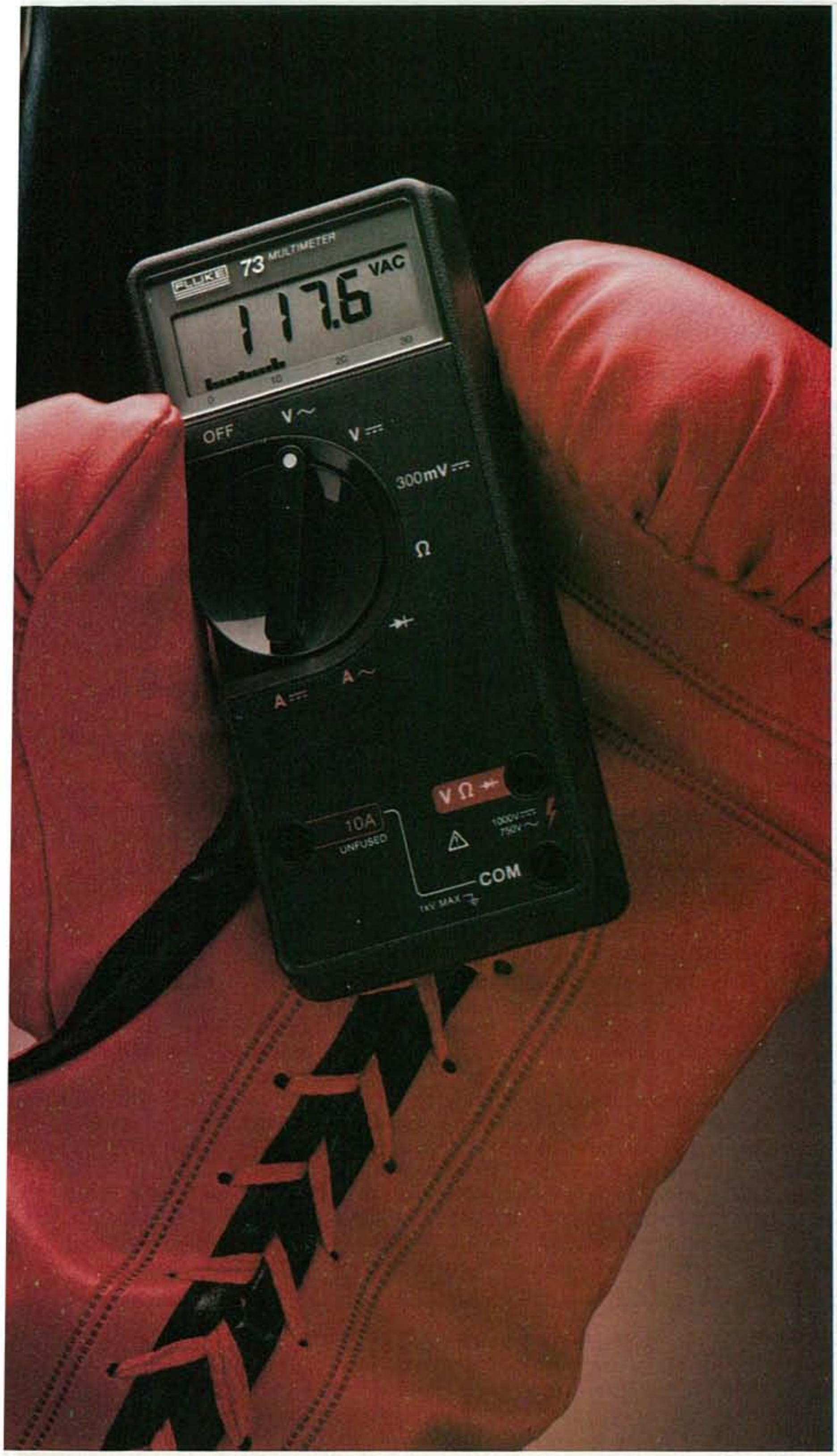

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		Multipurpose holster

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SATELLITE/TELETEXT NEWS

GARY ARLEN
CONTRIBUTING EDITOR

TRANSTEXT TO OFFER SERVICES

"Transtext"—a hybrid telephone-cable TV package offering home banking, shopping, information retrieval, energy management, security and other two-way services through a "gray box"—will be tested early next year. More than a dozen major companies, including Southern Bell Telephone, Georgia Power, a data-management company, cable-TV operators, and a home-computer retailer, are taking part in the experiment, which is being set up in a suburban Atlanta community.

The Transtext system includes delivery of video still-frames on demand when a customer pushes buttons on his telephone keypad; images are delivered via the cable-TV hook-up into a standard TV set. Conventional teletext information plus other sophisticated interactive services will be part of the package being tested, with an eye toward future national service possibly by next year (1985). Energy companies are interested in Transtext because the system can handle meter reading plus peak-load management.

Transtext is said to include a "breakthrough" facility that allows users to capture and manipulate video material that is fed through a one-way cable channel for downstream delivery; a telephone-line hookup is used for upstream transmission. At the technological heart of the system is a "superswitch gateway," which is an upgraded version of the Local Area Data Transport (LADT) packet-switched network being used for the south Florida Viewtron service. The companies setting up Transtext characterize it as an enhancement of current videotex/teletext projects offered in a lower-priced package.

TELETEXT-CAPABLE SETS

Matsushita, unveiling its first line of digital TV sets, which will be sold in the U.S. under the Panasonic label by late 1984, has put an unusual emphasis on the equipment's capacity to display videotex/teletext signals. One of the new Panasonic units is a collapsible, portable unit being promoted as a display terminal for videotex and other video-information services. Pricing and distribution plans have not been completed.

The 6.6-pound portable unit has a 6.3-inch projection-TV display screen. The digital technology will presumably deliver a sharper image when the unit is hooked into a videotex or teletext circuit.

Sony has also published a product-availability list for its line of videotex and teletext equipment to be sold in the U.S. during the coming year. The basic Prestel videotex terminal costs $912, with optional additions of a $280 full keyboard (as opposed to the small keypad that comes with the basic terminal) and a $560 black-and-white printer. Sony's NAPLPS videotex decoder will cost $975; the NABTS teletext decoder costs $950. There are no prices yet for the optional items that Sony plans to add to its NAPLPS format videotex items, such as a remote commander, optional keypad, and full keyboard. Prices are expected to drop dramatically after the first round of equipment is introduced.

SUPERSTATION SATELLITE

The European Broadcasting Union plans to launch a multinational satellite superstation during 1984 that will become a commercial TV programming service with up to five hours a night of programming. The European superstation will be beamed from Holland's transponder on the European Communications Satellite. The Pan-European Broadcast Satellite will include programming from England, West Germany, Sweden, Italy, Holland, Ireland, and Switzerland. EBU expects that the satellite broadcasting project may help European viewers bypass the cable TV systems that are now being built or planned in many European countries—an issue that is sure to raise political problems. Plans also call for commercials on the satellite service, a fairly unusual situation in Europe, where commercials are rare on the government owned broadcast TV channels.

AROUND THE SATELLITE CIRCUIT

AT&T has launched the first of its three Telstar 3 domestic satelites, with two others due to go up on the space shuttle in 1984 and 1985. Each bird will have 30 transponders.

RCA Astro-Electronics will build three high-powered Ku-band DBS satellites for sister company RCA Americom, at a total cost of more than $120 million. The first of this new generation is due to be launched in 1985, with all three slated for orbit by 1987. **R-E**

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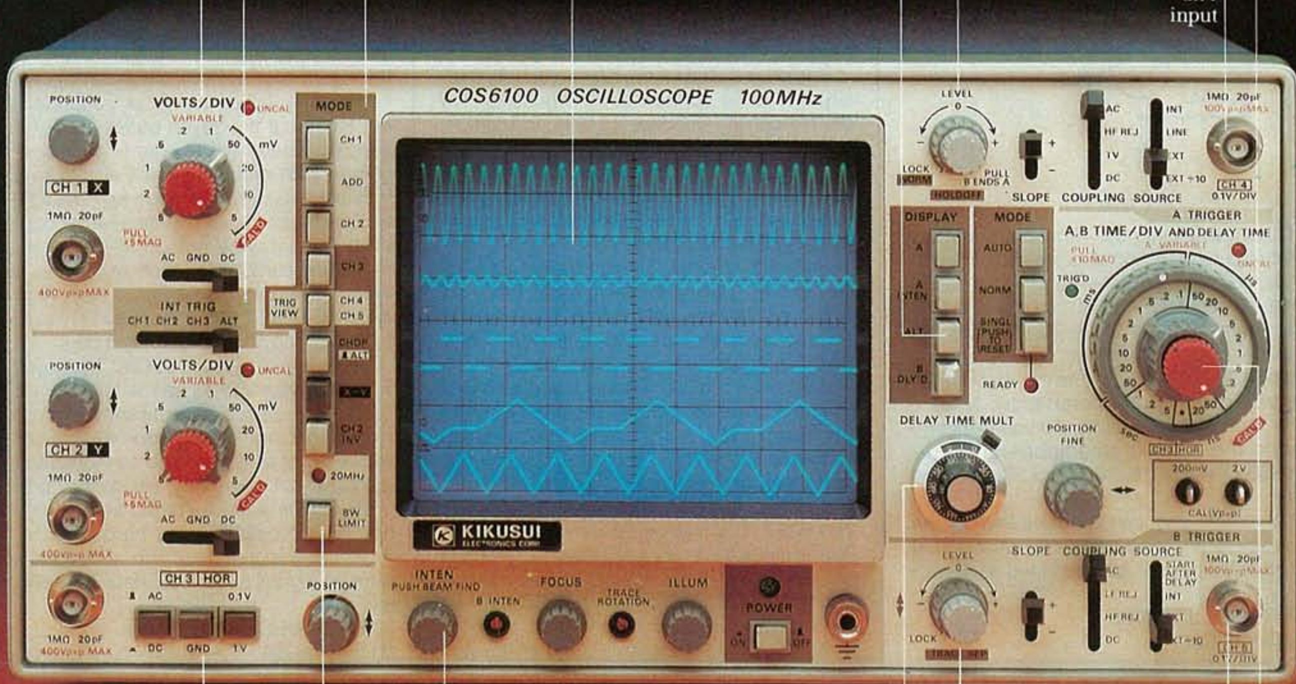

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LETTERS

Address your comments to: Letters, **Radio-Electronics,** 200 Park Avenue South, New York, NY 10003

VOLTAGE-REGULATOR CIRCUIT

I would like to comment on the high-current voltage-regulator circuit that Robert Grossblatt presented in the "Drawing Board" department, for July 1983. Although Mr. Grossblatt's circuit certainly works, it suffers from two drawbacks: First, it uses two expensive PNP power transistors, and, second, it is more complex than it needs to be.

National Semiconductor's *Voltage Regulator Handbook* suggests the following circuit (Fig. 1).

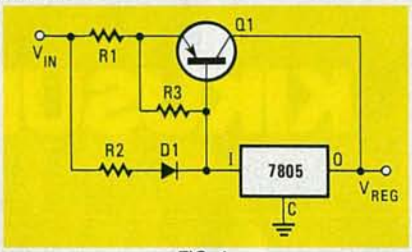


FIG. 1

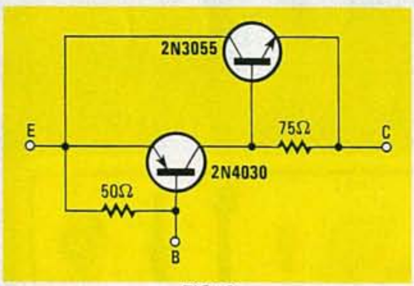


FIG. 2

This circuit uses the regulator's internal short-circuit protection to protect the transistor as well. The current through Q1 is R2/R1 times the regulator current, so the short-circuit current through Q1 is R2/R1 times the regulator's short-circuit current. Assuming appropriate heat-sinking, the regulator's thermal protection will also be extended to Q1.

For typical applications, National recommends the following components; Q1—2N4398, D1—IN4719, R2/R1≥3, R3—5 to 10 ohms.

Instead of using the expensive PNP power transistor, a small PNP transistor and an NPN power transistor can be combined as shown in Fig. 2.

LAWRENCE J. JONES
Cincinnati, OH

The short-circuit protection in the 7805 was designed to handle the current capabilities of the 7805. Aside from dunking it in liquid nitrogen, you must have external protection if you use a pass transistor to increase the current. The circuit you sent will dump all *the short-circuit current through the chip's internal protection and, believe me, you'll fry the chip ... absolutely. You must provide another path for the excess current, as I did with Q2. The capacitors I indicate are needed for obvious reasons, and I can only assume that you left them out to make the drawing simpler. The same goes for the diode, D1, I used to protect against an input short.*

As far as expense goes, the transistors needed only have to handle the current generated by the circuit that I developed, and you can get them for under $1.00—about the same cost as the transistor you showed in your drawing. In any event, expense is a minor factor if the circuit cashes in the first time you have a short circuit. Remember— always *design for* worst case *operation, because Murphy's Law shows clearly that pessimism can save you a lot of time and money.*
ROBERT GROSSBLATT

THE KAYPRO II

I was very interested in reading your review of the *Kaypro II* portable computer in the April 1983 **Radio-Electronics**. Having just sold my Osborne so that I might get the *Kaypro II*, I expected the review to confirm my good judgment. Instead, I was amazed at the very superficial coverage of a most excellent product.

The price stated for the Kaypro double density, $1795, is correct; but the price for the double-density Osborne is $1995. In addition, you must add $250 for the 80-line conversion, plus about $150 for a monitor big enough to see, plus $40 for a connector—bringing the total to $2185, or about $400 more for a somewhat similar product.

Software includes, as stated, *Perfect Writer, Speller, Calc,* and *Filer; Profit Plan,* an extremely flexible calculating spreadsheet and table maker; S-BASIC, a translator of a BASIC programs into machine language, so that they can run many times faster, and CP/M. Not advertised, but also included with the CP/M, are DDT, a well-known program debugger, and XAMN, a progam to examine a faulty disk and salvage it and the program. Also included are Microsoft's BASIC-80 and *The Word Plus.* Wayne Holder's The WORD Plus is fantastic; it has a 45,000-word dictionary, and a small-file specialty dictionary. It also has a word count, hyphen helper, a "in-context" one line viewer, plus FIND (h?t?o?s = hotdogs) and Anagrams. One of the advantages of the four Perfect programs is that they have a common keyboard language. You don't have to relearn for each program, and they can also co-mingle in the same edited product. Also included are about a dozen choice games that my kids enjoy and, I must confess, have been known to entrap me, too.

Your reviewer's comment that the *Kaypro II* "falls down on screen usability" would be good for a laugh if he were not serious. After using that "scrolling postage stamp" on the Osborne, he has to be kidding! As for the "green on green", has he never heard of a blanking-level adjustment? Every CRT has one; some use it for a brightness control (cheap design). Kaypro has a true video-level adjustment, and the blanking level is an internal pot. Maybe that is why he sometimes sees noise. It will take his service man about three minutes to adjust. His "soft-touch" keyboard complaint just is not valid. He just plain hasn't gotten used to things other than his 1936 Underwood. The Keytronics keyboard is used on some of the most expensive units around. And what's that "outer glass defeats the matte finish on the inner surface" that he talks about? All CRT's have bonded safety glass; there is no "inner-outer glass". RF noise? A high-resolution system means fast risetimes, infinitely rich in odd harmonics. And that CRT screen is a big window for them to get out of. I've designed high-rise monitors for the military ... shielding is a very tough problem. Who wants mesh screens over the face of the CRT?

Getting down to the nitty-gritty of what a computer is all about, why couldn't the reviewer point out the split-screen capability? The screens can scroll independently, and in the spreadsheet mode they can also scroll horizontally, either locked or separate. Why not tell about the seven-buffer capacity that keeps different files at your fingertips, doing its own auto-swapping to the disk to keep up with your usage? It makes any multiple-file work easy, and I can't name another computer that has it. Why not tell how easy it is to move the cursor, by letter, word, line, sentence, paragraph, screen, or file? Why not describe how easy it is to delete? I'm at a loss to think of anything that it can't do.

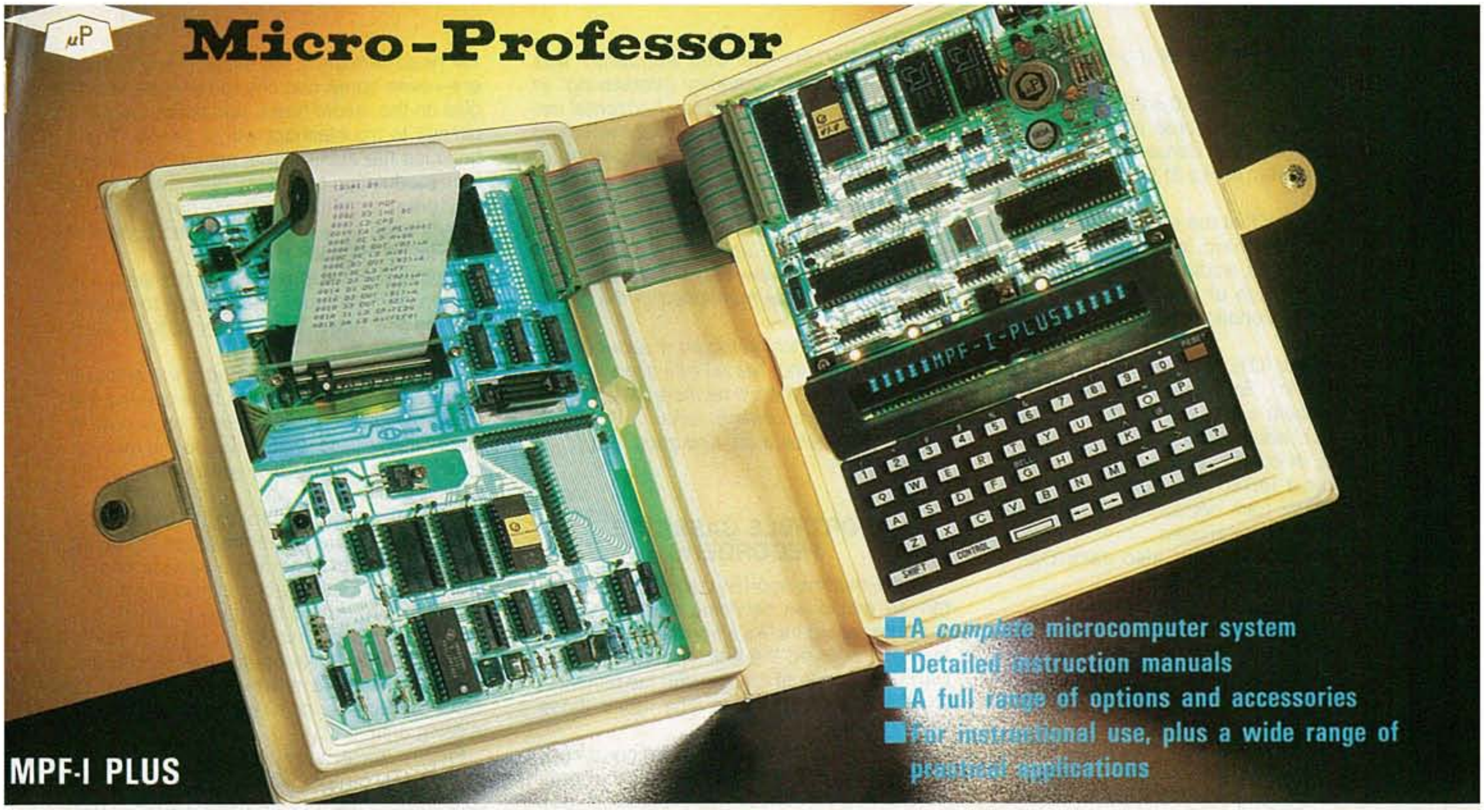
The computer is easy to use. The keyboard will sit in your lap. It has a telephone-type coiled cord ... not a cable off some power tool. How about not having your desk cluttered with wires of all types? The connectors are at the back, out of the way, where they belong.

Mr. Osborne really started something. But now the competition will be hard to catch. The *Kaypro II* is a great machine, with great software, at a great price. Let's hear it like it *really* is!

HARVEY DEGERING
Pasadena, CA

HORIZONTAL/VERTICAL OSCILLATORS

I have read most of your June 1983 issue with interest. However, I believe that Jack Darr has a problem on page 98 ("Service Clinic") wherein he says: "Since the horizontal-sync



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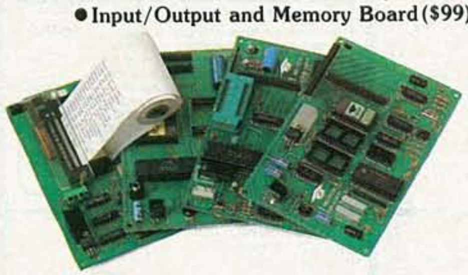

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CIRCLE 16 ON FREE INFORMATION CARD

frequency is a multiple of the vertical-sync frequency ...".

The ratio of 15,750 to 60 is 262.5, of course, and cannot be considered compatible with counting. When I first derived a raster in the late 40's, I started with a 31,500-cycle oscillator.

Next he says that the system uses no oscillators. Without them, in the absence of signals, the sweeps would collapse and there would be no high or boost voltages. That would not be conducive to well-being, methinks.

Perhaps the IC is doing something that it is not telling him. For example, phase-locked loops are built using the oscillator, phase comparator, and counters for multiple outputs. And, of course, they will lock a 31,500 oscillator to a 15,750 sync pulse ...

Incidentally, I am not acquainted with the circuits to which he alluded.

I like your magazine, also Jack Darr's items.

L.D. SMITHEY,
Pacific Palisades, CA

Dear Mr. Smithley:

Thank you for your letter. I'll give you one: I did say "No horizontal/vertical oscillators." There aren't any discrete oscillators as we used to have, but there would have to be some kind of "keep alive" circuit in there to make a raster with no signal. I should have made that plainer.

The horizontal frequency is a multiple of the vertical-sync frequency. In fact, in a color set, everything is a multiple of the horizontal frequency! Even the "3.58" MHz color oscillator, which isn't 3.58, but is rounded off from 3.574595 MHz. That odd frequency was chosen to allow "frequency interleaving" in the composite TV signal; the horizontal frequency isn't 15,750 any more but something like 15,749 or so (I can never remember it!) Vertical frequency is now 59.94 Hz—not even a nice 60. Hz. Same reason. So, the countdown IC's can divide or multiply those oddballs and come up with the proper frequencies for the sweep. I know that it does work, and the tests mentioned in the article are valid.

Thanks for catching the error about no oscillators. One other reader has already mentioned that, and there'll be more. Keep those cards and letters coming, folks.

Hope that helps a bit, and good luck.

JACK DARR

PORTABLE CASSETTE RECORDERS

Some months ago (September 1982), you ran an article on servicing small, portable cassette recorders. As a service technician, I read and enjoyed the article, but there were two important parts missing. For the benefit of other service technicians who repair those little horrors, here they are:

First, you have a recorder which plays back perfectly, but will not record at all, or records weakly and distortedly. If everything else checks out OK, change the head; that usually cures the complaint. Use a scope to check the signal on the head terminals.

Some of the cheaper recorders use DC for recording bias, as well as for erasing. Those are easy to troubleshoot—the scope clearly shows the presence or absence of signal at the head terminals. However, many recorders—even some real cheapies—use AC HF bias on the record head, and those are more difficult to troubleshoot with a scope. That's because the audio signal appears as amplitude modulation on the HF bias, and not with any great amplitude either—but it can be clearly seen as a ripple on top and bottom of the steady-state HF bias.

That is sufficient to modulate the tape, and if seen on a recorder that refuses to record, change the head. That cures 95% of such complaints.

Another fault not mentioned in the article is when a recorder winds the tape around the drive spindle or simply spews tape out. In nearly every case, that is due to the take-up spool either turning the wrong way or not turning at all.

When the spool is turning the wrong way, that is always due to the drive belt, replaced by the customer (and some service shops, too), passing on the wrong side of the pulley, which, in turn, drives the take-up spool. Before putting a tape into the recorder, check to be sure that the take-up spindle turns counter-clockwise. It is a very easy mistake to make if a recorder comes in with a broken or missing drive belt.

Finally, here is another hint: The long changeover switch, which operates on "record", is a source of trouble as well. If you have a recorder that is unstable (and even expensive machines are prone to that trouble), just try a good dose of contact cleaner to the switch. In probably 75% of cases, that will solve the problem.

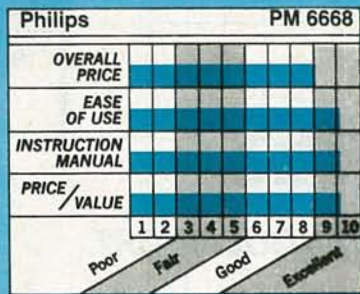
D.J. BRUYNS
Rep. of South Africa

R-E

EQUIPMENT REPORTS

Philips Model PM 6668 High-Resolution Frequency Counter

CIRCLE 101 ON FREE INFORMATION CARD



JUST BY LOOKING AT THE *PM 6668*, YOU might not think that there was anything special about it. It's packed in a gray plastic cabinet and its uncluttered front panel has only three controls and two input jacks. However, that frequency counter from Philips Test and Measuring Instruments, Inc. (85 McKee Drive, Mahwah, NJ 07430) proves that looks can indeed be deceiving.

Its 8048 microprocessor is what sets it apart from the run-of-the-mill counter. But before we talk about how the *PM 6668* uses the microprocessor, let's take a look at the front panel in more detail to get an idea of the counter's functions.

Controls

As we mentioned previously, there are only three front-panel controls, one of which is a pushbutton POWER switch. Next to that is another pushbutton switch labeled MEASUREMENT RATE. You have a choice of two rates. The first, NORMAL, sets the measurement rate to about one measurement-per-second. The FAST mode sets the rate to about five measurements-per second (one measurement every 200 ms). The fast mode can be used when measuring quickly changing frequencies.

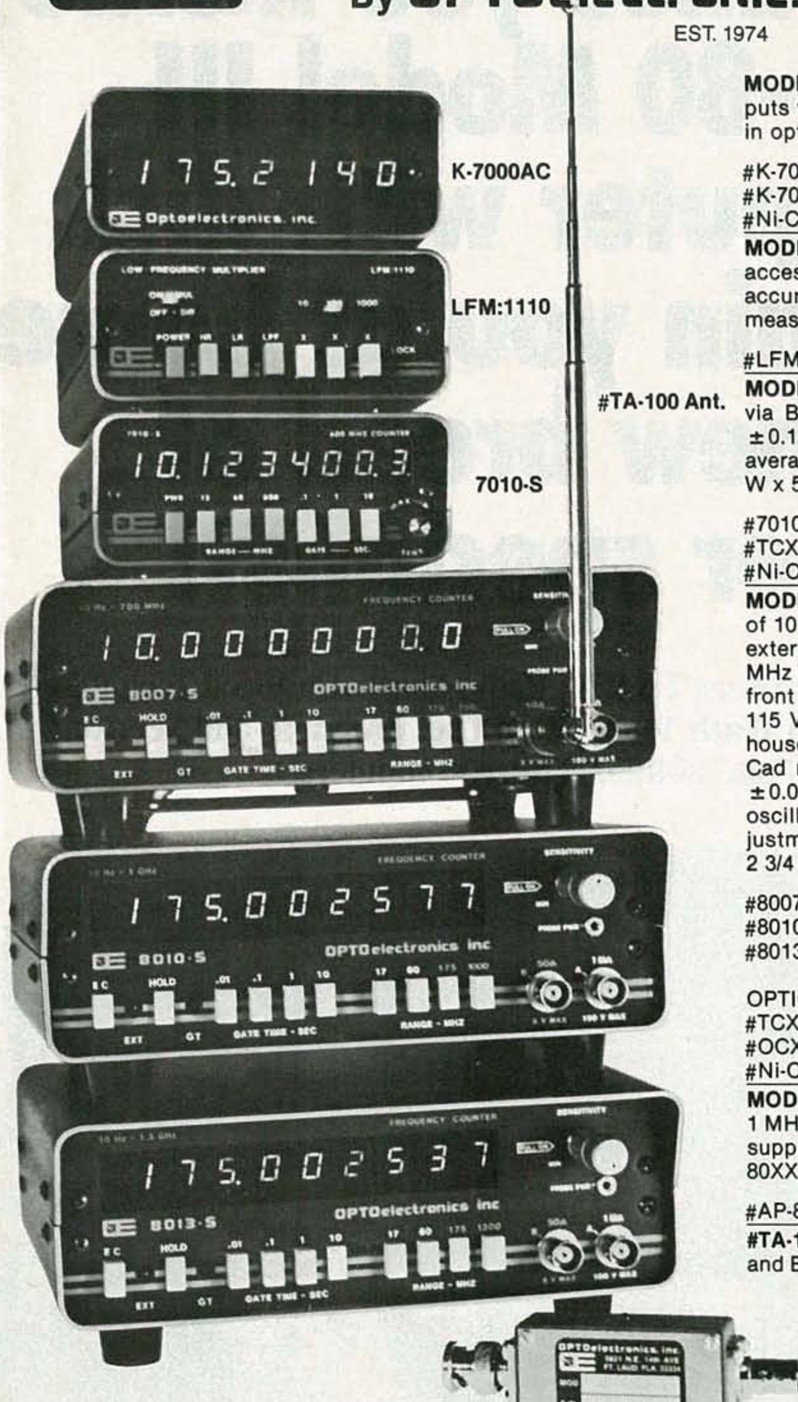
The third control, SENSITIVITY, lets you vary the input sensitivity in 6 steps, from

continued on page 20

FREQUENCY COUNTERS to 1.3 GHZ

By OPTOelectronics inc. Ft. Lauderdale, Florida

EST. 1974



MODEL K-7000-AC 10 Hz to 550 MHz counter. 50 Ohm & 1 Megohm inputs via BNC type connectors on rear panel. This model is available in optional kit form.

#K-7000-AC	counter assembled 115VAC/12VDC	$150.
#K-7000-ACK	counter kit form	120.
#Ni-Cad-70S	internal Ni-Cad battery pack	25.

MODEL LFM:1110 Low frequency multiplier. A frequency counter accessory enabling tone frequencies to be counted faster and more accurately. Has low pass filter for off-the-air. Tone-squelch measurements. BNC input/output.

#LFM:1110	115VAC/12VDC	$150.

MODEL 7010-S 10 Hz to 600 MHz counter. 50 Ohm & 1 megohm inputs via BNC type connectors on rear panel. ±1 PPM TCXO standard ±0.1 PPM TCXO time base optional for greater accuracy. 10 mV average sensitivity. Very compact 6 1/2 digit counter: Size 2" H x 4" W x 5" D, 1 lb.

#7010-S	600 MHz counter 115 V AC/12 V DC	$235.
#TCXO-80	±0.1 PPM TCXO time base	75.
#Ni-Cad-76	Internal Ni-Cad Battery Pack	25.

MODELS 8007-S, 8010-S, 8013-S Deluxe series with frequency ranges of 10 Hz to 700 MHz, 1 GHz and 1.3 GHz. Standard features include: external clock input/output, excellent sensitivity, sealed ±1 PPM 10 MHz TCXO time base, 4 gate times, 9 digit resolution to 175 MHz, front panel power jack for optional Broadband Preamp accessory, 115 V AC or 12 V DC operation, high quality compact construction housed in rugged aluminum cabinet. Optional features: internal Ni-Cad rechargeable battery operation, precision ±0.1 PPM TCXO or ±0.05 PPM proportional oven (OCXO) time base. All time base oscillators, including the standard TCXO, have 10 turn calibration adjustment accessible from rear panel. Size 3" H x 7 1/2" W x 6 1/2 D. 2 3/4 lbs.

#8007-S	700 MHz counter	$350.
#8010-S	1 GHz counter	425.
#8013-S	1.3 GHz counter	495.

OPTIONS:

#TCXO-80	±0.1 PPM TCXO time base	75.
#OCXO-80	±0.05 PPM (prop. oven) OCXO time base	125.
#Ni-Cad-86	Internal Ni-Cad battery pack	60.

MODEL AP-8015-A Broadband Preamp with 25 dB nominal gain from 1 MHz to 1 GHz, 10 dB gain at 1.3 GHz. Noise Figure less than 5.5 dB. supplied with AC adaptor or may be powered from power jack on 80XX-S series counters.

#AP-8015-A	$195.

#TA-100 Antenna, RF pick-up telescope style with right angle elbow and BNC connector ... $12.

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MODEL	RANGE (FROM 10 Hz)	TIME BASE		AVERAGE SENSITIVITY		GATE TIMES	MAX RESOLUTION					SENSITIVITY CONTROL	EXT CLOCK INPUT/OUTPUT	METAL CASE	PROBE POWER JACK
		FREQ	STAB-DESIGN	BELOW 500 MHz	ABOVE 500 MHz		12 MHz	17 MHz	60 MHz	175 MHz	MAX FREQ				
K-7000-AC	550 MHz	5.24288	±1 PPM-RTXO	15 mV −24 DBM	N/A	(2) .1, 1 SEC	10 Hz			100 Hz		No	No	Yes	No
7010-S	600 MHz	10.0 MHz	±1 PPM-TCXO *±0.1 PPM-TCXO	10 mV −27 DBM	20 mV −21 DBM	(3) .1, 1, 10 SEC	.1 Hz	1 Hz		10 Hz		Yes	No	Yes	No
8007-S	700 MHz														
8010-S	1 GHz	10.0 MHz	±1 PPM-TCXO *±0.1 PPM-TCXO *±0.05 PPM-OCXO	10 mV −27 DBM	20 mV −21 DBM	(4) .01, .1, 1, 10 SEC	.1 Hz		1 Hz		10 Hz	Yes	Yes	Yes	Yes
8013-S	1.3 GHz														

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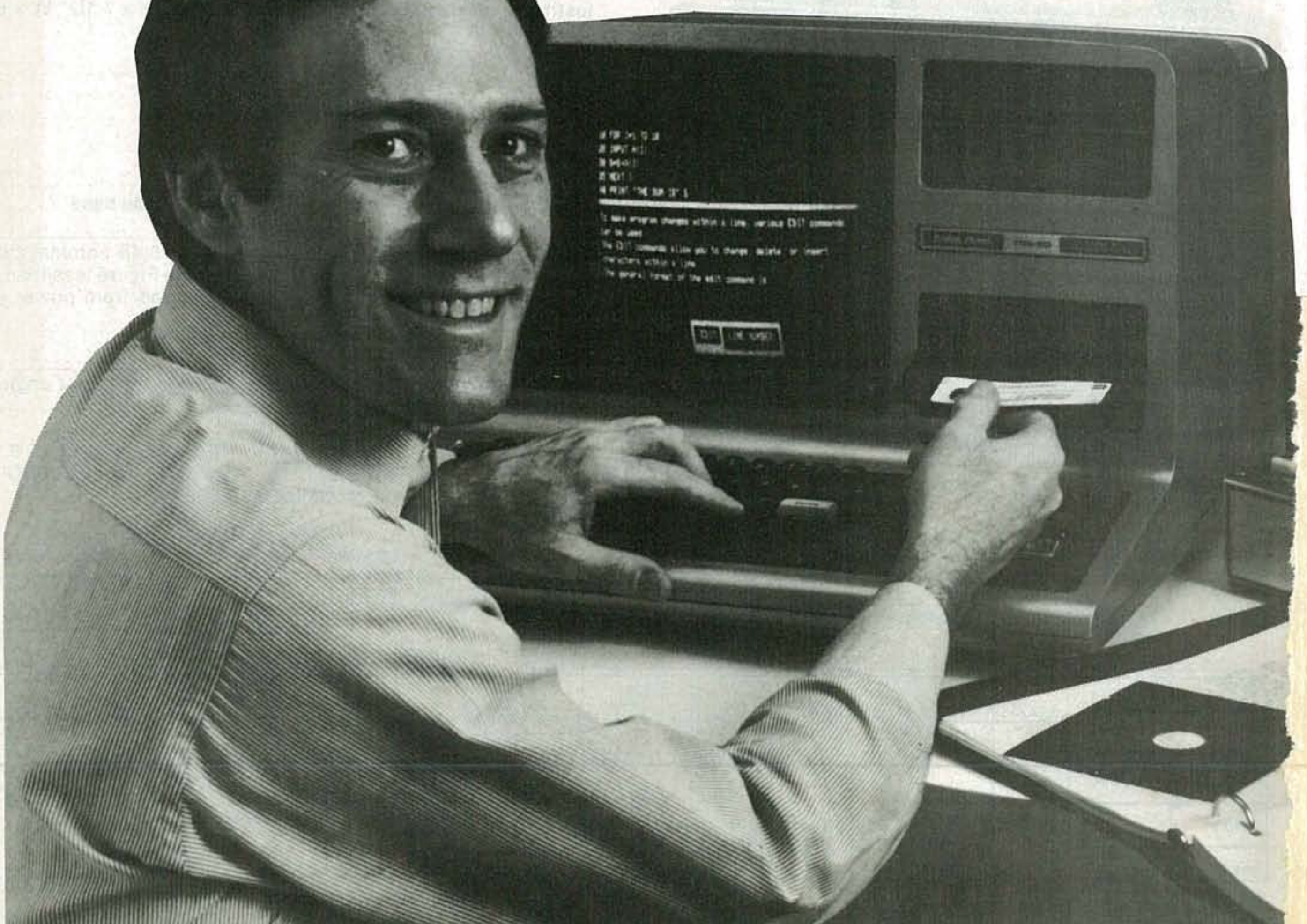


continued from page 14

15 millivolts RMS to 5 volts RMS. By setting the sensitivity only as high as necessary, you can reduce the effect of some interference.

At the bottom right of the panel is a high-impedance (1 megohm) AC-coupled input for signals with frequencies from 10 Hz to 120 MHz. To its left is a 50-ohm AC-coupled RF input for signals from 50 MHz to 1 GHz.

The accuracy of the counter is determined by several factors. The relative frequency-error (or innaccuracy) can be thought of as the sum of three terms: the resolution error, the trigger error, and the timebase error.

The resolution error is equal to LSD/input frequency, where LSD is the *L*east *S*ignificant *D*igit. The LSD varies depending on whether the NORMAL or FAST mode is in use. (The NORMAL mode yields 7-digit resolution, which results in an error between 1 part in 10^6 and 1 part in 10^7. The FAST mode yields 6- or 7-digit resolution, which results in an error between about 1 part in 5×10^6 and 1 part in 5×10^7.

The second term is the trigger error, which can be written (measurement rate/signal slope) × noise voltage (P-P). We can see that the error decreases as the input signal's frequency and signal-to-noise ratio increase.

The final term in the error expression is the timebase error. Regardless of its initial accuracy, an oscillator's frequency will change with time and temperature. (That's why an internal adjustment is provided.) The standard counter model has a temperature stability (referenced to 25°C) of 1 part in 3×10^6 between 20° and 30°C. An optional TCXO (or temperature-compensated crystal oscillator), which the unit we recieved was equipped with, improves that figure to 1 part in 3×10^7.

The oscillator's aging rate is the long-term stability when all factors (temperature, voltage, etc.) are held constant. It is dependent on the processing of the crystal. The standard model claims an aging rate of 1 part in 5×10^7/month, while with the TCXO that changes to 1 part in 10^7/month.

If you don't want to use the *PM 6668*'s internal oscillator, there is a BNC jack on the back of the unit that lets you connect your own 10-MHz oscillator. (A jumper inside the case must also be changed if you want to do that.)

Now that you have a general idea of the capabilities of this counter, let's take a look at how the 8048 microprocessor makes the *PM 6668* different from conventional counters.

Computing reciprocal counter.

In a conventional counter, the cycles of the input wave are counted during a set period of time—the gate time. As the frequency of the input signal increases, the number of cycles that are counted during the gate time increases and thus the relative resolution is increased. The *PM 6668* (called a computing reciprocal counter by Philips) however, uses two counting registers that permit high-resolution measurements on low-frequency signals. The event register counts the cycles of the input wave, while the time register counts the cycles from a 10-MHz reference oscillator. Both counts are sent to the microprocessor, which computes event counts/(time counts $\times 10^{-7}$) and sends that value to the display. The result is a resolution of ± 1 Hz in 10 MHz in the NORMAL mode (1-second gate time).

The measured frequency is always displayed with maximum resolution without overflow—the decimal point and unit (Hz, kHz, MHz) are automatically displayed properly. That automatic range selection is another feature that the microprocessor makes possible.

An available option—one our unit was not equipped with—is a rechargeable battery pack that fits inside the *PM 6668* case and permits portable operation. When batteries are installed, a low-battery indicator on the display will become visible when there is less than 15 minutes of operating time left. The external-oscillator jack that we just discussed can be replaced by a jack for connecting to an external 12-volt supply. Complete instructions are supplied in the manual.

Self diagnosis

Another feature of the *PM 6668* is the self-diagnosis routine that the microprocessor runs through whenever the unit is powered up. If a fault is found, then an error code (Error1 through Error6) will be displayed on the readout. By consulting the flowcharts in the service manual, you can isolate the fault. Let's give a quick example.

If "Error3" is displayed, you would, as the flowchart instructs, interchange two IC's that we'll call "A" and "B." If "Error2" is then displayed, you know to replace IC "A." However if that error message does not appear, then you have to check for a reset pulse at IC "A." If that pulse is missing, then you have to trace it to find the problem. But if the reset pulse is there, then the microprocessor must be replaced.

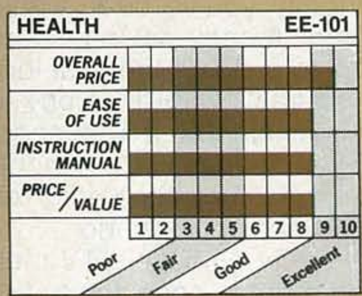
Of course, not all faults are handled by error displays. What the microprocessor does do is to test program memory and data memory; it also tests that the external logic can be set to zero. So, for example, a power-supply malfunction will not produce an error code. But even though there are many potential problems that the microprocessor will not indicate, you should have little problem if something goes wrong. As we have come to expect from Philips, the service manual is very helpful. It contains troubleshooting instructions and circuit descriptions, as well as maintenance instructions and performance checks.

In operation, the *PM 6668* worked well. It is an easy-to-use instrument. But you must be careful to use high-quality, shielded test leads to avoid misleading readings. That's especially true in noisy environments—around computers, for example. If you need a lab-quality, high-resolution frequency counter that can measure up to 1 GHz, we wouldn't hesitate to recommend this Philips unit. Its base price is $640. With the TCXO option, that increases to $820. The optional battery pack adds $200 to either unit. **R-E**

continued on page 22

Heath EE-101 Operational-Amplifier Course

CIRCLE 102 ON FREE INFORMATION CARD



AT ONE TIME OR ANOTHER DURING EVERYone's involvement with electronics,there comes a period when a refresher course might be needed. It doesn't matter whether you've worked with electronics for 25 years or 5 years, recent developments in the field have almost made it mandatory, especially if you want to remain current with up-to-date technology.

Even in such a take-it-for-granted area as operational amplifiers, there may come a need for fresh information. The problem that arises, though, is where do you get it? You can read manufacturers' specifications sheets or the latest technical manuals and papers, but those only give you the facts and figures. A better alternative is the op-amp course offered by Heath (Benton Harbor, MI 49022). It's part of their electronics technology education series and at $44.95 for the text and study materials, it's a bargain.

The Heath Operational Amplifier Course (*EE-101*) combines written theory materials and hands-on experiments into a package that provides a comprehensive overview of operational amplifiers. It's more than enough to provide even the most jaded veteran of the electronics wars with some new insights.

As usual, when the course first arrived in the office, we were quick to inspect the contents and we found that everything needed to complete it was there. It was packaged in a heavy cardboard box, which contained a binder, the course material, and parts needed for the course experiments. As we were opening the material, we also glanced through it and found it was well presented and very readable.

What's covered

The course material presents everything you wanted to know about op-amps, but might have been afraid to ask. For instance, the first chapter of the course takes you through op-amp basics and the characteristics of those devices. The second chapter takes you through some basic amplifier circuits and discusses the inverting and non-inverting amplifier, while the third chapter (Heath calls them units) moves to the differentiator and integrator.

The fourth chapter moves on to voltage and current regulator circuits, while chapter five takes you through non-linear signal-processing circuits and discusses such items as comparators and Schmitt Triggers. Chapter six covers various generators, including sinewave, squarewave, and triangular-wave generators.

Other chapters move on through active filters and discuss bandpass filters, state-variable filters and notch filters. Single-supply operation, including single-supply biasing, the inverting amplifier, the summing amplifier, and the difference amplifier are also covered.

The final chapter, chapter 10, includes a discussion of the instrumentation amplifier or "committed gain" amplifier.

As you can see, the Operational-Am-

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In its most basic form, the Trainer/Learning Computer is a 16-bit, cassette-based microcomputer.

Its unique design features access ports and solderless breadboards to allow you to build interfaces, design and modify circuits, or simply experiment with the inner workings of the microprocessor system.

The basic system has an 8088 processor, 32K ROM (including assembler, editor and debugger) and 16K RAM. The unit also features a serial I/O printer port, cassette interface and a detached 95-key keyboard (including 16 function keys and a numeric keypad) which generates a full ASCII character set. It's available either in kit form or factory assembled.

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plifier Course easily provides you with a good refresher on op-amps. In fact, it covers them from A to Z.

Not only does it supply the basics, but it also reinforces those basics with a constant series of review quizzes and tests. Those quizzes and tests culminate in a final exam for the course, which you may return to Heath for grading. That constant reinforcement is a good educational technique and assures that you will retain much of what you have learned.

Reinforcement is also supplied through a series of hands-on course experiments that help you understand the material you are learning. Those experiments are done using components which Heath supplies. Included in the course are resistors (both 1% and 5% film types); a special light-dependent resistor; a 20K linear control; various capacitors, including electrolytics, mylars, and ceramics; diodes; indicators, and, of course, the op-amps.

The experiments are very beneficial to the learning process and point to one improvement in the material that is noteworthy. In other Heath courses, the general guidelines for circuit breadboarding are presented and you are then left to sketch out any further experiment layout on a separate piece of paper. In this course, Heath has taken the time to provide you with a printed template to help you with the wiring.

A nice added benefit to the course is that it can also serve as a reference source when you've completed it. Two appendices contain some of the latest specification sheets on many of the operational amplifiers in common use.

What's needed

At this point, it is fair to note that while the initial price for the course seems low, it can actually work out to be quite expensive for the newcomer to the electronics business or hobby. That's because the course experiments use certain basic test instruments, such as an oscilloscope, frequency counter, frequency generator, and digital multimeter. And, while all service technicians and many hobbyists may already have access to that equipment, a beginner may find himself spending upwards of $800 to obtain all the items needed to get the full benefit of the course. In addition, the same breadboard/trainer (*ET-3300B*) used in the other Heath courses is used here. That trainer costs $99.95 in kit form; $179.95 assembled. It is also available in a package consisting of the trainer kit and the course for $129.95.

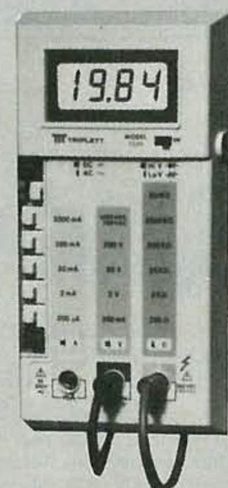
As you can see, it can be an expensive proposition to the person without access to the proper equipment. Keep in mind, though, that the list of need equipment includes only items that any reasonably equipped workshop should have.

One last note on the value of the course is the fact that it can earn you continuing education credits from Heath and those

credits are accepted by some colleges for work toward a degree.

Overall, the Heath *EE-101* Operational Amplifier Course is a worthwhile instructional program and one of the best ways we know of to learn about operational amplifiers. **R-E**

Triplett Model 3550 DMM



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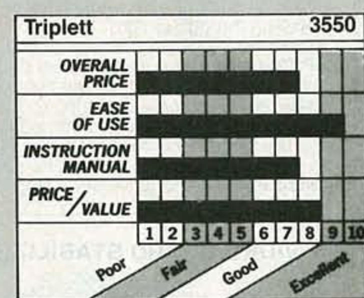

THE WORLD OF ELECTRONIC TECHNOLOGY is changing so rapidly that it is hard to imagine what tomorrow will bring. And as electronic equipment becomes more and more sophisticated, so must the instruments used to service it. That, of course, holds true for DMM's. Over the years, that basic instrument has been constantly upgraded and redesigned to make test and repair procedures more simple, less time consuming, and more accurate. The Triplett Corporation (One Triplett Drive, Bluffton, OH 45817) in keeping with that trend, has introduced the model *3550*, the latest in its line of DMM's. We thought you might like to know a little about it.

That meter is designed for ease of use. For instance, the eight range and function controls are located so that they can be operated by the hand holding the meter, leaving the other one free for placing probes, etc. Those probes connect to the device through three jacks that are located at the bottom of the case. The jacks are of the recessed type, meaning that there is no metal exposed when the probe is plugged

continued on page 32

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SATELLITE EARTH STATION, offers a 24-channel receiver with a wide range of features. Pushbutton tuning with automatic polarity switching and LED digital channel display are combined with a center/fine tuning meter and signal-strength meter for precise reception. Additional features include channel scan for rapid location of active transponders and a built-in modulator.

