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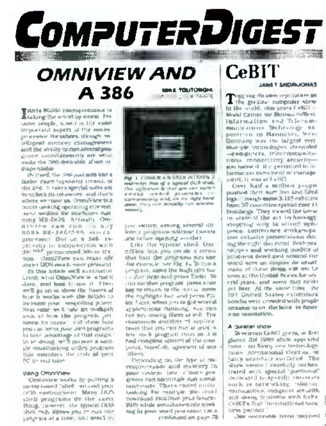

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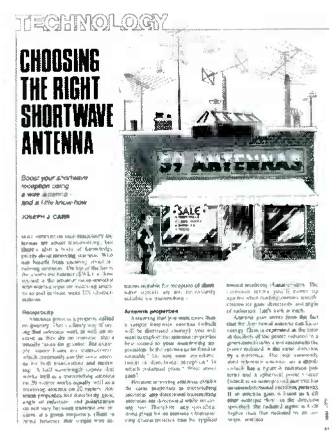

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ON THE COVER

Once in a while we get to present a project that's so much fun to build and use that you hardly realize you're learning while you build. Our Light Beam Communicator is a good example. Built using a high-intensity LED, a sensitive photodiode, and some basic optics, it can be used to communicate over distances that you wouldn't believe possible using an LED! With a range of more than ½ mile, it becomes much more than a toy. To get the full story, turn to page 31.

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Some servicing case histories.

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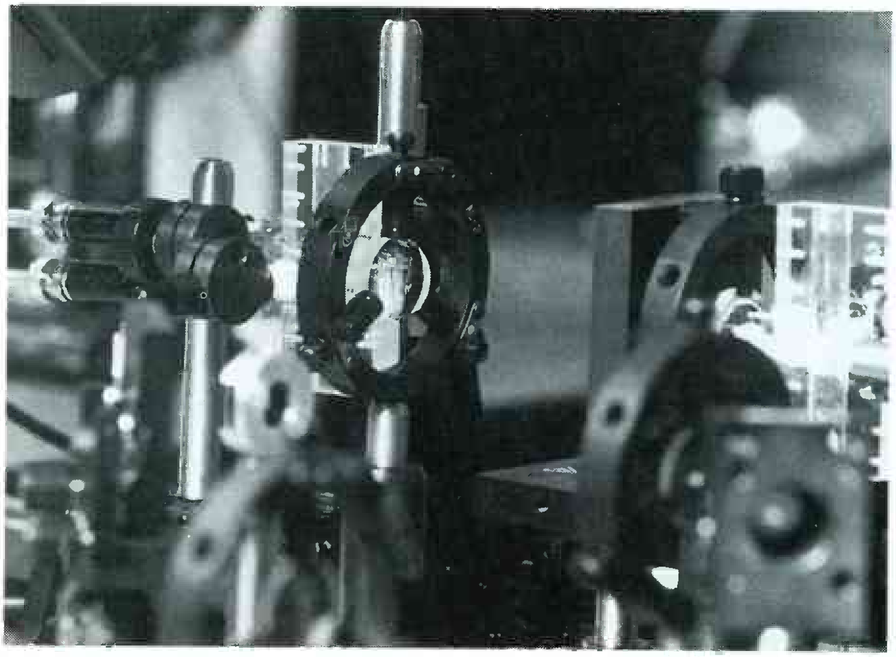
WHAT'S NEWS

New range opens for spectroscopy



NEW MICROWAVE SPECTROSCOPY TECHNIQUE, developed by IBM scientists, uses picosecond optoelectronic antennas to measure a material's delay and loss characteristics over the microwave spectrum.

Scientists at IBM's Thomas J. Watson Research Institute (Yorktown, NY) report a new spectroscopy technique able to measure the electrical properties of materials over the 10- to 125-gigahertz range. Up to now, information in that area—the microwave spectrum—could be gained only by individual measurements, and only at frequencies for which the required measuring equipment was available. The new system developed by IBM scientists determines the delay and loss characteristics of a material at all points over that wide frequency band, including the electrical connections between high speed computer components.

Circuits in today's computers can generate signals at about 1 GHz. But signals over 100 times as fast are technically feasible. The broad frequency range generated by such signals interacts with surrounding materials, causing delay and distortion. Knowledge of the delay and loss characteristics of those materials is essential to success in designing future, ultra-fast computers.

In operation, two optoelectronic antennas—fairly new devices in which both electronics and optical components are integrated on a single IC—are positioned 4 centimeters apart. They act as transmitter and receiver, with the material to be examined placed between them. A short laser-pulse photoconductively produces a broad-spectrum microwave pulse in the transmitter. The microwave pulse is transmitted through the sample to the receiver, where a laser pulse samples the signal and produces a record of the delay and loss as it passes through the sample.

New imaging sensor doubles resolution

Scientists at Eastman Kodak Labs have produced an ultra-high-resolution electronic image sensor with more than four million picture elements (pixels). The new development has more than twice the resolving power of sensors now on the market.

The four million pixels, each a tiny square measuring 9 × 9 microns (millionths of a meter), are in a square of 2,048 vertical columns and 2,048 horizontal rows. Each pixel senses incoming light and converts it into electronic current, which is processed by the device to produce video signals.

Efficient generators use hot gas instead of wires.

A new method of generating electricity, using a generator with conductors of hot gas instead of copper, was announced some years ago. The new method—called magnetohydrodynamics, or MHD—was stated to be 50% more efficient than conventional systems. Nothing further was heard about the method, and it was generally supposed to have been another brilliant but impractical idea.

Now a report comes of a prototype plant in Israel. It appears that the problem had been that the walls of the channel holding the hot gas would corrode and break down. Coating the vulnerable parts with a thin layer of platinum prevents the corrosion.

The plant is said to burn hot coal at 5,000°F. The hot gas is treated chemically to increase its conductivity. It is then injected through a channel in a magnet, generating current. Next, the gas—now cooler—spins a turbine to power a conventional generator, producing more current. That dual generation is said to convert 50% of the coal's energy into electricity, as compared with 34% achieved conventionally. **R-E**

VIDEO NEWS

DAVID LACHENBRUCH,
CONTRIBUTING EDITOR

• **What next for VHS?** Japan's VHS group hopes to continue the evolution of that format, and to keep it ahead of any competition. The next order of business is to try to cope with the problems of the small VHS-C cassette, which is currently being bested in the camcorder battle by the 8mm format. On the theory that the need for an adaptor to play VHS-C cassettes in standard machines is one of the basic problems, the VHS producers are studying the idea of a machine that will play both standard VHS cassettes and VHS-C tapes without requiring an adaptor. Currently, the best thinking is that the machine will be a standard VHS-type with a *built-in* adaptor, which would be pushed to the rear of the recorder when a full-sized cassette is inserted.

The second priority is a digital stereo soundtrack. While the 8mm format has an optional digital-audio system, most 8mm camcorders use a mono AFM analog track that is recorded helically along with the video. The VHS group is working on a helical PCM digital track, but an official of JVC was careful to explain that the aim is compact-disc quality and a substantial improvement on the already excellent AFM.

A longer-term goal is a digital-standards converter built into VHS recorders to eliminate the barriers imposed by different national television signal standards—PAL, SECAM, and NTSC—to make VHS a true worldwide medium. Such a converter would make it possible to play any tape on any TV set in the world, or to dub a recording from one standard to another. Although Matsushita has shown a prototype, it's considered a product for future years.

• **Digital still video.** Although the high-priced analog still-video cameras haven't exactly set the consumer market on fire, there's already discussion in Japan of a standard for a digital still system—which could become the world's first consumer product to employ digital video. The current electronic cameras use a 2-inch "mini-floppy" to record and store analog picture information. Toshiba and Fuji now have proposed an "IC card" camera with virtually no moving parts. The credit-card-sized IC card currently can store up to 13 exposures, but the two companies are working on signal-compression technology to store at least 50 exposures on one erasable card, and to develop a card that doesn't require a battery backup to keep the picture in storage. The companies say that they're aiming at pictures with at least 400 lines of horizontal resolution, as compared with about 300 in the current video-floppy system. They say that digital images stored on an IC card would allow easy processing of color and the addition or deletion of images, and that their system would bring simpler, more compact and more reliable cameras. The first professional digital cameras could be on the market next year, with a consumer version coming two or three years later.

• **The latest in Videodisc players.** Now available in the U.S. under the Philips brand is a laser-disc player that will play six kinds of discs—including audio CD's and a new type of 8-inch one-sided videodisc "single." It has separate color and luminance outputs, digital special effects, a remote controller with a jog-shuttle dial, and an LCD screen to identify different remote functions. The remote controller is capable of transmitting 750 different commands to TV's, VCR's, and audio equipment in addition to the laser-disc player.

• **A PAL-NTSC VCR.** but Panasonic's latest high-end VCR for the European market helps to eliminate national-standards boundaries. It will play back NTSC tapes through most PAL TV's. It can't convert NTSC's 525 lines into PAL's 625-line picture, nor can it change NTSC's 30 frames per second to PAL's 25. However, it does take advantage of the fact that many PAL sets use the same chips as NTSC sets and adapt themselves to the type of signals they receive. This new set will give many Europeans access to the vast amount of NTSC prerecorded tapes and let them play home movies taped by American friends and relatives. Panasonic is selling the VCR with the warning that it can't play back NTSC tapes on all PAL sets. **R-E**

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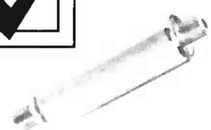

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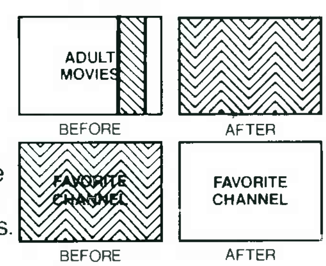

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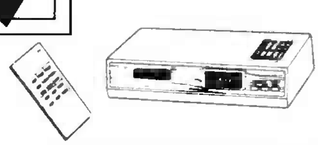

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CIRCLE 65 ON FREE INFORMATION CARD

AUDIO UPDATE

How loud is real?

LARRY KLEIN,
AUDIO EDITOR

DURING THE WILD AND CAREFREE DAYS of my youth, I once participated in a small psychoacoustic experiment. The object was to determine if there was a specific or minimum playback level necessary to achieve a reasonable simulation of "live" sound. After listening to a variety of selections from the best recordings of the day, the participants agreed that there did, indeed, seem to be a specific volume level (that varied somewhat with the recording) at which the music suddenly sounded more "natural." Below that point there was nothing specifically wrong with the sound—it just wasn't *right*. After spending about an hour or so sampling different discs, we found that we generally agreed—within several decibels or so—on the volume setting that sounded best. I don't mean to suggest that the sound was perfect at any level, only that there was a specific volume level at which, for obscure reasons, the reproduced music seemed more realistic.

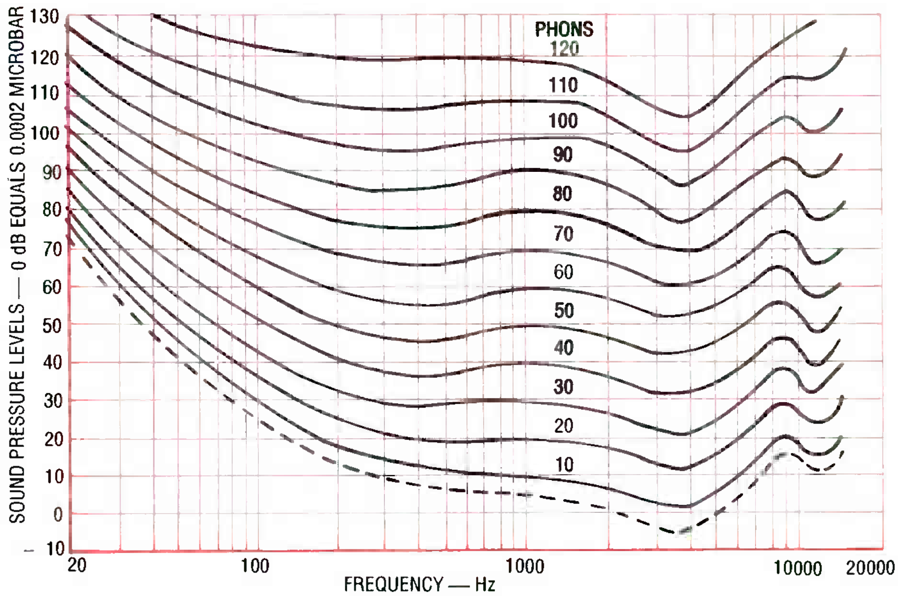

FIG. 1

Calibrating loudness

In the past several decades, I've learned something about the way that the human ear/brain responds to sound levels. Psychoacousticians make a clear and necessary distinction between *loudness* and *sound intensity*. Loudness is the ear/brain's *subjective* auditory reaction to *objective* sound-pressure-level stimuli. It's necessary to distinguish between the subjective and the objective simply because our perception of loudness lacks a one-to-one correspondence with the objective world.

There are good evolutionary reasons why that is so. In respect to volume, for example, the noise created by a jet plane at take-off is about ten-thousand-billion times as powerful as the quietest sound that we can hear. If, on a linear scale, a quiet whisper was assigned one intensity unit, a jet engine would have an intensity of ten-trillion units!

The ability to compress that enormous dynamic range into something that can be handled and evaluated by the human ear/brain was originally investigated by a 19th-century physicist and philosopher, Gustave Theodor Fechner. In 1860, he published a ground-breaking work, *Elements of Pyschophysics*, that attempted to establish a specific relationship between the outer objective world and the inner subjective one in *all* areas of sensation. Fechner's law states, for example, that each time the intensity of a sound is doubled, one step is added to the sensation of loudness. In Fechner's view, sensation increased as the logarithm of the stimulus.

The decibel, which measures sound energy in logarithmic units, would seem to fit nicely into Fechner's law. But it soon became apparent to anyone who listened carefully, that a noise level of, say, 50 dB, was *not* half as loud as 100 dB. (Fifty dB is the background noise in a library reading room; the perceived loudness of 100 dB—equivalent to a jet plane heard about 1,000 feet overhead—is about 30 times greater than 50 dB.) After much research effort, starting in the 1930's at the Psychoacoustic Laboratory at Harvard University, Fechner's logarithmic approach to auditory perception was ultimately replaced by a true scale of loudness: the *sone*. The sone scale has a rather straightforward rule: Each intensity increase of 10 decibels doubles the sensation of loudness. Today, it's generally accepted that sound levels have to be raised by 10 dB before they sound twice as loud.

Loudness contours

The names Fletcher and Munson are commonly invoked when amplifier-loudness controls are discussed. In 1933, they were among the first researchers to demonstrate the very non-linear relationships among the objective sound-pressure level of a sound, its frequency, and its subjective loudness. Aside from the fact that the research had conceptual and practical flaws, it also—at least in the audio-equipment area—was misunderstood and misapplied. Let's see where things went wrong.

In the original experiment, listeners in an anechoic chamber were asked to match test tones of different frequencies and intensities with calibrated, 1,000-Hz test tones produced at a variety of specific levels. The general results are familiar to most of us; it was found that the ear looses sensitivity to low frequencies as the sound level is reduced. Later work, by Robinson and Dadson in the mid-1950's, used superior instrumentation and produced a somewhat modified set of loudness contours (Fig. 1). Their results were subsequently adopted by the International Standards Organization and are now known officially as the *ISO equal-loudness contour curves*. Despite the international acceptance of the R-D curves, keep in mind that the techniques used to derive them (pure tones in an anechoic chamber) do not correspond exactly to music listened to in a living room.

Achieving reality

Anyone who has been following my columns with any regularity should, by now, be convinced that realistic reproduction of music is no easy task. The basic problem is the need to present to the listener's ears a *three-dimensional* acoustic simulation of the live musical event. It has become obvious that the problem can't be solved by conventional, two-channel stereo, and digital "dimension synthesizers" are now becoming commonplace. Although adding the extra channels is a necessary step, it's not a sufficient one; the original playback level at the listener's ears still has to be accurately reproduced.

Why should that be so? Although the question may seem dauntingly complex and laden with philosophical booby-traps, some simple—if incomplete—answers are available. Setting aside the question of the absolute accuracy of the loudness curves discussed earlier, we do know that the ear's frequency response changes in accord with the level of the impinging signal. For example, suppose that you were to make a good recording of a live dance band playing at an average level of 70 dB. If you were to subsequently play back the recording at a 50-dB level, the bass frequencies would automatically suffer a 13-dB loss relative to the mid frequencies, as per Fig. 1. Obviously, not only would the bass line be attenuated, but the entire sound of the orchestra would be thinned out.

Other problems

The ear has other loudness-dependent peculiarities. As a transducer, it is both asymmetrical and non-linear and, therefore, regularly creates (and hears) frequencies that are not in the original material. Known as *aural harmonics* and *combination tones*, they correspond to harmonic- and intermodulation-distortion products in non-biological audio equipment. Since the amounts of those acoustic artifacts generated by the ear depend on signal level, any level differences between the recording and playback are going to cause different reactions *in* the listener's ears.

To complicate matters further, low-frequency sounds appear to

continued on page 11

ASK R-E

WRITE TO:

ASK R-E
Radio-Electronics
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Farmingdale, NY 11735

DELAY CIRCUIT

I recently put an alarm system in my house and, to avoid making holes in the walls, I used digital switches inside the door. I'd like some simple circuit to provide a 15-second delay from the normally open switches, so that I can get out of the house before the system is armed.—L. Holmquist, Whitman, MA.

Whenever you need any simple time-delay circuits, the first thing to consider is the 555. Although there are lots of ways to generate a time delay, if your requirements aren't in the nanosecond range, the 555 is the way to go.

Since the 555 was designed for general-purpose timing applications, it can be configured to perform a wide variety of different jobs. The schematic in Fig. 1 is the basic circuit arrangement for setting up the 555 to operate as a pulse generator. You haven't included enough details about your application for me to be sure about the values of the components to use, but the time-delay formula is simple enough for you to fill in the blanks yourself.

The time delay is almost exclusively dependent on the values of R and C, and won't be affected much at all by temperature or reasonable variations in the supply voltage. All those good things are inherent characteristics of the 555. The trigger input is normally high and the 555 output will be normally low. When the trigger is brought low momentarily, the 555 will start the RC delay and the output will go high. When the 555 times out, the output will go low again and stay there until it's retriggered by your digital switch.

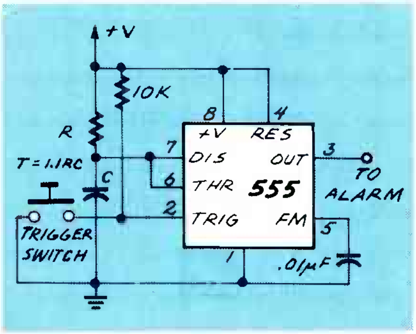


FIG. 1

The two important things to remember are that the 555 wants a low trigger and that it will put a high on the output for the delay time that's set by the resistor and the capacitor. You'll have to adapt that to your needs, because I don't know exactly what your setup is; but the 555 is so easy to use that you shouldn't have any trouble at all.

LINEAR TO LOG

Can you show me a simple IC-based circuit which would convert a linear-voltage input into a logarithmic output that could drive a meter? It would be very useful for extending the range of VU and S meters.—J. Cable, Lehigh Acres, FL.

Once upon a time, logarithmic amps were common circuit elements, but as digital stuff started to take over, analog log amps were used less and less. That's really a shame because an analog log amp is a simple one-IC solution to a lot of circuit problems. You're quite right that it's a perfect addition to metering circuitry and, if you get into it, you'll also find that it's great in audio-signal processing as well. It used to be that every compressor and limiter on the market was built around a log amp, but digital signal processing has shown up in that area as well. But enough nostalgia.

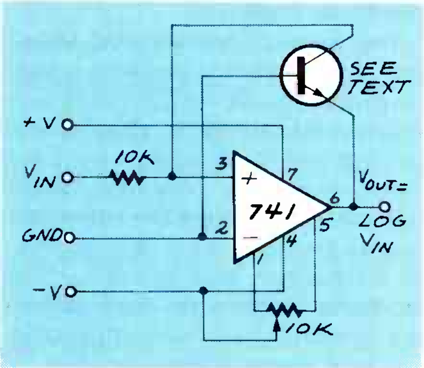


FIG. 2

The circuit in Fig. 2 is a basic log amp built around a single op-amp. The configuration is often referred to as a "transdiode" circuit, since the output of the op-amp is equal to the base-emitter voltage of the transistor. The current in the feedback loop of the op-amp is equal to the current flow at the input of the op-amp. Since the input current is proportional to the voltage across the input resistor, it's also proportional to the collector current in the transistor. The base-emitter voltage of the transistor is related logarithmically to the collector current so the output of the op-amp will vary logarithmically with the op-amp's input voltage.

The circuit is built around a 741 but you can use any op-amp you want. The transistor, however, should be a high-gain type, capable of handling the power; since you're only using it to drive a meter, you can probably get by with something like a 2N3391.

I'm sure you know that whenever you build a meter amp, getting the circuit working is only half the battle—you also have to calibrate it. In a straightforward linear amp that isn't much of a problem, but log amps make it a bit more difficult. You can use the brute-force approach of putting known signals at the input and then padding the output, but regardless of the method you use, you have to take into account the offset introduced by the op-amp. That's the purpose of the potentiometer across the offset adjustment pins of the op-amp.

Since the log of one is zero, you should feed the amp with one unit of positive signal and tweak the potentiometer to get zero out of the op-amp. The amount of accuracy you get depends on the gain, the temperature, and the level of the input.

If you really want to get into this, you'll find that there's a lot of math involved in calculating the circuit parameters and there's just not enough room here to go through all the gory details. It's safe to say, therefore, that the success you're going to have with log amps in general is directly proportional to the number of hours you spend doing research. Good luck. **R-E**

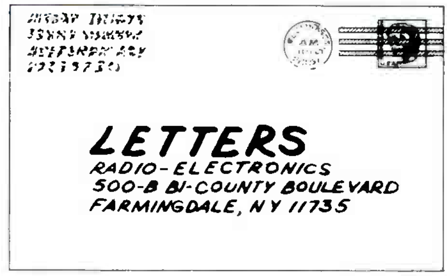
AUDIO UPDATE

continued from page 9

decrease in pitch when intensity is raised, while highs subjectively increase in pitch. Psychoacousticians know enough about that effect to chart it on what they call the *mel* scale.

Those, and other, reasons help explain why music sounds correct only when played at the level (the *original* level, that is) that properly relates to the ear's peculiar internal processing. I doubt that it's possible to design a loudness control that really works. So for the present at least, we will just have to do the best that we possibly can, loudness-wise—neighbors and spouses permitting. **R-E**

LETTERS



HDTV: A POPULIST'S VIEWPOINT

Day of wonders, time of HDTV miracles! The California Cowboys—who gave us Ronald Reagan, Paul Gann, and the shirking of all public responsibility—snuffle up to the Federal trough in their BMW's for HDTV grants.

We ought to let the Japanese pay for one of those boondoggles for a change: 99% of the national network/cable-show library is a trashy waste of time, and most of the remainder would gain little from being shown in HDTV format. When I can get an HDTV set for 120% of the price of a regular one then, maybe, I will buy one.

The comparison to compact discs is way off base. Most people buy CD's because LP's are so sickeningly easy to damage. Most likely, the recording will be dubbed onto cassette and played in a car, which is crawling on the freeway at 20 mph because the local government followed Don Lancaster's advice and tore up all those streetcar tracks. The headroom between background noise and gross ear damage will be maybe 40 dB, so who cares about fidelity? And, with today's longer work hours and slower commutes, who has time to listen at home?

I might be willing to fund the California Cowboys' toy development—in proportion to their willingness to fund items that are actually needed. (Even then, as a condition, I would require them to desist permanently from lecturing about "free enterprise," "bootstraps," and so on.) The public and semi-public services of this country—schools, housing, transportation, etc.—are disgraceful, and for the most part, cannot hold a candle to European and Japanese services. Until that is remedied, toys, however fashionable, deserve no public funding at all.

PAUL SCHICK
Madison, WI

HDTV: ANOTHER OPINION

Thank you for your clear summary of HDTV proposals (**Radio-Electronics**, January 1989). Don Lancaster's view in "Hardware Hacker" was well done, except that he suggested junking existing equipment.

Leave channels 2 through 13 alone, forever, so that folks with ordinary TV sets can tune in as always. Meanwhile, we can open up a brand new set of HDTV channels for the new sets—analogous to AM and FM radio.

No bandwidth available? Painfully untrue. 470–890 MHz is vacant, allocated for 69 little-used UHF channels—a massive piece of RF real estate, waiting for some decent usage. We'd only need half of it for HDTV; the rest could go to cellular and other uses.

Why doesn't the FCC share my opinion? I think that they are too spineless to tell channel 22 to take their re-runs and get off the air, and that they gave in to the political dreamers who think that American companies might manufacture VCR's, TV's, and camcorders. The Japanese did their homework and have their products ready; we didn't. We should just cooperate with their world standard, and enjoy their equipment.

Even if the FCC won't allocate broadcast space, Japan will prevail. Their widescreen TV's and VCR's will sell for pre-recorded

HIGH PLACES

TIGHT SPACES

No matter where you go, Tek's new 222 is a perfect fit.

Introducing Tek's new 222 Digital Oscilloscope. Weighing in at under 4.5 pounds, the new Tek 222 is an ultra-portable, 10-MHz digital storage scope that's perfect for service applications. So tough, rugged, and totally self-contained, it can go just about anywhere. And it's incredibly easy to use—even in extreme conditions.

Extraordinary capability and reliability at a great price. The 222 is a dual-channel scope that can measure a wide variety of electronic instrumentation and circuitry. It has rechargeable on-board batteries with a floating ground to 400 volts, and meets tough environmental standards.

Plus, the 222 lets you pre-define front-panel setups, and call them up with a single button in the field. You can also save waveforms in the scope's memory, then transfer them to a PC for analysis and hard-copy output when you get back to the shop.

Best of all, the 222 is yours for only $2350. And that includes Tek's remarkable three-year warranty on parts, labor, and CRT.

Get one to go! Pack a handful of power with you wherever you go. To order your 222, or for a free brochure, contact your local Tek representative or authorized distributor.

In a hurry? Call
1-800-426-2200.

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THH-911

CIRCLE 92 ON FREE INFORMATION CARD

movies and camcorder use. The cable networks can ignore the FCC. I'll be an early buyer, because I have no need for network-broadcast garbage anyway. I rent video movies.
NORMAN M. HILL
Bellevue, WA

AMPLIFIED SPEAKER MODIFICATIONS

I enjoyed Gary McClellan's "Amplified Speaker" article, which appeared in the September 1988 issue of **Radio-Electronics**. I built two of the speakers, using the exact parts that were specified in the Parts List. Both units performed as suggested in the check-out remarks at the end of the article. However, there's a problem present in both units that I'm hoping you can help me out with.

After turning the power switch on, it is necessary to turn the loudness potentiometer (R2) one-third to one-half a rotation before getting any volume. When the volume control is turned fully up, I get a moderate amount of sound—approximately half the audio that I get from a 5-watt amplifier that I've had for some time. Is there some slight change I can make that would put more audio into the circuit that would influence the volume potentiometer during the first one-third rotation? Could R1, or R12, or even R10 be reduced for more input to Pin 2 of IC1? Or, perhaps the one-third turn is normal? Not having experience with IC amps, I hesitate to make changes on my own.
T.E. DEWEY
Caney, KS

There are a few things that you can do to improve the sound level. If you think there is a low-volume problem, check the audio-input level, speaker system, and amplifier circuitry.

This unit is intended for input levels above 150 mV, as provided by tuners, tape decks, etc. If your level is less, there are two things you can do. First, connect a 22-µF electrolytic capacitor across R5. That boosts preamp gain a bit. For more gain, build an amplifier and connect it between the line and the amplifier's volume control. Duplicate the Q1 circuitry from C3 through R4, as shown on the schematic drawing, and power it from D1. With that setup, a dynamic microphone should drive the amplifier to full volume.

The speaker system itself is as important as the amplifier. If you use a low-efficiency unit, the volume will be low. I use a KLH *model 23 (8-inch woofer, 2½-inch tweeter), and the volume is enough to drive most reasonable-minded people from my workshop. The sound quality is also quite excellent.*

As for the amplifier, your volume-control action is characteristic for the modified log-taper potentiometer specified. If you don't like it, substitute a 100K linear-taper pot, leaving out C2–R1. I guarantee you will be startled by the difference!

Before modifying the circuitry, make sure that all voltages are present and that there is about 5 *volts on the collector of Q1. Also, turn up the volume and measure the voltage across C23. If it sags below 11 volts on the audio peaks, get a transformer with more current capacity. Understand that a small transformer cuts power output drastically!*

And, finally, to answer your questions on the power-amp IC, gain is set internally and can't be changed by varying parts values.—GARY McCLELLAN

PC DIS-SERVICE

As a long time subscriber/reader of **Radio-Electronics** and many other Gernsback publications, I would like to comment/complain about a practice that you have taken up recently. I'm an avid experimenter and builder, and I like to make my own printed circuit boards. However, I am not set up on a large scale, and do not own real photographic equipment or have access to any. When I make a board, it is a one-to-one layout with positive artwork transferred by contact exposure to a positive sensitized board.

When your magazine started printing the actual positive artwork for the articles printed in the issue—on a page all alone and with nothing behind them to mess things up—I was delighted. That was the best thing that could have happened for me, because I could directly transfer the layout from the magazine, and didn't have to have a transparency done.

I would like to complain very bitterly about your recent practice of putting a second layout or printing behind the artwork. I thought that the entire idea of putting the artwork on its own page, with nothing behind it, was for people like me who like to make their own boards, but don't have a regular board factory to do it.

Please, please go back to arranging the pages so that the layouts are free of anything behind them.
JIM PRUITT
Richland, WA

If we go back to the practice of leaving the back of PC Service pages blank, that's one less page of information we can print. Well, readers, let's take a vote. Send us your comments.—Editor **R-E**

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You build this powerful Packard Bell VX88 computer, all the while gaining a true mastery of computer electronics. Best of all, it's yours to keep for all your professional and personal computing needs.

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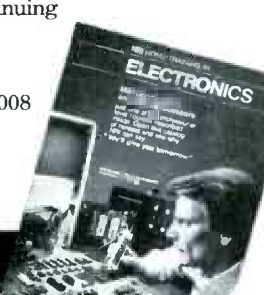

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EQUIPMENT REPORTS

Tektronix 222 Handheld Digital Storage Oscilloscope

10-MHz performance in a compact package.

CIRCLE 40 ON FREE INFORMATION CARD

THE IDEA OF A HANDHELD OSCILLOSCOPE has always been attractive. Unfortunately, the idea for the product has been, more often than not, more attractive than the final result. But we recently examined a handheld, dual-channel, 10-MHz scope that we could live with: the model *222* digital storage oscilloscope from Tektronix (P.O. Box 500, Beaverton, OR 97077).

First off, let's define what we mean by "handheld." The *222* measures about 3½ × 6 × 10 inches. It has a side-mounted strap and rubber-coated grip, so it is indeed designed for handheld operation. However, the scope weighs in at 4½ pounds, so you're not likely to hold it very long without tiring. Fortunately, Tektronix supplies a great carrying case with a shoulder strap that makes portable operation almost comfortable.

We can imagine many applications where the *222* could help the technician on the go. But if you're a field-service engineer, you can undoubtedly come up with dozens of your own applications that would be made easier with a handheld scope. Will the *222* fit your needs?

Specifications

The vertical sensitivity of the *222* is adjustable from 5 millivolts to 50 volts per division, and the timebase is adjustable from 50 nanoseconds to 20 seconds per division. The scope's 8 × 10-division graticule measures about 2.5 inches diagonally.

The *222* has a bandwidth from DC to 10 MHz and a digitizing rate of 10 megasamples per second. Its single-shot storage bandwidth is 1 MHz, while it's repetitive storage bandwidth is 10 MHz. For those who are not familiar with digital scopes, some explanation is in order. Digital storage scopes use two digitizing techniques: real-time and equivalent-time sampling. In real-time sampling, all samples for a signal are acquired in a single acquisition period. In equivalent-time sampling, the samples from a repetitive signal are stored; the final display is built up by taking samples of the repetitive signal over multiple sampling periods. Equivalent time sampling serves to extend the useful range of a digital scope.

Digital scopes like the *222* can do lot of things that an analog scope cannot. For example, you can easily freeze any waveform on the screen so that you can examine it closely. For field service, the ability to store up to four waveforms for examination—even hours or days later—can be a godsend. Conversely, you can arrive at the sight with four stored waveforms with which you can compare your field results.

Another example of where a digital scope offers advantages over a similar analog model is in finding glitches. The *222*'s envelope acquisition mode accumulates positive and negative peaks on the display. Any peaks that fall outside of the envelope can be easily spotted. If you use a glitch as a trigger event, only a digital scope like the *222* will let you see events that occurred before the trigger.

Using the *222*

As you might expect, every effort was made to keep the *222* as small as possible. One of the ways Tektronix accomplished their goal was to use a menu system for selecting many functions. Four *soft keys* are used to select functions from a menu that is displayed alongside the keys on the CRT. For example, when the TRIGGER SOURCE key is pressed, the four soft keys are used to choose between internal and external trigger sources.

The top panel of the scope has a set of 8 frequently-used controls that are used to call up waveform-storage, mode, setup, auxiliary, and trigger-position menus. The rear panel includes such infrequently used controls as intensity, focus, and trace rotation.

The *222*'s *auto setup* function makes it easy to get a meaningful display on the CRT. When that function is selected, the scope autoranges the vertical sensitivity, timebase, and trigger level. Another time-saving feature is the ability to store and recall up to four front-panel setups.

An RS-232 serial port is available on the rear panel of the *222*. A computer can upload front-panel setups and waveforms to the scope and vice-versa. That feature is attractive because, among other things, it lets you do troubleshooting from a remote location.

The Tektronix *222* is priced at $2350. It would be tough to find more scope for less money in a package this small. **R-E**

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Both instruments require an antenna. Order the model TA-100S Telescoping RF pick up antenna, $12, for maximum sensitivity. The flexible model RD-100 Rubber Duck is $20. Model CC12 vinyl zipper carrying case is $10. Aluminum cabinet is 3.9″ H x 3.5″ W x 1.″ One year parts and labor guarantee. Add 5% shipping (mininum $2) all orders.

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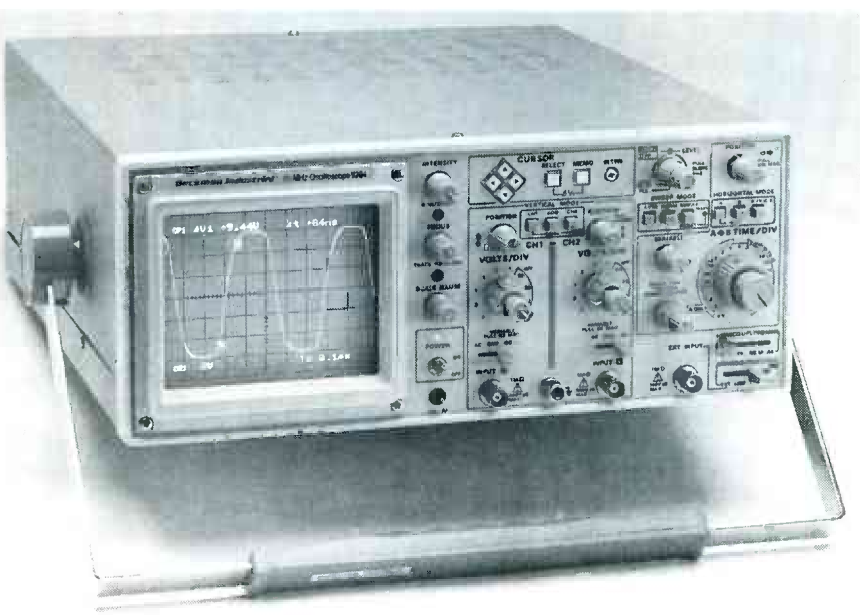

CIRCLE 10 ON FREE INFORMATION CARD

OSCILLOSCOPES. *Beckman's* 20-MHz model *9202* and 40-MHz model *9204* (pictured) oscilloscopes feature on-screen readouts of cursor positions and scale settings. The "Numeric Readout Display" has two special sets of cursor pairs. Each set has a reference and a delta cursor, both of which can be moved individually or as a pair in eight different directions. The cursors measure amplitude, time, frequency, duty cycle, and phase shift. Voltage and frequency readings can be taken simultaneously.

The scopes are recommended for general electronics- and video-service applications, as well as production tests, quality control, and engineering research and development. Both models feature "A" and "B" sweeps, with delayed sweep and segment magnification; TV-sync coupling for easy video service; and camera-mount CRT bezel, variable-scale illumination, and single-step operation for waveform photography. A variable hold-off control ensures proper triggering on complex signals. Two switchable ×1/REF/×10 probes are included along with each scope.

The *9202* and *9204* oscilloscopes cost $865.00 and $1095.00 respectively.—**Beckman Industrial Corporation**, Instrumentation Products Division, 3883 Ruffin Road, San Diego, CA 92123-1898.

PORTABLE CD SOUND SYSTEM. *Soundesign's* model *4955* offers on-the-go music lovers a choice of listening to CD's, cassette tapes, or AM/FM radio, through 2-way stereo speakers with "Extra Bass Sound (XBS)" or, more privately, via a headphone jack. The lightweight unit measures 24½ × 8 × 6 inches, and has a black, granite-like finish. It runs on AC power or D-size batteries, and has a fold-away carrying handle.

The front-loading CD player uses 3-beam, 1-laser pick-up, and features a 16-item, random-access memory for standard-size discs. The smaller CD singles can be played with the use of an adapter. Track number, total time, time remaining, program number, pause, and repeat are displayed on a 6-digit LCD.

The *4955*'s dual tape deck, with high-speed or normal dubbing, allows users to record from the other cassette deck, the CD player, the radio, or live (microphone not included). The cassette deck plays continuously from tape to tape. The AM/FM radio's sound is adjustable with slide controls on the 3-band graphic equalizer. The radio has automatic frequency control for improved reception, and PLL-MPX circuitry for better stereo separation.

CIRCLE 11 ON FREE INFORMATION CARD

The model *4955* portable CD sound system has a suggested retail price of $229.95.—**Soundesign Corporation**, Harborside Financial Center, 400 Plaza Two, Jersey City, NJ 07311.

CAR CD SYSTEM. *Pioneer's DEH-55* is a high-power, one-piece combination CD player, amplifier, and AM/FM tuner that provides the convenience of direct in-dash replacement. The audio package can be installed as either a front- or rear-mount DIN-sized replace-

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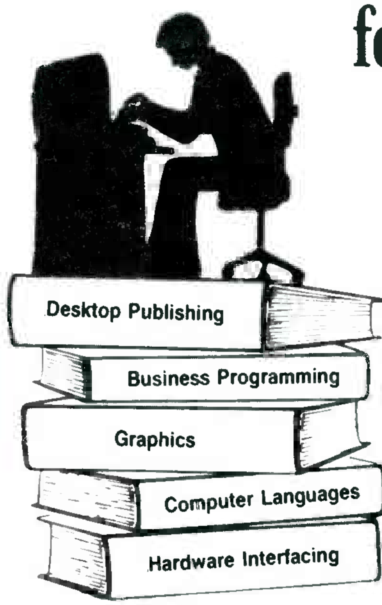

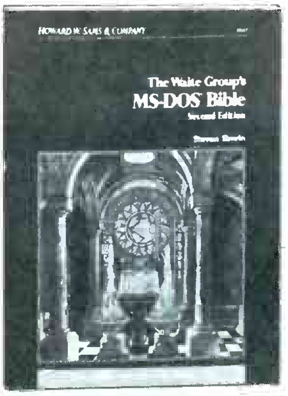

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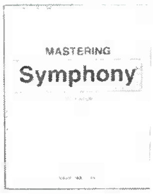

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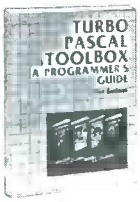

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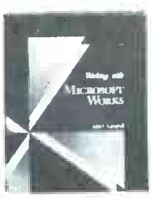

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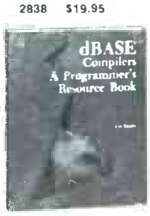

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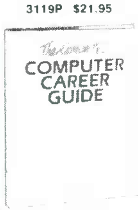

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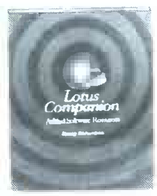

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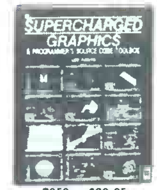

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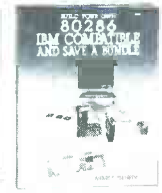

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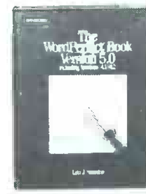

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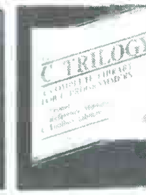

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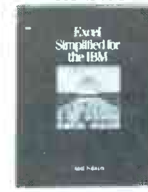

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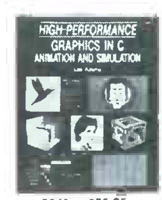

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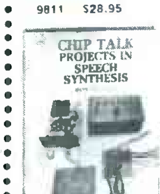

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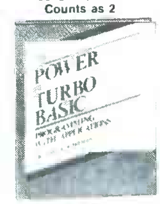

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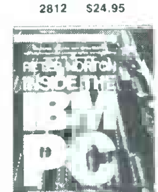

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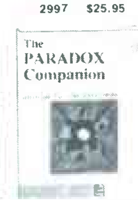

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ment unit; all it requires are a pair of digital-ready speakers and a dashboard opening.

The CD player offers a variety of playback modes, including track search, track scan, music repeat, and random play. The two-times oversampling unit with three-beam laser pick-up also offers fast-forward and reverse functions with sound; and power disk-load, power-eject, and auto-play features included.

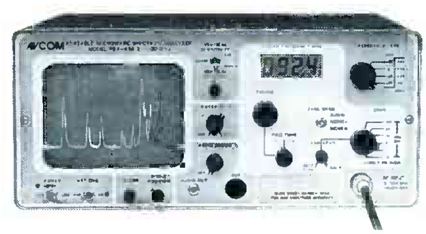
The AM/FM tuner uses PLL-quartz electronic digital tuning, with Pioneer's "Supertuner III." It has 24 station presets (18 FM and 6 AM), preset scan for finding local stations, and "best stations memory" that accesses and stores the 6 strongest stations in a designated area. A built-in pulse-noise suppressor eliminates ignition and static noise received through the antenna.

The unit's amplifier delivers 20-watts per channel, and has electronic volume/balance controls, separate bass and treble controls, and an electronic preamp fader control.

The "euro-style" unit has a digital multi-function level display that shows volume, bass, treble, balance, and fader settings in numeric values, rather than bar-graph level indicators. A large LCD with a clock readout is easy to read.

The *DEH-55* car-audio package has a suggested retail price of $600.00.—**Pioneer Electronics (USA) Inc.**, 2265 E. 220th St., P.O. Box 1720, Long Beach, CA 90801-1720.

PORTABLE SPECTRUM ANALYZER. The *Model PSA-65A* from *Avcom* is a portable microwave spectrum analyzer that covers frequencies through 1,000 MHz in one sweep,



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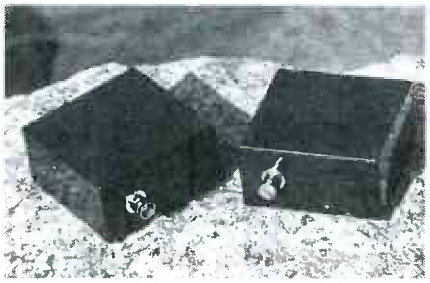
with greater than −90-dBm sensitivity at narrow spans. The lightweight instrument can be used for 2-way radio, cellular, cable, LAN, surveillance, production, and R&D work.

The *PSA-65A* measures 11½ × 5½ × 13½ inches, and weighs 18 pounds. It runs on batteries or AC power. Options include audio demodulators for monitoring, log-periodic antennas, a carrying case, and frequency extenders that enable the instrument to be used at Satcom and higher frequencies.

The *PSA-65A* portable spectrum analyzer costs $2,675.00.—**Avcom of VA, Inc.**, 500 Southlake Blvd., Richmond, VA 23236.

OUTSIDE CONNECTOR. The *WPO Window Coupler* from *Electron Processing* provides a novel way to connect an outside antenna to an indoor television, scanner, or UHF/VHF transceiver. The coupler,



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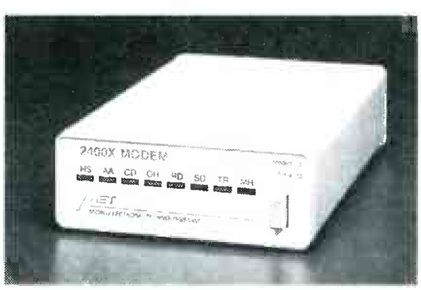
which consists of two boxes, mounts on a window using double-faced tape, and completely eliminates the need to drill holes in the window frame to route the antenna line—even coaxial cable. Each 3- × 3- × 1½-inch, weatherproof box contains either a BNC, UHF (PL-259 mate), or type-F connector for antenna and receiver (or transmitter) hookups.

The *Window Coupler* is available in three models. The *WPO-VHF* is for use in the 140–160-MHz range, and the *WPO-UHF* is for the 440–460-MHz range. Both of those models are rated for 25 watts and provide a 1.5:1 VSWR across a 10-MHz section of their bands with a loss of 2 dB or less on most windows. The third model, the *WPO-TV* covers the entire 60–800-MHz band, with only 8-dB loss. It is for TV, FM, and scanner receiving only.

The *WPO-UHF* and *WPO-VHF* cost $59.95 apiece, and the *WPO-TV* costs $49.95. An optional suction-cup mounting bracket (*SC-4*) is available for $20.00.—**Electron Processing, Inc.**, Sales Department, P.O. Box 708, Medford, NY 11763.

2400-BAUD MODEM. The *MET 2400X "Smart Modem"* eliminates



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the need to purchase an additional serial port. Because the modem incorporates two RS-232 ports, a printer, mouse, or other peripheral can be linked to the computer through the modem. The modem's "Pass Thru" feature automatically connects the peripheral and the computer when the modem is turned off.

Designed for high-speed synchronous and asynchronous communications, the *MET 2400X* works with all microcomputers that have a serial RS-232 port, and is Bell-103 and 212A compatible. It automatically detects and adjusts to a 2400, 1200, or 300 baud.

The *MET 2400X* costs $295.00. Volume discounts are available, as are packages including specially priced *Mirror III* (for IBM compatibles) and *Microphone* (for Apple Macintosh PC's) communications software.—**Micro Electronic Technologies Inc.**, Computer Products Division, 35 South Street, Hopkinton, MA 01748.