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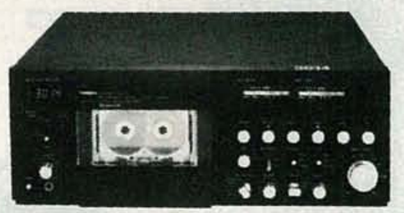
The antenna is eight feet high and its prime focus-feed assembly (LNA scaler feed and polarizer) and the downconverter are supported above the fiberglass dish by lightweight, high-strength aluminum struts. Once installed and aligned, the polar mount provides full domestic satellite coverage through a single manual (or optional remote-control) motorized adjustment. It is designed to withstand hurricane-force winds in excess of 100 miles per hour.

The *Satellite Earth Station* is priced at $2495.00.—**Channel Master,** Division of Avnet,Inc., Ellenville, NY 12428.

TAPE DECK, the model *TCD 3014* cassette recorder has separate record and playback heads to enable the user directly to compare the input signal with its recorded result. User adjustments for bias, sensitivity, and record-head azimuth are facilitated by two built-in test generators. Equalized peak-reading meters with rapid attack and slow release show the precise signal level being fed to the tape, and eliminate the uncertain readings of segmented-level displays. The meters show the signal applied to the record head at all times when in the RECORD mode, even if the TAPE/SOURCE switch is moved to the TAPE position. The meters only indicate the signal from the tape when in the PLAY mode.



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An 8-bit microprocessor with a 32K EPROM memory controls all transport operations. The microprocessor allows almost any conceivable function of scan, search, and memory functions, all accessed by pressing STOP and an appropriate combination of the other transport buttons. All transport touch sensors are multi-functional.

The model *TCD 3014* is priced at $1,395.00.—**Tandberg of America, Inc.,** Labriola Court, Armonk, NY 10504.

HYGRO-THERMOMETER, model *DH200,* checks relative humidity from 10 to 95% and temperature from 32 to 175 degrees F via a remote probe, with an accuracy of $\pm$2.0%

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(RH) and $\pm$0.5 degrees F (temperature). Response time is two to three minutes from 10 to

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50% RH and three to five minutes from 50 to 90% RH. It is supplied complete with remote probe, carrying case, and battery. The model *DH200* is priced at $249.00.—**Pacer Industries, Inc.,** 1450 First Avenue, Chippewa Falls, WI 54729.

COMPUTER SYSTEM, the *Jupiter Ace 4000,* uses the FORTH programming language and can serve as an intelligent programmable controller when combined with interfaces suitable for control of DC or AC power.

The basic machine includes the *Z80A* microprocessor operating at 3.25 MHz, an implementation of the FORTH 79 standard in ROM, and an internal timer. User RAM is expandable to 51K. It supports a text mode of 32 columns by 24 lines and a low-resolution graphics mode of 64 by 46 pixels. A 256- by 192-pixel mode is also available. The machine can be directly connected to video monitors.

The *Jupiter ACE 4000* has 40 moving keys with auto repeat, caps lock, and alternate functions. Sound is available through an internal speaker. A high-speed cassette interface provides program and data storage.

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Expansion capability has been provided through direct connection to the *Z80A* bus from a rear-panel connector. ROM, RAM, or peripherals can be connected to the expansion port. The FORTH words IN and OUT can directly address peripherals at assigned port numbers.

The *Jupiter ACE 4000* is priced at $175.00. The book, *Jupiter Ace—FORTH Programming,* is available for $14.95 separately.—**Computer Distribution Associates,** 17 South Main Street, Pittsford, NY 14534.

RECEIVERS, model *KR-950* (shown) and model *KR-930* are computerized AM/FM stereo receivers, featuring digital quartz-PLL synthesizer tuning systems, digital two-deck tape dubbing/monitoring, dual speaker-system capability (A, B, A+B), and headphone jacks. The tuner sections provide presets for six FM and six AM stations, and automatic scan tuning.

The model *KR-950* delivers 80 watts per channel, minimum RMS, both channels driven at 8 ohms from 20 to 20,000 Hz with no more than 0.01% harmonic distortion. FM sensitivity is 1.9 μV; signal-to-noise ratio is 80 dB in mono, 76 dB in stereo. It is priced at $530.00.

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The model *KR-930* has a minimum output of 50 watts per channel RMS, both channels driven at 8 ohms, with no more than 0.05% THD. FM sensitivity is 1.9 μV and signal-to-noise ratio is 80 dB (mono) and 76 dB (stereo). It is priced at $380.00.—**Kenwood,** 1315 East Watsoncenter Road, Carson, CA 90745.

LIGHTING INSTRUMENT, model *MX114,* is a combination fluorescent lamp with a 5-inch, 3× distortion-free magnifying lens. It is constructed of heavy-duty metal, fully adjustable to any angle, with a maximum reach of 45 inches. Included with the lamp is a 22-watt circline fluorescent light and a heavy-duty

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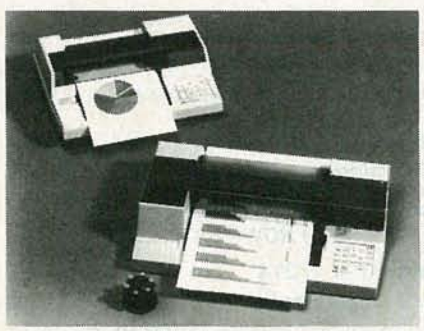
clamp-type mounting bracket. The model *MX114* is priced at $79.95.—**Ora Electronics,** 18215 Parthenia St., Northridge, CA 91325.

PLOTTERS, model *HP 7475A* (shown at right in photo) and model *HP 7470A* (shown at left in photo) are compatible with personal computers from Apple, IBM, Hewlett-Packard, and many others.



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The model *HP 7475A* accepts 11 × 17-inch paper, 8½ × 11-inch paper, and overhead-transparency film. With its six-pen carousel, the plotter can produce a variety of multicolor pie, bar, line, and text charts. Resolution is as fine as 0.001 inches.

Pens are selected from the carousel by either front-panel controls or program commands. When returned to the carousel, pens are capped automatically to prevent dry-out. A variety of pen colors and widths is available.

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EQUIPMENT REPORTS

continued from page 26

in. In addition, when plugged in, the probes seat firmly, making it difficult to accidently unplug them. The probes that come with the meter have a protective collar for working safely with high voltages, and sharp tips to make good contact on PC boards, etc.

All measurements are shown on a large, 3½-digit LCD readout. Decimal-point placement is automatic. Display annunciators include polarity and low battery. Battery life is claimed to be 200 hours with a standard nine-volt transistor-radio-type battery, or longer if alkaline units are used.

Looking more closely at the controls, two of them (located at the top and bottom of the row of pushbutton switches) are used to select the functions. The bottom switch is used to select whether current/voltage or resistance is to be measured; whether current or voltage is to be measured is determined by which of the input (MA or VΩ) jacks the positive lead is connected to.

The top switch is used to set the meter to measure either AC or DC voltage or current. Also, when measuring resistance, the top switch is used to set the meter to either the HI V or LO V mode. In the HI V mode, the meter has an output of 3 volts; that's enough to turn on any diode or transistor junction without damaging the device. That mode is useful for testing diodes, transistors, etc. In the LO V mode, the meter has an output of 0.26 volt; that is useful for testing circuits that contain semiconductors such as diodes and transistors because that low voltage level will not turn on a junction.

The remaining six switches are used for range selection. The meter measures AC and DC current in 5 ranges, from 200μA to 2000 mA, full scale. Resistance is measured over 6 ranges, from 200 ohms to 20 megohms, full scale. Turning to voltage, it is measured over 5 ranges, from 200mV to 1000 DC (750 AC), full scale.

Every range, including the resistance ranges, is overload protected to 250-volts RMS according to the manufacturer. The meter's accuracy is claimed to 0.25%. The response time is good for a meter of this type, varying between one and eight seconds, depending on the function and range.

The attractive tan case is made of high-impact plastic. There is a flip-out bail in the rear for bench use.

The instruction manual is simple, yet contains all the information most users are likely to need including a schematic and parts list. The meter is covered by a one-year limited warranty.

All-in-all, the model *3550* is a very useful little instrument for the hobbyist or technician. It carries a suggested list price of $85. **R-E**

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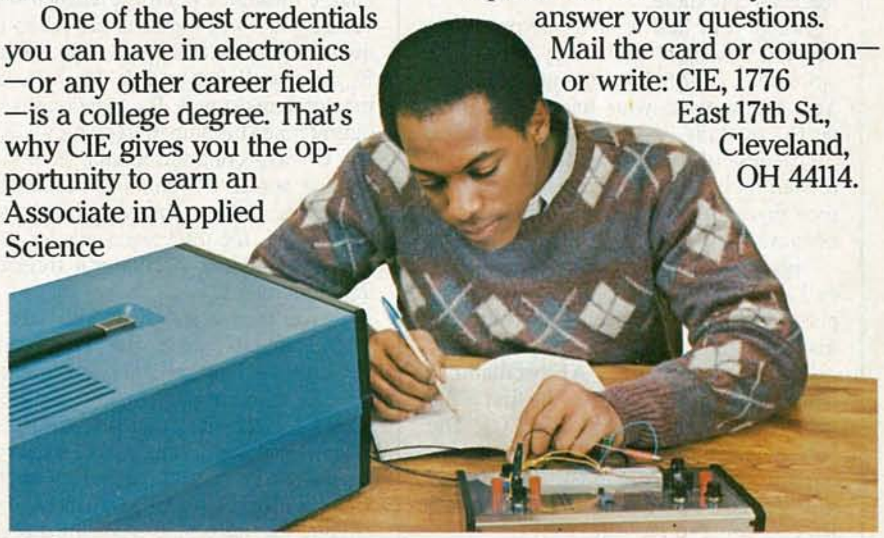

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NEW IDEAS

Sliding-tone doorbell

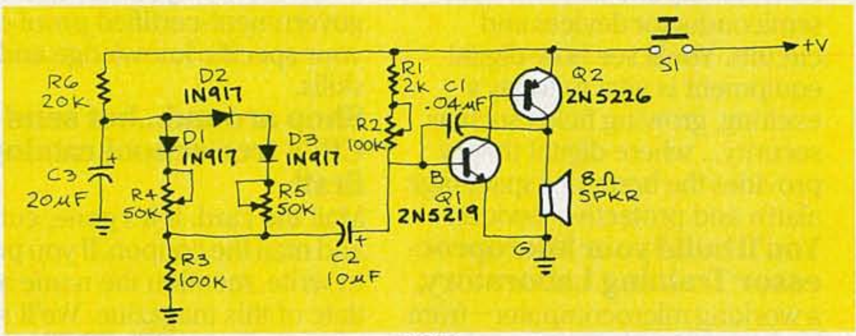


FIG. 1

HAVE YOU EVER BEEN STARTLED BY YOUR own doorbell? I have heard some doorbells that are so harsh and startling that they are sure to wreck anyone's nerves. But my doorbell is not of that type—at least not any more.

But if your bell *is* of that type, don't despair. I'll show you a way to prevent your quiet home from being disturbed. You can replace your harsh-sounding, nerve-wracking bell with what I'll call a "mild dose of sound stimulation." When the doorbell is pushed, you'll hear a low tone that will "slide up" to a higher frequency.

Figure 1 shows the sliding-tone doorbell circuit. It's made up of two main parts: an AF (*A*udio *F*requency) oscillator and a variable resistance.

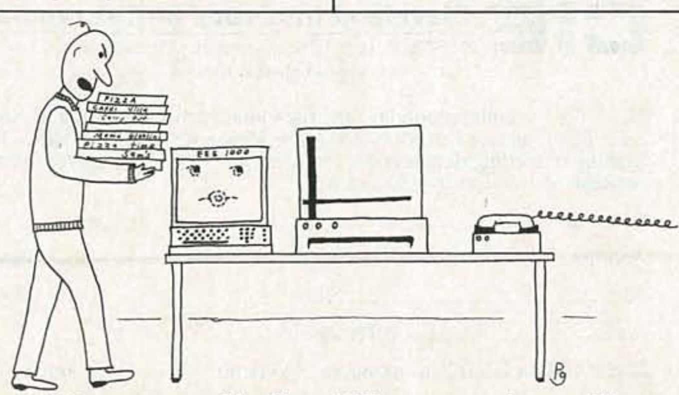
The frequency of the AF oscillator is determined by two factors. The first is the value of the coupling capacitor, C1. The second is the value of the resistance connected between the base of Q1 and ground. That resistance, which we'll call R_{BG}, is equal to $(R1+R2) \parallel R3$.

When either of those two factors increases, the frequency of oscillation will decrease. Thus, whenever R_{BG} or C1 decreases, the frequency will increase.

First, assume that S1 is closed and R2 has been adjusted to produce a pleasant, low-frequency tone. Capacitor C3 will charge through R6 until it reaches such a voltage that will cause diode D1 to conduct. When that happens, the value of R_{BG} is paralleled by R4. Thus, because the total resistance R_{BG} decreases, the output tone slides up in frequency. Capacitor C3 will continue to charge until the voltage across D2 and D3 causes those diodes to conduct. Then R_{BG} is paralleled also by R5, the total resistance again decreases, and the oscillator's frequency again increases.

If you're not satisfied with how the "bell" sounds, there are several things you can do. First, if you want to change the tone variation, feel free to try different values for R2, R4, and R5. And if you want to vary the sliding speed of the tone, then you can try different values of R6.

As with the rest of this easy-to-build circuit, the transistor types are not critical. Feel free to experiment!—*Tseng C. Liao*



"One more stunt like this and I'll cut your modem cord!"

NEW IDEAS

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C-QUAM AM STEREO CONVERTER

MARTY BERGAN*

AM stereo broadcasting is now well under way and more stations are beginning stereo broadcasts every week. Hear for yourself what all the fuss is about by converting your AM radio to receive C-QUAM stereo broadcasts.

STEREO BROADCASTING BY AM RADIO stations was authorized in March, 1982 by the Federal Communications Commission (FCC). AM broadcasters hoped that the introduction of stereo would help to bring back many of the listeners they lost to FM radio. If you want to find out what AM stereo sounds like, it's easier than you think. You don't have to go out and buy some special receiver—you can convert your present AM radio to receive stereo C-QUAM broadcasts.

The C-QUAM system, designed by Motorola, is one of four systems that the FCC authorized for AM stereo broadcasting. (The Commission declined to determine which of several competing technologies would become the industry standard and instead took a "wait-and-see" attitude. In that way, the marketplace could decide which system would become the standard.) In this article, we will take a look at what the C-QUAM system is and then we'll look at how an AM radio can be converted to decode stereo.

Let's say right from the start, though, that many radios are simply not capable of handling stereo. We'll explain the reasons for that and we'll explain ways around some of the problems. Because AM radios now on the market were not designed to accommodate stereo requirements, you might convert a radio but then be disappointed by the results. We'll give you some pointers on how to choose a good candidate for conversion.

Each of the hundreds of radio designs will probably behave and sound a little different. But each radio's problems can be resolved with the right know-how and test equipment. For those of you who are not equipped to handle such problems, the stereo conversion may be a disappointment, and you might be better off to wait a few months until the AM stereo receivers become available in the marketplace. But if you want to learn about this new system, and you have a good receiver to start with, then the conversion described here should be accomplished easily and successfully.

What is C-QUAM?

C-QUAM is an acronym for *C*ompatible *QU*adrature *A*mplitude *M*odulation. That's certainly a mouthfull—let's see what it means. The most important word there is *compatible*. That means that any ordinary (monaural) AM radio can receive a C-QUAM broadcast and produce the same results as it would if it received a monaural signal. In other words, the C-QUAM system does not make standard radios obsolete—as is necessary to gain FCC approval. C-QUAM is a *quadrature* system. That means that it somehow uses the relationship between two periodic functions that differ in phase by 90°. We'll take a closer look at that shortly. But let's first say that the final term in the acronym indicates that the transmitted signal is amplitude-modulated by each of the two periodic functions that we just mentioned.

A quadrature system combines and transmits two signals that are 90° out-of-phase with each other. Of course, those two signals must be separated again at the receiver, and that's the purpose of this

*Linear Applications, Motorola Inc., Semiconductor Products Sector

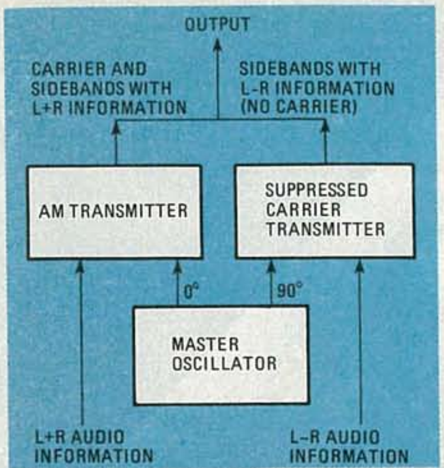


FIG. 1—YOU CAN THINK of a quadrature transmitter as one actually made up of two transmitters that are out of phase by 90°.

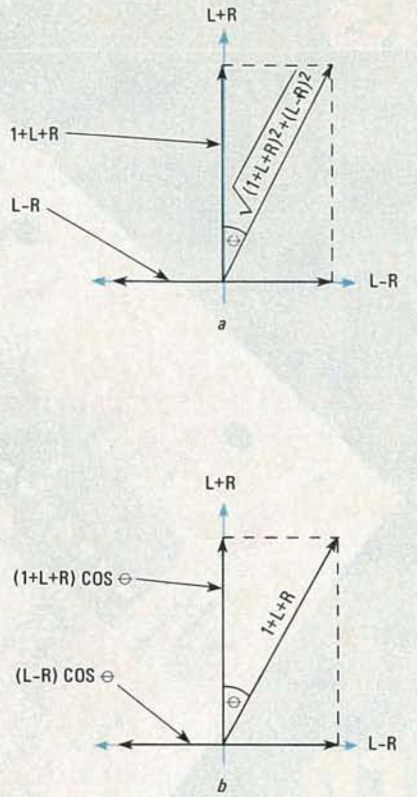


FIG. 2—QUADRATURE SIGNALS are not directly compatible with the detectors used in AM radios. Therefore, they must be converted into signals that will not produce distortion.

decoder. AM stereo is not the only place that quadrature modulation is used. For example, color information for TV broadcasts is transmitted in a similar way.

You can think of the quadrature transmitting system as one with two transmitters, as shown in Fig. 1. One transmitter is a standard AM transmitter at, say, zero phase. It transmits a carrier as well as sidebands that contain audio information (the I sidebands). The second transmitter operates 90° out-of-phase with the other. Because a carrier already exists to provide a phase reference for the receiver, we do not want another to be generated. So the second transmitter cancels out the carrier and produces only sidebands (the Q sidebands). Now, since those Q sidebands are generated from a carrier that is 90° out-of-phase from the original carrier, they are 90° out-of-phase with the I sidebands. In other words, the I and Q sidebands are in quadrature.

What information do the I and Q sidebands contain? The I sidebands contain the sum of the left- and right-channel audio information, or L + R signals. The Q sidebands contain the difference of the information of the two audio channels, or L − R signals.

There is a problem with quadrature-modulated signals, though. They produce distortion in the envelope detectors of normal AM radios. So a quadrature stereo system is not compatible with existing radios. That's because the envelope detectors in normal AM radios don't see the I and Q sidebands separately—they see the sum of the two, as shown in Fig. 2-a. One vector represents the L + R information that is modulated on the carrier (at what we'll call 0°). The other vector is the The L − R information that's modulated on the suppressed carrier (at what we'll call 90°). The magnitude of the sum of those two vectors—which the receiver's envelope detector sees—is:

$$\sqrt{(1+R+R)^2 + (L-R)^2}.$$

However, the envelope detector in a standard AM radio expects to see simply the carrier and the left- and right-channel audio, or 1 + L + R. That difference or error is the cause of the distortion or incompatibility problem.

Motorola found, however, that they could eliminate that error by multiplying each carrier axis by the cosine of the angle that resulted from the addition of the L + R and L − R signals. Figure 2-b shows that when that is done, the result is the 1 + L + R that we want—the standard AM radio sees this signal as the same signal received from a monaural AM broadcast. Thus we have complete compatibility.

The C-QUAM system adds a 25-Hz pilot tone to the L − R information at 4% modulation that serves several purposes. It signifies that a stereo transmission is present; it permits decoding of the L − R signal, and it aids in control of mono-stereo switching.

The MC13020P

The MC13020P decoder IC is housed in a 20-pin, standard dual in-line package, or DIP. A block diagram of the IC is shown in Fig. 3. The associated circuitry needed to build a complete decoder is made up of inexpensive components, and, in most cases, no coils or adjustments are necessary. A schematic of the decoder circuit is shown in Fig. 4. The schematic does not show the exact connection of the C-QUAM decoder circuit to the radio to be converted, or an exact external-oscillator circuit. But we'll give details later.

Taking an overall look at the block diagram of the decoder IC (Fig. 3), we see that the decoder takes the output of the AM IF amplifier, decodes the C-QUAM signal, and provides left- and right-channel audio outputs. In the absence of a good stereo signal, it will produce an undegraded monaural output from both channels.

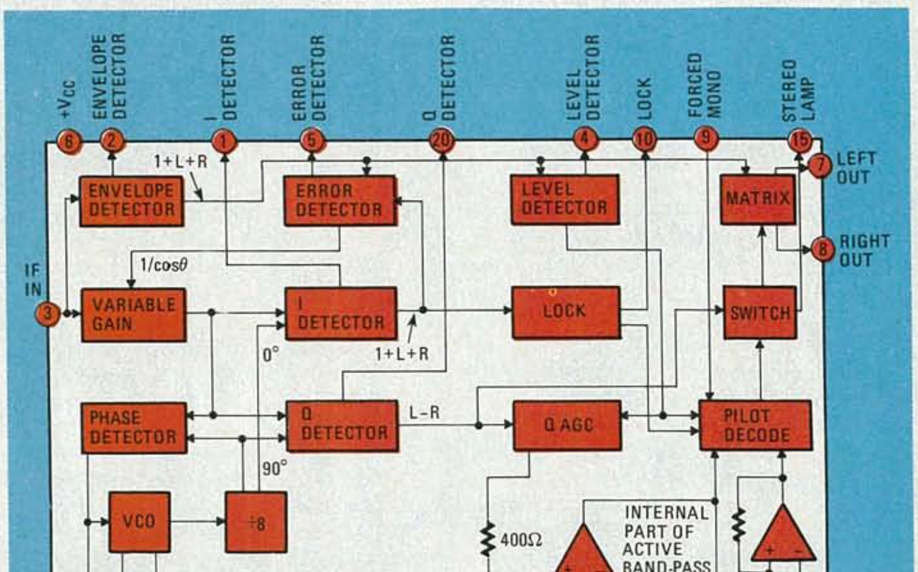


FIG. 3—A BLOCK DIAGRAM of the MC13020 AM-stereo decoder IC.

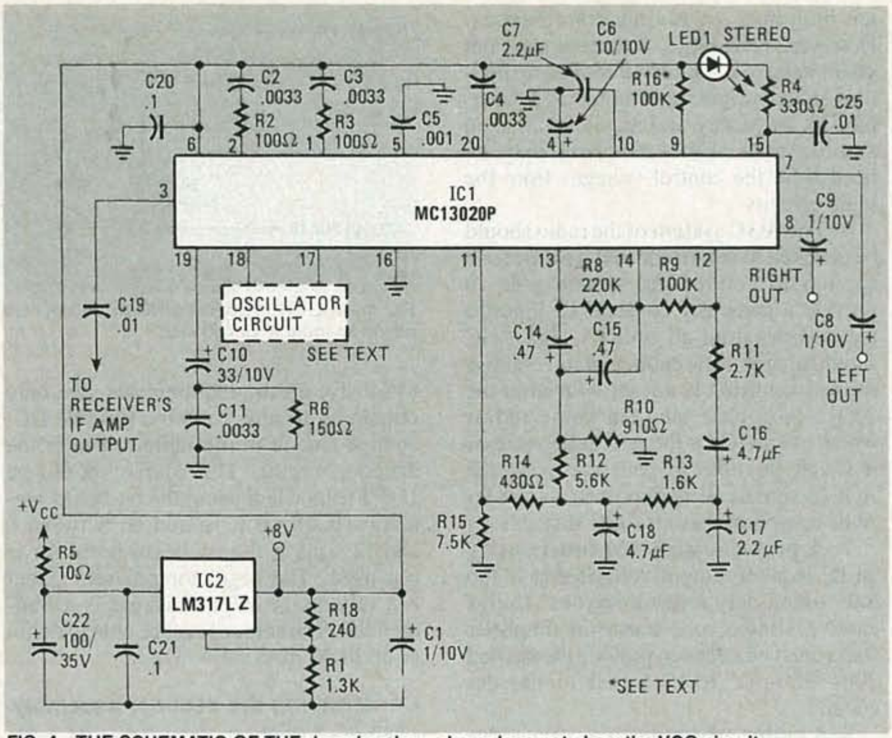


FIG. 4—THE SCHEMATIC OF THE decoder shown here does not show the VCO circuit.

The first step in decoding the stereo information is to convert C-QUAM to QUAM. That conversion is accomplished by comparing the outputs of the envelope detector and the I (L + R) detector in the error detector. Let's say, for example, that the incoming signal is monaural. Then it consists only of L + R information, and the envelope detector and I detector see the same signal. Therefore the error detector does not produce an error signal. However, when the incoming signal is stereo, there will be an error signal produced. That's because the envelope detector sees the same signal as it did before—the sum of the 1 + L + R and L − R signals—because it is not sensitive to the phase modulation. But the I detector—because it *is* sensitive to phase modulation—sees only the 1 + L + R information. When both signals are sent to the error detector, a 1/cosθ correction factor is produced.

In the variable-gain block, the incoming C-QUAM signal is multiplied by that 1/cosθ factor. The resulting product is a conventional quadrature or QUAM signal—not the C-QUAM that is compatible with standard AM-radio envelope detectors. It can be detected (synchronously) by conventional means.

The process to detect or demodulate the conventional quadrature signal involves first deriving a reference phase from the transmitted signal. That's the purpose of the phase-locked-loop (PLL) that we'll now describe. The phase detector is a product detector—its output is equal to the product of the two input signal voltages (in this case, a reference carrier from the VCO and the QUAM signal from the variable-gain block). If the two signals are of the same frequency and 90° out of phase, the DC output of the detector will be zero. That DC output of the phase detector is fed back to the VCO as an error signal. Thus, the frequency of the VCO "zeros in" and locks on the input carrier frequency and we have our phase reference to the I and Q demodulators.

The internal VCO operates at eight times the IF input frequency. That ensures that the VCO's frequency is outside the AM band, even if the receiver's IF is 262 kHz. (Typically, a 450-kHz IF is used with synthesized front ends. But the IF of many auto radios—even if synthesized—is 262.5 kHz.) A 450-kHz IF places the VCO at 3.6 MHz, so you can use an economic ceramic resonator instead of a crystal. (See the Parts List.) But, as we mentioned before, the oscillator configuration will be discussed later in the text.

In the PLL filter at pin 19, C10 is the primary factor setting a loop corner frequency of 8–10 Hz. An internally controlled fast pull-in is provided. (Pull-in time is the time required for achieving synchronization in a phase-locked loop.) Resistor R6 slightly overdamps the control loop, and C11 prevents high-frequency instability. The value of C10 can be increased to 68 μF to lower the filter corner frequency—that may be necessary to accommodate synthesized receivers. It may also be necessary if the filter affects the 25-Hz pilot signal (which must be 0.5 to 0.7 volts P-P at pin 14.). Resistor R6 may also affect the pilot amplitude, and can be decreased slightly if it's necessary to increase the pilot voltage to the required level.

The level detector senses carrier level and operates on the Q AGC block to provide a constant amplitude of the 25-Hz pilot signal at pin 11. It also sends information on signal strength to the pilot decoder.

The Q AGC output drives a low-pass filter, made up of a 400-ohm internal resistor, C18, and R15. From that point, an active filter (made up of both internal and external components) is coupled to the pilot decoder, pin 14, and another low-pass filter is connected to the co-channel input, pin 12.

Stereo/mono switching

A 50% reduction in the level of the 25-Hz pilot signal sent to the pilot-decode circuit will cause the system to go to monaural. A signal at a selected level to the co-channel input will also cause the system to go into its monaural mode.

That co-channel input signal contains any low-frequency beat notes caused by interference from a source very close in frequency to the desired signal. The level of the input that will cause the pilot-decode circuit to go into monaural can be adjusted by changing R11. The values that are shown in the schematic set the "trip" level at about 7% modulation.

The pilot decoder has two modes of operation. On a strong signal, the decoder will switch to stereo after it sees seven consecutive cycles of the 25-Hz pilot waveform. When conditions are bad, pilot decoder detects the interference and waits until it sees thirty-seven consecutive cycles of the 25-Hz pilot (that takes about 1.5 seconds) before it goes into the stereo mode. (In a frequency-synthesized radio, the logic that mutes the audio during tuning can be connected to pin 9 of the decoder to hold that pin low until the synthesizer and decoder have locked onto a new signal.) When pin 9 is held low, the decoder is held in its monaural mode and switches to the short count.

If no pilot is detected for seven consecutive counts, it is assumed the incoming signal is a monaural station and the decoder is switched to the long count (37 consecutive cycles of pilot). That reduces the possibility that noise or signal-level fluctuations will cause stereo triggering. The decoder will also switch to the long count if the PLL is out of lock, or if interference is detected by the co-channel detector before seven cycles are counted. (Each disturbance will reset the counter to zero.) The level detector will keep the decoder from going into stereo if the IF input level drops 10 dB, but will not affect the pilot counter.

Once the decoder has entered the stereo mode, it will switch instantly back to monaural if either the lock detector at pin 10 goes low, or if the carrier level drops below the preset threshold. Seven consecutive counts of no pilot also will cause the switch to monaural.

In stereo mode, the co-channel input is disabled. Then, co-channel or other noise is detected by negative excursions of the I detector. When those excursions reach a level caused by about 20% negative modulation of the L – R signals, the lock detector switches the system to monaural, even though the PLL may still be locked. Here, the higher tolerance to co-channel and other interference prevents chattering in and out of stereo because of a marginal signal or high noise-levels (such as during a thunderstorm). If you wish to decrease the effectiveness of the interference sensing (to keep the decoder in its stereo mode in the presence of some narrow spike type of interference) the 2.2 µF capacitor, C17, may be increased to as much as 47 µF.

When all inputs to the pilot-decode block are correct, and the appropriate (long or short) count is complete, the switch block is enabled. That block turns on the stereo-indicating LED and passes the L – R information to the matrix block, which outputs stereo audio signals.

Selecting a radio

Not every AM radio can be converted to receive broadcasts in stereo. But if you are careful when you examine the radio's capabilities, the conversion should go smoothly. Since there are literally hundreds of different radio designs on the market, we can't discuss the details of converting a particular radio. But we can give you some general pointers:

1. Old vacuum-tube radios are unacceptable. You'll undoubtedly have problems because of the high voltages and temperatures involved.

2. Cheap pocket radios, clock radios, small table radios, and the like should not be used in most cases. They typically have narrow bandwidths, poor sensitivity, and self-generated phase and frequency modulations that can seriously degrade channel separation and increase distortion and noise. (The C-QUAM system uses phase-related information, so the decoder is sensitive to phase variations or modulation.)

3. Manually tuned radios, whether variable-capacitor or variable-inductor types, may cause audible microphonics when in stereo mode. (Microphonics are electrical noise signals caused by mechanical disturbances of circuit elements.) Radios with self-contained speakers may be subject to microphonic problems because of the speaker vibrations. Those vibrations may generate phase modulation and the associated problems of poor separation, distortion, and noise.

4. The local oscillator must be stable and produce a reasonably clean sinewave. An unstable oscillator or a severely distorted waveform may cause a fluttering or warbling in the audio in the stereo mode. Disturbances of the front end and local oscillator introduce phase noise or ringing.

5. Radios with synthesizer front ends or logic-controlled varactor tuning are best adapted to AM stereo because of the more precise, automatic tuning, and better immunity to tuning disturbances. However, those types of receivers are not guaranteed to be trouble free. Phase modulation can originate from the PLL comparison frequency and may appear as an audible tone. Extra filtering may be needed on the control voltages from the logic circuits.

6. The AGC system of the radio should be checked to determine that it is effective enough to control the system gain to provide a generally constant IF input to the decoder from all stations. The AGC should also be slow enough in its response so that distortion is not introduced in the 25-Hz pilot-tone area. In some radios which use an IC for the AM tuner section, it is not possible to gain access to the AGC'd signals. It is important to test for AGC response after all AGC'd stages.

7. A problem with AM tuners using an IC is an IF output voltage that is too low—often only a few millivolts. In this case, a simple, one-transistor amplifier stage must be added to provide the needed 200—350-mV RMS signal to the decoder.

8. A major advantage is a radio with a tuned RF amplifier at the front end. The increased sensitivity and selectivity aid in stereo reception and stability.

9. The IF bandwidth should be at least 5 kHz and reasonably flat. The bandwidth

FIG. 5—HERE IS A FULL-SIZE foil diagram of the single-sided decoder board.

of AM radios can vary from 2 kHz to more than 10 kHz. The wider the bandwidth, the better the performance and audio quality. (The fact that so many radios have narrow bandwidth has prompted radio stations to pre-emphasize the upper audio frequencies—anywhere from 2 kHz on up—to improve sound quality. Such pre-emphasis will be reduced in the future as AM stereo encourages better receiver designs.

You can see that determining whether a particular radio is suitable for conversion to AM stereo is really the more difficult part of the conversion process. Once the radio has satisfied (or has been modified

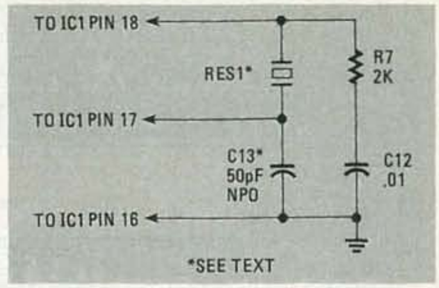


FIG. 6—THE OSCILLATOR CIRCUIT shown here needs an input IF of 450 kHz.

to satisfy) all the requirements, the only remaining need is to find a suitable DC-voltage source in the radio to power the decoder circuit. The source should be 11–30 volts when using the on-board regulator (IC2). Or it should be between 6 and 12 volts if the on-board regulator is not used. The regulator provides about 8.2 volts to the IC, and its use is recommended. The source must be able to deliver up to 40 mA continuously.

Constructing the decoder assembly

Figure 4 shows the complete schematic of the AM stereo decoder circuit and Fig.

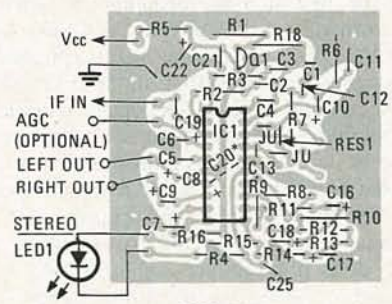


FIG. 7—THE PARTS-PLACEMENT diagram shown here corresponds to the VCO circuit of Fig. 6. Note that C20 is mounted on the foil side of the board.

5 shows a full-size foil pattern for a single-sided printed-circuit board. Before we talk about parts-placement, though, we have to select an oscillator circuit. We will discuss three.

The requirements of the VCO circuit design are not terribly critical—it must provide a one-volt P-P clean sinewave at 8 times the IF frequency to pin 14 of the MC13020P. One circuit that we can use is shown in Fig. 6. The corresponding parts-placement diagram for the decoder is shown in Fig. 7.

Of the three designs we'll discuss, the ceramic oscillator with its matched NPO (temperature-compensated) capacitor is preferred for its stability and simplicity. Both the ceramic resonator (RES1) and its matched (nominally 50 pF) capacitor are available from the source indicated in the parts list.

A quartz crystal can be used instead of RES1, but that will result in an extremely narrow pull-in range—only suitable for stable, accurate digital front ends. The

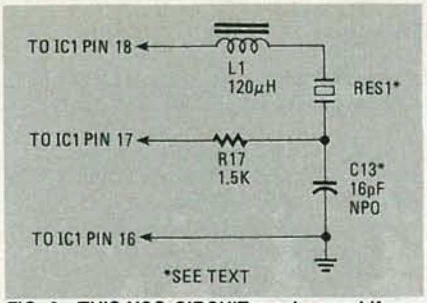


FIG. 8—THIS VCO CIRCUIT can be used if you need to broaden the tuning area to pull the resonator into lock at the required frequency. (Manually tuned radios may require that.)

ceramic resonator permits a much broader pull-in range, but it does have two drawbacks. The available resonator oscillates at 3.6 MHz—that requires a 450-kHz IF input to the decoder. Radios with a 455-kHz IF will have to be re-aligned. The second drawback concerns manually tuned radios. Tuning to the station's center frequency is quite critical. (That's not likely to be a problem with synthesized tuners.) To broaden the tuning area, R7 is added to lower the Q of the VCO. Capacitor C12 provides a DC block.

If greater broadening is needed, L1 and R17 may be added, and C13 changed, as shown in Fig. 8. (The corresponding parts-placement diagram is shown in Fig. 9.) That aids the circuit in pulling the resonator into lock at the required frequency. If L1 and R17 are not used, each must be replaced with a jumper wire as shown.

If your radio does not readily tolerate re-alignment, or if it has an IF of 260 or 262.5-kHz, or if you prefer not to attempt re-alignment, an alternative VCO, using a tunable L-C oscillator circuit, is shown in Fig. 10. It replaces the ceramic-resonator circuit and is very stable. The coil must be tuned so that the oscillator frequency is 8 times the radio's IF frequency. The circuit shown accommodates the 260-262.5-kHz IF range. Coil L2 is an adjustable RF coil made up of 60 turns of No. 36 enamelled wire tightly wound on a ⅛-inch-diameter form with a No. 2 ferrite core, a pot core (ferrite shield) and a shield can.

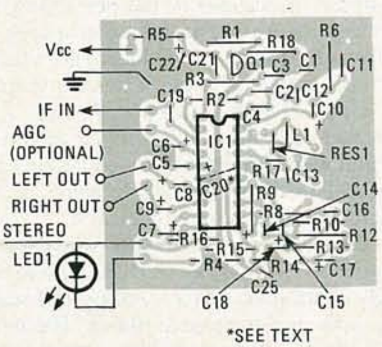


FIG. 9—THIS PARTS-PLACEMENT diagram corresponds to the VCO circuit shown in Fig. 8. Capacitor C20 is the only component mounted on the board's foil side.

PARTS LIST

All resistors ¼ W, 5%, carbon film
R1—1300 ohms
R2, R3—100 ohms
R4—330 ohms
R5—10 ohms
R6—150 ohms
R7—2000 ohms
R8—220,000 ohms
R9, R16—100,000 ohms
R10—910 ohms
R11—2700 ohms
R12—5600 ohms
R13—1600 ohms
R14—430 ohms
R15—7500 ohms
R17—1500 ohms
R18—240 ohms
Capacitors
C1,C8,C9—1 μF, 10 Volts, electrolytic
C2,C3,C4,C11—0.0033 μF, ceramic disc, 25–50 volts
C5—0.001 μF ceramic disc, 25–50 volts
C6—10 μF, 10 volts, electrolytic
C7, C17—2.2 μF, 10 volts, tantalum
C10—33 μF, 10 volts, electrolytic
C12,C19,C25—0.01 μF ceramic disc, 25–50 volts
C13—NPO. See Text and Figs. 6, 8, and 10
C14,C15—0.47 μF, 10 volts, tantalum
C16,C18—4.7 μF, 10 volts, tantalum
C20,C21,C24—0.1 μF ceramic disc or monolythic
C22—100 μF, 35 volts, electrolytic
C23—see text and Fig. 10
Semiconductors and other components
IC1—MC13020P C-QUAM decoder (Motorola)
IC2—LM317LZ adjustable regulator
LED1—standard red LED, 20 mA
L1—120 μH choke
L2—55 μH coil: 60 turns of #36 enamelled wire tightly wound on ⅛-inch diameter form with No. 2 ferrite core and shield can.
RES1—Ceramic resonator, Murata CSA2.60MT7 with matching capacitor (C13), Murata CSC500K7
The following are available from Circuit Specialists, Box 3047, Scottsdale, AZ 85257: Complete kit, including PC board and all parts (including parts for the VCO circuit as in Fig. 6 only), $24.95; Circuit board only, $4.95; Ceramic resonator RES1 with matching NPO capacitor (as in Fig. 6) only, $3; MC1320P decoder IC, $3.50. All prices include postage inside the US.

You can use the circuit in Fig. 10 (it's parts-placement is shown in Fig. 11) with an IF of 450 or 455 kHz by making C13 39 pF NPO and C23 10 pF NPO, and adjusting L2 so that the oscillator's center frequency is eight times the input IF.

Except, perhaps, for some of the oscillator parts, the components required for the decoder circuit are common parts. We recommend that you use tantalum capacitors for the polarized capacitors in the filter circuits at IC pins 10–14. They have

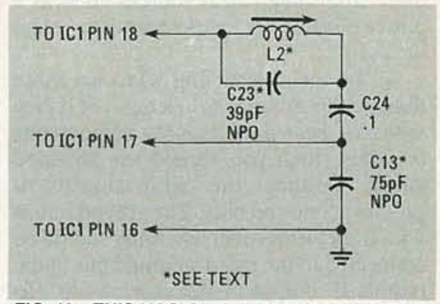


FIG. 10—THIS VCO CIRCUIT can be used to replace the ceramic-resonator circuit if your radio has an IF of 260 or 262.5 kHz. You can also use it with an IF of 450 or 455 kHz if you change the value of C13.

better tolerance and small size. But regular electrolytics, if accurate, can be used with no sacrifice of performance. Non-polarized capacitors may be ceramic-disc types unless otherwise specified in the parts list. The 0.1-μF capacitor, C20—shown in Fig. 4 connected from IC1 pin 6 to ground—should be soldered on the circuit side of the PC board under the IC from pin 6 (V_{CC}) to pin 16 (ground); use short leads when installing that unit. Note that there is intentionally no provision for this capacitor in the board layout.

Converting the radio

The input signal to the decoder must be at least 160 mV RMS for stereo. But for quiet, clean reception, it should be 200–350 mV. That is a typical range for most AM radios. In the radio, the stereo decoder goes where the detector would normally go—after the last IF stage before the detector diode. The radio's detector circuit may be disconnected by removing the diode or disconnecting one lead. In some radios, AGC voltages are obtained from the detector circuit and, in that case, the detector should be left connected. In most instances it won't interfere with the operation of the decoder. In any case, the audio output from the radio's detector must be disconnected, to avoid conflict with the two audio channels coming from the MC13020P.

The decoder assembly may be mounted in any convenient place, but try to keep it

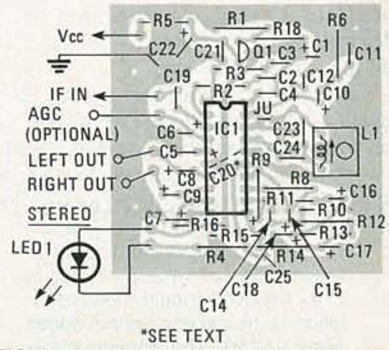


FIG. 11—THE PARTS-PLACEMENT diagram shown here corresponds to the VCO circuit of Fig. 10.

away from major heat sources such as a power transformer, output transistors, and heat sinks.

If the interconnecting wires are more than a couple of inches in length, or if they will pass near power-supply components or wires, then you should use shielded cable. Connect the cable shields to ground at one end only. The ground return wire from the decoder assembly should be connected to the radio's ground bus at the radio's IF output or detector circuit. To avoid ground loops, *this should be the only common ground connection.*

If the receiver has a high IF output (over 350 mV RMS) a series resistor can be added to drop the voltage to the desired level of 200-350 mV RMS at pin 3, the decoder input. The input impedance of the decoder is about 27 kilohms.

Pin 9 of the IC is the FORCED MONO control pin. Grounding that pin locks the decoder in its monaural mode. For automatic mono/stereo switching, pin 9 can be pulled up with a 100-kilohm resistor to the 8-volt supply (as shown in the schematic), *or* it can be connected to pin 10. (That permits the most rapid re-acquisition of stereo after retuning.) If you look closely at the parts-placement diagrams, you'll notice that, although the jumper is not shown, pads are provided on the board so that you can easily tie pin 9 to pin 10. You could also bring pin 9 out to a switch and manually force the decoder to its monaural mode by switching pin 9 to ground. If that is the case, the 100K resistor must be added. But be sure to remember: Do not add the resistor if you jumper pins 9 and 10.

The left and right audio outputs are "tuner-level" signals (100–200 mV RMS) and can be connected directly to the tuner or auxiliary inputs of a stereo amplifier. If the conversion is in an AM/FM receiver, one that has its own stereo amplifier, the decoder outputs should be connected through the band switch. Capacitors C8 and C9 will provide the necessary AC coupling to the audio circuits.

Troubleshooting

If the decoder will not go into the stereo mode even with a strong signal, then you should troubleshoot the circuit as we'll describe. Of course, before you start troubleshooting, you have to know that the local radio station is transmitting Motorola C-QUAM stereo—feel free to call the station to be sure.

When you're certain that a C-QUAM signal is being received, (we'll assume that you've checked that the power supply is working correctly and that 8 volts DC is supplied to pin 6) then, using an oscilloscope, look at the following signals:

1. Pin 3—The input signal. The signal envelope (and that at the IF output of the receiver) should show modulation at the top and bottom edges symmetrically. The average amplitude must be 1 volt peak-to-peak, ± 0.4 volt.
2. Pin 17—The VCO input. The oscillator input should be a sinewave of about 1-volt P-P at 8 times the input IF.
3. Pins 7 and 8—The left and right audio outputs. These signals should typically be about 200 mV P-P, centered on a DC level of about 1 volt.
4. Pin 14—Pilot tone. You should see a 25-Hz sinewave that is steady and 0.5–0.8 volts P-P. The amplitude can be increased, if necessary, by decreasing the value of R12 (but to no less than 1.8K). The pilot signal will be present, of course, only if the radio is properly tuned to a station transmitting C-QUAM stereo.
5. Pin 1—L+R signal. This signal looks like the audio signals on pin 7 and 8 but it is centered on a DC level of about 6 volts.
6. Pin 20—L−R signal. This should appear about the same as L+R signal. (If you observe closely, you should also see the 25-Hz pilot tone as a low-amplitude component of the complex waveform.)
7. Pin 10—DC lock voltage. The voltage should be 4 volts in lock, 0 volt out of lock. If it's out of lock, the VCO is not at 8 times the input IF. Adjust the VCO or re-align the radio's IF.
8. Pin 9—FORCED MONO. If wired to pin 10, it must have the same voltage condition as pin 10. If not wired to pin 10, pin 9 must have +4 V DC or higher via a 100k pull-up resistor (R16) to the 8 V supply. If the voltage at pin 9 is at or near 0 V DC, the decoder is held in monaural mode.

If all the above conditions are satisfied, the decoder will switch into the stereo mode. Failure at this point indicates a workmanship problem, defective component, a fault in the receiver system, or an incoming signal that is not correct for C-QUAM stereo detection.

WHERE TO LISTEN

As we went to press, these stations (listed alphabetically by city) were broadcasting C-QUAM stereo, with almost 50 orders on backlog. (Those stations wished to remain confidential.)