MAGNETIC WRIST BAND. If you've ever had to watch a tiny screw roll out of reach under your

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workbench while assembling a project, you'll appreciate the *Handy-Dandy Wrist Magnet* from *Yale Audio*. Presenting a simple, convenient solution to such dilemmas, the product resembles a wristwatch—but where you'd expect the face to be, there's a thin, square, flat-surfaced magnet fitted in a durable polymer mounting. Wearing the wrist magnet allows you to keep nails, screws, or tiny metal parts close at hand, leaving both hands free for working.

The *Handy-Dandy Wrist Magnet* costs $5.49, plus $1.25 shipping (in U.S.).—**Yale Audio of Florida Corp.**, 2702 Azeele St., Tampa, FL 33609; 813-876-6789.

NEW LITERATURE

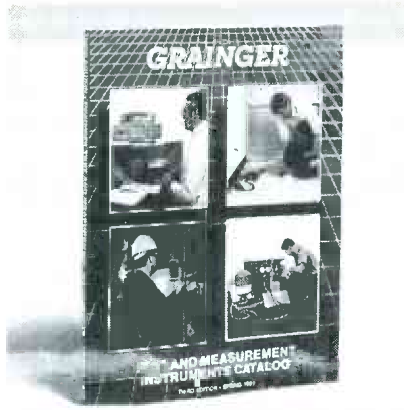
TOOL & TEST CATALOG. *Contact East's* sourcebook of instrument products for testing, repairing, and assembling electronics equipment features new products in such categories as analog/digital oscilloscopes, static-protection devices, soldering supplies and solder stations, test equipment, precision hand tools, and tool kits.

contact east

CIRCLE 17 ON FREE INFORMATION CARD

Other expanded lines include voice/data-communications test instruments, wire and cable aids, electronic adhesives, and inspection equipment. All products are described in detail, guaranteed, and mailed via the company's "Same-Day Shipment" policy. The *1989 General Catalog*, which includes one year of technical supplements, is free upon request.—**Contact East**, 335 Willow Street South, P.O. Box 786, No. Andover, MA 01845.

TEST/MEASUREMENT CATALOG. The third edition of *Grainger's* catalog contains more than 2,000 products from 45 leading manufacturers, including B&K Precision, Simpson, Pomona, Fluke, Beckman, Hitachi, and A.W. Sperry. Nine product categories—General Testing, Precision Measuring, Electronics, Electrical, Temperature/Humidity Measuring, HVAC/Refrigeration, Environmental, Auto Diagnostics, and Ac-



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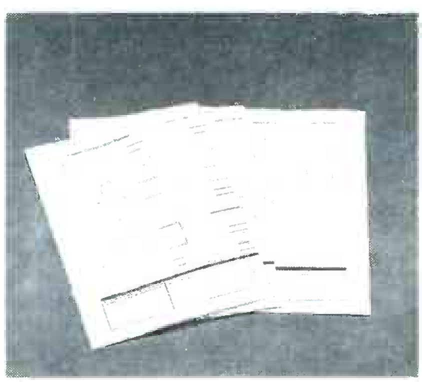
cessories/Reference—are included in the 156-page manual. The catalog is free upon request.—**W.W. Grainger, Inc.**, 1250 Busch Parkway, Buffalo Grove, IL 60089.

CONFIGURATION PLANNER. The *Heath/Zenith* planner is a fully-illustrated flow chart that proceeds, step by step, through logical choices in planning individualized data-acquisition and process-control systems.

The planner, designed for manufacturing and processing personnel, is a "guided tour" of digital or analog input, output, and I/O systems. It highlights the main fea-



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tures of Heath/Zenith's modular-instrument products, helping designers to quickly identify the correct components to convert a manual data-gathering or system-control operation into an interactive management-information system, or to make adjustments in an existing system when operations change. The *System Configuration Planner* is free upon request.—**Heath/Zenith Computer Based Instruments**, P.O. Box 21, St. Joseph, MI 49085. **R-E**

DRAWING BOARD

ROBERT GROSSBLATT,
CIRCUITS EDITOR

A complete circuit

OVER THE LAST COUPLE OF MONTHS we've gone through the steps needed to design custom-character generators and looked at some simple ways to use them.

Now let's turn all the pieces into a useful circuit.

The handiest thing to come up with is a way to use one character generator to drive several digits.

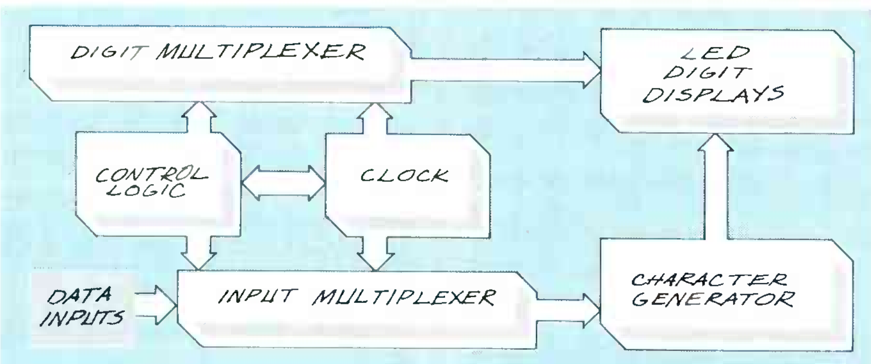

FIG. 1

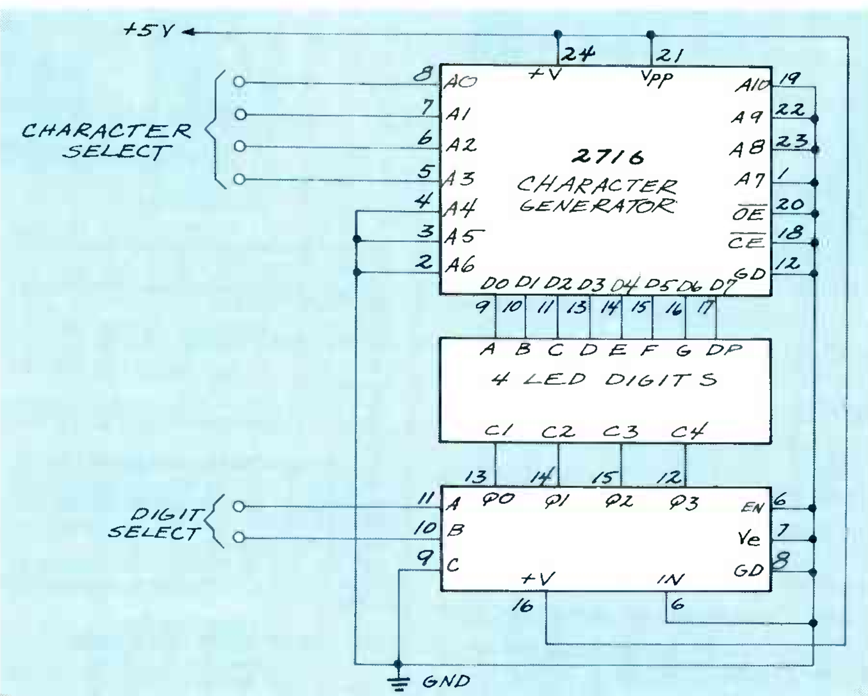

FIG. 2

257#1 OE	257#1 SEL	257#2 OE	257#2 SEL	DISPLAYED DIGIT
L	L	H	X	INPUT 1
L	H	H	X	INPUT 2
H	X	L	L	INPUT 3
H	X	L	H	INPUT 4

FIG. 3

OE	SEL#1	SEL#2	DISPLAY
L	L	X	INPUT 1
L	H	X	INPUT 2
H	X	L	INPUT 3
H	X	H	INPUT 4

FIG. 4

The basic idea here is to build a general-purpose display circuit.

Let's lay down some criteria:

1. The circuit will drive four digits.

2. Each digit will have its own set of inputs.

3. Only one character generator will be used.

4. The circuit will display all the hex digits from 0000h to FFFFh.

Even though we've been designing a character generator that can handle a lot of the ASCII characters, limiting our display to hex will keep the circuit simpler. If you absolutely must display ASCII characters, the circuit will be basically the same, but you'll need more bits assigned to each of the digits. A hex display only cares about the lower four bits while a full ASCII display has to deal with seven bits.

When you come right down to

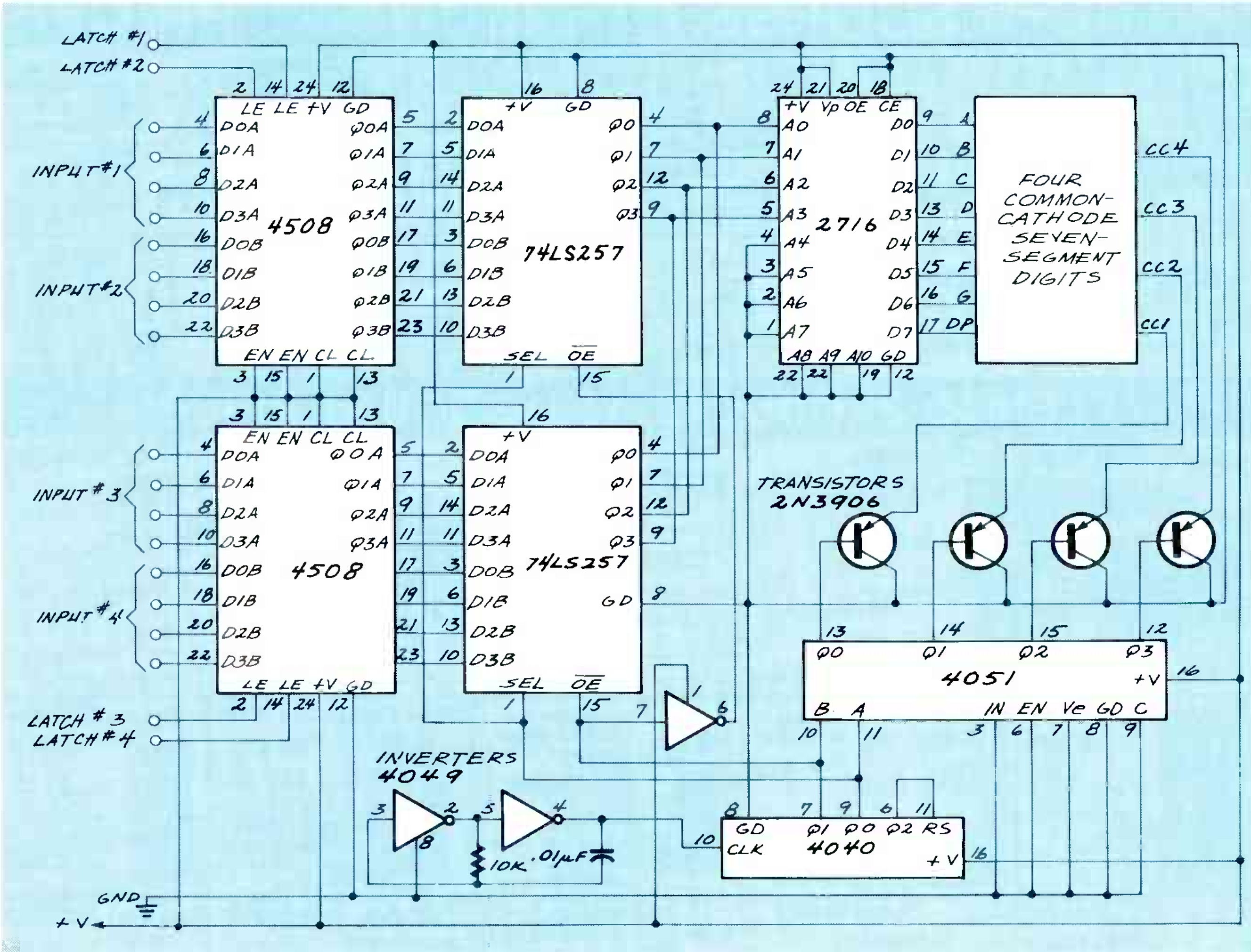

FIG. 5

it, we want the display circuit to be your basic black box with sixteen inputs—four for each of the four digits we'll be driving. Since we're actually building something that can be used elsewhere, we can eliminate some of the parameters we put into the EPROM. We're already disregarding the ASCII stuff and now we'll make the decision to use common-cathode displays.

That last decision is no big deal because it's a relatively trivial thing to convert the circuit to work with a common-anode digit...but we're getting ahead of ourselves.

The block diagram of the circuit we'll be designing is shown in Fig. 1. The heart of the circuit is really the control logic because it has the job of keeping everything in sync. We have to be sure that when we're sending character number 1 to the input multiplexer, that we're also turning on seven-segment LED number 1. If things get out of sync you might have something up on the display but it's not going to be anything useful.

The starting point of the circuit is shown in Fig. 2. It's similar to the circuit that we looked at in May, but there are two main differences. The first is that we're only using A0–A3 on the EPROM and the second is that the 4051 is going to drive only four digits so the "C" input (pin 9) is tied low. The same thing is done with all of the unused EPROM address lines.

We've already decided on the 4051 as the digit multiplexer so let's take a look at the input multiplexer as well before getting to the control logic. After all, you can't design control logic until you know what you have to control.

Just as the 4051 will sequentially turn on one digit after another, the input multiplexer has to select the corresponding digit data to be displayed. What we need is the electronic equivalent of a four-pole, four-position rotary switch, and one way to do that is to use a pair of 74LS257's. You can use the TTL version of the chip or the 74HC257 or 74HCT257 pin-equivalent CMOS parts.

The inputs that will appear at the outputs depend on the state of the SEL input. Making that pin low will select the first set of inputs and making it high will select the others. What makes the 257 a good IC for our application is that it also has an OUTPUT-ENABLE pin so that our output can have three states.

Now that we know what multiplexers we'll be using, we can work out what we need for control logic. Designing this kind of circuitry can be a really brain-bending exercise but one way to cut it down to size is to use a truth table like the one shown in Fig. 3.

It may seem a bit confusing at first glance, but one thing it tells us right away is that the OUTPUT-ENABLE pins of the 257's are always opposite each other. When one is high, the other is low, and vice versa. That means we can tie them

continued on page 85

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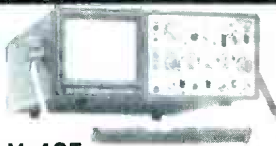

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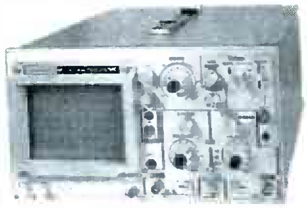

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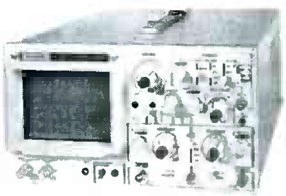

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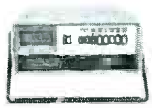

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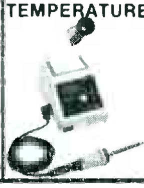

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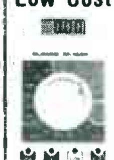

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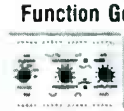

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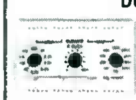

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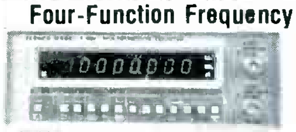

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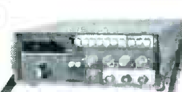

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A complete *L*ight-*B*eam *C*ommunicator (LBC) consists of a transmitter and a receiver, installed inside 2 tube-like assemblies, along with various optical components. Two complete LBC's are required for two-way communication, but you will need only one transmitter and one receiver for one-way communication. Full-duplex operation is provided, meaning that you can talk and listen at the same time—there is no transmit/receive switch.

Figure 1 shows the block diagram of the transmitter. The transmitter houses a high-intensity LED, powered from a constant-current source, as well as the circuitry necessary to modulate an audio signal from a microphone onto the LED's light output. Using the optics, the modulated light from the LED is focused into an intense, narrow beam.

That narrow light beam travels a surprisingly long distance. The standard unit has about a ¼-mile range. The high-power unit has an amazing range of better than ½-mile! (When testing the range of the units, we used small "toy" 100-mW walkie talkies to assist with setup and aiming—the walkie talkies "ran out of gas" long before the LBC did!) At the end of its travel, the beam is received by another identical LBC that turns the modulated light beam back into the original audio signal. The receiver's block diagram is shown in Fig. 2. Let's examine the individual sections more closely.

The difference between the standard LBC and the high-power LBC is the LED that is used. The standard unit has a high-intensity 3-candela-power (3,000 milli-candela or mcd) LED manufactured by Hewlett Packard (a *candela*, formerly candle, is a measure of luminous intensity). The high-power unit has a very-high-intensity 12-candela (12,000 mcd) LED, also manufactured by Hewlett Packard. Both of those LED's are much brighter than a normal LED, and they have a focusing rather than a diffusing lens. However, *any* LED will work but the useful range of the LBC will be greatly reduced if a high intensity LED is not used.

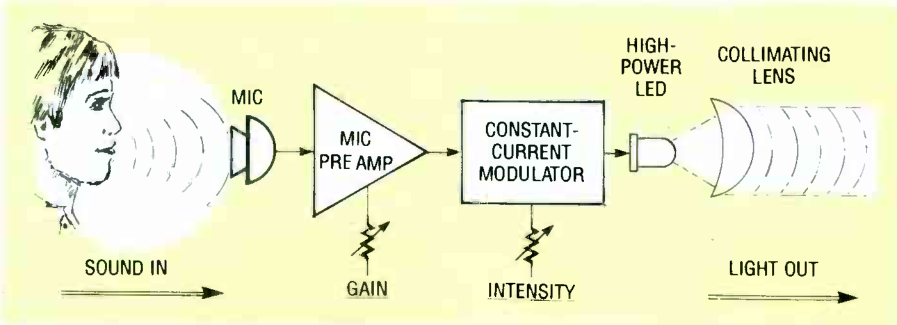


FIG. 1—BLOCK DIAGRAM OF THE TRANSMITTER. This circuit contains a high-intensity LED, powered from a constant-current source, and the circuitry necessary to modulate an audio signal onto the LED's light output.

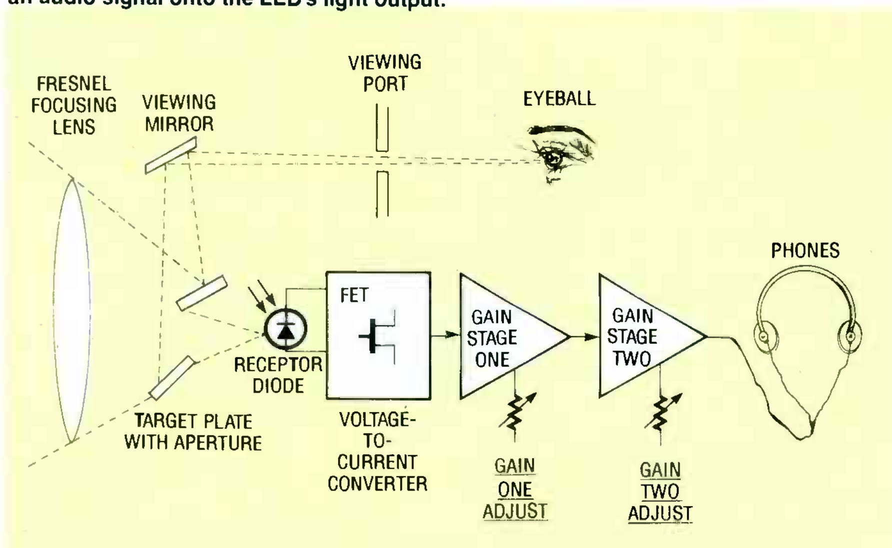


FIG. 2—RECEIVER BLOCK DIAGRAM. This circuit turns the modulated light beam back into the original audio signal.

The transmitter

There are two stages in the transmitter: a microphone preamplifier and a constant-current modulator (see Fig. 3). Each stage uses half of a 5532, which is an internally compensated, dual low-noise op-amp. After the microphone output is preamplified by IC1-a, the output signal from pin 1 is fed through C6 to pin 5 of IC1 where it is further amplified.

An adjustable constant-current source is fed to Q1, an NPN transistor capable of handling at least 3 amps. The audio signal at pin 7 of IC1 drives the base of Q1, modulating the signal onto the LED's light output. (An infrared LED can be used for this project, and will, in fact, increase the range. Unfortunately IR light is invisible, so it is not easy to work with. However, among the interesting things you can "hear" with the LBC are IR remote controls and IR burglar-alarm sensors.) Basically, the AC signal either adds or subtracts from the average DC level. Transistor Q1 and LED1 are in the feedback loop of the op-amp, and the DC current flowing through the LED remains constant due to the setting of R9. The DC current can be adjusted via R9 through a range from 1 to 50 mA.

The transmitter assembly, shown in Fig. 4, is fitted inside one end of a rugged cardboard tube that has a collimating lens at the other end. That lens focuses the light beam into a very narrow, intense beam, giving the light from an LED such an unusually long range.

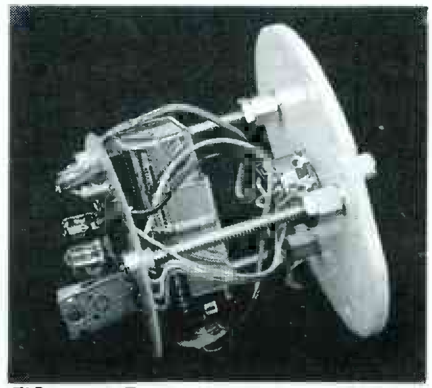


FIG. 4—THE TRANSMITTER ASSEMBLY. It is fitted inside one end of a rugged cardboard tube that has a collimating lens at the other end.

The receiver

The schematic for the receiver section of the LBC is shown in Fig. 5, and the receiver assembly is shown in Fig. 6. The receiver assembly is mounted inside one end of a large tube, which has a fresnel lens at the other end. The fresnel lens concentrates the light beam, and directs it to the photodiode, D1. The photodiode provided in the kit is actually a Kodak part, and not available to the general public. That part is well suited for this application, and it is more sensitive to infrared light than most photodiodes; but if you don't buy the kit, any silicon photodiode or phototransistor

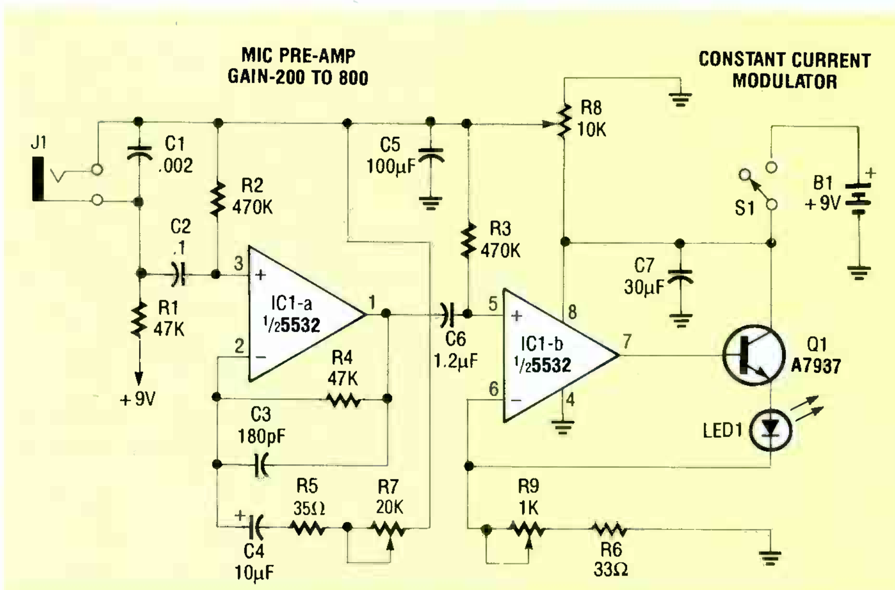


FIG. 3—THE TRANSMITTER CONTAINS TWO STAGES: a microphone preamplifier and a constant-current modulator. Each stage uses half of a 5532 op-amp.

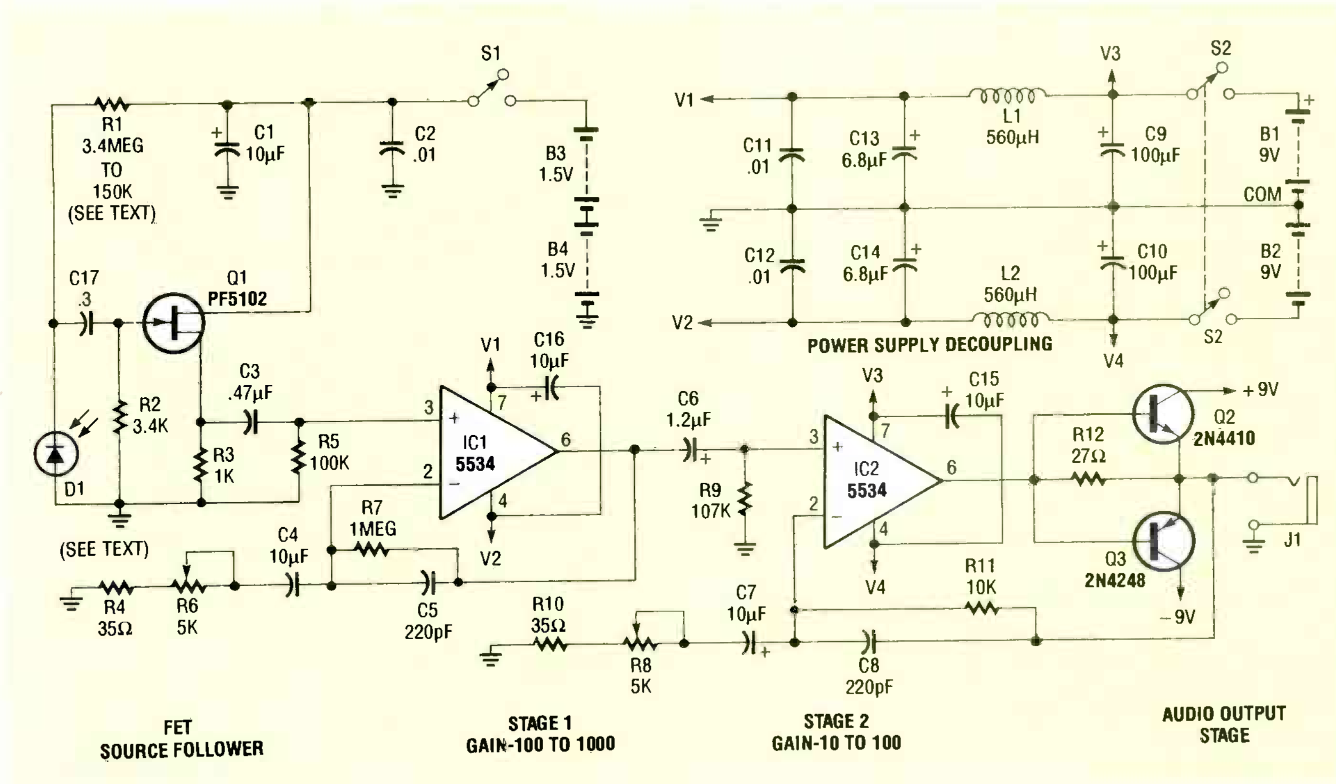


FIG. 5—THE RECEIVER SCHEMATIC.

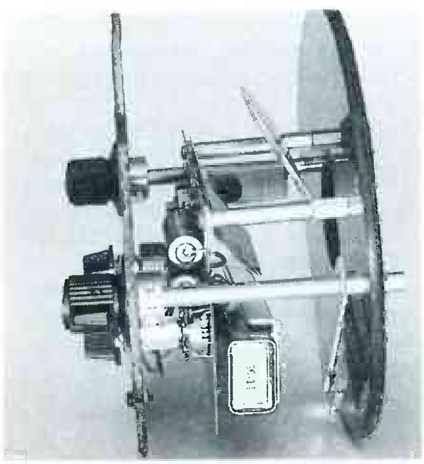


FIG. 6—THE RECEIVER ASSEMBLY. It is mounted inside one end of a large tube, which has a fresnel lens at the other end.

should do. The small signal that is generated by D1 is fed to pin 3 of IC1 via FET Q1.

Op-amp IC1 is the first gain stage in the receiver, and it amplifies the signal from Q1 100 to 1000 times, depending on the setting of gain-control potentiometer R6. The signal from pin 6 of IC1 is then fed through C6 to pin 3 of IC2, which is the second gain stage; the gain of the second stage is variable from approximately 10 to 100 via gain-control potentiometer R8. Two gain-control potentiometers are used to help improve stability, because stray oscillation is hard to avoid in a circuit with so much gain.

The signal at pin 6 of IC2 is then fed to R12, which is connected across the base-emitter junction of both Q2 and Q3. The voltage across R12 turns Q2 and Q3 on and off; those transistors are capable of driving a pair of low-impedance headphones.

Note that R1 is listed as being 3.4 megohms or 150 kilohms. That's because, if you use a value near 3.4 megohms, the receiver will be extremely sensitive, resulting in the greatest possible range. On the other hand, a value near 150K will decrease the sensitivity while providing a wide bandwidth, giving the unit higher fidelity. You can use any value between 3.4 megohms and 150 kilohms, but do not use a potentiometer, as it will be a source of noise in the circuit.

Construction

Let's start by building the transmitter board. Foil patterns for both boards are provided in PC Service. Figure 7 is the Parts-Placement diagram for the transmitter. First install the resistors, then the capacitors (bend the leads, solder, and then trim), and then the potentiometers. Cut some ribbon cable into 6 2-conductor pieces (3 for now and 3 for later), 1½-inches long, and then separate and strip the ends. (Any thin,

PARTS LIST—TRANSMITTER

All resistors are ¼-watt, 5%, unless otherwise noted.
R1, R4—47,000 ohms
R2, R3—470,000 ohms
R5—35 ohms
R6—33 ohms
R7—20,000 ohms, PC-mount potentiometer
R8—10,000 ohms, PC-mount potentiometer
R9—1000 ohms, combination potentiometer/switch (incorporates S1)

Capacitors
C1—0.002 µF, 50 volts, ceramic
C2—0.1 µF, 50 volts, ceramic
C3—180 pF, 100 volts, ceramic
C4—10 µF, 10 volts, electrolytic
C5—100 µF, 10–25 volts, electrolytic
C6—1.2 µF, 20 volts, electrolytic
C7—30 µF, 20 volts, electrolytic

Semiconductors
IC1—NE5532 dual low-noise op-amp
Q1—7937 3-amp NPN transistor
LED1—high-intensity light-emitting diode, can be Hewlett Packard HLMP-8103 (3000 mcd) or HLMP-8150 (12,000 mcd), or any other high-intensity LED.

Other components
B1—9-volt battery
S1—SPST switch (part of R9)
J1—mono phone jack

Miscellaneous: 9-volt-battery clip, 8-pin DIP socket, wire, solder, etc.

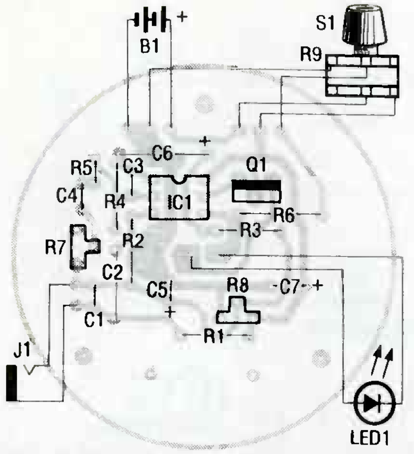


FIG. 7—TRANSMITTER parts-placement diagram.

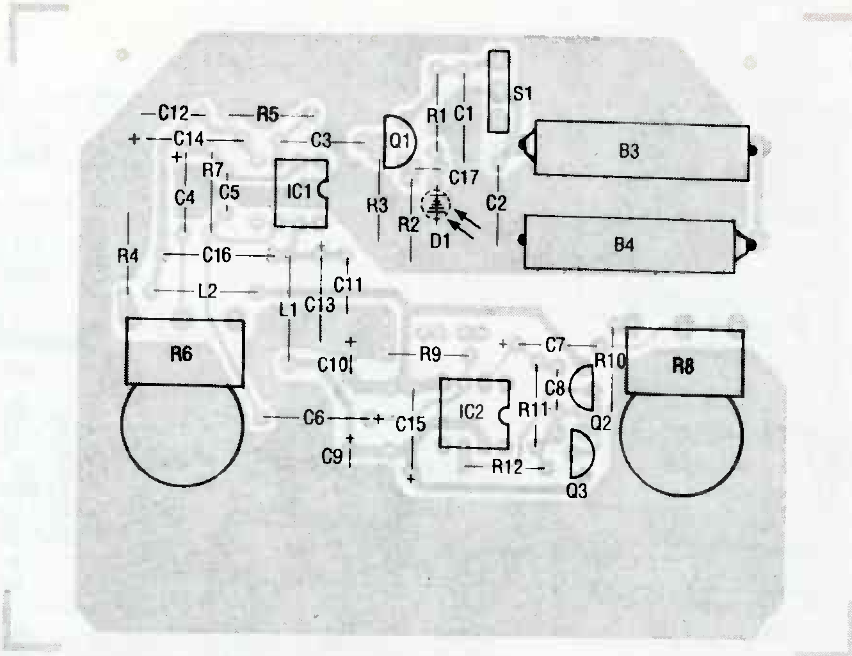


FIG. 8—RECEIVER PARTS-PLACEMENT DIAGRAM.

PARTS LIST—RECEIVER

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

R1—between 3.4 megohms and 150 kilohms (see text)
R2—3.4 ohms
R3—1000 ohms
R4—35 ohms
R5—100,000 ohms
R6, R8—5000 ohms, potentiometer
R7—1 megohm
R9—107,000 ohms
R10—35 ohms
R11—10,000 ohms
R12—27 ohms

Capacitors

C1—10 µF, 50 volts electrolytic
C2, C11, C12—0.01 µF, 10 volts, ceramic
C3—0.47 µF, 20 volts, ceramic
C4, C7—10 µF, 10 volts, electrolytic
C5, C8—220 pF, 100 volts, ceramic
C6—1.2 µF, 20 volts, electrolytic
C9, C10—100 µF, 15 volts, electrolytic
C13, C14—6.8 µF, 20 volts, electrolytic
C15, C16—10 µF, 25 volts, electrolytic
C17—0.3 µF, 50 volts, ceramic

Semiconductors

IC1, IC2—NE5534 single low-noise op-amp
D1—Siemans BPW-33 silicon photodiode (see text)
Q1—PF5102 field-effect transistor
Q2—2N4410 NPN transistor
Q3—2N4248 PNP transistor

Other components

L1, L2—560 µH
S1—SPST switch
S2—DPDT switch
B1, B2—9-volt battery
B3, B4—1.5-volt N-size battery

Miscellaneous: 2 9-volt-battery clips, DIP sockets, wire, solder, etc.

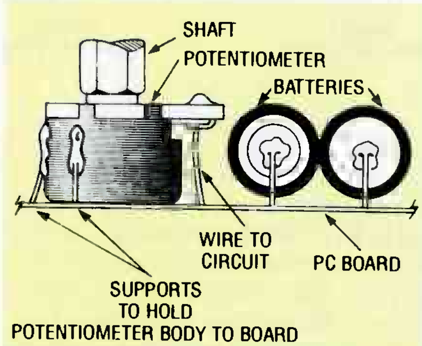


FIG. 9—YOU MUST USE PIECES of bus wire to attach potentiometers R4 and R6 securely to the PC board.

stranded wire will do if you don't have ribbon cable.) Then use one piece to connect the microphone jack, J1, to the pads indicated in Fig. 7, and two more to connect R8/S1.

Connect a 9-volt battery clip to the appropriate pads on the board, and then install IC1. (It's a good idea to use a socket for IC1.) Last, position LED1 (observe its polarity) so that it is standing perfectly straight off the PC board, then solder it in place.

For the assembly of the receiver board, see Fig. 8. First install resistors R1–R12, and then install the capacitors observing polarity where indicated. Then install L1 and L2, and sockets for IC1 and IC2. Using pieces of bus wire, attach potentiometers R4 and R6 securely to the PC board as shown in Fig. 9. Prepare B3 and B4 by soldering a short length of bus wire to each terminal (see Fig. 9) so that each battery can be PC mounted. PC-mount S2 and solder it in place. Now

ORDERING INFORMATION

The following are available from General Science and Engineering, P.O. Box 447, Rochester, NY 14603 (716-338-7001): Kit of all parts, including all electronic and mechanical components, $98; Set of two PC boards, $12.00; 6-inch Fresnel lens, $15.00; A headset with built-in microphone, $12.00; Telephone-type handset, $5.00; Siemans BPW-33 photodiode, $3.50; HLMP-8150 12-cd LED price to be determined (call GSE for information); Assembled and tested communicator, $198. Note: the spotting scope is not available from GSE.

turn the board over, and solder D1 (the photodiode) in place observing its pc larity indicated by a painted dot on it anode.

Take two 9-volt-battery clips and on one of them, clip the red lead dow to 1 inch and the black one to 2½ inches; on the other battery clip, cu the black lead down to 1 inch and th red to 2½ inches. Solder the leads t the PC board as shown. Using thre more pairs of leads (as was shown i Fig. 8), connect J1, the headphon jack, and S2.

Well, the boards are finished, bu that's all we have room for this month Next month we'll finish the project b detailing the mechanical assemblies We'll also present a list of the neces saray mechanical components. R-

DIGITAL CAPACITANCE METER

Any test bench would love to have our hand-held capacitance meter!

MICHAEL LASHANSKY

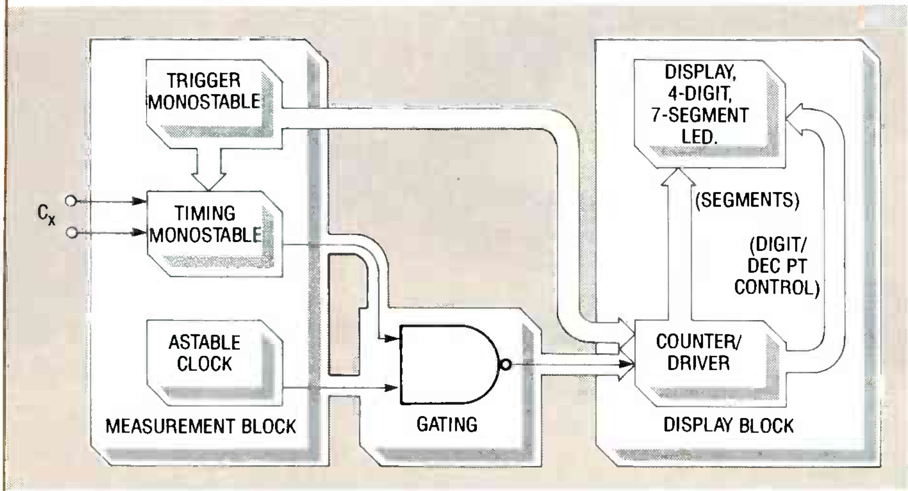


FIG. 1—BLOCK DIAGRAM of the capacitance meter.

HOW MANY TIMES HAVE YOU RUMMAGED through your parts box for a capacitor with a particular value, only to find a handful with confusing color codes or numerical markings that look like weird hieroglyphics? If you're lucky, you might find one you can decipher. Otherwise, you'll have to guess its value, and decide if you can stand a mistake. That's not too professional, but we all do it from time to time.

The problem is that most manufacturers have separate marking nomenclature for capacitors, causing total chaos for hobbyists. The military got smart and standardized their nomenclature requirements a long time ago, but consumer capacitor values are still almost impossible to read. There's been a push toward total standardization of capacitor values, but don't hold your breath.

So what do you do while the industry bickers over nomenclature? If you can't read your capacitors, you can either throw them out, or buy an expensive commercial capacitance meter. But perhaps the best solution is to build our inexpensive hand-held capacitance meter. It's accurate enough for hobbyists, uses readily available components, and can be powered from either a common 9-volt battery or 7.2-volt Ni-Cd.

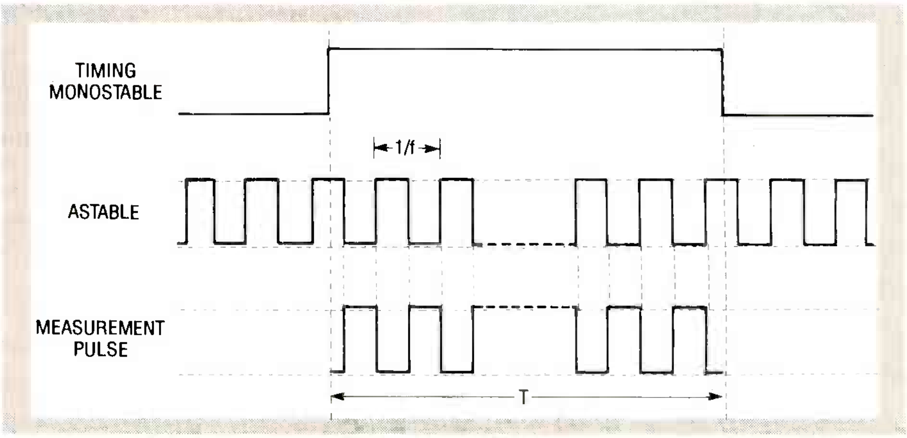


FIG. 2—TIMING WAVEFORMS of the capacitance meter. The number of astable pulses in the measurement pulse is proportional to the value of the unknown capacitor within a factor of 10.

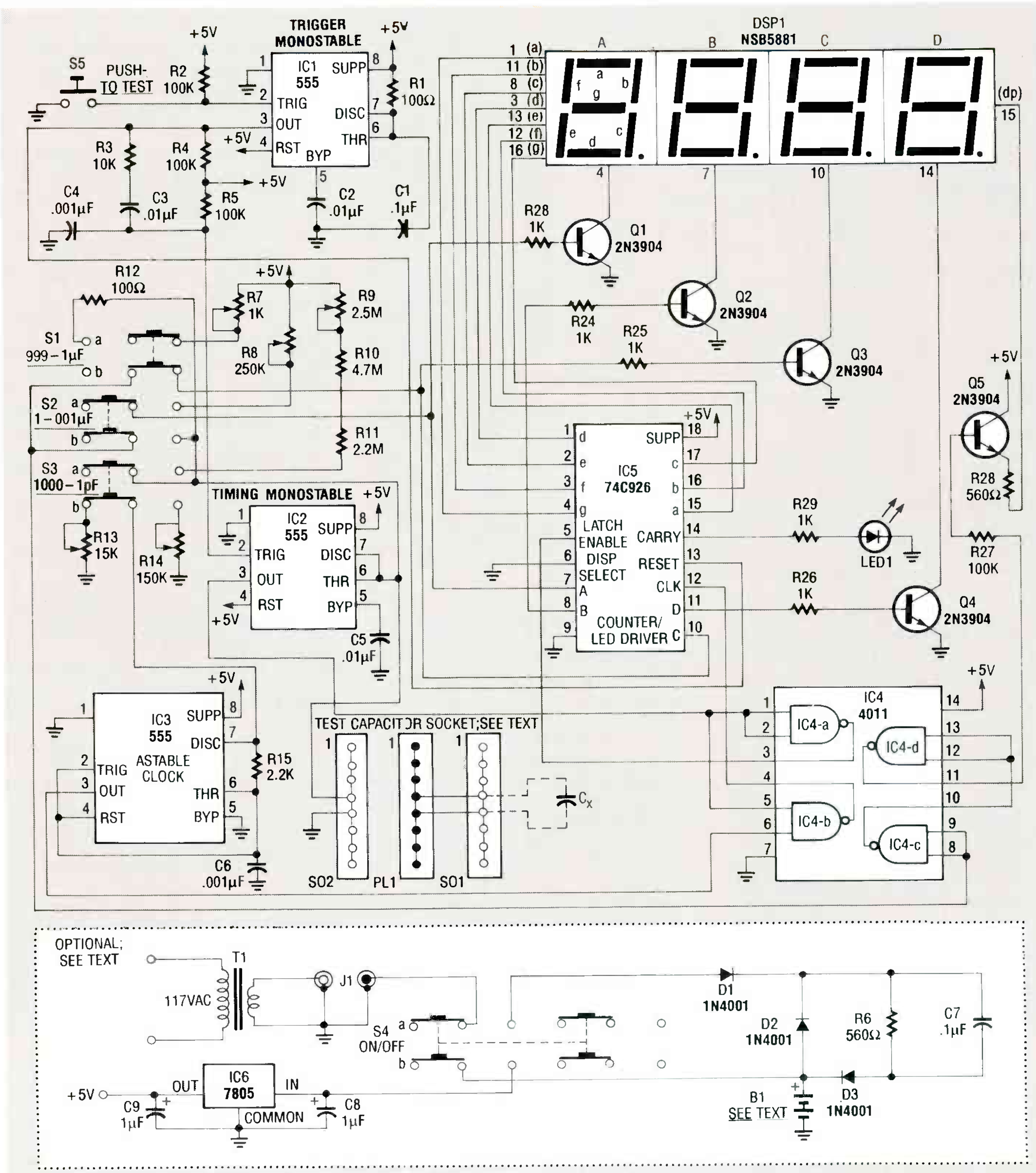


FIG. 3—COMPLETE SCHEMATIC of the capacitance meter.

Circuit theory

To determine the value of an unknown capacitor, C_X, the technique shown in the block diagram of Fig. 1 is used. The unknown capacitor controls the width of the output pulse from the timing monostable. And since the pulse width is proportional to C_X, its value can be determined by measuring the duration of the pulse.

An independent astable multivibrator generates a clock waveform that is NAND-gated with the timing monostable's pulse to yield a measurement pulse (see Fig. 2). The number of astable pulses fitting within the "window" of the measurement pulse is counted and scaled to C_X.

THE 555

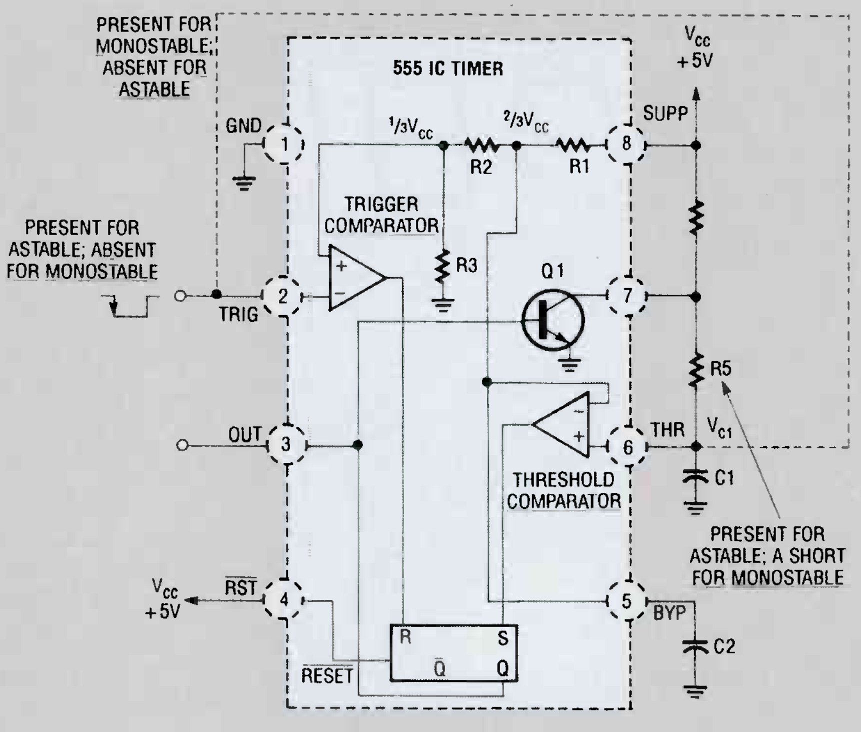


FIG. 1—THE BLOCK DIAGRAM of the 555 timer.

The 555 is the most versatile IC timer ever developed for astable/ monostable operating modes, and it needs very few external components to use it. Figure 1 shows the 555's block diagram, with its threshold and trigger comparators, set-reset (S-R) flip-flop, NPN discharging transistor (Q), a noninverting buffer, and an internal voltage divider R1/R2/R3 for comparator reference levels. The flip-flop is "set" if high, and "reset" if low. The comparators sense the variation in C1's voltage in either mode, and charges and discharges C1 between $1/3$ and $2/3$ of V_{CC}, or about 5 volts. C1's voltage is not the output, but it does govern the 555's operation.

Pins 2, 6, and 7 determine astable/ monostable operation. Figure 2 shows the 555 set up for astable mode, using R4, R5, and C1. Figure 3 shows the monostable setup, using R4 and C1, and an external down-going trigger pulse on pin 2. In both modes, pin 4 normally goes to V_{CC}; pin 5 is bypassed by C2 for added stability. In either mode, C1 charges through at least R4 toward V_{CC}, but R5 is present only in the astable mode, for which it varies the duty cycle. Figures 2 and 3 also show the outputs from pin 3 in relation to C1's voltage.

In the astable mode, assume that pin 3 is high, C1 is discharged, and Q is off. Now, C1 charges through R4 and R5 toward V_{CC}. When C1's voltage reaches $2/3$ V_{CC}, the threshold comparator sets the flip-flop, turning Q on, discharging C1 through R5 until its voltage reaches $1/3$ V_{CC}, driving pin 3 low. The trigger comparator resets the flip-flop, turning Q off, driving pin 3 high. This cycle repeats, yielding a rectangular waveform. If R4 is 0 ohm, charging/discharging is only through R5, giving a symmetric square wave. If R4 is greater than 0 ohm, an asymmetric square wave is generated.

In the monostable mode, an external down-going trigger (needed for each cycle) on pin 2 causes the trig-

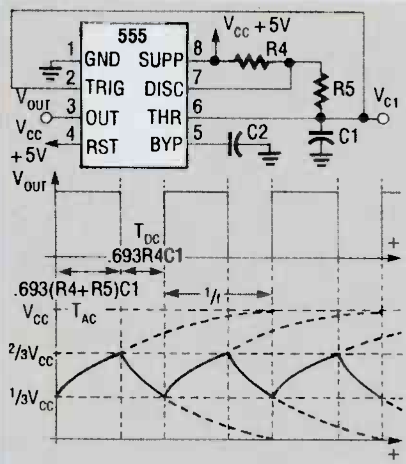


FIG. 2—ASTABLE MODE OF THE 555, showing the relation between the output on pin 3 and C1's voltage on pin 6.

ger comparator to reset the flip-flop, turning Q off, charging C1 from the saturation voltage of Q (effectively ground) through R4 to $2/3$ V_{CC}. The threshold comparator sets the flip-flop, turning Q on, discharging C1, driving pin 3 low, ending the timing pulse.

Frequencies and periods

To determine the astable frequency and monostable period, you have to know how C1 charges and dis-

The value of the timing resistors for both the monostable and the astable were selected so that the number of astable pulses is always an exact multiple of 10 times the value of the unknown capacitor. Finally, the trigger monostable is used to start a measurement, latch the count, and reset the meter.

The time constants for the monostables and astable are exact. However, each time an unknown capacitor is tested, variations in battery voltage, temperature, and comparator trigger levels will all contribute to vary the final reading for each trial. That's why you will get slightly different results each time you test the same C_X. For example, when testing a 0.1 µF capacitor, you may get a reading of 0.094 µF the first time and 0.103 µF the second.

The schematic

Looking at Fig. 3, 555 timers are used for the monostables (IC1 and IC2) as well as for the astable (IC3). A 4011 quad NAND gate (IC4) provides gating, inversion, and buffering, and a 74C926 display driver (IC5) is used to drive the 4-digit 7-segment display, DSP1.

Pressing S5 drives pin 3 of IC1 momentarily low, resetting IC5. A delay line (R3–R5 and C3 and C4) increases the rise time of IC1's output pulse, so that the triggering of IC2 is delayed until IC5 is reset. The switch array S1–S3 determines the capacitance range by adjusting the timing parameters of IC2 and IC3. Only one of the three switches in the array can be charges. Let R_{EFF} be the effective charging/discharging resistance in either mode. In astable mode, R_{EFF} is equal to R4 + R5 when charging, and R_{EFF} is equal to R5 when discharging. The duty cycle in the astable mode must be the ratio of those, or the duty cycle is equal to [(R4 + R5)/R5] × 100%, or equal to [1 + (R4/R5)] × 100%.

In monostable mode, R_{EFF} equals R4 when charging; there is no discharge path. If C1 is discharged and in series with R_{EFF}, with both connected to V_{CC}, C1 charges "exponentially" from ground toward V_{CC}. That basically means that C1's voltage never reaches V_{CC}, but gets very close.

The "time constant" is always: $\tau = R_{EFF} \times C1$, in secsonds. When speaking of a capacitor charging/discharging, one refers to the number of time constants that have elapsed. A capacitor charges to 63.2% of the dif-

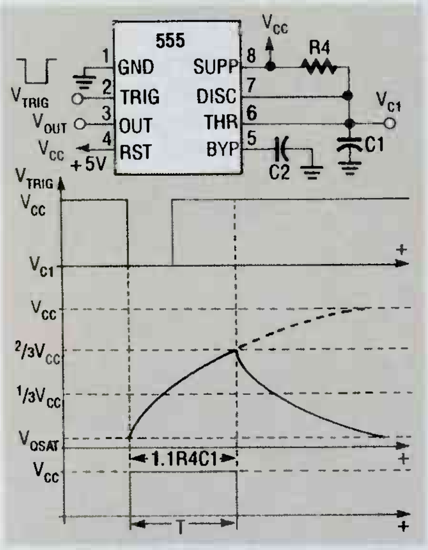


FIG. 3—MONOSTABLE MODE OF THE 555, showing the relation between the output on pin 3 and C1's voltage on pin 6.

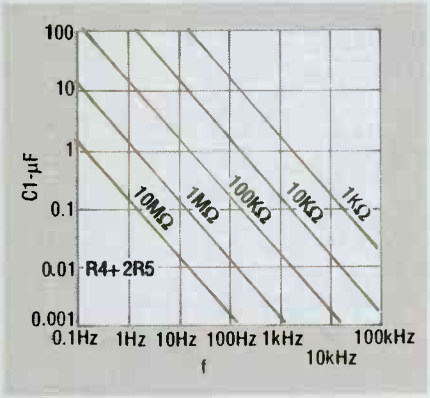


FIG. 4—NOMOGRAPHS FOR SELECTING component values for the 555 timer in the astable mode.

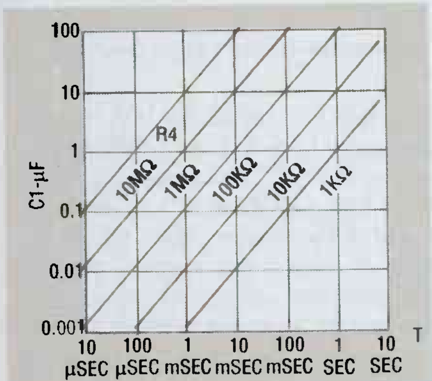


FIG. 5—NOMOGRAPHS FOR SELECTING component values for the 555 timer in the monostable mode.

ference between its initial and target voltages in one τ, and essentially fully charges/discharges to a target voltage within 5τ (99.33%).

The voltage divider partitions the charge/discharge cycle so that there are two sets of target voltages; those created by the divider, and those of V_{CC} and ground. The C1 voltage stays between ⅓ and ⅔ of V_{CC} in the astable mode. Since C1 either charges toward V_{CC} or discharges toward ground, the V_{CC}/ground target voltages are never reached in the astable mode, being outside the charging/discharging bounds created by the voltage divider.

The intervals required to reach the voltages due to the voltage divider, both charging and discharging, can be determined exactly. This eliminates the problem that C1 can only charge/discharge arbitrarily close to a target voltage.

In the astable mode, C1 cycles between ⅓ and ⅔ of V_{CC}, always charging/discharging to halfway between an initial and target voltage. When charging, the initial voltage is ⅓ V_{CC} and the target voltage is V_{CC}. When discharging, the initial voltage is ⅔ V_{CC}, and the target voltage is ground.

For C1 to charge/discharge through R_{EFF} from one divider voltage to the other, it always takes:
$T = 0.693 \times \tau = 0.693 \times R_{EFF} \times C1$.
In the astable, the charging interval is:
$T_{AC} = 0.693 \times (R4 + R5) \times C1$.
The discharge interval is:
$T_{AD} = 0.693 \times R5 \times C1$.
The total period is:
$T_A = T_{AC} + T_{AD} = 0.693 \times [R4 + (2 \times R5)] \times C1$
And the frequency is:
$f_A = 1/T_A = 1.44/[R4 + (2 \times R5)]C1$.

In the monostable mode, Q holds C1 at ground. After triggering, C1 charges through R4 to ⅔ V_{CC}. Both the charging cycle and the pulse are now ended by the threshold comparator, as mentioned earlier. For reasons too lengthy to discussin the space we have, pulse duration will be: $T_M = 1.1 \times R4 \times C1$.

Figure 4 is a nomograph of C1 vs. f_A in the astable mode for different values of R4 + (2 × R5). Figure 5 is a nomograph of C1 vs. timing-pulse width T_M in the monostable mode for different values of R4. **R-E**

pressed "in" at any given time, although all three can be "out" at the same time.

Each DPDT switch in the array (S1–S3) has two sets of contacts. To simplify our discussion, we will call the "upper" set of contacts (the set closest to the top of the figure) "a," and the lower set "b" (see Fig. 3). Note that S3 doesn't have to be pushed "in" to serve a function; because of the way in which it is wired, it does affect the circuit in the "out" position.

Switches S1-a, S2-a, and S3-a control the capacitance-measurement range by switching in the appropriate potentiometer—R7, R8, or R9. The potentiometers control the duration of the pulse from IC2, with the ranges as shown in Fig. 3. Switches S1-b and S2-b control which decimal point is selected, and S3-b controls the frequency of the astable 555, IC3. There are two potentiometers used to determine the astable frequencies: R13 and R14. Pressing either S1 or S2 switches R13 into the circuit for both the 999–1-µF and 1–0.001-µF ranges, for an astable frequency of 100 kHz. However, when S3 is pressed, R13 is removed from the circuit, and R14 is switched in for the 1000–1-pF range, for an astable frequency of 10 kHz.

Counter/driver IC5, a 74C926, contains a 4-digit negative-edge-triggered counter, a 4-digit internal output latch, drivers for a 4-digit 7-segment LED display, an internal multiplexer with four outputs, and its own free-running oscillator. A high on pin 13 resets the counter to zero

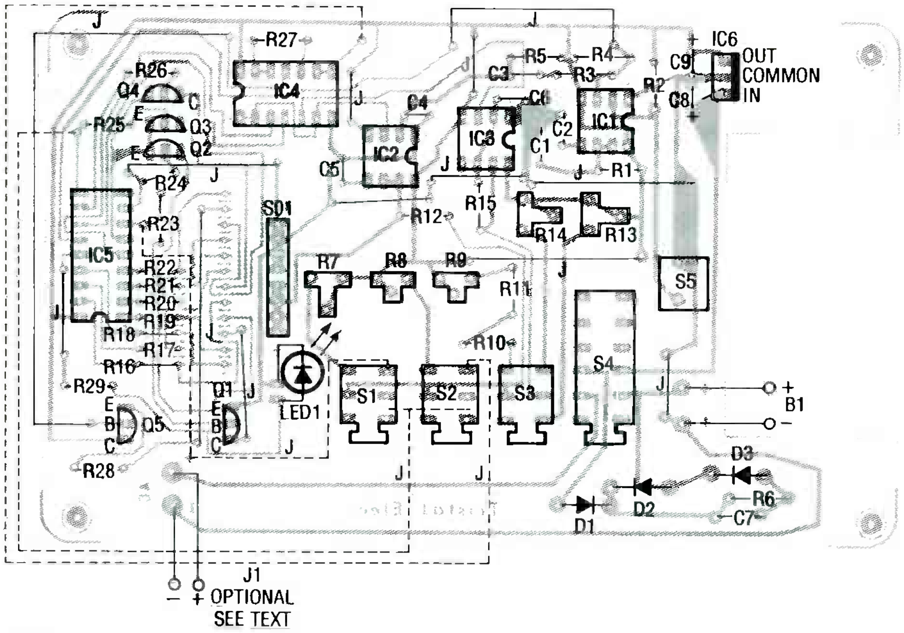


FIG. 4—PARTS PLACEMENT DIAGRAM. The jumpers shown in dashed lines are soldered to the solder lugs on top of the switches.

and drives pin 14 (CARRY OUT) low. A low on pin 5 (LATCH ENABLE) latches the number in the counter using the internal output latches, whereas a high on pin 5 permits a flow-through condition in which the internal latches ignore future counts. A high on pin 6 (DISPLAY SELECT) displays the number in the counter, while a low displays the number in the output latch. In this application, pin 6 is grounded, permanently displaying the contents of the latch, and never the output of the counter.

The pulse from IC2 is positive, and after being NAND'ed (by IC4-b) with the output from IC3, the resulting output in inverted. The down-going pulse from IC4-a enables IC5 to latch the count of the astable pulses within the measurement pulse. Because pin 5 of IC5 goes low during the timing pulse, the new value in the counter is automatically latched each time a count occurs.

The latched count is then converted into the value of the unknown capacitor by shifting the decimal point on DSP1 via transistors Q1–Q5. IC4-c and IC4-d buffer the outputs from the A and C digit drivers of counter/driver IC5, to provide sufficient logic swing for the display. When the counter in IC5 exceeds 9999, pin 14 goes high, lighting the range-overflow indicator, LED1.

Pin 7 of IC5 controls digit A, pin 8 controls B, pin 10 controls C, and pin 11 controls D. Pins 1–4 and 15–17 drive each individual segment of each digit. IC5's internal clock scans the digit-control lines fast enough to avoid display flicker. The decimal point is selected by feeding pin 7 of IC5 (which controls digit A) back to S1-a for the 1–.001 µF range, or pin 10 (which controls digit C) back to S1-b for the 999–1 µF range. The other two decimal points are not used. The display format has no leading-zero blanking or external scaling. Therefore, 100 pF is displayed as 0100, 0.001 µF is displayed as 0.001, and 4.7 µF as 004.7.

Switch S4 supplies power to the 7805 voltage regulator, which provides a steady 5-volts DC to the circuit. If you use a 9-volt battery, you can ignore the optional charger/adapter jack, J1. (Two pads labeled "AC" are provided on the PC board for J1.) A Ni-Cd battery can only be recharged when the meter is on; that's because S4 connects J1 to D1 and the battery to IC6. Charging the Ni-Cd battery pack normally draws about 300 mA, so be sure that whatever you're using can handle that.

PARTS LIST

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

R1, R8, R12, R16–R22—100 ohms
R2, R4, R5, R27—100,000 ohms
R3—10,000 ohms
R6, R28—560 ohms
R7—1000 ohms, PC-mount potentiometer
R8—250,000 ohms, PC-mount potentiometer
R9—2.5 megohms, PC-mount potentiometer
R10—4.7 megohms
R11—2.2 megohms
R12—7.1 megohms
R13—15,000 ohms, PC-mount potentiometer
R14—150,000 ohms, PC-mount potentiometer
R15—2200 ohms
R23–R26, R29—1000 ohms

Capacitors

C1, C7—0.1 µF, ceramic disc
C2, C3, C5—0.01 µF, ceramic disc
C4, C6—0.001 µF, ceramic disc
C9—1 µF, tantalum electrolytic

Semiconductors

D1–D3—1N4001 rectifier diode
Q1–Q5—2N3904 NPN transistor
IC1–IC3—555 timer IC
IC4—4011 CMOS quad 2-input NAND gate
IC5—74C926 CMOS counter/LED display driver
IC6—7805 5-volt regulator
DSP1—NSB5881 4-digit 7-segment LED display
LED1—red light-emitting diode

Other components

SO1, SO2—8-pin SIP wirewrap socket
PL1—8-pin SIP plug
S1–S3—board-mounted 3-pushbutton DPDT switch array, 3⁄16-inch lead spacing, with PC-contact pins and solder lugs for wires
S4—board-mounted pushbutton 4P2T switch, 3⁄16-inch lead spacing, with PC-contact pins and solder lugs for wires
S5—board-mounted momentary pushbutton, 5⁄16-inch lead spacing
B1—9-volt alkaline battery or optional 7.2-volt rechargeable Ni-Cd (see text)
J1—subminiature jack matching the plug of the charger/adapter (optional, see text)
T1—optional charger/adapter, 117/12-volts AC, 300 mA

Miscellaneous: Pacifitec Model HPL-000 project case, 9-volt battery clip, LED bezel, solder, wire, etc.

NOTE: The switches for the prototype were obtained from Active Surplus Annex, 347 Queen Street West, Toronto, Ont., Canada, (416) 593-0967. A kit of all parts except resistors, capacitors, and PC board is available for $39.95, plus $5.00 shipping and handling. A PC board is available for $12.00. Contact Tristat Electronics, 66A Brockington Crescent, NEPEAN, Ont., Canada K2C 5L1.

Construction

The Parts-Placement diagram is shown in Fig. 4, and a foil pattern is provided in PC Service. Before soldering, it's a good idea to clean the foil side of the board with steel wool to remove oxides; that ensures a smooth solder flow. Use sockets for the IC's and various transistors.

Figure 5 shows how to make the test socket, SO1, and its corresponding plug, PL1. SO1 is made from an 8-pin SIP wirewrap socket, and PL1 from an 8-pin SIP plug; the two are connected by a twisted pair. SO1 is epoxied into its opening in the case, and PL1 fits into SO2.

The display is connected to the PC board using 2 inches of No. 12 ribbon cable. Solder one side to the display and the other side to the PC board. (Be certain that pin 1 of the display goes to pad 1 on the PC board.) Only solder pins 1, 3, 4, 7, 8, and 10–16 of the display—the others are not used.

Solder LED1 approximately ¾ of an inch above the PC board, so that its top is flush with the case. You can use a mounting bezel for LED1.

Figure 6 is a photograph of the prototype meter. Study Figs. 3, 5, and 7 for the relationship of all components to one another, as well as the position of all components. Note that the 7805 is bent flat for case clearance, with its metallic side facing upward.

If you decide to use Ni-Cd batteries, the most convenient way to install the charging jack (J1) is to drill a hole in the meter case near the "AC" pads on the PC board. (Drill slowly to prevent damaging the plastic.) It's up to you to choose the type of jack for J1; it must, however, match the plug of the charger/adapter, and be small enough to fit in the case.

Before installing the IC's or transistors in their sockets, apply power to the board and check for correct voltages. Then, shut off the power, insert the IC's and transistors, and turn the meter on again; the display should now show a random 4-digit number. If not, turn the meter off and check the wiring, looking particularly for a short in the display foils.

Exact calibration

To calibrate the meter, you should use an oscilloscope or frequency counter, and one precision unknown capacitor for each range. Connect the oscilloscope or frequency counter between pin 3 of IC3 and ground. Then press either S1 or S2 and adjust R13 for 10 kHz. Now press S3 and adjust R14 for a reading of 100 kHz. If you've got precision capacitors, insert a suitable one for the 999–1 µF range, press S5, and adjust R7 until the display reads the nominal value.

Without precision unknown capacitors, use an iterative (repetitive) approach. Use three or four non-precision capacitors for each range, of the same nominal value. For the 999–1 µF range, test an unknown capacitor at random, adjusting R7 until C_X's nominal value appears on the display, and then set the capacitor aside. Next, without adjusting R7, test and record the other unknowns for that range, and average the results.

Now, using the first unknown capacitor tested (the one set aside), adjust R7 so that the meter shows your average value, rather than the nominal value. Without adjusting R7, test the other unknowns and average the new values. Now, let the first unknown in the new average have the first average value that you came up with. Repeat until the average value no longer changes much. The accuracy of the meter will increase with the number of unknowns tested per range, and the number of iterations. Repeat the procedures for the other two ranges, adjusting R9 for the 1–0.001-µF range, and R11 for the 1000–1-pF range.

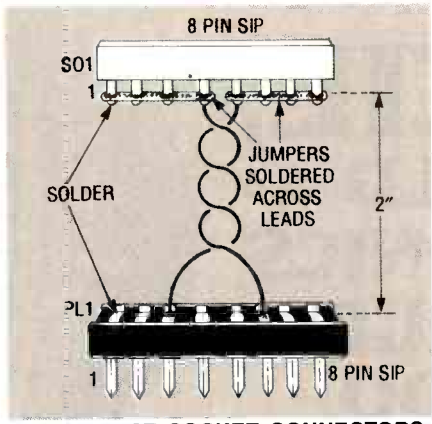


FIG. 5—TEST SOCKET CONNECTORS. This assembly connects the capacitor under test to the PC board's test socket.

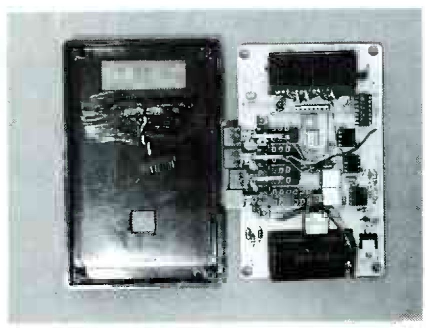


FIG. 6—THE CAPACITANCE METER. Notice how the various parts are oriented.

Approximate calibration

Without proper gear, you can get good but not perfect calibration. Use a nominal value of capacitor suitable for each range as an unknown, and set all potentiometers to mid-point. Select a range, and insert a suitable unknown capacitor. Don't vary R7 or R9; adjust R11, R13, or R14 until the nominal value of the capacitor being tested appears on the display. Set the first unknown aside, and repeat the procedure, sampling the other identical nominal value capacitors for this range without varying any of the potentiometers at this point, and average the display values. Using the first nominal-value capacitor tested, readjust R11, R13, or R14 for the first average value. Repeat the procedures for the other ranges.

Using the meter

Once calibrated, plug PL1 into SO2 on the PC board, and put the meter in its case. A polyethylene faceplate was epoxied to the prototype's case, but the front-panel design for your meter is up to you.

The meter's stray capacitance is about 30 pF, and can't be zeroed on the pF range. If you press S5 with no capacitor attached, while in the pF range, the meter should read about 30 pF. The stray capacitance is in parallel with the unknown, so it must be subtracted from any pF-range reading.

When testing a capacitor, watch LED1 to get higher precision on the two lower ranges. For a nominal value of 0.01 µF, the meter might read 0.010467 µF, in which case the pF range would overflow; the number of LED1 flashes gives the overflow digit. On the 1–0.001-µF scale, the nominal 0.01-µF capacitor might read 0.011. On the pF range, LED1 should flash once since the counter passed 9999 once; the display should read 0467. However, LED1 flashes rapidly, and is hard to count.

If LED1 flashes once, that means an overflow digit of one; then, C_X is 10,467 pF or 0.010467 µF. If LED1 flashes twice, the reading would be 20467 pF, etc. Note that holding S5 down doesn't increase accuracy, It just wastes current by repetitively testing a capacitor, and will prevent a reading from being displayed. **R-E**

BUILD THIS

AMATEUR TV TRANSMITTER

Get in the picture with our television transmitter.

WILLIAM SHEETS and RUDOLF F. GRAF

LAST MONTH WE ANALYZED THE TV transmitter circuitry in great detail, describing the function of virtually every transistor, capacitor, inductor, and resistor. Now we'll present the construction techniques in the same detail. They should pose no special problems, but your best bet is to duplicate the author's prototype as closely as possible. That's because when working with ultra-high-frequency RF, such things as PC-board layout, component placement, and especially lead lengths become critical.

Assembly hints

As long as the author's design is exactly duplicated, you shouldn't encounter any *off the wall* UHF problems, so follow these suggestions without compromise:

1. As you assemble this project, use only the parts specified in the Parts List because ultra-high frequency circuits are sensitive to changes in component type and value. Also follow the author's parts placement as closely as possible.

2. Lead lengths should be kept short. Handle the surface-mount components and ferrite beads with extra care. The 1/10-watt resistors and miniature NPO ceramics should have short leads, and close component spacing.

3. Wind your own slug-tuned coils with available materials, rather than using commercial, hard-to-get factory-made types. That gets rid of the coil headaches. If the dimensions are followed, no problems should result. As shown in Fig 1, you'll find that the coils are easy to wind, and the largest ones have only eight or nine turns of wire. In fact, several are only loops or pieces of wire because the inductors required at 420–500 MHz are usually in the 0.01 to 0.1-microhenry range. Complete technical data is compiled in Table 1.

4. Pay particular attention to supply bypassing. We have incorporated a tantalum chip capacitor to guarantee good bypassing. By keeping everything compact, and by using a shielded, double-sided PC board with good RF bypassing, all the possible "horrors" associated with VHF and UHF circuitry can be done away with.

5. The PC board is compact and parts are small, so a small iron with a pointed tip is recommended, especially for soldering the chip capacitors.

6. Use only 0.062-inch thick epoxy-fiberglass PC-board materials. Other materials and thicknesses could be used, but may result in different tuning conditions, and stray capacitances. Don't use paper-base phenolic materials; they're too lossy at UHF frequencies.

7. Transistor Q12 must be heat-sinked because it must dissipate up to 3 watts. The method shown in Fig. 2 has proven adequate if at least 1-ounce copper is used. On the other hand, Q7 is adequately heat-sinked if the metal case is soldered to the PC-board ground plane.

8. Solder as many component leads as possible (that pass through the ground plane) to the top and bottom of the board. In particular, the ground lugs on all trimmer capacitors should be soldered on both sides, and also the resistors that have one side connected to ground. The idea is to ground as much of the ground plane to the ground foil on the component side, in as many places as possible; that's especially important around Q4–Q7.

9. Use chip capacitors where specified. Do not substitute ordinary leaded capacitors.

10. Keep all component leads as short as possible, and as close to the board as possible.

11. Take care to make coils as accurately as possible. While some errors can be tolerated, accurate work will make tuneup easier.

Parts installation

Figure 3 shows the Parts-Placement diagram for the TV transmitter. First install all resistors and then diodes D1 and D3. Don't forget the ferrite beads on R15, R17, R19, and R21. Next install all disc ceramics (0.01 µF and 470 pF), and then the NPO capacitors. Now install potentiometers R22, R32, and R33, soldering the grounded side of R22 and R33 to both sides of the PC board. Install all trimmer capacitors. Note that C18 and C40 are different from the rest. Solder ground tabs of all trimmers to both top and bottom of the PC board. Install transistors Q1 through Q5, and Q8 through Q11, but don't install Q6, Q7, or Q12 yet.

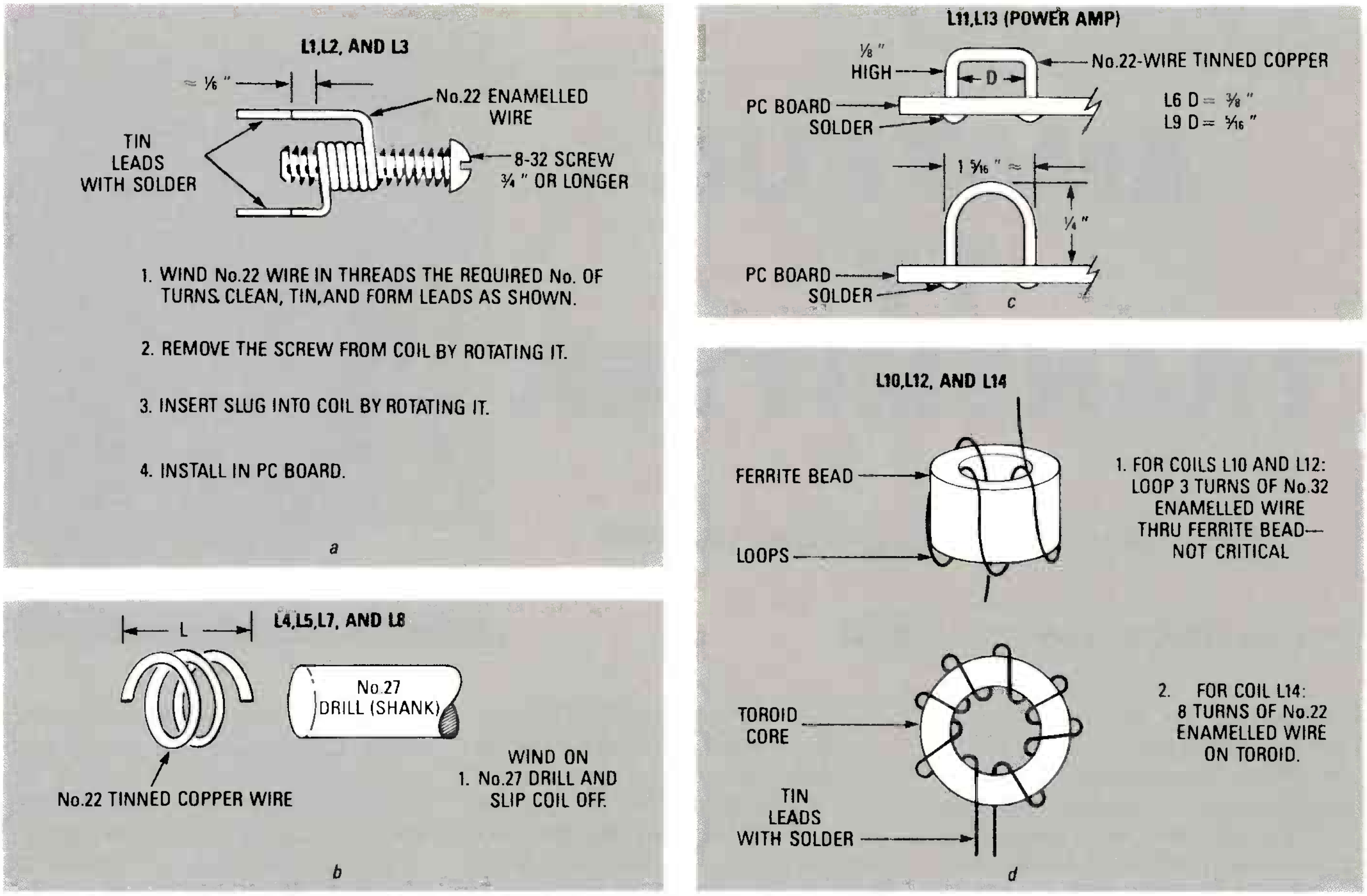


FIG. 1—IF YOU WANT TO CONSTRUCT THE COILS BY HAND, you have to wind them on the threads of a screw *(a)*, the shank of a drill bit *(b)*, using measured bends *(c)*, or around a ferrite bead *(d)*.

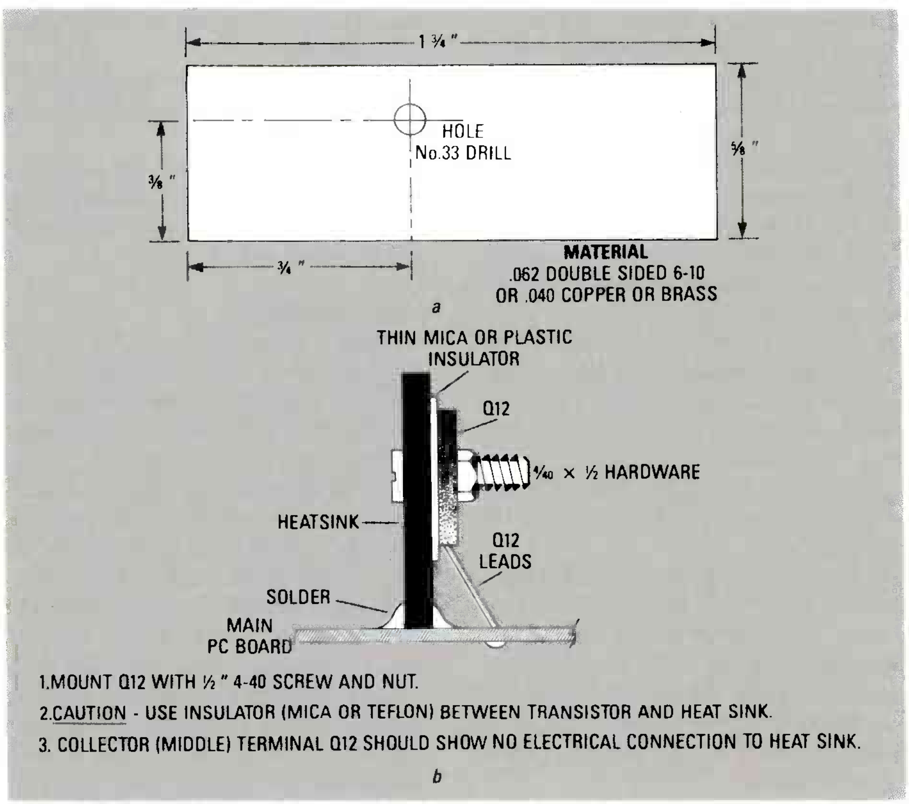


FIG. 2—THE ALUMINUM PLATE THAT IS USED AS A HEAT SINK FOR Q12 also functions as an RF shield for transistors Q6 and Q7.

Wind and install L1 through L9, and L14. If you're building the low-power version, leave out any components associated with Q6 and Q7, except L9; go ahead with the modification shown in Fig. 4, and be sure to omit C22. Install chip capacitors C22, C24, C44, and C20.

Check the PC board for shorts, solder bridges, and trim away any excess foil with a sharp knife (*X-acto* type or equal). Make sure that excess foil on the top side is not touching any component leads that are not intended to be grounded. Slight mis-registration of the top foil during PC fabrication may cause that.

Now install Q12 and its heat sink. Note that the heat sink also serves as an RF shield for Q6 and Q7 (if used). Be sure to solder the heat sink where it butts against the PC board. Note that Q12's case should be insulated from the heat sink. Use a TO-220 insulator (cut to size), or a scrap of mica, mylar, polyethylene, or teflon tape used in plumbing work.

You are now ready to test the main part of the board. If you're constructing the 2-watt version, Q6, Q7, and any associated components will be installed only after the rest of the PC board is tested.

Testing

After checking your work, measure the DC resistance between V_{CC} and ground; it should be greater than 200 ohms. If it's lower than that, check your work again for the cause before proceeding any further.

Next, install the slugs in L1, L2, and L3 if you haven't already done so. The slugs should be initially set fully inside the coils. Set R22, R32, and R33 about halfway between extremes of rotation. Set trimmer C40 and all other trimmer capacitors to half mesh. Final settings will depend on the operating frequency, coil-construction technique, and application.

Apply +12 volts after connecting the negative-supply lead to the PC-board ground plane. Immediately observe power-supply current; if it's over 130 mA, there may be a problem. If anything smokes or gets too hot, immediately remove the power and find the problem before proceeding.

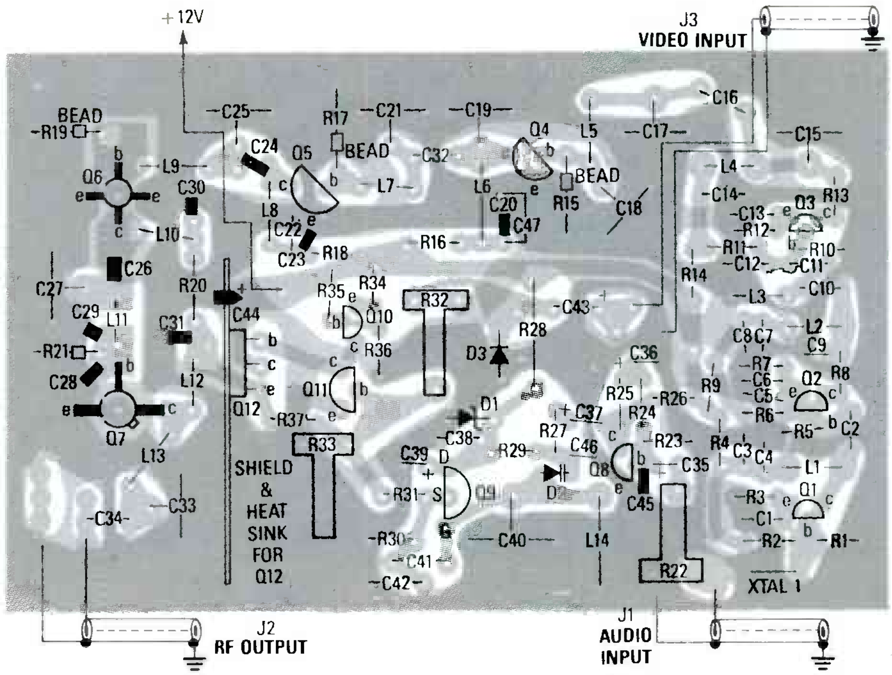


FIG. 3—PARTS PLACEMENT DIAGRAM shows capacitor chips (C20, C23, C24, C26, C28, C29, C30, C31, C45) mounted on the solder side, as is Q6.

If all seems OK, connect a VOM (preferably an analog meter) across R3, and then R7. You should read between 1.5 and 3-volts DC. Next connect the VOM across resistor R12 Q3;you should read 1 volt or less. Now connect the VOM between point A (emitter of Q12) and ground. Verify

TABLE 1—COIL DESCRIPTIONS L1–L14

COIL	FREQ. RANGE MHz	NO. TURNS & LENGTH	WINDING FORM	NOTES
L1	420-450 (HAM TV) 450-500 (VIDEO LINK)	9½ 8½	8-32 SCREW THREAD	NO. 22 ENAMEL WIRE
L2	420-450 450-500	4½ 3⅓		
L3	420-450 450-500	5½ 3½		
L4	ALL	3 TURNS ¼″ LONG	NO. 27 DRILL (0.144″ DIA) SPACE TURNS	MADE WITH NO. 22 TINNED COPPER
L5	ALL	4 TURNS ¼″ LONG		
L7	ALL	1½ TURNS 1/16″ LONG		
L8	ALL	2½ TURNS ⅛″ LONG		
L6, L9, L11, L13	ALL	PER FIG. 1	NONE (PC BOARD)	
L10, L12	ALL	PER FIG. 1	FERRITE BEAD	NO. 32 ENAMEL WIRE
L14	4.5 MHz (NTSC SOUND SUBCARRIER)	8 TURNS NO. 22 ENAMEL	TOROID	NO. 22 ENAMEL WIRE

NOTE: Due to individual winding technique and normal circuit tolerances, L1, L2, L3 and L14 may require one turn more or less than shown in Table 1. L4, L5, L7 and L8 may have to be squeezed or spread lengthwise. All dimensions are taken from average of several working units. Individual units vary somewhat from given dimensions due to tolerances, winding techniques, and installation.

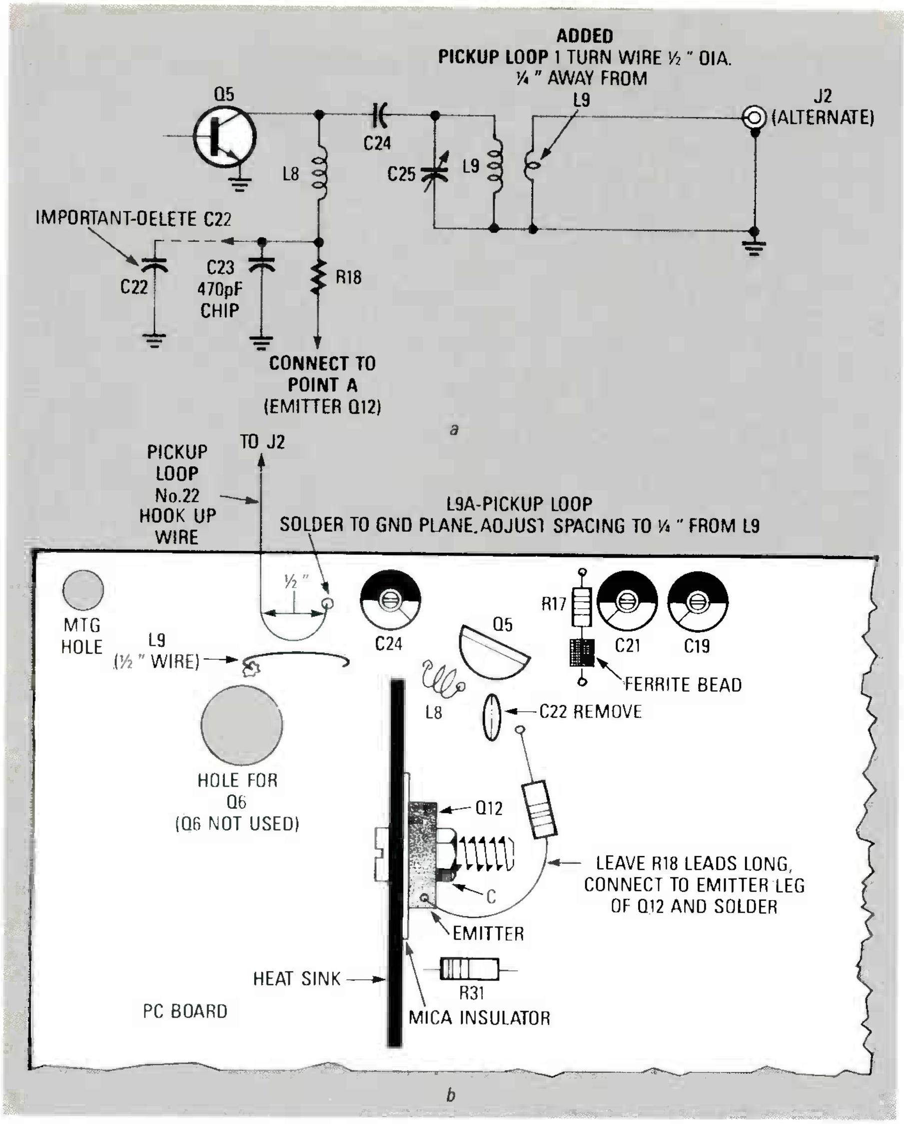


FIG. 4—TO OPERATE THE UNIT AT LOW POWER you should follow schematic *(a)* and assembly modification *(b)*.

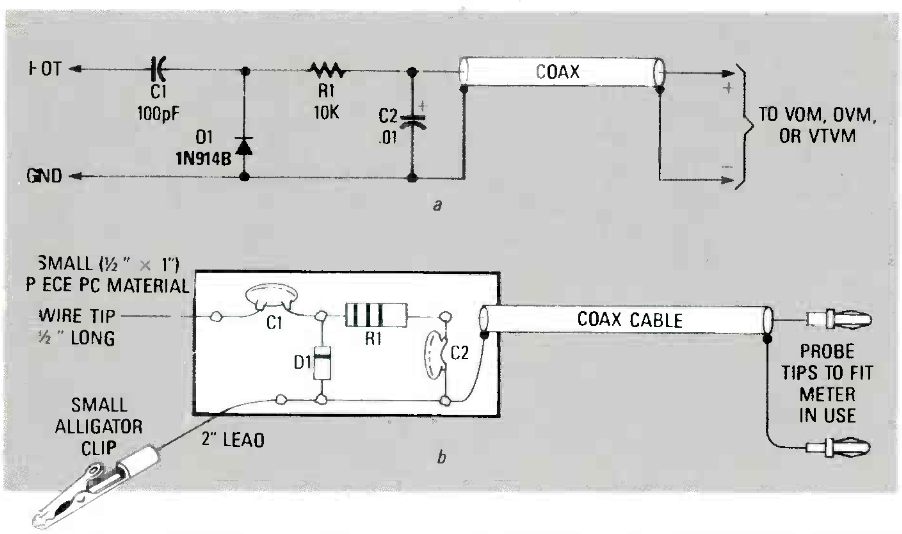


FIG. 5—HERE'S AN RF PROBE YOU CAN BUILD for your DMM, VOM, or scope. It's helpful in adjusting the transmitter for peak power.

that adjusting R33 through its full range will vary the voltage at point-A between less than 5 volts to greater than 11 volts. Set R3 for full voltage (greater than 11 volts) at point A for now.

Measure the voltage at Q8's collector; about 4 to 7 volts is OK. Next measure the voltage across D1; it should be between 8- and 10-volts DC. If it is more or less, that indicates a problem in Q8, Q9, or the associated circuitry. Check for 8- to 10-volts across D2. If it reads 1 volt, D2 is installed backwards or is shorted.

If all is good up to this point, install crystal XTAL1, connect a VOM across R7, and apply power. Tuning the oscillator is done as follows: Slowly back L1's slug out of the winding. You'll find that the voltage across R7 will suddenly increase, then slowly decrease as the slug is tuned. Adjust

PARTS LIST

All resistors are ⅛ or ⅒-watt, 5%.
R1, R5—3900 ohms
R2, R6, R11, R31—15,000 ohms
R3, R7, R15—330 ohms
R4, R9, R12, R14, R16–R19, R35—100 ohms
R8, R13—10 ohms
R10—680 ohms
R20—10 ohms, ¼-watt
R21—22 ohms
R22—100,000-ohms potentiometer
R23—22,000 ohms
R24, R29—100,000 ohms
R25—33,000 ohms
R26—4700 ohms
R28—470 ohms, ¼-watt
R30—2200 ohms
R32, R33—1000-ohm potentiometer
R34—15 ohm
R36—1000 ohms
R37—3300 ohms
Capacitors
C1—56 pF, NPO, ceramic disc
C2, C12—33 pF, NPO, ceramic disc
C3, C7, C19, C22, C38, C47—0.01µF, ceramic disc
C4, C6, C8, C13, C14—470 pF, NPO, ceramic disc
C5—82 pF, NPO, ceramic disc
C9, C11—15 pF, NPO, ceramic disc
C10—2.2 pF, NPO, ceramic disc
C15, C17, C19, C21, C25, C27, C33—2–10-pF, trimmer
C16, C32—1 pf, NPO, ceramic disc
C18—2–18 pF, or 2–20-pF trimmer
C20, C23, C24, C45—470 pF, ceramic chip
C26, C30, C31—100 pF, ceramic chip
C28, C29—22 pF, ceramic chip
C34—5 pF, silver mica
C35–C37—1 µF, 50 volt, electrolytic
C39—10 µF, 16 volt, electrolytic
C40—3–40 pF, trimmer
C41—220 pF, NPO, ceramic disc

C42—470 pF, NPO, ceramic disc
C43—220 μF, 16 volt, electrolytic
C44—10 μF, 16 volt, chip tantalum
C46—100 pF, NPO, ceramic disc
C47—0.01μF, ceramic chip
Semiconductors
Q1, Q2—2N3563, transistor
Q3–Q5—MPS3866, transistor
Q6—MRF559 or MRF627 transistor
Q7—MRF630, transistor
Q8—2N3565, transistor
Q9—MPF102, transistor
Q10—2N3906, transistor
Q11—2N3904, transistor
Q12—MJE180, transistor
D1—1N757A, diode
D2—MV2112, varactor diode
D3—1N914, diode
D4—1N4007, diode
Inductors
L1–L14—See table 1
Other components
XTAL1—52.5-62.5 MHz
Notes: The following kits are available from North Country Radio, PO Box 53, Wykagyl Station, New Rochelle, NY 10804: Low-Power Kit w/ATV crystal for operation on 439.25 MHz, $79.95 plus $2.50 shipping and handling; 2-Watt Kit w/ATV crystal for operation on 439.25 MHz, $104.95 plus $2.50 S/H; extra crystals for CH14, CH15 operation, $6.50 plus $1.50 S/H; PC board only plus Cores, chip capacitors, and D2, (partial kit), $49.95 plus $2.50 S/H; Crystals can be purchased separately from Crystek Corporation, PO Box 06135, Fort Myers, FL 33906. Kits do not include jacks, connectors, batteries, power-supply components, or case.