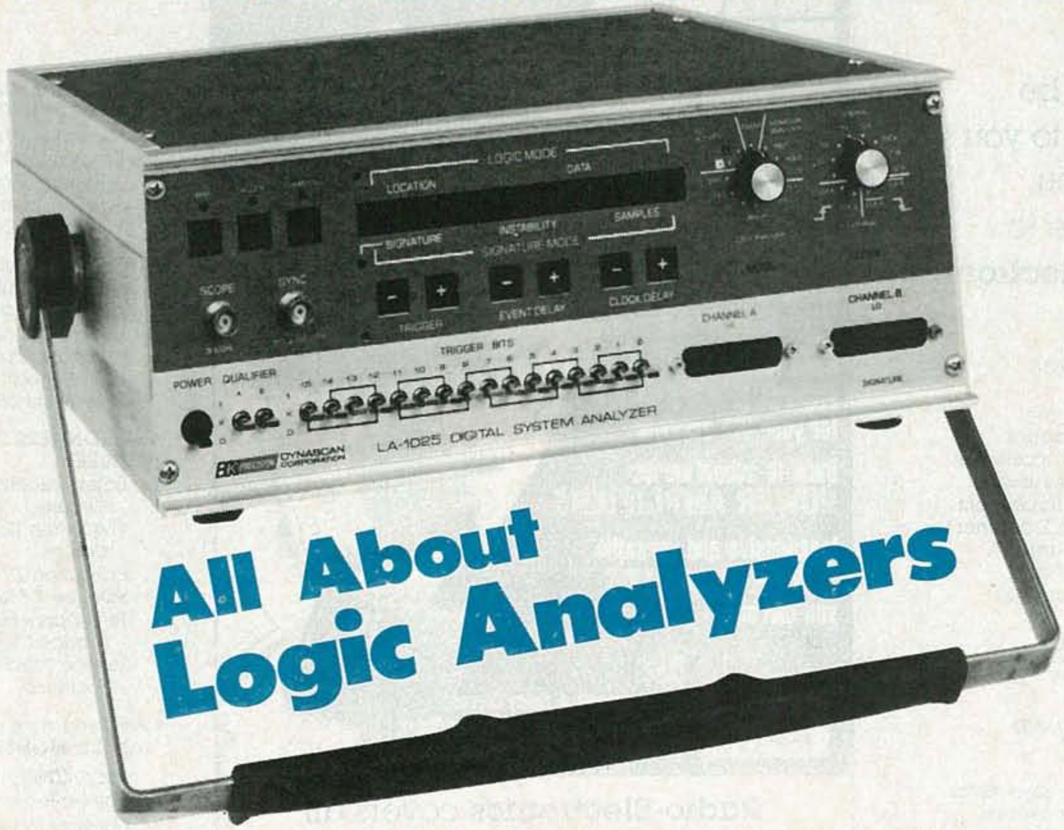
KRZY	1450	Albuquerque, NM	CKNW	980	New Westminster, BC
WSAN	1470	Allentown, PA	KXXY	1340	Oklahoma City, OK
WCHL	1360	Chapel Hill, NC	CJSB	540	Ottawa, ONT
WAIT	820	Chicago, IL	KGW	620	Portland, OR
WFAA	570	Dallas, TX	CJCI	620	Prince George, BC
WJR	760	Detroit, MI	WHWH	1350	Princeton, NJ
KQWB	1550	Fargo, ND	KIPN	1350	Pueblo, CO
WKQT	1010	Garyville, LA	KKLS	920	Rapid City, SD
WGSW	1350	Greenwood, SC	KKYX	680	San Antonio, TX
CKOC	1150	Hamilton, ONT	KFMB	760	San Diego, CA
WIRE	1430	Indianapolis, IN	KYA	1260	San Fransisco, CA
WNDE	1260	Indianapolis, IN	KRDZ	1230	Steam Boat Springs, CO
CKOV	630	Kelowna, BC	KJOY	1280	Stockton, CA
WITL	1010	Lansing, MI	CFRB	1010	Toronto, ONT
CFPL	980	London, ONT	KRMG	740	Tulsa, OK
KFI	640	Los Angeles, CA	CJVB	1470	Vancouver, BC
KZLA	1540	Los Angeles, CA	CKWX	1130	Vancouver, BC
WISM	1480	Madison, WI	CKLW	800	Windsor, ONT
WSM	650	Nashville, TN			

Proven conversions

In preparation of this article, three radios were converted in our lab. The first was an AM (only) portable radio, a Realistic (Radio Shack) model *12-656A*. (It is not listed in Radio Shack's latest catalog.) That radio was chosen because it has an FET-tuned RF amplifier in front, no ceramic filters, (they usually narrow the bandwidth), three tuned IF stages, and a substantial AGC system. Our testing showed that its 3-dB bandwidth was 12 kHz with a very flat response. One AGC voltage is developed from the detector circuit, so the detector was left connected as is. The IF was re-aligned to 450 kHz. The speaker and battery holder were removed to make room for the decoder circuit and a complete 4-watt-per-channel stereo amplifier with volume, balance, bass, and treble controls. The radio's original audio section was disconnected. The radio lent itself readily to the conversion with only one problem. As previously discussed, manually tuned radios often prove to be microphonic. The *12-656A* was no exception. The main culprit was the oscillator coil. Filling the coil assembly with beeswax to stop vibration greatly improved it. The tuning capacitor also was sensitive, but no attempt was made to suppress it because of the possibility of damage. Even so, at this point it took a substantial rap on the cabinet to get a little "ping" sound. The radio was connected to a pair of Radio Shack's *Minimus-3.5* speakers that presented a full, clean stereo sound with both laboratory equipment as the C-QUAM signal source and a commercial radio station in Chicago.

The second radio converted was a Sears model *564.50800*, a car radio with digitally controlled varactor tuning, FM stereo, and an 8-track tape player. The unit presented a different challenge because of its compact assembly and complexity. The selected frequency is digitally dis-

continued on page 102



All About Logic Analyzers

The logic analyzer is a not-too-well-understood test instrument. We'll try to make you more familiar with it by taking an in-depth look at one.

KENNETH PIGGOT

THE LOGIC ANALYZER CAN BEST BE thought of as the digital equivalent to the (analog) oscilloscope. However, unlike the oscilloscope—which displays events as they happen—the logic analyzer samples digital signals and stores them as logic-level 1's and 0's so they can be reviewed later. Because of that fundamental difference, the operation of a logic analyzer may, at first glance, appear intimidating.

In order to dispel that feeling, we'll discuss the basic operation of logic analyzers and take a close look at a relatively low-cost ($2075/$2475) unit: the model *LA-1020/25* (manufactured by B&K Precision 6460 W. Cortland, Chicago, IL 60635). We'll also build a simple, single-IC logic analyzer. Although limited in its capabilities, it can be used to demonstrate some of the logic-analyzer techniques we'll describe.

Applications of logic analyzers

Although logic analyzers can be used to monitor any logic circuit, they are mainly used on microprocessor-oriented circuits, usually to monitor the logic states of the address bus. That way, you can follow the execution of the program steps in a program.

That's helpful because a program is rarely executed in a straight-line manner. Instead, it will frequently branch off or jump from one address to another at different parts of the program. That action is analogous to a hobbyist on his way home from work. He will not always travel in a straight-line manner. Instead he may stop at the computer store, parts shop, etc.

In the real world we can observe the path taken by the hobbyist simply by looking at him. However, in the world of the microprocessor, our senses fail us and we must rely on instruments—like the logic analyzer that uses techniques such as address-state analysis—to see what is happening.

When the address bus is monitored by a B&K Precision logic analyzer during each instruction-fetch cycle, 250 steps of the processor's program sequence will be stored in its memory. By using various trigger modes (we'll discuss those later), you can begin the storage of program steps at any selected point of the program's execution.

The B&K Precision models *LA1020* and *LA1025* logic analyzers feature many of the capabilities of larger, more expensive machines. (The two models are identical except for the inclusion of signature-analysis capability in the *LA1025*.) The *LA1020* allows you to monitor and store 250 16-bit TTL-level data samples. In a typical microprocessor system, you would monitor the address, data, and control buses.

To hook the analyzer up to the system under test, two *data pods*, like the one shown in Fig. 1, are used. Each data pod or probe samples eight TTL-level data lines, one QUALIFIER line, and one CLOCK line. The QUALIFIER and CLOCK lines will be explained in the "Triggering" section. Each data pod also contains the circuitry to terminate the sampling leads and to drive the connecting ribbon cable between the data pod and the main unit. The logic analyzer's MODE switch can be turned to the POD ACTIVITY position. When in that position, each data pod acts as an 8-bit logic probe with the display

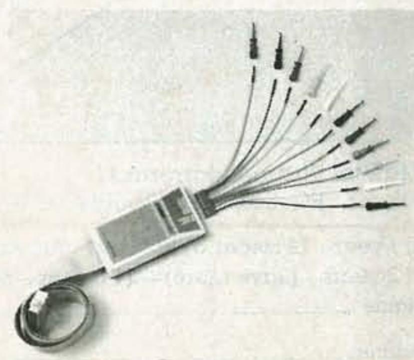


FIG. 1—THE *LP1* DATA POD or probe that is used with the *LA1020/25*. Each pod monitors eight bits of data, a qualifier line, and a clock line.

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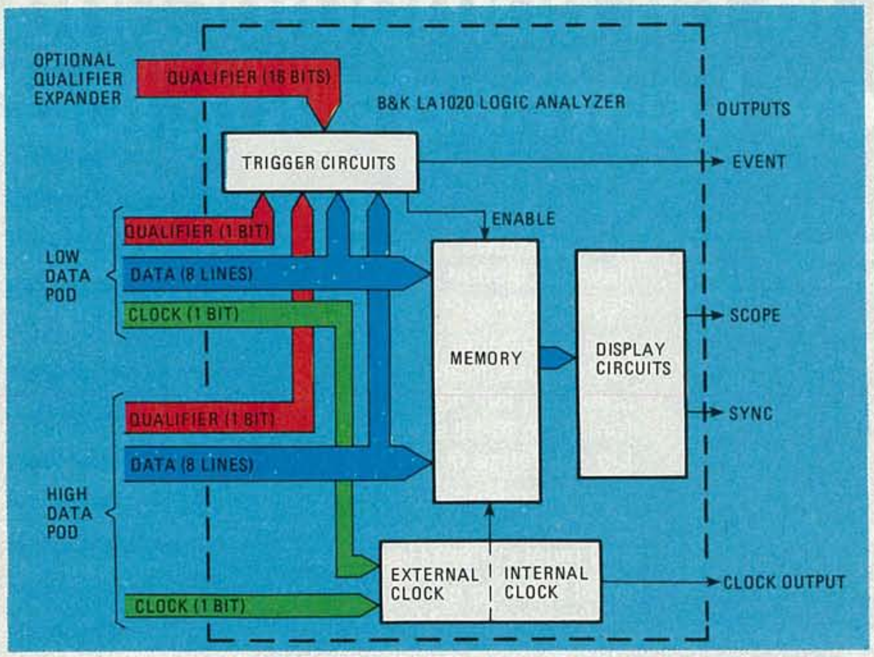


FIG. 2—SIMPLIFIED BLOCK DIAGRAM if the *LA1020* showing the external inputs and outputs.

indicating 0's, 1's, or P's (pulses), depending on the logic activity on each data line.

As can be seen in the block diagram in Fig. 2, the two 8-bit sets of data samples from the data pods are routed to the logic analyzer's memory and trigger circuits. As previously mentioned, the *LA1020* can store up to 250 16-bit samples in its internal memory. Data sampling can occur at sample rates of up to 20 MHz. (That equates to a minimum time between samples of 50 nanoseconds.)

Triggering

The trigger circuit of the logic analyzer lets you select the starting point for storing data samples. It continuously compares the incoming data bits to a user-selected trigger word. That trigger word is selected by throwing each of the 16 three-position TRIGGER BITS switches on the front panel to either 1, 0, or X, where the X stands for "don't care." In the "don't care" position, the incoming data line will satisfy the trigger requirements whether it is a logic 1 or a logic 0.

The *LA1020* also monitors a QUALIFIER line from each of the data pods. That bit is not stored in memory and is only used by the trigger circuit. Each of the qualifier bits has a corresponding switch that operates identically to the TRIGGER BITS switches. The easiest way to describe the purpose of the qualifier lines is to give an example of how they could be used. If you hooked one of the qualifier lines to a control signal such as a microprocessor's READ line, data storage would be triggered only when the READ pin was high (or low, depending on how the qualifier switch was set). If the two qualifier lines are not used, their trigger switches can be set to the "don't care" position and they will be ignored.

An optional *LP-3* qualifier pod (seen in Fig. 3) adds 16 more trigger bits to the trigger word. With it, you could monitor a system's data lines while triggering from the address lines that are connected to the qualifier pod. Sixteen three-position switches on the qualifier pod can also be set to a logic 0, 1, or a "don't care" position. That optional expander pod is plugged into a connector on the rear panel of the logic analyzer.

The easiest way to picture the operation of the trigger circuit is as a multi-input AND gate for which the active levels can be user-defined by setting the TRIGGER BITS switches. When the logic levels on the 16 DATA lines and the QUALIFIER lines being sampled match those set on the TRIGGER BIT switches, the memory-storage process will be enabled.

Before the various trigger modes are described, it would be appropriate to examine how the 250 samples are loaded into memory.

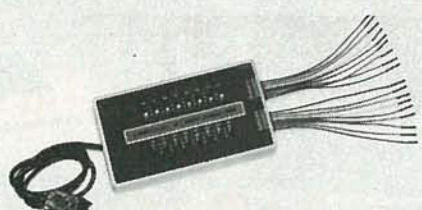


FIG. 3—THE *LP3* TRIGGER EXPANDER PROBE or qualifier pod adds 16 more trigger bits to the trigger word.

Clocking

Once the trigger circuit enables the storing of data samples, it no longer has any effect on sample loading—the storing of the data samples occurs in conjunction with the clock circuit.

The clock circuit tells the memory when the incoming data samples are valid. You can select between two external clock lines (one located on each data pod) or an internal clock. If you decide to use the external clock signals, either clock line—and whether the rising or falling edge of the signal on that line is used—can be selected. It is important to note that the clock as it is referred to here is not necessarily the microprocessor system's clock. It can be any control signal that's used to indicate when the sampled data is valid.

The appropriate control-bus signal for clocking the logic analyzer will vary with the type of data being observed and the particular microprocessor in the system. For example, if you wanted to look at the address lines of a Z80 microprocessor during the instruction-fetch cycle, the clock line would be hooked to the $\overline{\text{READ}}$ line and the clock edge would be set to FALLING EDGE. Or, even better, a qualifier line would be connected to the $\overline{\text{M1}}$ line with the corresponding trigger switch set to logic 0.

When the internal clock is used, data will be stored at one of eight user-selected sampling rates ranging from 10 MHz (a sample every 100 ns) to 1 Hz. That means it can take a minimum of 24.9 microseconds or a maximum of 249 seconds to fill the logic analyzer's memory.

The internal clock allows you to observe a circuit that has no clock signal available. You could set the logic analyzer to begin storing samples when a particular set of inputs occurs and then store periodic samples over the user-selected period of time. (See Fig. 4.)

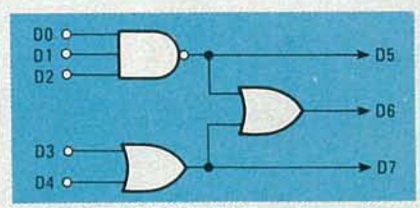


FIG. 4—A TTL CIRCUIT THAT can be monitored by a logic analyzer. The TRIGGER-BIT switches would be set for the desired logic levels for D0 - D4, and for x for D5 - D15. The internal-clock selector is used to set the sampling rate.

Data storage

Once the trigger word and the clock source have been selected, the machine is simple to use. You simply push the ARM button to activate the trigger circuit. When the data on the incoming lines match the trigger word, the analyzer will begin storing samples in conjunction with the selected clock. During the data-storing process, the TRIGGER LED will light. When all 250 samples have been stored, the TRIGGER LED will go out and the COMPLETED LED will light.

Let's consider, however, the real-life situation where the incoming data never matches with the trigger word. That typically occurs when a program locks up in a loop. You can manually initiate storage of the data samples by pushing the TRIGGER button. In that instance, if you are sampling the address lines, the data stored will be the locations of the program instructions then being executed. Also, if you were to encounter an instance where a program halted before 250 samples were stored, you could manually complete the sampling process by pushing the COMPLETE button. Once the sampling process is complete, you can view the analyzer's stored data.

Data display

The display circuit shown on the block diagram in Fig. 2 lets you observe the stored samples. The *LA1020* will display its stored information one word at a time on its LED display when in the DISPLAY mode. By pushing the + and − TRIGGER switches you can examine, individually, each of the 250 data samples stored in the *LA1020*'s memory. You can select your choice of displaying the memory in a decimal, octal, binary, or hex format by turning the MODE switch to the appropriate position. In addition to the data being displayed, the location of the data word in the logic analyzer's memory is also displayed. The display circuit also supplies the synchronizing and vertical-input signals to allow an oscilloscope to be used as a 16-word by 16-sample display. The data displayed on the oscilloscope will scroll as you scroll through the logic analyzer's memory.

There are two additional outputs on the logic-analyzer unit. One is a CLOCK output. When you select an internal clock rate, an output at the same rate is available from a BNC connector on the rear panel. The other output is the EVENT output.

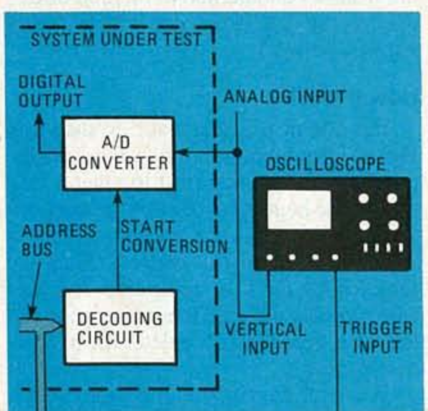


FIG. 5—THE LOGIC ANALYZER can be used as a digital trigger for an oscilloscope. If the selected trigger word is the starting address of the A/D conversion routine, the scope will be triggered every time the conversion is started.

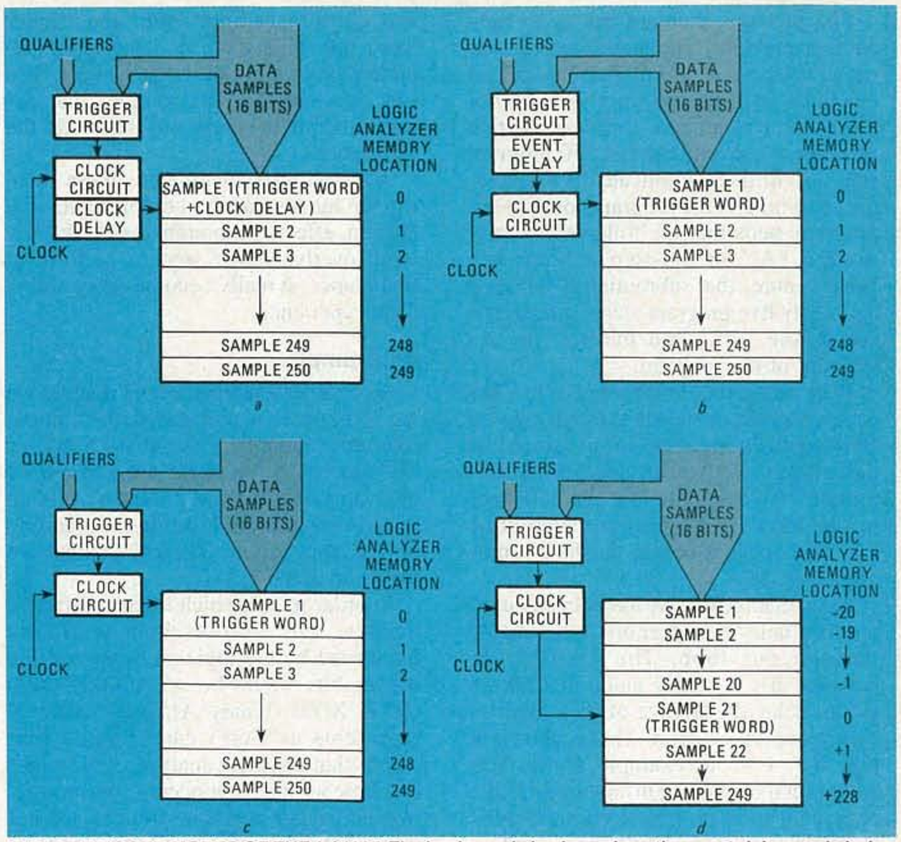


FIG. 6—TRIGGER MODES OF THE *LA1025*. The basic mode is shown in *a*; the event-delay mode in *b*; the clock-delay mode in *c*, and the trigger-position mode in *d*.

When the logic analyzer's MODE switch is changed to the EVENT position, the logic analyzer acts as a digital trigger for an oscilloscope. Whenever the incoming data sample matches the trigger word as selected on the TRIGGER BIT switches, a pulse that can be used to trigger an oscilloscope will be generated on the EVENT output line.

A typical application would be to troubleshoot the analog input of an erratic A/D converter. By hooking the data-sampling lines to the address lines and setting the trigger bits to the starting address of the A/D conversion routine, as shown in Fig. 5, the oscilloscope can monitor the stability of the input voltage to the A/D converter.

Trigger modes

The real versatility of the logic analyzer lies in its triggering modes. We have already discussed the basic trigger mode—the configuration when the logic analyzer is powered up. As shown in Fig. 6-a, the logic analyzer's trigger circuit monitors the incoming 16 data sampling lines and qualifier bits. When the incoming data samples match the user-selected 16-bit trigger word, a condition we'll call the *trigger event* occurs and the storage of data samples on subsequent clock signals begins. In this mode, the first word stored in the logic analyzer's memory will be the trigger word. (If some of the trigger bit switches are set to the x or "don't care" position, the actual data stored in the corresponding bit position may be either a logic 1 or 0).

The basic trigger scheme can be altered when the MODE switch is turned to the STAT (status) position. In that position, you can select any combination of event-delay, clock-delay, or trigger-position modification.

Figure 6-b shows the effect of the event delay, which can probably best be thought of as a loop delay and can be used in the following way: Let's assume that you want to look at a program with a 300-step loop that is going astray in its tenth pass through the loop. In the basic triggering mode shown in Fig. 6-a, the logic analyzer would trigger and fill its 250-word memory on the first pass through the loop. Using the event delay you can trigger the logic analyzer on the tenth pass through the loop. To accomplish that, the MODE switch is set to the STAT position and, for the example above, the event delay is set to 9 by using the + and − EVENT DELAY switches. By setting 9 as the event delay, you are instructing the logic analyzer to ignore the first 9 trigger-word matches (events) and to enable the logic analyzer's memory when the tenth trigger event occurs. The event delay can be user selected to any number from 0 (no event delay) to 999. As with the basic triggering mode (Fig. 5-a), the first data sample stored in memory will be the sampled data that matches the triggering requirements.

The previous problem brings to light another problem. The loop length in our example above is 300 program steps and our logic analyzer can only store 250 of those. Let's assume for this example that we want to see only the last 250 program steps. To further complicate the problem, the beginning of the program contains ten program steps that are followed by subroutine "A" (a ten-step subroutine). What's more, that subroutine is followed by twenty-five program steps, a repeat of subroutine "A," and then by the remainder of the program.

Note that since subroutine "A" executes both from step 11 through step 20 and step 46 through step 55, we cannot set the trigger word to an address in subroutine "A" to capture the last 250 steps in our loop. That's because subroutine "A" also occurs before the loop's program-step 50.

Keep in mind that we have already used our loop delay to trigger on the tenth pass through our loop. The *LA1020/25*, however, has a trigger mode that allows you to delay the storage of data samples by a preset clock delay. That is shown in Fig. 6-c. For our example above, you would set the TRIGGER BIT switches to the beginning address of our loop and set the clock delay to 50 by using the + and − CLOCK DELAY switches. The result is that after the event delay (Fig. 6-b) is satisfied (it has priority over the clock delay), the unit will not store any samples until the 51st clock pulse occurs. The remaining samples will then be loaded on subsequent clock pulses. In that manner, the clock-delay feature gives you another tool for "zeroing in" on the portion of the program that you want to observe. The clock delay can be set for values from 0 (no clock delay) to a maximum of 999.

The last triggering modification to be discussed is the trigger position (Fig. 6-d). With the + and − TRIGGER POSITION switch, you can locate the trigger event anywhere within its 250 word memory. If, for example, 20 was set into the TRIGGER POSITION register and the trigger event occurs, 20 samples prior to the trigger event will be stored in the first 20 words of the logic analyzer's memory. The trigger word will be stored in the 21st position in the logic analyzer's memory and then 229 samples will be stored after the trigger word.

This example, of course, assumes that the clock delay was not set. The trigger-position feature is perhaps the most useful on the logic analyzer. Let us look at an example where you have a program that contains a subroutine where the program is locking up. The trigger word can be set for the starting address of the subroutine (found by manually triggering the unit) and the trigger position set to 125. (The trigger-position register can be set to any number from 0 to 249.) Now, when the sampling process is completed, you will not only be able to view the trigger word and the 124 samples after the trigger word, but also the 125 samples immediately preceeding the trigger event. You can then see the data samples that occurred before the entry was made into the subroutine.

As previously mentioned, these three trigger modes can be combined for the desired effect. Although that task may seem overly complicated to perform at first glance, it really becomes easy after a little experience.

An example

As another example, let us assume we are looking at a problem with multiple interrupt routines for the 8080, 8085, or Z80 (mode 0). As there are 8 levels of interrupts possible, the program could go to any one of eight locations, depending on the application. These locations are shown in Table 1.

In order to see which interrupt routine occurs, the address bus would be monitored by the logic analyzer and the trigger bits would be set to 0000 0000 00XX X000 (binary A15-A0) where X represents a "don't care" state. That means that the logic analyzer will trigger any time an interrupt occurs. By modifying the trigger position, you can see not only what interrupt occurs but the address of the program steps occurring before the interrupt. If the interrupt routine were a long one, the clock-delay function could position the start of the sampling process anywhere within the interrupt routine.

TABLE 1

Interrupt level	Subroutine starting address (hex)
0	0000
1	0008
2	0010
3	0018
4	0020
5	0028
6	0030
7	0038

Extended bus monitoring

In the case of monitoring a system with extended addressing (more than 16 bits), the LP3 qualifier probe (Fig. 3) is useful. Even though the logic analyzer will only store 16 bits at one time, the extended address bits can be used to trigger the unit with the LP-3 qualifier pod. Then, by knowing the address location of the trigger word, the 16 stored bits would generally be enough to follow the program sequence.

A similar situation occurs when monitoring the data buses. Eight- and sixteen-bit data buses can be monitored without problems. A trade-off must be made, however, when you want to monitor both the address and data bus; let's see what's involved.

With an eight-bit data bus, eight address lines (usually the lower eight bits) can be stored in addition to the eight data lines. The high-order address lines could then be used as part of the trigger word by using the *LP3* qualifier pod. Similarly, when monitoring a 16-bit data bus, the address lines could only be used for triggering. It is important to note that we are confronted with the basic design limitations of a 16-bit machine—only 16 bits of data can be stored at one time. Two alternatives are possible. One is to run two *LA1020/25* units in tandom. The other would be to buy a unit with more than 16 bits of data storage. Generally, though, a unit with 16 bits of data storage is sufficient for most requirements.

A single-IC analyzer

So far we have explored a commercially available logic analyzer. Unfortunately, not everyone can afford more than $2000 for such a logic analyzer. Recently, I found myself in the same situation. The B&K unit that had been loaned to me wasn't available any longer and I didn't have the money to spend for one. Yet, the project I was working on—a stand-alone printer interface card with an on-board Z80 microprocessor—was giving me a rough time. The program just wasn't executing as it should. Fortunately, a circuit that I had recently run across, was adaptable to my needs. Based on that circuit, I was able to design a one-IC "logic analyzer" to perform the function of address-state analysis.

Obviously, a one-IC logic analyzer will have many limitations. The first limitation with ours is that it will only work on Z80 microprocessors. The second limitation is that the output from the circuit under test has to be fed into 2 parallel ports on a host computer.

Figure 7 shows the typical hookup between the circuit under test and the host computer for address-state analysis. Figure 8 shows an alternative method of displaying the data if you don't have 2 extra parallel ports.

How it works

The circuit (its schematic is shown in Fig. 9) is really quite simple. It causes the microprocessor under test to enter a wait state at the beginning of every instruction-fetch cycle. While the microprocessor is in its wait state, the address lines are sampled by the host computer. The host computer then clears the wait signal and the microprocessor completes the instruction cycle.

When the next instruction fetch occurs, the $\overline{\text{WAIT}}$ signal again goes low and the whole cycle begins again. A limitation that you should be aware of is that, unlike the B&K logic analyzer, which samples the circuit in real time (without slowing down the program's execution), this circuit halts the program's execution after each program step. Therefore, it is possi-

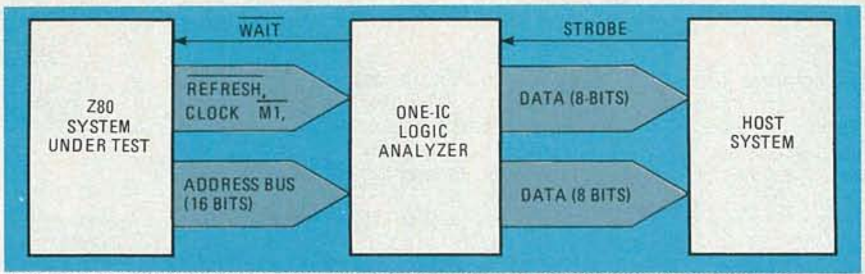


FIG. 7—INTERCONNECTION BETWEEN the logic analyzer host system and the test system.

ble that this circuit could cause some strange occurences in programs that have critical timing loops.

The heart of the circuit is a simple dual D-type flip-flop. When the Z80's instruction-fetch cycle begins and the $\overline{\text{M1}}$ line goes low, the next clock pulse toggles the flip-flop, and the $\overline{\text{WAIT}}$ line is pulled low via Q1. That transistor functionally acts as an open-collector output. Pin 24, the $\overline{\text{WAIT}}$ line on the Z80, should be connected to a pull-up resistor. To protect any other non-open-collector gates hooked up to the $\overline{\text{WAIT}}$ line, they should be disconnected. Since a wait state occurs each instruction cycle when using this logic analyzer, that shouldn't cause too many difficulties. When a positive-going strobe is sent from the host system, the second flip-flop is toggled and the wait state ends. The $\overline{\text{REFRESH}}$ line prevents the wait cycle from repeating until it goes high during the next

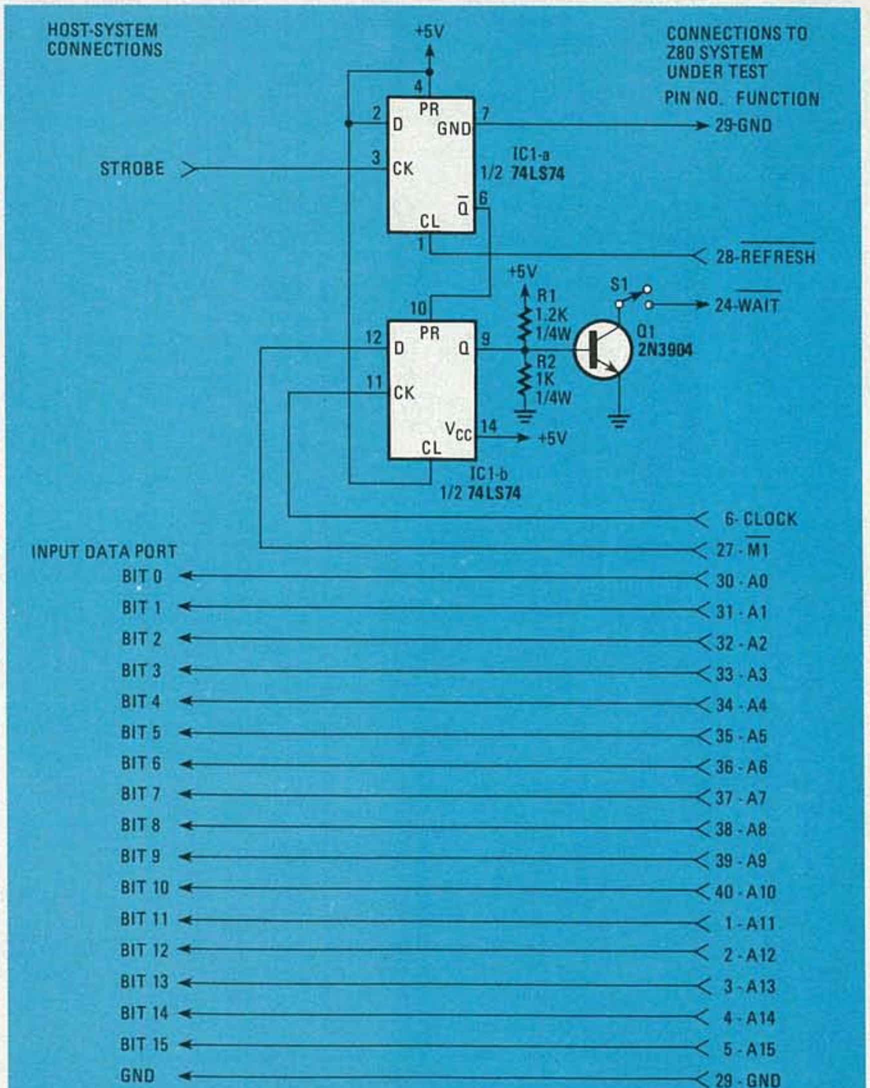


FIG. 9—SCHEMATIC OF THE LOGIC ANALYZER. No on-board buffering is provided because enough time for the data to settle is provided in software. When S1 is closed, the analyzer controls the test system. When open, it has no effect on the test system.

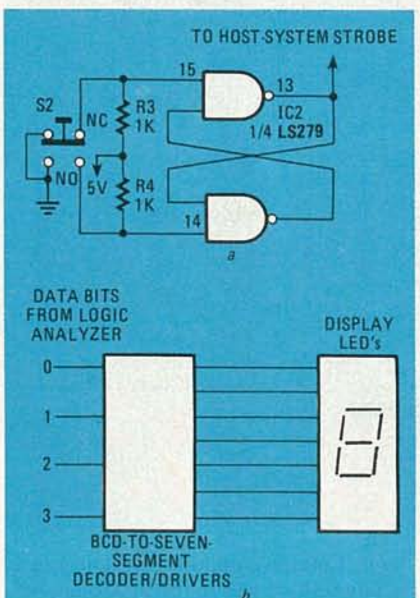


FIG. 8—AN ALTERNATE METHOD to display data from the one-IC logic analyzer. The circuit in *a* will cause an additional data sample to be taken each time S2 is pressed. Three additional BCD-to-decimal decoder/drivers and LED's are needed to display the value of the 16 data bits.

instruction cycle. At the end of this article we'll explore some options to expand the capabilities of this circuit.

The circuit was built on a small piece of perf board using wire wrap techniques and is shown in Fig. 10. The connection to the host system was made by a 25-conductor ribbon cable with DB-25 connectors at each end. Connection to the system under test was accomplished by using a 40-pin clip with standard DIP spacing that attached to the Z80. No buffering was used on the address lines between the system under test and the host system. The software (Table 2) that I used leaves a long enough delay time—from the start of the wait state until the host takes its sample—for the address lines to settle for a stable sample. Nonetheless, it is strongly recommended that the length of the connections between the tested system and the host system be kept as short as possible.

When the program in Table 2 is entered, a "*" is printed as a prompt. You can then press any number between 1 and 9 on the keyboard. That number of program-step addresses will be displayed on

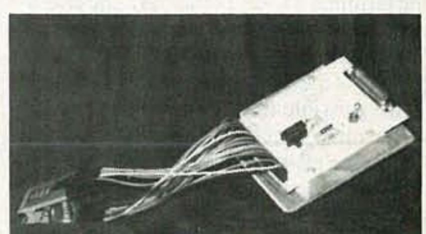


FIG. 10—THE ONE-IC LOGIC ANALYZER doesn't look elegant, but it does work! It was built using wire-wrap techniques. Connection to the Z80 test system is by a 40-pin clip.

TABLE 2—LISTING

This is a simple program to display the addresses of instructions as they are executed. When run, the program displays an "*". The user then selects a number between 1-9 on the keyboard. That number of program steps will then be displayed on the console. If the RETURN key is hit, the system reboots. This program is written in 8080 code for the ASM assembler.

```
         ORG   1ØØH
BDOS     EQU   5              ;BDOS ENTRY POINT
CONOUT   EQU   2              ;CONSOLE OUT
                              ; FUNCTION CODE
CONIN    EQU   1              ;CONSOLE IN
                              ; FUNCTION CODE
         1XI   SP,2ØØH        ;LOAD NEW STACK
                              ; POINTER
PMT:     MVI   E,ØDH          ;PRINT LINE FEED &
                              ; CARRAGE RETURN
         MVI   C,CONOUT
         CALL  BDOS
         MVI   E,ØAH
         MVI   C,CONOUT
         CALL  BDOS
         MVI   E,2AH          ;PRINT PROMPT
         MVI   C,CONOUT
         CALL  BDOS
;           MY SYSTEM I/O PORTS ARE:
;           STROBE OUT PORT = Ø3H
;           STROBE OUT BIT = Ø2H
;           LOW ADDRESS INPUT PORT = Ø6H
;           HIGH ADDRESS INPUT PORT = Ø5H
;           PORTS AND BITS SHOULD BE CHANGED
;           TO REFLECT YOUR SYSTEM
         MVI   C,CONIN        ;GET THE NUMBER OF
                              ; STEPS
         CALL  BDOS
         CPI   ØDH            ;COMPARE TO
                              ; CARRAGE RETURN
         JZ    Ø              ;YES- THEN JUMP TO
                              ; CPM
         CPI   2ØH            ;CHECK FOR SPACE
                              ; BAR
         JNZ   INC            ;YES-THEN ENTER 1
         MVI   A,31H          ;ENTER 1
INC:     ORA   A              ;CLEAR CARRY FLAG
         SBI   3ØH            ;MAKE ZERO RELATIVE
         MOV   D,A            ;PUT RESULT IN D
                              ; REGISTER
         PUSH  D              ;SAVE IT
         MVI   E,2ØH          ;OUTPUT A SPACE ON
                              ; THE CONSOLE
         MVI   C,CONOUT
         CALL  BDOS
         POP   D              ;GET COUNT BACK
LOOP:    PUSH  D              ;SAVE LOOP COUNT
         MVI   A,2            ;OUTPUT STROBE
         OUT   Ø3H
         CALL  DELAY          ;ALLOW SIGNALS TO
                              ; SETTLE
         IN    Ø5H            ;GET UPPER 8 DATA
                              ; BITS
         CALL  PRTHX          ;PRINT HEX NUMBER
         IN    Ø6H            ;GET LOWER 8 DATA
                              ; BITS
         CALL  PRTHX          ;PRINT HEX NUMBER
         MVI   E,2ØH          ;OUTPUT A SPACE ON
                              ; THE CONSOLE
         MVI   C,CONOUT
         CALL  BDOS
         POP   D              ;GET LOOP COUNT
                              ; BACK
         DCR   D              ;DECREMENT LOOP
                              ; COUNT
         JNZ   LOOP           ;LOOP UNTIL OUTPUT
                              ; IS DONE
         JMP   PMT            ;DONE - PROMPT
                              ; USER
;   SETTLING DELAY - ALLOW DATA LINES TO SETTLE
DELAY:   MVI   C,1Ø           ;LOAD DELAY
TLOOP:   DCR   C              ;DECREMENT COUNT
         JNZ   TLOOP          ;LOOP UNTIL DELAY IS
                              ; OVER
         RET                  ;DONE - RETURN
;   PRINT TWO HEX NUMBERS ON CONSOLE
PRTHX:   PUSH  PSW            ;SAVE REGISTER
         CALL  ASCII          ;OUTPUT ONE
                              ; CHARACTER
         POP   PSW            ;GET CHARACTER
                              ; BACK
         JMP   BYPASS         ;SKIP ROTATION
ASCII:   RLC                  ;POSITION DIGIT
         RLC
         RLC
         RLC
BYPASS:  ANI   ØFH            ;MASK HIGH FOUR
                              ; BITS TO ZERO
         CPI   ØAH            ;CHECK FOR HEX A-F
         JC    PASS           ;NOT THEN SKIP
                              ; NEXT
         ADI   7              ;INDEX TO "A"
PASS:    ADI   3ØH            ;INDEX TO ASCII
         MOV   E,A            ;POSITION OUTPUT
         MVI   C,CONOUT       ;OUTPUT IT
         CALL  BDOS
         RET
         END
```

the terminal's CRT. In that way, the execution of the program can be followed. When you want to exit the program, simply press the carriage return.

It's possible that you would like to see all memory accesses by the Z80 in addition to the instruction fetches. The memory-request signal (Z80 pin 19—$\overline{\mathrm{MREQ}}$) and the $\overline{\mathrm{READ}}$ and $\overline{\mathrm{WRITE}}$ signals (pins 21 & 22) are candidates for triggering signals that could be used in place of the $\overline{\mathrm{M1}}$ signal to trigger the unit.

If you use a microprocessor other than the Z80, the requirement for the refresh signal can be eliminated by adding an inverting gate from a 74LS00 or 74LS04. The input of that gate would be connected from pin 12 of the 74LS74 and the output of the gate would be connected to pin 1 of the 74LS74, eliminating the requirement for the resetting of the logic analyzer via the Z80 refresh signal. Although I haven't actually tried it, the address latch enable (ALE) of the 8085 or the valid memory address (VMA) of the 6800 should take the place of the $\overline{\mathrm{M1}}$ signal in triggering this circuit. Caution should be used to insure that any restrictions on the maximum duration of the wait signal should not be exceeded. (The Z80 has no restriction on the maximum duration of the wait signal).

Despite its limitations, this simple logic analyzer enabled me to successfully complete my project and saved me the cost of an expensive logic analyzer. With a little work with the software, many of the features of the commercial logic analyzer we previously discussed could be implemented. **R-E**

Typewriter -to- Computer Interface

BILL GREEN

Build this interface/buffer and use your IBM typewriter as a low-cost letter-quality computer printer. The 30K buffer can be used with the typewriter or any parallel printer.

Part 2 WE HAVE ALREADY looked at the theory behind the interface and looked at its features. Now we'll go through the assembly and begin the interface installation.

As we now go through the assembly instructions, be sure that you install parts in their proper locations and double check your work! Make sure all parts are properly oriented or polarized. Solder all leads and clip the leads close to the board. Don't forget that MOS devices are static sensitive—use sockets and follow proper handling procedures to avoid damage.

Follow the parts-placement diagrams shown in Figs. 9 and 10 to help with the assembly. To start, install sockets for (preferably all) the IC's. Note that IC1 and IC2 are MOS devices and should definitely be socketed. The same holds true for IC12 through IC27, which are used in the buffer. Two high-current drivers, IC10 and IC11, are used only with the *Selectric*. You might want to install sockets there, anyway—it will make the interface easier to modify in the future.

Next, install the fuse clip and a 20-position right-angle header at SO1. Install the voltage regulator and its heatsink. Then, connect switches S1, S2, and S3. Install D1, all the resistors except R3, and all the capacitors except C5.

There are still some components and jumpers to be installed. Which components you now install—and where you install them—depends on what printing device you're going to use. We'll discuss each case in the following paragraphs.

If you will be using a *Selectric*, install R3 near pin 1 of IC1. (Note that the parts-placement diagram shows two possible locations for R3.) Install jumper JU1 and diodes D2–D4. Next, connect switch S4, following the parts-placement diagram for the proper pads. (Again, note that there are two possible ways to connect S4.)

For the *Electronic* typewriter, install R3

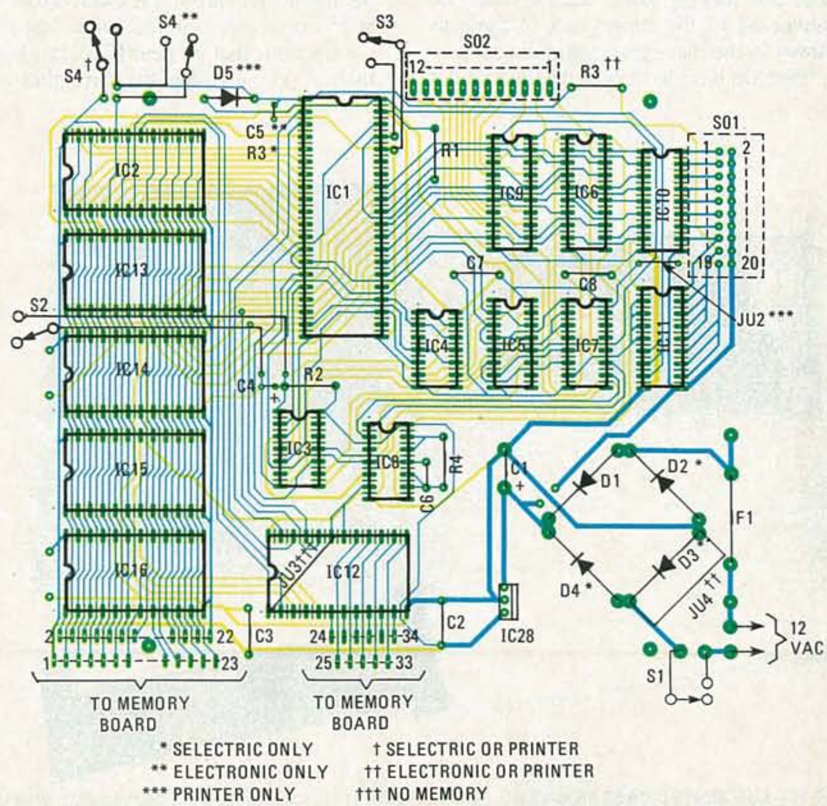


FIG. 9—PARTS-PLACEMENT DIAGRAM for the main board. Note that some components depend on what printing device you're going to use.

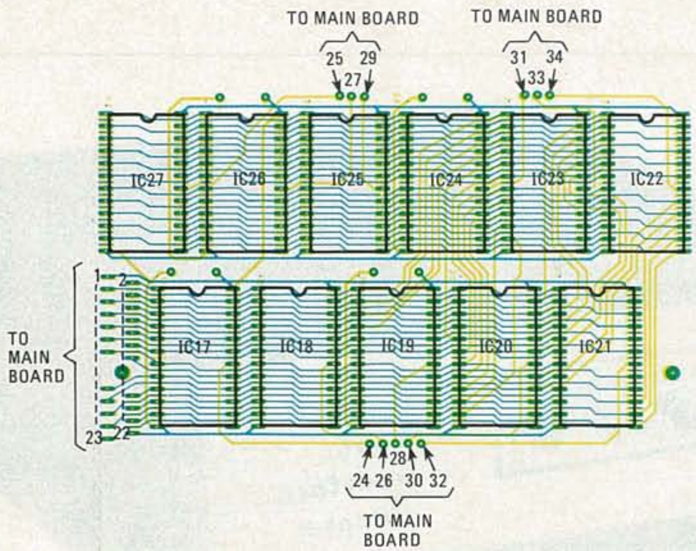


FIG. 10—PARTS-PLACEMENT DIAGRAM for the memory board, and connections to the main board are shown here.

above IC6 and then install C5. Install JU4, JU5 – JU11, and JU13 (See Figs. 2 and 9). As we mentioned earlier, you may want to install a socket at IC10 and insert a properly jumpered DIP header in the socket. Next connect S4 to the proper pads as indicated for the *Electronic* in the parts-placement diagram.

If you will use this interface only with a printer, install R3 above IC6. Then install diode D5 and install JU2, JU4, and JU5 – JU13 (See Figs. 3 and 9). Here, too, you may want to use a DIP socket and header for those jumper connections. Wire S4, making sure that the wires are connected to the proper set of pads as shown in the parts-placement diagram.

Next we have to decide whether or not buffer memory will be installed. If you don't want any buffer memory, then install jumper JU3. If you do want the buffer, but need only 8K or less, then install sockets on the main board for IC12 through IC16, and then install the IC's.

If more than 8K of buffer memory is to be used, then you need the separate memory board. Install and solder sockets for the IC's on that board. Of course, the main board and the memory board have to be wired together. As you can see from the photo in Fig. 11, ribbon cable helps to keep things neat. The connections from the memory board to the main board near IC15 are about 3 inches long. The other connections that go near IC12 are about 6 inches. As you follow the parts-placement diagrams, you'll note that the interconnections near IC16 are tricky. If you arrange the boards as shown in Fig. 11, then you'll note that all the wires cross.

Now, again referring carefully to Figs. 9, 10, and 11, connect the 34 three-inch and six-inch wires from the main board to the memory board.

The next step is attaching the interface to your computer. You'll need a 3-foot length of flat ribbon cable and a suitable connector to connect to the parallel port of your computer. The other end will just be stripped, tinned and soldered to the main board at SO2. Referring to the manual for your computer and the pinout of SO2 (as shown in the schematic), attach the cable between the two. If you have a Radio Shack computer (*Models III* or *4*) or an IBM *PC*, then you don't even have to look at your manual—the proper pin connections are shown in Fig. 12.

Connect a 6-foot length of No. 22 zip cord to the main board near the fuse clips and install a 5-amp fuse. Now we're ready to install the board(s) in a suitable case. Use No. 4 × ¼-inch self-tapping screws to mount the boards. Punch or drill holes for the switches in the front panel of the case, install the switches, and label them. Orient S1 and S3 so that the unused terminal of those toggle switches is up. Punch or cut the rear panel to clear the connection to the header at SO1. Leave plenty of extra room to allow for ventilation.

Connect the free end of the zip-cord wires to a 12-volt, 2-amp, wall-mounted transformer. Turn on the POWER switch and measure for 5 volts at the output of IC28. If that voltage is not correct, or if the fuse blows, double check *everything*. Check carefully for solder bridges and check the polarity of the voltage regulator, diode(s), and electrolytic capacitors.

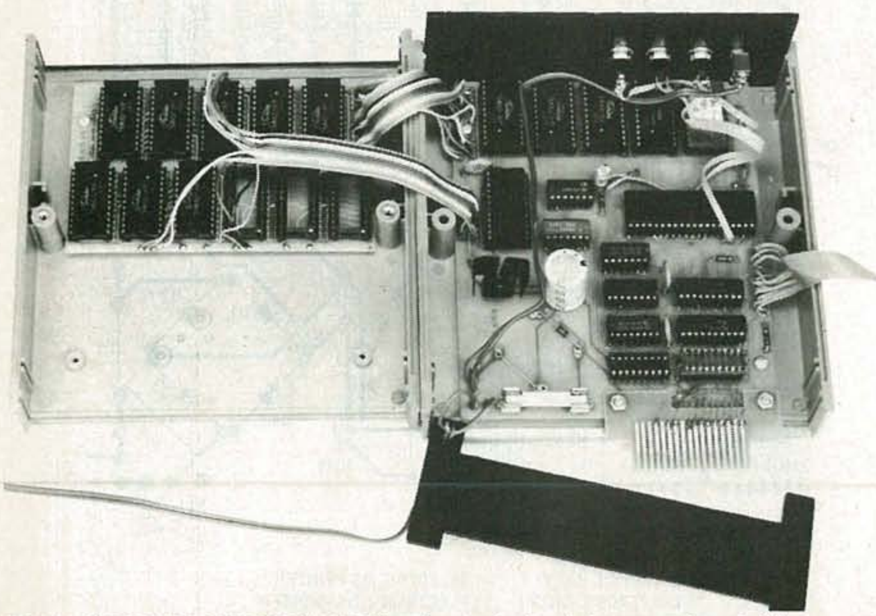


FIG. 11—SUGGESTED CASE MOUNTING. When the case is closed, the memory board will be on top of the main board, and the components on each board will face the other. Note that a right-angle header was not used at SO1—we used what we had on hand.

Installation

Now that assembly is complete and the interface is hooked to your computer, it's time to connect it to your printing device. In the following sections, we'll go through installation for each of the three cases: printer, *Selectric*, and *Electronic*. We'll start assuming that the adapter will be used only as a printer buffer along with a standard parallel printer.