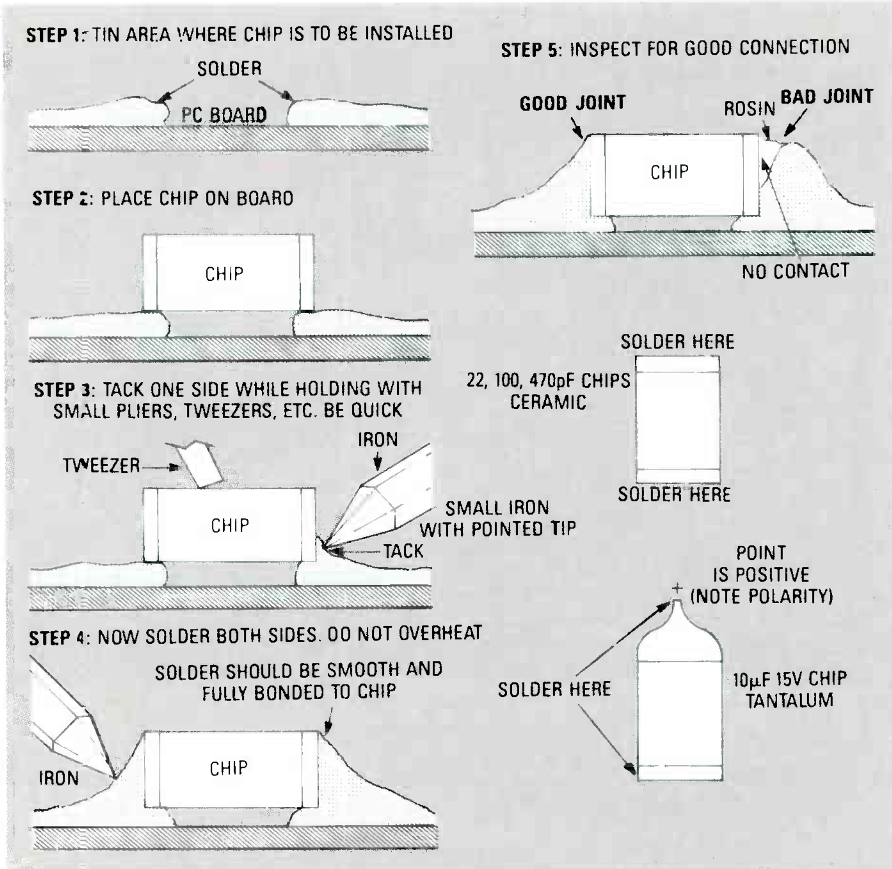


FIG. 6—IF YOU FOLLOW THESE STEPS when soldering the chip components to the PC board, you'll have no problems with them.

the slug for maximum voltage (3 to 5 volts), then back out the slug for about a 10% drop to ensure stable oscillation. As a check, a frequency counter connected to the junction of C2 and C5 should indicate the crystal frequency. An unstable reading indicates that the crystal is not controlling the frequency. If that's the case, try re-adjusting L1.

Here's how to tune the 1st doubler. Connect the VOM across R12, and adjust L2 and L3 for maximum voltage (about 1 to 2 volts). If adjusting the L1 and L2 slugs doesn't peak the voltage, then add or subtract a turn from the coil as required, after first checking C9, C10, C11, and C12 for correct values.

Here's how to tune the 2nd and 3rd doublers. Connect an RF probe to the junction of L9 and R19, or to the junction of C25 and L9 if you're building the low-power version. Figure 5 shows you how to build an RF probe if you don't already have one. Adjust C15, C17, C18, C19, C21, and C25 for a maximum reading. You should be able to obtain at least 1.5 volts of RF energy at the junction of R19 and L9 for the high-power version, and about 2 volts at the junction of C25 and L9 for the low-power version. If everything looks good, that checks out stages Q1 through Q5.

To adjust the RF output for the low-power version connect a 47-ohm resistor to J2A (Alternate). Adjust C25 and the position of L9A (Alernate) with respect to L9 for maximum output. Don't couple L9A too close to L9—just enough for about 1 volt across the 47-ohm resistor.

Final assembly

If you're building the 2-watt version, now is the time to install Q6 and Q7, and then L10 through L13. You may now install the chip capacitors C26, C28, C29, C30, and C31, but

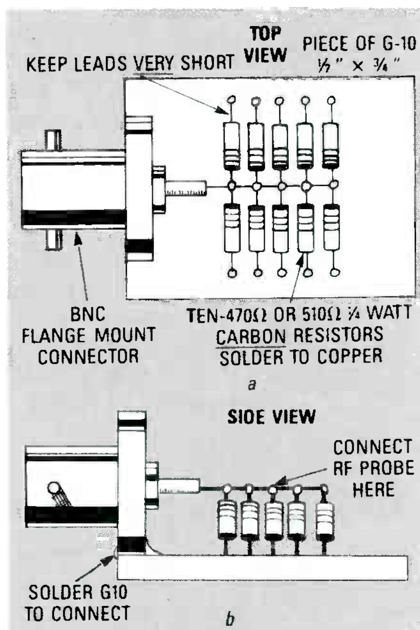


FIG. 7—A DUMMY LOAD SHOULD BE USED while adjusting the power output.

don't overheat them! Make sure that the PC board is tinned in the areas where chips are installed. The best way to install them is to first tack-solder one side to hold it down, solder the other side, and then go back and

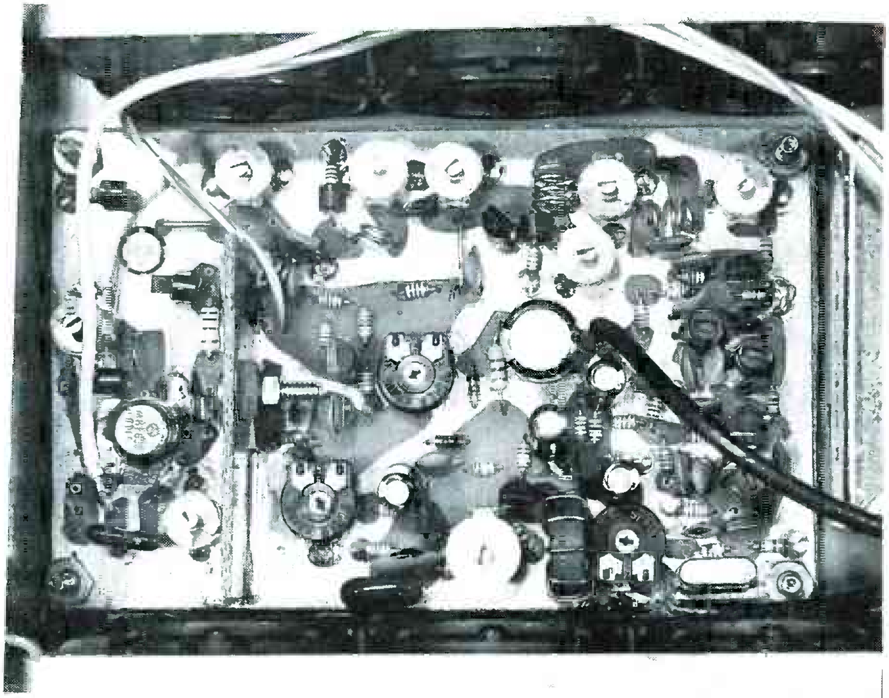


FIG. 8—THE FINISHED PC BOARD has a neat, clean appearance. Sloppy workmanship can not be tolerated on this circuit layout.

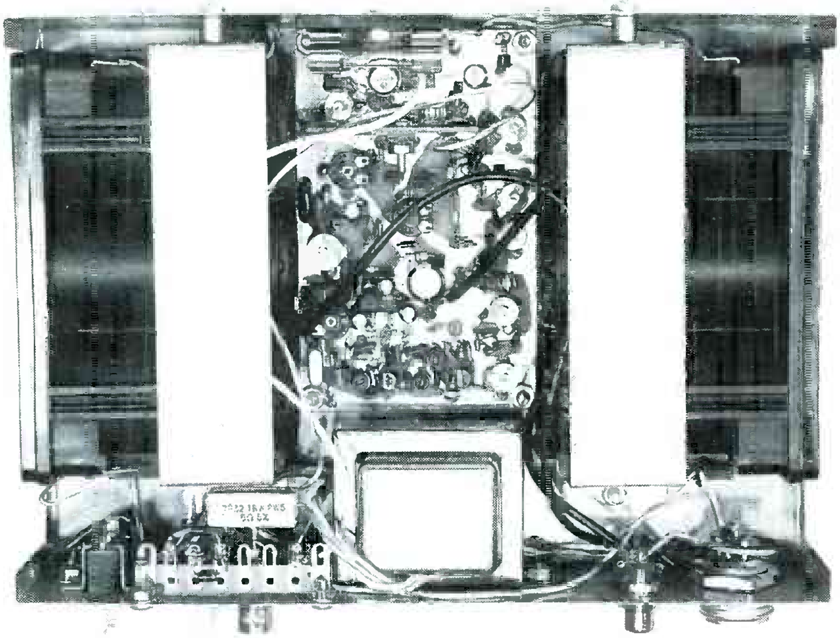


FIG. 9—The AUTHOR'S PROTOTYPE USED 2-Ni-Cd BATTERY PACKS, one on either side of the PC board, which makes the transmitter portable. You'll also notice a power transformer and associated circuitry used for running the transmitter off household AC-line voltage.

resolder the first (tack-soldered) side.

Figure 6 shows you how to solder chip components. Use a 25-watt iron with a pointed tip. Fine-point needle-nose pliers or tweezers should be used to manipulate the chip capacitors.

Finally, install C34 and a suitable length of small-diameter 50-ohm coax to J2. Check all joints for solder bridges. Make sure that the metal case of Q7 is soldered to the ground plane (top side), and connect its leads to the PC-board underside using as little lead length as possible.

Apply power and quickly adjust C25, C27, and C33 for maximum power into a 50-ohm load connected to J2. You can use a 47-ohm, 2-watt carbon resistor, or the dummy load which can be assembled as shown in Fig. 7. An RF probe can be connected to the hot side of the resistors (center conductor of connector) to read the RF voltage, but an RF power meter is nice to have.

You should get at least 1.5 watts (about 8.5-volts RMS) into the 50-ohm load, which should become warm when operating. Power-supply current will be about 500 mA. Now adjust R33 for an output voltage about half that, or a quarter the power as read on the power meter, if used. Leave the RF load connected as you proceed to the next step.

For either the low- or high-power unit, adjust R33 for about +6 volts at point A (emitter of Q12). Connect a frequency counter to point A, and adjust C40 for exactly 4.500 MHz. Now apply video and audio signals to J3 and J1, respectively. Watch the transmitted image on a TV receiver tuned to the transmitter frequency; adjust the video gain (R32) for best picture contrast and stability, then adjust the audio level (R22) until its level is comparable to a commercial station. Now alternately adjust R32 and R33 for maximum video contrast without seeing any side effects such as instability, audio buzz, or other evidence of clipping. You may also wish to go over all tuning adjustments again for best results. The finished PC board is shown in Fig. 8

Enclosure

Mount the PC board in a shielded metal-case, as shown in Fig. 9, and connect leads from the board to suitable jacks for J1, J2, or J2A, and J3. Also provide a suitable connector for the 12-volt supply, if desired. The transmitter case can house an AC supply, or batteries for portable operation. Use the right size *Ni-Cd* batteries to handle the 100-mA drain (low power), or 500-mA drain (2-watt unit). Use a BNC-type fitting for the antenna jack, J2.

A suitable antenna would be a 6-inch whip or a center-fed dipole, 12-inches long. For amateur TV, a linear amplifier may be installed between J2 and the antenna for greater power output. For the low-power version, use the 6-inch whip antenna. **R-E**

CIRCUITS

OP-AMP OSCILLATORS

Op-amp oscillators give good vibrations.

RAY MARSTON

OP-AMPS CAN BE USED TO GENERATE SINE-wave, triangular-wave, and square-wave signals. We'll start by discussing the theory behind designing op-amp oscillators. Then we'll examine methods to stabilize oscillator circuits using thermistors, diodes, and small incandescent lamps. Finally, our discussion will round off with designing bi-stable op-amp switching circuits.

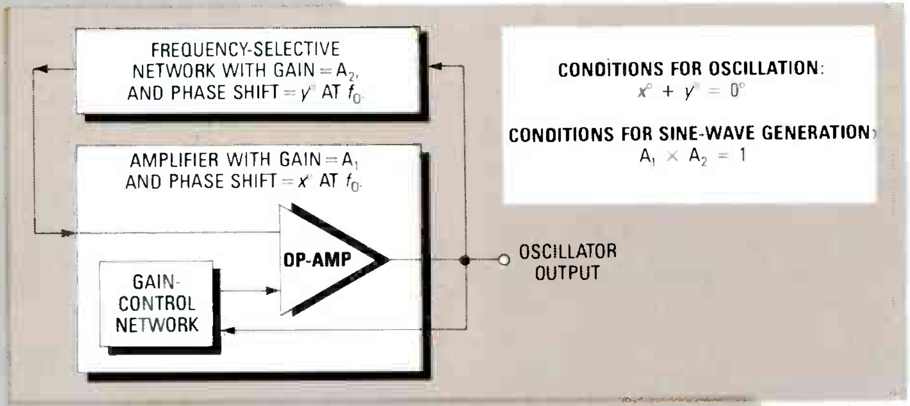


FIG. 1—STABLE SINE-WAVE OSCILLATION requires a zero phase shift between the input and output, and an overall gain of 1.

Sine-wave oscillator

In Fig. 1, an op-amp can be made to oscillate by feeding a portion of the output back to the input via a frequency-selective network, and controlling the overall voltage gain.

For optimum sine-wave generation, the frequency-selective network must feed back an overall phase shift of zero degrees, while the gain network provides unity amplification at the desired oscillation frequency. The frequency network often has a negative gain, which must be compensated for by additional amplification in the gain network, so that the total gain is unity. If the overall gain is less than unity, the circuit will not oscillate; if the overall gain is greater than unity, the output waveform will be distorted.

As Fig. 2 shows, a Wien-bridge network is a practical way of implementing a sine-wave oscillator. The frequency-selective Wien-bridge is constructed from the R1-C1 and R2-C2 networks. Normally, the Wien bridge is symmetrical, so that C1 = C2 = C and R1 = R2 = R. When that condition is met, the phase relationship between the output and input signals varies from −90° to +90°, and is precisely 0° at a center frequency, f_O, which can be calculated using this formula:

$$f_O = 1/(2\pi CR)$$

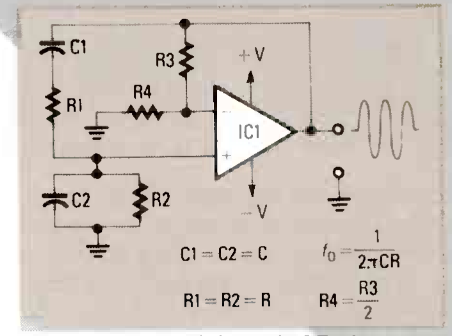


FIG. 2—BASIC WEIN-BRIDGE sine-wave oscillator.

The Wien network is connected between the op-amp's output and the non-inverting input, so that the circuit gives zero overall phase shift at f_O, where the voltage gain is 0.33; therefore, the op-amp must be given a voltage gain of 3 via feedback network R3-R4, which gives an overall gain of unity. That satisfies the basic requirements for sine-wave oscillation. In practice, however, the ratio of R3 to R4 must be carefully adjusted to give the overall voltage gain of precisely unity, which is necessary for a low-distortion sine wave.

Op-amps are sensitive to temperature variations, supply-voltage fluctuations, and other conditions that cause the op-amp's output voltage to vary. Those voltage fluctuations across components R3-R4 will also cause the voltage gain to vary. The feedback network can be modified to give automatic gain adjustment (to increase amplifier stability) by replacing the passive R3-R4 gain-determining network with a gain-stabilizing circuit. Figures 3 through 7 show practical versions of Wien-bridge oscillators having automatic amplitude stabilization.

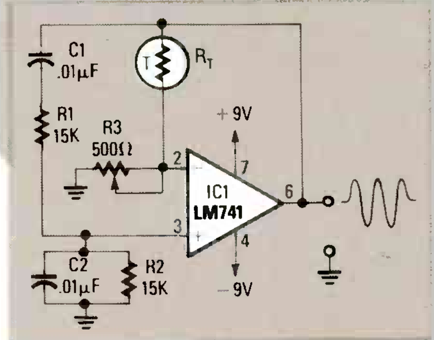


FIG. 3—THERMISTOR-STABILIZED 1-kHz Wein-bridge oscillator.

Thermistor stabilization

Figure 3 shows a 1-kHz fixed-frequency oscillator. The output amplitude is stabilized by a *N*egative *T*emperature *C*oefficient (NTC) thermistor R_T which, together with R3 forms a gain-determining feedback network. The thermistor is heated by the mean power output of the op-amp.

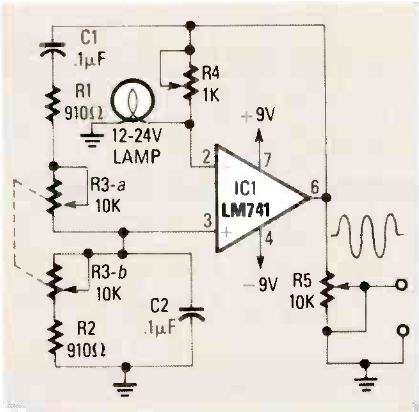


FIG. 4—LAMP-STABILIZED Wien-bridge oscillator.

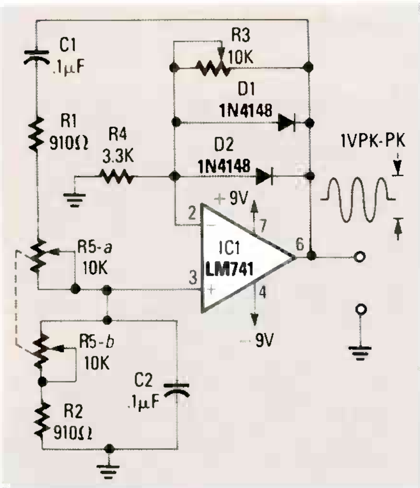


FIG. 5—DIODE-REGULATED Wien-bridge oscillator.

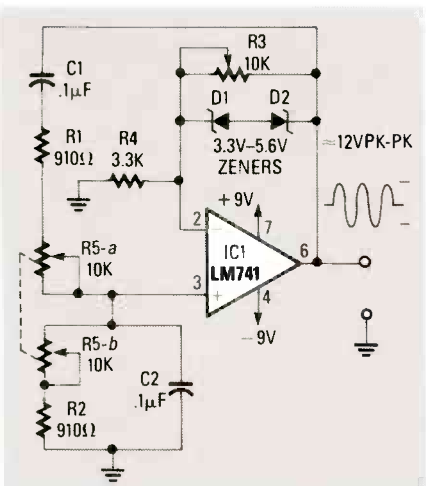


FIG. 6—ZENER-REGULATED Wien-bridge oscillator.

The desired feedback thermistor resistance value is triple that of R3, so the feed-back gain is ×3. When the feedback gain is multiplied by the frequency network's gain of 0.33, the overall gain becomes unity. If the oscillator output amplitude starts to rise, R_T heats up and reduces its resistance, thereby automatically reducing the gain of the circuit, which stabilizes the amplitude of the output signal.

An alternative method of thermistor stabilization is shown in Fig. 4. In that case, a low-current lamp is used as a *P*ositive *T*emperature *C*o-efficient (PTC) thermistor, and is placed in the lower part of the gain-determining feedback network. If the output amplitude increases, the lamp heats up thereby increasing its resistance, reducing the feedback gain, and providing automatic amplitude stabilization. That circuit also shows how the Wien network can be modified by using a twin-ganged potentiometer to make a variable-frequency oscillator over the range 150 Hz to 1.5 kHz. The sine-wave output amplitude can be made variable using R5.

A slightly annoying feature of thermistor-stabilized circuits is that, in variable-frequency applications, the output amplitude of the sine wave tends to "jitter" or "bounce" as the frequency control potentiometer is swept up and down its range.

Diode stabilization

The jitter problem of variable-frequency circuits can be minimized by using the circuits of Figs. 5 or 6, which rely on the onset of diode or Zener conduction for automatic gain control. In essence, R3 is for a circuit gain slightly greater than unity when the output is close to zero, causing the circuit to oscillate; as each half-cycle nears the desired peak value, one of the diodes starts to conduct, which reduces the circuit gain, automatically stabilizing the peak amplitude of the output signal. That "limiting" technique typically results in the generation of 1% to 2% distortion on the sine-wave output. The maximum peak-to-peak output of each circuit is roughly double the breakdown voltage of its diode regulator element.

In Fig. 5, the diodes start to conduct at 500 mV, so the circuit gives an output of about 1-volt peak-to-peak. In Fig. 6, the Zener diodes D1 and D2 are connected back-to-back, and may have values as high as 5 to 6 volts, giving a p-p (peak-to-peak)output of about 12 volts. Each circuit is set up by adjusting R3 for the maximum value (minimum distortion) at which oscillation can be maintained across the frequency band.

The frequency range of Wein-bridge oscillators can be altered by changing the C1 and C2 values; in-

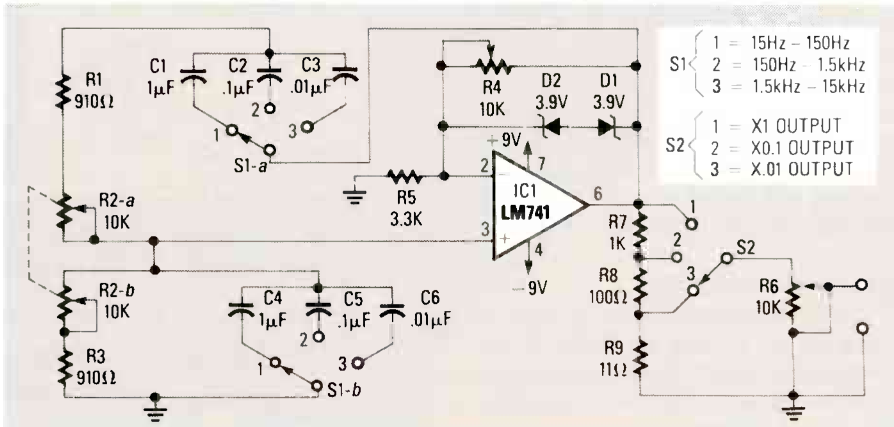


FIG. 7—THREE DECADE 15 Hz–15 kHz Wien-bridge oscillator.

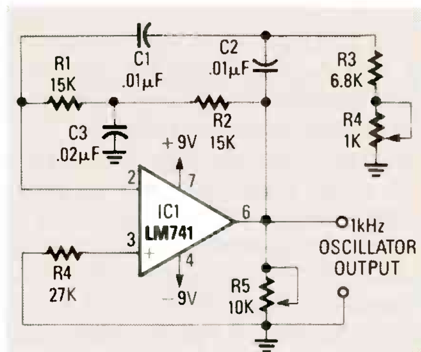


FIG. 8—1-kHz TWIN-T oscillator.

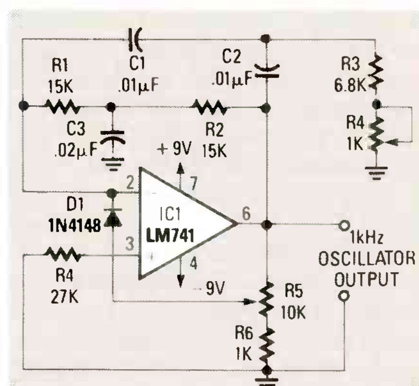


FIG. 9—DIODE-REGULATED 1-kHz twin-T oscillator.

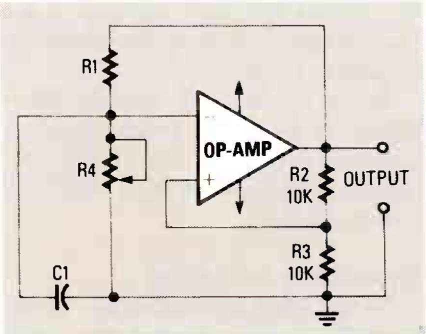


FIG. 10—RELAXATION SQUARE-WAVE oscillator.

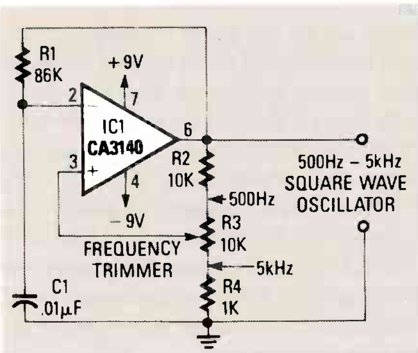


FIG. 11—500 Hz–5 kHz SQUARE-WAVE oscillator.

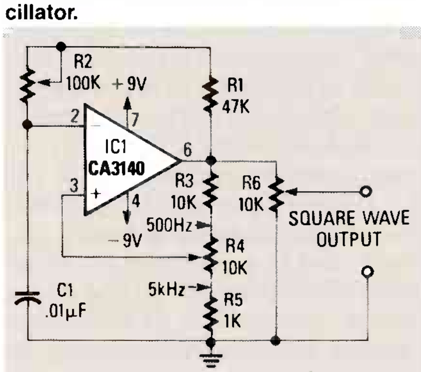


FIG. 12—IMPROVED 500 Hz–5 kHz square-wave oscillator.

creasing C1 and C2 by a decade reduces the output frequency by a decade. Figure 7 shows the circuit of a variable-frequency Wien oscillator that covers the range 15 Hz to 15 kHz in three switched-decade ranges. The circuit uses Zener-diode amplitude regulation, and its output is adjustable by both switched and fully-variable attenuators. Notice that the maximum useful operating frequency is restricted by the slew-rate limitations of the op-amp. The limit is about 25 kHz using a LM741 op-amp, or about 70 kHz using a CA3140.

Twin-T oscillators

Another way of designing a sine-wave oscillator is to wire a twin-T network between the output and input of an inverting op-amp, as shown in Fig. 8. The twin-T network comprises R1-R2-R3-R4 and C1-C2-C3. In a "balanced" circuit, those components are in the ratios $R1 = R2 = 2(R3 + R4)$, and $C1 = C2 = C3/2$. When the network is perfectly balanced, it acts as a notch filter that gives zero output at a center frequency (f_O), a finite output at all other frequencies, and the phase of the output is 180° inverted. When the network is slightly unbalanced by adjusting R4, the network will give a minimal output at f_O.

By critically adjusting R4 to slightly unbalance the network, the twin-T gives a 180° inverted phase shift with a small-signal f_O. Because the inverting op-amp also causes a 180° input-to-output phase shift, there is zero overall phase inversion as seen at the inverting op-amp input, and the circuit oscillates at a center frequency of 1 kHz. In practice, R4 is adjusted so that oscillation is barely sustained, and under that condition the sine wave has less than 1% distortion.

Figure 9 shows an alternative method of amplitude control, which results in slightly less distortion. Here, D1 provides a feedback signal via potentiometer R5. That diode reduces the circuit gain when its forward voltage exceeds 500 mV. To set up the circuit, first set R5 for maximum resistance to ground, then adjust R4 so that oscillation is just sustained. Under those conditions, the output signal has an amplitude of about 500 mV p-p. Further R5 adjustment enables the output signal to be varied between 170 mV and 300-mV RMS.

Note that twin-T circuits make good fixed-frequency oscillators, but are *not* suitable for variable-frequency operation due to the difficulties of varying three or four network components simultaneously.

Square-wave generator

An op-amp can be used to generate square-waves by using the relaxation oscillator configuration of Fig. 10. The circuit uses dual power supplies, and the op-amp output switches alternately between positive and negative

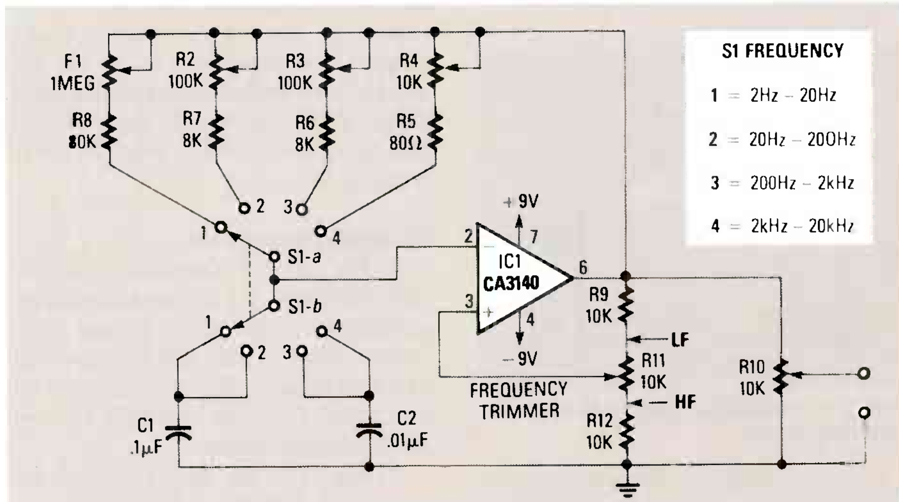


FIG. 13—FOUR DECADE 2 Hz–20 kHz SQUARE-WAVE generator.

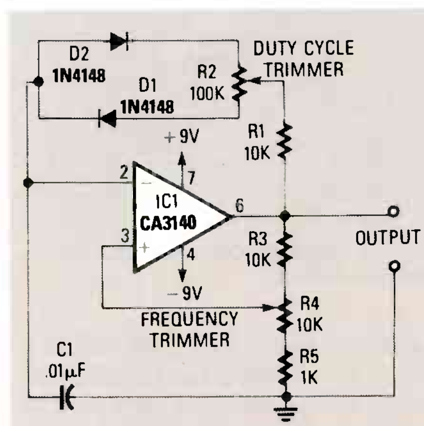


FIG. 14—SQUARE-WAVE GENERATOR with variable duty-cycle, and frequency.

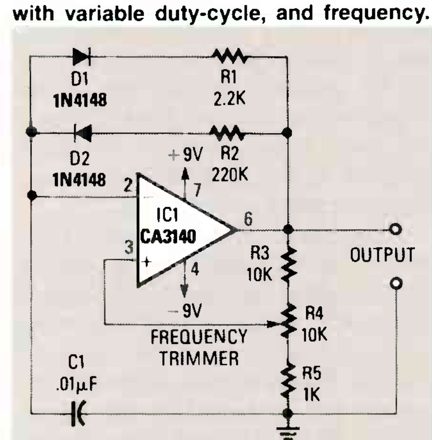


FIG. 15—VARIABLE FREQUENCY narrow-pulse generator.

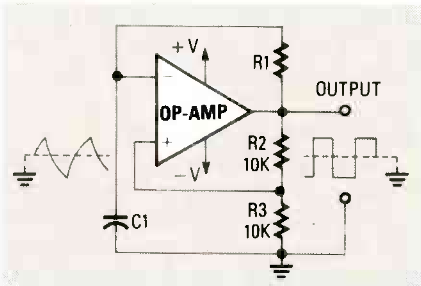


FIG. 16—RESISTANCE-ACTIVATED relaxation oscillator.

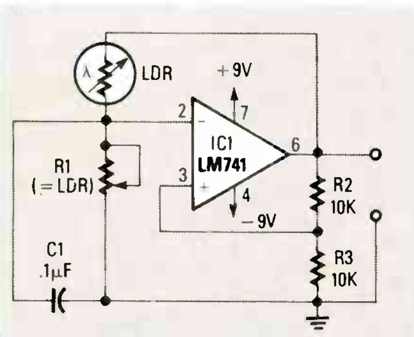


FIG. 17—PRECISION LIGHT-ACTIVATED oscillator/alarm.

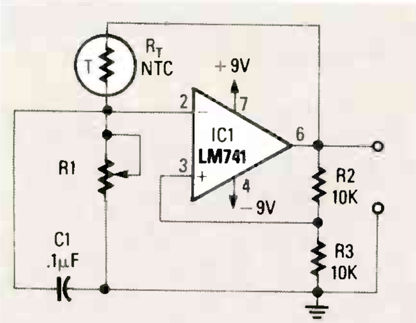


FIG. 18—PRECISION over-temperature oscillator/alarm

saturation levels. When the output is high, C1 charges via R1 until the stored voltage becomes more positive than the value set by R2-R3 at the non-inverting input. The output then regeneratively switches negative, which causes C1 to start discharging via R1 until C1 voltage falls to the negative value set by R2-R3. The output then regeneratively switches positive again, and the whole sequence repeats *ad infinitum*.

A symmetrical square wave is developed at the output, and a non-linear triangular waveform is developed across C1; those waveforms swing symmetrically on both sides of ground. Notice that the operating frequency can be varied by altering either the R1 or C1 values, or by altering the R2-R3 ratios, which makes that circuit quite versatile.

Figure 11 shows how to design a practical 500 Hz to 5-kHz square-wave generator, with frequency variations obtained by altering the attenuation ratio of R2-R3-R4. Figure 12 shows how to improve Fig. 11 by using R2 to preset the range of frequency control R4, and by using R6 as an output amplitude control.

Figure 13 shows how to design a general purpose square-wave generator that covers the 2 Hz to 20-kHz range in four switched-decade ranges. Potentiometers R1 to R4 are used to vary the frequency within each range: 2 Hz–20 Hz, 20 Hz–200 Hz, 200 Hz–2 kHz, and 2 kHz–20 kHz, respectively.

Variable duty-cycle

In Fig. 10, C1 alternately charges and discharges via R1, and the circuit generates a symmetrical square-wave output. That circuit can be modified to give a variable duty-cycle output by providing C1 with alternate charge and discharge paths.

In Fig. 14, the duty cycle of the output waveform is fully variable from 11:1 to 1:11 via R2, and the frequency is variable from 650 Hz to 6.5 kHz via R4. The circuit action is such that C1 alternately charges through R1-D1 and the bottom of R2, and discharges through R1-D2 and the top of R2. Notice that any variation of R2 has negligible effect on the operating frequency of the circuit.

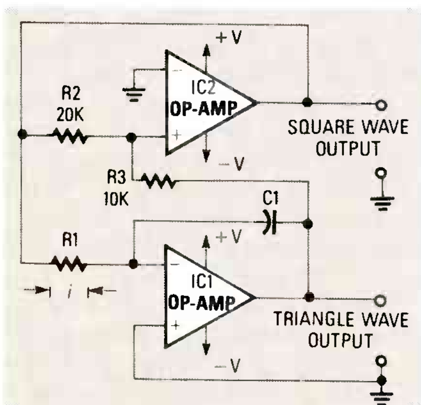


FIG. 19—BASIC FUNCTION GENERATOR for both triangular, and square waves.

In Fig. 15, the duty cycle is determined by C1-D1-R1 (mark), and by C1-D2-R2 (space). The pulse frequency is variable between 300 Hz to 3 kHz via R4.

Resistance activation

Notice from the description of the oscillator in Fig. 10 that the output changes state at each half cycle when the C1 voltage reaches the threshold value set by the R2-R3 voltage divider. Obviously, if C1 is unable to attain that value, the circuit will not oscillate. Figure 16 shows a resistance activated oscillator that will oscillate *only* when R4, which is in parallel with C1, has a value greater than R1. The ratio of R2:R3 must be 1:1. The fact that R4 is a potentiometer is only for illustration. Most resistance-activated oscillators use either thermistors or LDR's, which simulate the potentiometer action.

Figure 17 is a precision "light-activated" oscillator (or alarm), and uses a LDR as the resistance activating element. The circuit can be converted to a "dark-activated" oscillator by transposing the position of LDR and R1. Figure 18 uses a NTC thermistor, R_T, as the resistance-activating element, and is a precision over-temperature oscillator/alarm. The circuit can be converted to an under-temperature oscillator by transposing R_T and R1.

The LDR or R_T can have any resistance in the range from 2000 ohms to 2 megohms at the required trigger level, and R1 must have the same value as the activating element at the desired trigger level. R1 sets the trigger level; the C1 value can be altered to change the oscillation frequency.

Triangle/square generation

Figure 19 shows a function generator that simultaneously produces a

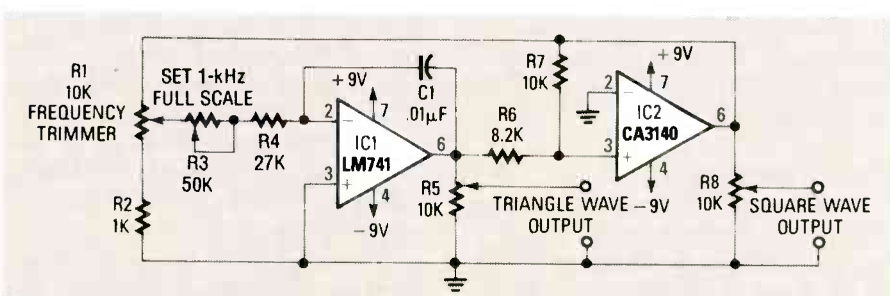


FIG. 20—100 Hz–1 kHz FUNCTION GENERATOR for both triangular, and square waves.

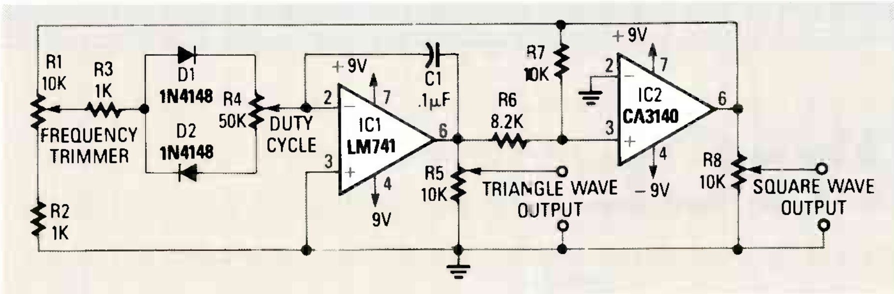


FIG. 21—100 Hz–1 kHz FUNCTION GENERATOR with variable slope and duty cycle.

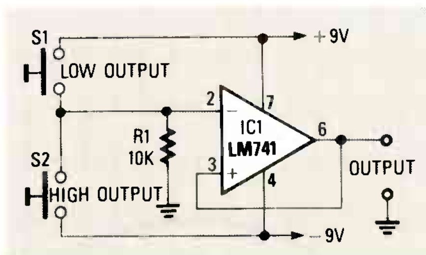


FIG. 22—BI-STABLE with simple manual triggering.

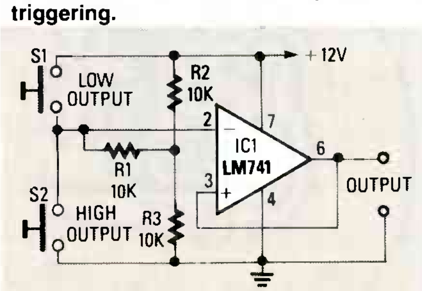


FIG. 23—SINGLE SUPPLY BI-STABLE.

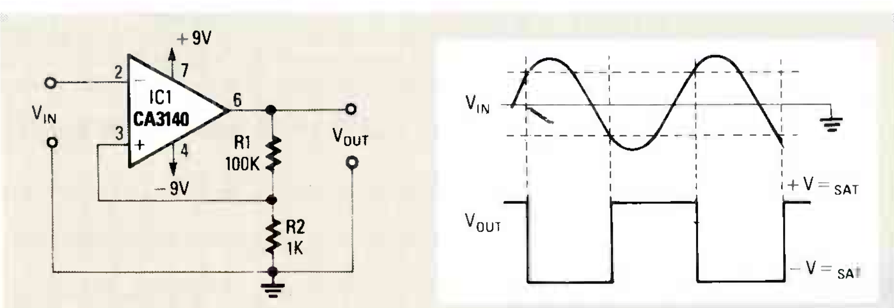


FIG. 24—SCHMITT TRIGGER prevents output oscillations caused by triggering off a slow sine-wave.

linear triangular wave and a square wave using two op-amps. Integrator IC1 is driven from the output of IC2, where IC2 is wired as a voltage comparator that's driven from the output of IC1 via voltage divider R2-R3. The square-wave output of IC2 switches alternately between positive and negative saturation levels.

Suppose, initially, that the output of IC1 is positive, and that the output of IC2 has just switched to positive saturation. The inverting input of IC1 is at virtual ground, so a current I_{R1} equals $+V_{SAT}/R1$. Because R1 and C1 are in series, I_{R1} and I_{C1} are equal. Yet, in order to maintain a constant current through a capacitor, the voltage across that capacitor must change linearly at a constant rate. A linear voltage ramp therefore appears across C1, causing the output of IC1 to start to swing down linearly at a rate of 1/C1 volts per second. That output is fed via the R2-R3 divider to the non-inverting input of IC2.

Consequently, the output of IC1 swings linearly to a negative value until the R2-R3 junction voltage falls to zero volts (ground), at which point IC2 enters a regenerative switching phase where its output abruptly goes to the negative saturation level. That reverses the inputs of IC1 and IC2, so IC1 output starts to rise linearly until it reaches a positive value that causes the R2-R3 junction voltage to reach the zero-volt reference value, which initiates another switching action.

The peak-to-peak amplitude of the linear triangular-waveform is controlled by the R2-R3 ratio. The frequency can be altered by changing either the ratios of R2-R3, the values of R1 or C1, or by feeding R1 from the output of IC2 through a voltage divider rather than directly from op-amp IC2 output.

In Fig. 20, the current input to C1 (obtained from R3-R4) can be varied over a 10:1 range via R1, enabling the frequency to be varied from 100 Hz to 1 kHz; resistor R3 enables the full-scale frequency to be set to precisely 1 kHz. The amplitude of the triangular waveform is fully variable via R5, and the square wave via R8. The output generates symmetric waveforms, since C1 alternately charges and discharges at equal current values determined by R3-R4.

Figure 21 shows how to modify Fig. 20 to make a variable symmetry ramp/rectangular generator, where the slope of the ramp and duty cycle is variable via R4. C1 alternately charges through R3-D1 and the upper half of R4, and discharges through R3-D2 and the lower half of R4.

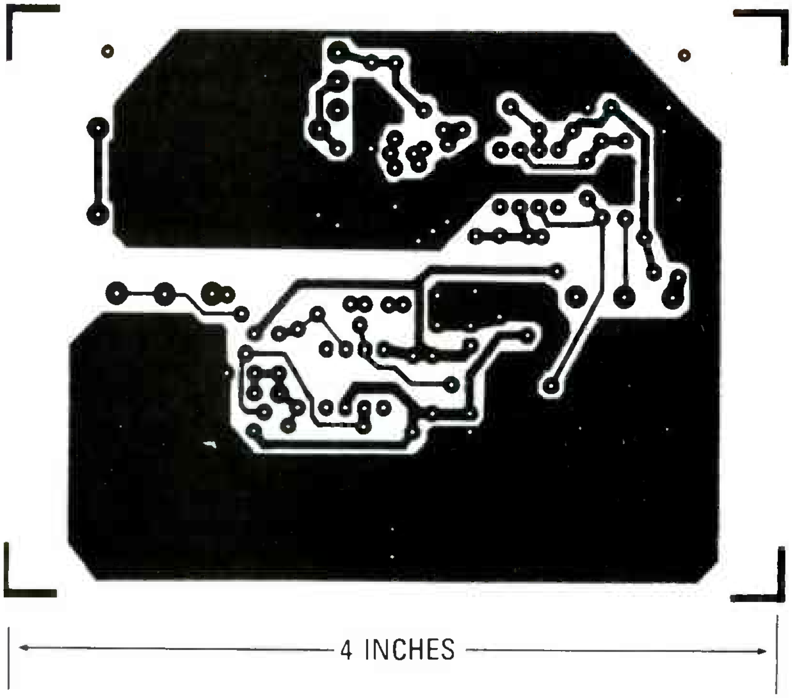
Switching circuits

Figure 22 shows the connections for making a manually triggered bi-stable circuit. Notice that the inverting terminal of the op-amp is tied to ground via R1, and the non-inverting terminal is tied directly to the output. Switches S1 and S2 are normally open. If switch S1 is briefly closed, the op-amp inverting terminal is momentarily pulled high, and the output is driven to negative saturation; consequently, when S1 is released again, the inverting terminal returns to zero volts, but the output and the non-inverting terminal remains in negative saturation. The output remains in that state until S2 is briefly closed; that switches the output to a stable positive saturation state until S1 is closed again.

Figure 23 shows how Fig. 22 can be modified for operation from a single-ended power supply.