Printer installation

This is by far the easiest configuration, which is why we're starting with it. The only thing you have to do here is to make up a custom cable. You need to get a connector that will plug into the parallel input of your printer, a connector to mate with the 20-pin jumper header at SO1, and some cable to run between the two.

Refer to the manual for your printer and to the schematic in Fig. 3 for the pinouts of your printer's port and SO1. Wire the cable to go between the appropriate pins of the interface and your printer. Then after double checking that your cable is wired correctly, attach the cable to each

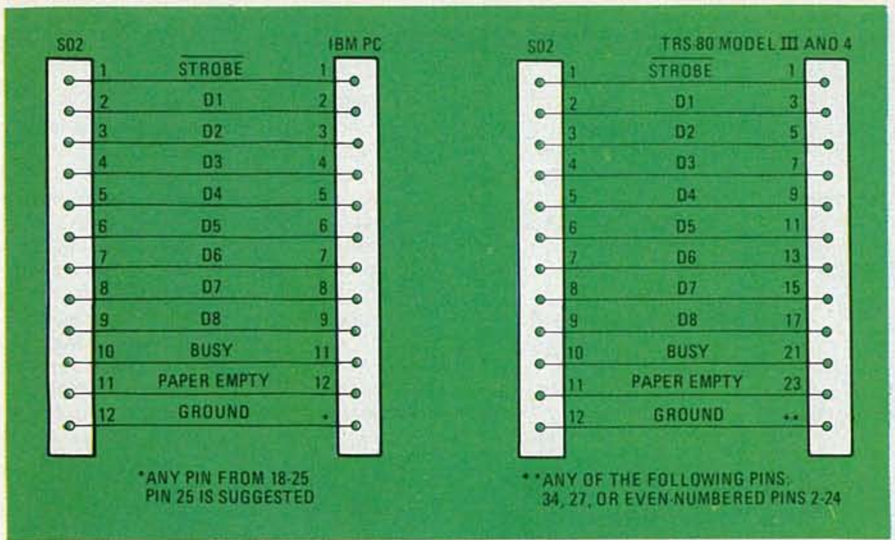


FIG. 12—HOOKING UP THE INTERFACE to your computer is straightforward but requires making a custom cable. Shown here are the connections to a *TRS-80* and IBM *PC*.

device. Check everything again to make sure that the connectors are properly polarized (not inserted backwards). Then turn the interface on and power your printer and computer in the usual order, and press RESET. Dump some text from the computer to the interface. If you have buffer memory installed, press PRINT. (If no buffer memory is installed, printing should begin immediately.) That's all there is to it! If the interface has been assembled correctly and the cables are correctly connected, the text should be printed correctly on the printer.

Electronic installation

Now we're going to look at how to adapt your *Electronic* model *50*, *60*, or *75* typewriter for use as a printer. You're probably worried about what the connection will do to your warranty. IBM Corporation's policy on this (as pertains to warranty and service policies) is to inspect and accept for service each installation on an individual basis. Their interest is primarily to assure that their service personnel will not be subjected to hazardous conditions or voltages. The adapters that this interface requires present no hazards. Contact your IBM field service office for inspection.

Before we get to the "nuts and bolts" of the installation, we should point out that if you do not use care (and some common sense) in the following procedures it is possible that you'll damage your typewriter—so be careful. With that in mind, position the typewriter carriage near the center and *unplug the power cord* until we tell you otherwise.

The first step is to remove the top of the machine; following Fig. 13 will help you. Raise the cover and pivot the paper table up and back. Remove the platen by pressing the release levers on either end of it. Raise the carriage pointer. Using a screwdriver with a long blade, slide the left and right cover-latches forward. These latches are directly below where the platen was.

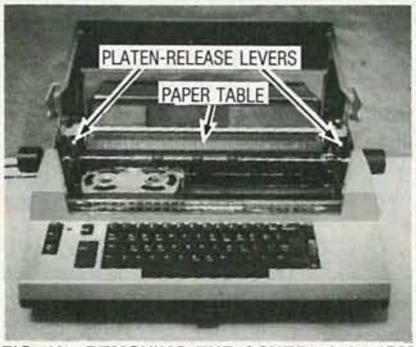


FIG. 13—REMOVING THE COVER of the IBM *Electronic* is an easy process.

Remove the cover by lifting it straight up. Then reinstall the platen. Lift the typewriter by the metal frame at the front and pull forward a few inches. Then tilt it back until it rests on the rear support brackets, as shown in Fig. 14. At the top right side of the assembly is the keyboard-switch plate. There are seven reed switches mounted on this plate. Their designations are shown in Fig. 14.

You will be connecting wires from SO1 on the main board to the reed switches (or, as we'll describe, to the wires leading to the switches).

Cut the wire ties on the wire harness running to the reed switches. Referring to the schematic in Fig. 2, note the pinout of SO1 for the *Electronic*. The odd-numbered pins are the output to the reed switches. (Only one even-number pin, we chose pin 14, is used here.) Spread the wiring harness from the reed switches open to determine what switch each wire goes to. The black wire which loops between one terminal of each reed is ground. At a point an inch or so to the left of *KBMD*, splice the wire from pin 14 of SO1 into that black wire. (The *KBMD* or *K*ey*B*oard-*M*o*D*e reed is what tells the *Electronic* to print shifted characters.) Following Fig. 3, splice the other wires from SO1 to the other wires from the reeds—pin 1 to reed *1*, pin 3 to reed *2*, etc.—until all seven reeds are connected. Solder and tape the splices.

About halfway up and on the left side of the machine is the *PFB* (*P*rint *F*eed*B*ack) reed. (See Fig. 15.) Splice the wire from pin 17 of the header at SO1 to the light-colored wire from this reed. Solder and tape this splice. Rebundle the wire harness from the switch plate using wire ties. Position the flat cable as shown and secure with wire ties. Be sure that the ties do not interfere with the moving parts of the ma-

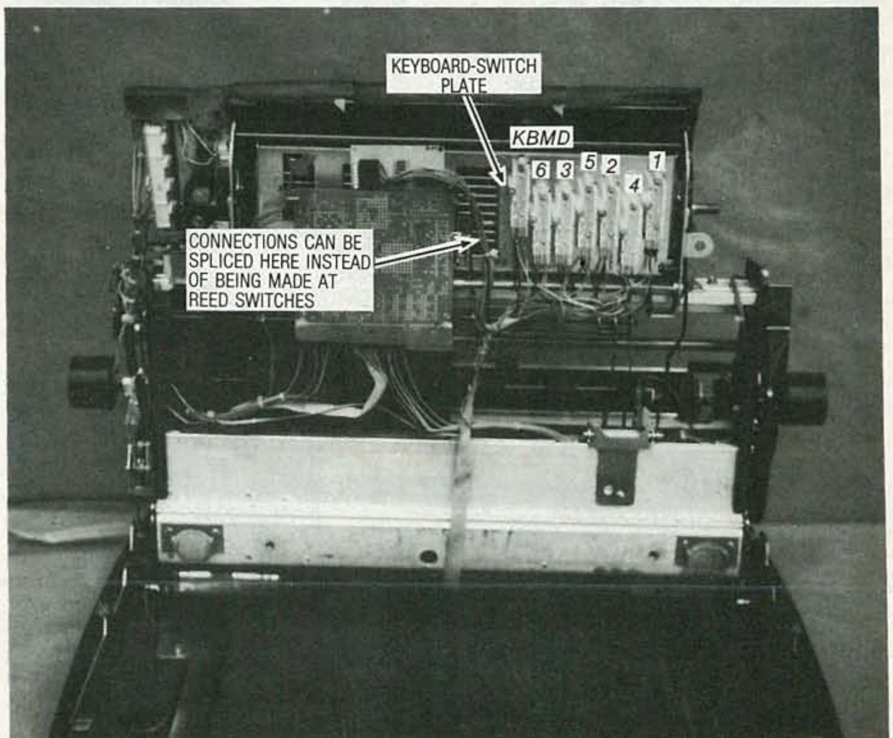


FIG. 14—BOTTOM VIEW of typewriter assembly showing reed-switch locations.

PARTS LIST—PRINTER AND ELECTRONIC INTERFACE

All resistors ¼-watt, 5%, unless otherwise specified
R1,R3—1000 ohms
R2—10,000 ohms
R4—220 ohms
Capacitors
C1—2200 µF, 25 volts, electrolytic
C2,C3,C7,C8—0.1 µF, 6 volts, ceramic disc
C4—4.7 µF, 10 volts, electrolytic
C5—1 µF, 6 volts, electrolytic (used only with *Electronic*)
C6—1500 pF, 6 volts, ceramic disc
Semiconductors
IC1—2650 microprocessor, (Signetics)
IC2—13941 PROM, (Alpha)
IC3—74LS14 hex inverter
IC4—74LS20 dual 4-input NAND gate
IC5—74LS139 dual 2-to-4 line decoder/multiplexer
IC6,IC9—74LS373 octal D-type latch
IC7—74LS279 quad S-R latch
IC8—7400 quad 2-input NAND gate
IC12—74LS154 4-to-16 line decoder/demultiplexer (for buffer)
IC13-IC27—TMM2016P 2K × 8 static RAM (Toshiba) (for buffer)
IC28—LM340T five-volt regulator
D1—1N5400
D5—1N4148 (used only with printer)
F1—5-amp fuse
S1,S3—Switch, SPDT toggle
S2,S4—Switch, SPST, momentary push button
T1—12-volt 2-amp wall-mounted transformer
Miscellaneous: PC boards, fuse clip, IC sockets, 20-pin header for SO1, 5-watt heat sink for IC28, suitable case, wire, connectors and cables for your computer and printer

The following are available from Alpha *Electronics*, PO Box 1005, Merritt Is., FL. 32952 (305-453-3534). A complete kit of parts—including main PC board, memory PC board, cable, case—for printer conversion (does not include memory IC's): $129 plus $6 postage; complete kit for *Electronic* conversion (does not include memory PC board or memory IC's): $119 plus $6 postage; 2K × 8 static RAM IC's, $6.50 each postpaid; 13941 PROM, $25; memory PC board (PC1832) $13 postpaid; main PC board, (PC1831), $18 postpaid; ABS plastic case, $12. Florida residents please add 5% tax. Canadian orders please add $2 per order in addition to U.S. postage. Other countries please add $6 per order in addition to U.S. postage.

OOOOOOOPS!

Last month, some errors crept into the article: In Fig. 1, the LM340T voltage regulator should have been labled IC28 and R3 should have been labled 1K. In Fig. 4 and the Parts List, IC's 13–27 are TMM2016's. We're sorry for any inconvenience this may have caused you.—*ED*

chine. Lower the assembly backs to its proper position. Run the flat cable along with the power cord out through the notch in the bottom cover. Remove the platen and lower the top cover into place. Relock the two case latches, reinstall the platen, and pivot the paper tray forward. Lower the carriage pointer and the cover.

Now that that's done, we can try it out. Plug the flat cable into the interface and plug the cable from SO2 into your computer. Turn on the interface (making sure that PAUSE is off), the typewriter, and then the computer. Then press RESET. Enter some text into the computer and dump it to the interface. If you have buffer memory installed, press PRINT. (If you don't have any buffer memory, printing should begin immediately.) Check the characters printed. If they're not correct, double check the wiring to the reeds and to the computer, and be sure that all components are installed correctly in the interface.

Unfortunately, that's all we have room for here. Next time we'll look at how to install the interface in a Selectric. **R-E**

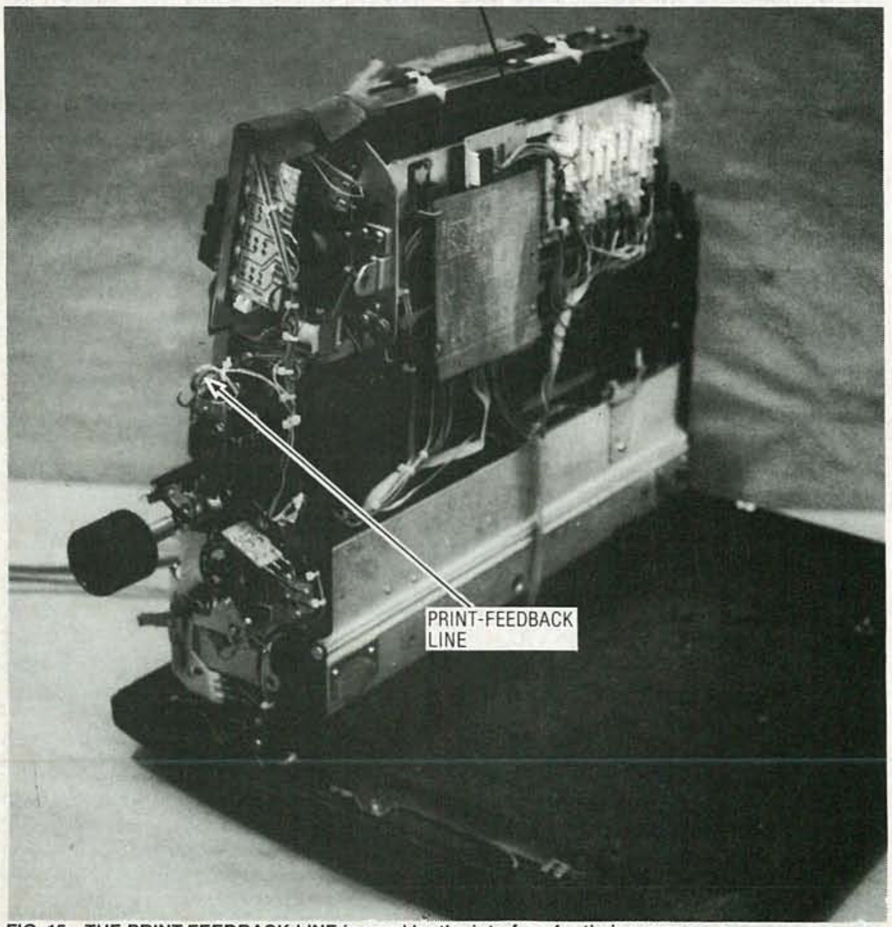
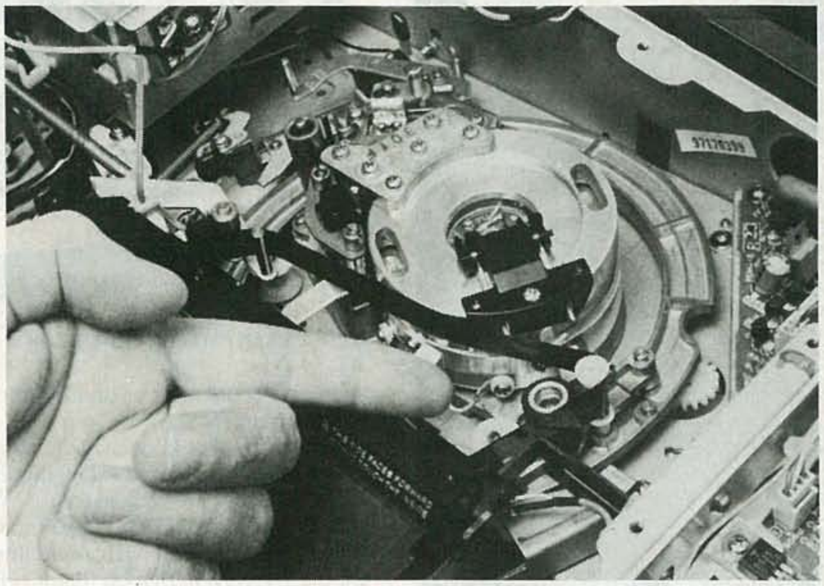


FIG. 15—THE PRINT-FEEDBACK LINE is used by the interface for timing purposes.

PARTS LIST—SELECTRIC ADAPTER

All parts mentioned in the Parts List for the *Electronic* and Printer versions, plus:
IC10, IC11—ULN2813A or ULN2803A high-voltage/current darlington transistor array, (Sprague)
D2 – D4—1N5400
SOL1 – SOL10—Solenoid, 12-volts DC
Miscellaneous: PC boards, No. 6 hardware: (two 1 × ¼ inch male/female threaded round spacers, two ⅜-inch flathead screws, two ⅛-inch pan-head screws, hex nut), music wire (12 inches, .031-inch diameter), plastic-covered stainless steel cable (27 inches, .020-inch diameter) 18 crimp sleeves (.040-inch diameter), wire ties, ribbon cable, etc.
A complete kit of all parts for *Selectric* conversion, including main PC board, case, cable for typewriter, solenoids, etc. (not including memory board or memory IC's) is available from *ALPHA* Electronics, PO Box 1005, Merritt Is., FL. 32952 (305-453-3534) for $169 plus $6 postage. The mechanical adapter alone (solenoid boards and solenoids) is available for $90 plus $5 postage. The ULN2813A or ULN2803A IC's can be purchased for $3 each postpaid. Florida residents please add 5% sales tax. Canadian orders please add $2 additional to US postage; other foreign orders please add $6 additional to US postage.

VCR REPAIRS AND ADJUSTMENTS THAT YOU CAN DO



JOHN D. LENK

Repairing and aligning VCR's isn't easy, but it is possible to do some of the work yourself if you know how! In this article we'll tell you what repairs and adjustments you can make using standard test equipment.

Part 2 LAST MONTH, IN THE first part of this article, we skimmed through the basics of VCR's. We looked at VCR circuits and at how a video signal is recorded. Now let us drop the subject of circuits, and get on to more practical matters.

Keep in mind that about 95% of the circuits we've described are contained in a few special-purpose IC's. (That applies equally to video, audio and servo circuits.) You can not get at the detailed circuits for test or analysis. Likewise, if there is a failure of even one circuit in an IC, the entire IC must be replaced (as is the case with most TV circuits). About the only electronic components in a VCR that can be replaced on an individual basis are adjustment controls. We will talk about those components and the related adjustments later on. But before that, let us discuss the test equipment and tools you need for VCR service.

Test equipment and tools for VCR's

The test equipment used in VCR service is basically the same as that used in TV and audio service. Most service procedures are performed using meters, signal generators, color generators, oscilloscopes, frequency counters, power supplies, probes, and so on. However, there are some problems to be considered when selecting test equipment for VCR service.

The subject of tools, test jigs, and fixtures for VCR service is an entirely different matter. Generally, each VCR requires a special set of tools, available from the VCR manufacturers in the form of kits. Although there are some tools found in all kits, such as tension gauges, there are many special-purpose tools for most VCR's. Keep in mind that it is impossible to perform a full set of manufacturer-recommended test and adjustment procedures without having all of those special tools.

Let us consider the minimum requirements for test equipment and tools that you'll need to work with VCR's.

Meters

Any meter suitable for TV and audio work is probably suitable for VCR service. (However, most VCR service literature lists audio signals in terms of dB's rather than volts, so a meter with a dB scale would be useful and time-saving.)

Signal generators

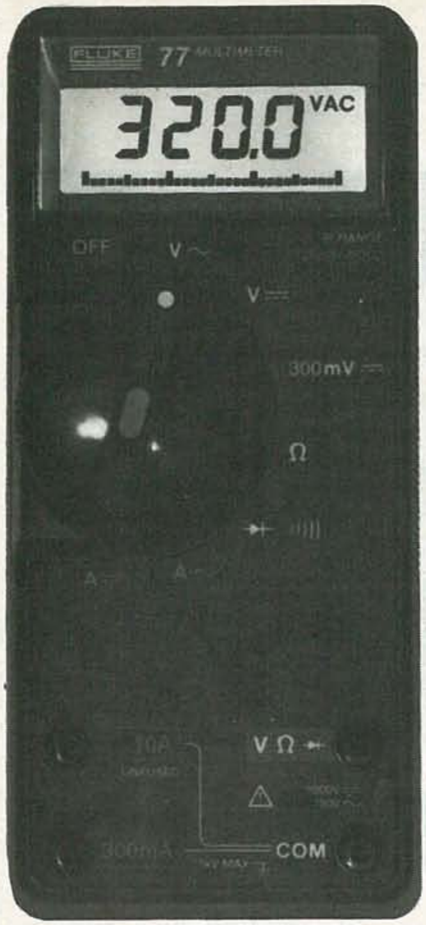
As a minimum you should have a sweep/marker generator as well as an analyst and/or pattern generator for basic VCR service.

Color generators

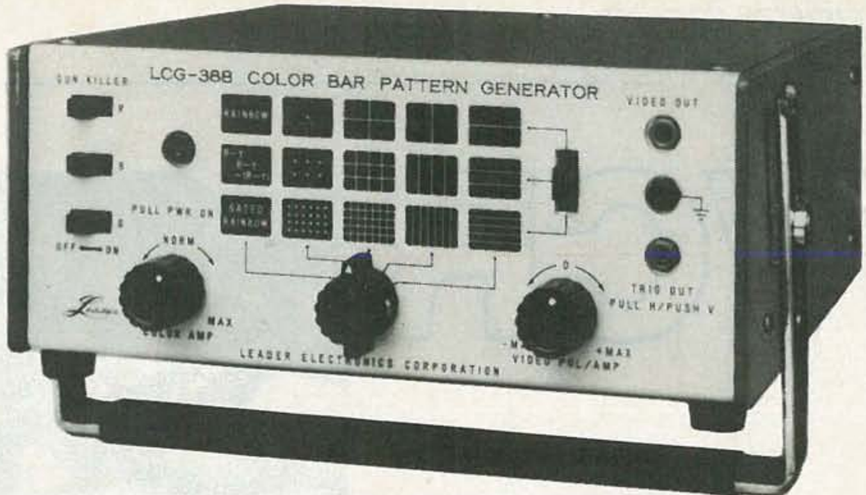
You can perform some of the adjustments required for VCR service with a keyed rainbow generator, but you must have an NTSC color generator to perform all of the adjustments. As a minimum, the NTSC generator should produce the standard NTSC bar pattern (for display on the TV screen) and a five-step linear staircase pattern (for display on an oscilloscope being used to monitor various points in VCR circuits).

Oscilloscopes.

As in the case of meters, any oscilloscope suitable for TV and audio work will be fine for VCR service. That means a bandwidth of at least 10 MHz is best, although you probably could get by using a scope with a bandwidth of as low as 5-6 MHz.



A HANDHELD MULTIMETER like this one should be fine for VCR servicing.



A COLOR BAR PATTERN GENERATOR is useful, but an NTSC generator is preferred.

Frequency counters

If you want to go through a full set of VCR adjustments, you will need a frequency counter to check or adjust the various 3.58-MHz oscillators in the color record and playback circuits, and to measure servo-system timing. Most frequency counters have a sufficient frequency range to measure the 3.58-MHz signals; but many of the servo-system signals are in the 30-Hz range, and low-cost counters often do not go down that far, or are not that accurate. Typically, low-cost counters have an accuracy of about 100 Hz. (Accuracy is not to be confused with counter resolution, which is set by the number of digits in the readout.)

One way to overcome the accuracy problem is to use the period function of the counter. (Again, many inexpensive counters do not have a period function.) When period is measured on a counter, the unknown input signal controls the counter timing gate, and the timebase frequency is counted and read out. For example, if the timebase frequency is 1 MHz, the indicated count is in microseconds (a count of 333 indicates that the gate has been held open for 333 microseconds. In effect, the timebase accuracy is divided by the time period. For 30-Hz signals, where the time period is approximately 1/30-second, an accuracy of 100 Hz is increased to 3.3 Hz (100/30). Of course, the period count must be divided into 1 to find the frequency.

No matter what frequency counter you select, check its accuracy at regular intervals. If it is not convenient to use WWV signals for such checks, a simpler method is to monitor the 3.58-MHz oscillator in a color TV receiver. That oscillator is locked in frequency to a color broadcast at a frequency of 3.579545 MHz. The TV receiver oscillator remains locked to that frequency, even though the phase and color hue may shift. Keep in mind that the TV receiver should be operating properly (with good color rendition), and that a 7-digit counter is needed to get the full frequency resolution.

Probes

Both the meters and oscilloscopes used for VCR service should have a full set of probes, including RF, demodulator, and low-capacitance probes. High-voltage probes are not usually needed for any VCR circuit.

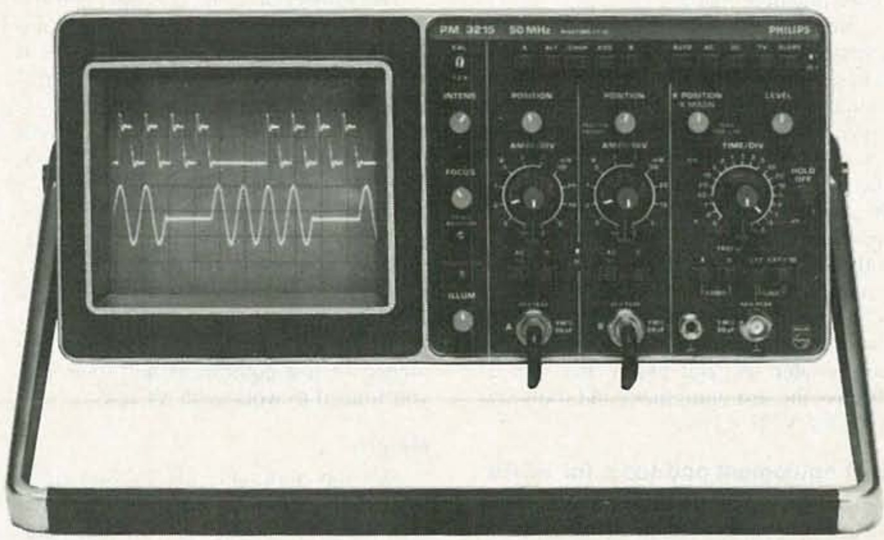
Video monitor

If you are planning to go into VCR service on a full-scale basis, you should consider a receiver/monitor such as used in studio or industrial video work. Those receiver/monitors are essentially TV receivers, but with video and audio inputs and outputs brought out to some accessible point (usually the front panel).

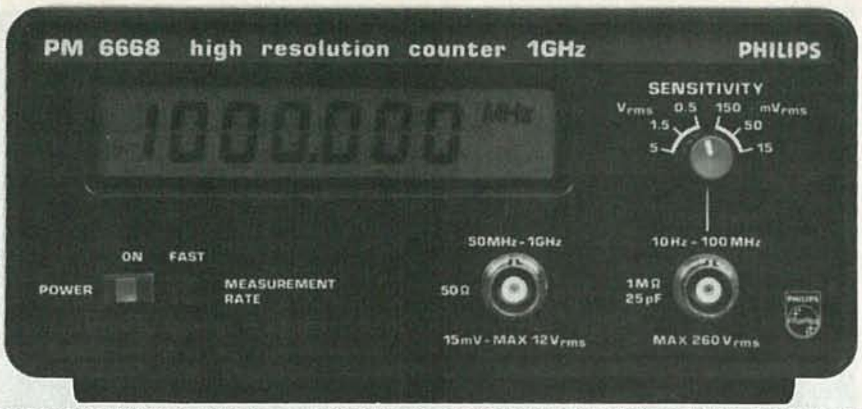
The output connections make it possible to monitor broadcast video and audio signals as they appear at the output of a TV-receiver IF section (the so-called baseband signals, in the range 0 to 4.5 MHz, at 1 volt P-P for video, and 0 dB, or 0.775 volt, for audio). Those output signals from the receiver/monitor can be injected into the VCR at some point in the signal flow after the tuner IF section.

The input connections make it possible to inject video and audio signals from the VCR (before they are applied to the RF output unit), and monitor the display. In that way, you can check the baseband output of the VCR independently from the RF unit.

If you do not want to go to the expense of a monitor, you can use a standard TV receiver to monitor the VCR. Of course, with a TV receiver the VCR video signals



THOUGH THE PHILIPS SCOPE shown here has a bandwidth of 50 MHz, you should do nicely with a scope with a 10-MHz bandwidth.



THIS FREQUENCY COUNTER measures frequencies up to 1 GHz. But more important for VCR work, it measures signals down to 10 Hz.

are used to modulate the VCR RF unit. The output of the RF unit is then fed to the receiver's antenna input. Under those conditions, it is difficult to tell if faults are present in the VCR video or in the VCR RF unit. Similarly, if you use an NTSC generator for a video source, the generator output is at an RF or IF frequency, not at the baseband video frequencies.

If you use a TV receiver as a monitor, adjust the vertical height control to underscan the picture so you can see the video switching point in relation to the start of vertical blanking.

Special tools and fixtures

VCR service literature usually describes a number of adjustment procedures in extensive detail. Those procedures are useful in that they illustrate the use of special tools and fixtures available from the manufacturer, often in kit form. There are also other tools and fixtures used by the manufacturer for both assembly and service of VCR's. Those factory tools are not available for field service (not even to factory service centers in some cases). That is the manufacturer's subtle way of telling service technicians that they should not attempt any adjustments (electrical or mechanical) not recommended in the service literature.

The author strongly recommends that you take that subtle hint! He has heard many horror stories from factory service people concerning virtually ruined VCR's brought in from the field. Most of those problems are the result of tinkering with mechanical adjustments (although there are some technicians who can destroy a VCR with a simple electrical adjustment). One effective way to avoid any chance of destroying a VCR is to use only recommended factory tools and perform only recommended adjustment procedures (i.e. when all else fails, follow instructions!).

Hand tools

Except for those cases where special tools and fixtures are required, most VCR's can be disassembled, adjusted, and reassembled with common hand tools such as wrenches and screwdrivers. Keep in mind that most VCR's are manufactured to Japanese metric standards, and your tools must match. For example, you will need metric-sized Allen wrenches and Phillips' screwdrivers with Japanese metric points. You will also need tools and applicators to apply solvents and lubricants (cleaner sticks for the video heads, etc.).

Alignment tapes

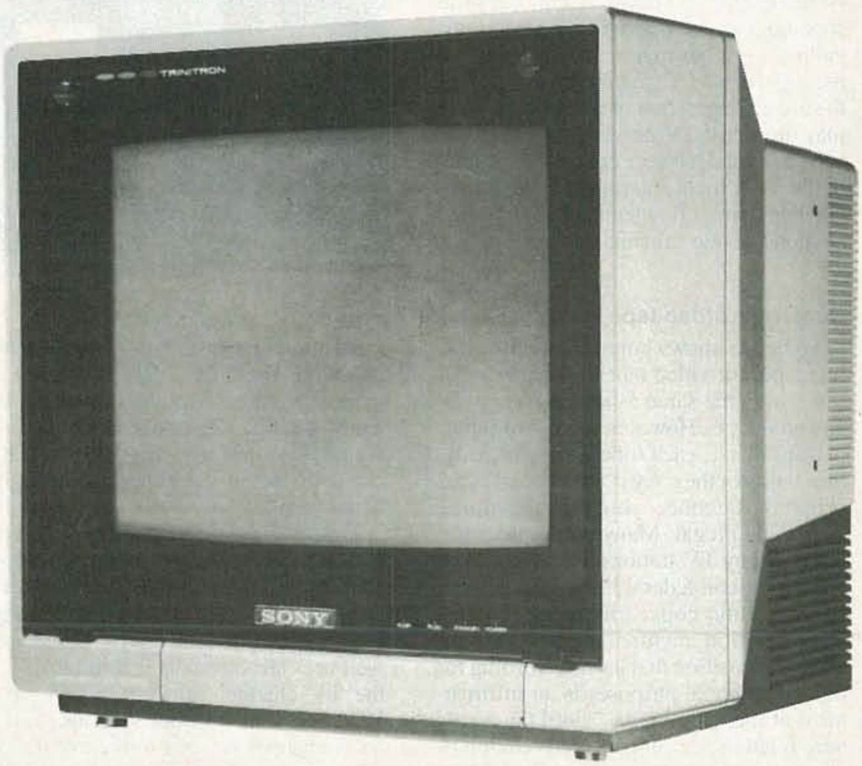
Most VCR manufacturers provide an alignment tape as part of their recommended tools. An alignment tape is housed within a standard cassette and has several very useful signals recorded at the factory using precise test equipment and signal sources. Although there is no standardization, a typical alignment tape contains audio signals (at low and high frequencies, such as 333 Hz and 7 kHz), an RF-sweep signal, a black-and-white signal or pattern, and NTSC color-bar signals. If you intend servicing one type of VCR extensively an investment in the recommended alignment tape would be well worth it.

A typical use for the audio signals recorded on the alignment tape is to check overall operation of the servo-speed and phase control systems. For example, if the frequency of an audio playback is exactly the same as recorded (or within a given tolerance), and remains so for the entire audio portion of the tape (as checked on a frequency counter), the servo control systems (both speed and phase) must be functioning normally. If there are any mechanical variations, or variations in servo control, that produce wow, flutter, jitter, and so on, the audio playback varies from the recorded frequency.

If you do not want to invest in a factory alignment-tape, or if you do not want to wear out an expensive factory tape for routine adjustments (alignment tapes do deteriorate with continued use), you can make up your own alignment tape or "work" tape using a blank cassette. The TV stations in most areas broadcast color bars before or after regular programming. (Use the VCR timer for convenience.) Those color bars can be recorded using a VCR known to be in good operating condition. Any stationary color pattern with vertical lines (such as the white color bar that extends down to the bottom of the screen) is especially useful.

Lapping cassette

A lapping cassette contains a non-magnetic tape coated with an abrasive. The idea is to load the lapping cassette and run the abrasive tape through the normal tape



A VIDEO MONITOR, such as this one from Sony, is extremely useful to have in almost any VCR-service application.

path (across the video heads, around tape guides, etc.) for a few seconds. That cleans the entire tape path (especially the video heads) quite thoroughly. However, prolonged use of a lapping tape can result in damage (especially to the video heads). Follow the manufacturer's recommendations. Never use any lapping cassette for more than a few seconds; there are other ways to clean the heads and tape path.

Installing a VCR

On the off-chance that you may not know how to install and connect a VCR, let us review some basics. Fig. 12 shows the connections for a typical VCR and applies to the great majority of VCR installations. As shown, if the antenna cable is 75-ohms, connect it directly to the VHF-IN terminal; use an F-type connector. If the cable is a 300-ohm ribbon type, connect the cable to a 300Ω-to-75Ω adapter, then connect the adapter to the VHF-IN terminal.

Connect the VHF-OUT connector on the VCR to the VHF antenna terminal on the TV receiver with a 75-ohm coax cable. If the TV is equipped with 300-ohm antenna terminals, use an adapter. Connect the UHF-OUT terminals on the VCR to the TV's UHF-IN terminals with the 300-ohm cable.

Where a combination VHF/UHF antenna is used, separate the VHF and UHF signals using a signal separator, and connect the VHF and UHF lead-ins to VHF-IN and UHF-IN, respectively.

One note of caution: Connections between the VHF-OUT connector of a VCR and the antenna terminals of a TV should be made only as shown in Fig. 12, or as specified in the operating instructions. Failure to do so may result in operation that violates FCC regulations regarding the use and operation of RF devices. (You may broadcast TV programs to the entire neighborhood!) Never connect the output of the VCR to an antenna or make simultaneous (parallel) antenna and VCR connections at the antenna terminal of the TV!

Copying a video tape

Figure 13 shows connections for making copies of video tapes. The process is essentially the same as making a copy of an audio tape. However, keep two points in mind. First, each time a copy is made, the quality of the copy is not as good as the original. Second, you may be doing something illegal. Many of the programs broadcast by TV stations are protected by copyright, and federal law imposes strict penalties for copyright infringement. Some motion picture companies have taken the position that home recording for non-commercial purposes is an infringement of their copyrights. Until the courts have ruled on the proper interpretation of the law as applied to home video recording, a VCR used to record copyrighted

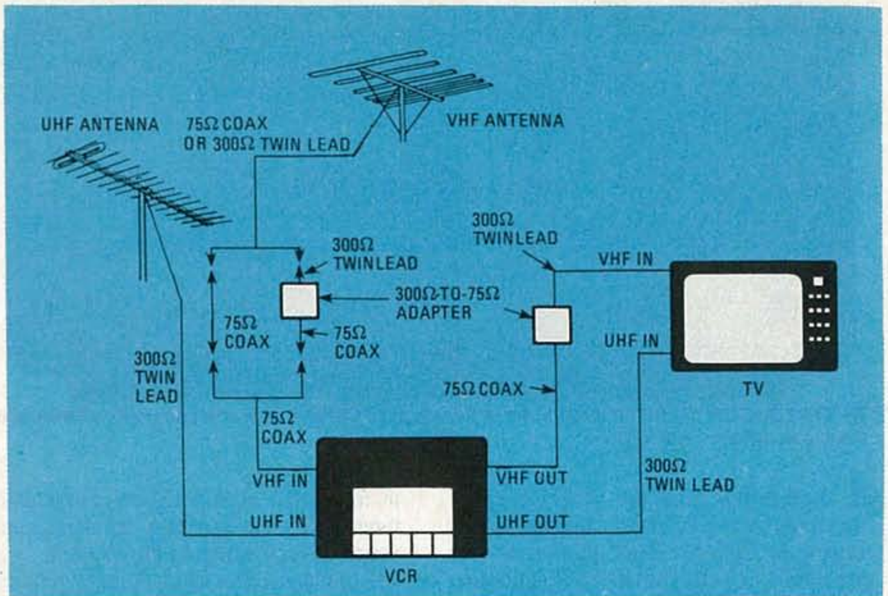


FIG. 12—FOLLOWING THIS VCR connection scheme will help insure that your video system will work properly.

material should be operated at the user's own risk.

Connecting a VCR to a CATV system

It is recommended that you consult with the cable TV company before installing any VCR. Always follow their recommendations for installation. Also, before operating the VCR with any cable TV system, set the RF-modulator channel selector on the VCR to channel 3 or 4, whichever is not active in the area. If both channels are in use, check which gives better results.

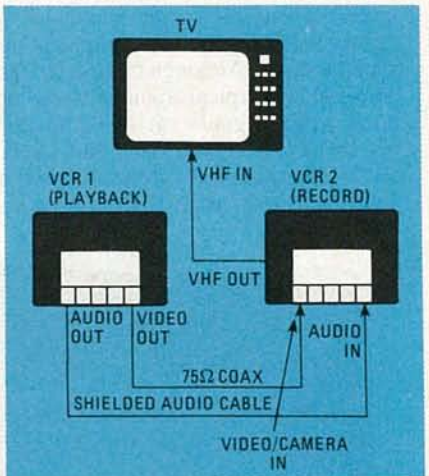


FIG. 13—BASIC SET UP for making a copy of a videotape.

Fig. 14 shows the most often recommended configuration for connecting a VCR to a CATV system. With the set up shown in that figure, it is possible to record programs from all CATV channels, as well as VHF channels 2 through 13. Set the TV channel selector to that of the VCR RF unit channel selector. Set the VCR channel selector to receive the output channel of the converter. Set the VCR program select switch to the VCR posi-

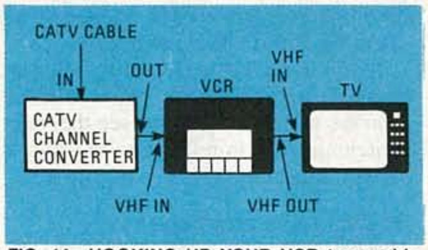


FIG. 14—HOOKING UP YOUR VCR to a cable system.

tion. With that connection, the channel to be viewed or to be recorded is selected on the converter.

Figure 15 shows another possible configuration for connecting a VCR to CATV. With that set up it is possible to view one program from the converter, while recording another program on VHF

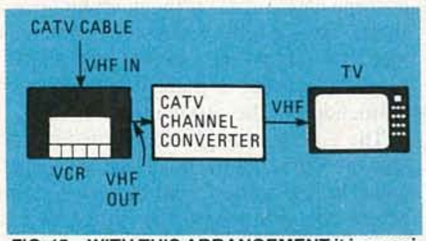


FIG. 15—WITH THIS ARRANGEMENT it is possible to record a cable channel while viewing a VHF channel.

channels 2 through 13. Set the TV channel selector to the output channel of the converter and set the VCR program select switch to the TV position. For playback of the program recorded on the VCR, set the channel selector on the converter to that of the VCR RF-modulator channel selector. When the CATV channel converter is not needed, connect the CATV input to the VCR, then connect the VCR and TV receiver in the normal manner.

When we continue, we'll look at some troubleshooting procedures for VCR servicing. **R-E**

SOUND GENERATOR DESIGN CONSOLE

D.L. HOLMES

Discover the the wonders of a sound-generator IC, without the bother of breadboarding, using this easy-to-build design console.

TEXAS INSTRUMENTS FEATURES A NUMBER of interesting sound-generator IC's in their semiconductor line; one of the most versatile is their SN76488N. That IC, an improved version of their SN76477N, is a monolithic device that combines both analog and digital circuitry. Like the other devices in the line, it boasts a noise generator, a VCO (*V*oltage-*C*ontrolled *O*scillator), an SLF (*S*uper-*L*ow-*F*requency) oscillator, a noise filter, a mixer, attack/delay circuitry, control circuitry, and even one-shot circuitry for generating momentary sounds. In addition to those features, the 76488 offers an internal 125-milliwatt audio amplifier capable of driving an 8-ohm speaker, and external outputs for the VCO, the SLF oscillator, the noise clock, and the one-shot circuitry.

The device can produce noises, tones, or low-frequency sounds either individually or in any combination. All sounds are programmed using control inputs and user-selected external components. The uses for that versatile IC are limited only by the user's imagination; and if you run out of ideas, a little experimentation is sure to turn up many more.

While most hobbyists like to breadboard with discrete components when either designing or experimenting, that technique has several drawbacks when designing with this IC. Since this IC can produce a wide variety of sounds, with each sound being determined by the value of the external components connected to it, it is far easier to listen to the sounds produced by this IC while varying the value of the external components. The design console described here does just that; it enables you to control the value of those external components while listening to the sound produced.

Before we look at the console, and how it is built, it will be helpful to get to know the 76488 a little better. A block diagram of the device is shown in Fig. 1. Let's examine the operation of each functional circuit block.

SLF oscillator

The SLF feeds a 50%-duty-cycle squarewave to the mixer. It also feeds a triangular wave to the external VCO or SLF-select logic circuitry; that circuit selects either external-voltage or SLF modulation of the VCO. If the VCO-SELECT pin, pin 20, is high, the SLF is fed through to modulate the frequency of the VCO; if it is low, an external voltage is used (more on that shortly). The SLF's normal operating range is 0.1 to 30 Hz, but it will

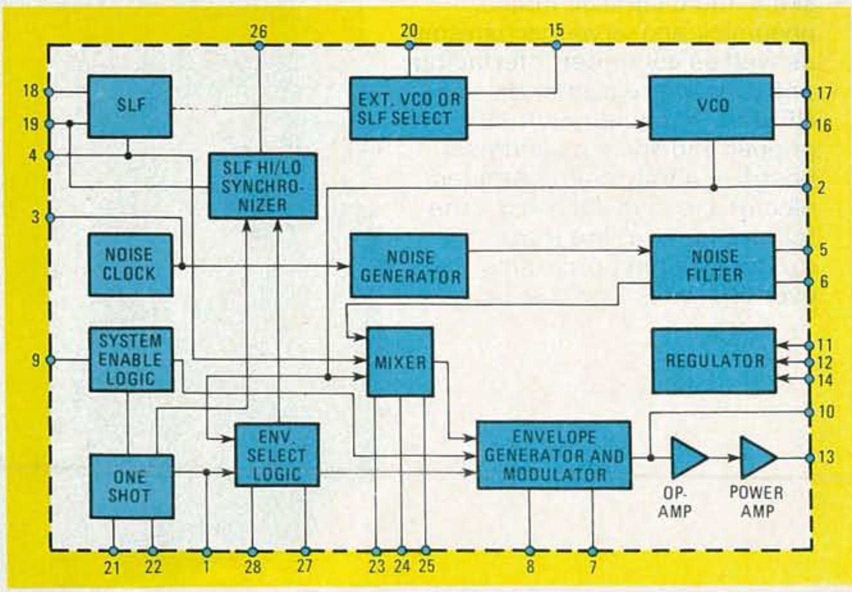


FIG. 1—BLOCK DIAGRAM of SN76488N sound generator. Refer to this figure as we describe the operation of the device.

produce frequencies of up to 20 kHz. The SLF frequency is determined by two external components, the SLF-control resistor connected to pin 18 and the SLF-control capacitor connected to pin 19. The output of the SLF is available externally from pin 4 and can drive one TTL load.

Voltage controlled oscillator (VCO)

The VCO produces a tone whose frequency depends upon the voltage at its input. That controlling voltage can be either the SLF output described above, or an externally generated signal applied to the EXTERNAL VCO CONTROL pin, pin 15. The higher the voltage applied to the VCO, the lower the VCO frequency. The minimum VCO frequency is determined by two external components: the VCO-control resistor connected to pin 17 and the VCO-control capacitor connected to pin 16. The maximum frequency of the VCO is ten times the minimum frequency. The method of controlling the VCO is selected by the logic-level present on pin 20. If that logic level is low, the VCO frequency is controlled by the external signal applied to pin 15. The input at pin 15 may be a DC voltage, which produces a constant tone, or any digital or analog signal. If the logic level at pin 20 is high, the VCO frequency is controlled by the output from the SLF oscillator.

The output of the VCO is a squarewave and is supplied to the mixer and, if selected by the envelope-select logic, to the envelope generator and modulator. The VCO output is available at pin 2 and can drive a single TTL load.

Noise clock

The noise clock internally generates a clock signal and supplies it to the noise generator; the minimum frequency of that clock signal is 10 kHz. The clock signal is also available externally at pin 3; it is capable of driving one TTL load.

Noise generator/filter

The noise generator produces pseudo-random white noise that passes through the variable-bandwidth low-pass noise filter before being fed to the mixer. That filter has its cutoff point defined by the noise-filter control resistor connected to pin 5 and the noise-filter control capacitor connected to pin 6.

Mixer

The mixer combines one or more signals from the SLF, VCO, and noise generator by performing a logical AND function and feeds the resulting output signal to the envelope generator and modulator. The signals that are to be input to the mixer are chosen by setting the logic levels present on the MIXER-SELECT pins, pins 23, 24, and 25, in accordance with those shown in Table 1. Figure 2 shows how the mixer combines an SLF and noise signal to produce an SLF/noise output. If more than

TABLE 1—MIXER

Mixer select inputs

A (PIN 24)	B (PIN 25)	C (PIN 23)	Mixer output
L	L	L	VCO
H	L	L	SLF
L	H	L	noise
H	H	L	VCO/noise
L	L	H	SLF/noise
H	L	H	SLF/VCO/noise
L	H	H	SLF/VCO
H	H	H	inhibit

H = high level
L = low level or open

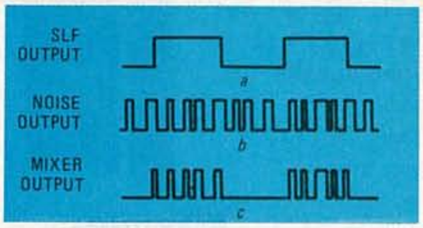


FIG. 2—THE MIXER combines the SLF output, shown in *a*, and a noise signal, shown in *b*, to produce the output shown in *c*.

one sound at a time is desired, (for example, a car engine and siren, or a steam engine and whistle), multiplexing is required. That can be done by switching the mixer-select lines at such a rate that the two sounds seem to occur simultaneously. A multiplexing-drive signal with a 50% duty cycle is required to provide equal amplitudes for both sounds. The frequency of that signal should be above the range of human hearing (i.e., above 20 kHz).

One shot

The one-shot circuit controls momentary sounds, and is triggered by a high-to-low logic-level transition at the SYSTEM-ENABLE pin, pin 9. The duration of the one-shot's output is determined by the one-shot control resistor connected to pin 22 and the one-shot control capacitor connected to pin 21. The maximum duration of the signal is approximately 10 seconds. The signal can be cut off earlier by taking the SYSTEM-ENABLE pin high. If that is done, however, the one-shot timing must be allowed to end before another one-shot timing sequence can be triggered; that is necessary to allow an internal latch to reset. The output of the one-shot is fed through the envelope-select logic to the envelope generator and modulator. Rather than being a sound source, the one-shot signal merely provides an envelope for the sound that is output from the mixer. The one-shot circuit is operational only when the one-shot envelope is selected as explained in the next section. Its output is available at pin 1 and can drive one TTL load. While in the one-shot mode, the SLF ramp can be forced to start at either a high or low level by placing a high or low logic-level respectively on the SLF-SELECT pin, pin 26.

Envelope select

The envelope-select logic determines which envelope is combined with the mixer output in the envelope generator and modulator. That envelope is selected using the ENVELOPE-SELECT pins, pins 27 and 28. The operation of the envelope-select circuit is summarized in Table 2. Figure 3 shows the four possible envelopes that could be generated. The noise and VCO inputs to the mixer are shown in Fig. 3-a. If the mixer-only function is selected as shown in Fig. 3-c, the mixer output is supplied continuously to the audio amplifier. If the VCO function is selected as shown in Fig. 3-b, the squarewave output of the VCO is the envelope for the mixer output, meaning that the mixer output is passed on to the audio

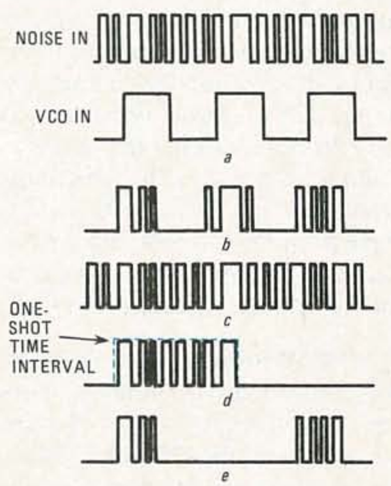


FIG. 3—WITH THE MIXER AND VCO outputs as shown in *a*, the four possible envelopes that could be generated are shown in *b–e*.