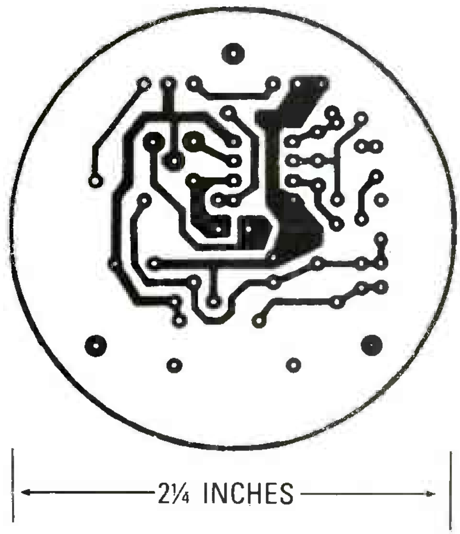
Finally, Fig. 24 shows how to connect an op-amp as a Schmitt trigger, which can be used to convert a sine wave into a square wave. Suppose, initially, that the op-amp's output is at a positive saturation value of 8 volts. Under that condition the R1-R2 divider feeds a positive reference voltage about 80 mV to the non-inverting input. Consequently, the output remains in that state until the input voltage rises to a value equal to 80 mV. The op-amp's output will then switch regeneratively to a negative saturation level of −8 volts, thereby feeding a reference voltage of −80 mV's to the non-inverting input. The output remains in that state until the input falls to −80 mV; at that point, the output regeneratively switches back to the positive saturation level. The switching levels can be altered by changing the R1 value. **R-E**

PC SERVICE



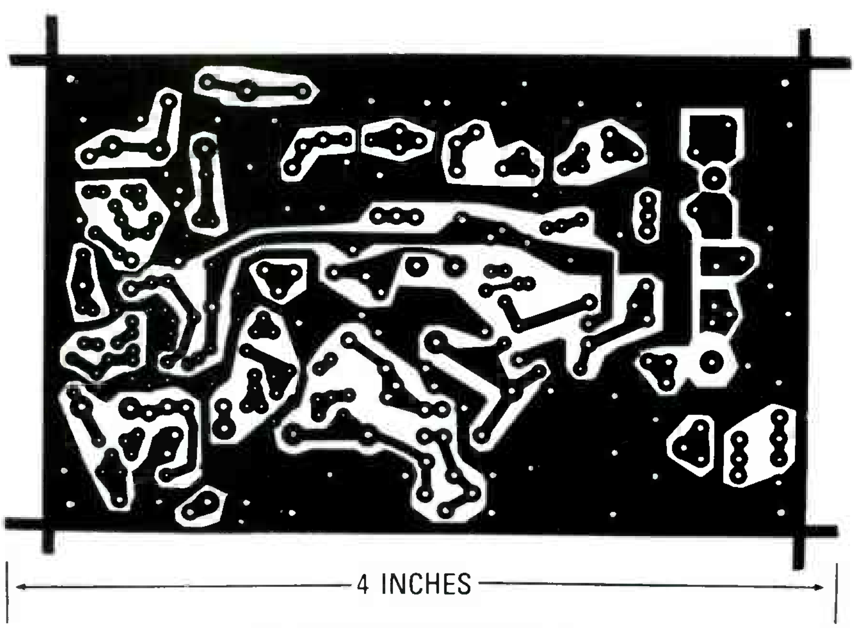
4 INCHES

THE LBC'S RECEIVER BOARD.



2¼ INCHES

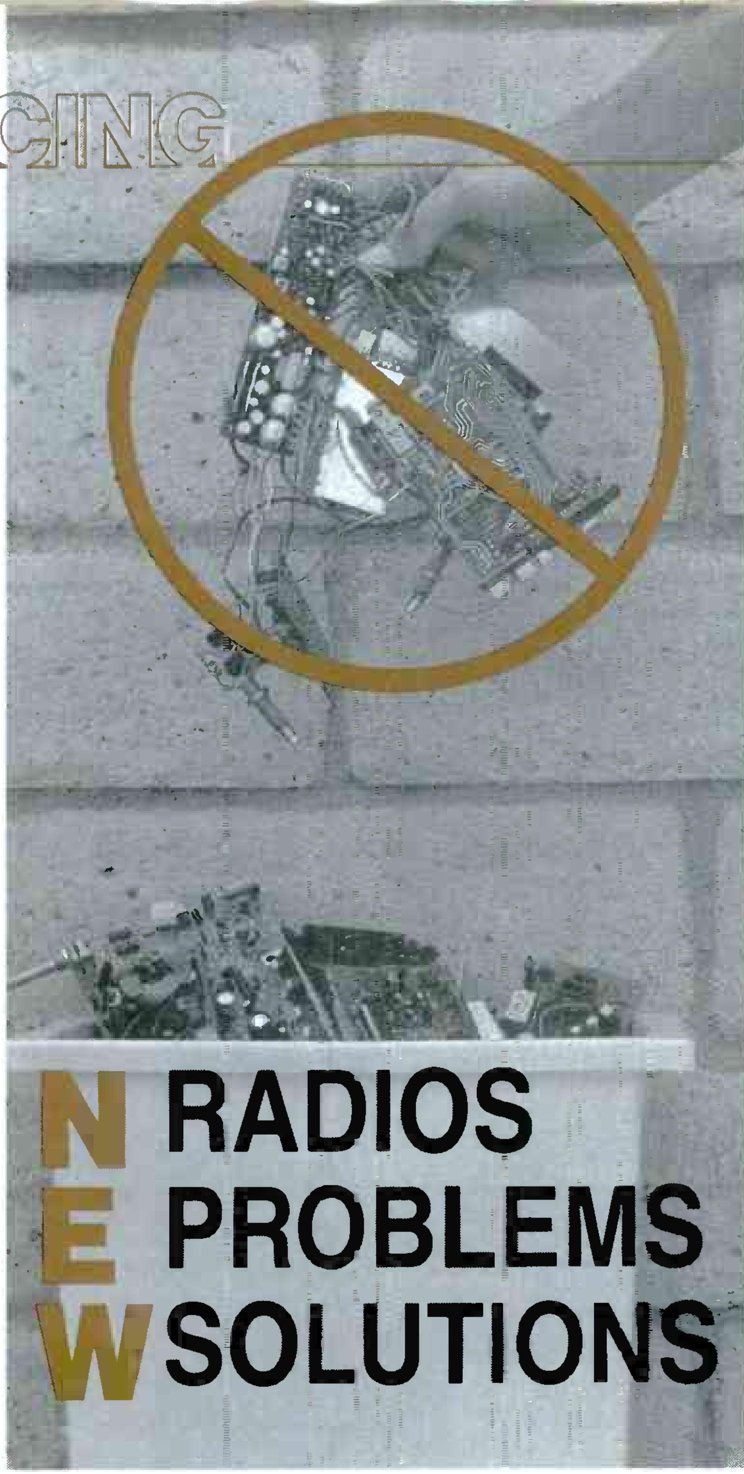
THE LBC'S TRANSMITTER BOARD.



4 INCHES

FOIL SIDE OF TV TRANSMITTER.

MORE PC SERVICE ON PAGE 84



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But don't despair; we'll get you started in servicing those radios. You'll learn about synthesizer circuitry and the most commonly used IC's. We'll also take a look at some troubleshooting techniques that might be new to you.

Synthesizer blues

A lot of technicians have sung the synthesizer blues. Here are some real-life reasons why: One receiver had an annoying whine in the audio on AM. The sound got louder when a station was tuned in. Power-supply problem? Not quite; it turned out to be an open capacitor in the loop filter. Another radio worked on AM but not on FM. Bad FM circuitry? Nope, a dead prescaler IC. And finally a third receiver was dead except for a rushing noise on both AM and FM. Bad power supply or any part in the synthesizer circuitry? You're getting close. That radio had a bad voltage regulator, which powered the synthesizer's controller IC. Let's examine the parts just mentioned a little closer, along with their typical symptoms when they fail.

Actually, the toughest symptom to troubleshoot is the "receives no AM or FM stations," because that fault could be in the synthesizer, the tuner, or even the power supply. Good news! Since the early 1970's, synthesizer radios have gone from PC boards loaded with IC's to a four-IC set. That means that troubleshooting today's circuits will be a lot easier than with the earlier monsters, although the broken-radio symptoms remain the same.

Radio circuitry

Digital tuning offers the advantage of drift-free reception along with such features as station presets and signal-seeking tuning. That makes radios easier for consumers to use, and highly profitable for the manufacturers. Modern car radios are a perfect example of synthesizer radios using presets; that's when you just push a button and the station you preset is automatically tuned in. Of course, the old-fashion pushbutton car radios worked fine, but the manufacturer had the added costs of manually installing the mechanical pushbuttons along with its pulleys and sliding pointer. Quality control then depended on how the assembler felt that day. Now a machine just picks up an IC and solders it in place

Figure 1 shows a typical synthesized AM/FM stereo receiver. Notice that the AM/FM front end uses conventional superhetodyne circuitry—but with a few modifications. Instead of the familiar mechanical tuning capacitor, a set of varactor (variable capacitor) diodes control the tuning frequency. Varactors change their capacitance in direct proportion to the driving voltage. The

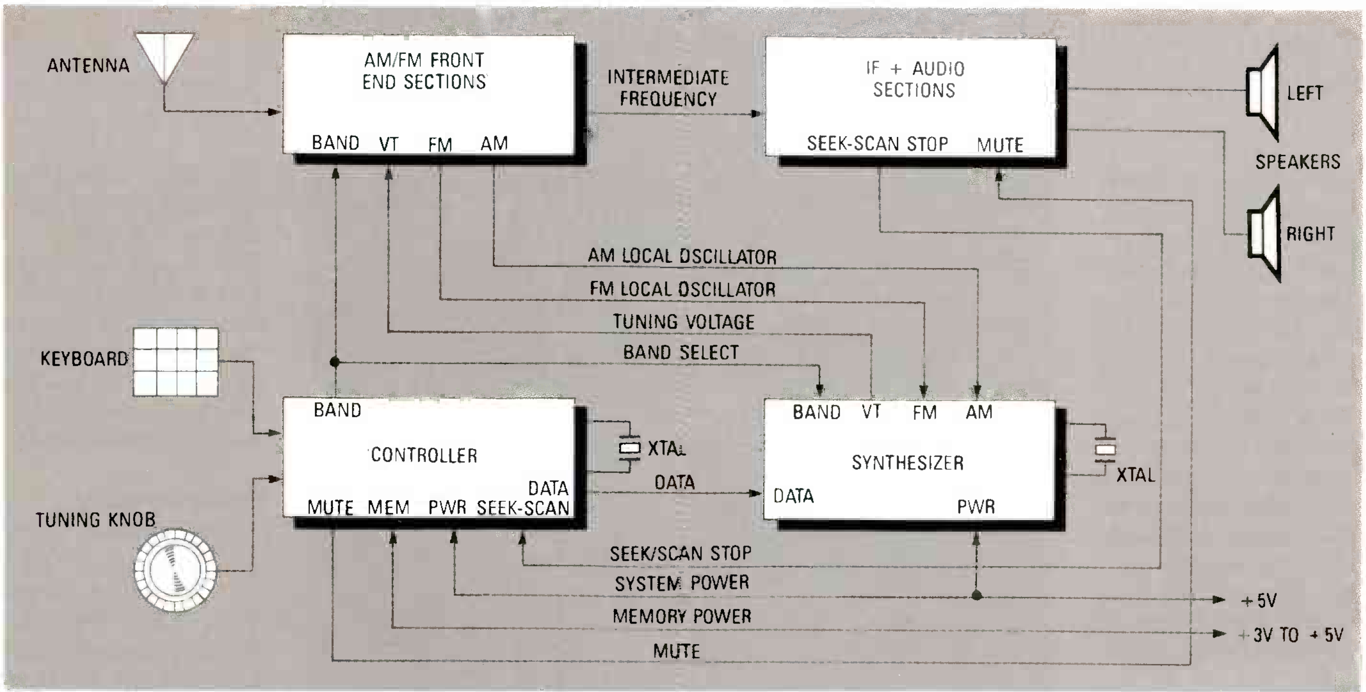

FIG. 1—DIGITALLY TUNED RADIO showing the control lines between the AM/FM front end, controller, prescaler, synthesizer, IF and audio sections, LED display, and keyboard.

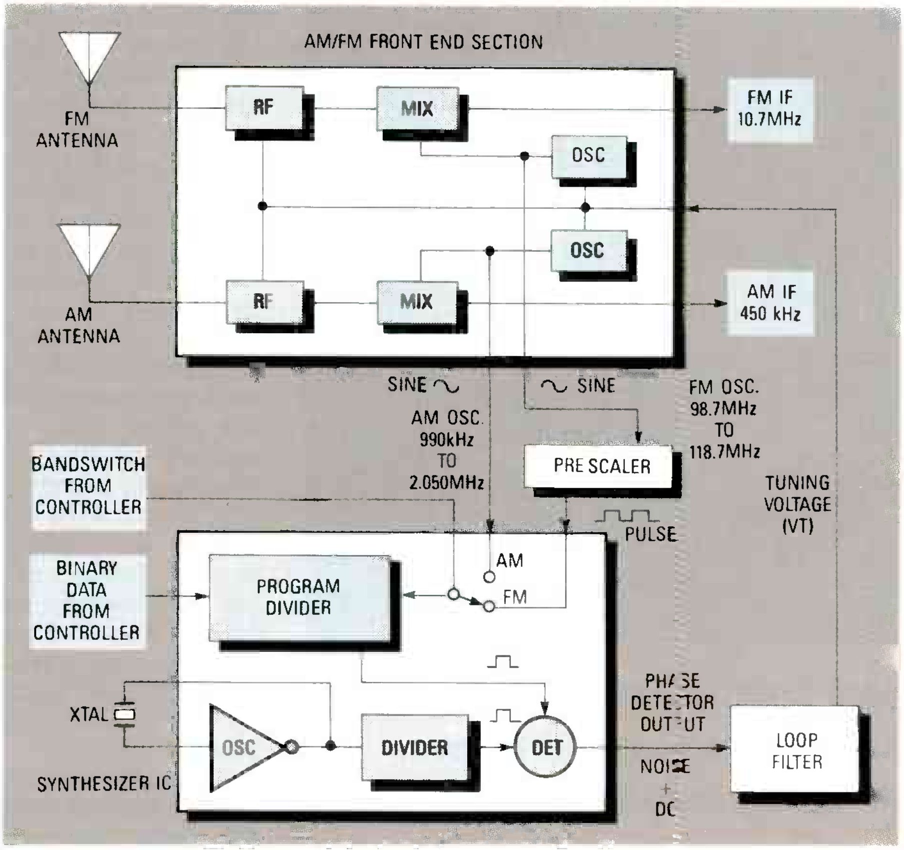

FIG. 2—THE RADIO'S SYNTHESIZER works closely with the AM/FM front end.

synthesizer monitors the AM- or FM-local oscillator and varies V_T, the tuning voltage that drives the varactor diodes, thereby controlling the receiver frequency.

Unique to digitally tuned receivers is the controller, which accepts inputs from the keyboard (presets, AM, FM, Seek, Scan) or the tuner switch. The inputs are converted into a binary code that drives the synthesizer IC via the data lines—essentially, it tells the synthesizer what to do. Notice that the DATA output from the controller drives the synthesizer, and is also decoded for the digital display. Understand that the digital display does *not* read the frequency that the receiver is tuned to; it is the frequency entered into the controller. That's an important fact to know when it comes to radio-tuning problems. The BAND-SELECT output selects AM or FM operation. Incidentally, if the receiver contains a clock, that function is also performed by the controller. Last, the controller also includes a MUTE output, which silences the radio during the tuning interval.

Deluxe receivers may contain an additional pushbutton called seek/scan stop tuning; when depressed, the controller forces the receiver to scan the radio band until a station is found. The radio's IF section then drives the SEEK/SCAN STOP line low, which stops the controller at the received station.

Two power sources are used to run the controller. Memory power is derived from batteries, or a large-value capacitor charged by receiver operation. System power (usually a 5-volt supply) runs the rest of the controller circuitry while the receiver is operating, including the display.

As shown in Fig. 2, the synthesizer IC accepts AM and FM local-oscillator signals from the front end. After receiving a divided-down signal from either local oscillator, a phase detector compares it with a signal derived from a crystal oscillator whose frequency is typically 10 kHz. The phase-detector output is an analog tuning voltage that varies with the difference between local-oscillator and crystal-oscillator frequencies. If the local-oscillator frequency is too low, the tuning voltage rises to a maximum; if the frequency is too high, the tuning voltage drops to zero. When the two frequencies are exactly the same, the voltage reaches an equilibrium and the desired frequency is tuned in. That condition is known as being "in lock."

Although all synthesizers directly accept the AM local oscillator, few work at FM local-oscillator frequencies. So, you'll find a prescaler IC nearby that divides the 98.7-MHz to 118.7-MHz FM local-oscillator frequency down to a frequency that the synthesizer IC can handle.

The analog tuning voltage from the synthesizer output must be filtered, and possibly level shifted (scaled) to suit the AM/FM front end. The filtering is simply a low-pass filter (dubbed a loop filter) that removes noise pulses generated by the phase detector for a clean DC output. Often, several transistors or an op-amp is used to improve filter performance.

Typical tuning voltages for AM reception range from 1.5 volts (540 kHz) to 6.9 volts (1600 kHz) in car radios. Home receivers may increase that range from 3.0 to 21 volts, especially in older models. On the other hand, FM-tuning voltages tend to be a little less than the AM tuning voltages. Note that the received frequency increases with tuning voltage; that information is sometimes useful.

Sought after IC's

Figure 3 is a typical synthesizer radio that features AM/FM digital-tuning along with seek/scan modes, and five station presets per band. There is also a clock feature.

The heart of the radio is the UPD1701 (IC1), manufactured by NEC of Japan. That device sports nearly all of the controller and synthesizer functions in one 28-pin DIP package. It is widely used in both home and car receivers; you'll find it in expensive receivers from Japan and in the "no name" specials from Hong Kong. Another popular IC is the UPD1703, which is like the UPD1701, but without the clock.

A popular FM prescaler is the UPB553 (IC2). It accepts the FM local-oscillator signal on pin 2, divides it by either 15 or 16, and outputs on pin 5 to the synthesizer. One interesting feature is the "divide by" pins 6, 7, and 8, that are controlled by IC1. The division ratio depends upon the frequency programmed by the controller and other factors.

The TD6250 (IC3) drives the display segments, and the UPA53 (IC4) drives the display cathodes. Note that the common-cathode LED display has four digits, plus LED indicators for functions like preset number, AM, FM, and memory. Sometimes you'll find individual transistors replacing the TD6250, and five transistors substituting for the UPA53.

When the keyboard is used, the synthesizer (IC1) internally decodes the key pressed and performs the desired function. Incidentally, the knob-

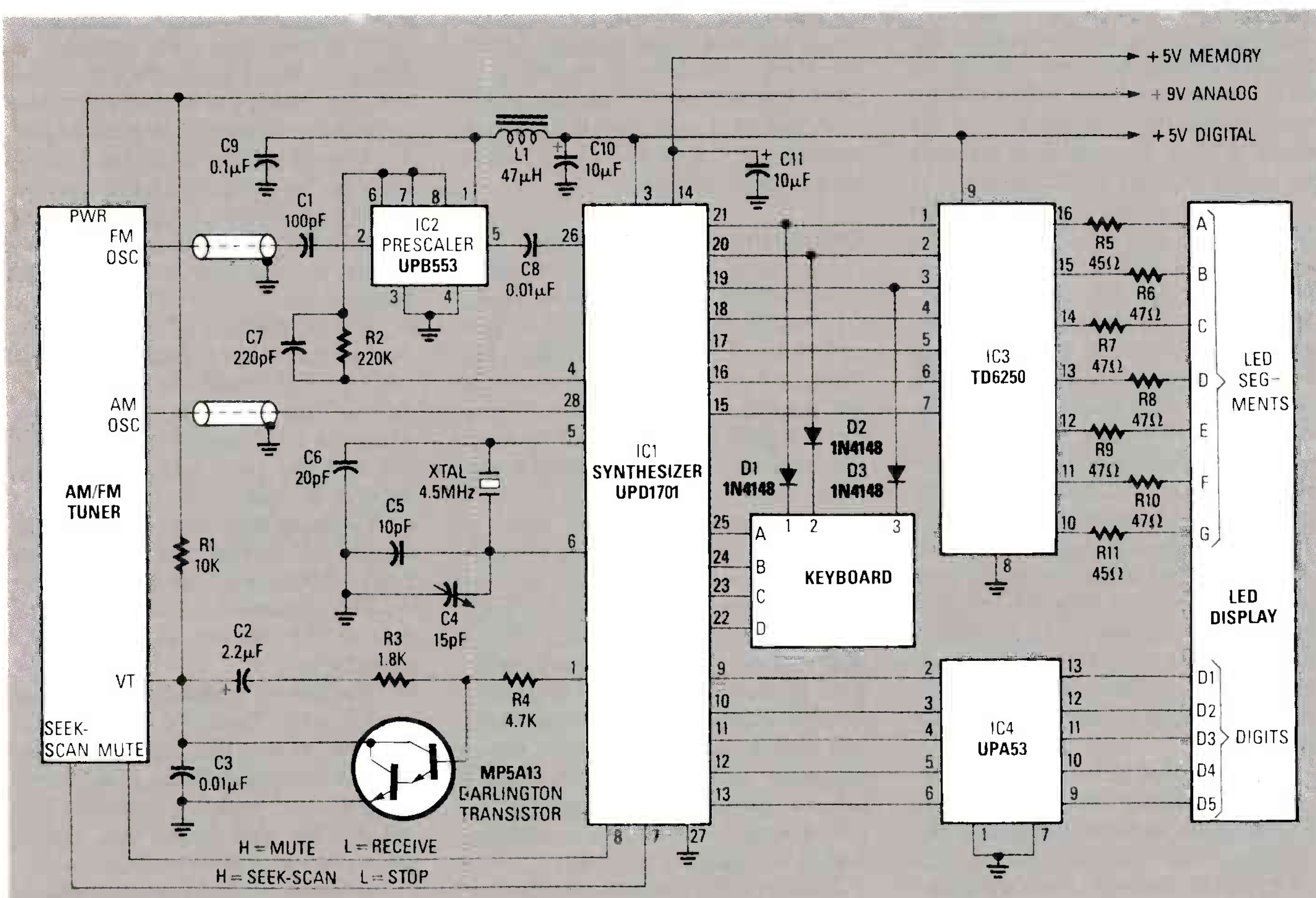

FIG. 3—THIS DIGITALLY TUNED RADIO uses custom IC's that perform complex functions. To fully understand each IC's operation, you really need the manufacturer's service manual.

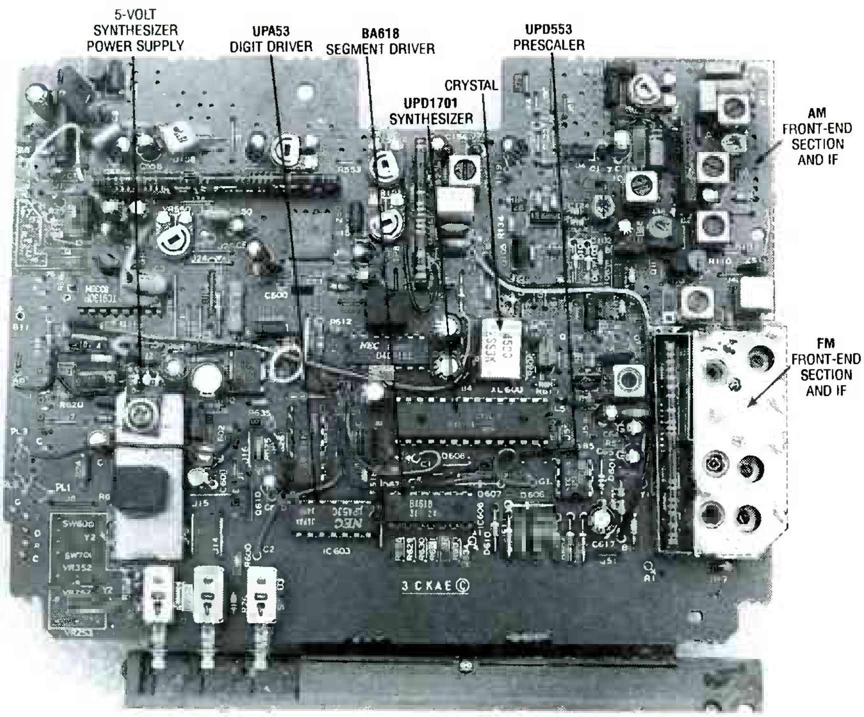

FIG. 4—THIS IS WHAT THE INSIDE of a digitally tuned radio looks like.

tuning feature found in car radios connects exactly like the keyboard. The tuning assembly uses two cam-driven SPST switches. One switch closes momentarily to tune down, and the other closes momentarily to tune up—a simple, but clever device.

The phase-detector output is taken from pin 1 of IC1, through a loop filter consisting of a Darlington transistor, and a few capacitors and resistors. Sometimes you'll find a FET transistor combination used instead. Some high-end receivers substitute op-amps, in their loop filters, for supposedly better results.

The AM/FM tuner may be a collection of discrete components on the board, or more likely a module from Alps or Mitsumi Corporation. It provides buffered local-oscillator outputs on the order of 100–400 mV, and accepts the tuning voltage. Some tuner modules also include IF circuitry; in that case, they can have a seek/scan stop output, and audio-muting provisions.

The increased desire for more presets has forced receiver manufacturers to return to separate controller and synthesizer IC combinations. Chrysler, for example, uses a National COP-series controller and a DS8908 synthesizer-IC set in their recent-model car radios. Headphone portables use a single IC for controller, synthesizer, and display driver functions—available from Sharp or NEC. Should one of those parts fail, you can buy it *only* from the receiver manufacturer, and that often makes repairs uneconomical.

Troubleshooting techniques

Now let's look at some winning troubleshooting procedures. Well, OK, nothing can replace good ol' factory training, full service data, plus five-years experience, but these tips will get you off to a good start. Figure 4 is a typical digitally tuned receiver that you might come across in any repair shop.

Here's the *test* procedure, which is simple enough. Before you do anything else, try all receiver controls and functions to verify and duplicate the customer's complaints. Doing that will help you avoid those problems caused by customers who have trouble using electronic equipment and may simply be confused. Other problems you want to immediately rule out include the obvious: wiring disconnected, blown fuses, and tinkering by Saturday mechanics.

Just trying the controls can uncover digital-tuning defects like stuck keyboards and intermittent switches. Clean or replace the bad part and your work is done. Suffice to say, "Always fix the obvious problems first."

Now let's evaluate receiver problems to isolate a bad power supply or dead amplifier. Only when everything else is working should you turn your attention to the digital tuner. Many times, you'll find fixing the simple problems clears up over half of the "it won't get any stations" problems.

As you might expect, to service the digital tuner, it helps to obtain the radio's service manual from the manufacturer; at least then you'll know what voltages to expect, and can identify the parts on the board.

To troubleshoot down to the component level in a digital tuner, the following tips should be helpful:

- **The AM/FM front-end** is good if you hear a rushing sound with the volume turned up. That can be verified by connecting an antenna, and listening for any stations near 540-kHz AM or 88.1-MHz FM. If you have no local stations, try a signal generator.
- **The controller** is probably good if all keys work, and it stores the frequencies you enter. If you observe one or more bad keys, the keyboard is likely to be at fault—bridging the connections behind the bad key with a screwdriver blade will show that fault.
- **The display** has common problems like missing segments, and are usually caused by an open connection between the display and driver. Look for an unsoldered connection or broken wire.
- **The synthesizer** IC is good if you can tune in AM or FM stations. If you can't get FM, check the prescaler circuit. If you can't get AM, suspect either the local oscillator output from the AM/FM front end, or the synthesizer IC itself.
- **The loop filter** is good if you can tune in AM stations across the entire band, without a whine in the sound.
- **The prescaler** is good if you can tune in FM stations—either it works or it doesn't.
- **The power supply** is a common trouble spot. Typically that defect is obvious because the display is not lit.
- Test or substitute the major components in the area you isolated. Look out for the little things like broken parts and unsoldered connections.

Next time we'll dig deeper into receiver problems. And we'll top that off with tips on where to obtain those tough-to-find parts. **R-E**

CHOOSING THE RIGHT SHORTWAVE ANTENNA

Boost your shortwave reception using a wire antenna—and a little know-how.

JOSEPH J. CARR

MOST ARTICLES ON HIGH-FREQUENCY ANtennas are about transmitting, but there's also a body of knowledge purely about receiving antennas. Who can benefit from knowing about receiving antennas? On top of the list is the *s*hortwave *l*istener (SWL); a close second is the amateur radio operator who wants a separate receiving antenna to pull in those weak DX (distant) stations.

Reciprocity

Antennas possess a property called *reciprocity*. That's a fancy way of saying that antennas work as well on receive as they do on transmit; that's usually taken for granted. For example, many hams use transceivers, which commonly use the same antenna for both transmitting and receiving. A half-wavelength dipole that works well as a transmitting antenna on 20 meters works equally well as a receiving antenna on 20 meters. Antenna properties like directivity, gain, angle of radiation, and polarization do not vary between transmit and receive at a given frequency. (Bear in mind, however, that simple wire antennas suitable for reception of shortwave signals are not necessarily suitable for transmitting.)

Antenna properties

Assuming that you want more than a simple longwire antenna (which will be discussed shortly), you will want to explore the antenna properties best suited to your monitoring application. Is the antenna to be fixed or rotatable? Do you want omnidirectional or directional reception? In which polarized plane? What about gain?

Because receiving antennas exhibit the same properties as transmitting antennas, any directional transmitting antennas are directional while receiving, too. Therefore, any specifications given for an antenna's transmitting characteristics can be applied toward receiving characteristics. The common terms you'll come up against when reading antenna specifications are gain, directivity, and angle of radiation. Let's look at each.

Antenna gain stems from the fact that the directional antenna can focus energy. Gain is expressed as the ratio in decibels of the power radiated in a given direction by a test antenna to the power radiated in the same direction by a reference. The two commonly used reference antennas are a dipole (which has a figure-8 radiation pattern) and a spherical point source (which is an isotropic radiator that has an omnidirectional radiation pattern). If an antenna gain is listed as 8 dB over isotropic then, in the direction specified, the radiated signal is 8 dB higher than that radiated by an isotropic antenna.

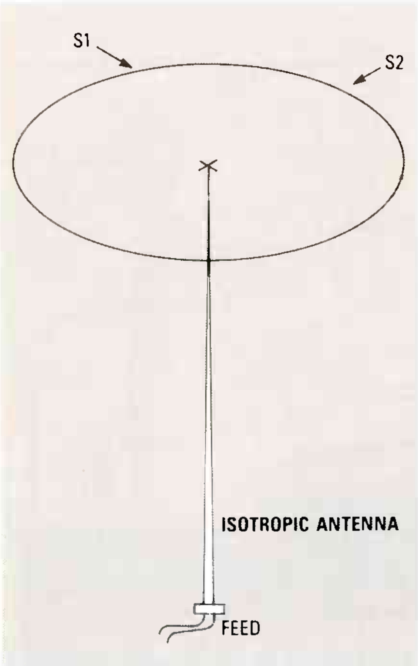

FIG. 1—AN ISOTROPIC ANTENNA is a theoretical construct that receives equally well in all directions.

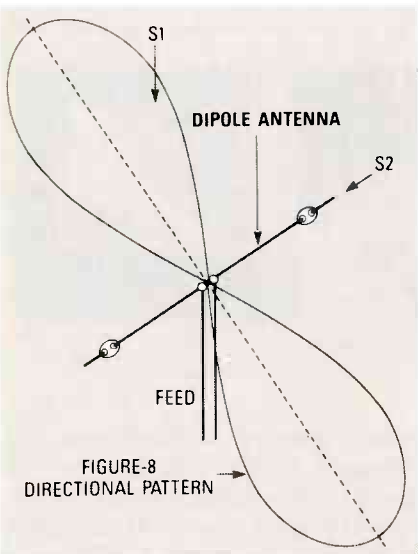

FIG. 2—A DIPOLE ANTENNA has a figure-8 directivity pattern.

So what good is antenna gain? By accumulating more signal, the apparent receiver sensitivity is increased. Note that the antenna gain does *not* create a higher powered signal, but merely increases the *apparent* signal power by focusing energy —like an electromagnetic lens—from a given direction. Note that antenna gain implies directivity.

Directivity is often taken to mean horizontal directivity. But all antennas radiate in three dimensions, so both azimuth and elevation angle of radiation are important. Certain VHF/UHF vertical antennas are listed as "gain antennas", yet the pattern in the horizontal direction is 360 degrees, implying omnidirectional behavior. In the vertical plane, however, lost energy is compressed into a smaller range of elevation angles, so gain occurs by refocusing energy that would have been radiated at a higher-than-useful angle.

A second application of directivity is to suppress interfering signals. On the regular AM- and FM-broadcast bands, each station is allowed a channel (called channelization), permitting receiver selectivity to overcome adjacent channel interference. But in the *h*igh *f*requency (HF) amateur radio and international broadcast bands, channelization is either nonexistent, poorly defined, or ignored altogether. In those cases, interference from adjacent channel signals can wipe out a weaker desired station.

A similar circumstance occurs in co-channel interference when both stations are on the same frequency. In Fig. 1, two 9540-kHz signals, S1 and S2, arrive at the same omnidirectional vertical antenna; both will be heard, or the stronger will drown out the weaker. In Fig. 2, a dipole is used as the receive antenna, so a little directivity is obtained. The main lobes of the dipole are wide enough to provide decent reception of S1 even though the antenna is positioned in such a way that S1 is not along the maxima line (dotted). Better yet, the positioning places interfering co-channel S2 in the null (off the ends of the dipole), weakening response to S2. The result is enhanced S1 reception.

The idea is not to exploit the antenna's gain to increase the response to S1, but rather to place the unwanted signal S2 into the null. Note that the notch is sharper than the peak of the main lobe. If the dipole is placed on a mast with an antenna rotator, the ability to place undesired signals in the null is increased even more.

Another antenna parameter of considerable interest is angle of radiation, which also means angle of reception. Because long-distance HF propagation is caused by skip, the angle of incidence for the signal with the ionosphere becomes extremely important. Figure 3 shows two skip conditions from the same transmitting station. Here S1 has a high angle of incidence a_1, so skip distance D1 is relatively short. For S2, however, the angle incidence a_2 is low, so the skip distance D2 is much longer than D1.

The angular range of effective radiation of an antenna is fixed by its design. The angle of refraction in the ionosphere is a function of ionospheric properties at the time and frequency of interest. For that reason, some well-equipped radio hobbyists use several different antennas. The radiation angle can vary with antenna height as well.

Receiver connection

It's rather naive to state, I suppose,

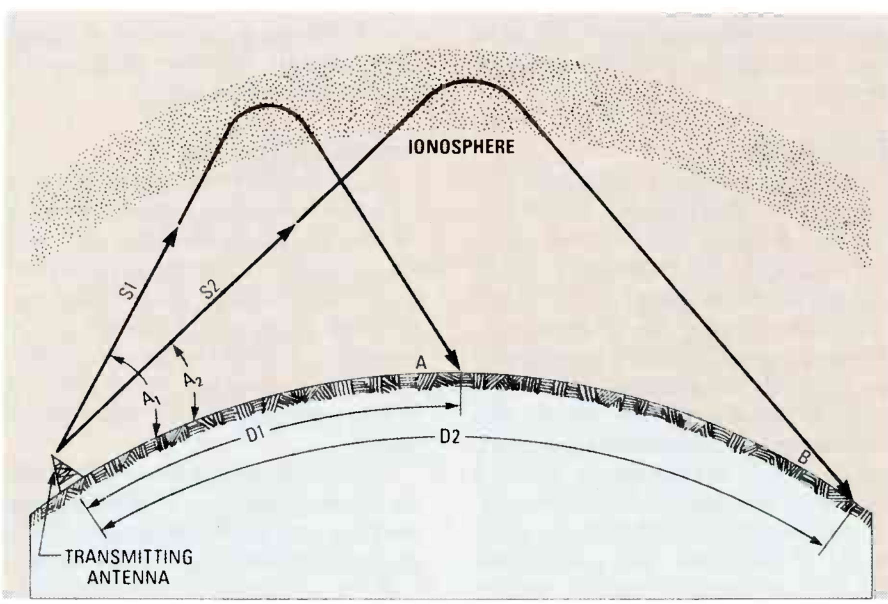

FIG. 3—THE SKIP DISTANCE OF A RADIO WAVE depends upon the angle of elevation at which it's transmitted.

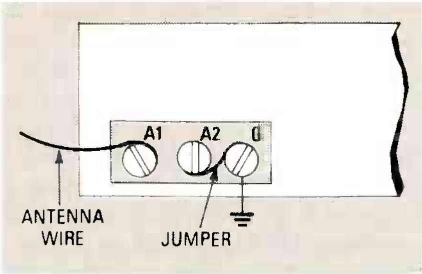

FIG. 4—A RECEIVER'S BALANCED antenna input can be converted to an unbalanced input by connecting A2 and G (ground) together.

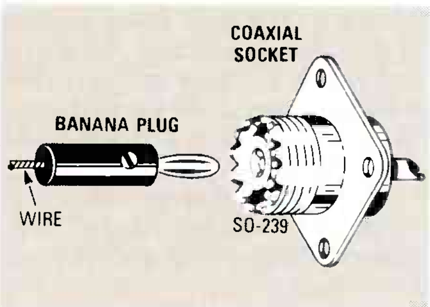

FIG. 5—USE A MINIATURE banana plug to connect your antenna's downlead wire to a standard SO-239 coaxial connector.

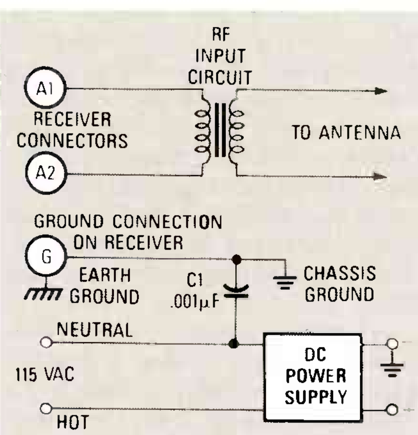

FIG. 6—MANY OLDER VACUUM-TUBE receivers use power supplies that are not isolated from the AC power line. When working on such units, *always* use a 1:1 isolation transformer—for safety.

but let's do it anyway: An antenna must be properly connected to a receiver to be effective. If your antenna uses coax, and the receiver accepts coax, simply attach the proper connector; however, in other cases, non-coaxial cable antennas are used.

There are two major forms of antenna connectors used on shortwave receivers. One uses two or three screws for wrapped wire leads or spade lugs, while the other uses some type of coaxial connector. Consider first the screw-type connector (Fig. 4).

If only two screws are found, then one is for the antenna and the other is for the ground. Those screws will be marked something like "A/G" or "ANT/GND," or with the schematic symbols for antenna and ground.

Three-screw designs are intended to accommodate balanced transmission lines such as twin-lead or ladder line. When balanced parallel lines are used, connect one lead to A1 and the other to A2. Of course, the ground terminal G is connected to Earth ground. On the other hand, for single-lead antennas, connect a jumper wire or bar (a short piece of bare No.22 solid hook-up wire) between A2 and G to convert a balanced input to unbalanced. As an interesting aside, shortwave listeners sometimes use ordinary AC-line cord (called zip-cord) as a twin-lead transmission line. Zipcord has an impedance that approximates the 75-ohm impedance of a dipole.

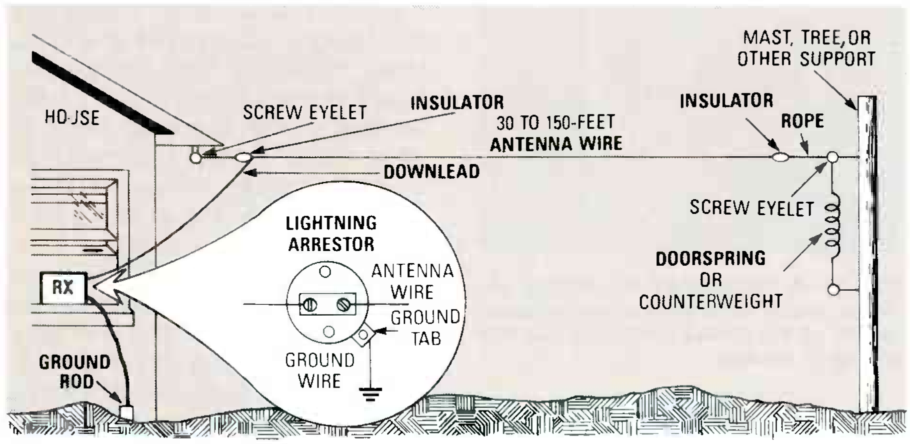

FIG. 7—HERE'S A TYPICAL LONG-WIRE INSTALLATION. Notice the insulator, rope, and spring mechanism, which helps holds the antenna steady when the wind is blowing.

On receivers that use an SO-239 coaxial connector, there are two techniques to connect a single-lead antenna. First, using a PL-259 mating plug, solder the antenna lead to the center conductor pin, and then screw the connectors together. An alternative that's easy enough, as shown in Fig. 5, is to attach a (miniature) banana plug to the downlead wire, and then firmly to insert that banana plug into the SO-239 receptacle.

Grounds that bite

Danger! Certain low-cost receivers, especially older vacuum-tube models, have a so called AC/DC (transformerless) internal DC power supply. On most modern receivers the DC common is the chassis, which also serves as the RF common. However, on older AC/DC models the neutral AC power-line wire serves as both DC common and RF-signal ground. In Fig. 6, C1 sets the chassis at RF ground potential, while isolating the DC common from the 60-Hz AC. A danger exists if either the AC plug is installed backwards, or someone wired the socket in the wall incorrectly (which often happens)!

Even if C1 is intact, you can get a nasty shock by touching the antenna ground (G or GND) terminal. The capacitive reactance of C1 is about 2.7 megohms for 60-Hz AC, so you'll get

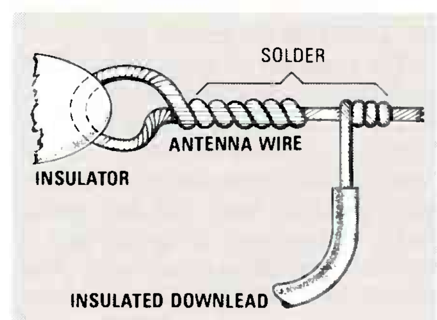

FIG. 8—A GOOD MECHANICAL connection will keep your antenna from falling down prematurely. Solder will keep the electrical connection from corroding to quickly.

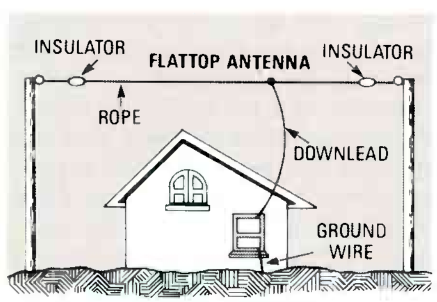

FIG. 9—A FLATTOP ANTENNA is a long wire tapped in the center.

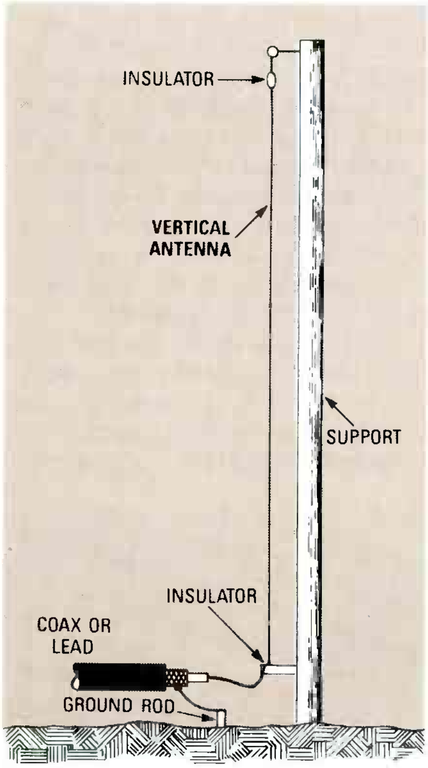

FIG. 10—A VERTICALLY POLARIZED antenna should be at least a quarter wavelength of the lowest frequency that you expect to receive.

a "bite." But if that capacitor is shorted, as is likely on older receivers, then the bite might prove *fatal*. The problem is that a reversed polarity AC-line will set the hot line from the AC socket on the ground lead.

The usual advice given to owners of such radios is to make sure that C1 is intact before using the radio. A better solution might be to use a 110:110 VAC isolation transformer to isolate your receiver from the AC power lines. Using such a transformer is standard practice in repair shops, and should be standard practice in your house, too.

Wire antennas

Figure 7 shows the common receiving longwire. The antenna element should be 150 to 300-feet long. Although most texts show it horizontal to the ground and, indeed, a case can be made that performance is better that way—it is not strictly necessary. If you must slope the wire, then it's doubtful that you will notice any reception problems. The far end of the wire is attached to a supporting structure—a building, tree, or mast—through an insulator and rope.

Wind will cause motion in the antenna wire, and its supporting structure. Over time, the wind movement will fatigue the antenna wire and cause it to break. Also, if a big enough gust or a sustained storm comes along, then even a new antenna will either sag badly or break altogether. You can do either of two things to reduce the problem. First, as in Fig. 7, a door spring can be used to provide some variable wire slack. The spring tension is selected to be only partially expanded under normal conditions. When the wind begins to blow, the wire's tension will increase, thereby stretching the spring. Make sure that the spring does not become over-stretched, or it won't work.

Another tactic is to replace the spring with a counterweight that's heavy enough to keep the antenna nearly taut under normal conditions, but light enough to move in wind. In other words, antenna tension should exactly balance the counterweight under normal conditions, and not stretch the antenna wire excessively.

The antenna wire should be either No.12 or No.14 hard-drawn copper, or stranded wire. The latter is actually steel-core wire with a copper coating. Because of "skin effect," RF signals only flow in the outer copper coating. Soft drawn copper wire will stretch and break prematurely, and should be avoided.

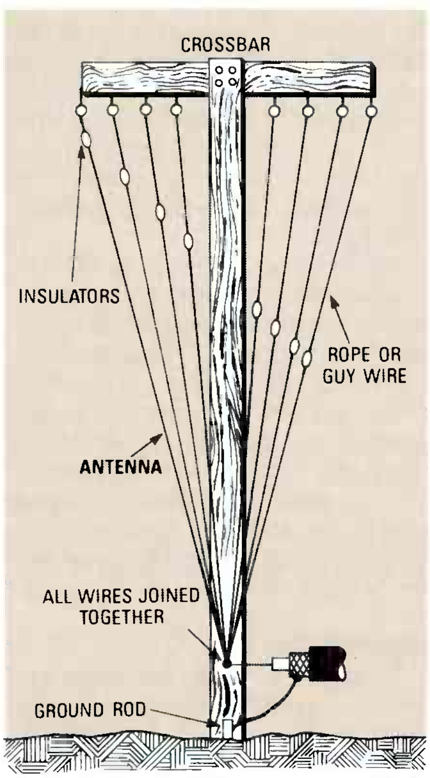

FIG. 11—TUNE IN THE WORLD with eight antennas in one.

The antenna downlead should be insulated and stranded; stranded wire breaks less easily than solid wire. Again, use No.12 or No.14 wire, although No.16 could be used. The point where the downlead and antenna wire are joined should be soldered to prevent the joint from corroding over time. Do not depend on the solder for mechanical strength, for it has very little. Instead, as shown in Fig 8, mechanical strength is provided by proper splicing technique.

There are several ways to bring a downlead into a building. If you can tolerate a slight crack in the junction of the sash and sill, then run a wire underneath the sash and close the window. However, the job looks mechanically nicer with a flat strap connector that passes under the window. Of course, you can always drill a hole in the wall, slip the coaxial cable through, then putty around the seam for a snug fit.

Grounding

The ground lead should be a heavy conductor, such as heavy wire, braid, or the shield stripped from RG-8 or RG-11 coaxial cable. For reception purposes only, the ground may be a cold-water pipe inside the house. Do not use either the hot-water pipes (which are not well grounded), or gas pipes (which are dangerous). Also, be aware that residential air-conditioner liquid lines look like copper cold-water pipes in some cases—don't use them.

A lightning arrester is a safety precaution, and *must* be used. It provides a low resistance path to ground in the event of a lightning strike. Don't consider the arrester optional—it isn't. Besides the obvious safety reasons (which are reason enough), there may be legal and economic reasons for using the arrester. Your local government building and fire codes may require one. Also, your insurance company may not honor your homeowner's policy if the lightning arrester required by local code is not used.

Warning! Do not ever attempt to install an antenna by crossing a power line! No matter what you believe or what your friends tell you, it's never safe—and it may very well kill you.

What about antennas other than the receiver longwire? The flattop antenna is shown in Fig. 9. That antenna is a close relative of the longwire, with the exception that the downlead is in the approximate center of the antenna section. The flattop antenna should be at least a half wavelength (492/*f* MHz) at the lowest operating frequency. The advantage of the flattop antenna over other designs is that it allows maximum use of available space in the configuration shown.

It is also possible to build vertically polarized shortwave receiving antennas; Fig. 10 shows one such version. The support structure (a tree or building) should be at least a quarter-wavelength high on the lowest operating frequency. The vertically polarized antenna is fed at the base with coaxial cable. The center conductor goes to the antenna element, while the coaxial cable's shield gets connected to the ground rod at the base of the support structure.

It's possible to install the wire (or multiple wires of different lengths) inside a length of PVC plumbing pipe. The pipe serves as the support, and the conductors go inside. If you use a heavy pipe gauges of PVC, then the antenna support can be disguised as a flag pole (townhouse dwellers take note)!

Different conductor lengths (L = 246/*f* MHz) are required for different operating bands. In Fig. 11, several bands are accommodated from the same feedline using the same support. In fact, eight different antenna elements are supported from the same tee-bar. Be sure that you insulate them from each other, as well as from the support; again, PVC piping can be used for the support structure. Figure 12 shows a method for accommodating several bands by tying the upper ends of each antenna wire to a sloping rope.

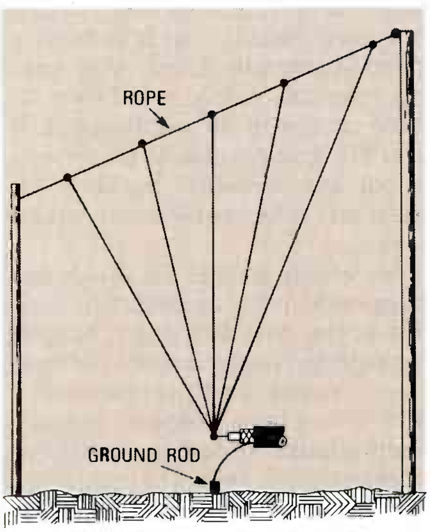

FIG. 12—BY USING A SLANTED ROPE, you can tied together any number of antennas tuned to different wavelengths.

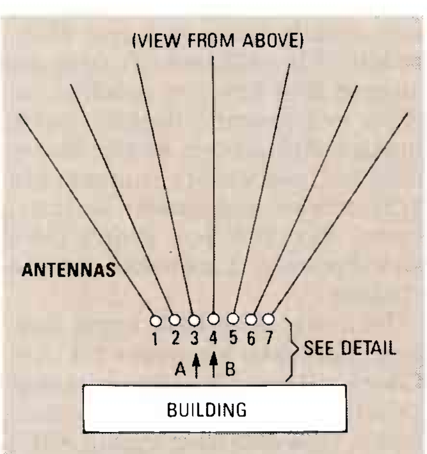

FIG. 13—SELECT THE DIRECTIONAL pattern of the antenna system by interchanging antenna elements of different wavelengths and position.

Directional wire antenna

A directional antenna has the ability to enhance reception of desired signals, while rejecting undesired signals arriving from slightly different directions. Although directivity normally means a yagi beam, a wire-quad beam, or at least a rotatable dipole, certain designs and techniques allow fixed antennas to be more or less directive. One crude but effective approach uses pin plugs or a rotary switch to select the direction of the antenna's reception.

Figure 13 shows a number of quarter-wavelength radiators fanned out from a common feedpoint at various angles from a building. At the near end of each element is a female banana-jack. A pair of balanced feedlines from the receiver (300-ohm twin-lead, or similar) are brought to where the antenna elements terminate. Each wire in the twin-lead has a banana plug attached. By selecting which banana jack is mated to which banana plug, you can select the directional pattern. If the receiver has a balanced antenna input, then connect the other end of the twin-lead directly to the receiver; for receivers with unbalanced inputs, you will have to use a balanced-to-unbalanced (balun) antenna coupler.

Figure 14-*a* shows a balun antenna coupler tuned to the receiving frequency. The coil is resonantly tuned by the interaction of the inductor and capacitor. Antenna impedance is matched by selecting the inductor taps to which the feedline is attached.

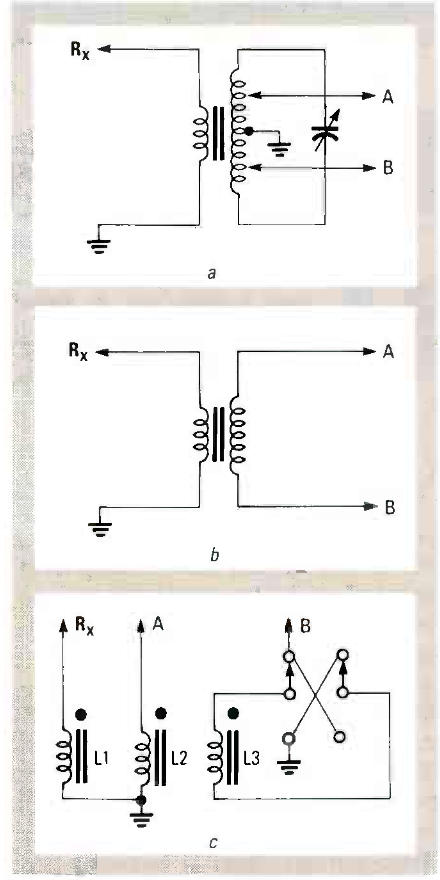

FIG. 14—MATCH A BALANCED ANTENNA with an unbalanced receiver input using any of three methods, *(a)*, *(b)*, or *(c)*.

A simple RF broadband coupler is shown in Fig. 14-*b*. The transformer is wound over a ferrite core using 12 to 24 turns of No.26 enameled wire, with more turns for lower frequencies, and fewer turns for the higher frequencies. Experiment with the number of turns to determine the correct value.

By combining the right antenna and matching network, the best of both worlds can be had. For example, the antenna in Fig. 13 works by phasing the elements so as to null or enhance the reception in certain directions.

The nulling operation becomes a little more flexible if you build a phasing transformer, like the one in Fig. 14-*c*. Windings L1, L2, and L3 are wound trifilar style on a ferrite toroidal core using 14 turns of No.26 enameled wire. The idea is to feed one element from coil L2 (the A port), the same way all the time; that port becomes the 0-degrees phase reference. Port B is fed from a reversible winding, so it can either be in-phase, or 180-degrees out-of-phase with port A. **R-E**

HARDWARE HACKER

Toner reloading tools
More on digital audio
Getting an oscilloscope
Simple CMOS oscillators
Some bar code resources

DON LANCASTER

Getting an oscilloscope

THERE SURE WAS QUITE A BIT OF INTEREST in the digital audio front end we looked at last month. For those of you that missed it, Crystal Semiconductor has a few reasonably priced A/D converters and evaluation boards which can give you everything you will need to input full 16-bit stereo digital audio into your personal computer or other digital recording system—in short, a plug-and-go digital audio front end.

One possible recording device is a plain old SCSI hard-disk drive. In fact, they are approaching a gigabyte in storage capacity, which means that any old personal computer can record several hours of first-rate CD-quality stereo audio. That also means that the so-called "DAT controversy" is now totally moot, since there is now an installed user base of several tens of millions of computer systems that can, at least in theory, do a compact-disc-quality digital audiophile recording.

It should also be easy to adapt the digital-audio front end to an ordinary VCR. That would make probably a very interesting construction project.

What about the playback? Getting from digital to analog isn't nearly the hassle as going the other way. One obvious route is to use any old CD player and intercept and override the bits halfway through. Otherwise, the needed D/A chips are readily available from Analog Devices, Sony, or from Burr-Brown.

Naturally, we've opened up some golden new opportunities here. All of the folks at **Radio-Electronics** would be most interested in publishing some workable construction projects that you can come up with.

As usual, this is your column, and you can get technical help and off-the-wall networking per that "Need Help?" box. Best calling times are 8–5 weekdays, Mountain Standard Time.

We seem to have a mixed bag this month...

Getting an oscilloscope

I have long been a great fan of doing things on the cheap. The whole purpose of hacking is to get all the effects that you are after to show up reasonably well using the minimum possible time, cost, and effort. And I have seen countless projects ruined or changed into something entirely different and totally out of control by throwing far too much money at them far too soon.

On the other hand, there are one or two essential tools to any endeavor that are best done on a positively first-rate and top-notch basis.

As an obvious example, no photo-journalist would ever try to operate without a camera. And his or her camera choice will almost always be a Nikon. Instamatics need not apply.

It amazes me how many hardware hackers out there do not own a personal oscilloscope or have no reasonable access to one. That is not only absurd, but it is even a contradiction in terms. Very simply, you absolutely *must* own or have access to an oscilloscope if you are going to be at all serious about any hardware hacking. Almost any other equipment can be faked.

So which scope? So much has happened in the oscilloscope market in the past few years. Scopes have gotten better in terms of both performance and specifications, and prices have dropped dramatically thanks in part to increasing competition. Even Tektronix has some bargains.

For instance, outstanding hacker choices would be either their $695 model 2205 or their somewhat fancier model 2225. I personally own and use their much older 455, which cost me around four times as much as today's instruments, besides being bulkier and heavier. All our beginning EAC electronics students use 2225 scopes and similar workstations, the stuff you didn't even dare dream of back when I was a student.

Tektronix does have some freebies that make life easier for you. Check out their *Tek Direct* catalog, or any of their many free videotapes. They also have a good *ABC's of Oscilloscopes* experimenter book available. It's supposed to cost $3, but you can often talk them out of a free copy or two.

NEED HELP?

Phone or write your **Hardware Hacker** questions directly to:
Don Lancaster
Synergetics
Box 809
Thatcher, AZ 85552
(602) 428-4073

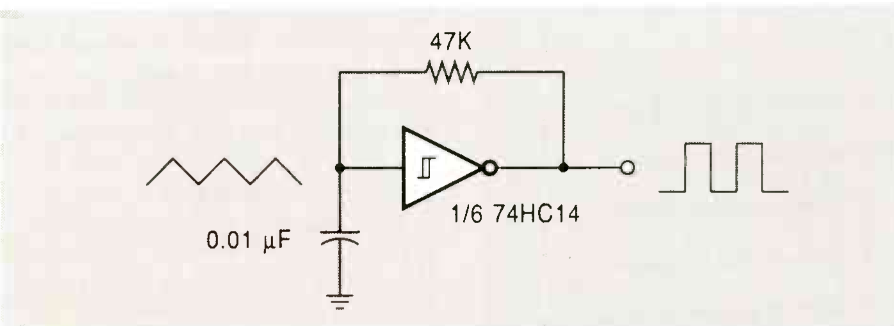

FIG. 1—AN ELEGANTLY SIMPLE OSCILLATOR can be built using nothing but one resistor, one capacitor, and ⅙th of a CMOS hex Schmitt trigger. Your output is a full-supply square wave, while the input is a triangular wave that "saws" between the trigger's upper and lower trip points.

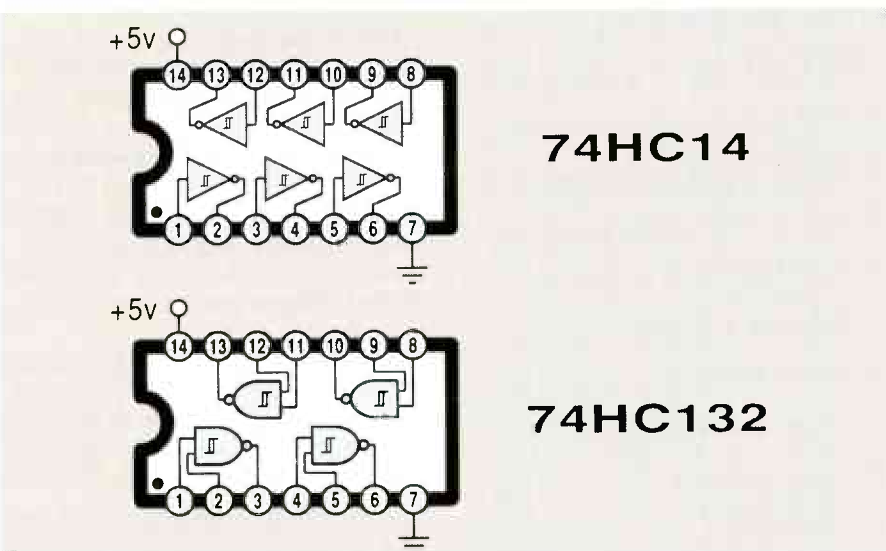

FIG. 2—THE PINOUTS for the two most popular CMOS Schmitt chips include the hex inverting 74HC14 and the quad NAND 74HC132. While intended for +5-volt use, they will work over a +2- to +6-volt range. For higher voltages, use the older 4093 or 4584 devices instead. The chips are shown top view.

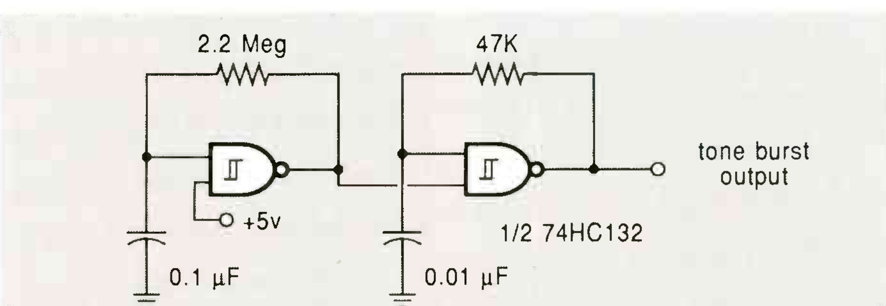

FIG. 3—A GATED OSCILLATOR produces repeated tone bursts. The RC values on the right side set the frequency, while the ones on the left determine the repeat rate.

My favorite circuit

One recent hacker helpline caller needed a tunable 10- to 15-megahertz square-wave generator—preferably in the next ten minutes. I got to thinking about it for a while, and realized that a favorite circuit of mine could easily do the job, and then some.

I always have liked elegant simplicity—any stuff that can do more with less at lower cost. And I know of no better circuit than this one to use as an example.

Figure 1 shows you an oscillator that uses only 2⅙ components. One resistor, one capacitor, and one-sixth of a hex CMOS Schmitt trigger.

Let's review a bit here. A CMOS Schmitt trigger is a digital-logic device that will output a "1" when you input a "0," and vice versa. If you are using the usual +5-volt supply, then the output "1" state will normally be +5 volts, and the output "0" state will normally be ground.

Now, if we used an ordinary inverter, any logic level above 2.5 volts would be considered a "1" and will drive the output low. And any logic level below 2.5 volts would be considered a "0" and would drive the output high. As this is a CMOS device, essentially zero input current is needed, so you can treat the input as an open circuit.

But, a Schmitt trigger has a built-in snap-action or *hysteresis*. A *rising* input level has to exceed an *upper trip point*, typically around +3 volts, before the output will suddenly snap low. Similarly, any falling input level has to go *below* a *lower trip point*, usually around +2 volts, before your output will once again suddenly snap high. We can say that the device has a

NAMES AND NUMBERS

Analog Devices
One Technology Way
Norwood, MA 02062
(617) 329-4700
AT&T Microelectronics
961 Macon Blvd
Allentown, PA 18103
(800) 372-2447
Burr-Brown
6730 S Tucson Blvd
Tucson, AZ 85734
(602) 746-1111
Caplugs
2150 Elmwood Ave
Buffalo, NY 14207
(716) 876-9855
Computer Shopper
5211 S. Washington
Titusville, FL 32780
(470) 269-3211
Crystal Semiconductor
4210 S Industrial Drive
Austin, TX 78744
(512) 445-7222
Custom Technology
192 Lakeshore
Texarkana, TX 75501
(214) 838-0243
EVCO
3451 Lorna Lane
Birmingham, AL 35236
(205) 822-5381
Fair Radio Sales
1016 E Eureka St
Lima, OH 45802
(419) 227-6573
Hewlett-Packard Manuals
1320 Kifer Road
Sunnyvale, CA 94086
(415) 857-1501
Jensen Tools Inc
7815 South 46th Street
Phoenix, AZ 85044
(602) 968-6231
Jerryco
601 Linden Place
Evanston, IL 60202
(312) 475-8440
Lazer Products
12741 E Caley Ave #130
Englewood, CO 80111
(303) 792-5277
Lindsay Publications
PO Box 12
Bradley, IL 60915
(815) 468-3668
Linear Technology
1630 McCarthy Blvd
Milpitas, CA 95035
(408) 432-1900
Merryweather Foam
11 Brown Street
Barberton, OH 44203
(216) 753-0353
NEC Electronics
401 Ellis Street
Mountain View, CA 94039
(800) 632-3531
Niagara Plastics
7090 Edinboro Road
Erie, PA 16509
(814) 868-3671
Nuts & Volts
Box 1111
Placentia, CA 92670
(714) 632-7721
Science Magazine/AAAS
1333 H Street NW
Washington, DC 20005
(202) 326-6400
Small Parts
6891 NE Third Ave
Miami, FL 31238
(305) 751-0856
Sony
One Sony Ridge
Park Ridge, NJ 07656
(201) 930-1000
Synergetics
Box 809
Thatcher, AZ 85552
(602) 428-4073
Tektronix
PO Box 500
Beaverton, OR 97077
(800) 426-2200
Texas Instruments
PO Box 809066
Dallas, TX 75380
(800) 232-3200
Thompson & Thompson
23072 Mullin
El Toro, CA 92630
(714) 855-3838
Value Plastics
3350 Eastbrook Dr
Ft Collins, CO 80525
(303) 233-8306
Vortec
10125 Carver Road
Cincinnati, OH 45242
(800) 441-7475

one-volt hysteresis, or dead band. If you are sitting inside the dead band, you will not cause the output to change—unless you exceed your upper trip point or go below the lower one.

The intended use of CMOS Schmitt triggers is to clean up a sloppy, noisy, or slowly changing input waveform. It is often a good idea to use them for almost any real-world input going into a hacker's circuit.

So how does our oscillator work? Let us assume that we have just applied power. The charge on the capacitor cannot change instantaneously. Thus, there will be zero volts on your capacitor and the input will be held low, far below either trip point. The output of the inverter will now go high because of the low input.

The capacitor will slowly charge up through the resistor, following the usual R-C exponential time-constant rules. Eventually the voltage on the capacitor will exceed the upper trip point. That snaps the inverter output low, and the capacitor will now start discharging to the lower trip point.

When the lower trip point is finally reached, the output once again goes high, and the cycle will continuously repeat. Your capacitor will have a triangular waveform across it that ranges from two to three volts. Your inverter's output will be a sharp, full-supply square wave whose frequency depends on the chosen resistor and capacitor values.

Because you are using CMOS, the oscillation frequency can be anything from just a few cycles per hour to beyond 20 MHz. Because of the open-circuit input, there is

BAR CODE RESOURCES

A.I.M.
1326 Freeport Rd
Pittsburgh, PA 15238
(412) 963-8588
Automatic I.D. News
7500 Old Oak Blvd
Cleveland, OH 44130
(216) 243-8100
Bar Code Information Service
500 South Fourth St
Minneapolis, MN 55415
(800) 328-4960
ID Systems
174 Concord St
Peterborough, NH 03458
(603) 924-9631
Identification Journal
2640 N Halsted St
Chicago, IL 60614
(312) 528-6600
UPC Council
8163 Old Yankee Rd #J
Dayton, OH 45458
(513) 435-3870
MacBarCoda
ComputaLabel Ltd
18a Regent St
Narborough, Leicester
England LE95DJ
011-44-533-750131

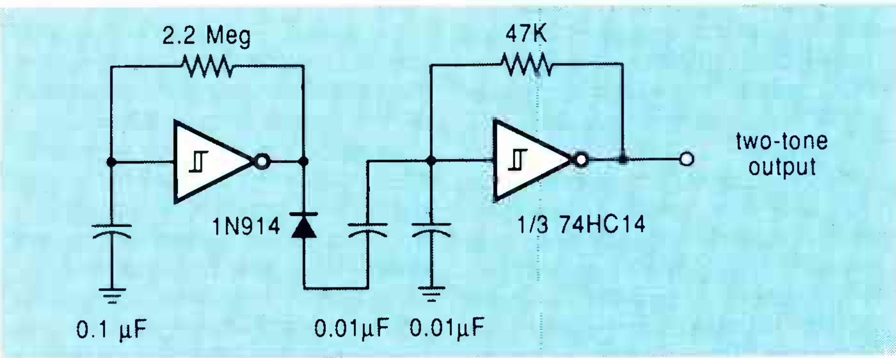

FIG. 4—THIS TWO-TONE ALARM produces a distinctive "twee-dell" output. The spread between the high and low pitch is set by the ratio of the two timing capacitors on the right side. Experiment to get the best-sounding results.

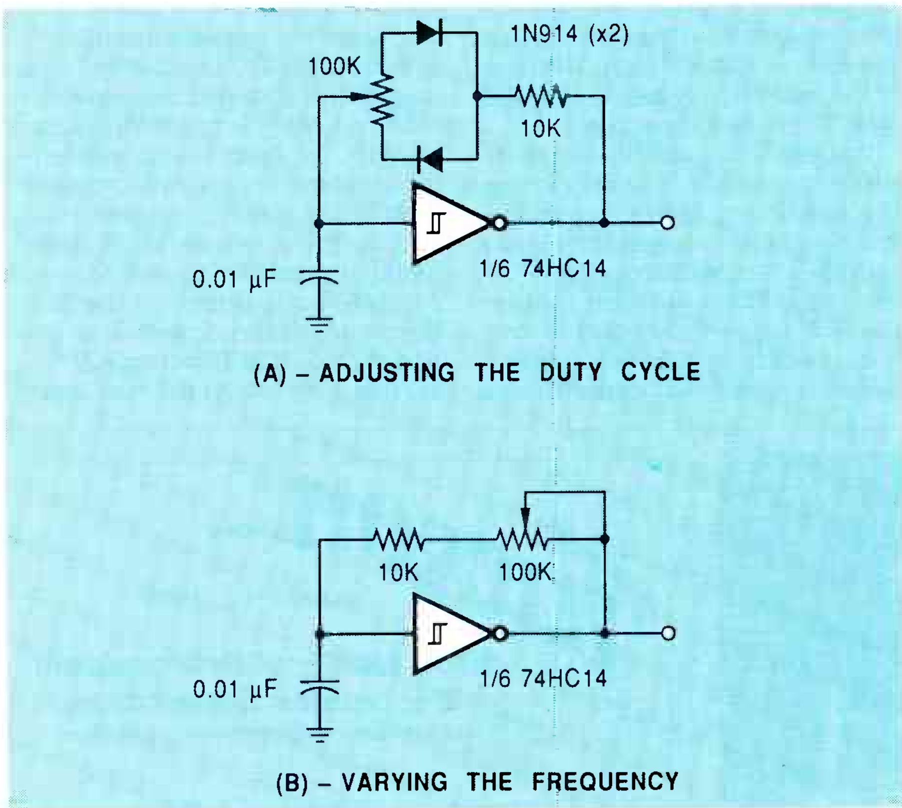

FIG. 5—ORDINARY VOLUME CONTROLS can be used to vary either the duty cycle or the frequency as shown here.

virtually zero loading on the R-C network.

Two obvious chip choices are the hex 74HC14 or else the quad NAND 74HC132. Pinouts for them are shown in Fig. 2. The pricing should be around a quarter or so.

Some older and traditional CMOS devices that also work quite well here would include the 4093 and the 4584. They can be used with a 9-volt battery or power supplies as high as 15 volts, while the '14 and the '132 are intended for use with supplies in the 2- to 6-volt range. Don't try to use HC devices above 6 volts or you will destroy them!

What can you do with all the other inverters or gates in the package? One obvious thing to do is take all five remaining inverters and put them in parallel for use as an output buffer. That isolates your RC timing from any changes in loading. Yes, you can even audibly power a speaker that way. No, it is not very loud. But it does give you an instant cable or continuity checker, a simple logic probe, or even a burglar alarm. The NAND chips can be gated, or turned on and off with an external signal. The rule is that a +5-volt input will run the oscillator, while a grounded input stops oscillation. Figure 3 shows you a gated alarm that beeps at a selected rate.

Once again, you set the frequency with either your resistor or capacitor. Recommended resistor values range from 10K to 10 megohms for most of the lower frequencies. Its simplest to experiment with component values to get the best-sounding results or the most-useful range.

Otherwise, you can calculate your charging current by using Ohm's law and the 2.5 volts that is the average across the resistor. There is a formula that says:

$$C = i\Delta t/\Delta v$$

where C is the capacitance in picofarads, Δt is the half time period in microseconds, i is the charging current in microamps and Δv is 1 for the one-volt triangular amplitude. The same formula will also work if C is in microfarads, i is in milliamps, and Δt is in milliseconds.

Naturally, Fig. 3 is a rather sloppy circuit, to be used only where exact or precise frequencies are not required. Accuracies better than five percent will be hard to keep or hold. Even with the best of calculations, some trimming is likely to be needed.

Figure 4 shows you a crude but effective way to do a two-tone alarm for an emergency siren or a sound effect. There are two oscillators here. One runs slowly to set the duration of the low and high notes. The second runs fast to create the actual tones. That second timing capacitor will get switched into the circuit whenever the first oscillator is low and will get removed from the circuit when the first oscillator is high. The ratio of the two frequencies is set by the ratio of the two capacitors.

You can vary your resistance or switch your capacitors to change the frequency. Figure 5-*a* shows you how to add a potentiometer to provide a 10:1 frequency range. If you use a linear pot your calibration will be very cramped to one end. Switching to a logarithmic potentiometer will make things much worse. The trick is to use a logarithmic potentiometer and put your calibration markings on the potentiometer dial rather than on the panel. Sneaky, eh what?

In gated circuits, the first cycle after gating will usually be longer than the others, since the capacitor now has to charge all the way down from the positive supply, rather than from the upper trip point. A place where you can purposely use that effect might be in a keyboard auto-repeat circuit.

Figure 5-*b* shows you how to adjust the duty cycle by using different resistors to charge and discharge the timing capacitor.

Tellyawhat. For our contest this month, just show me any variation at all on CMOS Schmitt-trigger oscillators. To keep things interesting this time around, you actually must build, verify, and test your circuit. There will be all of those usual *Incredible Secret Money Machine* book prizes for the best dozen or so entries, and an all expense paid (FOB Thatcher, AZ) tinaja quest for two to the best entry of all.

As usual, send your entries directly to me per the "Need Help?" box, rather than to **Radio-Electronics'** editors.

Toner refilling tools

In the past issues, as well as in all the Hardware Hacker reprints, we've seen how the Canon toner cartridges widely used in lots of popular laser printers and copiers can be reloaded many times. That can either be done as a rather profitable sideline service for others, or else to reduce your own per-page toner costs down into the jiffy printing range.

Since there's two brand new toner-cartridge reloading tools available this month, I thought it might be a good time to review all of those top-secret reloading tools and sources.

But first, the new stuff. A great SX cartridge pin puller is now available from Thompson and Thompson as their model AXP43-007.09R GlompenStractor. It neatly and cleanly pulls the pins with zero damage. The older techniques included traverse cutting pliers, screw extractors, woodworking screw starters, or an obscure craftsman tool known as a #8 gimlet.

The really big news, though, is that it looks as if SX-drum hard recoating is now a reality. In theory, that could greatly extend SX-cartridge life and might eventually reduce or even eliminate the 15:1 per-page toner-cost penalty of the LaserJet II or either the LaserWriter NT or NTX.

One source of recoating drums and services is Arlin Shepard from Lazer Products. Their projected recoating costs are in the $8 range. It will be rather interesting to see how effective drum recoating actually becomes.

Let's go back to the old stuff. The best source for detailed maintenance and repair manuals on the CX and SX engines is Hewlett Packard. In fact, it is pretty near impossible to intelligently apply any Apple LaserWriter without owning the related HP manual that will cover it. The older CX engine (LaserJet, LaserWriter, LaserWriter Plus) manual is #02686-90904, while the newer SX engine (LaserJet II. LaserWriter NT and NTX) manual is part number #33440-90904.

HP has traditionally been a great source for the repair and replacement parts for all of the Apple machines, but lately they have been selling the major assemblies only. If the part you want is not individually available from HP, try Custom Technology or Thompson and Thompson.

As I've mentioned a time or two before, there are two reloading methods, the *punch and go* and the *total teardown*. I overwhelmingly prefer punch and go since it delivers far and away the lowest per-page toner costs to the end user. We charge $24 for local CX and SX reloads. I can still get away with such an outrageously high price since I live in a rather remote rural area.

At any rate, if you insist on a total teardown of a CX cartridge, the magic T-10 tamperproof Torx bit you will need is manufactured by Evco in their 945B700 set, and can be gotten through Jensen Tools.

For punch and go, the best way to produce smooth and truly round reloading and draining holes is to use a #3 Unibit from ViseGrip, or one of their imitators. Those are once again available from Jensen Tools or almost any of the large electrical contracting supply houses. One rather good way to replug the holes is with the tapered plastic closures from either Caplugs or Niagara Plastics.

Fusion-roller wiper pads should be replaced each time you reload. One source of the custom-manufactured peel-and-stick and silicon pressure-lubricated Nomex felt strips is Lazer Products. They are normally included free with each bottle of their reload toner. A plain old 5/16-inch wood chisel is often the best way to remove the old wiper pad.

Note that washing and reusing a wiper pad is a no-no. Their purpose is to deliver a very precisely metered amount of silicon fusion oil. Improperly redone wiper pads might rather dramatically shorten the life of the rather expensive fuser assemblies.

A good drum lubricant is essential to a proper reload. You can get drum lubricant in bulk from those larger copier repair houses, while smaller quantities are available as Pixie Dust from Lazer Products.

Several plastic strips are useful as well. A twelve-mil-thick piece of the clear butyrate plastic is useful as the feeler gauge for regapping cartridges that have heavy streaking problems. Similar plastic strips can be used for sealing the fresh toner in reloads that have to be shipped somewhere else or stored for long periods of time. Further details on all of this appear in the Hardware Hacker II reprints.

Bar-code resources

There's a lot of recent hacker interest in bar codes. So, in continuing our series of hacker resources, all of the needed insider information appears in our Bar-Code Resources sidebar.

While there are lots of different bar codes today, far and away the most popular is called the UPC code, otherwise known as the *U*niform *P*roduct *C*ode. A complete set of standards is available from The UPC Council.

The leading bar-code trade association is called the AIM, short for the *A*ssociation of *I*dentification *M*anufacturers. Among other things, they provide a free list of most major bar-code sources.

There are around a dozen free bar-code trade journals. Those that I am the most familiar with include *I.D. Systems, Automatic I. D. News*, and the *Identification Journal*.

One interesting resource is called The Bar Code Information Service. They supply a $4.95 *Bar Code Film Masters* book and a $19.95 *Technical Reference Guide*.

Generating your own bar codes by using the PostScript language along with your favorite word processor is simple, and also turns out to be a very good initial project in PostScript programming. Surprising as it may sound, there just are not that many plug and go PostScript bar-code font packages out there on the market just yet, although dozens of low-cost versions are almost certain to shortly appear. As of this writing, the only PostScript bar-code product that I do know about is an English one called MacBarCoda.

For more on PostScript in general, see my "Ask The Guru" column in *Computer Shopper*, or my "Ask The Guru" reprints.

New tech literature

Let us quickly review five of my favorite hacking resources. For "old line" or traditional military-surplus electronics, its real hard to beat Fair Radio Sales. For a mind-boggling collection of nearly anything else in surplus, electronics and otherwise, Jerryco has to be the hands-down winner. For anything you can't find at your hardware store, along with the ability to custom cut up small pieces of metal or plastics cheaply, Small Parts is the only way to go.

For unusual publications, ranging the gamut from early machine-shop techniques through antique radios all the way on down to perpetual-motion machines and the free-energy scams, check out *Lindsay Publications*. And for electronics bargains direct from electronics startups and other hackers, there's the great little *Nuts and Volts* shopper newsletter.

Texas Instruments has a new free PAL Evaluation Kit, which can even get you those sample programmable logic devices programmed for free. From AT&T, a thick new *Communication Devices* data book. And from NEC Electronics, the new *Memory Products* data book. That one includes full details on an improved-definition television front end. It will accept an ordinary NTSC interlaced TV input and doubles the horizontal scan rate, to give you a flicker-free and apparently much sharper solid-scan video output suitable for display on a Multi-Sync monitor or whatever.

One "must read" recent paper on levitation in physics appeared back in the January 20, 1989 *Science* that shows you proven methods to levitate both solids and liquids. Half a dozen viable methods are covered in depth, with a good bibliography.

There's lots of mechanical stuff this month. The Vortec people have all sorts of ultra-simple solid-state cooling devices that use nothing but shop air to produce temperatures as low as −40 degrees Fahrenheit!

Value Plastics has free samples of their ultimate solution to low-cost custom robotics pneumatic connectors—bondable fittings that can be mixed and matched almost any way. And Merryweather Foam now has a free sample card of their urethane- and polyester-foam products.

Turning to my own stuff, if you are at all into Apple computing, you will find autographed copies of my *Enhancing Your Apple IIe*, volumes I & II, my *Apple Assembly Cookbook*, and my *AppleWriter Cookbook*, along with their companion disks available directly from me at Synergetics.

And if you want to get further into PostScript, the magic language that does all of the artwork you see here, using nothing but your favorite word processor, check out my *Intro To PostScript* video or my *PostScript Show and Tell* disks, now available for most personal computers. **R-E**

OMNIVIEW AND A 386

MIKE TOUTONGHI,
SUNNYHILL SOFTWARE

Intel's 80386 microprocessor is taking the world by storm. For some people, speed is the most important aspect of the microprocessor. For others, though, intelligent memory management and the ability to run several programs simultaneously are what make the 386 desirable, if not indispensable.

By itself, the 386 just acts like a faster, more expensive version of the 286. It takes special software to unlock its treasures, and that's where we come in. OmniView is a multi-tasking operating environment written for machines running MS-DOS. Actually, OmniView can run on any 8088/86/286/386 microprocessor. But on a 386, especially in conjunction with 386^MAX (pronounced 386-to-the-max), OmniView can make life under DOS much more pleasant.

In this article we'll summarize briefly what OmniView is, what it does, and how to use it. Then we'll go on to show the basics of how it works with the 80386 to increase your computing power. Next time, we'll take an in-depth look at how the program performs its magic, and show how you can write your own programs to take advantage of that magic. In so doing, we'll present a sample multitasking utility program that monitors the state of your PC in real time.

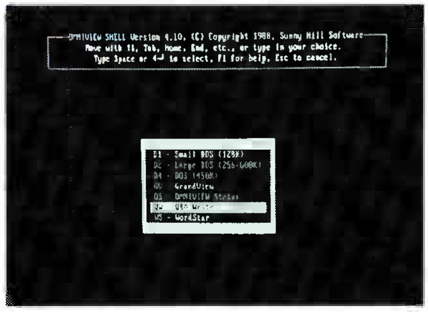

Fig. 1. OMNIVIEW'S USER INTERFACE resembles that of a typical DOS shell. The difference is that you can switch among loaded programs instantaneously, and, on the right hardware, they can actually run simultaneously.

Using OmniView

OmniView works by putting a menu-based "shell" around your DOS environment. Many DOS shell programs do the same thing; however, the typical DOS shell only allows you to run one program at a time, and won't let you switch among several different programs without closing one before opening another.

Like the typical shell, OmniView lets you create a menu that lists the programs you use (for example, see Fig. 1). To run a program, move the highlight bar to that item and press Enter. To run another program, press a hot key to return to the menu, move the highlight bar, and press Enter. Later, when you've got several applications running, you can hot-key among them at will. The maximum number of applications that you can run at once is ten; each program runs as if it had complete control of the computer, blissfully ignorant of any others.

Depending on the type of microprocessor and memory in your system, two or more programs can seemingly run simultaneously. That's called multitasking. For example, you could download data from your favorite BBS while simultaneously working in your word processor. On a

continued on page 78

CeBIT

JANET ENDRIJONAS

Topping its own reputation as the greatest computer show in the world, this year's CeBIT—World Center for Bureau (office), Information and Telecommunications Technology—exposition in Hannover, West Germany was the largest ever. Multiple technologies abounded—computers, telecommunications, connectivity, security—you name it. If it pertained to information movement or management, it was at CeBIT.

Over half a million people pushed their sore feet and tired legs through some 3,125 exhibits from 37 countries spread over 14 buildings. They viewed the latest in state-of-the-art technology, stopping only to attend symposia, conference workshops, and industry presentations during the eight-day event. Both prototypes and working models of products developed around the world were on display. As usual, many of those items will not be seen in the United States for several years, and some may never get here. At the same time, the 197 United States exhibitors' booths were crowded with people anxious to see the latest in American innovation.

A quieter show

To veteran CeBIT goers, at first glance the 1989 show appeared tame—no flashy new technology, noisy international rivalries, or juicy scandals surfaced. The show seemed carefully orchestrated with special "pavilions" dedicated to specific interests such as networking, telecommunications, computer security, and doing business with India, CeBIT's first "international business partner."

One noticeable trend involved

Japanese manufacturers rushing to comply with new requirements pertaining to putting "Made in Europe" or, more specifically, "Made in Germany" labels on their products. Last year, the Common Market countries raised the tariffs on imported technology while also establishing minimum percentages for the amount of local content required to earn the coveted labels, putting outsiders in a difficult situation.

CeBIT's overall atmosphere seemed geared toward promoting the harmony that will become reality in 1992 when the European Common Market drops trade barriers within its domain and becomes the European Economic Community, often referred to as the "Untied States of Europe."

Developments such as those, however, could not represent the major excitement—there had to be more going on at CeBIT. You can't have a show this big with nothing new and unexpected to report. Macintosh Apples or Does the Recipe Call for Jonathans?

Last year we reported that there was a rumor floating around CeBIT of "MacClones" being developed in the Orient. Enter Jonathan, a working Macintosh clone developed by a small company, Akkord, in Taiwan who contracted with a friendly West German distributor, Jonathan Computers Deutschland, to display the machine at CeBIT.

The literature made no mention of Apple compatibility. It expressly referred to "tomato compatibility" in an international play on words. The editor of the monthly German Macintosh publication, MacUP, spent three days during CeBIT putting Jonathan through its paces and declared that there could be no question of Macintosh compatibility—every program he tried worked, even the games.

Over the years, several US companies have attempted to clone the Macintosh and wound up losing court cases to Apple. Akkord's legal business consultant insisted that there were no copyright infringements and a spokeswoman for Apple Germany said that to the best of her knowledge, Jonathan did not violate Apple copyrights. How could that be?

There was a simple explanation. All the previous law suits had been based on infringing the copyrights for the Apple ROM (read only memory) set. So Jonathan is being shipped with ROM sockets but no ROM's. Of course, if you are familiar with US computer-component mail-order opportunities, you know you can buy Mac Plus 128K ROM's for about $90 from several vendors.

Overall specs indicate that Jonathan is a low-cost Macintosh alternative, more powerful than a Mac Plus thanks to an internal hard disk, but less expensive than a Mac SE. Akkord claims to have showed Jonathan only to prove that a Mac clone is possible. The company will make no specific marketing plans until all legal questions are answered. Hence, there are no price quotes available nor is there word on when (or if) the first Jonathan might turn up in the United States.

Color LCD's—Boom or Bust?

Do consumers really want big LCD screens in monitors or laptops? "They shouldn't until resolution improves," said a spokesman for Casio, one of the manufacturers. Another manufacturer with prototypes on display, Toshiba, agreed that current resolution is only adequate for small-screen television viewing, certainly not for use with computers. Toshiba's spokesperson went so far as to say that his company considered it useless to market an imperfect item just for the sake of selling a product.

So why all the excitement at Hitachi? At their booth, what was said to be the world's first laptop with a color LCD display was being touted as the key product in a hot new market. And at the Sharp booth there was a 386 computer with a 14-inch color LCD that will be available to European consumers by year's end.

Networking

Special pavilions displaying networking and telecommunications occupied large space in two halls. Here the march toward 1992 resulted in emphasis being placed on internal corporate, external national, and international voice and data communications. ISDN (*I*ntegrated *S*ervices *D*igital *N*etworks), which had been the hot topic a year earlier, was somewhat in the background for the moment as European and American companies demonstrated communications solutions that can already be put into place.

The US is the current leader in networking and telecommunications thanks, in part, to the breakup of the Bell system and the growth of smaller, more innovative and competitive telecommunications companies. Telecommunications in most European countries are still controlled nationally. Some change will occur when the new Economic Community becomes a reality in 1992 and, in preparation, the emphasis on importing US telecommunications technology is heavy at the moment.

ISDN wasn't completely ignored during CeBIT. Video conferencing via ISDN lines was a big hit and even enabled Indian Prime Minister Rajib Gandhi to participate in the opening ceremonies from Bombay. The picture phone we've all been joking about and in some cases dreading was available and working much to the dismay of those of us who answer the phone before putting on makeup. And if that wasn't bad enough, one phone not only showed the person on the other end; it also displayed a small inset of you in the corner. It was worse than staring into a mirror.

Hannover Hacker

Just before CeBIT started, newspaper headlines around the world revealed the existence of three computer hackers based in Hannover who had been stealing data from US government computers on behalf of the KGB. The fact that the US claimed that the stolen data was low level didn't lessen the concern for computer security among exhibitors and attendees alike.

This year, an entire floor in one of the exhibit halls was devoted to security solutions. It was a place where hackers could go to attempt to outsmart the experts. The experts didn't always win. Toward the end of the eight-day show, two ten-year-old schoolboys entered a booth at CeBIT and in the process of hacking managed to lock up the booth's entire computer demonstration. They generously offered to undo the damage if the company running the booth would pay them DM 10. The company paid and the boys put the system back in working order.

Calling Moscow

Not everyone was worried about hackers or the KGB. There was evidence of glasnost at work. Deutsche Mailbox, one of Europe's largest electronic-mail (E-Mail) companies announced a link with the Soviet Union. Once hardware, software, and a hotline are installed in Moscow, Deutsche-Mailbox users will be able to send and receive electronic messages from people in the Soviet Union.

As you might expect, there are limitations on the Russian side of that setup. The Soviets will be controlling what their users are allowed to do. The system will not be available to every Igor, Ivan, and Vladimir, and those who are allowed to use it will find themselves unable to access certain functions like data bases.

Right now, the service is restricted to users in Moscow but there are plans to extend it to 30 cities throughout the Soviet Union via the Moscow gateway.

How red is your nose?

Even at CeBIT, technology does not totally supercede humanitarian concerns. One day a year the people of the United Kingdom set aside their self-consciousness and don bulbous red clown noses in support of a charity for needy children organized by Comic Relief, a successor to Band Aid/Live Aid. Since Red Nose Day fell in the middle of CeBIT, one enterprising UK company brought along a supply of red noses and sold them to attendees. By noon, certain areas of CeBIT looked like everyone had enjoyed too much German beer the night before.

Walking shoes before 1990

If you have decided that you want to be a part of the CeBIT excitement in 1990, you had better buy a pair of sturdy walking shoes. CeBIT plans for expansion in 1990 call for at least an additional 200 exhibitors.

Actually, it might be wise to buy two pair. CeBIT has spawned a new little sister, CeNIT, the Asian Center and Conference for Information and Telecommunications, which is to be held in the new Hong Kong Convention and Exhibition Center.

Attendance at CeBIT has always favored European countries. While many products originating in the Orient are introduced to the world at CeBIT, no doubt there are countless other new products being developed in the Far East that none of us, European or American, have ever seen. Now, with CeNIT, the world will get to see what it has been missing.

It has always taken a world-class exhibit attendee to traverse the length and breadth of CeBIT, enduring blisters and back aches for the sake of seeing new technology as it first appears on the scene. The pain and suffering, sensory overload, and jet lag we have been privileged to endure for CeBIT will now be extended to a new group of technology buffs at CeNIT. We wish them the very best. CD

"Productivity has really jumped since we switched to the new computers with built-in coffee pots."

EDITOR'S WORK-BENCH

Utility Wars: Mace vs. Norton

What do you do when (accidentally, of course):

- you format your hard disk, or
- you erase a crucial file or directory, or
- you can't boot from your hard disk or even access it, or
- disk operations on certain files seem to be taking longer and longerand longer?

You reach for Mace Gold or Norton 4.5 Advanced—or maybe both. The latest versions of those programs offer several powerful tools for both guarding against disaster and dealing with it when it does occur.

Norton Advanced

Actually, the Norton utilities is a collection of programs designed to make life with PC's easier. Some of those programs have nothing to do with data recovery, but they're useful in their own right. However, the core of the Norton suite has always been NU.EXE. It provides several functions for getting at the data on your disk at various levels. Depending on how you use NU, you can get at physical tracks and sectors, logical (DOS-level) sectors, files, the FAT's (File Allocation Tables), the partition table, and directories.

NU lets you access different structures in different ways: Generally, you can view and edit any structure in hex and ASCII formats; you can also edit higher level structures in an intelligent format. For example, you can change file times and dates without having to compute DOS's packed formats.

One of the most popular uses for NU is to unerase files. The program provides semi-automatic and manual ways of doing so; a separate, fully automated program (QU, for Quick Unerase) is also provided. The automatic modes work well on disks whose files are stored in contiguous sectors; with non-contiguous files, some amount of manual intervention is usually required, and NU provides useful tools for doing so. Of course, manual reconstruction is usually only possible with text files, in which you can verify a continuous flow of data.