TABLE 2—ENVELOPE SELECT

Envelope select 1 (Pin 28)	2 (Pin 27)	Function selected	Waveform (see figure 3)
L	L	VCO	*b*
L	H	Mixer only	*c*
H	L	One-shot	*d*
H	H	VCO with alternating cycles	*e*

H = high level
L = low level or open

amplifier while the VCO output is high but not when it is low. The VCO with-alternating-polarity function, shown in Fig. 3-e, is similar to the VCO function described above except that the output from the mixer is enabled only during every other VCO pulse. When the one-shot function is selected, the output from the mixer is enabled only for the duration of the one-shot pulse as shown in Fig. 3-d.

Decay control

The decay circuitry, which is part of the envelope-generator-and-modulator block, alters the fall time of the envelope selected by the envelope-select logic. The decay time is determined by the decay-timing capacitor that is connected to pin 8, and the decay-timing resistor that is connected to pin 7. The decay has no effect on the mixer-only function, but for the one-shot, VCO, and VCO-with-alternating-cycle functions, the decay ramp is triggered by each high-to-low transition of the envelope; it serves to prolong the sound at a decreasing volume that is proportional to the selected decay-rate. Figure 4 shows examples of how a waveform may be modified by decay when the mixer output is noise and the one-shot envelope is selected. Figure 5 shows a similar example, this time using a VCO rather than a one-shot envelope.

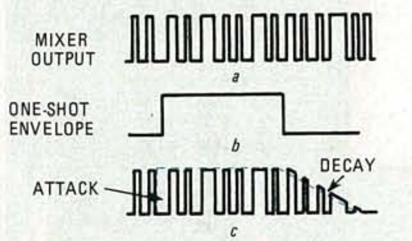


FIG. 4—HOW A WAVEFORM IS MODIFIED by decay when the mixer output is noise and a one-shot envelope is selected.

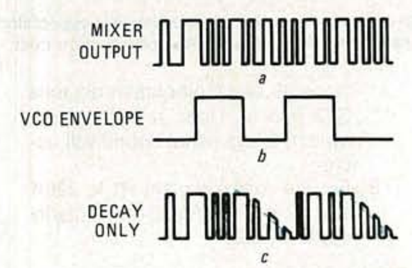


FIG. 5—IN THIS EXAMPLE of how a waveform is modified by decay, the VCO envelope is selected.

System enable

The system-enable logic provides enable/select control for the sound output of the system. A high logic-level at the SYSTEM ENABLE pin (pin 9) inhibits the sound output, a low logic-level (or open pin connection) enables it. That pin is also used to trigger the one-shot circuit for momentary sounds such as gunshots, bells, explosions, etc. The one-shot logic is triggered on the negative-going edge of a system-enable input signal. The input applied to pin 9 must be held low for the entire duration of the one-shot sound, including attack and decay periods, if the sound is to be completed. Taking pin 9's input high early, terminates the sound.

Output amplifier

The output amplifier (see Fig. 6) is contained entirely on the IC and and has a push-pull output capable of delivering 125 mW into an 8-ohm load connected to pin 13. External signals may be input to the amplifier via pin 10.

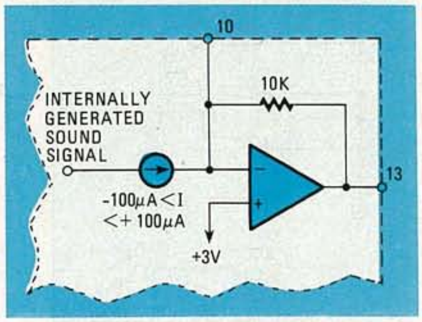


FIG. 6—THIS AMPLIFIER is entirely contained on the IC and is capable of supplying 125 mA into a capacitively-coupled 8-ohm load.

Regulator

The 76488 will operate from a single-voltage power supply connected between pin 12 (positive) and pin 14 (ground); an internal 5 volt regulator allows use of an unregulated supply of between 7.5 and 10.5 volts. In addition to supplying power for the IC, the regulator is capable of providing a regulated 5-volts, at up to 5 mA, from pin 11 for use by any external circuitry. That is used to supply the high-level logic voltage used by the design console.

That concludes our look at the SN76488; its pinout is shown in Fig. 7. We'll now turn to construction of the design console itself.

Console construction

Construction of the design console is relatively simple and straightforward. The schematic for the circuit is shown in Fig. 8. Little about the design is critical, and substituting freely from your junk-box can help hold down the device's cost. In the author's version, for instance, mica capacitors were used in place of ceramic discs in some instances simply because they were on hand. You can't, of course, substitute for the sound-generator IC. If your local supplier does not stock that device, it is available from Active Electronics, PO Box 1035, Framingham, MA 01701.

A 8⁷⁄₁₆ × 7⁷⁄₁₆-inch instrument case and cover were used to house the prototype

PARTS LIST

All resistors 5% unless otherwise noted
R1-R6—1 megohm, potentiometer, linear taper
R7—100,000 ohms
R8—50 ohms, potentiometer, audio taper
Capacitors
C1, C18—390 pF, ceramic disc
C2 9—680 pF, ceramic disc
C3—1000 pF, ceramic disc
C4, C13—.22 μF, ceramic disc
C5, C12—.47 μF, ceramic disc
C6, C11—4.7 μF, 25 volts, electrolytic
C7, C9, C10, C15—10 μF, 25 volts, electrolytic
C8—220 μF, 10 volts, electrolytic
C14—22 μF, 10 volts, electrolytic
C16—1 μF, 10 volts, electrolytic
C17, C22—0.1 μF. ceramic disc
C20—.005 μF, ceramic disc
C21—.01 μF, ceramic disc
Semiconductors
IC1—SN76488N sound generator (TI)
B1—9-volt battery
S1-S5—1 pole, 6 position rotary switch
S6-S19—SPST miniature slide switch
S20, S21—SPDT miniature slide switch
S22—SPST momentary pushbutton switch, normally open
TP1-TP18—test point jack
J1-J3—phono jack
Miscellaneous: IC socket, perforated construction board, case, etc.
Adhesive backed overlays for the front panels are available from Design Specialty, 15802 Springdale St, No. 80, Huntington Beach, CA 92649. The cost is $3.00 each, postpaid. California residents add state and local taxes.

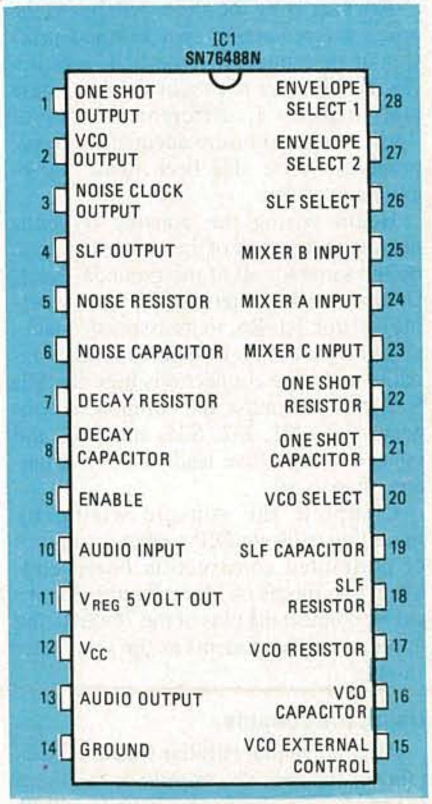


FIG. 7—PINOUT of the SN76488N sound generator IC from Texas Instruments.

console. In lieu of a phenolic case cover, a ⅛-inch piece of plywood may be used. We've used both and prefer the plywood because it is easier to work with.

Assembly is begun by mounting the capacitors on rotary switches S1-S5 so that when looking at each switch from front to back and rotating it clockwise, the component values are selected in the order shown in Fig. 8. The layout of the front panel can be seen in the photo on the first page of this article. After the switches are wired, cut holes in the console cover to match that layout. Although not required, the easiest way to do that is to mount a full-sized version of the front panel layout and use it as the cutting template. For those who wish to go that route, full-sized copies of the overlay, with adhesive backing so that it can be applied directly to the front panel, are available from the source given in the Parts List.

After the cover preparation is complete, mount the slide switches to the cover, using either screws or an adhesive. If using screws, use the flat-head type and countersink them flush with the cover surface. If an adhesive is used, a cyanoacrylate adhesive (super glue) works well on the phenolic material, while a silicone-rubber compound works well with plywood. When using a cyanoacrylate adhesive, use extreme caution to avoid getting any of it on your fingers or on the movable-slide part of the switch. If a silicone rubber compound is used, be sure to allow ample time for the compound to cure before attempting any further work with the switches.

After securing the slide switches to the cover, the remaining switches and jacks should be mounted. If desired, attach a 2½ inch speaker to the inside of the case after drilling a sufficient number of "grill" holes to insure adequate volume; provisions have also been made for an external speaker.

Begin wiring the console by connecting together all of the +5-volt points; do the same for all of the grounds. Next, connect the wiper terminal of each variable resistor, R1–R6, to its associated jack, and that jack to its associated switch. Finally, make the connections between S8, S22, and J21; make the component connections to J21, J22, S21, and S20, and connect the positive lead of a 9-volt battery snap to S9.

Complete the console wiring by mounting a 28-pin DIP socket on a piece of perforated construction board and, using two pieces of 14-conductor ribbon-cable, connect the pins of the 76488 to the appropriate components as the schematic shows.

Using the console

After becoming familiar with the functions of the console controls, using them to create your own custom sounds will be easy, fun, and exciting. To help with the familiarization process, console set-up procedures for a few sounds are provided below. Before setting up the console for each new sound, set all controls and switches so that no component or control signals are connected to the 76488.

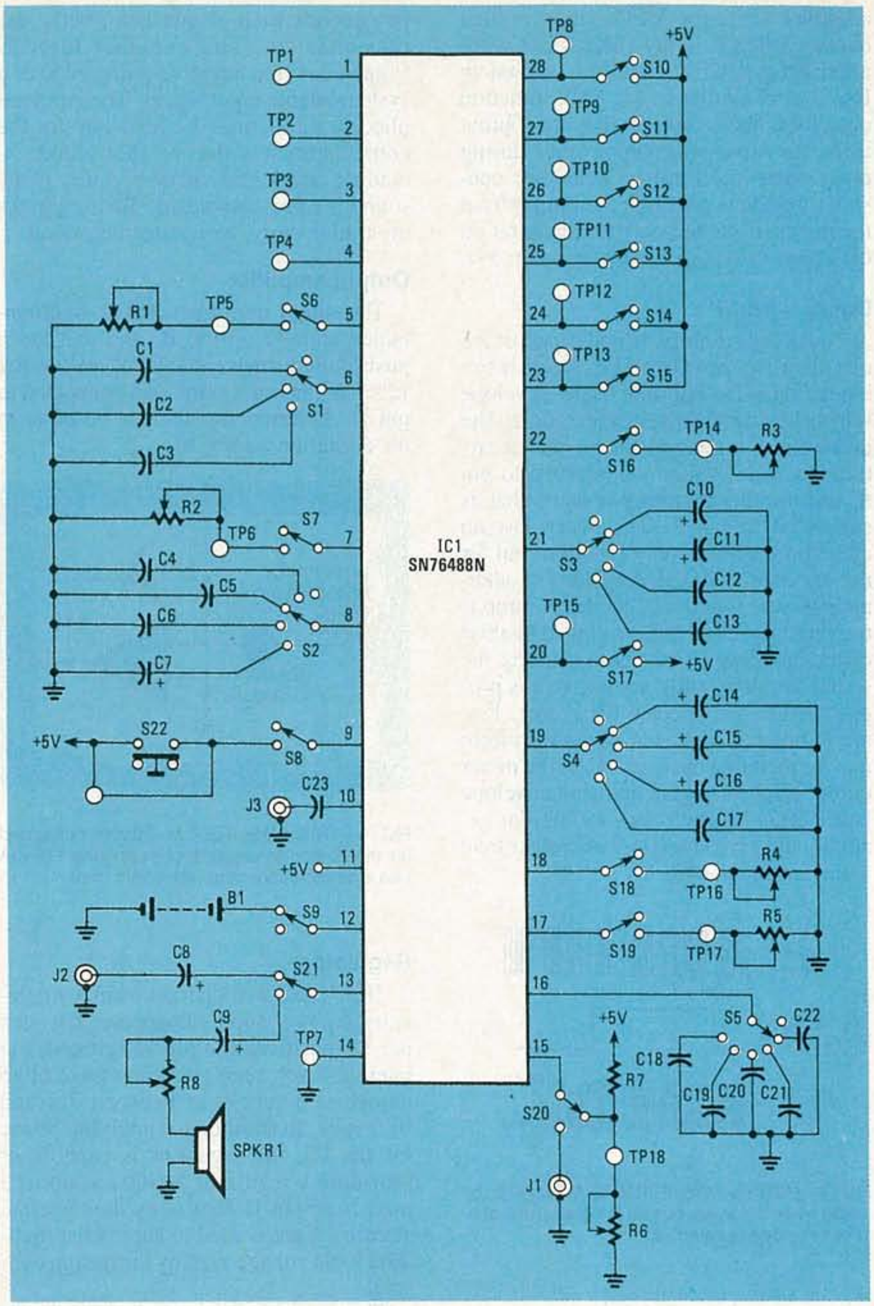


FIG. 8—SCHEMATIC DIAGRAM of the SN76488N design console. As nothing in the circuit is especially critical, reasonable substitutions from your junkbox can be made to reduce the construction cost.

Gunshot/explosion

1. Close S10 and S13 (pins 28 and 25).
2. Set R3 (pin 22) to 330K by using a voltmeter to measure the resistance between TP7 and TP14 (pins 14 and 22). After the resistance value is set, close S16 (pin 22).
3. Set S3 (pin 21) to .47 μF.
4. Set S1 (pin 6) to 680 pf.
5. Following the same procedure as outlined in step 2, set R2 (pin 7) to 120K.
6. For the gunshot, set R1 (pin 5) to 33K and S2 (pin 8) to .47 μF.
7. Turn the console power on at pin 12, close S8, and momentarily depress S22 (pin 9). Upon release of the switch, the gunshot sound will occur.
8. For the explosion, set R1 to 220K and S2 to 10 μF. Again momentarily depress S22.

Siren/phasor

1. Set S17 (pin 20) to +.
2. Set S4 (pin 19) to 10 μF.
3. Set R5 (pin 17) to 1.8K.
4. Set S5 (pin 16) to .1 μF.
5. Turn on console power.
6. Vary R4 (pin 18) to obtain the siren and phasor sounds.

Those are just a few of the sounds that the console is capable of generating. There are, of course, quite a few more. To find them, all you need is a little practice and patience. Happy experimenting! **R-E**

How to Design Transistor Switching Circuits

MANNY HOROWITZ

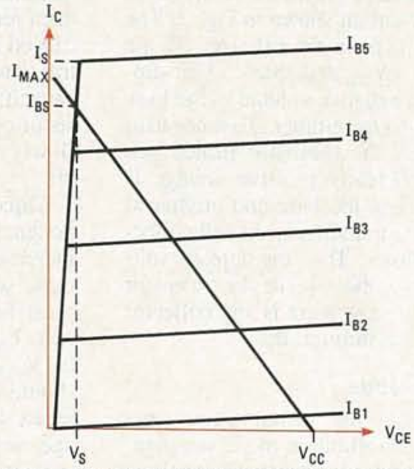


FIG 1.—CHARACTERISTIC CURVE of a typical bipolar transistor.

This month we'll learn how to design switching circuits using transistors, as well as other devices.

WE'VE ALREADY LEARNED ABOUT HOW transistors and other solid-state devices are used in circuits such as amplifiers, oscillators, etc. There are, of course, many other applications for those devices. One of the most common, and useful, of those applications is in electronic switching circuits. Unlike analog circuits where the output signal is some function of the input, in switching circuits the output is in one of only two states—on or off. This month, we are going to begin our look at electronic switching circuits, beginning with the most basic of them, the transistor switch.

Transistor switches

To use a transistor as a switch it must be biased so that the device is in either one of two states. In one of those states, the transistor is "off" and no collector current flows. In the other, the transistor is "on" and the collector current is limited only by the resistances in the emitter and collector circuits.

There are three common ways to bias a transistor so that it operates as we just described. Those methods of biasing are refered to as modes of operation. In what is referred to as the *saturated mode* of operation, the transistor is turned on by biasing it so that it is in, as you might have guessed, saturation. When that happens, the voltage across the transistor, called the saturation voltage, is at a minimum and depends on the collector current and load resistance. The device is turned off by biasing it so that it is in cutoff.

When a transistor is turned on in the second mode of operation, the *current mode*, it is biased so that the transistor operates near, but not quite in saturation. The collector-emitter voltage is somewhat above the saturation voltage of the device. Once again, the transistor is turned off by biasing it so that it is in cutoff.

Switching speed is faster in the current mode of operation than it is in the saturated mode. It is still faster, however, when the transistor is used in the *avalanche mode*. In that mode, the on and off states of a transistor are maintained in the breakdown portion of its curve. The switching speed of a transistor in the avalanche mode is exceeded only when tunnel, snap-off, hot-carrier, or pin diodes are used as the switching devices.

Switching modes

A transistor's characteristic curves can be approximated as shown in Fig. 1. Each curve (which here is shown as a relatively horizontal line) represents the relationship between the collector current, I_C, and the collector-emitter voltage, V_{CE}. You'll note that several of those curves are plotted in the figure. That's because the relationship between I_C and V_{CE} depends on the base current, I_B; each curve shows the relationship for a specific value of I_B.

The more-or-less vertical solid line near the vertical axis represents the saturation resistance of the transistor. That resistance is equal to V_S/I_S. At the maximum permissible transistor collector current, I_S, the minimum voltage that can be across the transistor is V_S, the saturation voltage. That voltage is reduced at lower collector currents.

A load line is also shown in the figure. It extends from V_{CC} on the V_{CE} axis to

I_{MAX} on the I_C axis. You'll note that even when the transistor is fully turned on by the application of a large current to the base, the collector current cannot reach I_{MAX} if the device's load line is as drawn in Fig. 1. The maximum current that flows is determined from the point where the load line crosses the saturation resistance curve. Collector current at the intersection of the two lines is at its maximum. It cannot be made any larger no matter how much the base current is increased.

Saturation and current modes of operation function only if a steady input voltage is applied to the base circuit of the transistor to keep it in either the on or off state. Examine the circuit shown in Fig. 2. The transistor is kept in the off state by the presence of $-V_{BB}$ at the base. That supply applies a negative voltage to the base with respect to the emitter. That negative voltage keeps the transistor turned off. When a sufficiently positive voltage is applied between the base and emitter at input V_{IN}, the transistor is on and collector current flows. Thus the applied voltages determine the state of the transistor and whether or not there is any collector current flowing through R_L.

Saturation mode

Switching is not instantaneous, especially in the saturation mode of operation. It takes time for the transistor to go from an off state to an on state as well as from an on state to an off state. Let's start our examination of the saturation mode by assuming the transistor is turned off. We'll be referring to Fig. 2 once again as we proceed through the following discussion.

When a positive pulse of voltage is applied to V_{IN}, it is also applied to the base of the transistor. That positive pulse causes base current to flow instantly, but there is a lapse of time before the base-emitter voltage reaches even a 0-volt level. Collector current, on the other hand, does not start to flow until the base-emitter voltage is just above zero. The time between the application of the positive voltage to the base and the instant that the collector current reaches 90% of its maximum, is referred to as the turn-on time. The phrase "delay time" is also used to describe that turn-on period.

After the positive input voltage has been removed, the negative ($-V_{BB}$) supply takes over to restore the transistor to an off state. But that does not occur instantly. First, the base current becomes negative for a while, but eventually the base-emitter junction ceases to conduct current in either direction. As for the base-emitter voltage and collector current, they remain positive for a short interval after the positive switching voltage has been removed. The time it takes for the collector current to drop to 90% of its maximum after the positive voltage has been removed is called storage time. It is caused by the capacitances formed in the transistor when it is in saturation. Those capacitances are charged when the transistor conducts and discharged relatively slowly after the transistor has been turned off.

Capacitor C_B is not an essential component in the circuit. It is included only to increase the switching speed. To determine what its capacitance must be you must first determine the saturation current, $I_{C(SAT)}$, of the transistor; it is equal to V_{CC}/R_L. Next, calculate what R_X should be by setting it equal to V_{BB}/I_{CBO} where I_{CBO} is the collector-to-base leakage current when the transistor is operating at its maximum temperature. Continue the design by plotting the load line for the collector circuit as shown in Fig. 1. From that plot, estimate the approximate base current, I_{BS}, at the point where the load line crosses the transistor's saturation resistance curve. In Fig. 1, it is about midway between I_{B4} and I_{B5}. If the maximum voltage applied to the input of the circuit is $V_{IN(max)}$,

$$R_B = V_{IN(max)}/I_{BS} - I_{CBO}$$

Capacitor C_B is used to increase the positive drive on the transistor at the instant that V_{IN} is applied. Its capacitance can be calculated mathematically, but it is best that the circuit be built and different capacitors placed across R_B until it is determined which capacitor will provide you with reasonable performance in a particular switching application.

Another factor that you may run into when designing a switching circuit is latch-up. In that situation, the reverse voltage applied to the base circuit is insufficient to bring conduction down to its lowest level. Instead, collector current drops only to some level above the desired minimum. That low current is determined by the point where the load line crosses the breakdown section of the collector curve. (The breakdown portion of the curve is illustrated in Fig. 3. It is the vertical sections of curves 1, 2 and 3.) Should latch-up occur, increase the negative or reverse-bias voltage that is applied to the base circuit.

Current mode

To improve the switching speed of a transistor it should be kept out of saturation when turned on. When that is done, the transistor is said to be operating in the current mode. In that mode of operation, the off states are identical to those in the saturated mode, while the on states differ in that in the current mode the transistor is kept just slightly out of saturation. (The excess charge in the base is kept to a minimum.)

In the current mode of operation, the transistor can be kept off by a resistor-battery combination connected between the base and ground. That is shown in the current-mode switching circuit shown in Fig. 4. Note that there is also a resistor-battery-diode combination in the emitter circuit of the transistor; let's take a closer look at it.

Diode D1 is kept turned on at all times because of the polarity of the V_{EE} supply. If a silicon junction diode is used, about 0.7 volt is across the device. If there is no voltage between ground and the base,

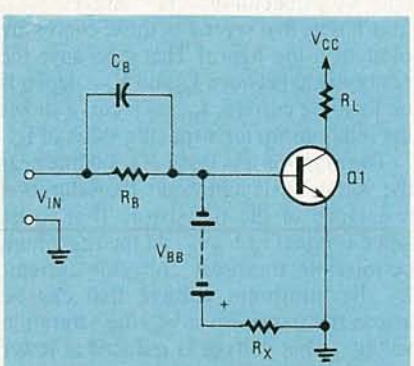


FIG. 2—CURRENT FLOWS through R_L when a positive pulse is applied to V_{IN}. The flow is stopped when that pulse is removed.

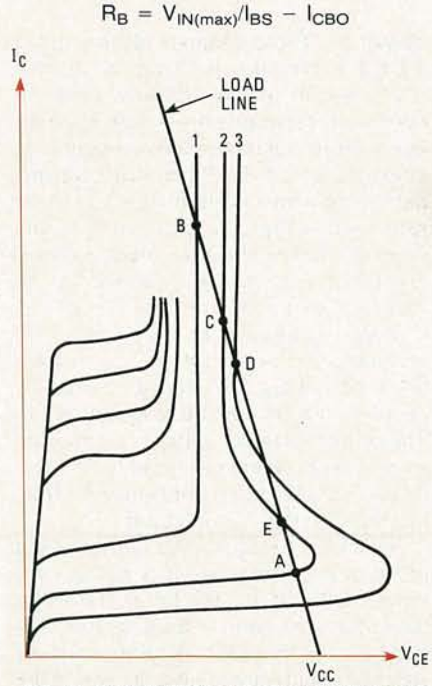


FIG. 3—IN THE AVALANCHE switching-mode transistors operate in the breakdown region of their characteristic curves.

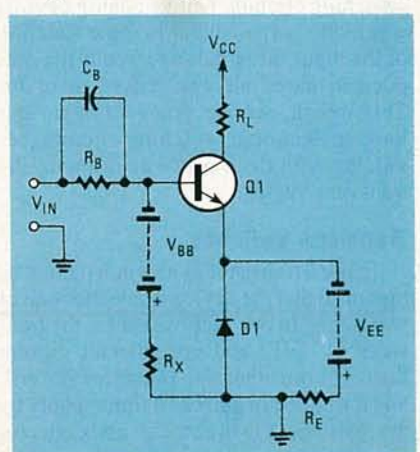


FIG. 4—A BATTERY AND RESISTOR are connected between the base and ground in a current-mode switching circuit.

only that diode voltage would be between the base and emitter of the transistor, keeping it turned on. But the transistor does get turned off due to the presence of the $-V_{BB}$ supply. To keep the transistor turned off, V_{BB} must be large enough to counter the voltage across the diode.

The real significance of the emitter circuit is seen when the transistor is turned on by a positive pulse at V_{IN}. If there's only a resistor in the emitter circuit, or a short as in Fig. 2, the collector current will be equal to the beta of the transistor multiplied by the base current I_{IN}. If I_{IN} is sufficiently large, the collector current can be driven into saturation. But the presence of D1, R_E and V_{EE} in the emitter circuit prevents that from happening so that the maximum transistor current level is less than its saturation current. That maximum is set by the components in the emitter circuit.

Because of the orientation of the diode in the circuit, no current from the emitter can flow through it. But it does limit the current through R_E because of the 0.7 volt developed across the diode. The current flowing through R_E is the maximum current that can flow through the emitter or collector circuit of the transistor. With that as the current limit when the transistor is turned on, the transistor will stay out of saturation if V_{CC}/R_L is greater than is the current in R_E. For practical purposes, the current through R_L should be limited to a maximum of V_{EE}/R_E.

Avalanche mode

In current- and saturation-mode switching, a voltage with a specific polarity must be maintained at the base of the transistor to keep it either in an on or an off state. The relative polarity of the applied voltage depends on whether you want to keep the transistor turned on or off. In the avalanche switching-mode, however, an instantaneous pulse is all that is required to keep the transistor in either an on or off state. An additional advantage for that arrangement is that the circuit switches at almost the instant that the switching pulse is applied.

The circuit used in that mode of operation is basically the same as is used for the saturation mode (see Fig. 2). Now, however, C_B is not needed to improve the switching speed, for it is quite rapid even without the capacitor in the base circuit. In addition, the V_{CC} voltage in the avalanche mode of operation is quite high, so that operation of the transistor is in the voltage breakdown region of the collector characteristic. The characteristic curves in that breakdown region, along with the load line for R_L, are shown in Fig. 3.

Curve 1 shows the collector characteristics when the base current is 0 mA; curve 2 is the collector voltage-current relationship when the base current is somewhat negative. Curve 3 is for the case where the base current is very negative but within the region where the transistor will not be destroyed. (Reverse base current obviously depends to a large degree upon the reverse base voltage applied for test purpose to the base circuit.) Besides the load line, the other curves shown illustrate the usual transistor characteristics when the base current is positive. The latter group of characteristics is the one usually shown on data sheets.

When the transistor is idling, assume that the negative base voltage, $-V_{BB}$, is of such magnitude that the transistor idles at point a on curve 2. A positive voltage at V_{IN} will push the idling point to a second curve. That second curve is determined by the magnitude of the positive voltage applied to the base. If we assume that that curve is for $I_B = 0$, then the new idling point is at B on curve 1. It remains on that curve as long as a base voltage is applied. At the instant the positive voltage is removed, the on-point drops to point C on curve 2 because only $-V_{BB}$ remains to bias the base-emitter junction. The transistor keeps idling at that point despite the absence of any voltage or additional pulse. It is stable because the slope of the load line, $1/R_L$, is less than the slope of the transistor curve. Ordinarily, a point on that portion of the curve would not be stable because of the transistor's negative resistance. But in this case, operation does not shift from point C because of the relative slopes of the load line and transistor curve.

A negative pulse must be applied to the circuit in order to turn the transistor off or to lower the collector-current level. If the negative pulse is of sufficient magnitude, the collector current will drop to point D on curve 3. When idling there, the transistor remains turned on. But at the instant the negative pulse is removed, operation reverts to a point on curve 2. That point is point E. Because the slope of the transistor curve around point E is less than the slope of the load line, the transistor cannot remain in an idling condition at that point. If the transistor is idling in the off state, it reverts rapidly to point A, the starting point. Here, current is at a minimum and the transistor is effectively turned off.

Switching FET's

Even though their switching speed is slower than that of bipolar devices, FET's have the advantage of superior on-to-off current ratios. The slower switching speed is due to the FET's large internal capacitances.

The characteristic curves of an n-channel FET, and the load line for the drain circuit, are shown in Fig. 5. Although the curves shown are not of any particular device, they can be used to describe the switching action of the FET in general. A schematic of an FET switching circuit is shown in Fig. 6.

With no positive voltage applied at V_{IN}, a negative voltage exists between the source and gate due to the $-V_{GG}$ supply.

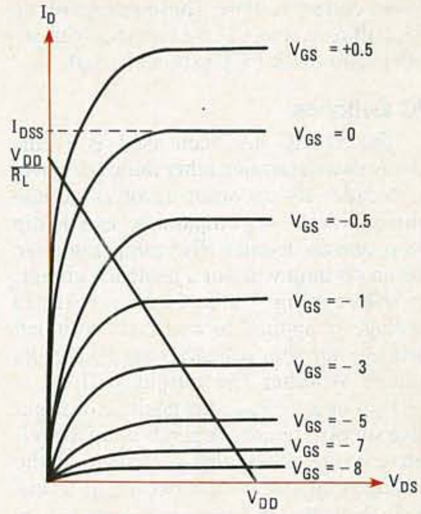


FIG. 5—THE CHARACTERISTIC CURVES of a typical FET, as well as a load line for the device, is shown here.

If that voltage is more negative than -8 volts (that is the pinch-off voltage for the device we are examining) very little current flows through the drain circuit. This can be found from the curves; note that I_D is very low when $V_{GS} = -8$. Thus, drain current is negligible because the transistor is operating in the pinch-off region.

A positive voltage at V_{IN}, or 0-volt at the gate, puts the operation of the transistor at the upper end of the I_D range where conduction is at a maximum. No matter what the collector load is, current flows through it.

FET switches can be considered in another way. When the transistor current is at a minimum, operation is in the pinch-off region (the right hand section of the curves). Because the curves there are almost parallel to the x-axis, the drain resistance is extremely high. That high resistance limits the drain current to minute levels.

Once it has been turned on, the FET operates in the ohmic region (the left-hand portion of the curves). In the ohmic region the characteristic is almost vertical and the drain resistance is extremely low, permitting relatively large amounts of

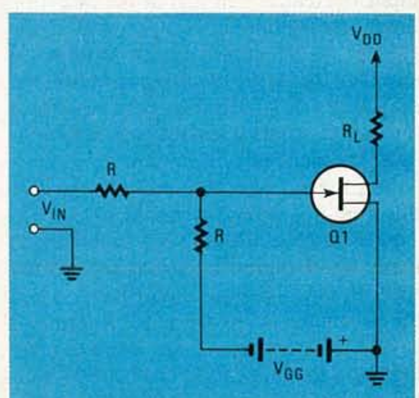


FIG. 6—AN FET SWITCHING CIRCUIT. In such a circuit, the ratio of the on and off resistances is very high.

drain current to flow. Those respective on and off resistances make the on-to-off current ratio of an FET extremely high.

IC switches

The 555 IC has been used as a time delay switch (among other things) for over a decade. Its operation revolves around three circuits—a comparator, an S-R flip flop, and an inverter. The comparator can be an op-amp without a feedback circuit, as shown in Fig. 7-a. In the circuit, a fixed voltage is applied to one input terminal while a variable voltage is applied to the other. Whether the output will be at $+V_{CC}$ or at $-V_{CC}$, the positive or negative supply voltage, depends upon the relative magnitudes and polarities of the voltages applied to the two input terminals. Note that in some circuits, $-V_{CC}$ is set equal to 0 volts, so that the output from the op-amp will vary from 0 to $+V_{CC}$.

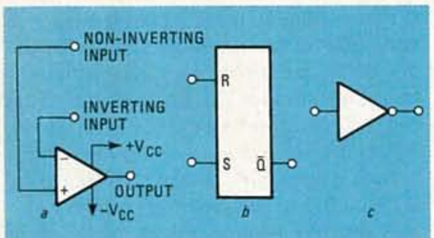


FIG. 7—THE THREE MAJOR circuits in a 555 timer IC. They are a comparator (*a*), an S-R flip-flop (*b*), and a NOT gate (*c*).

Suppose a fixed +5 volts is applied to the non-inverting input of the comparator and less than +5 volts (or even a negative voltage) is applied to the inverting input; then the output will be $+V_{CC}$ volts. Should the voltage at the inverting input be greater than +5, regardless of how little, the output becomes $-V_{CC}$. In a similar fashion, if the inverting input is set at a fixed +5 volts, the output is minus V_{CC} when the voltage at the non-inverting input is less than +5 volts, and is $+V_{CC}$ when the voltage at the non-inverting input is higher than +5 volts.

To sum up, the comparator compares the respective voltages at its input terminals. If the voltage at the non-inverting input is greater than that at the inverting input, the output is $+V_{CC}$, and if the voltage at the non-inverting terminal is less than that at the inverting terminal, the output is $-V_{CC}$. The change in polarity at the output occurs when the two input voltages are identical.

The second circuit in the IC is an S-R flip-flop; it is shown symbolically in Fig. 7-b. By itself, a flip-flop is a switch that's made up of digital logic circuits. In the type of flip-flop considered here, when the S terminal is low while the R terminal is high (the actual voltage levels for the high and low depend upon the flip-flop), the $\overline{Q}$ output is high. Should the conditions at the R and S inputs be reversed, the $\overline{Q}$ output is low.

Next, let's look at what happens when an input that's high is taken low again. Say, for instance, that the R input is high and the S input is low. When the R input is taken low again, the $\overline{Q}$ output does not go low again as you might expect; instead it is latched high and will remain so until the S input is taken high. If the conditions were reversed (i.e. the S input high and the R input low) the $\overline{Q}$ output would remain low until the R input is taken high. When both inputs are low the output remains in its previous state. Thus, this flip-flop can act as a switch. To change the state at the output all you need to do is reverse the states of the voltages at the inputs. In this type of flip-flop, care should be taken to prevent both inputs from being taken high at the same time.

The third circuit in the 555 is an inverter, often called a NOT gate; the symbol for that circuit is shown in Fig. 7-c. It gets its name from the fact that its output is the inverse of its input. Specifically, when the input to the gate is high the output is low, and vice versa.

A functional block diagram of a 555 is shown in Fig. 8. In it you can see how the three circuits we've just discussed are used in that device. The IC is idling when a voltage higher than $2V_{CC}/3$ is applied to pin 2. A 0.01-μF capacitor is usually connected between pins 5 and 1; that stabilizes the DC voltage at the input to comparator A. The switched voltage from the IC is developed across a load resistor, R_L, or some other device. That load is connected between pins 3 and 8.

In addition to the above, an R-C timing network is connected between pins 8 and 1, with the junction of the resistor and capacitor connected to pin 6. The time it takes to charge the capacitor is instrumental in determining the time it takes for the output to switch from a high to a low state. The charging process can take place only after a negative pulse has been applied to pin 2. Pin 7 is connected to pin 6 so that the capacitor will discharge after the internal transistor, Q1, connected to pin 7 has been turned on. All of the external components and connections we've discussed are shown in Fig. 9.

Before power is applied to pin 5, it is at ground potential because the capacitor connected there is fully discharged by the two identical internal resistors that run from it to ground. A slight potential may exist at pin 6 because the "hot" terminal of the capacitor in the timing circuit, C_T, is brought only close to ground potential through the internal discharging transistor (Q1 via pin 7), but is never precisely at ground. The slight voltage on the capacitor is due to the existence of a saturation voltage in the discharging transistor, just as it exists in any other transistor. That voltage, however small, is always across

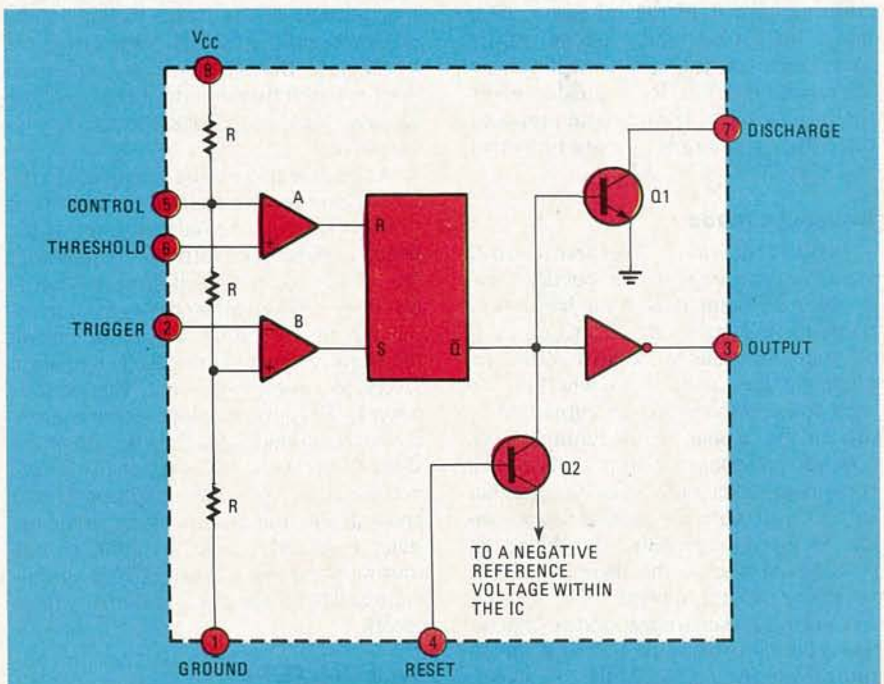


FIG. 8—FUNCTIONAL BLOCK DIAGRAM of a 555 timer IC.

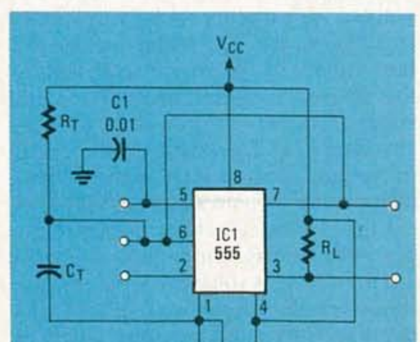


FIG. 9—SWITCHING CIRCUIT using a 555.

the transistor, and is consequently across the capacitor. As a result, voltage at the output of op-amp A is high at the instant that power is applied to the circuit.

Voltage at the output of op-amp B is at zero because when power is initially applied to the device, the non-inverting input of that op-amp is again grounded through an internal resistor in the IC. At the same time, the inverting input, which is tied to pin 2, is held at some value above $2V_{CC}/3$ as discussed above. That condition is one that must be satisfied if the 555 is not to be triggered.

The outputs from op-amps A and B are applied to the R and S inputs of the flip-flop respectively. Thus, when the output from op-amp B is low and the output from op-amp A is high, the $\overline{Q}$ output of the flip-flop is high. But the signal available at pin 3 of the 555 is low; that's because the output from the flip-flop is passed though the NOT gate before it is fed to pin 3. The discharge transistor, Q1, is turned on by the high voltage at $\overline{Q}$. The transistor shorts the timing capacitor, to maintain the status quo of the circuit and keep the output low.

The initial low output level from the IC is maintained from the time that power is applied to the circuit until a negative pulse is applied to the trigger input, pin 2. That status quo is maintained because almost immediately following the application of power, the supply voltage is applied, via a resistor, to the inverting input of op-amp A. Because of that, a low is applied to the R input of the flip-flop. As for op-amp B, its output is maintained low because the idling voltage from the trigger input, pin 2, which is high, is applied to the non-inverting input of that op-amp. As low voltages are at the R and S inputs of the flip-flop, the output from the IC cannot change states; it remains low. The discharge transistor remains turned on until the S input goes high.

When a short negative pulse with a voltage of less than $1/3V_{CC}$ is applied to pin 2, op-amp B's output goes high and that signal is applied to the S input of the flip-flop. That brings $\overline{Q}$ low. The low signal is subsequently inverted by the NOT gate and is available as a high at pin 3 of the 555. In the meantime, the low at the $\overline{Q}$ output of the flip-flop, which is connected directly to Q1, turns that discharging transistor off. That, in turn, removes the short from across the timing capacitor, C_T, allowing it to charge. When voltage across C_T exceeds the voltage at pin 6, or is more than $2/3V_{CC}$, the state of op-amp A changes and a high appears at its output. (The output from op-amp B went low immediately after the trigger pulse was completed.) That brings $\overline{Q}$ high, the output at pin 3 low, and the discharging transistor is once again turned on to discharge the timing capacitor.

The time it takes for the capacitor to charge and trip the circuits is $1.1R_TC_T$ seconds. During that time, voltage at the output is high. It stays there until the charging period has been completed. The capacitor is then discharged, the output becomes low, and the circuit awaits the next negative pulse to start the next timing cycle.

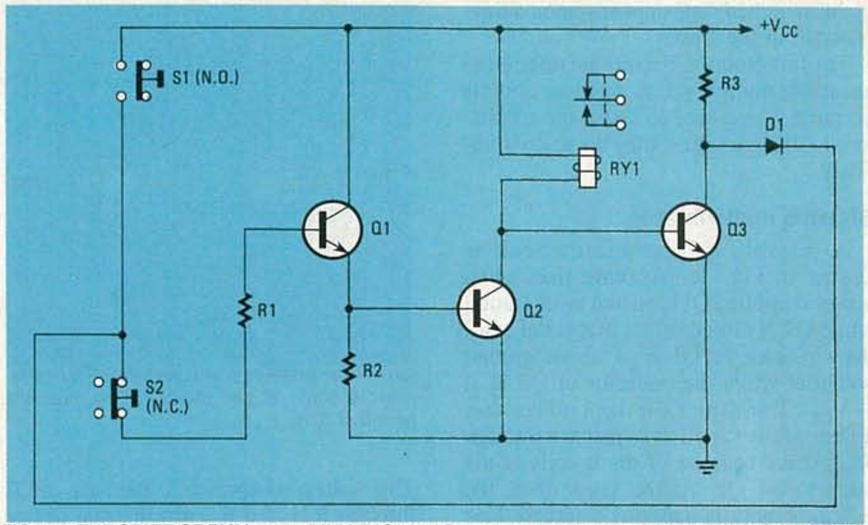


FIG. 10—THE STATE OF RY1 is controlled by S1 and S2—pressing S1 closes the relay while pushing S2 opens it.

The charging cycle of the capacitor can be disturbed only by placing a low voltage pulse at the reset input of the IC, pin 4. That pulse turns on transistor Q2, which, in turn, turns on the discharging transistor. If the reset terminal is not to be used, it should be connected to a fixed high voltage such as the $+V_{CC}$ supply.

Latching relay

Circuitry can be built around a mechanical relay so that its operation is controlled by a pair of momentary switches. Closing one switch closes the relay and closing the second switch opens it. A transistor circuit that can be used to accomplish that goal is shown in Fig. 10. When S1 is pressed, current flows through the the relay's coil and the contacts close. When S2 is pressed, the current ceases to flow and the contacts open. Of course, a normally closed relay could be used in place of RY1; in that case the action of the relay is reversed.

Let's start our look at the circuit by assuming that S2 has been pressed for an instant, thereby opening the circuit to the base of Q1. No current flows through it or through Q2, so that the supply voltage, $+V_{CC}$, is at the collector of Q2. This voltage is there because, in the absence of current, there is no voltage drop across the coil of the relay. The high voltage at the collector of Q2, and hence at the base of Q3, turns on the latter transistor. Collector current through Q3 is limited only by R3. Because of the voltage drop across R3, there is close to 0 volt at the collector of Q3. That is fed back and causes 0 volt to also be applied to the base of Q1, keeping both Q1 and Q2 turned off so that current does not flow through the relay coil.

Current will flow through the relay coil after S1 has been pressed momentarily. When that is done, $+V_{CC}$ is applied for an instant to the base of Q1. That turns on Q1 as well as Q2. Because Q2 then conducts, current flows through the relay coil. A voltage, very close to zero, is at the collector of Q2 due to the voltage drop across the transistor. That is also applied to the base of Q3 but is insufficient to turn that device on. The collector voltage of Q3 is high because there is no voltage drop across R3. That relatively high voltage is applied through D1, S2, and R1, to the base of Q1, keeping it and Q2 turned on.

Multivibrators

Two switching transistors are used to form a multivibrator. In their stable states, one transistor is turned on and one is turned off. The purpose of a multivibrator is to switch (and possibly even keep switching) the stable states of the two devices. To accomplish that, positive feedback is placed around the two transistors so that the circuit becomes unstable. That instability must be present if the states of the transistors are to be interchanged.

There are three basic types of multivibrator circuits. In one of those, the bistable multivibrator, both transistors are in stable states—one transistor is on and the second one is off. When a pulse is applied to the circuits, the states of the device reverses. The transistors remain in their new states until another pulse is applied; that once again reverses the states of the devices.

The second group of multivibrators are monostable. Here, the two transistors assume specific states, depending upon the circuitry. States are interchanged after a pulse has been applied but they do not remain indefinitely in those new states. After a period of time, the transistors in the monostable multivibrator revert to their original states. The time they remain in the switched state depends upon a time constant in the circuit.

The last group of circuits are referred to as astable multivibrators. In those circuits no pulse is required to cause the transistors to change states; they do so continuously.

Bistable multivibrator

A bistable multivibrator circuit is shown in Fig. 11. Assume that when power is applied Q1 is on and in saturation while Q2 is turned off. If that is the case, the collector of Q1 is at about ground potential while the collector of Q2 is at $+V_{CC}$. Transistor Q2 is kept off because no current is supplied to its base through R_F2; that's because of the 0 volts at the collector of Q1. At the same time, the $-V_{BB}$ supply is applying a reverse bias voltage to the base through R_B2. Transistor Q1 is kept turned on despite the fact that the $-V_{BB}$ supply is applied to its base. That is because there is a current flowing through R_F1; that current is due to the voltage at the collector of Q2. The states of Q1 and Q2 are interchanged if a negative pulse is applied to the base of Q1 to turn it off while Q2 gets turned on. After that, the transistors remain in their newly acquired states. A similar change of states can be accomplished by applying a positive pulse to the base of Q2 to turn it on.

For the circuit to behave as described, several design criteria must be satisfied.

1. The values of R_C1 and R_C2 (as they are identical we'll simply refer to their value as R_C from now on) must be less than $V_{CC}/I_{C(sat)}$. $I_{C(sat)}$ is the minimum saturation current of the transistor.
2. Assume that $R_B1 = R_B2 = R_B$. To keep the off transistor in that state, V_{BB}/R_B must be greater than the leakage current, I_{CBO}, of the off transistor at the maximum temperature at which it is to be used.
3. Assume that $R_F1 = R_F2 = R_F$. For the transistor to be in saturation, beta multiplied by R_C must be greater than R_F. The Beta of both transistors should be about the same.
4. To keep the on transistor in saturation, the base current must be

$$\frac{I_{C\,(sat)}}{\beta\left(\frac{V_{CC}}{R_C + R_F} - \frac{V_{BB}}{R_B}\right)}$$

Monostable multivibrator

A monostable multivibrator is shown Fig. 12. In that circuit, Q1 is kept turned on because the $+V_{CC}$ supply provides base current to that transistor through R_B1. Transistor Q2 remains off because of the negative voltage applied to its base from the $-V_{BB}$ supply. Those states are interchanged after a negative pulse has been applied to the base of Q1. When such a pulse is applied, Q1 is turned off and the voltage at the collector jumps to $+V_{CC}$.

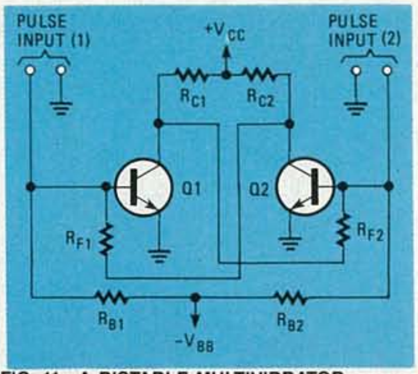


FIG. 11—A BISTABLE MULTIVIBRATOR can remain in either of two states for an indefinite period of time.

That voltage is applied to the base of Q2 through R_C1 and R_F, turning that device on. Transistor Q2 remains on until after capacitor C1 has had time to discharge through Q2 and R_B1. The time that Q2 remains on, is equal to about $0.69R_B1C1$. After that time, the transistors return to their original states.

For this circuit to perform properly, the following circuit details must be satisfied.

1. Q1 is on when V_{CC}/R_C1 is greater than $\beta(V_{CC}/R_B1)$.
2. From the transistor's specifications, determine the saturation voltage, $V_{CE(sat)}$, of Q2. If that information is not available, assume it to be 0.5 volt for a small signal transistor and 2 volts for a large power device. Use intermediate values for intermediate size devices. The base-emitter voltage, $V_{BE}1$, due to $V_{CE(sat)}$ is $V_{CE(sat)} \times R_B2/(R_F + R_B2)$. The base-emitter voltage, $V_{BE}2$, due to the $-V_{BB}$ supply, is $-V_{BB} \times R_F/(R_F - R_B)$. Q2 is off when $V_{BE}1 + V_{BE}2$ is negative.