To help you avoid non-contiguous files, Norton includes a program (SD, Speed Disk) that rearranges your disk so that files are stored contiguously. Other disk and file-oriented utilities include: DS (Directory Sort), which allows you to sort the lists of files in your directories according to time, date, name, and extension, and even to order them manually; DT, which scans the surface of your disk searching for bad sectors, and allows you to lock them out, repair them, move files off of them, etc; SF (Safe Format), a menu-driven replacement for DOS's FORMAT program; and FR (Format Recover), which lets you recover data from an accidentally formatted disk (see Fig. 1).

A number of other utilities are included for listing files and directories, printing files, obtaining information about your system (including the infamous SI rating), wiping files and entire disks completely clean of data (using a government-specified security procedure, if desired), and more. Everything is tied together through an easy to use menu-driven interface (shown in Fig. 1); after learning the programs you can run them from the DOS command line with the proper switches. Invoking a program with a ? (e.g: CSD ?) displays a help screen.

The latest version of the Norton utilities also adds NDD (the Norton Disk Doctor, or NDD), which provides automated recovery from several severe disk problems: a corrupt master boot record, bad partition table, bad FAT, cross-linked files, etc. One really nice feature of NDD is the ability to make any disk bootable; it will rearrange files on disk as necessary to make room for the system files necessary to boot DOS.

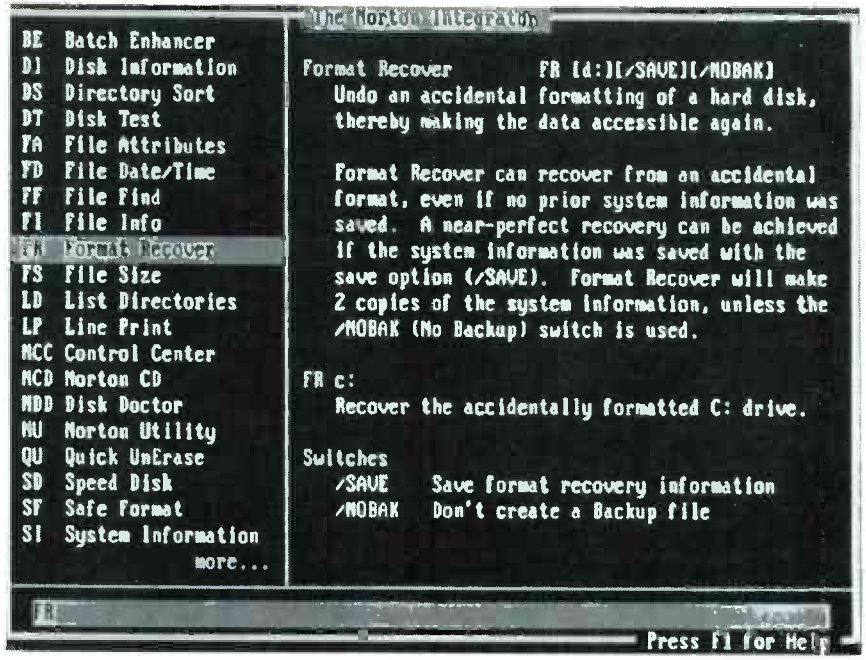

FIG. 1.

The programs all have attractive, easy-to-use screens, and everything is well documented. Now included is *The Norton Troubleshooter,* a 150-page book that contains specific procedures to follow, using various Norton tools, to recover from specific kinds of disasters.

Mace Gold

This package includes programs comparable to the disk-management programs in Norton, skips some of the frillier items, and adds a disk cache, a hard-disk backup program, and programs specifically designed to recover dBASE and text files. Also included is VACCINE, a virus-protection program, and POP, a program like BookMark that allows you to take an occasional "snapshot" of the state of your entire PC, and reload that snapshot later. A sector editor is also included.

Gunfight at the OK Corral

In general, Mace's programs and documentation are less polished than Norton's. In the sector editor, the menus are non-intuitive, and the program's screen output is quite slow.

The real question, of course, is the ability of each to recover data, so I devised several tests to see how well each could do. All tests were run on a generic XT clone with an ST-225 (20MB) hard disk running PC-DOS 3.30.

Both Mace and Norton offer special programs that save copies of critical system information (boot sector, FAT, and root directory) in a special file with a "signature" that the recovery programs can find even on a disk without directories, FAT's, etc. Normally you run these programs from your AUTOEXEC.BAT file, so at most you'll lose data only since the last time you booted.

Both Mace and Norton offer data-recovery procedures that work both with and without the signature files; each was *much* more successful at restoring data with the signature file than without it.

My first test was to try to restore an accidentally formatted drive. With the signature files present on the disk, Norton's FR (Format Recover) recovered the disk without problem; Mace's UNFORMAT did fairly well, but failed to restore the media descriptor byte in the boot record properly. Norton's NDD, however, was able to correct that fault without manual intervention. Norton gets a slight edge here.

Without the signature file, Norton's format recovery program literally made a mess of the disk. The disk actually contained about 2MB of files, but after running FR, every cluster had been allocated, many files were cross-linked, and the few "recovered" program files I tried to run crashed the machine. Mace did better in the same situation; it found the requisite files and correctly stored them in subdirectories with names UB000, UB001, etc. Files in the root were unrecoverable, but at least the subdirectories and associated files were intact. Score one for Mace.

In another test, I corrupted the first few bytes of the boot record; neither Norton's NDD nor Mace's UNFORMAT was able to properly restore the boot record. Mace = 0, Norton = 0.

Next I erased (made all bytes 00h) the first copy of the FAT. Without the signature file, NDD claimed to fix the problem, but didn't. I couldn't boot from the disk, and after doing its thing, NDD left both copies of the FAT totally corrupt. With its signature file intact, Mace's UNFORMAT seemed to recover everything, but again left an incorrect media descriptor, which NDD happily fixed. Mace = 1, Norton = 0.

Other program tests that we ran revealed similar disappointments and inconsistencies.

Conclusions

If you've got anything of value on your hard disk, back it up. Under the best of circumstances, you may be able to recover some of it; but don't wait until a disaster strikes to buy a copy of either Mace or Norton. Both operate much better with the signature files than without. Norton gets the nod if you're buying pre-disaster; Mace, if you're buying post-disaster. Don't let Norton's NDD loose on a drive with really severe problems.

In case you're wondering, I do weekly backups on an Irwin tape drive, daily backups to floppy, and I often copy on-going projects to temporary disks during the day. Paranoid? You bet! I've lost too many files to the bit bucket.

Duncan's DOS book

If you want to find out how DOS really works, and how to make it work for you, check out Ray Duncan's *Advanced MS-DOS Programming*, second edition. About half the book explains how DOS loads and controls PC operation thereafter; the second half consists of reference information on BIOS interrupts, DOS function calls, mouse functions, and EMS functions. The book includes numerous example and skeleton programs in both assembler and C. Topics covered include DOS basics, hardware control (keyboard, mouse, and I/O ports), file and disk management, device drivers, and more. OS/2 counterparts of DOS functions are discussed briefly; unfortunately, however, DOS 4.0's new disk structure is not. ◆CD◆

PRODUCTS REVIEWED

- Norton Utilities Advanced Edition Version 4.5 ($150), Peter Norton Computing, Inc., 2210 Wilshire Boulevard, Santa Monica, CA 90403. (800) 365-1010. (213) 319-2010.
CIRCLE 50 ON FREE INFORMATION CARD
- Mace Gold ($149), Paul Mace Software, 400 Williamson Way, Ashland, OR 97520. (800) 523-0258. (503) 488-2322.
CIRCLE 49 ON FREE INFORMATION CARD
- *Advanced MS-DOS Programming*, second edition ($24.95), Ray Duncan, Microsoft Press (c. 1988). 16011 NE 36th Way, Box 97017, Redmond, WA 98073-9717. (206) 882-8080.
CIRCLE 48 ON FREE INFORMATION CARD

OMNIVIEW

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system without a 386 or EMS 4.0 memory, you can only multitask as many programs as will fit in the first 640K of memory simultaneously. But on a 386 (or an 8088 or 80286 with EMS 4.0 memory), you can multitask several large programs.

Even without multi-tasking, OmniView can be useful by letting you switch among several programs quickly. For example, suppose you run a small business from your home, selling microprocessor-based widgets. You use a spreadsheet to track your accounts, a database program to keep your inventory, a word processor to write business letters, and a telephone manager to dial and log your calls. With OmniView and the proper memory, all four could be loaded in memory ready for instant access. So when Mr. Jones calls up wondering where his order of widgets is, you could check his account and your inventory—all while he's on the phone.

After you gain a little experience with OmniView, you can skip loading programs by menu and create a batch file that will load your desired system configuration automatically with just a few keystrokes. You can still hot-key among your programs.

Inside OmniView

What's going on beneath the surface that allows you to do those things? To understand the answer to that question, you must understand the differences between the three types of memory: conventional, extended, and expanded. Briefly, conventional memory is that in the first 640K; extended memory is located above the 1-megabyte boundary, and is addressed linearly by the 80286 and 80386; expanded memory is bank-switched in 16K chunks beneath the 1-megabyte boundary. Expanded memory is available on all three members of the Intel family; with a proper memory manager, extended memory on a 386 can function as expanded memory (see Fig. 2).

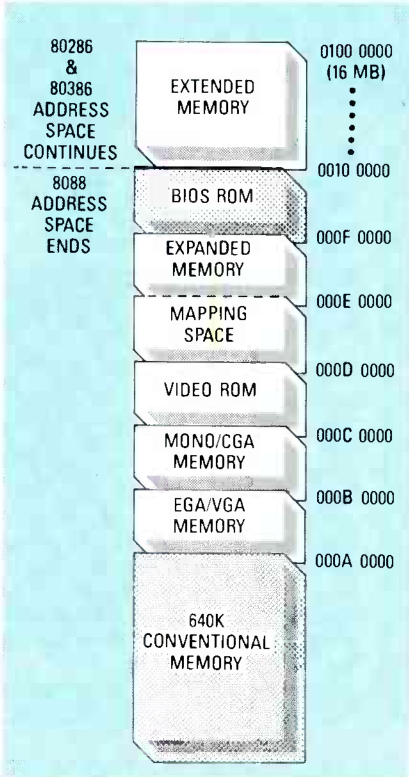


Fig. 2. *MEMORY MAP of Intel microprocessors. Expanded memory is available on the 8088/86, the 286, and the 386. Extended memory is available only on 80286 and 80386 microprocessors; on the latter it can function as expanded memory.*

Internally, OmniView consists of 5 major modules, as shown in Fig. 3. Basically, the task scheduler determines when each program gets its turn to do its thing. The device-driver module provides control (and emulation, when necessary) of devices including keyboard, screen, mouse, and printer. The message-passing module allows tasks to communicate with each other through a standard mechanism. The memory manager allocates memory both to OmniView itself and to the tasks that it controls. Last, the applications-interface module ties the others together, making OmniView's functions available to external applications programs.

The user interface (i.e., the menu for starting and running programs) is not an integral part of OmniView. Rather, it's simply an applications program that, through the use of the OmniView Applications Program Interface (OAPI), makes OmniView's functions available to the user. As such, it can easily be replaced, and is not necessary at all in some applications.

Although OmniView contains 5 major modules, two of them could easily be broken down into other, more distinct units. For example, the device-driver module actually contains as many parts as there are devices to control: one for the screen, one for the keyboard, etc. In addition, the memory manager delegates much of its work to an EMS 4.0 driver if one is present.

This modular architecture has a number of advantages. Since OmniView supports, but does not require, an 80386, it can be used across a wide range of machines. Other operating environments are designed specifically for, and are therefore limited to running on, the 80386.

Of course, with a proper memory manager, OmniView really shines on a 386, because several features of the 386 simplify the process of building multitasking software: hardware support for task control blocks, segmented and paged memory manage-

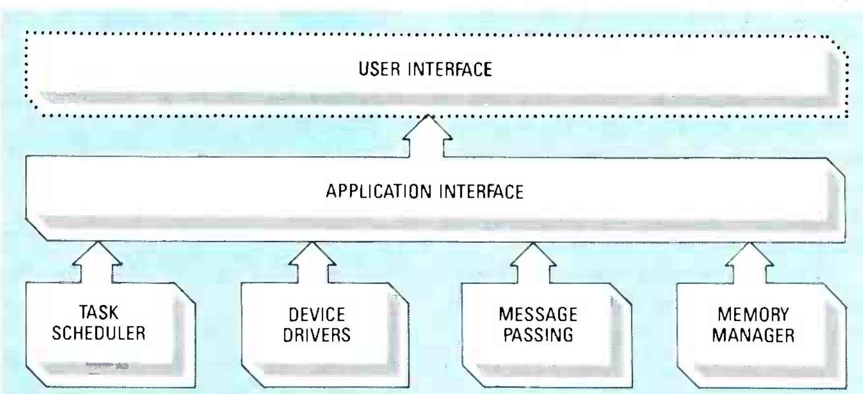


Fig. 3. *OMNIVIEW CONSISTS of four modules tied together by an application interface, and an optional user interface.*

ment, virtual 8086 (V86) mode, and hardware I/O protection. OmniView uses all of those; let's talk about memory management first.

Memory management

Several 386 memory managers are available commercially, but OmniView has been optimized to work with 386^MAX. In addition to emulating EMS 4.0 memory using plain extended memory, 386^MAX includes special "hooks" that OmniView uses to virtualize direct screen accesses, to arbitrate between processes that service hardware interrupts, and to allow multitasking with 32-bit protected-mode applications.

For example, by using the EMS 4.0 functions available in 386^MAX, OmniView can run multiple programs simultaneously, periodically switching them to conventional memory from extended memory. OmniView does so using the 386's memory paging tables to allocate a desired number of 4K pages, and then mapping those pages in or out of conventional memory as needed. Simply by loading a new value into register CR3, the *P*age *D*irectory *B*ase *R*egister (PDBR), entire memory-mapped "contexts" can be loaded into conventional memory nearly instantaneously.

386^MAX makes that function available to system-level software through the *A*lternate *M*apping *R*egister *S*et (AMRS) concept, which is part of the EMS 4.0 specification. 386^MAX implements that operation very efficiently, so OmniView can switch memory-mapped contexts fast enough to allow programs running in extended memory to service as many as 1000 hardware interrupts per second on a 20-Mhz 80386.

The point is that multiple programs, which would not normally fit together in conventional memory, can service hardware interrupts with no knowledge that OmniView is switching them in and out of memory many times per second.

I/O port virtualization

Since the typical DOS developer designs his program for a single-tasking operating system, he often assumes (and rightly so) that the program has complete control of the hardware on which it is running. For that reason, many programs access display memory and other hardware directly, without considering that they may be in competition for those resources. Of course, by doing so, programs that would otherwise run sluggishly run much faster. Those programs, labeled "ill-behaved" include the vast majority of most popular commercial applications.

What's so bad about ill-behaved programs? For example, assume two ill-behaved applications are running simultaneously without proper control software. Each can do whatever it wants whenever it wants, so the video display is liable to be visual mishmash, as each writes its data to the screen. Even worse, if both tried to write to disk simultaneously, the FAT (*F*ile *A*llocation *T*able or directory structure could be corrupted, rendering the disk useless.

However, the 386 provides a number of built-in mechanisms that, when properly used, can help prevent those types of disasters—and the OmniView/386^MAX combination takes advantage of those mechanisms to tame most ill-behaved programs.

To facilitate protection, 386^MAX provides hooks that OmniView uses to "virtualize" screen and I/O access. Using those hooks, OmniView can control video memory mapping, and it can fool programs running in the background into thinking that they have access to actual video memory. In truth, background programs have access only to a virtual screen storage area, as shown in Fig. 4, which can later be mapped into memory via the 386's paging mechanism to its normal address.

Other hooks can prevent a program from accessing the CRTC (*CRT* Controller) hardware, and even from moving the cursor directly. By using the 386's I/O-port privilege map, all accesses to the CRTC cursor registers can be trapped and simulated without affecting the actual hardware.

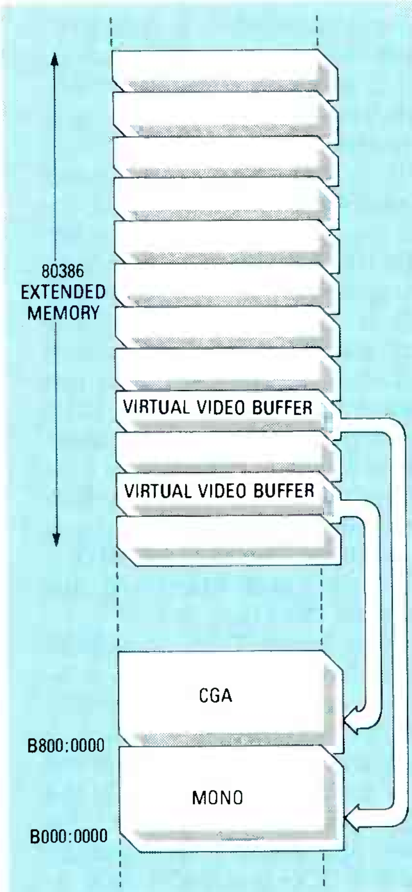


***Fig. 4.** EXTENDED MEMORY ON AN 80386 can be mapped in 4K chunks anywhere in memory. For example, two programs can write to virtual video buffers, which can be mapped to the normal addresses at the appropriate time.*

Again, that allows an invisibly running program to think it is accessing the hardware directly, when in fact it is only modifying or reading its virtual position, as recorded by OmniView.

VCPI

OmniView/386^MAX also supports the *V*irtual *C*ontrol *P*rogram *I*nterface (VCPI), which provides a standard by which 32-bit protected-mode programs and real-mode (DOS) programs can multitask together. The VCPI's chief claim to fame is that it works around the limitation that only one program can control an 80386 in protected mode at a time. By defining a way for protected-mode programs to cooperate with each other, the standard helps bring OmniView/386^MAX into the realm of advanced, protected-mode operating systems (UNIX, OS/2).

However, under a full protected-mode operating system, the OS itself is protected from corruption by applications, and applications are prevented from corrupting each other. But most of OmniView and DOS must coexist in the memory space beneath the 1-megabyte boundary, leaving them vulnerable to corruption. Because of the ill-behaved nature of many of today's programs, OmniView could not provide its almost 100% DOS compatibility without at least some of its code running in that manner. To understand why, let's review some known facts about the 80386, the XT/AT BIOS, DOS, and some standard applications' behavior.

As you know, DOS and BIOS services are usually called via issuing a software interrupt. For example, executing an INT 13H causes the BIOS to perform some sort of disk function; INT 21H is the DOS services interrupt. An 80386 operating environment can filter DOS and BIOS calls by trapping the software interrupt and determining at that time whether to emulate or pass on the original call.

The problem is that real-life programs often don't use software interrupts to access system services. Rather, many programs actually use FAR CALL and FAR JUMP instructions to pass control.

For example, a memory-resident TSR (Terminate and Stay Resident) typically "chains" an interrupt. INT 9 (the keyboard interrupt) might be chained by a keyboard-enhancement utility that would watch for a special hot key. Each time the user presses or releases a key, an INT 9 is generated. The TSR would check to see if the defined key (or combination) was struck. If so, the program might substitute its own keystroke or perform some other action; otherwise, it would execute a FAR JUMP (or CALL) to the original BIOS code. Things become even more complicated when several programs "chain" an interrupt in that manner.

The problem is that calls and jumps are not trapped by the 386's support mechanisms when it is running in V86 mode. If the objective is to filter only the system service, without hampering the application program's filter, then a multitasking system must have V86 code that takes control only at the appropriate time.

Although OmniView must always have some code in the V86 address space (i.e., beneath the 1-megabyte mark), the program occupies only 48K of RAM. And since it can load into EMS memory that is mapped above the screen buffers (refer back to Fig. 2), its affect on the amount of contiguous DOS memory is minimized. And note that that is not a 386-specific feature; 8088/86 and 286 machines with EMS 4.0 memory can also benefit from it.

By way of contrast, other operating environments go to great lengths to keep the environment's own code protected and out of conventional memory. One approach, taken by VM/386, executes most of the operating environment in protected mode and loads a separate copy of DOS in its own protected V86 partition for each program running under it. However, there are problems inherent in that approach. Sharing one disk by multiple copies of DOS, each of which maintains a separate FAT, is difficult. Not only does it require a great deal of overhead to arbitrate between the different copies of DOS, but running certain programs together may corrupt disk files.

So, rather than rewrite DOS completely and risk the inevitable incompatibilities that have plagued DOS replacements, OmniView shares one copy of DOS among all programs running under it. Therefore, both OmniView and DOS must remain accessible to the programs that run under them. That means that a program that writes to memory outside that which it has been allocated may be able to crash the entire system. However, on a 386, OmniView is able to prevent a program running in one partition from corrupting the memory space of another program, of DOS, or of OmniView.

Coming attraction

Next time we'll delve deeper into the internal structure of OmniView, and discuss use of the OAPI. In the process, we'll create a program that requests information about presently executing tasks, uses efficient timed delays, and continuously displays the current tasks and available OmniView resources. R-E

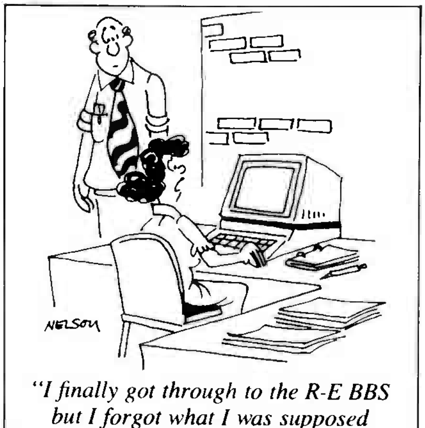
Special Discount

SunnyHill Software has arranged special 30% discounts off the list prices of OmniView and 386MAX for readers of **Radio-Electronics.** OmniView normally lists for $89.95; the discount price is $62.95. 386MAX normally lists for $74.95; the discount price is $52.45.

To order, call the number below. Be sure to mention this article. The discount expires on December 31, 1989. SunnyHill also has separate documentation on the OmniView API; contact the company for details.

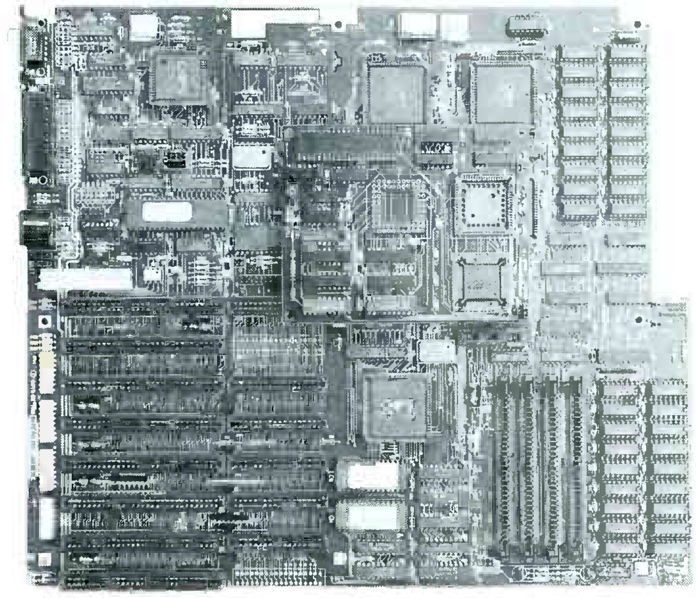
For more information on OmniView (formerly called TaskView), see Editor's Workbench, May 1988. For more information on the 386 microprocessor, see the January, February, and March 1989 issues. And stay tuned for an article describing the construction of a low-cost 386SX motherboard.

- OmniView, SunnyHill Software, P.O. Box 33711, Seattle, WA 98133-3711. (800) 367-0651 or (206) 367-0650.
- 386MAX, Qualitas, Inc., 8314 Thoreau Drive, Bethesda, MD 20817-3164. (301) 469-8848. Note that the discount is available only through SunnyHill.



"I finally got through to the R-E BBS but I forgot what I was supposed to do when I got it!"

BUILD AN 80386SX MOTHERBOARD



Part II

BERNARD A. McILHANY

Before starting construction of the PT-386-PLUS, here are a few cautions. The PC board is a four-layer board, and soldering a four-layer board requires a hotter soldering iron than usual. A temperature-controlled iron set at 700° is preferable, but if one is not available, use at least a 50-watt iron. Use of a smaller iron can overheat the board because of the long time required to properly heat the connections. The soldering iron should also have a small tip because of the closely spaced connections on the board. If you have limited soldering experience, we suggest that you get assistance from someone with more experience. Otherwise, buy the assembled board.

Most of the board must be built before any testing can be performed. Use the Parts-Placement diagram (shown in Fig. 1) and the Parts List to locate where each part should be mounted. Figure 2 shows a finished motherboard.

Start construction by installing all resistors, including the DIP and SIP packages. Note that each DIP and SIP pack has a mark that designates pin 1. The board itself has different marks for each type: for the DIP resistors, the board shows a square notch at the pin-1 end, but for the SIP resistors, the pin-1 end is shown on the board with an open square. Make sure that you install the pin-1 ends correctly!

Next, install all of the capacitors, except the variable capacitor (C60) Observe the polarity of the electrolytic and tantalum capacitors as you solder them.

Next, install the IC sockets, including the PGA for the microprocessor (IC57) and the five PLCC sockets (IC43, IC45, IC48, IC61, and IC75). NOTE: No socket is installed at position IC900. When installing the PLCC sockets, be certain the pin-1 designation faces the dot on the board. Although at first glance the PLCC sockets may appear square, they are not. Not only does the socket have orientation (an angled corner and a "1" indicating pin 1), but the IC's themselves also have orientation, indicated by an indented dot or dimple, as well as the angled corner. Of course, the IC's orientation marks will mean nothing if the socket is installed incorrectly!

Install the SIMM sockets next. The sockets should be oriented so that their outlines match the ones on the board.

Now mount and solder the 36- and 62-pin expansion-slot card-edge connectors (J1–J16). Note that nothing is installed in positions J2 and J16; the absence of connectors in those positions leaves space for older 8-bit expansion cards.

Next, install the oscillators and crystals. The oscillators should be soldered directly to the board. Once again, be sure to observe the pin-1 orientation of the oscillators, usually a square corner or a dot (or both).

The transistors and diodes are next: install the flat side of the transistors facing the line marked on the board. The banded end of the diodes should correspond with the line on the board.

Solder the jumper headers (P1–P4, P7–P10), the variable capacitor (C60), the keyboard connector (J17), and the power connector (P6) to the board next. The power connector should be installed with its back side (the high plastic part) toward J15 (an expansion-slot connector).

Using solid wire or scrap left over from cutting off the resistor leads, solder 37 jumper wires in positions CH-1 through CH-37.

At this point, all of the parts on the board that require soldering should have been installed. We suggest that you clean the board of all surplus flux using an aerosol methylene chloride flux remover and cleaner, available from most electronics stores. Now carefully inspect the board for solder bridges and unsoldered pins. Defluxing the board is recommended because excess flux may hide unsoldered connections or hairline solder bridges.

Now insert all IC's into the appropriate sockets. Be careful not to accidentally fold any pin under the IC as you insert it into the socket! Install 512K of DRAM in Bank 0 (near the front left corner of the board); that's the minimum required to test the board.

When we continue next time, we'll discuss how the 80386SX daughterboard is built and installed. Then we'll show you how to configure the system, and finally, we'll power it up and put it to work! R-E

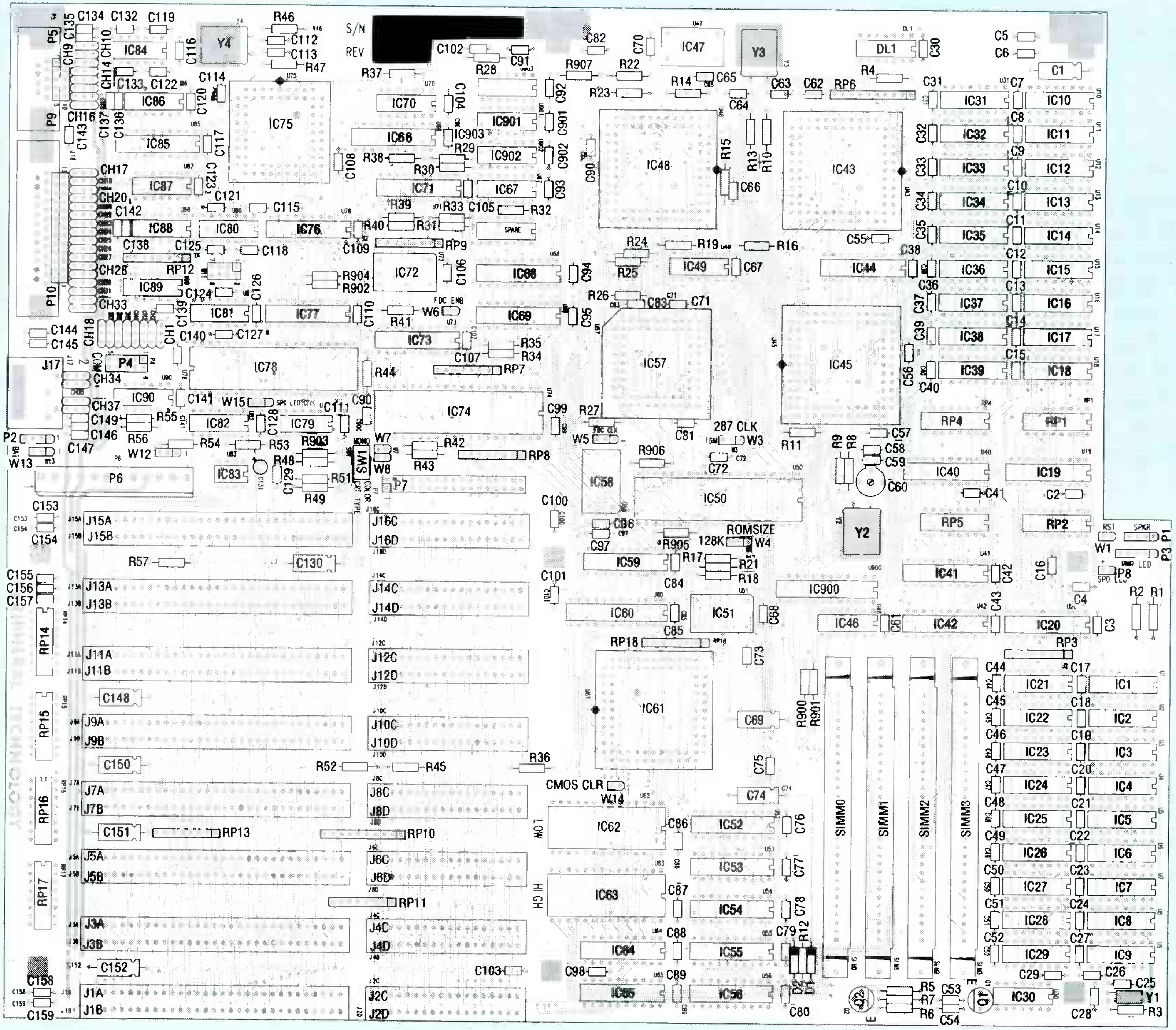


Fig. 1. MOTHERBOARD PARTS-PLACEMENT DIAGRAM.

Parts List—80286 MOTHERBOARD

Resistors

All resistors are ¼-watt, 5%.

R1, R2	150 ohms
R3, R46	2 megohms
R4, R15, R17, R22, R29, R32, R35, R37–R40, R42, R43, R48, R51, R902–R904	4700 ohms
R5, R12, R21, R34, R55, R56, R900, R901, R905, R906	10,000 ohms
R6	51,000 ohms
R7, R23, R33, R47	1000 ohms
R8, R13	10 ohms
R9, R10	1 megohm
R11, R14, R16, R18, R19, R24–R28, R41, R44	33 ohms
R20, R50, R907	not used
R30	620 ohms
R31	51 ohms
R36, R45, R52, R57	330 ohms
R49	2200 ohms
R53, R54	470 ohms

Resistor packs

RP1, RP2, RP4, RP5	33 ohms × 8, 16 pins, DIP
RP3	33 ohms × 4, 8 pins, SIP
RP6, RP10	10,000 ohms × 9, 10 pins, SIP
RP7, RP9, RP11, RP13	10,000 ohms × 7, 8 pins, SIP
RP8	150 ohms × 7, 8 pins, SIP
RP12	4700 ohms × 7, 8 pins, SIP
RP14–RP17	330 (or 470) × 14, 16 pins, DIP

Capacitors

C1, C69, C130, C148, C150–C152	22 µF, 16 volts, aluminum electrolytic
C2–C6, C16, C26, C28–C30, C38, C41–C43, C54–C57, C61, C62, C65–C68, C70, C72, C73, C75–C101, C103–C111, C114, C116, C117, C120, C123, C126, C128, C129, C134–C145, C149, C153–C159	0.1 µF, 50 volts, ceramic
C7–C15, C17–C24, C27, C31–C37, C40, C44–C52	0.33 µF, 50 volts, ceramic
C25	22 pF, 5%, 50 volts, mono
C53	4700 pF, 50 volts, ceramic
C58, C59, C63, C64, C112, C113	10 pF, 10%, 50 volts
C60	5–50 pF variable
C71	0.047 µF, 50 volts, ceramic
C74	4.7 µF, 20%, 15 volts, aluminum electrolytic
C102	27 pF, 5%, 50 volts, ceramic
C115, C118, C119, C121, C122, C124, C125, C127, C132, C133	100 pF, 5%, 50 volts, mono
C131	10 µF, 25 volts, tantalum
C146, C147	47 pF, 5%, 50 volts, ceramic

Semiconductors

IC1–IC18, IC21–IC29, IC31–IC39	DRAM, 256K × 1, 100 ns
IC19, IC20, IC41	74F244
IC30	MC14069
IC40, IC42–74F240	
IC43	82C215
IC44	74ALS245
IC45	82C212
IC46	74F00
IC47	32-MHz oscillator
IC48	82C211
IC49, IC901	74F74
IC50	80287 or cable to daughterboard
IC51	24-MHz oscillator
IC52, IC53	74LS373
IC54, IC55, IC56, IC64, IC65, IC69, IC71, IC77, IC85	74LS245
IC57	80286 or plug from daughterboard
IC58, IC900	not used
IC59	74F573
IC60	74F543
IC61	82C206
IC62, IC63	27256-17 BIOS EPROMS
IC66, IC73, IC76	74LS244
IC67	74F08
IC68	PAL16L8A
IC70	74LS30
IC72	9.6-MHz oscillator
IC74	WD37C65
IC75	82C605
IC78	8742AH keyboard controller
IC79	74ALS04
IC80, IC81, IC84	MC1489
IC82, IC90	7407
IC83	TL7705
IC86, IC88	MC1488
IC87	74LS14
IC89	74LS05
IC902	74F02
IC903	74F11
Q1	2N3906
Q2	2N3904
D1, D2	1N4148
DL1	100-ns delay line
SIMM0–SIMM3	DRAM, 30 pins, SIMM, 1024K × 9, 100 ns

Other components

Y1	32.768-kHz crystal
Y2	14.318-MHz crystal
Y3	20-MHz crystal
Y4	1.8432-MHz crystal
J1, J3, J5, J6, J9, J11, J13, J15	2 × 31 edge connector (bus)
J2, J7, J14	not used
J4, J6, J8, J10, J12, J16	2 × 18 edge connector (bus)
J17	5-pin DIN keyboard connector
P1, P2	1 × 4 header strip
P3	1 × 5 header strip
P4, P9	2 × 5 header strip
P5	not used
P6	1 × 12 power connector
P7	2 × 17 header strip
P8	1 × 2 header strip
P10	2 × 13 header strip
W1, W6, W7, W8, W14	1 × 2 header strip
W2, W5, W9, W10	not used
W3, W4, W12, W13, W15, SW1	1 × 3 header strip
W11	2 × 4 header strip
Circuit board	

IC Sockets

1 8-pin DIP **18** 14-pin DIP **36** 16-pin DIP **23** 20-pin DIP **1** 24-pin skinny DIP **2** 28-pin DIP **3** 40-pin DIP **1** 68-pin PGA **1** 68-pin PLCC **4** 84-pin PLCC **4** 30-pin SIMM (ANGLE). ◆CD◆

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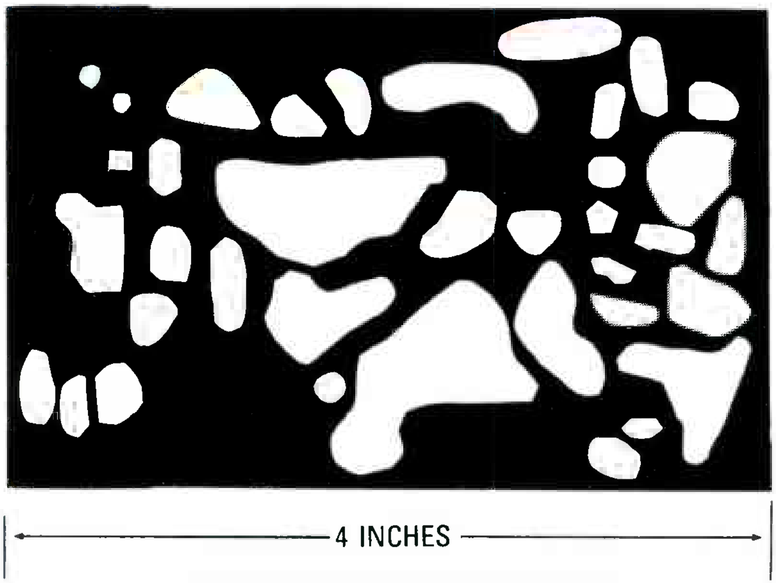

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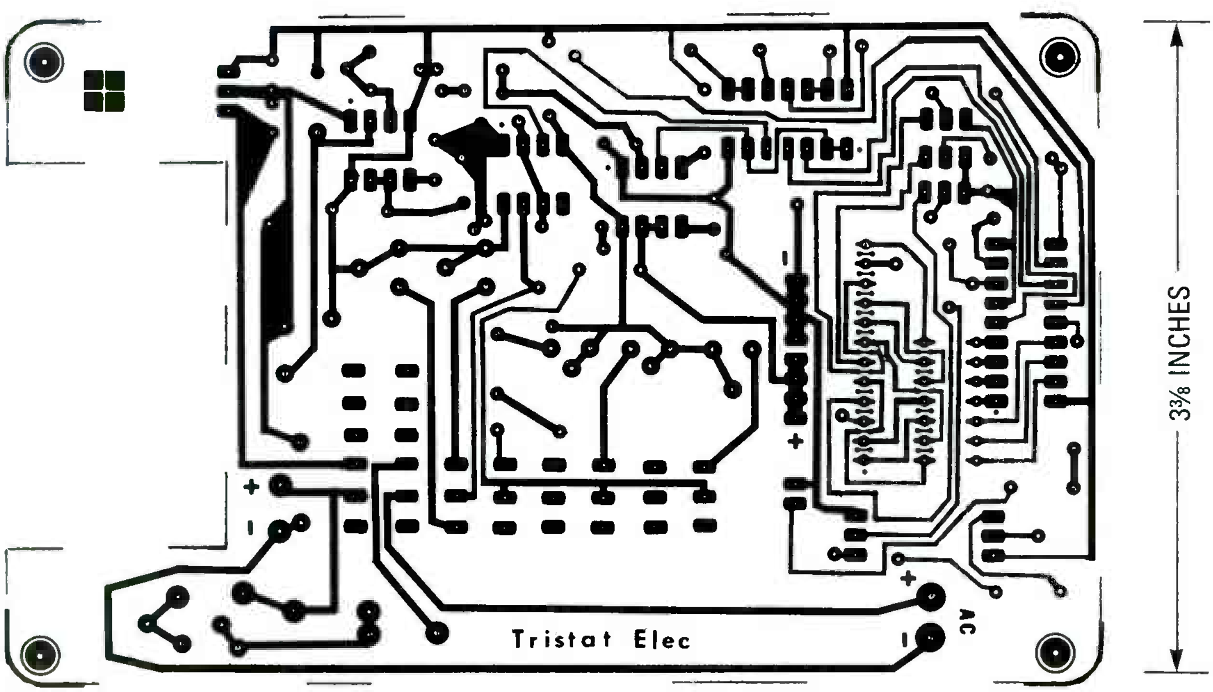

THE CAPACITANCE METER'S FOIL PATERN.

DRAWING BOARD

continued from page 29

together through an inverter and eliminate one column in the table. We can tie the two SEL inputs together as well since their state is only important when the chip is enabled. By re-arranging the truth table slightly we'll wind up with the one shown in Fig. 4, and that, as you should realize, is simple to implement because it's just counting up in a plain binary.

Not only that, but we can use a straight binary counter and use the "C" output to toggle the reset. Putting that into practice will produce a circuit like the one shown in Fig. 5. You should work out the logic in your own mind to make sure that you understand what's going on there.

The last part of the control logic is the counter and that can be any binary counter. You can use a 74LS93, 4040, half a 4520 or 4518, half a 74LS393, or just about anything that can count up to four in binary. The 4040 in Fig. 5 is a good choice because it's easy to use and is a mainstream CMOS part, but don't hesitate to use something you happen to have lying around.

The circuit we've come up with will fill all the design criteria we laid out earlier but it has three sections we still have to go over. The first is the clock, the second is the input latching, and the third is the use of pass transistors to drive the cathodes.

Some time ago we spent several columns talking about the ins and outs of scan oscillators and we found that you can use any frequency as long as it's high enough to eliminate flickering. Anything over 10 kHz or so will fill the bill and any oscillator capable of driving the clock inputs will be as good as any other. I've built mine out of a pair of inverters but if your application has a handy clock line that fills those minimal requirements, you may use that.

Input latches aren't really necessary but they can be useful if the data you want displayed doesn't stay around too long. That would be the case if you want to snatch bus data when a certain pulse shows up elsewhere in the circuit.

I'm using 4508 octal latches but only because I happened to have a bunch of them in the parts box. Notice that I didn't say "junk-box"—the only thing junk parts are good for is building junk. One thing that's nice about 4508's is that they're really two separate four-bit latches in a single package.

The last thing to talk about is the use of pass transistors. If you put together the circuit we showed you in May you probably noticed that the display was rather dim. There's nothing you can do about the scan time, but it is possible to zip more current through a digit when it's selected. That is exactly what the pass transistors are doing.

One disadvantage of that approach is that the brightness of the digit will depend somewhat on how many segments are being lit, but it's not enough of a problem to make the use of individual current-limiting resistors in your circuit an absolute necessity.

Breadboard the circuit of Fig. 5 and feed the sixteen inputs with two cascaded 4040's. You'll see the display count up in true binary, and you'll also know that the circuit works. The circuit is extremely useful and it's well worth the time to generate a PC board for it. The complexity is such that it will more than likely require a double-sided board, but once you've got it done, you can make as many of them as you want. I know it's not easy to produce a double-sided board, but there are some tricks you can use to make the job easier. We'll be looking at that, and some other things as well, next time. **R-E**

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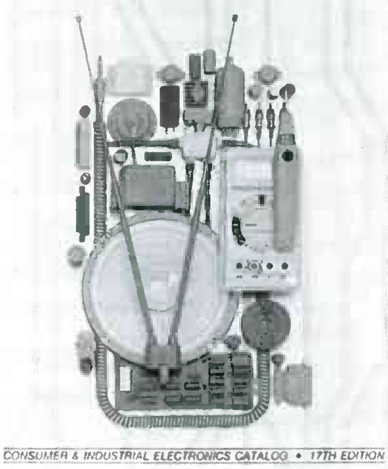

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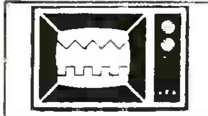

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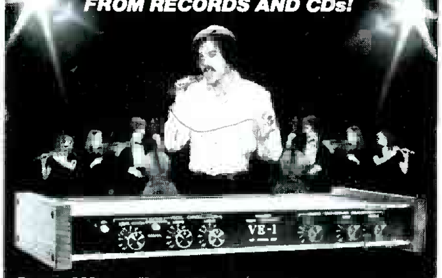

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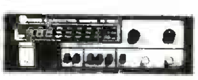

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$192.00

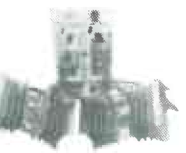
The FC-1000A is a multi-function 10 hertz to 1ghz dual-range frequency counter. It can measure frequency, period and total events. Readout is a large 0.5" 8-digit 7-segment LED display.

It utilizes two crystal oscillators which can be individually calibrated for maximum long term accuracy against a frequency standard such as WWV transmissions.

Additional features include a valuable self-check mode and a two step input attenuator.

SPECIFICATIONS
Frequency range 10hz to 10mhz 10mhz to 10mhz 100mhz to 1000mhz
Resolution 1000hz to 0.1hz depending on range
Accuracy ± 1 digit, ± time base error
Period measurement 10hz to 10mhz
Period measurement resolution 10^{-7} to 10^{-10} seconds depending on gate time
Totalization measurement 10hz to 10mhz
Totalization display 99999999
Sensitivity 15mV 10hz to 70mhz 30mV 70mhz to 100mhz 15mV 100mhz to 1000mhz
Input impedance 1 megohm 10hz to 100mhz 50ohms 100mhz to 1000mhz
Attenuation X1 X10
Power requirements 110 to 120VAC 60hz or 220VAC 50 to 70hz
Dimemsion 3" high 9.69" wide, 7.87" deep

120W MOSFET POWER AMPLIFIER (MONO) TA-477 ▲▲

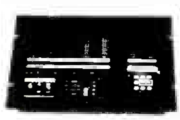


Complete kit **$68.00**
Assembled & tested **$85.00**

This amplifier is designed specifically for low TIM distortion. It uses parallel MOSFET output transistors. This is a very popular kit because of its superior sound reproducting ability and high power reserve.

SPECIFICATIONS
Power output 120 Watts into 8ohms
Frequency response 8hz to 20khz, +0.0 −0.4 dB
2.8hz to 65khz, +0.0 −3 dB
Sensitivity 1V
Power requirements 55VDC @ 3amps
Recommended transformer for a power supply is # 003

PROFESSIONAL COLOR LIGHT CONTROLLER SM-328 ★



Assembled & tested **$165.00**

The SM-328 professional color light controller is keyboard programmable for ease of use. It allows full control of intensity and flash rate. It has four separate channels with capacity of 1170 watts per channel. Total wattage capability is 4.68 killowatts. This is equivalent to 46, 100-watt light bulbs or 936 5-watt colored bulbs and is sufficient for the largest halls and auditoriums.

- Independent input signal control
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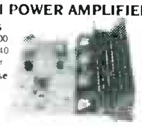
- Chaser speed controls
- Automatic chaser operation
- 4 preset chaser programs
- Clockwise chaser control
- Anti-clockwise chaser control

SPECIFICATIONS
Input sensitivity (music mode) 100mV
(music + program) 2V
Output power 1170W per channel 4680W total
Power requirement 105 - 120V, 60hz
Dimensions 11.32" wide 9" high, 3.19" deep

300W HI-FI POWER AMPLIFIER (MONO) TA-3600 ▲▲▲



SPECIFICATIONS
Power output 300 watts sine wave 540 watts music power
Frequency response
Total harmonic distortion Less than 0.05%
Intermodulation distortion Less than 0.05%
Sensitivity 1Vrms at 47K
Power requirements 60 to 75VDC at 8amp

The TA-3600 is an extremely high power amplifier specifically designed to reproduce the high dynamic range available on compact discs. It has low noise, high stability, low distortion, extended frequency range and high efficiency in a compact package.
Two of these units with approoriate power supply and pre-amplifier are required for stereo reproduction.