Astable Multivibrator

The multivibrator behaves as an oscillator when used in an astable circuit. In that arrangement, both transistors are usually in identical circuits with the collector of one transistor coupled through a capacitor to the base of the second. The states of both devices keep changing from on to off, and back again, at a fixed rate. A basic arrangement of an astable multivibrator is in Fig. 13.

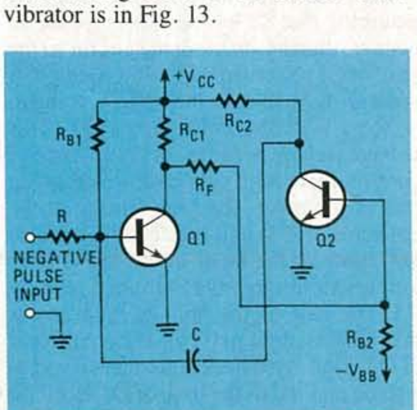


FIG. 12—A MONOSTABLE MULTIVIBRATOR has only one stable state.

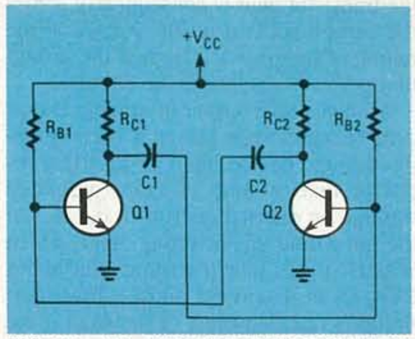


FIG. 13—AN ASTABLE MULTIVIBRATOR Changes states continuously.

Start by assuming that Q1 is turned fully on and is in saturation while Q2 is off. Because the collector of Q2 is at $+V_{CC}$, C2 charges to just under $+V_{CC}$, with the polarity as shown in the diagram. (The curved side of the capacitor represents the side at the lower potential.)

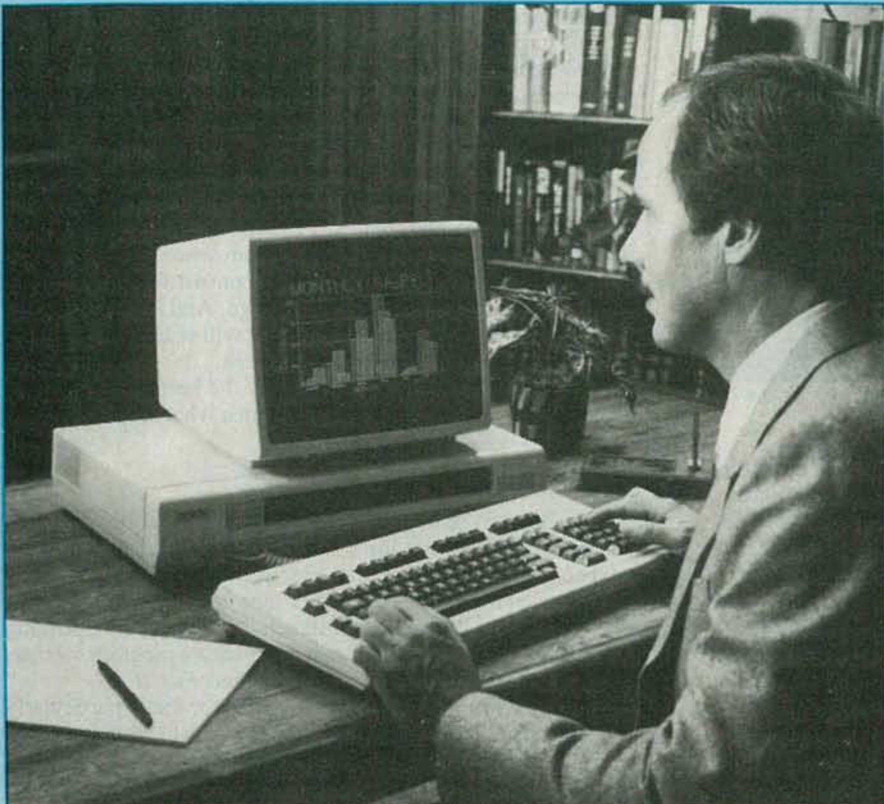
Capacitor C1 was charged, with the polarity as shown, during the previous half-cycle. When C1 is discharged, a base current flows in Q2 due to the current flowing through R_B2; the current in the resistor is caused by $+V_{CC}$. The presence of a base current turns Q2 on, putting its collector as well as the positive side of C2, at ground potential.

Because the voltage across C2 has the polarity shown, the base of Q1 is placed at a negative voltage with respect to ground. That turns Q1 off. While Q1 is off, C1 charges, with the polarity shown, to just under $+V_{CC}$, just as C2 did when the transistors were in their previous states. In the meantime, C2 is being discharged through R_B1 so there is no voltage left across C2 and thus none applied to the base of Q1. Transistor Q1 is turned on because the only major factors that now affect its base current are $+V_{CC}$ and R_B1. Transistor Q2 is turned off because of the negative voltage at its base. It is negative because the positive end of C1 is at ground potential after Q1 has been turned on.

The process continues without a stop. The time for switching from one state to the other is $0.69R_B1C2$ or $0.69R_B2C1$. If R_B1 is not equal to R_B2 and C1 is not equal to C2, then the time in which the transistors are in alternate states differ. Should $R_B1 = R_B2 = R_B$ and $C1 = C2 = C$, both switching times are identical. Fully symmetrical squarewave cycles will then be seen at the collector of either Q1 or Q2. The period of the full cycle is $1.38R_BC$ and the frequency will be $1/1.38R_BC$.

More switching devices

In this article, switching circuits using bipolar transistors, FET's, and IC's were described. But there are other semiconductor devices designed to perform as switching devices. Those include UJT's, SCR's, PUT's, and so on. Those and similar devices will be discussed in our next article. **R-E**



Radio-Electronics YOUR OWN Software

Business Software

You've finally decided to computerize your small business. Now you have a computer, but no software to run. Let's take a look at the features of some programs to help you decide what you need.

Small Budget Business Software

HERB FRIEDMAN

IN RECENT MONTHS, THE TREND OF BUSINESS-RELATED SOFTware has been to the all-inclusive computer program. The way most of the computer shops tell it now, the best software is a big, accounting program that costs upwards of $1500, or integrated (multi-function) software that serves as a database, word processor, electronic spreadsheet, communications package, and heaven knows what else. And if an integrated package still won't meet your needs, they are ready to sell you a super-duper program that will let you write virtually any kind of imaginable database system.

While multi-function software and database generators are very nice to have, they are not only expensive, most are so complex it can take weeks or even months to learn how to use them. In fact, the heavily advertised, consumer-recognized, and expensive *dBase II* is virtually a high-level programming language that needs an almost equally expensive software package as an intermediary so that the average user—the non-programmer—can write a database using it.

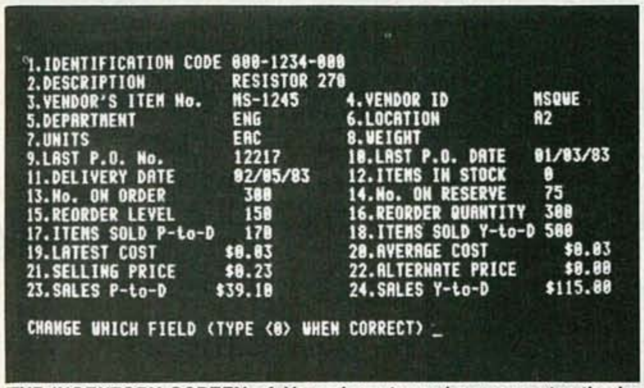
Having all the records in one gigantic database isn't always the easiest way to do things, particularly for the individual entrepreneur who has enough trouble finding time to take care of business, let alone spend hours keying data into a computer. As a general rule, many small electronics-related businesses can get along with much lower-cost and less complex software by using the computer solely for the most difficult jobs. In many instances, individual specific-function programs are less expensive and more convenient to use.

To illustrate the kind of feature that's available in relatively inexpensive software packages for the small businessman, we'll look at some of the best software we've recently had a chance to try. We make no recommendation that they are the best available; they simply have so many decent and often unusual features, they may give you—the typical **Radio-Electronics** reader—a good insight to the particular type of software that will work best for you.

Don't skip over some of the software we'll cover because "...you know it's the wrong format for your computer." Keep in mind that most software is now available in many formats: much software that used to run only on Radio Shack computers is now available in CP/M, PC-DOS and MS-DOS, and vice versa. And if it's not available in your computer's disk format there might be conversion software that will permit your computer to run alien software. For example, *File-Tran* by Business Micro Products (311½ 8th, Suite 400, Glenwood Springs, CO 81601), will convert just about any CP/M or TRS-80 5¼-inch format to that of the Osborne I computer (data files and BASIC programs), while *UniForm*, by Micro Solutions, Inc. (Suite 19113, 1608 El Paso Rd., Las Cruces, NM 88001), will not only do the same for the *Kaypro II*; it will also record CP/M Kaypro files in the format of other computers. And by the time you read this, there will probably be "conversion" software for PC-DOS software, MS-DOS, etc. So it's a good chance that the type of software we cover will be available for your computer. And if you don't have conversion software, many software houses will "PIP" the software to your computer's format.

Small packages, large power

For the electronics service shop dealing primarily with consumer appliances such as TV, Hi-Fi, air-conditioners, etc., there's usually no need to computerize the accounts receivable



THE INQENTORY SCREEN of *Versa-Inventory* when you enter the information for a single item is shown here.

because most work is paid for cash-on-delivery; there are probably only a handful of jobs on open account or credit. Similarly, there's probably no need to computerize accounts payable because the shop deals with maybe a handful of distributors. Most likely, the primary need is for computerized inventory control: simply knowing how many widgets are in stock, what's the re-order limit, and maybe how many widgets were used last month, or last quarter, or last year; and where in heck you store the stuff you have. (Micro-widgets are hard to find if you don't remember where you put them.)

That kind of inventory system doesn't require an expensive database generator nor weeks of programming and debugging. Some notably good inventory systems are available in the range of $50 to $150. For example, a system such as *Versa-Inventory*, from Computronics, Inc. (50 N. Pascack Rd., Spring Valley, NY 10977), is probably better than the average computerist could write with a database program. It will print reports showing the part description, the vendor's item number and ID, the department or equipment it's used in, where the part is stored, two levels of selling price (wholesale or retail), actual stock, items on hold, items on order, and the reorder level. And it will print period-to-date and year-to-date reports on sales, cost, or whatever.

The number of inventoried items is determined by the size of the disk drive; for example, the 500K disk of a TRS-80 Model *II* computer will accommodate about 4000 individual items.

The amount of information that the program can print in reports is awesome when you consider it comes from a relatively inexpensive program. It might take days, weeks, or months of work to create that kind of report structure using an expensive database generator.

Versa-Inventory runs under MBASIC (Microsoft BASIC), which must be supplied by the user. MBASIC is indigenous to Radio Shack computers, and is available for most popular CP/M computers.

Another program that doesn't have to be integrated with a giant database is the mailing list. *MicroMailer*, from MicroVentures, Inc., is an example of the kind of thing that delivers the maximum bang-for-a-buck for a service shop's mail campaign. How? By outstanding utilization of *identifiers*.

An identifier is a code embedded in a mailing-list record that helps identify the person. As a general rule, mailing lists will accept several one, two, or three character alpha or numeric codes that stand for something. Perhaps the letter "A" would mean "Purchased a TV," or "ANT" might mean "Installed an antenna," etc.

MicroMailer, however, permits up to seven multi-word identifiers for each person, such as "VCR SERVICE CONTRACT," or "TUNER REPAIR 1983." It keeps track of the identifiers and automatically plugs in the correct date each time the identifier is used. It will even attempt an identifier match when printing labels. For example, if one identifier is VCR, meaning the person purchased a VCR from your store, it will flag this person and ask if you want their label if you are running a mailing list of people with a "VCR SERVICE CONTRACT."

If you send periodic mailings to your customers, the identifiers will strip out precisely the information you want; it can tell you whose service contracts are expiring, who purchased what appliance, who had warranty repairs, etc. You can prepare the mailing record at the time of each sale or at the end of the day. At the time of record entry you can not only key in all relevant identifiers, but even the salutation for a form letter, such as "Dear Ms. Austin:," or "Dear VCR Owner," or "Dear Jim."

You can sort on just about any field or identifier, have a wide assortment of label styles to choose from when printing—even design your own—and you can even convert the data into the correct format for a *WordStar* mail-merge. And in case you can't keep track of who your customers are, it will search for duplicate mailing list entries by address and name.

While *MicroMailer* isn't necessarily the best mailing list for small businesses, it gives you a good idea what to look for your own use.

Create your own forms

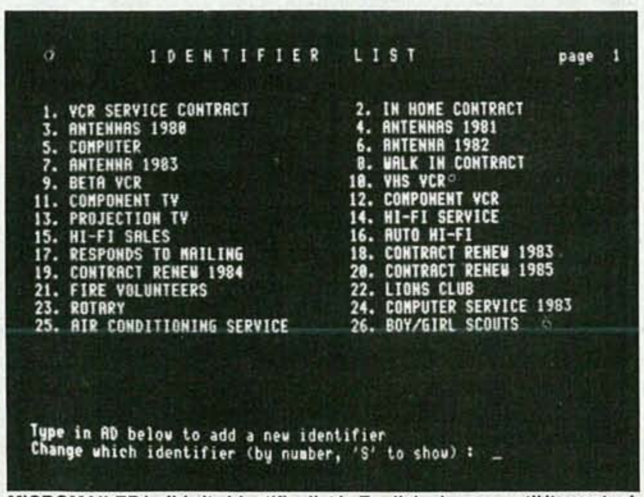
Let's assume you have a need for a program that allows you to create a precise format for a filing system and that there's no inexpensive program that does precisely what you want. Let's say you want to catalog a record or tape collection in your own way: you would like to design screen displays and the printing formats yourself. OK—there's an inexpensive program for that, too. It's by Swan Software and it's called *File It*.

File It is a sort of mini-database generator that's particularly well suited for catalog-type files. It allows you to write your own screens and printout formats without days or perhaps weeks of training. The program is relatively inexpensive, but works quite nicely if you are aware of some of its limitations. For example, its high speed sort is only on the "key" field, the "key" being the first field—which should be a "catalog number." While it can search rapidly on the key field, search and sorts on other fields can be relatively very slow. The user must work it out the way that works best for him.

File It searches can be by date, math operators such as < (less than) and > (greater than), equal, not equal, limits, specific numbers, match and not match, forced match, etc. While *File It* is really a miniature database system, it's easy to learn and use; the busy technician can learn it in a couple of hours and do some heavy customized design before the evening is out.

Automatic check printing

If your business or interest requires writing a stack of checks at the end of the week or the beginning of the month, or you're trying to keep the personal expenses separate from the tax-deductibles, then some form of electronic checkbook program will make the paperwork a little easier. There's a junior, intermediate, and sophisticated version of checkbook programs for every computer, from the least to most expensive. The



MICROMAILER builds its identifier list in English phrases until it eventually runs out of disk space.

trouble is that most are oriented for home use and don't have the muscle for commercial records. An exception to this rule is *Bookkeeper* by Chuck Atkinson Programs.

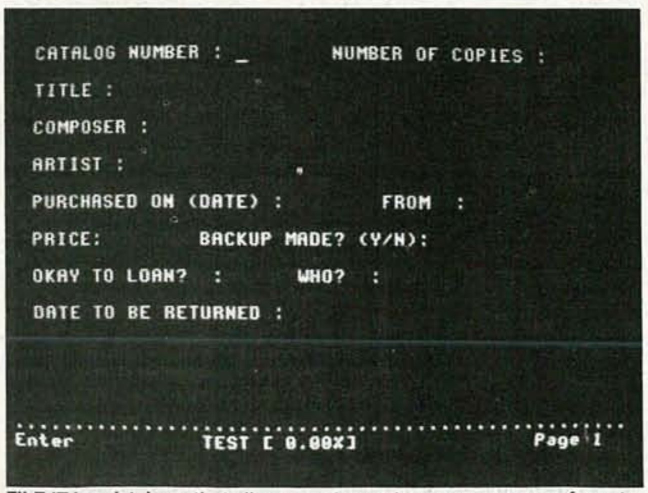
Bookkeeper is an electronic checkbook system that seems almost tailor-made for the small business person who periodically writes an unusually large number of checks for either personal or business expenses. It not only keeps a balance account of the checks, it actually writes them, catalogs them, and distributes them into individual tax-deductible and non-deductible expense categories. There are 50 deductible category codes: Codes 1 through 32 are pre-named; 33 through 50 can be named by the user. Codes 51 through 98 are pre- and user-named non-deductible expenses. The last code, No. 99, is used to split a check up to four ways; the amounts are added to the proper expense categories.

Bookkeeper even remembers the last person to whom a check was issued, and will automatically print the recipient directly on the check if desired. For example, assume the printer is loaded with "tractor-feed" blank checks and the user writes a check to the local telephone company. The program has remembered the name of the telephone company, and when the amount is keyed in, the check is automatically printed with the amount and company name. Just as a checkbook, *Bookkeeper* will accept data entry on deposits and withdrawals, keeping a running account of the balance. There is even provision for manually correcting the information to accommodate bank fees and out-of-pocket cash expenditures. In addition to printing the check itself (using standard tractor-feed checks), it will prepare pay checks; provide a check register; list outstanding checks; provide a listing of check registers by alphabet, expense code, or deposits; and provide lists-of-cash summaries by date, by reference, code, credits, cash analysis, and expenditures.

Hide and seek

Do you need to store and selectively retrieve information of any kind, such as what magazine had what article? What page it was on? Where did you put the schematic of the signal generator you purchased from the Army 10 years ago? Who will volunteer their services for your favorite charity? There are almost as many "datafile" programs as there are checkbook systems and word processors. Most do more or less the same thing in similar ways: you put the information in and the software lets you find it by looking for key words. The problem is, most electronic filing systems require precise information; if you misspell a word, enter an extra character—even a space—the computer will reject your search.

However, an electronic filing system such as *Cardfile* from Digital Marketing (2363 Boulevard Circle, Walnut Creek, CA 94595) will ignore your mistakes as long as you don't try to deliberately fool the computer. It will dig out your information if all you can remember is a few letters of a single word. Basically, its search is similar to the electronic file index of computerized libraries.



FILE IT is a database that allows you to create your own screen formats. This sample was for a tape library.

Cardfile works this way. There are four fields. They can be used for any type of filing system because the program permits the user to create individual prompts for the fields. For a book file, the fields might be: "Subject," "Title," "Author," "Text," To keep a file on your music library, you might have prompts for the composer, title, artist, and for comments. Each set of prompts can be named so it is maintained as an individual file, and there can be several files on a disc. The information is literally poured in when creating the file. To search for any information you simply key in as much as you know for one or any of the four fields. The program searches the specific file reserved for the prompts and comes up with the data.

Now suppose you're not too certain of what the data is. Assume that a long time ago you stored information on a Kurtzweil reading machine, an optical scanner/computer that reads books to the blind. You don't recall how to spell Kurtzweil. The best you can do is Kurt. That's all you need for *Cardfile*. The search will take a little longer but *Cardfile* will find the entry. As long as you don't enter an erroneous string (fooling the computer) the program will locate your data record. The more words and descriptions, or partial words, the faster the search. If you wanted to locate a magazine article on transistor oscillators and you could not recall how to spell either word, simply keying in as much as you know, say, "trans" and "osc," will find it faster than just the single string "trans" or "osc."

The amount of information you can store in the low-cost electronic file programs varies from as low as six lines of 32 characters to almost 100 lines of 80 characters. As a general rule, the quantity is not as important as how easy it is to retrieve the data.

The do-anything database

Eventually, everyone wants a DBMS, a *D*ata*B*ase *M*anagement *S*ystem. That's a system of storing information in selected fields that can be interrelated in any order by the user. A DBMS can hold all the information on your business or other interests: the names and addresses of your customers, your suppliers, your inventory, accounts receivable and payable, the general ledger--anything you want. You then create screens (video monitor displays) that allow you to enter or retrieve only the specific data for a given purpose. For example, suppose you have created your own inventory system with perhaps twenty fields, everything from the part number to the name and address of the supplier to a complete set of purchase order records. If desired, the DBMS will use the purchase-order data to calculate the average costs for any time period. The DBMS will do this for you because you set up the fields and their relationships any way you want.

To make life easier for you when a customer comes in, you would like a TV monitor display of only the part item and description, the quantity in stock, and the selling price. It's simple: you just create a screen display that selects only those fields from the database, and you create the screen layout exactly as you want it. Normally, you can create several different screens for a DBMS, just as you can create several different formats for printed reports. As a matter of fact, the DBMS can run the cash register. When you sell an item, keying it into the database will automatically calculate the cost and update the inventory; and if you entered the customer's name and address, enter the information for use in billing, mail campaigns, warranty records, or whatever.

The potential power of a DBMS is enormous, which is why many are virtually complete programming languages unto themselves, often extremely difficult to learn and use. For the non-programmer who needs a powerful database but doesn't have the time, energy, or inclination to learn programming, there are two outstanding DBMS systems that can be learned in a couple of evenings, and even mastered within a week. The first is almost a legend because someone with the barest of knowledge about computers can create quite sophisticated database systems without too much trouble. It's Radio Shack's *Profile III+* for their *Model III* and *4* computers and its sister program *Profile Plus* for their *Model II* computer. While not the most powerful DBMS by any means, its level of sophistication is extremely high—yet it is created by on-screen menus rather than programming statements or free-form creating on the screen. *Profile's* capabilities are much too extensive to describe here; basically, if you can think of it *Profile* will probably do it. Third-party enhancements add even greater power to *Profile*. For example, the program will sort or search on up to four fields. However, the people that wrote the program for Radio Shack, The Small Computer Company, Inc. (230 West 41 St., Suite 1200, New York, NY 10036), have a set of enhancements for both versions of Profile that make them almost standards of excellence, or at the least, reference standards to which others are compared. One enhancement allows selection by up to sixteen criteria, and then sorts on up to five of those. Another allows the preparation of forms such as shipping invoices—with graphics no less. Still another allows you to rearrange a screen without having to re-do the database. There are data-transfer enhancements, cross references, and a whole series of other easy-to-use but complex functions. If you go for either version of *Profile*, find out what enhancements are available from the people who wrote the programs.

One final note on *Profile III+*. The documentation is good, but not great; there are some sections which are a bit confusing. A third-party outfit called Crest Software (2132 Crestview Drive, Durango. CO 81301) publishes a set of notes, called *Plus Explained*, that clears up virtually all the rough spots in Radio Shack's manual. If you use *Profile III+* it's the best $14 investment you can make.

The second user-friendly DBMS is *Super*, from the Institute for Scientific Analysis (Dept. M-3, Box 7186, Wilmington, DE 19803). It is available for TRS-80 Models I and III using NEWDOS, LDOS and DOSPLUS operating systems, for *Model II, III*, and *16* under the TRS-DOS operating system. Versions are also available for CP/M and IBM-PC.

A menu-driven DBMS, it is offered as competition for *dBase II*, not *Profile*. The reason appears to be that *Super's* structure is intended specifically for business. It's oriented towards ease in setting up customer files, depreciation, cost accounting, accounting systems, and manufacturing control. Most important, it will integrate with word processors such as *WordStar, Scripsit*, and *Newscript*. It, too, is jam-packed with features; you really must send for a descriptive brochure to see if it meets your needs because it sets up a rather sophisticated database and report generator.

Unlike *Profile*, which can be handled by a beginner, *Super* requires some knowledge of what goes into a DBMS because the documentation often leaves a lot to be desired. At times it is pedantic (deadly dull reading); other times it assumes you know too much. There aren't enough illustrations, and what there are are not where they should be—accompanying the associated text. Also, screen formatting for reports is not menu-driven and is relatively difficult and frustrating; our CP/M version in no way conformed to the documentation. Perhaps that was a result of the conversion process from the TRS-DOS format to CP/M. Whatever the reason, it needs much superior documentation.

Essentially, *Super* would be an excellent DBMS for the beginner and non-programmer if the manual were somewhat improved. Most likely, if the program becomes popular, someone will come out with a special "how to use *Super*" manual, much like the insert notes for *Profile*. With or without the extra documentation, *Super* is still a good DBMS for the small businessman.

Itty-bitty programs

We have gotten into some pretty heavy stuff with our database-management systems, so I'd like to close with an absolute dynamite program, actually 100 programs in all; one of the best software packages for a small business even if you don't use the computer for any other purpose.

This software package is called *Business Pac 100*, from Computronics, Inc., and it's available for just about every popular computer. *Pac-100* consists of 100 ready-to-run BASIC programs, all of which are the kind you often need, and would write yourself if you had the time or programming expertise. They run under Radio Shack's version of BASIC or MBASIC. (The programs were originally written for the Radio Shack computers.)

The 100 programs encompass virtually every financial calculation needed by a business, from calculating the apportionment of interest, to calculating the future or present value of an investment or compound interest, to calculating the value of a bond or an annuity. It will calculate how much your children's educational fund will be worth when they go off to college, determine the NPV (*N*et *P*resent *V*alue) of a project, and the effects of inflation. There is even an electronic version of the *Dome* business bookkeeping system.

And away from straight calculations, there are programs to print multiple labels of any kind, keep an in-memory mailing list (great for small lists of a few hundred names), and prepare shipping labels. There's a letter-writing system that interlocks with its own mailing list, a computerized telephone directory, a UPS-zone-from-ZIP-code directory...it just goes on and on. There are 100 of the greatest mini-programs, and it comes with excellent documentation. Every program is described on its own page(s), and is listed in alphabetic order. As we said, it's exactly what you would do for yourself.

The one problem is the conversion from the original Radio Shack BASIC to MBASIC. Radio Shack's Microsoft BASIC can handle a statement such as "GOTO150." Note there is no space between "GOTO" and "150." MBASIC, however, requires the space; the statement must read "GOTO 150." In a few programs we found that the conversion from Radio Shack to MBASIC missed a few GOTO statements and there were no spaces; the program crashed. MBASIC will crash on the line with the problem so you can go directly into the EDIT mode and insert the space. Or you can LIST the program and check all statements for the proper GOTO. *PAC-100* programs are not protected; you can modify them, make copies, do whatever you want.

We've covered a lot of ground in our trip through software for small businesses. As we stated earlier, the purpose was not to recommend any specific software, but rather to illustrate the many features (and some of the problems) in some of the best or most convenient software we used.

Keep in mind that software doesn't come cheap; it starts to add up a hundred dollars here, a few hundred there. Before you know it the software has cost more than the computer. Perhaps some of our illustrations will assist you in keeping software costs at rock-bottom. When in doubt, remember the adage: "If it works well on a 3 × 5 file card, a computer probably won't do it any better." **R-E**

HOBBY CORNER

Multiplexed readouts

EARL "DOC" SAVAGE, K4SDS, HOBBY EDITOR

IF YOU EVER INTEND TO BECOME INvolved in repairing, modifying, or building a device that has a readout with several digits, you should have a clear understanding of the principals of multiplexed displays. Consider, for instance, a letter we recently received. One of our readers, Gerry Vrbensky (Nova Scotia, Canada) wants to use larger readouts as an external display for his calculator but is having some problems with his modification. Our guess is that it's the multiplexed circuit that is causing the confusion.

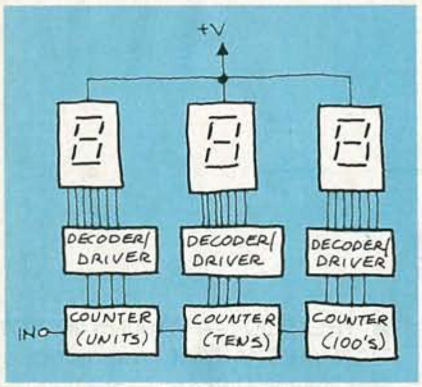


FIG. 1

Figure 1 shows a typical non-multiplexed display. Here, each LED readout has its own decoder/driver. There is no sharing of circuits or components except, of course, the carry-over signal to the next counter IC. That is the type of schematic you will find in most construction articles that involve displays. It is straight-forward and easy to understand.

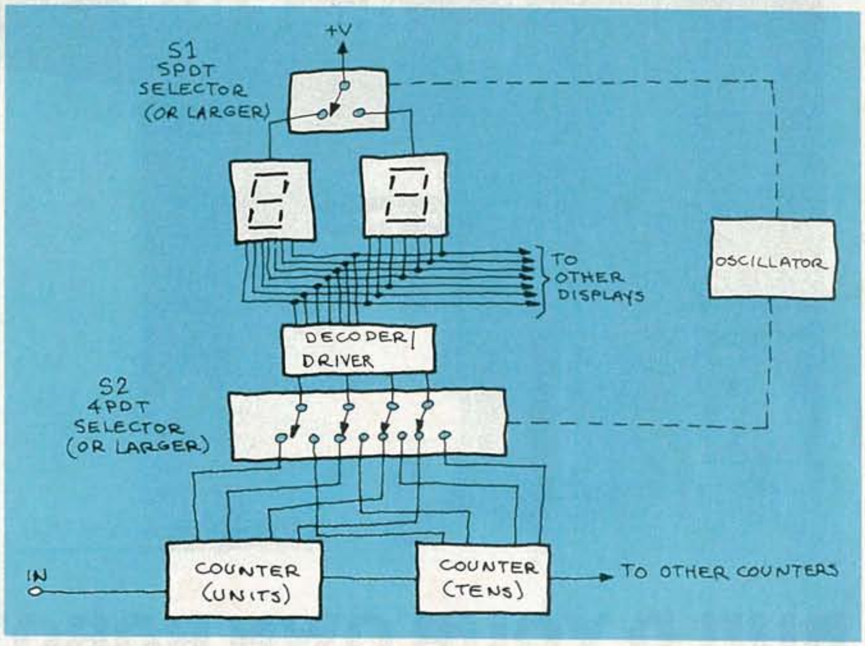


FIG. 2

Figure 2 shows the block diagram of a typical multiplexed display such as the one you might find in a calculator. For clarity, only two readouts are shown. Note that there is only one decoder/driver regardless of the number of readouts used. That's possible because of the multiplexer, shown here as two separate switches and an oscillator.

Let's see how that circuit works. The oscillator serves as both a timing and triggering device. (That is, it synchronizes the switches as well as causing them to open or close.) Switches S1 and S2 simultaneously select one readout and its associated counter. The signal from the selected counter is applied to the decoder/driver, where it is converted and passed on to the appropriate segments of *all* the displays. But only *one* display lights—because only one display is connected to the supply voltage at a time (through S1). Now a second counter and its readout are selected by the switches, the signals are processed in the same manner, and so on. The process continues and all readouts are lighted sequentially. The same sequence is repeated again and again. But you don't see the digits flicker—instead, the readouts appear to be lighted constantly because of the very rapid switching action of the multiplexer circuit.

Thus, you can replace all but one decoder/driver in a non-multiplexed display circuit with one oscillator and two switching arrays. Say, for example, you are building a display that is to have 12 digits in the readout. Using the non-multiplexed method, 12 decoder/drivers would be needed. But if that same circuitry is multiplexed, the number of decoder/drivers can be reduced to four. That's a substantial savings when you're trying to cut costs in order to be competitive and/or make a smaller device.

Also, don't be confused if you find far fewer IC's in your calculator (or clock) than you expect. Very often, the oscillator, selectors, and decoder/driver are built right into one IC package. So, if you understand Fig. 2 and are able to trace out the wiring to the digits, you can easily determine what is going on in the circuit. That information should enable you to attach that larger readout to your calculator, or at least get you on the right track. Good luck, Gerry.

continued on page 93

AN INVITATION

To better meet your needs, "Hobby Corner" has undergone a change in direction. It has been changed to a question-and-answer form. You are invited to send us questions about general electronics and its applications. We'll do what we can to come up with an answer or, at least, suggest where you might find one.

If you need a basic circuit for some purpose, or want to know how or why one works, let us know. We'll print those of greatest interest here in ""Hobby Corner." Please keep in mind that we cannot become a circuit-design service for esoteric applications; circuits must be as general and as simple as possible. Please address your correspondence to:

Hobby Corner
Radio-Electronics
200 Park Ave. South
New York, NY 10003

HOBBY CORNER

continued from page 88

Tilt switch

Donald Wendel (TX) is looking for a device to detect a tilt from the vertical. Unfortunately he didn't mention the intended application, so we don't know if a simple switching arrangement will suffice—or if the device is to be used to determine the degree of tilt. So we'll take a look at both.

Let's consider the switching device first since it's the simpler of the two. The easiest approach would be to use a mercury switch such as the "position-determining" type available from Radio Shack. If you can't get those, several standard mercury switches can be arranged so that the contacts close whenever they are moved from the horizontal.

A second possible switching arrangement is one that you can build. It consists of a hanging metal wire (braided for flexibility) with a weight on the free end. The wire hangs through a metal ring, as shown in Fig. 3, and completes a circuit when it touches the ring. The size of the ring and its distance from the supported end of the wire can be adjusted to increase or decrease the sensitivity of the device.

If the device is to show the degree of

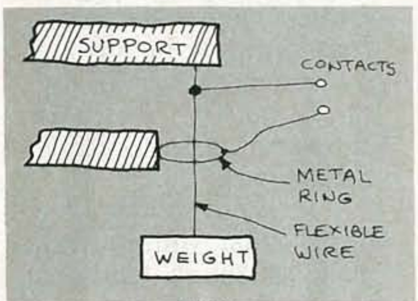


FIG. 3

tilt, that complicates matters considerably. One method that comes to mind uses a joystick (the kind that use potentiometers, not the ones that contain switches). The joystick is supported upside down and a suitable weight is attached to the handle. When the joystick (or the device it's attached to) is tilted in any direction, the resistance of its potentiometer (which you can read on an ohmmeter) will change. That reading will be in direct proportion to the degree of tilt. One supplier of the type of joystick mentioned above is Jameco Electronics (1355 Shoreway Road Belmont, CA 94002). Check the ads in the back of this magazine for other sources.

Perhaps another reader will come up with a better idea. If not, those suggestions should get you going in the right direction.

DC to AC converter

It must have been the summer storms—we have received several inquiries lately about building converters. The letters came from all over, including Puerto Rico and the Philippines.

The gist of those requests is for a converter circuit that will produce 115 volts AC from a square-wave generator. The writers want to power everything from refrigerators to computers. Among the various square-wave generators suggested are the 555 oscillator and the 5369 crystal oscillator.

Sorry fellows, but there's no way those oscillators can output enough wattage to operate those devices. That is, you cannot get both more voltage and current out than you put in. Electronics is no exception to the rule of life that says "You never get something for nothing."

Many people mistakenly believe that some electronic circuits manufacture power. That's probably because they see circuits where you put a couple of volts in and get 5000 volts out. Or, perhaps, a circuit that outputs ten amps when the input is only 500 milliamps. But that doesn't indicate a change in *power*. Power is equal to the product of voltage and current.

So those devices that you might *think* are creating power are not. (Don't take our word for it, though. Take any device and compare the product of the input voltage and current and the product of the output voltage and current. We *guarantee* that at best you'll wind up with equal numbers. You'll actually get *less* power out than you put in. That's because the circuit itself will use up some portion of the input power.)

Low power oscillators (such as those mentioned) cannot handle the kind of power necessary to produce 500 watts at 115 volts (even though that's only 4.4 amps). Remember—what we are dealing with are milliwatt devices.

There are two types of devices that are commercially available and can provide emergency power. One device attaches to the alternator of your car and reportedly produces 110 volts AC for operating radios, drills, and so on. As to whether or not they would be satisfactory for powering TV's or a moderate size refrigerator, we have no idea. And it's likely that the output will be to noisy for a computer. Because we have not had first-hand any experience with those units, we can't recommend them.

The other device that can produce the needed power is 12-volt DC to 110-volt AC converter or inverter. That device can produce an output of a couple hundred watts. But if more power is needed, you can simply use more than one unit. If you decide to go that route, expense will be a major factor. A device of that type—in kit form with an output of 175 watts—is available from the Heath Company (Benton Harbor, MI 49022) for about $55. Several years ago we mounted a Heath unit in my car and used it successfully for a variety of purposes, including a ham transceiver (but not a computer).

Transformer direction

Steve Pearson (WA) attempted to build the high-voltage generator shown in "Hobby Corner" last February. His project was unsuccessful, apparently because of the transformer used. Let's see if we can lend a hand and help clear up some of the confusion.

Any transformer can be used as a step-up or step-down transformer (provided that the primary and secondary have an unequal number of turns of wire in them). If the transformer has a small number of turns at its input (primary) and a large number of turns at its the output (secondary), it is a step-up transformer. On the other hand, if you apply the input to the high-turns side, you have a step-down transformer. (The relationship between the number of turns of wire in a transformer's primary and secondary is referred to as the *turns ratio.*)

For example, take the case of a 110-volt to 12-volt transformer. If you apply 110 volts to one side and get 12 volts out the other, you are stepping-down the voltage. However, you can just as easily reverse the transformer so that the input side is now the output. A transformer can step up or step down the voltage that is applied to it depending on which side is used as the primary.

As far as the high-voltage generator is concerned, what you need is a transformer with very high turns ratio. A filament transformer, such as the one you used, doesn't step-up the voltage enough because it doesn't have a sufficiently high turns-ratio.

In these days of low-impedance transistor circuits, it has become increasingly more difficult to purchase transformers with a high turns-ratio. As pointed out last February, your best bet is an audio-output transformer designed for a tube receiver. Perhaps you can take on from an old radio or even a tube-type TV. If you do find such a transformer, apply the input to the side that was connected to the speaker and you should get a sufficiently high voltage from the other side.

Control-voltage source

Very often the solution to a problem is just a matter of using a circuit in a slightly different way. That's our advice to H.B. Armstrong (OH), who is looking for a way to control a relay with a signal from a tape recorder.

If you-look back at the July "Hobby Corner" you'll see a circuit that used the audio signal from a radio to turn a device on and off. That circuit can be used to turn on a light, activate a relay, or do almost anything when an audio signal is fed to it. Now, if we understood your problem correctly, all you have to do is to connect the same device across the audio output of your recorder. R-E

THE DRAWING BOARD

More about counters

ROBERT GROSSBLATT

BEFORE STARTING OUR USUAL HEAVY-duty discussion this month, we have a few announcements to get out of the way. So put your brains back in neutral and relax a bit, while we take care of them.

Last August's contest is officially closed. A lot of you out there sent in answers regarding the use of trimmers in the power supply we designed. The reasons you gave had to do with everything from electron flow to the price of resistors. Well, the correct answer is somewhere in between. Take a look at Fig. 1 to refresh your memory. R_s and R_B had to be 2-watt resistors—so the only kind of trimmers we could use were the wire-wound ones.

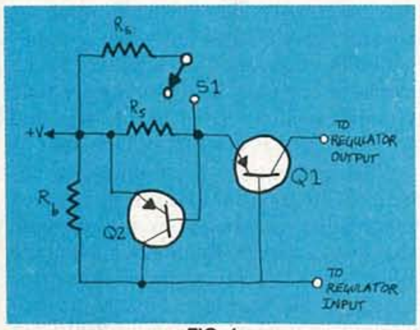


FIG. 1

The real question, then, is why couldn't wire-wound resistors have been used. Well, those two resistors have to pass a lot of current. Not only that, but if the circuit being powered by the supply suddenly draws more or less current, the voltage across the resistors is going to vary wildly from one moment to the next. Since wire-wound resistors are just long coils of resistive wire, inductive effects are definitely going to rear their ugly heads. More specifically, current spikes through the resistors are going to generate back EMF and that will momentarily change the apparent value of the resistors. As a result, all the protective circuitry for the supply, which we've spent so much time designing, would become ineffective at the exact time it's needed most. If the values of the resistors changed, the cutoff points we planned on would change. Take it from us: All the work we did would mean nothing and there'd be a good chance that the power supply would go up in smoke. An unsatisfactory state of affairs, to say the least!

And now we'll open the envelope and announce the winner of the contest.—It's Steve Geist of Des Plaines, IL. Congratulations, Steve. No prize money (we haven't been able to collect from the loser); just congratulations.

Our second announcement is that a lot of people out there have been sending in answers to another problem we outlined last August: namely, how to generate a negative supply from a two terminal transformer. Bill McFadden of Corvallis, OR not only sent us a solution, but also did a really good job of analyzing the circuit and explaining how it works. What he didn't send me was his return address. Maybe that's because we blew the prize money budget on the other contest. Seriously though—if you're taking the time to drop us a note, make sure to put your return address on the note, as well as the envelope, so we can answer you.

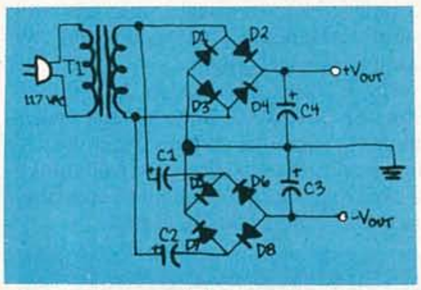


FIG. 2

Bill's final circuit is shown in Fig. 2. It could really come in handy when you're designing circuitry that needs a bit of juice from a negative supply. Its operation has all the hallmarks of a slick design—simplicity, elegance, and common sense.

Diodes D1 through D4 form a full-wave bridge rectifier and produce a positive DC voltage with respect to system ground—nothing really unusual there. But, as you all should know, that positive DC voltage is generated on every positive half-wave of the incoming AC signal from the secondary of the transformer. What Bill did was to take advantage of the negative half-cycle of that signal. Capacitors C1 and C2 charge up on the positive half-cycle of the input—as you would expect—and then dump their charges across diodes D5 to D8 on the negative half-cycle. Since C1 and C2 are always looking at signals that are 180° out-of-phase with each other, none of the input is wasted (both sides are used). Capacitor C3 is the filter capacitor for the negative supply and Bill has indicated that the best performance is obtained from that circuit when C1, C2, and C3 are of equal value. Anyone who needs a negative supply should take advantage of his work and give the circuit a try. If you do use it, let us know how things worked out and we'll pass the information along.

Although it wasn't mentioned when we stated the problem, there's one circuit possibility that no one has even taken into account. Suppose you need a negative supply and you're powering your circuit from batteries. There's no negative AC half-cycle to use, so everything we've discussed so far is, unfortunately, irrelevant. Therefore, our new contest is to generate a bipolar supply, with a real negative side, using only a single nine-volt transistor battery.

Now let's get on with other business.

In November's and December's "Drawing Board" we looked at counters (in particular the 4017 decade counter) and saw how they can be used as frequency dividers. We've also found that most of the obstacles associated with devices of that type can be overcome in one way or another.

But we're still left with the problem of the output duty-cycle. In a word, the duty-cycle changes every time we change the number we're dividing by. Although even-numbered divisions can be squared up by some sort of gating arrangement, (at the output) odd-numbered divisions present more of a problem.

You could work out some electronic equivalent of a "Rube-Goldberg" scheme to solve the problem—but it's much easier to try a different IC. That's exactly what we're going to do. More specifically, we'll look at the 4018— another ring counter. Not only can it divide an input frequency, but also provides a squared-up output waveform—without any unnecessary brain damage. Although that IC is superficially like the 4017, its operation is different and requires a bit of special handling to make it work properly.

Figure 3 shows the pinout of the 4018. If you compare it to the 4017 you'll see that it requires a bit more than connecting one pin to the other in order to divide by a particular number. The 4018 must be pro-

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COMMUNICATIONS CORNER

Recreating sound

HERB FRIEDMAN, COMMUNICATIONS EDITOR

SEVERAL YEARS AGO WE PROPOSED IN AN article on the future of high fidelity that, through the computer and frequency synthesis, it would be possible to reconstruct the sounds of yesteryear. That is, one would be able to play an old cylinder recording, process the sound through a computerized device that had stored in its memory the waveform characteristics of every musical instrument including the human voice, and eventually end up with a perfect recreation of the original signal source. Imagine hearing the full-fidelity voice of Enrico Caruso, or the legendary sound of the Original Dixieland Jazz Band.

Though we haven't quite reached that stage yet—if memory serves, we predicted it would take place sometime around 1985—we have recreated the actual voices of modern day sports announcers, and in a few emergency situations we have recreated the sound of "live" music.

Recreate voices and music? Let's explain what we mean. In the early days of broadcasting a "remote broadcast"—be it sports, drama, or whatever—meant a special radio line installed by the telephone company. Depending on the type of program material, the line might be equalized out to 15 kHz, 8 kHz; 5 kHz, or it might be unequalized (for voice transmission), and all that was missing were the upper-midrange and high frequencies. Putting the cost of that special line aside for a moment, if the head of the station called the phone company at 9 AM for a line at 1 PM it was in, equalized, and working by 1 PM—particularly if the input and output were in the same city. Today, it can take a week just to process the paperwork, possibly another week to a month to install the line, and then one hopes the line doesn't crash in the middle of the remote.

To get around the problems of cost and slow installation, many sports broadcasters went to the dial-up phone system. Using a special portable amplifier that clipped directly to a telephone line (usually across the handset's transmitter terminals), the field crew dialed the radio station's telephone, and when the phone was answered they clipped onto the handset. At the station, technicians connected the phone line's signal to the studio console, and eventually broadcast the signal they received through the dial-up telephone system.

As time progressed, the remote equipment got a little fancier and the connection was neater, but one problem remained. Because the dial-up system has a restricted frequency response range of approximately 250–3000 Hz (actually more like 300–3000 Hz), not only was the announcer unhappy with his basso voice coming out sounding like a thin squeak but, what was even worse was that the shrill sound of 300–3000 Hz eventually wears down the listener.

It took a number of years, but both problems—that of the thin voice and shrill reception—were resolved by reconstructing the "missing" low frequencies with a device users call a Comrex, which is actually the name of the company that manufacturers the device. Now the full-fidelity low frequencies of the announcers's voice could be broadcast over the dial-up system, and it was even possible in case an equalized radio line failed, to broadcast a "musical" program with some semblance of "balanced sound" by using the phone system.

The Comrex borrows its technology from the "freqwee," a device that makes humans sound like chipmunks in the TV and movie cartoons; the same technology is used to reduce the amount of spectrum used by a radiotelephone signal.

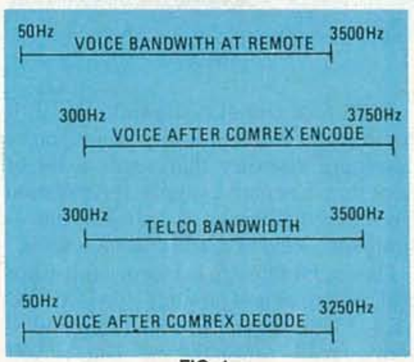

FIG. 1

Figure 1 shows how its done. At the sending or input side of the circuit, the microphone signal is passed into a Comrex encoder that slides the entire frequency range up 300 Hz by beating the audio against a fixed crystal-controlled carrier. The lower voice frequency of 50 Hz becomes 300 Hz, while the voice frequency of 3000 Hz becomes 3250 Hz. That signal is fed into the dial-up telephone system. Because of the bandwidth restrictions of the dial-up system and the Comrex equipment, the frequency range of 300 Hz to 3000 Hz is passed to the receiving end, while the frequencies below 300 Hz and above 3000 Hz are attenuated.

At the receiving end of the circuit a Comrex decoder "beats" the 300–3000 Hz signal back down to the range of 50 to 2750 Hz. Now, the announcer's original "bass" tones are reproduced at the radio studio. True, the upper frequencies are attenuated above 2750 Hz, but with the low frequencies back in the voice the "timbre" is restored, and the sound quality at the receiver is "more natural"—not hi-fi, but more closely approximating the "real" voice, and certainly more comfortable to listen to.

Another advantage of the Comrex is that the 300-Hz filter of the Comrex attenuates the telephone line's hum components of 60, 120, and 180 Hz caused by the telephone company using a common pole with the electric utility. The decoded Comrex signal is essentially hum-free.

What happened to the frequencies between 2750 and 3000 Hz? They are lost because the Comrex does not recreate what does not exist. Remember, when the signal from the microphone was processed by the sending Comrex the frequencies between 2750 and 3000 Hz became 3000 to 3250, and were sharply attenuated by the phone system; for all practical purpose they weren't received. The highest received frequency was 3000, which was Comrex'd down to 2750.

Keep in mind that the upper frequency limit is determined by the upper cut-off frequency of the telephone system. If by chance one were using the Comrex on a Schedule A phone line, which has a frequency range of 100-5000 Hz, the Comrex'd upper frequency limit would be a definitely acceptable 4750 Hz.

The success of the Comrex—and it is an unqualified success—raises the question of how superior the recreation might be if the receiving end had a computer that "remembered" the announcer's "actual voice." Certainly, having the low frequencies in addition to the midband should make a "high fidelity" recreation possible. And if we can do it with voice, why not with music.

Just imagine 1985—if we take a long length of string, two paper cups, and a Comrex, we might just be able to eliminate the phone company! **R-E**

STATE OF SOLID STATE

An interesting "melody-maker" IC

ROBERT F. SCOTT, SEMICONDUCTOR EDITOR

WE HAVE RECENTLY COME ACROSS SEVERal dedicated IC's that are used in unusual and/or interesting applications. The one we'll look at this month is the MP1173A-NI. It's a thirty-tune melody microprocessor from SRJ International (1936 Hillman Avenue, Belmont, CA 94003). The 4-bit microprocessor is a P-channel MOS device with on-chip ROM, RAM, and ALU. It's programmed to play thirty different melodies electronically.

The 28-pin DIP device can be used for many applications. For example, it can be used as a door chime, a replacement for your telephone bell, an intercom annunciator, or a music box. In your car, it could be used as a musical horn or for warning signals (door ajar, low fuel, etc.). A few inexpensive discrete components can be added for melody selection, automatic melody-sequencing, and additional power-amplification (when needed). Briefly, the features offered by the MP1173 are:

1. It plays thirty different melodies.
2. Sixteen tunes can be played automatically in sequence.
3. Melody selection can be controlled by two six-position rotary switches.
4. Its tone and volume are variable.
5. Tune speed is variable.
6. A 50-60-ohm speaker can be directly driven.
7. It can be powered by two 9-volt batteries.
8. Its scale is chromatic.
8. Tempo is programmmed for each melody.

Figure 1 shows how the IC can be used for a door-chime (or for a similar application). The optional CD4015 CMOS 4-bit shift register (IC2) is added so that, with S1 open (in the AUTO position) the melodies are automatically sequenced as S4 is pressed and then released. The door chime can be operated from two 9-volt batteries or from rectified AC from a 12-18-volt bell transformer. Figure 2 shows how a general-purpose power transistor—fed from output pins 12 through 17—can be used to obtain higher volume or to drive a low-impedance speaker.

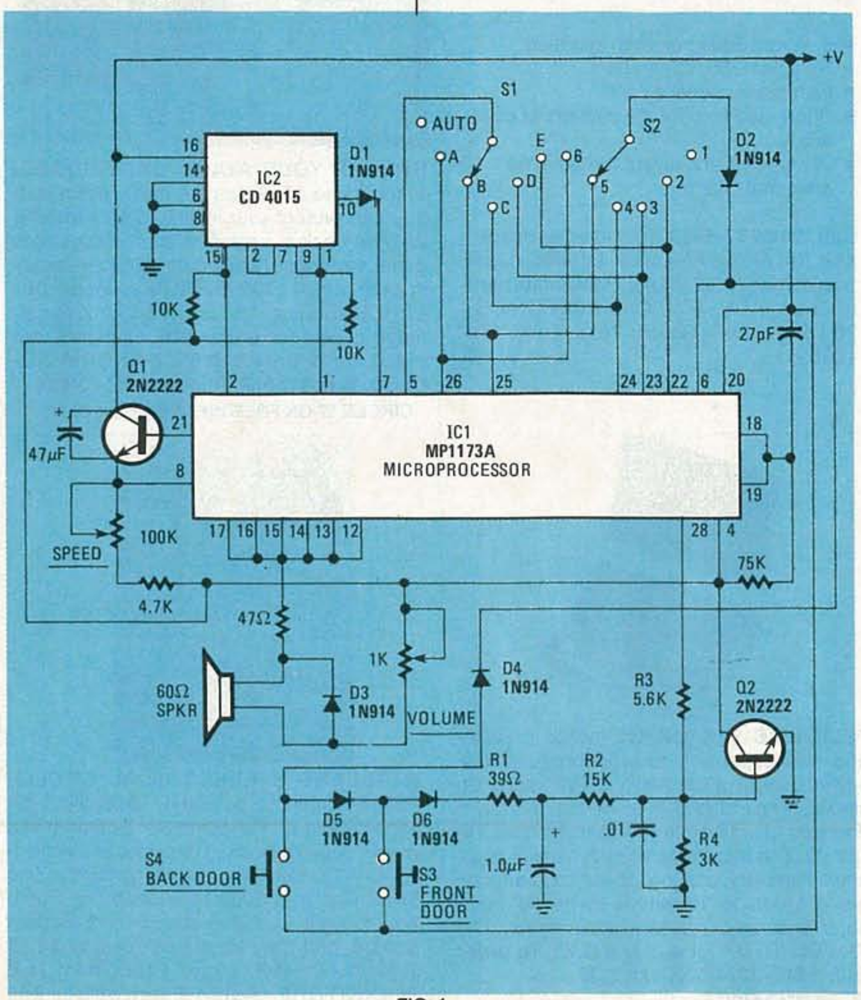

FIG. 1

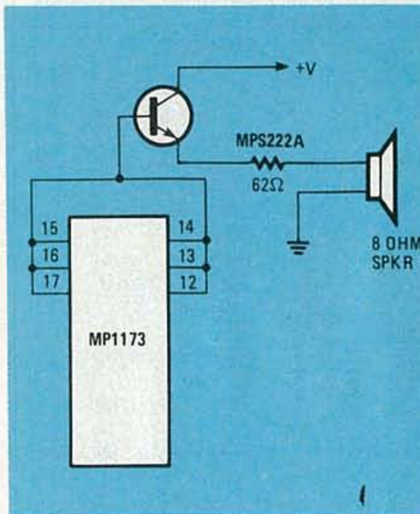

FIG. 2

In its standby mode, the MP1173 is turned on but consumes very little power. The CD4015C (IC2) has a quiescent current drain ranging from 1 μA (typically) to a maximum of 100 μA when V_{DD} is 10 volts. Thus, for the circuit shown, the battery's life should approximate its "shelf life".

How it works

When either momentary switch (S3 or S4—the back- and front-door bell buttons) is pressed, current through R1, R2 and the diode(s) causes Q2 to saturate. That, in effect, grounds pin 4 (IC1's V_{DD} terminal) and turns on the microprocessor. Output pin 28 goes high and the base of Q2 is now held on by current flow through R3 and R4. This keeps IC1 turned on after momentary switch S3 or S4 is released. At the end of the melody selected by S1 and S2—or the next tune in sequence if the chimes are set in the automatic-sequence mode—pin 28 of the MP1173 goes low and Q2 turns off.

If S3 is held down (closed) the tune selected by S1 and S2 repeats or the sixteen melodies will play in sequence if the chimes are set for automatic sequencing. A momentary closure of S4—the backdoor button—connects pin 6 to the positive supply voltage through diode D4 and the chimes will play the single tune "Oranges and Lemons." Holding S4 down causes the melody to repeat.

TABLE 1

Switch Code	Auto-mode Number	Melody
A1		Pomp & Circumstance (Land of Hope & Glory)
A2		Happy Birthday
A3		Wedding March (Mendelssohn)
A4		Jingle Bells
A5		Auld Lang Syne
A6		Soldier's Chorus (Faust)
B1	13	Sailor's Hornpipe
B2	14	Charge!
B3	15	Close Encounters Theme
B4	16	Shave and a Haircut
B5		Rule Brittania
B6		O Canada!
C1	9	Colonel Bogey March
C2	10	Westminster Chimes
C3	11	Mexican Hat Dance
C4	12	Twinkle, Twinkle Little Star
C5		Deutschlandlied
C6		God Save The Queen (My Country 'Tis of Thee)
D1	5	William Tell Overture
D2	6	Greensleeves
D3	7	Lorelei
D4	8	Eyes of Texas (I've Been Working on the Railroad)
D5		Star Spangled Banner
D6		*Oranges & Lemons
E1	1	Mozart Sonata
E2	2	Blue Danube Waltz (Strauss)
E3	3	Beethoven's 5th Symphony
E4	4	Bach Toccata in D Minor
E5		La Marseillaise
E6		Wilhelmus
		*Back door tune:

Switches S1 and S2 select the thirty different melodies according to the letter/number combinations listed in Table 1. The table also lists the sequence of the 16 melodies that are played when S1 is in the AUTO position.

The MP1173A-NI melody generator IC is available from SRJ for \$6.95 (\$13.00 for two) plus \$1.50 for postage and han-

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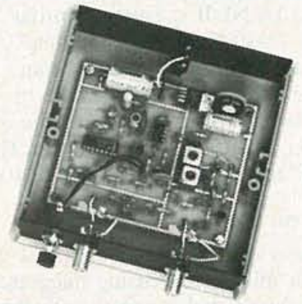

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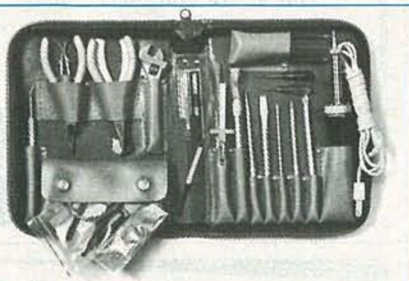

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CIRCLE 89 ON FREE INFORMATION CARD

dling. SRJ also sells the *Phone-Tunes*, which is an FCC approved telephone-bell replacement that connects easily to the telephone system. It, of course, uses the MP1173A-NI IC. Thirty familiar tunes can be selected and different tunes can be used to identify different phones. The *Phone-Tunes* ($39.95) can be operated from two 9-volt batteries or from an AC adapter ($6.95). **Honeywell Inc.,** Honeywell Plaza, Minneapolis, MN 55408.

Mike on a chip

Honeywell has just developed a new type of microphone using integrated-circuit technology that consists of a thin film of zinc oxide on a silicon substrate that is direct-coupled to the gate of a PMOS FET amplifier. The sensing element of the new mike is passive; the FET amplifier dissipates less than 40 mW so it can operate for many months before the batteries need to be replaced.

Zinc oxide, like piezoelectric crystals and ceramics, produces electric charges when subjected to stress. The new mikes have response down to 0.1 Hz while the response of most ceramic mikes is well down at 20 Hz.

The integrated-circuit sensors are lighter and smaller than their ceramic counterparts. They are one-quarter inch square while ceramic mike elements are often one-quarter inch thick and one-half inch in diameter. Their reliability is greater because they are solid state—no parts to cement or solder as with ceramics.

The new mike is expected to have many applications. For example, it is expected to reduce hearing-aid size.

Logic optocouplers

Motorola has announced a series of infrared optocouplers with Schmitt-trigger outputs for coupling digital logic circuits in situations that require a high degree of electrical isolation between the control circuits and the controlled equipment. The digital output of the couplers eliminates the need for comparators or other wave-shaping circuitry between computer terminals and peripheral equipment. The infrared optocouplers also have many applications in digital control of power supplies, motors and servos.

The MOC5007, H11L1, MOC5008, MOC5009 and H11L2 optocoupler/isolators feature a V_{ISO} (isolation voltage) of 7500-volts AC minimum, and guaranteed switching times (t_{on}, t_{off}) less than 4 μs. The LED trigger current is specified as 1.6 mA for the first two devices, 4 mA for the MOC5008, and 10 mA for the MOC5009 and H11L2. The rise and fall times for the output of the Schmitt-trigger waveform is specified as 0.1 μs.

The H11L1, and H11L2 are equivalents of devices introduced earlier by General Electric. Prices range from $3.30 to $1.55 in lots of 100 and up. **Motorola Semiconductor Products,** PO Box 20912, Phoenix, AZ 85038. R-E

It's like no other magazine in the world!

Between the covers of this special annual publication are carefully selected articles on scientific developments, recent technical advances, consumer products trends, development of services, exotic communications advances, design information, hobbying tips, and "what's new" material compiled for your reading pleasure and information. Each article was specifically chosen and prepared for publication by the editorial staff of *Radio-Electronics* magazine, updated to the moment it went on press and printed. Here's what you will read about in the 1984 edition:

VIDEO ENTERTAINMENT—It couldn't be said all in one article so we compiled a 16-page special section covering the changing and growing field of entertainment in the home: new video components with screens from the gigantic to the tiny postage-stamp size, accessories that didn't exist last year, and tips on getting the most from what you own or plan to buy.

SATELLITE TV—The countryside is strewn with parabolic tracking dishes installed by home owners to pull-in the countless television channels transmitted back to earth by satellites poised in space in geosynchronous orbits. You, too, can enjoy the programming selection—and much of it is commercial-free, too!

MOBILE TELEPHONES—What was once a status symbol for the idle rich is quickly becoming a working tool for the common man. Cellular technology promises more channels with a little help from applied computer technology.

DIGITAL AUDIO DISCS—Laser rays are bringing new noise-free, pulse-encoded audio programming to your stereo system embedded in a plastic disc immune to strawberry jam, sandpaper, and desert heat.

MAIL ORDER BUYING—You've heard the bad points, including the myths. Now, here are the facts and economics of buying mail order that will be an asset to your business or hobby.

PLUS—There's so much more, we have space only to mention an electronic guitar tuning project, theory on digital filters, how to make inexpensive computer cables, build a programmable home thermostat, tips on buying pocket-size shortwave receivers, stereo audio for TV, all about VLF active antennas, news on pagers, how to restore antique radios, and....

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AM STEREO

continued from page 46

played along with the band, mono-stereo mode and tape track. The IF is 262.5 kHz, and the bandswitching is all-electronic. The section of the tuner that is not in use has its DC supply turned off. Therefore a single-transistor switch was added to appropriately operate the AM-stereo decoder-circuit. The entire AM-receiver section is a single IC but, fortunately, its IF output voltage is high enough. In fact, we had to decrease it by using a 4.7K resistor in series with the decoder input. The decoder VCO circuit shown in Fig. 10 was used to match the 262.5-kHz IF. The audio outputs were connected in parallel with the outputs of the FM multiplex decoder. Since power is switched for band selection, the connected audio outputs did not interfere with each other. Series resistors had to be inserted in the decoder's audio outputs because their level was higher than that of the FM section of the radio. Doing that kept the sound level about the same when switching between bands. Also, we made up a special PC board for the decoder so that we could fit it inside the tightly packed radio.

The stereo system worked well, but the digital control-system caused phase-generated tones at about 600 Hz and also at about 10 Hz (fluttering). The tuner PLL loop compensation frequency was sneaking through the DC control lines to the varactor in the tuner section, causing phase modulation and some frequency modulation that appeared loud and clear in the audio. Rolling off the audio response below 50 Hz with smaller coupling capacitors at the AM decoder outputs took care of that low-frequency problem. An RC filter on the DC line to the varactors eliminated the 600 Hz tone.

That Sears radio worked out very well. Although it is not microphonic, it is sensitive to phase changes. Faint modulation from other stations can sometimes be heard when the selected station is quiet or has very low modulation. That would probably not be a problem in an automobile. Its bandwidth is much narrower than the Realistic portable which is noticeable in the audio-frequency response. But it's still acceptable, especially for automotive use.

The third conversion was installed in a home stereo receiver, a Technics model *SA-222*. This receiver has a fully synthesized control and tuning system that's operated by a microprocessor. The synthesizer presented noise problems in the very-low-frequency area and required a minor modification to a filter in the preset tuning circuit.

A small resistor was added to the loop-antenna circuit to lower the Q of the loop. That helped maintain a satisfactory band-

continued on page 114

COMPUTER CORNER

Computer environments

LES SPINDLE*

PREVIOUS COLUMNS IN THIS SERIES HAVE discussed the various hardware and software components that make up a computer system. The terminal, CPU, mass storage devices, and printer, with the software, make up the tangible materials that you will need to get started. But once you have those important components assembled, what electrical and environmental factors will you have to take into account to ensure smooth, error-free operation? This month, let's take a look at the necessary steps in achieving a safe, efficiently-operating computer system.

Before we look at such things as power requirements, let's look at two often overlooked factors—ambient temperature and air quality. Like all other electrical appliances, computers generate heat. Most units are equipped with some form of ventilation or internal cooling system. But the temperature of the computer room itself is not to be overlooked. In many instances, suitable air conditioning will help dissipate the hot air emanating from the computer and will help ensure longer-lasting performance. The sensitive electric components will not wear out as quickly if you avoid running them for long periods of time in a hot, stuffy office. If your processing workflow can be scheduled so that the computer runs minimally on especially sweltery July or August afternoons, so much the better. You will be giving the system an extra lease on life by sparing it from such a demanding workout.

Clean air is another matter of concern. Needless to say it is wise to take whatever steps are possible to keep the system dust-free. If the air filters in, say, a hard-disk drive become too clogged with floating debris, excessive heat will be trapped within the unit, taking its toll on the longevity of the system. Worse yet, a worn-out filter will not prevent dust from settling on the components. Since a hard-disk drive stores so much information in a small space, the damage that can be caused by that is obvious. Although the disk head does not actually touch the disk surface, it travels only a minute distance above it. A scratch on either surface may well cause permanent damage to both the disk and the drive—causing an expensive repair bill and the likely loss of valuable data.

*Managing Editor, *Interface Age* magazine

When you buy the components, make sure the sales person shows you where all filters are located. Check them regularly and replace them at prescribed intervals. The importance of that cannot be overemphasized.

Power requirements

Next, consider the power requirements of your system and prepare ahead for those inevitable power disturbances—voltage dips and surges, excessive line noise, and brownouts and blackouts caused by storms and other unpredictable factors.

Generally speaking, common AC line levels are sufficient for the majority of home and business computer installations. Also, most computer equipment is delivered complete with a power supply that converts that AC to the appropriate DC voltage and current levels needed for the system.

In some cases, however, either the power supply is not included with the equipment, or more current than the supply can deliver is needed to handle add-on peripherals or the like. In those cases, you can purchase an external power supply (see Fig. 1).

FIG. 1

There are too many variables involved to suggest the purchase of a specific power supply, but be sure that whichever one you choose supplies the voltage and current levels that you require. As to the current levels, be sure that the supply can satisfy the demands of your equipment comfortably. Cutting things too close can cause overheating, so as large a margin of safety as possible is recommended.

Now, what about power outages or disturbances and the loss of data that they can cause? While every computer has a degree of built-in protection against such occurrences, the amount of that protection varies from system to system. The kind of protection a computer offers should be one of the things that you look into when buying your system. If, however, *any* loss of data is unacceptable, you will want to invest in additional power-protection devices for added security. Let's look at what's available.

Line regulators (which typically range in price from \$350-\$700) automatically alter the voltage when it gets too low (referred to as a sag) or too high (spike or surge). Sags are sometimes caused by large appliances in the building—air conditioners, compressors, or other computer systems—switching on or off. Spikes (fleeting, imperceptible increase in voltage) and surges (longer increases, often obvious to the user) can be caused by electrical storms, equipment failure on a communications network, or switching of power equipment.

Line isolators (\$150-\$400) weed out interfering signals from such devices as television sets, medical equipment, and CB radios. They also head off voltage spikes.

Power conditioners (\$300-\$800) combine the functions of isolators and regulators, providing spike/surge/sag protection and also eliminating spurious electronic signals.

In cases of severe disturbances or extensive power interruptions, more sophisticated protection is needed. A brownout is a deliberate reduction of power distribution by the electric company due to heavy demand or unpredicted inadequate supply. A blackout is a total loss of power for from a few minutes to several days. Both can be disastrous, in terms of computer operation, if backup support has not been planned. An uninterruptible power supply (\$1,500-\$2,500) is the only remedy for such conditions. In the event of trouble, those supplies switch instantaneously to a powerful battery back-up system, preventing any loss of data or damage to equipment. Besides that, the device will perform all of the combined duties of isolators, regulators, and conditioners. Obviously, such a power supply is too expensive for many situations, but is necessary where the loss of computer operations data will result in a crisis of one form or another, such as the total loss of a company's payroll records. **R-E**

SERVICE CLINIC

The more things change...

JACK DARR, SERVICE EDITOR

WE HAD JUST RECEIVED A REPRODUCTION copy of the very first issue of Hugo Gernsback's first magazine—the April 1908 issue of *Modern Electrics*. (See Fig. 1). We were vastly amused, and amazed at the column "How To Remedy Troubles in Wireless Telegraph Instruments." (I said to my wife, "Look! the very first 'Service Clinic!'" Then she asked if I wrote it. Naturally, my answer was no—since I wasn't even *born* until 1910).

There's an amazing resemblance between it and the more recent columns of

FIG. 1

"Service Clinic." In reading over that issue, we found some advice that's just as good today as it was then. That advice went something like this: "Sharpen your senses and learn to observe...In hunting for trouble, work first with your brain and then with your hands. If vice versa more trouble is sure to arise." Notice the resemblance? Some things never change. (There's a French proverb on that, which we'll spare you.) Oddly enough, we've been mulling over the idea for a clinic, along the same lines.

Think before you jump

Over the years, we've received lots of letters from readers who were stuck on one electronics problem or another. A few years ago, we started looking into why that happens—so, we used the most available subject that we could find—ourselves! From the study of ourselves, together with the letters you've sent in, we learned a couple of things. That information has benefited us, so we thought we'd pass it along. In fact, we've got an almost complete manuscript on the subject. We'll finish it one of these days (we keep saying).

Many of our readers, who've written to us for help, are competent electronics technicians. Therefore, they're familiar with most of the electronic circuitry found in audio and video equipment. Why then, do they still get jammed up. That's what we wanted to know, and found out. Very often we get stuck because we don't attack the problem with the right mental attitude. In other words, we simply don't work the brain first. That's because we become so familar with the circuits and the problems associated with them, that we tend to jump in with both feet.

Think positive!

When starting a job, its a good idea to have a positive attitude—that is, keep an open mind and have confidence in yourself. You'll find that the problem isn't so great that you can't handle it. Often, what gets us into a hole is that we start with a fear that we can't handle the job, for one reason or another. In that case, you've got the proverbial two strikes against you before you even come to bat. (You're whipped before you start.) That belief is demonstrably false. You can find any problem and fix it, so forget all that gloom and doom.

Electronics repair, like anything else, is not sharply defined in black and white—there are gray areas. We ourselves cause faults without knowing it, thus adding to the confusion. Overconfidence is one very common cause of unnecessary repair-problem headaches. Such as, when we diagnose the fault before we've even looked at the equipment. However, if the job is approched calmly, confidently, and with an open mind you won't experience the agony of defeat.

Does this sound like you? "That's what's wrong! It's the vertical output transistor etc"—and you haven't even picked up a test prod! Because you've made a decision without hard evidence, the laws of chance are against you. Sure you stiffened up sitting at a bench all day, but jumping to conclusions for the exercise isn't the answer! It's OK to suspect that a transistor or another device may be causing the problem. From there, simply test that stage and if you're right, all that's left to do is to replace the defective component or stage. Again, the best asset you can have is a completely open mind. Who cares what part is bad? All you want is to find it.

If you think some stage is bad, and after testing find you're wrong, don't worry about it. One suspected fault is already eliminated, so go on to the next. By using the process of elimination, you're bound to find the one you're looking for. It's in there somewhere. The fact that the set doesn't work, tells you there's a bad part somewhere. That may sound silly, but we've had letters that said, "There's nothing wrong in there!" That's impossible; if there were nothing wrong, the unit would work.

So, there you have our short course on successful electronic servicing. Remember, use positive thinking. You do know how the thing works, so simply make tests to find out where the abnormality is. It's in there somewhere. Keep this old saying in mind; "If you think you can do it, you can." Old sayings got to be old because they were true! Keep that good thought—and good luck! **R-E**

SERVICE QUESTIONS

DEAD SONY

This Sony KV-1510 came to me dead. The dial lamp and auto-AFT lamps were lighted, though. I measured B+ to be 113 volts, which is OK. I measured no flyback-derived voltages at all, though. The horizontal oscillator was not running. At turn-on, B+ is applied to C517. The "kick" voltage is fed to the oscillator through R519. The problem was C517, When I took it out, one lead fell off in my hand! With that open, there was no charging kick and thus no horizontal-oscillator start. Incidentally, the correct Sams folder for that chassis (SCC-25A-A) is 1322-2.

Thanks a lot to Douglas P. Hoff, Doug's Electronics of Vacaville, CA for that one. Feedback of that type is always very appreciated.

MODIFICATION FOR VCR USE

RCA offers a modified MAH-001A (horizontal oscillator) module to replace the original. The differences between the two units are as follows: Capacitor C14 changed to 10 μF, 75 volts; R25 removed, and C6 shored with a jumper. That modification cleared up rolling and flag-waving at the top.

Thanks to Roy John, electronics technician at Youngstown State University, for that one.

TUBE SUB

I needed a 5KD8 tube the other day but couldn't find one. I looked it up in a substitution guide and came up with some subs: 6U8A, 6AX8, 6KD8, and even the old faithful 6GH8. Those seem to work very well, and the slight current difference doesn't seem to bother anything. Besides, those tubes are cheaper than the 5KD8!—D. Chinn, Chinn TV-Radio, Watertown, WI

TEARING IN RASTER

This Admiral 2K18-2A color chassis develops a small "tearing" at the upper left hand corner that gets increasingly worse as the set warms up. The problem eventually gets so bad that it blanks out the entire top of the screen. Please help!—B.B., Sepulveda, CA

Based on the symptoms you've described. an educated guess tells me that the problem is being caused by heater-to-cathode leakage in one of the tubes. The most likely culprit here is the 11BT11 (V302) video amplifier tube.

VERTICAL LINE

During a recent hot spell, the horizontal went out on my RCA CTC-76 leaving only a vertical line. When the set cooled off, everything worked fine once again. This is the second time that that has happened. Do you know anything about it?—M.G., West Hempstead, NY

Our crystal ball tells us that most times that problem can be traced to a loose connection on T-402, the pincushion transformer on the PW-400 board. Pinpointing the problem more closely may be possible, because at most times the condition of the connections can be found simply by inspection.

TWO PROBLEMS

A strange thing happened while working on a Sears 528.419450. The set was dead until, (when I turned the set over), the fail-safe transistor (Q553) fell out. Without that transistor, the set began to play, but not everything was normal. A special capacitor (C701) became very hot after just a few minutes and the B+ voltages were somewhat high and could not be adjusted. After trying this a few times, for just a little while for each test, everything went out again.

I am also working on a Philco B424JBG. The problem with that one is no vertical sweep. That set, too, has me going around in circles. Can you help with either one?—I.I., Philadelphia, PA

Well, one thing seems to be sure, that fail-safe transistor must have been doing its task until it fell out. The first thing you'll have to do is find out why that set failed in the first place. Once that is cured, you'll have to find what further damage was done by operating the set without the fail-safe. As to the first part of the job, the key may lie in the reason why the B+ was too high and could not be adjusted. This is a closed-loop type of system. If the B+ rises, so does the high voltage. If the high voltage is too high, it triggers the fail-safe transistor, which shuts down the entire system. That is apparently what happened in your case.

As for the Philco, check that set with a scope. In particular, make sure that Q302 and Q304 are oscillating. If not, use the scope to trace through the circuit until you find the point where things are not right. From there, voltage and resistance measurements should lead you to the defective component or components. **R-E**

DRAWING BOARD

continued from page 95

grammed before it can function—that's accomplished through use of the JAM inputs. Its feedback circuit is a bit more complicated than the one-wire feedback used with the 4017. Pins 4, 5, 6, 11, and 13

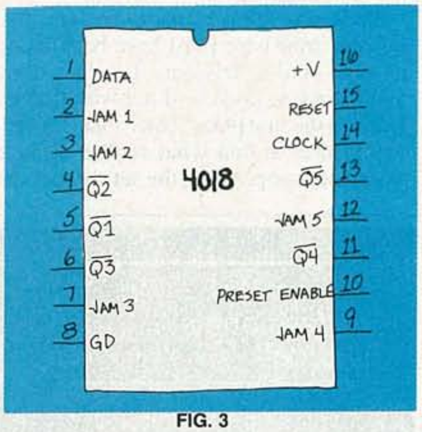

FIG. 3

are output pins. Connecting various combinations of those outputs to pin 1 allows the IC to divide by any number from 2 to 10. Pin 10 is the ENABLE pin for the JAM inputs; when pin 10 is brought high, it allows the 4018 to be programed using the JAM inputs. Those inputs make that IC extremely interesting.

TABLE 1

Division by	Pins to connect To pin 1
2	5
3	4 and 5
4	4
5	4 and 6
6	6
7	6 and 11
8	11
9	11 and 13
10	13

Using the 4018 is a bit more difficult, but it's still a lot less complicated than trying to square-up the output of the 4017. Let's forget about the JAM inputs for the time being and look at what must be done to get the IC working. Using the IC without those inputs is really very simple. Dividing by a particular number is merely a matter of choosing the appropriate outputs and connecting them to pin 1. Different combinations of those outputs let you divide as shown in Table 1.

The problem immediately facing us is the external gating necessary to make the IC divide by an odd number. Since it's necessary to use two output pins for each odd number, it's difficult to get switch-selectable divisions. It could be done, but the wiring diagram for the switches would be a nightmare and ultimately unnecessary. Using the JAM inputs is far easier.

Try experimenting with the 4018. If you're lucky enough to have a scope, take a look at the output waveform—it should be relatively square. If you were to use all the capabilities of that IC, you'd understand why it's so versatile. If you do experiment with it remember—the reset pin and JAM inputs must be held low and enable held high for the IC to work. Next month we'll see how to take advantage of those JAM inputs and see how to cascade 4018's in order to extend the division range. R-E

NEW BOOKS

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

STUDY GUIDE FOR THE ASSOCIATE LEVEL CET TEST edited by J.A. Sam Wilson, ISCET Test Director; International Society of Certified Electronic Technicians, 2708 West Berry, Fort Worth, TX 76109; 88 pp; 8½ × 11 inches; softcover; $5.00.

Here is a new study guide that describes the associate test and gives some hints for those who want to take it. Each of the sections on the associate-level CET exam is discussed in detail, with descriptions of what the technician should know, and includes some sample questions with detailed explanations of the answers. The explanations in the guide were developed following an extensive survey of what types of questions were most frequently missed by those taking the test.

Subjects covered include basic components, basic mathematics, DC circuits, AC circuits, transistors and semiconductors, electronics components and circuits, tests and measurements, digital logic, and troubleshooting and network analysis.

While the price of this book is $5.00 for a single copy, lots of 10 or more may be purchased at $3.50 each.

CIRCLE 121 ON FREE INFORMATION CARD

COMPUTER ART AND ANIMATION FOR THE TRS-80, by David L. Heiserman; Prentice-Hall, Inc., Englewood Cliffs, NJ 07632; 246 pp including appendices and index; 6⅛ × 9⅛ inches; hardcover; $17.95.

While the subject of computer graphics is often treated as a novelty, this book treats TRS-80 computer graphics and animation as a topic worthy of study and experimentation. The discussions and examples should help a programmer build up a sense of confidence in developing programs that use graphics features.

The material in the book stresses the point that the quality of the finished product requires applying time and effort, rather than just following a routine technique. The animation technique features high-speed graphics that do not require a knowledge of machine-language programming and methods. It's all in BASIC. Sample applications of the principles are given to spark the reader's imagination.

The program and procedures given here apply to the TRS-80 Model *III* and the original Model *I*. The book emphasizes a modular approach to creating some of the more complicated animation routines.

CIRCLE 122 ON FREE INFORMATION CARD

DIGITAL PLL FREQUENCY SYNTHESIZERS Theory and Design, by Ulrich L. Rohde; Prentice-Hall, Inc., Englewood Cliffs, NJ 07632; 494 pp including index; 7 × 9½ inches; hardcover; $49.95.

The objective of this book is to provide as much practical circuit information as possible while presenting only the necessary mathematical background and formulas. It is slanted toward college students who have to get acquainted with phase-locked loops (*PLL*) or have to build certain projects; as well as toward practicing engineers who are designing synthesizers for various applications, and toward senior engineers and people in management functions who want to be able to evaluate new trends and techniques. The reader is introduced to practical and reliable circuits that can be used as starting tools.

The book is divided into seven sections: Charpter 1 deals with loop fundamentals; chapter 2 outlines the noise and spurious response of loops; chapter 3 deals with special loops, most of which have been developed recently, and chapter 4 covers analyzing PLL components.

Chapter 5 goes into the details of multiloop synthesizers, starting with such earlier design principles as mix and divide, triple mix, or drift-canceling loops. The ground rules for setting up complex loops are then laid out, and the use of microprocessors in frequency synthesizers, and their use in communication equipment, is covered.

Chapter 6 consists of the analysis and schematic details of three practical synthesizers as a design guide. The final section is the appendix, which is divided into a mathematical review and a list of useful computer programs.

CIRCLE 123 ON FREE INFORMATION CARD

AMATEUR RADIO Theory and Practice, by Robert L. Shrader, Gregg/McGraw-Hill, 1221 Avenue of the Americas, New York, NY 10020; 340 pp. including index; 7¼ × 9¼ inches; softcover; $14.95.

This manual presents in easy-to-read language, the latest information required by the FCC for all five amateur-grade licenses: Novice, Technician, General, Advanced, and Extra. The author covers the specifics of radio operation and the electricity and electronics theory that are required for each level.

The material is divided into easy-to-follow topics, with many diagrams, and a reinforcing quiz is presented at the end of each chapter. Each paragraph is prefaced with a bold letter indicating the particular grade license it prepares the student for, and a number that refers to the end-of-the-chapter FCC-exam-type questions on that material. Those questions are listed under the five amateur-license grades and are suffixed with references to chapter sections.

CIRCLE 124 ON FREE INFORMATION CARD

32 ELECTRONIC POWER SUPPLY PROJECTS, by Robert J. Traister; TAB Books, Inc., Blue Ridge Summit, PA 17214; 291 pp including appendices and index; 5 × 8¼ inches; softcover; $10.95.

This book offers the reader a chance to get practical experience building DC power-supply circuits for a variety of applications that range from amateur radio or audio projects to all types of experimental electronics devices. The reader will also learn fundamentals of power-supply theory that will be valuable later on.

The 32 DC power-supply projects range from the very simple (a half-wave supply and a Zener-diode regulator) to such advance units as a unique variable supply or a 12-volt inverter circuit.

Each project includes detailed, step-by-step building instructions, complete schematics, and parts list. Every one of the devices dealt with in this book can be built in a few hours from low-cost, readily available components.

CIRCLE 125 ON FREE INFORMATION CARD

COMPUTERS THAT THINK? The Search for Artificial Intelligence, by Margaret O. Hyde; Enslow Publishers, Bloy Street and Ramsey Avenue, Box 777, Hillside, NJ 07205; 126 pages, including selected reading list and index; 9½ × 6¼ inches; hardcover, $9.95; paperback, $4.95.

There is wide disagreement among experts as to whether any computer can be said to "think" or exhibit real intelligence. A computer or robot is labelled "smart" or "intelligent" when it performs tasks that require smartness or intelligence for a human being to perform. However, no computer can create, or initiate a line of research, or go behind the literal meaning of the words in its memory banks and interpret what it is really being asked. Fallibility is another matter; computers are infallible so long as their power supply doesn't fail, or some component go out of order. But that isn't intelligence. Neither is the

continued on page 111

NEW BOOKS

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machine's incapacity for boredom or getting tired.

Nonetheless, some experts consider that computers may be constructed that will fit at least some definitions of intelligence. This book is an introduction to the research and development of artificial intelligence systems, such as computers and robots, exploring the similarities and differences between computers and the human brain. Can a computer learn something that it has not specifically been told? How do they work? What is the difference between the way computers and human beings reach conclusions? What about computer sense perception? How do computers and the human brain differ in understanding commands?

All of the above questions and more are covered in this well-written book, which will enhance the readers' understanding of computers and robots. There are numerous, excellent photographs. As to the question that the book's title poses: The author presents the evidence, both positive and negative, and leaves it to the reader to render the verdict.

CIRCLE 126 ON FREE INFORMATION CARD

ELECTRONIC COMMUNICATIONS: A Step-by-Step Introduction; Prentice-Hall, Inc., Englewood Cliffs, NJ 07632; 249 pages plus index; 9¼ × 6¾ inches; softcover; $12.95.

This book starts off with a simple definition of "communication." "Communication is defined as 'a process by which information is exchanged.' For the purposes of this course, information is defined as any electrical signal representing data."

What we have here is an introduction to the fundamentals of electronic communications that uses proven training methods to explain state-of-the-art forms of communication fully. It covers communications fundamentals, amplitude modulation, AM receivers, angle modulation, pulse modulation, antennas, communications systems, and much more. It is a volume in the Heathkit/Zenith Educational Systems series.

CIRCLE 127 ON FREE INFORMATION CARD

INTRODUCTION TO PROGRAMMING USING FORTRAN 77, by Glenn A. Gibson and James R. Young; Prentice-Hall, Inc., Englewood Cliffs, NJ 07632; 461 pages, including appendices and index; 9¼ × 6¾ inches; softcover; $19.95.

Designed as a text for a three-semester-hour introductory programming course, this book opens with a brief introduction to computer systems. That is followed by sufficient basics of a computer language to enable the readers to write simple programs. The intent is to give the student a little programming experience; then he or she will be ready for the fundamentals of problem formation and programming procedure. After that, we have a detailed study of the language and, finally, a thorough discussion of programming techniques. That approach, known as the spiral method of teaching, allows the student to begin programming early and to mix the study of details of the language with such topics as program structure, testing, debugging, and documentation.

Two types of exercises are featured: brief section-end exercises that are designed to force the reader to review the preceding section, and programming problems at the end of each chapter. Although a section-end exercise may request that a program be written, it is not intended to be run on a computer; it is, rather, the chapter-end programming problems that are meant to be tested and run on a computer.

CIRCLE 128 ON FREE INFORMATION CARD

DIGITAL IC PROJECTS, by F.G. Rayer, T. Eng. (CEI), Assoc. IERE; Electronic Technology Today, Inc., PO Box 83, Massapequa Park, NY 11762; 91 pages; 7 × 4⅜ inches; softcover; $5.00.

This book contains both simple and more advanced projects. Various forms of assembling and wiring the integrated circuits are shown, and that aspect of a project can be quite straightforward; printed-circuit boards are not needed.

There are introductory chapters dealing with components and power supplies (battery running, transistor regulation, AC supply, IC regulator, etc.).

22 projects are then set forth, each illustrated. They include a Nixie Numerator, Roulette, Noiseless Switch, Multi-Digit Counter, Digital Stop-Clock, and 1-Armed Bandit. The more ambitious projects can be built and tested step-by-step.

CIRCLE 129 ON FREE INFORMATION CARD

AUDIO AND VIDEO INTERFERENCE CURES, by Larray Kahaner; Hayden Book Company, Inc., 50 Essex Street, Rochelle

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NEW LITERATURE

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

METERS, catalog of digital and analog instrumentation meters is 67 pages on coated paper, many of them in part or full color, and is 8½ × 11 inches. The instruments include digital panel meters, wide-vue panel meters, segmented-scale panel meters, pyro-meters, edgewise controllers, solid-state non-indicating controllers, digital multimeters, hand-portable DMM's, function generators, oscilloscopes, milliameters, micro-testers, and many others. The catalog is free on request from **Simpson Electric Company,** 853 Dundee Avenue, Elgin, IL 60120.
CIRCLE 111 ON FREE INFORMATION CARD

SOLDERLESS TERMINALS, catalog of new electrical products from Vaco is 24 pages in full color and contains all Vaco products related to electrical and electronics applications. The major section is a comprehensive listing of Vaco's solderless terminal line, which includes actual-size, actual-color illustrations, and complete specifications for each individual terminal. Also included are special-purpose connectors, alligator clips, wire connectors, nylon ties, and wire holders. Electrical tools included are wire strippers, crimping tools, and electrical testers. The catalog is free from **Vaco Products Company,** 1510 Skokie Blvd., Northbrook, IL 60062.
CIRCLE 112 ON FREE INFORMATION CARD

DMM, data sheet is an 8½ × 11 inch flyer, in full color, that describes and specifies the performance of Fluke's handheld DMM, the model *8026B,* that features true rms measurements of AC voltage and current. Free from **John Fluke Mfg. Co., Inc.,** Mail Stop 250 C, PO Box C9090, Everett, WA 98206.
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COMPONENTS, catalog is 80 pages, illustrated, 8½ × 11 inches, for the hobbyist, experimenter, student, or professional. Included are semiconductors, integrated circuits, microcomputer boards, microprocessor and support circuits, transistors, diodes, capacitors, resistors, optoelectronics, potentiometers, test meters, switches and knobs, connectors and sockets, PC boards, plastic enclosures, artwork aids, electronics tools, soldering equipment, and data and reference books—and many other categories. Free from **Active Components** (a division of Future Electronics), PO Box 8000, Westborough, MA 01581
CIRCLE 114 ON FREE INFORMATION CARD

GRAPHICS PLOTTER, brochure on the *7470A* Graphics Plotter, is 6 pages, part in full color, on coated stock, 8½ × 11 inches. Provides photos, charts, and a list of specifications for the device. The specifications include the plotting area, resolution, repeatability, interfaces, and media, as well as a list of accessories supplied with the Plotter. Free from **Hewlett-Packard,** 1501 Page Mill Road, Palo Alto, CA 94304. **R-E**
CIRCLE 115 ON FREE INFORMATION CARD

NEW BOOKS

continued from page 111

Park, NJ 07662; 114 pages, including appendices and index; 8¼ × 5¼ inches; softcover; $6.10.

Complaints about interference get higher each year, and most people who can get through the FCC's jammed phone lines receive a recorded message that anticipates the inquiry, instructing the caller on how to file a formal interference complaint. And those who complain formally are only a percentage of those who suffer from the problem.

This book was written both for those who suffer from interference and those who are the unintentional cause of it. It covers the problems of interference caused by transmitters, CB radios, home appliances, atmospheric noise sources, neon lights, hair dryers, and numerous other sources. Written in easy-to-understand language, the book provides all the information needed to halt interference, whatever the source may be, whether it's transmitter or non-transmitter oriented. It gives step-by-step instructions on how to detect the offending source and cure the interference. The final chapter tells the reader where to find outside resources for help with particularly difficult interference problems.

CIRCLE 130 ON FREE INFORMATION CARD

DON LANCASTER'S MICRO COOKBOOK (Volume 1: Fundamentals); Howard W. Sams & Co., Inc., 4300 W. 62nd Street, Indianapolis, IN 46268; 381 pages, including appendices and index; 8½ × 5¼ inches; softcover, $15.95.

This book contains a set of rules that will help the reader win the game of microcomputers and microprocessors. It gives many of the micro resources that you can use, and lists some of the micro trainers that are available. There is an examination and explanation of essential numbering systems and basic logic, and microcomputer/microprocessor codes and coding systems are covered. There is also a discussion of the different kinds of memory available. The author shows you how micros work, and how you can build your own micro skills. It is the first in a series on microprocessors and microcomputers.

CIRCLE 131 ON FREE INFORMATION CARD

THE COMPLETE GUIDE TO HIGH FIDELITY, by Martin Clifford; Howard W. Sams & Co., Inc., 4300 West 62nd Street, Indianapolis, IN 46268; 368 pages, including glossary and index; 8½ × 4¼ inches; softcover; $15.95.

In the preface, the author immediately disposes of the myth that a first-class high-fidelity system "will bring the concert hall into your home." It won't do anything of the kind, he notes, and it would be unfortunate if it did. The sound of the cannon in Tchaikovsky's *1812 Overture* would probably break your windows if the music were played at concert-hall volume. What high fidelity *does* do, through a series of compromises, is to give the listener the effect of being in a good seat in a concert hall; and certainly on some stereo records you can clearly hear details that you probably would not hear—or not notice—in the concert hall.

This book leads the reader through the hi-fi maze, providing enough technical information so that the principles can be understood. It shows 30 basic systems ranging in cost for those with limited to those with unlimited budgets. Digital recording, amplifiers, tuners, receivers, preamplifiers, drive motors, proximity effect, and impedance matching are all covered. There are many diagrams and illustrations, and a thorough glossary in the back of the book for those unfamiliar with high-fidelity's various technical terms and abbreviations or acronyms.

CIRCLE 132 ON FREE INFORMATION CARD

DIGITAL ELECTRONICS (Second Edition), by William H. Gothmann; Prentice-Hall, Inc., Englewood Cliffs, NJ 07632; 383pp, including index; 9½ × 7 inches; hardcover; $21.95.

Subtitled "An introduction to theory and practice," this newly revised text is an up-to-date course in basic design techniques that will help engineers and technicians to deal with the growing use of digital electronics. The book explains both digital theory and logic hardware, bridging the gap between theory and practice and giving the designer tools with which to solve digital problems today and in the future.

Revisions of the earlier text include introducing the binary, octal, and hexadecimal systems—those used by our friendly computers; covering combinational logic and the reduction of Boolean expressions; reviewing the increasing importance of bus structures and memory systems, and presenting the principles of analog-to-digital and digital-to-analog conversion. R-E

CIRCLE 133 ON FREE INFORMATION CARD

NEW PRODUCTS

continued from page 31

The model *HP 7475A* is priced at $1895.00.

The smaller model *HP 7470A* plotter has many of the performance specifications and features of the model *HP 7475A*, but has pen-changing capability for only two pens. It is priced at $1095.00.—**Hewlett-Packard,** 3000 Hanover Street, Palo Alto, CA 94304.

LOGIC ANALYZER, the *System 2100*, features a remote-control capability that allows the operation of an analyzer located at a field site using a logic analyzer located at the home office. All analyzer functions are available, including state and timing displays.

CIRCLE 116 ON FREE INFORMATION CARD

Messages may be sent by either analyzer to signal the operator, including "Pick up the phone."

Keyboard-to-keyboard remote control is a standard feature in these analyzers when the RS-232 I/O port is installed. Prices start at $8995.00 for the mainframe, including the stringy floppy; and 16-channel 100-MHz modules are priced at $1995.00, including a 1-megohm 7.5-picofarad active probe with external clock capacity.—**Intech, Incorporated,** 282 Brokaw Road, Santa Clara, CA 95050. **R-E**

AM STEREO

continued from page 102

pass over the entire AM band. The original detector circuit was also modified to smooth AGC response and control. (The detector circuit, although not used for stereo reception, generates AGC voltages and had to be kept intact.) That modification could have been skipped, but a noticeable improvement resulted in output from stations across the band with widely varied signal strengths.

Audio outputs were connected in parallel with the outputs from the FM multiplex system. The stereo indicator already in the receiver could be driven directly from the AM decoder lamp drive through a 470-ohm resistor. The result with this receiver was excellent AM stereo, although the lack of a front end RF amplifier made reception of some stations difficult.

Final suggestions

In radios that are AC powered, it may be necessary to suppress noise caused by rectifier circuit diodes. If a sharp buzz is heard, it may be the result of these power-switching diodes. The problem can usually be corrected by installing a .05 μF, 250-volt (minimum) ceramic disc capacitor across each diode in the power supply circuit.

Household devices such as lamp dimmers or remote-control units that operate lights and appliances can generate tremendous noise, which is distributed by the building's electrical wiring like a huge antenna. AM radios will pick up this noise and make listening very unpleasant if not altogether impossible. The manufacturers of these devices may be able to offer methods or reducing the problem. Otherwise, they will have to be turned off or disconnected when using the AM receiver.

Installation of an outdoor, long-wire antenna for the broadcast band may alleviate most of those interference problems. Another, perhaps more important benefit is that an outdoor antenna will provide a greater source of stereo signals to choose from.

In the near future, when many major, music-program AM stations have introduced C-QUAM stereo broadcast, you'll no longer be limited to hearing good stereo from local FM station whose range is limited roughly to line-of-sight. You'll be able to hear the AM stations from hundreds of miles away (as you can now, especially at night), but in full stereo! **R-E**

MARKET CENTER

BUSINESS OPPORTUNITIES

WHOLESALE MATV/CATV/VCR equipment, antennas, audio cables, adaptors, original/replacement cartridges & styli, telephone accessories, radios, cassette recorders, speakers, etc., send letterhead for free catalog (212) 897-0509 **D&WR,** 68-12 110th St., Flushing, NY 11375.

MECHANICALLY inclined individuals desiring ownership of small electronics manufacturing business—without investment. Write: **BUSINESSES,** 92-R, Brighton 11th, Brooklyn, NY 11235.

VIDEO game repair business. Start your own. Information/parts list $5.00. **BEST ELECTRONICS,** 4440 Sheena, Phoenix, AZ 85032.

E-Z learn security alarm systems. Employment-business terrific. Information $2.00 (redeemable) **SECURITY** PO Box 1456-H, Grand Rapids, MI 49501.

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VIC-20 make backup tape of game cartridge, tape program, complete instructions $6.00. **SHERWIN** So. 11 Foxcroft Rd, N. Hartford, NY 13413.

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CB EQUIPMENT

CB radio books, kits, modifications, catalog $1.00 refundable. **APS,** PO 263RE, Newport, RI 02840.

PALOMAR/PRIDE electronics — exclusive repair facility. Service — update — improvements on these and similar equipment. **PALOMAR PRIDE REPAIR,** 1320 Grand, San Marcos, CA 92069 (619) 744-0720.

WANTED

WANTED: old Western Electric & RCA tubes, speakers, amplifiers. Mcintosh, Marantz, tube amps. (713) 728-4343. **MAURY CORB,** 11122 Atwell, Houston. TX 77096.

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SCANNERS— discount prices Bearcat BC-100 $279.99; Bearcat 210XL $214.99; Bearcat 300 $335.99; Regency MX3000 $186.99; JIL SX100 $138.99; JIL SX200 $269.99; Bearcat 20/20 $275.99; Spectrum radar detector $214.99; plus $3.00 shipping. Free discount catalog. Lowest prices anywhere on scanners, radar detectors, marine radios, two-way accessories. **SCANNER WORLD,** 10-RE New Scotland, Albany, NY 12208 (518) 436-9606.

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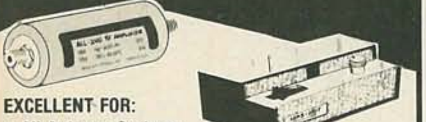

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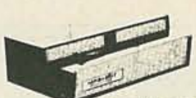

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1330	1 60	14 50	7818	95	7 90
1350	1 47	12 50	7824	75	6 90
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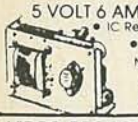

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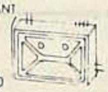

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THE Intelligence Library— Restricted technical information & books on **electronic surveillance, surveillance-device schematics, lock-picking, investigation, weapons, identification documents, covert sciences,** etc. The **best** selection available. **Free brochures. MENTOR,** (Dept. Z), 135-53 No. Blvd., Flushing, NY 11354.

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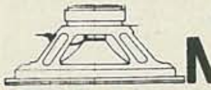

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SEND $2.00 for 1983 CATALOG

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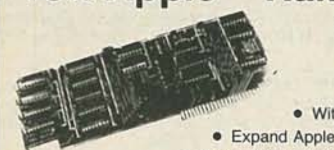

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15 key Keypad with 1-10 keys and tab, return, (-), (.) and ().

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Holds 4 EPROM's at a time.

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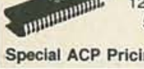
AMD MODEM IC

P/N AM7910
1200 Baud
5 Volts



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2102	.79	4027	4.69	6604	3.99
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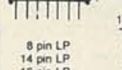

	1-24	24-49	50-100
8 pin LP	.16	.15	.14
14 pin LP	.20	.19	.18
16 pin LP	.22	.21	.20
18 pin LP	.29	.28	.27
20 pin LP	.34	.32	.30
22 pin LP	.29	.27	.24
24 pin LP	.38	.37	.36
28 pin LP	.45	.44	.43
40 pin LP	.60	.59	.58

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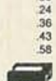

	1-24	25-49	50-100
8 pin WW	.55	.54	.49
10 pin WW (Tin)	.65	.63	.58
14 pin WW	.75	.73	.67
16 pin WW	.80	.77	.70
18 pin WW	.95	.90	.81
20 pin WW	1.15	1.08	.99
22 pin WW	1.45	1.35	1.23
24 pin WW	1.35	1.26	1.14
28 pin WW	1.60	1.53	1.38
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78H05K	$5.95	LM1414N	$1.90
78M06	1.49	LM1458CN/N	.49
78M.G	1.49	MC1488N	.99
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LM301CN	.35	LM1556N	1.50
LM304H	1.98	LM1820N	.95
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LM320H-XX*	1.25	LM3053N	1.49
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LM324N	.95	CA3060N	3.19
LM337K	5.95	CA3062N	4.95
LM338K	6.95	LM3065N	1.49
LM339N	.95	CA3080T	1.29
LM340K-XX*	1.75	CA3081N	1.69
LM340T-XX*	1.25	CA3082N	1.69
LM340H-XX*	1.25	CA3083N	1.55
LM344H	1.95	CA3086N	.80
LM348N	1.20	CA3089N	2.99
LM350K	5.60	CA3096N	3.49
LM358CN	.98	CA3097N	1.99
LM360N	1.49	CA3130T	1.30
LM372N	1.95	CA3140T	1.19
LM376N	3.75	CA3146N	2.49
LM377N	2.75	CA3160T	1.19
LM380CN/N	1.25	CA3190N	1.95
LM381N	1.79	CA3410N	.59
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74S64	.46	74S195	1.89	74S570	5.75
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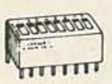

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7422	.29	74109	.37	74185	2.25
7423	1.19	74116	1.25		
7425	.29	74121	.29		
7426	.29	74122	.39	74190	1.15
7427	.25	74123	.45	74191	1.15
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7432	.29	74128	.59	74194	.75
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7438	.29	74136	.75	74196	.75
7439	1.19			74197	.75
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74LS96	.89	74LS242	1.99	81LS96	1.69
74LS107	.39	74LS243	1.99	81LS97	1.69
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4012	.24	4049	.35	14415	8.95
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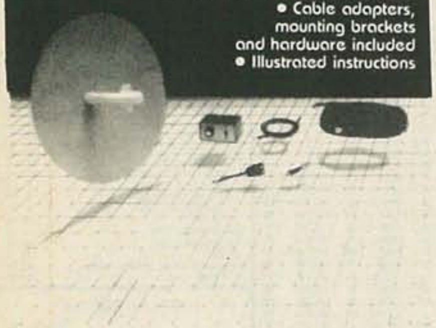

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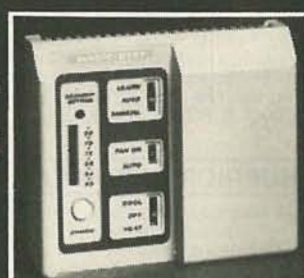

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SN7413N	14	.39	SN7491N	14	.79	SN74174N	16	.69
SN7414N	14	.49	SN7492N	14	.39	SN74175N	16	.69
SN7416N	14	.25	SN7493N	14	.39	SN74176N	14	.69
SN7417N	14	.25	SN7494N	14	.89	SN74177N	14	.69
SN7420N	14	.19	SN7495N	14	.49	SN74179N	16	1.49
SN7421N	14	.49	SN7496N	16	.49	SN74180N	14	.69
SN7422N	14	.49	SN7497N	16	3.25	SN74181N	24	1.95
SN7423N	16	.59	SN74100N	24	1.95	SN74182N	16	1.19
SN7425N	14	.29	SN74104N	14	1.19	SN74184N	16	2.49
SN7426N	14	.29	SN74105N	14	1.19	SN74185N	16	2.49
SN7427N	14	.25	SN74107N	14	.29	SN74190N	16	.69
SN7428N	14	.59	SN74109N	16	.39	SN74191N	16	.69
SN7430N	14	.25	SN74116N	24	1.49	SN74192N	16	.69
SN7432N	14	.29	SN74121N	14	.39	SN74193N	16	.69
SN7437N	14	.25	SN74122N	14	.69	SN74194N	16	.69
SN7438N	14	.25	SN74123N	16	.69	SN74195N	16	.69
SN7439N	14	.59	SN74125N	14	.45	SN74196N	14	.69
SN7440N	14	.19	SN74126N	14	.45	SN74197N	14	.89
SN7441N	16	.89	SN74132N	14	.49	SN74198N	24	1.19
SN7442N	16	.45	SN74136N	14	.69	SN74199N	24	1.19
SN7443N	16	1.25	SN74141N	16	.69	SN74221N	16	1.19
SN7444N	16	1.25	SN74142N	16	3.95	SN74251N	16	.79
SN7445N	16	.69	SN74143N	24	2.49	SN74276N	14	.79
SN7446N	16	.69	SN74144N	24	3.95	SN74279N	16	.79
SN7447N	16	.69	SN74145N	16	.59	SN74283N	16	1.49
SN7448N	16	.69	SN74147N	16	1.49	SN74284N	16	2.95
SN7450N	14	.19	SN74148N	16	1.19	SN74285N	16	2.95
SN7451N	14	.19	SN74150N	24	1.19	SN74365N	16	.55
SN7453N	14	.19	SN74151N	16	.59	SN74366N	16	.55
SN7454N	14	.19	SN74152N	14	.59	SN74367N	16	.55
SN7459N	14	.25	SN74153N	16	.59	SN74368N	16	.69
SN7460N	14	.39	SN74154N	24	1.25	SN74390N	16	1.49
SN7470N	14	.29	SN74155N	16	.59	SN74393N	14	1.49

74LS

74LS00	14	.25	74LS92	14	.55	74LS192	16	.79
74LS01	14	.25	74LS93	14	.55	74LS193	16	.79
74LS02	14	.29	74LS95	14	.79	74LS194	16	.69
74LS03	14	.25	74LS96	16	.89	74LS195	16	.69
74LS04	14	.29	74LS107	14	.39	74LS197	14	.79
74LS05	14	.29	74LS109	16	.39	74LS221	16	.89
74LS08	14	.29	74LS112	16	.39	74LS240	20	1.09
74LS09	14	.29	74LS113	14	.39	74LS241	20	1.09
74LS10	14	.29	74LS114	14	.39	74LS242	14	1.09
74LS11	14	.35	74LS122	14	.49	74LS243	14	1.09
74LS12	14	.35	74LS123	16	.79	74LS244	20	1.49
74LS13	14	.39	74LS125	14	.59	74LS245	20	1.49
74LS14	14	.59	74LS126	14	.49	74LS247	16	1.09
74LS15	14	.35	74LS132	14	.59	74LS248	16	1.09
74LS20	14	.35	74LS133	16	.59	74LS249	16	1.09
74LS21	14	.29	74LS136	14	.39	74LS251	16	.59
74LS22	14	.29	74LS138	16	.59	74LS253	16	.59
74LS26	14	.29	74LS139	16	.59	74LS257	16	.59
74LS27	14	.29	74LS151	16	.59	74LS258	16	.59
74LS28	14	.35	74LS153	16	.59	74LS260	14	.59
74LS30	14	.29	74LS154	24	1.29	74LS266	14	.59
74LS32	14	.29	74LS155	16	.69	74LS273	20	1.49
74LS33	14	.55	74LS156	16	.69	74LS279	16	.49
74LS37	14	.35	74LS157	16	.69	74LS283	16	.69
74LS38	14	.35	74LS158	16	.59	74LS290	14	.89
74LS40	14	.25	74LS160	16	.69	74LS293	14	.89
74LS42	16	.49	74LS161	16	.69	74LS298	16	.89
74LS47	16	.75	74LS162	16	.69	74LS352	16	1.29
74LS48	16	.75	74LS163	16	.69	74LS353	16	1.29
74LS49	14	.75	74LS164	14	.69	74LS363	20	1.49
74LS51	14	.25	74LS165	16	1.19	74LS365	16	.49
74LS54	14	.25	74LS166	16	1.19	74LS366	16	.49
74LS55	14	.29	74LS169	16	1.19	74LS367	16	.49
74LS73	14	.39	74LS170	16	1.49	74LS368	16	.49
74LS74	14	.49	74LS173	16	.69	74LS373	20	1.69
74LS75	16	.39	74LS174	16	.69	74LS374	20	1.69
74LS76	16	.39	74LS175	16	.69	74LS375	16	.69
74LS78	16	.39	74LS181	24	2.95	74LS377	20	1.49
74LS83	16	.65	74LS190	16	.89	74LS385	20	3.95
74LS85	16	.89	74LS191	16	.89	74LS386	14	.45
74LS86	14	.39				74LS393	14	1.19
74LS90	14	.55				74LS399	16	1.49
						74LS670	16	1.49
						74LS682	20	3.20
						74LS688	20	2.49
						81LS95	20	1.49
						81LS97	20	1.49

74S/PROMS*

74S00	14	.35	74S114	14	.55	74S243	14	2.49
74S02	14	.35	74S133	16	.45	74S244	20	2.49
74S03	14	.35	74S134	16	.50	74S251	16	1.19
74S04	14	.45	74S135	16	.69	74S253	16	1.19
74S05	14	.45	74S136	14	1.39	74S257	16	1.19
74S08	14	.39	74S138	16	.89	74S258	16	1.19
74S09	14	.39	74S139	16	.89	74S260	14	1.19
74S10	14	.35	74S140	14	.55	74S280	14	1.95
74S11	14	.35	74S151	16	.99	74S287*	16	1.95
74S15	14	.35	74S153	16	.99	74S288*	16	1.95
74S20	14	.35	74S157	16	.99	74S373	20	2.49
74S22	14	.35	74S158	16	.99	74S374	20	2.49
74S30	14	.35	74S160	16	2.49	74S387*	16	1.95
74S32	14	.45	74S161	16	1.95	74S471*	20	5.95
74S38	14	.89	74S174	16	1.19	74S472*	20	4.95
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74S51	14	.35	74S188*	16	1.49	74S474*	24	4.95
74S64	14	.39	74S194	16	1.49	74S475*	24	4.95
74S65	14	.39	74S195	16	1.49	74S570*	16	2.95
74S74	14	.55	74S196	14	1.49	74S571*	16	2.95
74S85	16	2.49	74S240	20	2.25	74S572*	18	4.95
74S86	14	.55	74S241	20	2.25	74S573*	18	4.95
74S112	16	.55	74S242	14	2.49	74S940	20	2.49
74S113	14	.55				74S941	20	2.49

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CA3039H		1.35	CA3082N	16	1.19	CA3140E	8	.79
CA3046N	14	1.35	CA3083N	16	1.49	CA3160H		1.95
CA3059N	14	2.95	CA3086N	14	.69	CA3161E	16	2.95
CA3060N	16	2.95	CA3089N	16	1.69	CA3162E	16	6.95
CA3065E	14	1.49	CA3096N	16	1.49	CA3189E	16	1.59
CA3080E	8	.89				CA3401N	14	.59

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CD4001	14	.29	CD4041	14	1.19	CD4506	16	1.19
CD4002	14	.29	CD4042	16	.89	CD4507	14	1.19
CD4006	14	1.19	CD4043	16	.79	CD4508	24	3.95
CD4007	14	.29	CD4044	16	.79	CD4510	16	1.29
CD4009	16	.59	CD4046	16	1.19	CD4511	16	1.19
CD4010	16	.59	CD4047	14	1.29	CD4512	16	1.19
CD4011	14	.29	CD4048	16	.59	CD4514	24	2.49
CD4012	14	.29	CD4049	16	.39	CD4515	24	2.49
CD4013	14	.39	CD4050	16	.39	CD4516	16	1.19
CD4014	16	1.19	CD4051	16	.99	CD4518	16	1.19
CD4015	16	.39	CD4052	16	.99	CD4519	16	.59
CD4016	14	.49	CD4053	16	.99	CD4520	16	1.19
CD4017	16	1.19	CD4056	16	2.95	CD4526	16	1.49
CD4018	16	.99	CD4059	24	7.95	CD4528	16	1.49
CD4019	16	.59	CD4060	16	1.49	CD4529	16	1.69
CD4020	16	1.19	CD4066	14	.39	CD4543	16	1.95
CD4021	16	1.19	CD4068	14	.39	CD4562	14	6.95
CD4022	16	1.19	CD4069	14	.29	CD4566	16	1.39
CD4023	14	.29	CD4070	14	.39	CD4583	16	2.49
CD4024	14	.69	CD4071	14	.29	CD4584	14	.69
CD4025	14	.33	CD4072	14	.29	CD4723	16	1.19
CD4026	16	2.49	CD4073	14	.29	CD4724	16	1.19
CD4027	16	.45	CD4075	14	.29	MC14409	16	13.95
CD4028	16	.69	CD4076	16	1.19	MC14410	16	13.95
CD4029	16	1.29	CD4078	14	.49	MC14411	24	11.95
CD4030	14	.39	CD4081	14	.29	MC14412	16	13.95
CD4034	24	2.49	CD4082	14	.29	MC14419	16	7.95
CD4035	16	1.49	CD4093	14	.49	MC14433	24	13.95
						MC14538	16	1.19
						MC14541	14	1.19

(More in Catalog)

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MICROPROCESSOR CHIPS

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MC6502	40	MPU w/Clock	5.95
MC65602B	40	MPU w/Clock at 3MHz	9.95
MC6802CP	40	MPU w/Clock and RAM	7.95
6809	40	CPU—8-bit (Internal Clock) 1MHz	14.95
INS8035N-6	40	MPU—8-bit (6MHz)	5.95
INS8039N	40	CPU-Sgl. chip 8-bit (128bts Ram)	5.95
INS8040N-6	40	CPU (256 bytes RAM)	9.95
INS8070N	40	CPU (64 bytes RAM)	29.95
INS8073N	40	CPU w/Basic Micro Interpreter	29.95
P8085A	40	CPU	4.95
8086	40	CPU 16-bit 5MHz	24.95
8088	40	CPU 8/16-bit	29.95
8155	40	NMOS RAM I/O Port Timer	6.95
8748	40	NMOS EPROM MPU	24.95

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Z80	40	CPU (MK3880N)(780C) 2MHz	$3.95
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Z80-DART	40	Dual Asynchronous Rec./Trans.	10.95
Z80-DMA	40	Direct Memory Access Circuit	9.95
Z80-PIO	40	Parallel I/O Interface Controller	3.95
Z80-SIO/0	40	Serial I/O (TxCB and RxCB Bonded)	12.95
Z80-SIO/1	40	Serial I/O (Lacks DTRB)	12.95
Z80-SIO/2	40	Serial I/O (Lacks SYNCB)	12.95
Z80-SIO/9	40	Serial I/O	12.95
Z80A	40	CPU (MK3880N-4)(780C-1) 4MHz	4.49
Z80A-CTC	28	Counter Timer Circuit	4.95
Z80A-DART	40	Dual Asynchronous Rec./Trans.	11.95
Z80A-DMA	40	Direct Memory Access Circuit	12.95
Z80A-PIO	40	Parallel I/O Interface Controller	4.49
Z80A-SIO/0	40	Serial I/O (TxCB and RxCB bonded)	12.95
Z80A-SIO/1	40	Serial I/O (Lacks DTRB)	12.95
Z80A-SIO/2	40	Serial I/O (Lacks SYNCB)	12.95
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Z80B	40	CPU (MK3880N-6) 6MHz	9.95
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Z80B-PIO	40	Parallel I/O Interface Controller	9.95
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Z8002	40	CPU Non Segmented	34.95
Z8030	40	Serial Comm. Controller	44.95
Z8036	40	Counter/Timer & Parallel I/O Unit	29.95

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MC6520	40	Peripheral Inter. Adapter	4.95
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MC6828	24	Priority Interrupt Controller	15.95
MC6830L8	24	1024x8-bit ROM (MC68A30-8)	9.95
MC6850	24	Asynchronous Comm. Adapter	3.95
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MC6860	24	0-600bps Digital MODEM	7.95
MC68000L8	64	MPU 16-Bit (8MHz)	49.95
MC68488P	40	General Purpose Int. Adapter	9.95
MC68652P2	40	Multi. Protocol Comm. Controller	24.95
MC68661PB	28	Enhanced Prog. Comm. Int.	9.95
MCM68764	24	64K EPROM (450ns)	24.95
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INS8080A	40	CPU	2.95
TMS5501	40	Synchronous Data Interface (SIRC)	14.95
INS8154	40	128 Byte RAM 16-Bit I/O	13.95
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DP8212	24	8-bit Input/Output (74S412)	2.25
DP8214	24	Priority Interrupt Control	2.95
DP8216	16	Bi-Directional Bus Driver	1.95
DP8224	16	Clock Generator/Driver	2.25
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DP8238	28	System Controller (74S438)	4.49
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INS8245	18	16-Key Keyboard Encoder (74C922)	4.49
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DP8307	20	8-Bit Bi-Directional Receiver	2.95
DP8308	20	8-Bit Bi-Directional Trans.	2.95
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DS0026CN	8	Dual MOS Clock Driver (5MZ)	1.95
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COP402MN	40	Microprocessor w/64-digit RAM & Direct LED Drive w/N Buss Int.	5.95
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MM5369EST	8	Prog. Oscillator/Divider (100Hz)	1.95

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4027	16	4096x1	(250ns)	2.49
4116N-2	16	16,384x1	(150ns)	1.89/8/14.95
4116N-3	16	16,384x1	(200ns)	1.69/8/12.95
4116N-4	16	16,384x1	(250ns)	1.49/8/10.95
4164N-150	16	65,536x1	(150ns)	6.95/8/49.95
4164N-200	16	65,536x1	(200ns)	5.95/8/44.95
MM5261	16	1024x1	(300ns)	.49/8/1.95
MM5262	22	2048x1	(365ns)	.49/8/1.95
MM5270	18	4096x1	(250ns) MK4096	4.95
MM5280	22	4096x1	(200ns) 2107	3.95
MM5290-2	16	16,384x1	(150ns)	1.89/8/14.95
MM5290-3	16	16,384x1	(200ns)	1.69/8/12.95
MM5290-4	16	16,384x1	(250ns)	1.49/8/10.95
MM5298-3	16	8192x1	(200ns)	1.69

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2101	22	256x4	(450ns) 8101	2.49
2102	16	1024x1	(350ns)	.89
21L02	16	1024x1	(450ns) L.P.	1.49
2111	18	256x4	(450ns) 8111	2.95
2112	16	256x4	(450ns) MOS	1.95
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2114-2	18	1024x4	(200ns)	1.75/8/11.95
2114L-2	18	1024x4	(200ns) L.P.	2.25/8/14.95
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TMS4045	18	1024x4	(450ns)	3.95
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MM5257	18	4096x1	(450ns) 4044	4.95
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HM6116-4	24	2048x8	(200ns) CMOS	4.95
HM6116LP-4	24	2048x8	(200ns) L.P. CMOS	5.49
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7489	16	16x4	(35ns) 3101	2.25
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74C921	18	256x4	(250ns) CMOS	3.95
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74S206	16	256x1	(60ns) 93411	3.95
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82S25	16	16x4	(50ns) O.C. (74S289)	2.25

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2764-3	28	8192x8	(300ns)	14.95
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ST

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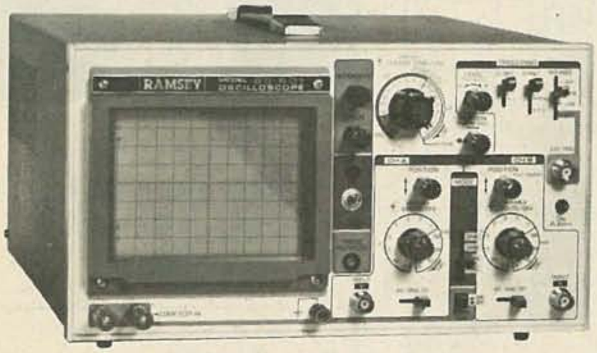

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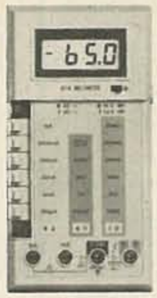

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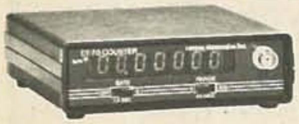

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TIP3055	NPN	276-2020	1.59
MPS2907	PNP	276-2023	.79
MJE34	PNP	276-2027	1.49
2N3053	NPN	276-2030	.89
MPS3638	PNP	276-2032	.79
TIP120	NPN	276-2068	1.29
2N3055	NPN	276-2041	1.99
MJ2955	PNP	276-2043	2.19
2N4124	NPN	276-2057	.59
2N4401	NPN	276-2058	.59
MPSA06	NPN	276-2059	.59
MPSA13	NPN	276-2060	.59
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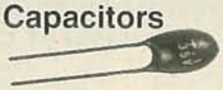

µF	WVDC	Cat. No.	Each
0.1	35	272-1432	.49
0.47	35	272-1433	.49
1.0	35	272-1434	.49
2.2	35	272-1435	.59
10	16	272-1436	.69
22	16	272-1437	.79

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10	35	272-1013	.59
22	35	272-1014	.69
47	35	272-1015	.69
100	35	272-1016	.79
220	35	272-1017	.89
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1000	35	272-1019	1.59
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4700	35	272-1022	3.59
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470	16	272-957	.89
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22	35	272-1026	.69
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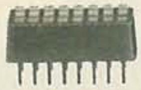
C  Low As **1.49**  D

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270	271-1314	33k	271-1341
330	271-1315	47k	271-1342
470	271-1317	68k	271-1345
1k	271-1321	100k	271-1347
1.8k	271-1324	220k	271-1350
2.2k	271-1325	470k	271-1354
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LP = Low Power Qstat = Quasi-Static

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4116-150	16384 x 1 (150ns)	8/14.95
4116-120	16384 x 1 (120ns)	8/29.95
2118	16384 x 1 (150ns) (5v)	4.95
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4164-200	65536 x 1 (200ns) (5v)	5.95
4164-150	65536 x 1 (150ns) (5v)	6.95
MCM6665	65536 x 1 (200ns) (5v)	8.95
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5V = single 5 volt supply

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2732	4096 x 8 (450ns) (5v)	4.95
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2764	8192 x 8 (450ns) (5v)	9.95
2764-250	8192 x 8 (250ns) (5v)	14.95
2764-200	8192 x 8 (200ns) (5v)	24.95
TMS2564	8192 x 8 (450ns) (5v)	17.95
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5v = Single 5 Volt Supply 21vPGM = Program at 21 Volts

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	Timer	Capacity Chip	Intensity (uW/Cm²)	
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PE-24T	X	12	9,600	175.00
PL-265T	X	30	9,600	255.00
PR-125T	X	25	17,000	349.00
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LM566	1.49
XR2206	3.75
8038	3.95

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UPD7201	29.95
TMS99532	29.95
ULN2003	2.49
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2513-001 UP	9.95
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MM5369	3.95
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MM58167	12.95
MM58174	11.95
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AY5-3600	11.95
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74LS00

74LS00	.24	74LS173	.69
74LS01	.25	74LS174	.55
74LS02	.25	74LS175	.55
74LS03	.25	74LS181	2.15
74LS04	.24	74LS189	8.95
74LS05	.25	74LS190	.89
74LS08	.28	74LS191	.89
74LS09	.29	74LS192	.79
74LS10	.25	74LS193	.79
74LS11	.35	74LS194	.69
74LS12	.35	74LS195	.69
74LS13	.45	74LS196	.79
74LS14	.59	74LS197	.79
74LS15	.35	74LS221	.89
74LS20	.25	74LS240	.95
74LS21	.29	74LS241	.99
74LS22	.25	74LS242	.99
74LS26	.29	74LS243	.99
74LS27	.29	74LS244	1.29
74LS28	.35	74LS245	1.49
74LS30	.25	74LS247	.75
74LS32	.29	74LS248	.99
74LS33	.55	74LS249	.99
74LS37	.35	74LS251	.59
74LS38	.35	74LS253	.59
74LS40	.25	74LS257	.59
74LS42	.49	74LS258	.59
74LS47	.75	74LS259	2.75
74LS48	.75	74LS260	.59
74LS49	.75	74LS266	.55
74LS51	.25	74LS273	1.49
74LS54	.29	74LS275	3.35
74LS55	.29	74LS279	.49
74LS63	1.25	74LS280	1.98
74LS73	.39	74LS283	.69
74LS74	.35	74LS290	.89
74LS75	.39	74LS293	.89
74LS76	.39	74LS295	.99
74LS78	.49	74LS298	.89
74LS83	.60	74LS299	1.75
74LS85	.69	74LS323	3.50
74LS86	.39	74LS324	1.75
74LS90	.55	74LS352	1.29
74LS91	.89	74LS353	1.29
74LS92	.55	74LS363	1.35
74LS93	.55	74LS364	1.95
74LS95	.75	74LS365	.49
74LS96	.89	74LS366	.49
74LS107	.39	74LS367	.45
74LS109	.39	74LS368	.45
74LS112	.39	74LS373	1.39
74LS113	.39	74LS374	1.39
74LS114	.39	74LS375	.95
74LS122	.45	74LS377	1.39
74LS123	.79	74LS378	1.18
74LS124	2.90	74LS379	1.35
74LS125	.49	74LS385	3.90
74LS126	.49	74LS386	.45
74LS132	.59	74LS390	1.19
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74LS137	.99	74LS399	1.49
74LS138	.55	74LS424	2.95
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74LS145	1.20	74LS490	1.95
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74LS156	.69	74LS674	14.95
74LS157	.65	74LS682	3.20
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74LS160	.69	74LS684	3.20
74LS161	.65	74LS685	3.20
74LS162	.69	74LS688	2.40
74LS163	.65	74LS689	3.20
74LS164	.69	81LS95	1.49
74LS165	.95	81LS96	1.49
74LS166	1.95	81LS97	1.49
74LS168	1.75	81LS98	1.49
74LS169	1.75	25LS2521	2.80
74LS170	1.49	25LS2569	4.25

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6840	12.95
6843	34.95
6844	25.95
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6850	3.25
6852	5.75
6860	9.95
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6880	2.25
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6800 = 1MHZ

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68B09	29.95
68B10	6.95
68B21	6.95
68B40	19.95
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68B00 = 2 MHZ

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8214	3.85
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8224	2.25
8226	1.80
8228	3.49
8237	19.95
8237-5	21.95
8238	4.49
8243	4.45
8250	10.95
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8279	8.95
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8283	6.50
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8287	6.50
8288	25.00
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2.5 Mhz

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Z80-DART	10.95
Z80-DMA	14.95
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Z80-SIO/1	16.95
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Z80A-SIO/1	16.95
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Z80B-CPU	11.95
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6504	6.95
6505	8.95
6507	9.95
6520	4.35
6522	7.95
6532	9.95
6545	22.50
6551	11.85

2 MHZ

6502A	6.95
6522A	9.95
6532A	11.95
6545A	27.95
6551A	11.95

3 MHZ

6502B	14.95

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2797	59.95
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4N37	1.25
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MCT-6	1.50
MCA-7	4.25
MCA-255	1.75
IL-1	1.25
ILA-30	1.25
ILQ-74	2.75
H11C5	1.25
TIL-111	1.00
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MPS918	.25	2N3772	1.85
2N2102	.75	2N3903	.25
2N2218	.50	2N3904	.10
2N2218A	.50	2N3906	.10
2N2219	.50	2N4122	.25
2N2219A	.50	2N4123	.25
2N2222	.25	2N4249	.25
PN2222	.10	2N4304	.75
MPS2369	.25	2N4401	.25
2N2484	.25	2N4402	.25
2N2905	.50	2N4403	.25
2N2907	.25	2N4857	1.00
PN2907	.125	PN4916	.25
2N3055	.79	2N5086	.25
3055T	.69	PN5129	.25
2N3393	.30	PN5139	.25
2N3414	.25	2N5209	.25
2N3563	.40	2N6028	.35
2N3565	.40	2N6043	1.75
PN3565	.25	2N6045	1.75
MPS3638	.25	MPS-A05	.25
MPS3640	.25	MPS-A06	.25
PN3643	.25	MPS-A55	.25
PN3644	.25	TIP29	.65
MPS3704	.15	TIP31	.75
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1N759	12.0 volt zener	.25
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20	.65	5.70	1.25	11.00
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34	.98	8.60	1.65	14.50
40	1.32	11.60	1.92	16.80
50	1.38	12.10	2.50	22.00

D-SUBMINIATURE

DESCRIPTION	SOLDER CUP		RIGHT ANGLE PC SOLDER		IDC RIBBON CABLE		HOODS	
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE	BLACK	GREY
ORDER BY	DBxxP	DBxxS	DBxxPR	DBxxSR	IDBxxP	IDBxxS	HOOD-B	HOOD
CONTACTS 9	2.08	2.66	1.65	2.18	3.37	3.69	—	1.60
15	2.69	3.63	2.20	3.03	4.70	5.13	—	1.60
25	2.50	3.25	3.00	4.42	6.23	6.84	1.25	1.25
37	4.80	7.11	4.83	6.19	9.22	10.08	—	2.95
50	6.06	9.24	—	—	—	—	—	3.50

For order instructions see "IDC Connectors" below.

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IDC CONNECTORS

DESCRIPTION	SOLDER HEADER	RIGHT ANGLE SOLDER HEADER	WW HEADER	RIGHT ANGLE WW HEADER	RIBBON HEADER SOCKET	RIBBON HEADER	RIBBON EDGE CARD
ORDER BY	IDHxxS	IDHxxSR	IDHxxW	IDHxxWR	IDSxx	IDMxx	IDExx
CONTACTS 10	.82	.85	1.86	2.05	1.15	—	2.25
20	1.29	1.35	2.98	3.28	1.86	5.50	2.36
26	1.68	1.76	3.84	4.22	2.43	6.25	2.65
34	2.20	2.31	4.50	4.45	3.15	7.00	3.25
40	2.58	2.72	5.28	4.80	3.73	7.50	3.80
50	3.24	3.39	6.63	7.30	4.65	8.50	4.74

ORDERING INSTRUCTIONS: Insert the number of contacts in the position marked "**xx**" of the "order by" part number listed. **Example:** A 10 pin right angle solder style header would be IDH**10**SR.

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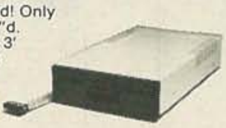

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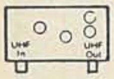

Features:
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Your reception will dramatically improve! This unit will enable you to pull in signals you never knew were there!
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TA-802
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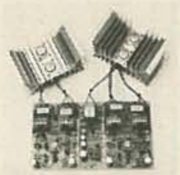

SOLID STATE STEREO GRAPHIC EQUALIZER PRE AMP KIT TA-2500

Specifications: • Total Harmonic Distortion: Less than 0.05% • Intermodulation Distortion: (70Hz: 7KHz = 4:1 SMPTE Method) Less than 0.03% • Frequency Response: Overall 10Hz ~ 100KHz +0.5db.—1dB. • RIAA Curve Deviation: (Phono) +0.2dB.—0.2dB (30Hz ~ 15KHz) • Channel separation (at rated output 1 KHz) • Phono. Tuner. Aux and Tape Monitor better than 70dB. • Input sensitivity and impedance (1KHz for rated output)
Phono: 2MV 47K ohms Aux: 130MV 50K ohms. **Tuner:** 130MV 50K ohms **Tape:** 130MV 50K ohms. **Graphic Equalizer control:** 10 Band Slide Control. **Frequency Bands:** 31 5Hz: G3Hz: 125Hz: 250Hz: 500Hz:1Khz: 2KHz: 4KHz: 8KHz: 16KHz also with on panel selector for Phono. Tuner. Aux 1 and Aux 2. **Power Supply:** 117 VAC
Kit comes with all electronic components, transformer, instructions and a 19" rack mount type metal cabinet.

MODEL TA-2500
$119.00 PER KIT

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INFRA-RED REMOTE CONTROL SWITCH KIT

Infra-red Remote Control switch can be used to control appliances up to 500 W. The TK-41 has effective control up to 10 meters.
No antenna needed. Features latest IC controller which excludes interferences from light or AC pulse signal.

TK-41 Kit $24.95

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PHILIPS VARACTOR TUNER

Comes with adaptor board to directly replace Mitsiumi tuner! Can use this with any board drilled for Mitsuimi! High gain and phenomenal picture quality.
SPECIFICATIONS: • Freq. Range: 470-899 mHz • Output: Channel: 3 • Input: 75 ohm • Gain: 18 dB

ELC 1045 .... $23.95

DIGITAL MULTIMETER

- 3½ digit LCD meter
- Input impedence 20 Ohm
- hFE measurement
- DC .5% accuracy
- DCA up to 10 amps
- Leads and battery included

MIC-3300A.............. $59.95
Carrying Case ....$ 9.95

TTL/CMOS LOGIC PROBE

- 4 LED states
- Pulse memory
- Supply Voltage 3 ~ 18 VDC
- TTL CMOS checking made easy!

L101A $34.95

LOGIC PULSAR PROBE

- Easily repair logic circuits
- .5Hz or 500Hz signal
- External Sync Input
- Supply Voltage 3 ~ 18 VDC

L201A $34.95

LOW TIM DC STEREO PRE-AMP KIT TA 2800

Incorporates state of D.C. design that gives a frequency response from OHz-100KHz ± .5dB. • Features tone defeat switch, loudness, treble, midrange, bass, balance. • TA-2800 contains quad BiFet op-amp to develop T.H.D. of .005% at rated output • Input sensitivity: phone 2.5 MV tuner, aux, tape play 100MV/100K • Power supply ± 15 volt DC at .2A. Kit comes with regulated power supply, all you need is a 15-20 VCT .2 amp. XFMR.

Only $44.50

XFMR
$4.50 ea.

AMATEUR MICROWAVE RECEIVER KIT 1.9-2.5 GHZ

PS-1 Assembled 32 element antenna **$19.95**
PS-2 20 dB gain microwave receiver kit with variable power supply kit **$50.00**
PS-3 Complete package PS-1 & 2.... **$65.00**

MOUNTING HARDWARE INCLUDED

MICROWAVE PREAMP! NEW KIT

Use with PS-3 Kit. Adds 20-25 dB gain to boost reception distance.
- Low Noise
- High Gain
- Can be used with all existing stop sign board receivers!
- 1.9-2.5 gHZ freq. range

PS-4 (Kit) $34.95

SOLID STATE STEREO REVERBERATION AMPLIFIER

Specifications:
- Total harmonic distortion less than .05%
- Frequency response 10 Hz to 50KHz ±ldB
- S/N Ration 90dB
- Reverberation time 1 to 3 sec
- Input 150MV/50K ohm
- Max. input 2V
- Accepts input from tape, phono, or aux.

Includes an LED Reverb Level display. Kit comes with all electronic components, transformer and instructions, and 19" rack mount cabinet.

Model TA-2400 .... $89.95

SPY EAR!

A very popular device designed to listen to sounds & voices through rooms or 3 ft. thick concrete walls. Place listening sensor against wall and earphone in ear. Adjust volume control! Hear clearly to things you might not want to!

CM-8 .... $89.95

TY-45 20 STEP LED POWER LEVEL INDICATOR KIT

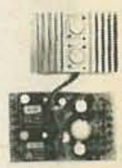
This new stereo level indicator kit consists of 40 3-color LED's to indicate sound level output of your amplifier from -57 dB to 0 dB. Comes with an attractive silk screen printed panel. Has selector switch to allow floating or gradual output indicating.
Kit includes all parts, Front panel and power supply.

TY-45 KIT
$34.95

MICRO COMPUTER POWER SUPPLY TR-626

The TR-626 is a power regulator for use with popular microcomputer circuits. Features:

- ±5V 6A
- -5V .5A
- +12V 1.5A
- -12V .5A



Each unit contains current limit protect circuit and two Darlington power transistor on a heatsink. Transformers included.

$39.95 each

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Diablo Daisy Printer HI-Type II

1355-WP Word Processing Daisy Printer

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7808	.80
7812	.80
7815	.80
7818	.80
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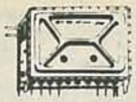
2N2222	.30
MC1349	1.79



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300 ohm INPUT **$17.95**

CHOKES

.33 uh	33 uh
.47 uh	100 uh
15 uh	10 mh
18 uh	69¢ each

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2102L-2	1024 x 1 (250ns) (LP)	1.45
2111	256 x 4 (450ns)	2.45
2112	256 x 4 (450ns)	2.95
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2114-25	1024 x 4 (250ns)	8/9.95
2114L-4	1024 x 4 (450ns) (LP)	8/11.95
2114L-3	1024 x 4 (300ns) (LP)	8/12.45
2114L-2	1024 x 4 (200ns) (LP)	8/12.95
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TMS4044-4	4096 x 1 (450ns)	3.45
TMS4044-3	4096 x 1 (300ns)	3.95
TMS4044-2	4096 x 1 (200ns)	4.45
MK4118	1024 x 8 (250ns)	9.90
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TMM2016-150	2048 x 8 (150ns)	4.90
TMM2016-100	2048 x 8 (100ns)	6.10
HM6116-4	2048 x 8 (200ns) (cmos)	4.70
HM6116-3	2048 x 8 (150ns) (cmos)	4.90
HM6116-2	2048 x 8 (120ns) (cmos)	8.90
HM6116LP-4	2048 x 8 (200ns) (cmos)(LP)	5.90
HM6116LP-3	2048 x 8 (150ns) (cmos)(LP)	6.90
HM6116LP-2	2048 x 8 (120ns) (cmos)(LP)	9.95
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LP = Low Power Qstat = Quasi-Static

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MM5280	4096 x 1 (300ns)	2.95
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MM5298	8192 x 1 (250ns)	1.80
4116-300	16384 x 1(300ns)	8/10.75
4116-250	16384 x 1(250ns)	8/10.95
4116-200	16384 x 1(200ns)	8/11.95
4116-150	16384 x 1(150ns)	8/13.95
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4164-200	65536 x 1(200ns) (5v)	5.90
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5V = single 5 volt supply

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2758	1024 x 8 (450ns) (5v)	5.90
2716	2048 x 8 (450ns) (5v)	3.90
2716-1	2048 x 8 (350ns) (5v)	5.90
TMS2516	2048 x 8 (450ns) (5v)	5.45
TMS2716	2048 x 8 (450ns)	7.90
TMS2532	4096 x 8 (450ns) (5v)	5.90
2732	4096 x 8 (450ns) (5v)	4.90
2732-250	4096 x 8 (250ns) (5v)	8.90
2732-200	4096 x 8 (200ns) (5v)	10.95
2764	8192 x 8 (450ns) (5v)	9.90
2764-250	8192 x 8 (250ns) (5v)	13.95
2764-200	8192 x 8 (200ns) (5v)	23.95
TMS2564	8192 x 8 (450ns) (5v)	16.95
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27128	16384 x 8Call	Call

5v = Single 5 Volt Supply

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74LS00	.23	74LS173	.68
74LS01	.24	74LS174	.54
74LS02	.24	74LS175	.54
74LS03	.24	74LS181	2.10
74LS04	.23	74LS189	8.90
74LS05	.24	74LS190	.88
74LS08	.27	74LS191	.88
74LS09	.28	74LS192	.78
74LS10	.24	74LS193	.78
74LS11	.34	74LS194	.68
74LS12	.34	74LS195	.68
74LS13	.44	74LS196	.78
74LS14	.58	74LS197	.78
74LS15	.34	74LS221	.88
74LS20	.24	74LS240	.94
74LS21	.28	74LS241	.98
74LS22	.24	74LS242	.98
74LS26	.28	74LS243	.98
74LS27	.28	74LS244	1.25
74LS28	.34	74LS245	1.45
74LS30	.24	74LS247	.74
74LS32	.28	74LS248	.98
74LS33	.54	74LS249	.98
74LS37	.34	74LS251	.58
74LS38	.34	74LS253	.58
74LS40	.24	74LS257	.58
74LS42	.48	74LS258	.58
74LS47	.74	74LS259	2.70
74LS48	.74	74LS260	.58
74LS49	.74	74LS266	.54
74LS51	.24	74LS273	1.45
74LS54	.28	74LS275	3.30
74LS55	.28	74LS279	.48
74LS63	1.20	74LS280	1.95
74LS73	.38	74LS283	.68
74LS74	.34	74LS290	.88
74LS75	.38	74LS293	.88
74LS76	.38	74LS295	.98
74LS78	.48	74LS298	.88
74LS83	.59	74LS299	1.70
74LS85	.68	74LS323	3.45
74LS86	.38	74LS324	1.70
74LS90	.54	74LS352	1.25
74LS91	.88	74LS353	1.25

74LS92	.54	74LS363	1.30
74LS93	.54	74LS364	1.90
74LS95	.74	74LS365	.48
74LS96	.88	74LS366	.48
74LS107	.38	74LS367	.44
74LS109	.38	74LS368	.44
74LS112	.38	74LS373	1.35
74LS113	.38	74LS374	1.35
74LS114	.38	74LS377	1.35
74LS122	.44	74LS378	1.13
74LS123	.78	74LS379	1.30
74LS124	2.85	74LS385	1.85
74LS125	.48	74LS386	.44
74LS126	.48	74LS390	1.15
74LS132	.58	74LS393	1.15
74LS133	.58	74LS395	1.15
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74LS155	.68	74LS674	9.60
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74LS157	.64	74LS683	3.15
74LS158	.58	74LS684	3.15
74LS160	.68	74LS685	3.15
74LS161	.64	74LS688	2.35
74LS162	.68	74LS689	3.15
74LS163	.64	74LS783	23.95
74LS164	.68	81LS95	1.45
74LS165	.94	81LS96	1.45
74LS166	1.90	81LS97	1.45
74LS168	1.70	81LS98	1.45
74LS169	1.70	25LS2521	2.75
74LS170	1.45	25LS2569	4.20

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6551	10.85

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6532A	10.95
6545A	26.95
6551A	10.95

3 MHZ

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8253-5	7.90
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8259	6.85
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8272	38.95
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8272	6.45
8283	6.45
8284	5.45
8286	6.45
8287	6.45
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4.0 Mhz

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Z80A-PIO	4.90
Z80A-SIO/0	15.95
Z80A-SIO/1	15.95
Z80A-SIO/2	15.95
Z80A-SIO/9	15.95

6.0 Mhz

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2797	58.95
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8T28	1.84
8T95	.88
8T96	.88
8T97	.88
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7805T	.74	7905T	.84
78MO5C	.34	7908T	.84
7808T	.74	7912T	.84
7812T	.74	7915T	.84
7815T	.74	7924T	.84
7824T	.74	7905K	1.44
7805K	1.34	7912K	1.44
7812K	1.34	7915K	1.44
7815K	1.34	7924K	1.44
7824K	1.34	79L05	.78
78L05	.68	79L12	.78
78L12	.68	79L15	.78
78L15	.68	LM323K	4.90
78H05K	9.90	UA78S40	1.90
78H12K	9.90		

C,T = TO-220 K = TO-3 L = TO-92

DIP SWITCHES

4 POSITION	.84
5 POSITION	.89
6 POSITION	.89
7 POSITION	.94
8 POSITION	.94

IC SOCKETS

	1-99	100
8 pin ST	.12	.10
14 pin ST	.14	.11
16 pin ST	.16	.12
18 pin ST	.19	.17
20 pin ST	.28	.26
22 pin ST	.29	.26
24 pin ST	.29	.26
28 pin ST	.39	.31
40 pin ST	.48	.38
64 pin ST	4.20	call
ST = SOLDERTAIL		
8 pin WW	.58	.48
14 pin WW	.68	.51
16 pin WW	.68	.57
18 pin WW	.98	.89
20 pin WW	1.04	.97
22 pin WW	1.34	1.23
24 pin WW	1.44	1.30
28 pin WW	1.64	1.44
40 pin WW	1.94	1.75
WW = WIREWRAP		
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5.0	3.90
5.0688	3.90
5.185	3.90
5.7143	3.90
6.0	3.90
6.144	3.90
6.5536	3.90
8.0	3.90
10.0	3.90
10.738635	3.90
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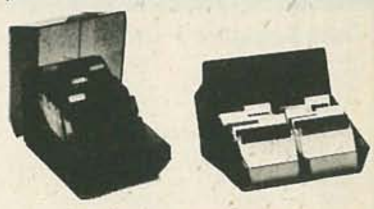

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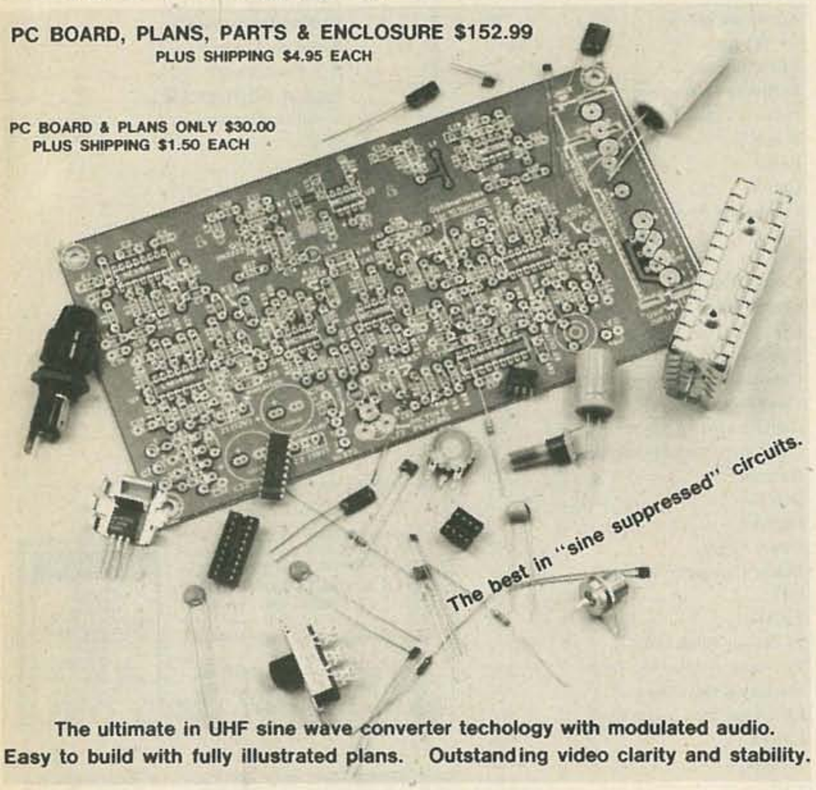

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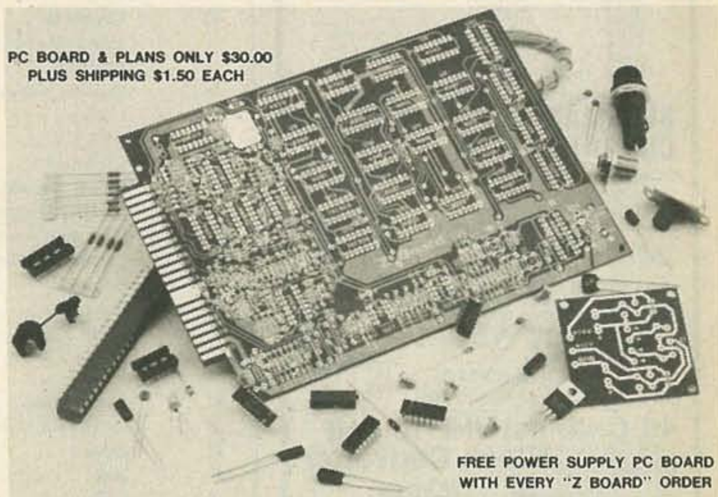

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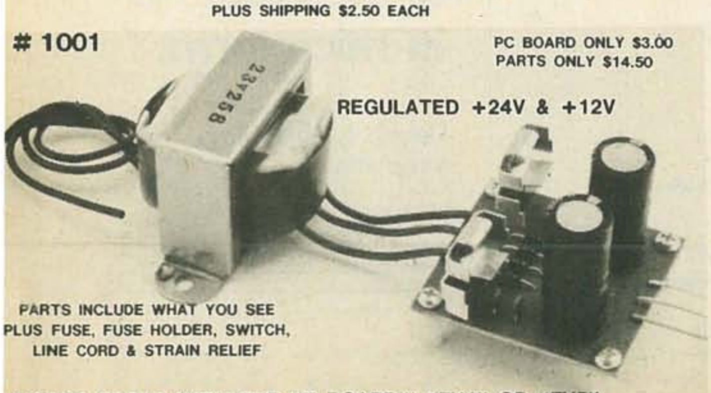

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