Complete kit **$66.00**
Assembled & tested **$110.00**
10,000 UF 80V E. Cap **$20.00**
Transformer **$38.00**

80W – 80W PURE DC STEREO MAIN POWER AMPLIFIER TA-802 ▲▲

Complete kit **$45.94**
Assembled & tested **$59.72**

Modern circuit design utilizes full complementary power output and differential cascode input stage. DC coupling provides superb transient response. A special output circuit guards against short circuits and overload operation.

SPECIFICATIONS
Power output 80 watts per channel into 8ohms
Total harmonic distortion Less than 0.05% at rated power
Intermodulation distortion Less than 0.05% at rated power
Frequency response DC to 200khz -0 dB -3 dB, @ 1 watt
Power requirements 30VAC x 2 @ 6amp May use Mark V model 001 transformer
Suggested cabinet is Mark V LG1924

HI-FI BI-FET PRE-AMP TA-2800 ▲▲

Complete kit **$48.90**

This super low distortion stereo pre-amplifier uses high slew rate wide bandwidth op-amps for 0.005% total harmonic distortion. RIAA curve deviation is 0.2 dB. Tone controls and loudness controls can be switched in and out. Fully regulated power supply. Low, High and Mid tone controls.

SPECIFICATIONS
Frequency response 10hz to 100khz ±0.5 dB
Total harmonic distortion 0.005% at rated output
Intermodulation distortion 0.005% at rated output
Sensitivity
Phono 2.5mV @ 47K
Aux and tape 100mV @ 100K
RIAA deviation ±0.2 dB, 20hz to 20khz
Signal to noise ratio
Phono 75 dB
Tuner, aux and tape 90 dB
Output 1V
Tone controls
Bass ±10 dB at 50hz
Mid ±5 dB at 1khz
Treble ±10 dB at 15khz
Power requirements 15V DC @ 0.5 to 1amp
Suggested power transformer for power supply is 15V AC x 2 @ 0.5 to 1amp
This model will match our 120W Mosfet Power Amplifier (TA-120)

4½ DIGIT HI-PRECISION DPM WITH DIN CASE SM-48A ▲▲▲

Complete kit **$41.20**
Assembled & tested & CAL **$52.00**

This is essentially our very popular SM-48 digital panel meter but in a standard DIN case. Like the SM-48, it has a large 0.55" LED readout. It is also temperature compensated to 100 PPM °C. Operating temperature range is 0° to +70° C.

This is a sensitive unit. An input of 1.999 volts results in full scale display. The unit operates on 5VDC at 200ma.

SPECIFICATIONS
Rear outputs BCD data, Busy, Strobe
Range
DC voltage 1mV to 2000V DC current 1 microamp to 20amps
Accuracy ±0.025% ±2 digits
Power requirements 5 to 6 volts DC at 200ma
Dimensions 3⅝" wide x 1⅝" high 4-1/16" deep

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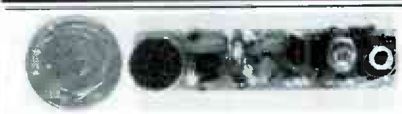

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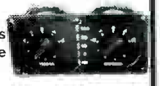

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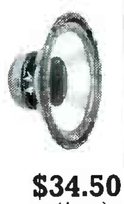

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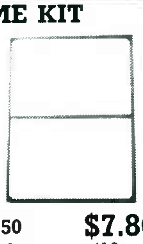

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STEREO AMP. 2 X 50W PEAK. INPUT SENSITIVY 47K/300mV OUTPUT 4/8Ω. SUPPLIEDWITH HEATSINK AND BALANCE. VOLUME, BASS, TREBLE CONTROLS.POWER SUPPLY 40V D.C./2A-3A

TSM 118 — $62.31
320W PEAK POWER AMPLIFIER MODULE. 8Ω OUTPUT IMPEDANCE INPUT 47K/800mV FREQUENCY RESPONSE 15HZ TO 60KHZ, POWER SUPPLY 2 X 40V D C /6A. HEATSINKS NOT INCLUDED IN THE KIT.

TSM 89 — $30.38
AUDIO BOOSTER STEREO 2 X 40W FOR CAR RADIO, OUTPUT 2.5Ω POWER SUPPLY 12/16V D.C./4A.

TSM 102 — $22.50
18 LED OUTPUT POWER LEVEL, METER, POWERED BY THE MODULATION.

TSM 128 — $20.31
2 X 6 LED OUTPUT LEVEL METER, STEREO 2 X 50W, POWER SUPPLY 15/20V D.C.

TSM 9 — $14.00
AUDIO PREAMPLIFIER FOR GUITAR, INPUT SENSITIVY 47K/5mV, OUTPUT LEVEL 47K/1. 5V, VOLUME CONTROL VARIABLE, POWER SUPPLY 25V D.C. / 0 1A

TSM 34 — $9.19
STEREO RIAA PREAMPLIFIER; INPUT SENSITIVY 47K/3mV, OUTPUT 700mV, POWER SUPPLY 12V D C./ 0. 1A

TSM 35 — $9.19
MICROPHONE STEREO PREAMPLIFIER; INPUT SENSITIVY 5mV/200Ω OR MORE, OUTPUT 700mV, POWER SUPPLY 12V D.C. /0.1A

TSM 122 — $13.96
ALL BAND FM/VHF/UHF ANTENNA. 20dB AMPLIFIER-. POWER SUPPLY 8/12V D.C./ 0.15A.

TSM 31 s — $14.77
FM STEREO DECODER, POWER SUPPLY 12V D.C. / 0.1A

TSM 62 — $13.00
CAR ANTENNA PREAMPLIFIER MW/LW/FM, POWER SUPPLY 12/16V D.C./0.1A.

TSM 61 — $25.48
FM RECEIVER, OUTPUT 1 WATT 4/8Ω, POWER SUPPLY 12/16V D.C. /0.2A.

TSM 158 — $27.42
FM RECEIVER, OUTPUT 20 WATTS/8Ω. POWER SUPPLY 12/16V D.C. /2A.

TSM 211 — $10.00
MEDIUM WAVE RECEIVER. 1 W,0.5 W RMS AUDIO POWER. POWER SUPPLY 9-12V D.C./ 0 1 A.

TSM 205 — $35.40
FM RECEIVER, HEADPHONE STEREO OUTPUT POWER SUPPLY 9/12V D.C./0.1A

TSM 201 — $26.77
DIGITAL CLOCK, 5/16" READ OUT; POWER SUPPLY 12V D.C./0.2A WITH HOUR AND MINUTE SETTING CONTROLS

TSM 157 — $40.00
DIGITAL CLOCK AND UP TO 24 MN 1/100 S CHRONOMETER. COUNT-DOWN CAPABILITY FOR THE CLOCK. POWER SUPPLY 12V D.C. OR A.C.

TSM 177 — $33.20
DIGITAL VOLTMETERS 0 V TO 999 V D.C. POWER SUPPLY 12V D.C /0/.5A

TSM 206 — $10.15
METRONOME: POWER SUPPLY 9 - 12V D.C

TSM 210 — $10.50
FULLY RANDOMISED ELECTRONIC DICE, POWER SUPPLY 9 - 12V D.C./0.1A

TSM 54 — $13.85
FM TRANSMITTER, POWER SUPPLY 9V D.C. / 0.5A

TSM 150 — $82.50
HOME PROGAMMER 4 DEVICES CONTROL 20 PROGRAMS. OPERATION WITH RELAYS POWER SUPPLY 12V D.C./0.8A.

TSM 105 — $15.15
ELECTRONIC ALARM SIREN, 8Ω IMPEDANCE, 10 WATTS RATING. POWER SUPPLY 12V D.C., HORN SPEAKER NOT INCLUDED.

TSM 85 — $22.52
TIME DELAY SYSTEM FROM 1SEC TO 15 MINUTES. POWER SUPPLY 12V D.C.

TSM 69 — $15.93
TELEPHONE AMPLIFIER WITH INDUCTIVE PICK-UP AND SPEAKER, ADJUSTABLE VOLUME, POWER SUPPLY 9/12V D.C./0,1A

TSM 168 — $12.92
MOSQUITO REPELLER. POWER SOURCE 9V D.C.

TSM 88 — $38.77
FUNCTION GENERATOR, FREQUENCY RANGE 8HZ TO 200KHZ,PROVIDING SINE/TRIANGLE /SQUARE/SAW TOOTH WAWE FORMS. POWER SUPPLY 12V D.C./0.3A

TSM 58 — $19.94
TWO STATION INTERCOM WITH SPEAKER VOLUME CONTROL, POWER SOURCE 9/12V D C. / 0.4A

TSM 160 — $16.62
STEREO SIMULATOR, POWER SUPPLY 12V D C./0.1A.

TSM 196 — $19.71
7 INPUT MIXER STEREO PREAMPLIFIER OR 14 INPUT MONO WITHOUT ATTENUATION, INPUT 47K/100 TO 700mV,OUTPUT 47K/100 TO 750mV, POWER SUPPLY 24V D.C. /0.1A

TSM 99 — $130.00
VEGAS KIT. FESTIVE LIGHT DISPLAY (LED) POWER SUPPLY 12V D.C. / 2.5A. 64 LED S, AS MANY AS 800 PROGRAMS

TSM 2 V2 — $22.20
VARIABLE SOLID STATE REGULATED POWER SUPPLY 8V TO 38V/2A.TRANSFORMER IS NOT INCLUDED WITH THE KIT.

TSM 116 V5 — $11.50
REGULATED POWER SUPPLY 5V D.C. POWER TRANSFORMER NOT INCLUDED WITH THE KIT

TSM 116 V12 — $11.50
REGULATED POWER SUPPLY 12V D.C. POWER TRANSFORMER IS NOT INCLUDED WITH THE KIT

TSM 163 — $12.92
POWER SUPPLIES 5, 7,5, 9, 12V/1A. POWER TRANSFORMER NOT INCLUDED WITH THE KIT.

TSM 2 V4 — $25.85
VARIABLE SOLID STATE REGULATED POWER SUPPLY 3V TO 14V/6A.TRANSFORMER NOT INCLUDED IN THE KIT.

TSM 212 — $17.50
LOW OPERATING VOLTAGE. SPOT TSM 220 AND TSM 221 COMPATIBLE CONTROLED BY A MICROPHONE. POWER SUPPLY 12V/ 1A. OUTPUT 0.5A SAFE 3 CHANNEL LIGHT MODULATOR.

TSM 214 — $29.50
8-CHANNEL CATERPILAR. SAFE LOW VOLTAGE OPERATION USING TSM 220 AND 221 SPOT. 9V D.C./ 0.5 A

TSM 220 — $25.30
64 LED'S SPOT FOR SAFE LIGHT MODULATION. SUPPLIED WITH BOX.

TSM 221 — $17.20
25 LED'S SPOT FOR SAFE LIGHT MODULATION. SUPPLIED WITH BOX.

PROSPECT ELECTRONICS
PO BOX 9144 ALLENTOWN, PA 18105
TEL: (215) 770 - 9029

YES I PLEASE SEND ME THE FOLLOWING ITEMS -

ITEM NO.	HOW MANY ?	DESCRIPTION	PRICE	TOTAL
			TOTAL	

Shipping & handing : we ship UPS unless otherwise specified. Add $3 plus 10% of total. Canadian: 3$ plus P.O. cost. Charge only.
Sales Tax (P.A. residents only, please add 6% of total).
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• COMPLETE CUSTOMER SATISFACTION • SUPERIOR SERVICE • FRIENDLY, KNOWLEDGEABLE SALES STAFF

EPROMS

PART	SIZE	SPEED	Vpp	PRICE
2708	1024x8	450ns	25V	4.95
2716	2048x8	450ns	25V	3.49
2716-1	2048x8	350ns	25V	3.95
2732	4096x8	450ns	25V	3.95
2732A	4096x8	250ns	21V	3.95
27C64	8192x8	250ns	12.5V	4.95
2764	8192x8	450ns	12.5V	3.49
2764-250	8192x8	250ns	12.5V	3.69
2764-200	8192x8	200ns	12.5V	4.25
27128	16384x8	250ns	12.5V	4.95
27128A-200	16384x8	200ns	12.5V	5.95
27C256	32768x8	250ns	12.5V	7.95
27256	32768x8	250ns	12.5V	5.95
27256-200	32768x8	200ns	12.5V	7.95
27512	65536x8	250ns	12.5V	11.95
27C512	65536x8	250ns	12.5V	12.95
27C101-20	131072x8	200ns	12.5V	34.95

■ CALL TO CONFIRM CURRENT PRICES ■

STATIC RAMS

PART	SIZE	SPEED	PRICE
2114	1024x4	450ns	.99
2114L-2	1024x4	200ns	1.49
TC5516	2048x8	250ns	3.95
TMM2016-200	2048x8	200ns	3.25
TMM2016-150	2048x8	150ns	3.29
TMM2016-100	2048x8	100ns	4.29
HM6116-4	2048x8	200ns	4.95
HM6116-3	2048x8	150ns	5.95
HM6116-2	2048x8	120ns	6.45
HM6116LP-4	2048x8	200ns	5.95
HM6116LP-3	2048x8	150ns	6.45
HM6116LP-2	2048x8	120ns	6.95
HM6264LP-15	8192x8	150ns	9.95
HM6264LP-12	8192x8	120ns	10.95
HM43256LP-15	32768x8	150ns	17.95
HM43256LP-12	32768x8	120ns	19.95
HM43256LP-10	32768x8	100ns	24.95

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DYNAMIC RAMS

PART	SIZE	SPEED	PRICE
4116-200	16384x1	200ns	.89
4116-150	16384x1	150ns	.99
4164-150	65536x1	150ns	2.89
4164-120	65536x1	120ns	3.19
4164-100	65536x1	100ns	3.95
TMS4416	16384x4	150ns	8.95
41128-150	131072x1	150ns	5.95
TMS4464-15	65536x4	150ns	14.95
TMS4464-12	65536x4	120ns	15.95
41256-150	262144x1	150ns	7.99
41256-120	262144x1	120ns	8.49
41256-100	262144x1	100ns	8.79
41256-80	262144x1	80ns	9.49
MK4332	32768x1	200ns	6.95
HM51258-100	262144x1	100ns	13.95
1 MB-120	1048576x1	120ns	24.95
1 MB-100	1048576x1	100ns	27.95

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CO-PROCESSORS

8087	5 MHz	97.95
8087-2	8 MHz	139.95
8087-1	10 MHz	189.95
80287	6 MHz	157.96
80287-8	8 MHz	219.95
80287-10	10 MHz	264.95
80387-16	16 MHz	397.95
80387-SX	16 MHz	389.95
80387-20	20 MHz	469.95
80387-25	25 MHz	589.95

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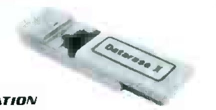
EPROM ERASERS

DATARASE II $39.95

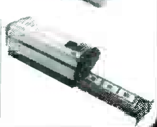
■ SHIRT POCKET SIZE!
■ ERASES MOST EPROMS/EPLD'S IN 3 MINUTES ■ ALL SIZES UP TO 4 AT A TIME

DATARASE II



SPECTRONICS CORPORATION

Model	Timer	# of Chips	Intensity (uW/Cm²)	Unit Cost
PE-140	NO	9	8,000	$ 89
PE-140T	YES	9	8,000	$139
PE-240T	YES	12	9,600	$189
PL-265	YES	30	9,600	$255



HIGH-TECH SPOTLIGHT

NEW! FAST PAGE-MODE DYNAMIC RAMS

THESE NEW CMOS 262144X4 DRAMS ARE IDEAL FOR LARGE CAPACITY MEMORY SYSTEMS REQUIRING HIGH SPEED AND LOW POWER DISSIPATION. HIGHER DENSITY REQUIRES FEWER CHIPS FOR SYSTEM DESIGN. SUPPORTS EXTREMELY LOW POWER STANDBY MODE. 8 MS REFRESH RATE.

PART NUMBER	SPEED	PRICE
414256-100	100 NS	$28.95
414256-80	80 NS	$36.95

PARTIAL LISTINGS ONLY! CALL FOR COMPLETE CATALOG

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6502	2.25
6502A	2.69
6502B	4.25
65C02*	7.95
6522	2.95
6526	13.95
6532	5.95
6551	2.95
6581	14.95

* CMOS

6800

6800	1.95
6802	2.95
68B02	3.95
6803	3.95
6809	2.95
68B09	5.99
6809E	2.95
68B09E	5.49
6808	2.49
6810	1.95
6821	1.25
68B21	1.85
6840	3.95
6845	2.75
6847	4.75
6850	1.95
68B50	1.75
6852	4.95
6883	22.95
68000	9.95
68020	189.95

8000

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8035	1.49
8039	1.95
8052AH BASIC	34.95
8080	2.49
8085	1.95
8085A-2	3.75
8088	5.99
8088-2	7.95
8155	2.49
8155-2	3.95
8156	2.95
6741	9.95
8748	7.95
8749	9.95
8755	14.95

8200

8205	3.29
8212	1.49
8216	1.49
8224	2.25
8228	2.25
8237	3.95
8237-5	4.75
8238	4.49
8243	1.95
8250	6.95
8251	1.29
8251A	1.69
8253	1.59
8253-5	1.95

8200

8254	2.79
8255	1.99
8255-5	2.49
8256	15.95
8259	1.95
8259-5	2.29
8272	4.39
8274	4.95
8275	16.95
8279	2.49
8279-5	2.95
8282	3.95
8283	3.95
8284	2.25
8286	3.95
8287	3.95
8288	4.95

Z-80

Z80-CPU	1.25
Z80A-CPU	1.29
Z80B-CPU	2.75
Z80A-CTC	1.69
Z80B-CTC	4.25
Z80A-DART	5.95
Z80B-DART	6.95
Z80A-DMA	5.95
Z80A-PIO	1.89
Z80B-PIO	4.25
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Z80A-SIO/1	5.95
Z80A-SIO/2	5.95
Z8671BASIC	9.95

SIMM MODULES

41256A8B-15	256K x 8-BIT	FOR MAC	150ns	$89.00
41256A8B-12	256K x 8-BIT	FOR MAC	120ns	$95.00
41256A8B-10	256K x 8-BIT	FOR MAC	100ns	$99.00
41256A9B-15	256K x 9-BIT	FOR PC	150ns	$94.00
41256A9B-12	256K x 9-BIT	FOR PC	120ns	$99.00
41256A9B-10	256K x 9-BIT	FOR PC	100ns	$109.00
41256A9B-80	256K x 9-BIT	FOR PC	80ns	$119.00
421000A9B-10	1MB x 9-BIT	FOR PC	100ns	$329.00
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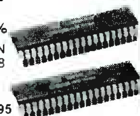
■ LOW POWER CMOS
■ SUPERSET OF 8088 INSTRUCTION SET

V20	5 MHz	6.95	V20	8 MHz	8.95
V20	10 MHz	11.95	V30	8 MHz	13.95



PALS

16L8	$2.95	20R4	$4.95
16R8	2.95	20R6	4.95
16R6	2.95	20R8	4.95
16R4	2.95	20X8	4.95
20L8	4.95		

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EASY TO USE PAL PROGRAMMING KIT FOR ALL THE PAL DEVICES AT LEFT.
MCT-PAL-SOFT $99.95

74 SERIES LOGIC

7400

7400	.19
7402	.19
7404	.19
7405	.25
7406	.29
7407	.29
7408	.24
7410	.19
7411	.25
7414	.49
7416	.25
7417	.25
7420	.19
7432	.29
7447	.89
7473	.34
7474	.33
7475	.45
7476	.35
7586	.35
7489	2.15
7490	.39
7493	.35
74121	.29
74123	.49
74151	.55
74154	1.49
74157	.55
74166	1.00

74LS00

74LS00	.16
74LS02	.17
74LS03	.18
74LS04	.16
74LS05	.18
74LS08	.18
74LS10	.16
74LS11	.22
74LS14	.39
74LS20	.17
74LS21	.22
74LS27	.23
74LS30	.17
74LS32	.18
74LS38	.26
74LS42	.39
74LS47	.75
74LS51	.17
74LS73	.29
74LS74	.24
74LS75	.29

74LS76	.29
74LS83	.49
74LS85	.49
74LS86	.22
74LS90	.39
74LS92	.49
74LS93	.39
74LS109	.36
74LS112	.29
74LS123	.49
74LS125	.39
74LS132	.39
74LS138	.39
74LS139	.39
74LS151	.39
74LS153	.39
74LS154	1.49
74LS155	.59
74LS156	.49
74LS157	.35
74LS158	.29
74LS161	.39
74LS163	.39
74LS164	.49
74LS165	.65
74LS166	.95
74LS175	.39
74LS192	.69
74LS193	.69
74LS197	.59
74LS221	.59
74LS240	.69
74LS241	.69
74LS244	.69
74LS245	.79
74LS251	.49
74LS257	.39
74LS258	.49
74LS259	1.29
74LS260	.49
74LS273	.79
74LS279	.39
74LS322	3.95
74LS323	2.49
74LS367	.39
74LS373	.79
74LS374	.79
74LS377	.79
74LS393	.79
74LS541	1.49
74LS670	.89
74LS682	3.20
74LS688	2.40

74S

74S00	.29
74S02	.29
74S04	.29
74S74	.49
74S86	.35
74S112	.50
74S287	1.69
74S288	1.69
74S374	1.69
S32	.35
S138	.79
S240	1.49
S244	1.49
S373	1.69

74F

74F00	.35
74F04	.35
74F08	.35
74F32	.35
74F74	.39
74F138	.79
74F244	1.29

74HC

74HC00	.21
74HC04	.25
74HC08	.25
74HC14	.35
74HC32	.35
74HC74	.35
74HC138	.45
74HC139	.45
74HC154	1.09
74HC157	.55
74HC244	.85
74HC245	.85
74HC373	.69
74HC374	.69

74HCT

74HCT00	.25
74HCT04	.27
74HCT08	.25
74HCT32	.27
74HCT138	.35
74HCT240	.89
74HCT244	.89
74HCT245	.99
74HCT373	.99
74HCT374	.99

LINEAR COMPONENTS

TL071	.69	TL497	3.25	MC3487	2.95
TL072	1.09	NE555	.29	LM3900	.49
TL084	1.49	NE556	.49	LM3909	.98
LM301	.34	NE558	.79	LM3914	1.89
LM309K	1.25	LM565	.95	IC7760	1.99
LM311	.59	LM567	.79	7805T	.49
LM311K	3.49	NE570	2.95	7808T	.49
LM317T	.69	NE590	2.50	7812T	.49
LM318	1.49	LM723	.49	7815T	.49
LM319	1.25	LM741	.29	7905T	.59
LM323K	3.49	MC1330	1.69	7912T	.59
LM324	.34	MC1350	1.19	7915T	.59
LM334	1.19	LM1458	.35	MAX232	7.95
LM336	1.75	LM1488	.49	ICL8038	3.85
LM338K	4.49	LM1489	.49	ICM7207A	5.95
LM339	.59	LM1496	.85	ICM7208	15.95
LF353	.59	ULN2003	.79	75150	1.95
LF356	.99	XR2206	3.95	75154	1.95
LM358	.59	XR2211	2.95	75188	1.25
LM380	.89	CA3046	.89	75189	1.25
LM386	.89	CA3146	1.29	75451	.39
LM393	.45	MC3470	1.95	75452	.39

MISC.

ADC0804	2.99
ADC0809	3.85
DAC0800	3.29
DAC0808	1.95
1793	9.95
8272	4.39
COM8116	8.95
UPD765	4.39
1691	6.95
2143	6.95
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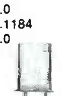
AY3-1015	4.95
AY5-1013	3.95
MC146818	5.95
MM58167	9.95
MM58174	9.95
MSM5832	2.95
IM6402	3.95
IM6403	9.95
INS8250	6.95
NS16450	10.95

CRYSTALS

32.768 KHz	.95
1.0 MHz	2.95
1.8432	2.95
2.0	1.95
2.4576	1.95
3.579545	1.95
4.0	1.95
5.0688	1.95
6.0	1.95
8.0	1.95
10.0	1.95
12.0	1.95
14.31818	1.95
16.0	1.95
18.0	1.95
20.0	1.95
22.1184	1.95
24.0	1.95



CRYSTAL OSCILL.

1.0MHz	5.95
1.8432	5.95
2.0	5.95
2.4576	5.95
4.0	4.95
5.0688	4.95
8.0	4.95
10.0	4.95
14.31818	1.95
16.0	4.95
18.432	4.95
20.0	4.95
24.0	4.95

STD. CMOS LOGIC

4001	.19	4050	.29
4011	.19	4051	.69
4013	.35	4060	.69
4015	.29	4066	.29
4016	.29	4069	.19
4017	.49	4093	.49
4024	.49	14411	9.95
4040	.69	4511	.69
4046	.69	4538	.95
4049	.29	4702	9.95

SHORTING BLOCKS

5/$1.00

DISCRETE

1N751	.49	2N3904	.10
IN4004	10/1.00	2N3906	.10
IN4148	25/1.00	2N4401	.25
KBP02	.55	4N26	.69
2N2222	.10	4N35	.89
2N2907	.25	JMBO RED	.10
2N3055	.79	JMBO GRN	.14

BYPASS CAPS

CERAMIC DISC:

.01UF	100/5.00
.1UF	100/6.50

MONOLITHIC:

.01UF	100/10.00
.1UF	100/12.50

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CIRCLE 113 ON FREE INFORMATION CARD

POWER SUPPLIES

135 WATT POWER SUPPLY
- UL APPROVED
- +5V @15A, +12V @ 4.2A, -5V @ .5A, -12V @ .5A

PS-135 $59.95
PS-150 150W SUPPLY $69.95

200 WATT POWER SUPPLY
- UL APPROVED
- +5V @ 20A, +12V @ 7A, -5V @ .5A, -12V @ .5A

PS-200 $89.95

APPLE TYPE SUPPLY
- WITH APPLE CONNECTOR
- +5V @ 6A, +12V @ 3A, -5V @ 1A, -12V @ 1A

PS-A $49.95

36 WATT POWER SUPPLY
- +5V @2.5A, +12V @1.5A
- 3 PIN INPUT, 6 PIN OUTPUT
- SELECTABLE 110V-220V

PS-3045 $12.95

SOLDER STATIONS

SOLDER/DESOLDER STATION
- OIL-FREE VACUUM PUMP
- TEMP ADJUSTS (212°F-900°F) & VACUUM (0-60 CM/HG)
- WITH GUN-REST, COOLING TRAY, WIRE BRUSH & TIP CLEANER ROD

XY999SD $399.95
XY999D DESOLDER ONLY $349.99

DELUXE SOLDER STATION
- ROTARY SWITCH TEMP CONTROL (200°F-878°F RANGE)
- LED TEMPERATURE READOUTS
- INCLUDES COOLING TRAY

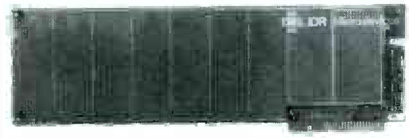
XY9-60L $79.95

SOLDER STATION
- UL APPROVED
- HEAT SETTING ADJUSTS
- TIP TEMPERATURE READOUT
- REPLACEMENT TIPS @ $2.95

168-3C $59.95

WIREWRAP PROTOTYPE CARDS

FR-4 EPOXY GLASS LAMINATE WITH GOLD PLATED EDGECARD FINGERS AND SILK SCREENED LEGENDS



	FOR XT	
JDR-PR1	WITH +5V AND GROUND PLANE	$27.95
JDR-PR2	ABOVE WITH I/O DECODING LAYOUT	$29.95
	FOR AT	
JDR-PR10	16 BIT WITH I/O DECODING LAYOUT	$34.95
JDR-PR10PK	PARTS KIT FOR JDR-PR10 ABOVE	$12.95
	FOR PS/2	
JDR-PR32	32 BIT PROTOTYPE CARD	$69.95
JDR-PR16	16 BIT WITH I/O DECODING LAYOUT	$49.95
JDR-PR16PK	PARTS KIT FOR JDR-PR16 ABOVE	$15.95
JDR-PR16V	16 BIT FOR VIDEO APPLICATIONS	$39.95

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35 MHZ DUAL TRACE OSCILLOSCOPE
- WIDE BAND WIDTH ■ VARIABLE HOLDOFF

MODEL-3500 (SHOWN) $499.95

20 MHZ DUAL TRACE OSCILLOSCOPE
- TV SYNC FILTER ■ COMPONENTS TESTER

MODEL 2000 $389.95

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- AUTORANGING ■ AC/DC 2V - 500V, RESIS. 2K-2M

DPM-1000 (SHOWN) $54.95

3.5 DIGIT POCKET SIZE DMM
- BASIC DC ACCURACY ±0.5% ■ 14 RANGES

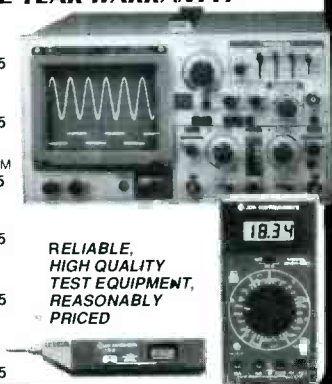
DMM-100 $29.95

3.5 DIGIT FULL FUNCTION DMM
- BASIC DC ACCURACY ±0.25% ■ 22 RANGES

DMM-200 $49.95

THE ULTIMATE 3.5 DIGIT DMM
- BASIC DC ACCURACY ±0.25% ■ 34 RANGES
- TEMP, TRANSISTOR & RESISTANCE FEATURES

DMM-300 (SHOWN) $79.95



RELIABLE, HIGH QUALITY TEST EQUIPMENT, REASONABLY PRICED

DATA SWITCH BOXES

TYPE	# OF POS.	PARALL.	SERIAL	PRICE
PUSHBTTN.	2-WAY	AB-P	AB-S	39.95
ROTARY	2-WAY	RSP-2	RSS-2	24.95
ROTARY	3-WAY	RSP-3	RSS-3	27.95
ROTARY	4-WAY	RSP-4	RSS-4	29.95

COMPUTER CABLES

GOLD-PLATED CONTACTS; 100% SHIELDED

CBL-PRINTER	PC PRINTER CABLE	9.95
CBL-PRINTER-25	AS ABOVE-25 FT	15.95
CBL-PRINTER-RA	RT ANGL PRINTER	15.95
CBL-DB25-MM	DB25 MALE-MALE	9.95
CBL-DB25-MF	DB25 MALE-FEMALE	9.95
CBL-9-SERIAL	9 PIN-25 PIN SERIAL	6.95
CBL-KBD-EXT	KEYBOARD EXTEN.	7.95
CBL-CNT-MM	36 PIN CENTRON. M/M	14.95
CBL-HD-20	20 PIN HARD DISK	3.95
CBL-HD-34D	34 PIN DUAL HARD DISK	6.95
CBL-FDC-EXT	37 PIN EXT. FLOPPY	9.95
CBL-MNT-9	9 PIN MONITOR EXTEN.	6.95
CBL-MODEM	DB25 DB25 FEMALE	7.95

EXTENDER CARDS

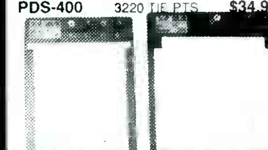
FOR PROTOTYPE DEBUGGING, TESTING AND TROUBLESHOOTING

EXT-8088	XT COMPATIBLE	$29.95
EXT-80286	AT COMPATIBLE	$39.95
EXT-16	MICROCHANNEL 16-BIT	$69.95
EXT-32	MICROCHANNEL 32-BIT	$99.95

NEW LOW PRICES!

SOLDERLESS BREADBOARDS

PDS-100	1360 TIE PTS	$12.95
PDS-200	1660 TIE PTS	$19.95
PDS-300	2390 TIE PTS	$24.95
PDS-400	3220 TIE PTS	$34.95



IDC CONNECTORS/RIBBON CABLE

DESCRIPTION	ORDER BY	CONTACTS 10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.31	2.72	3.39
WIREWRAP HEADER	IDHxxW	1.86	2.98	3.64	4.50	5.28	6.63
RIGHT ANGLE WIREWRAP HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	.63	.89	.95	1.29	1.49	1.69
RIBBON HEADER	IDMxx	--	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	.85	1.25	1.05	1.75	2.05	2.45
10' RIBBON CABLE	RCxx	1.60	3.20	4.10	5.40	6.40	7.50

FOR ORDERING INSTRUCTIONS, SEE D-SUBMINIATURE CONNECTORS BELOW

RS-232 BREAKOUT BOX

FOR TROUBLESHOOTING SERIAL COMMUNICATIONS

- OPEN/CLOSE INDIVIDUAL CIRCUITS ■ 20 JUMPERS CROSS-CONNECT ANY TWO CIRCUITS ■ 10 CIRCUIT ACTIVITY LEDS

GENDER-BO $34.95

PC BREADBOARD

- 62 CLEARLY LABELLED BUS LINES
- ACCEPTS UP TO 24 14-PIN ICS
- 1940 TIE POINTS
- EXT FEMALE DB25 D-SUB CONNECT.

PDS-604 $49.95

D-SUBMINIATURE CONNECTORS

DESCRIPTION		ORDER BY	CONTACTS 9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.45	.59	.69	.69	1.35	1.85
	FEMALE	DBxxS	.49	.69	.75	.75	1.39	2.29
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	.49	.69	--	.79	2.27	--
	FEMALE	DBxxSR	.55	.75	--	.85	2.49	--
WIREWRAP	MALE	DBxxPWW	1.69	2.56	--	3.89	5.60	--
	FEMALE	DBxxSWW	2.76	4.27	--	6.84	9.95	--
IDC RIBBON CABLE	MALE	IDBxxP	1.39	1.99	--	2.25	4.25	--
	FEMALE	IDBxxS	1.45	2.05	--	2.35	4.49	--
HOODS	METAL	MHOODxx	1.05	1.15	1.25	1.25	--	--
	PLASTIC	HOODxx	.39	.39	--	.39	.69	.75

ORDERING INSTRUCTIONS: INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED. EXAMPLE : A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR

MOUNTING HARDWARE .59

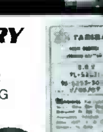
SURGE SUPPRESSOR

PROTECTS YOUR EQUIPMENT!

- SIX 3-PRONG AC OUTLETS
- 15 AMP CIRCUIT BREAKER
- 6' HEAVY DUTY CORD
- 15 AMP MAX LOAD, 1875 WATTS
- UL APPROVED

POWER-SURGE $12.95
POWER-STRIP W/O SURGE $9.95

LITHIUM BATTERY

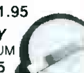


- 6V FOR 286 AND 386 PCS
- MOTHERBOARD CONNECTOR
- ADHESIVE VELCRO MOUNTING STRIP

LITHIUM6.8V $11.95

COIN TYPE BATTERY

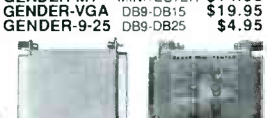
LONG-LASTING 3V LITHIUM



3V-MHW $1.95
HOLDER $1.49

GENDER CHANGERS

GENDER-FF	FEMALE-FEMALE	$7.95
GENDER-MM	MALE-MALE	$7.95
GENDER-MF	MALE-FEMALE	$7.95
GENDER-NM	NULL MODEM	$8.95
GENDER-JB	JUMPER BOX	$8.95
GENDER-MT	MINITESTER	$14.95
GENDER-VGA	DB9-DB15	$19.95
GENDER-9-25	DB9-DB25	$4.95



IC SOCKETS/DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 8	14	16	18	20	22	24	28	40
SOLDERTAIL SOCKETS	xxST	.11	.11	.12	.15	.18	.15	.20	.22	.30
WIREWRAP SOCKETS	xxWW	.59	.69	.69	.99	1.09	1.39	1.49	1.69	1.99
ZIF SOCKETS	ZIFxx	--	4.95	4.95	--	5.95	--	5.95	6.95	9.95
TOOLED SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
TOOLED WW SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2.90	3.15	3.70	5.40
COMPONENT CARRIERS	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
DIP PLUGS (IDC)	IDPxx	.95	.49	.59	1.29	1.49	--	.85	1.49	1.59

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE CONNECTORS ABOVE

APPLE-COMPATIBLE PRODUCTS

FLOPPY DRIVE FOR APPLE II SERIES
AP-150 *(W/CABLE, CONNECTOR)* $99.95

REPLACEMENT KEYBOARD FOR APPLE II & II+
KEYBOARD-AP $59.95

EPROM PROGRAMMER. NOT REC. FOR CMOS.
RP-525 *(NO POWER SUPPLY REQ.)* $89.95

16K RAM CARD BOOSTS 48K APPLE TO 64K
RAM-CARD (2 YEAR WARRANTY) $39.95

"SNAPABLE HEADERS"

SNAP APART TO MAKE ANY SIZE HEADER, WITH .1" CENTERS

1 x 40	STRAIGHT LEAD	.99
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2 X 40	RIGHT ANGLE LEAD	$2.99

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NEC V20 & V30 CHIPS

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Part No.		Price
UPD70108-5	(5MHz) V20 Chip ~~$7.49~~	$6.49
UPD70108-8	(8MHz) V20 Chip ~~$9.49~~	$7.95
UPD70108-10	(10MHz) V20 Chip ~~$12.25~~	$10.95
UPD70116-8	(8MHz) V30 Chip ~~$9.95~~	$7.95
UPD70116-10	(10MHz) V30 Chip ~~$16.95~~	$15.49

7400

Part No.	1-9	10+	Part No.	1-9	10+
7400	SALE	.15	7474	SALE	.25
7402	.29	.19	7475	.49	.39
7404	SALE	.15	7476	.45	.35
7405	.35	.25	7483	.69	.59
7406	.39	.29	7485	SALE	.45
7407	SALE	.25	7486	SALE	.29
7408	.35	.25	7489	1.95	1.85
7410	SALE	.15	7490	.49	.39
7411	.35	.25	7493	.45	.35
7414	SALE	.25	7495	.59	.49
7416	SALE	.19	74107	.25	.15
7417	SALE	.19	74121	SALE	.25
7420	.29	.19	74123	SALE	.35
7427	.29	.19	74125	SALE	.35
7430	SALE	.15	74147	1.79	1.69
7432	.39	.29	74150	SALE	1.10
7438	SALE	.25	74151	.25	.15
7442	SALE	.29	74154	1.35	1.25
7445	SALE	.59	74161	.69	.59
7446	.89	.79	74173	SALE	.59
7447	.89	.79	74174	SALE	.35
7448	1.95	1.85	74175	SALE	.35
7473	.39	.29	74193	.79	.69

74LS

Part No.	1-9	10+	Part No.	1-9	10+
74LS00	SALE	.15	74LS139	SALE	.29
74LS02	SALE	.15	74LS151	.49	.39
74LS03	.28	.18	74LS153	.49	.39
74LS04	SALE	.16	74LS154	1.19	1.09
74LS05	SALE	.16	74LS157	.45	.35
74LS06	.59	.49	74LS161	.49	.39
74LS07	.59	.49	74LS163	SALE	.35
74LS08	.28	.18	74LS164	SALE	.35
74LS09	.28	.18	74LS165	.75	.65
74LS10	SALE	.15	74LS166	SALE	.69
74LS11	.29	.19	74LS173	SALE	.25
74LS14	SALE	.29	74LS174	SALE	.25
74LS20	.28	.18	74LS175	SALE	.25
74LS21	.35	.25	74LS191	SALE	.39
74LS27	SALE	.19	74LS192	.69	.59
74LS30	SALE	.15	74LS193	.69	.59
74LS32	SALE	.19	74LS194	.69	.59
74LS38	.35	.25	74LS221	SALE	.49
74LS42	.49	.39	74LS240	SALE	.45
74LS47	.89	.79	74LS241	.59	.49
74LS73	SALE	.25	74LS244	SALE	.49
74LS74	SALE	.19	74LS245	SALE	.59
74LS75	SALE	.25	74LS257	.49	.39
74LS76	.39	.29	74LS259	.99	.89
74LS83	.59	.49	74LS273	.89	.79
74LS85	.59	.49	74LS279	.49	.39
74LS86	.29	.19	74LS367	SALE	.29
74LS90	SALE	.29	74LS373	SALE	.59
74LS93	SALE	.29	74LS374	SALE	.49
74LS123	SALE	.35	74LS393	SALE	.69
74LS125	.49	.39	74LS541	1.29	1.19
74LS132	.49	.39	74LS590	5.95	5.85
74LS138	.49	.39	74LS688	2.39	2.29

74S/PROMS*

74S00	SALE	.19	74S188*		1.49
74S04	SALE	.19	74S189		1.49
74S32	SALE	.19	74S240		1.39
74S74	SALE	.19	74S244	SALE	.75
74S112		.39	74S287*		1.49
74S124	SALE	1.25	74S288*		1.49
74S138		.59	74S373	SALE	.99
74S153		.39	74S374	SALE	.99
74S163		.99	74S387*		1.29
74S174	SALE	.25	74S472*	SALE	2.49
74S175	SALE	.25	74S571*		2.49

CD-CMOS

CD4001	.19	CD4051	.59
CD4002	.19	CD4052	.59
CD4007	.25	CD4053	.59
CD4011	.19	CD4060	.65
CD4012	.25	CD4066	.29
CD4013	.29	CD4069	.19
CD4015	.49	CD4070	.29
CD4016	.29	CD4071	.22
CD4017	.49	CD4072	.22
CD4018	.59	CD4073	.22
CD4020	.59	CD4081	.22
CD4021	.59	CD4093	.35
CD4024	.45	CD4094	.89
CD4027	.35	CD4503	.39
CD4028	.49	CD4511	.69
CD4029	.69	CD4518	.75
CD4030	.35	CD4520	.75
CD4040	.65	CD4522	.79
CD4042	.59	CD4528	.69
CD4043	.59	CD4538	.79
CD4046	.65	CD4543	.79
CD4047	.65	CD4584	.49
CD4049	.29	CD4585	.69
CD4050	.29		

EEPROMS

2816A	2048x8	350ns (9V 15V)	5V Read Write	5.25
2816A 25	2048x8	250ns (9V 15V)	5V Read/Write	5.49
2817A	2048x8	350ns	5V Read Write	6.95
2864A	8192x8	250ns	5V Read Write (Pin 1 No R.B)	13.95
2864A 30	8192x8	300ns	5V Read Write (Pin 1 No R.B)	12.95
2865A 30	8192x8	300ns	5V Read Write	9.95
52B13	2048x8	350ns (21V)	5V Read Only	1.49

MICROPROCESSOR COMPONENTS

Z80, Z80A, Z80B, SERIES

Part No.	Price
Z80	1.19
Z80A	1.29
Z80A-CTC	1.65
Z80A-DART	~~4.95~~ 3.95
Z80A-PIO	~~1.80~~ 1.49
Z80A-SIO/O	~~3.95~~ 2.95
Z80B	2.75
Z80B-CTC	~~3.95~~ 3.25
Z80B-PIO	3.95
Z8681B1	~~8.95~~ 6.95

8000 SERIES

Part No.	Price
8031	~~3.95~~ 3.49
80C31	~~9.95~~ 8.95
8035	~~1.95~~ 1.25
8039	~~1.95~~ 1.59
8052AHBASIC	24.95
8080A	~~2.25~~ 1.49
8085A	2.49
8085A-2	3.59
8087 (5MHz)	~~99.95~~ 94.95
8087-1 (10MHz)	184.95
8087-2 (8MHz)	134.95
8088 (5MHz)	~~4.95~~ 3.49
8088-2 (8MHz)	~~6.05~~ 5.95
8116	~~4.95~~ 3.95
8155	2.49

8000 SERIES Continued

Part No.	Price
8155-2	3.49
81C55	3.95
8156	2.95
8205	10.95
82C11	6.95
8212	2.29
8216	1.39
8224	~~2.25~~ 1.95
8228	~~1.95~~ 1.49
8237-5	~~4.25~~ 3.95
8243	1.75
8250A	~~4.95~~ 3.95
8250B (For IBM)	~~5.95~~ 4.95
8251A	1.69
8253	1.89
8253-5	1.95
82C53-5	3.95
8254	3.95
8255A-5	2.95
82C55A-5	3.49
8259-5	~~2.25~~ 1.75
8272	~~3.95~~ 2.95
8274	5.95
8279-5	~~2.95~~ 2.75
8282	3.49
8284	1.29

8000 SERIES Continued

Part No.	Price
8286	2.29
8741	9.95
8742	~~19.95~~ 17.95
8748 (25V)	7.95
8748H (HMOS)(21V)	9.95
8749	9.95
8751H (3.5-12MHz)	39.95
8755	~~13.95~~ 12.95
80287-3 (5MHz)	149.95
80287-8 (8MHz)	209.95
80287-10 (10MHz)	259.95
80386-16 PGA	279.95
80387-16 (16MHz)	395.95
80387-20 (20MHz)	459.95
80387-25 (25MHz)	569.95
80387-SX (16MHz)	369.95
82284 (8MHz)	9.49
82288 (8MHz)	9.95

DATA ACQUISITION

Part No.	Price
ADC0804LCN	2.79
ADC0808CCN	~~5.95~~ 5.49
ADC0809CCN	~~3.69~~ 3.29
ADC1205CCJ-1	19.95
DAC0808LCN	~~1.75~~ 1.49
AY-3-1015D	~~4.95~~ 3.95
AY-5-1013A	1.95

STATIC RAMS

Part No.	Function		Price
2016-12	2048x8	120ns	~~3.75~~ 2.95
2102	1024x1	350ns	.89
2112	256x4	450ns MOS	~~2.49~~ 1.95
2114N	1024x4	450ns	~~.99~~ .79
2114N-2L	1024x4	200ns Low Power	1.49
21C14	1024x4	200ns (CMOS)	.49
5101	256x4	450ns (CMOS)	~~2.95~~ 2.49
6116P-1	2048x8	100ns (16K) CMOS	~~3.95~~ 3.19
6116P-3	2048x8	150ns (16K) CMOS	~~3.49~~ 2.79
6116LP-1	2048x8	100ns (16K) LP CMOS	~~4.39~~ 3.59
6116LP-3	2048x8	150ns (16K) LP CMOS	~~3.95~~ 3.09
6264P-10	8192x8	100ns (64K) CMOS	~~9.95~~ 9.49
6264P-15	8192x8	150ns (64K) CMOS	~~9.25~~ 7.49
6264LP-10	8192x8	100ns (64K) LP CMOS	~~10.95~~ 10.25
6264LP-12	8192x8	120ns (64K) LP CMOS	~~10.49~~ 8.95
6264LP-15	8192x8	150ns (64K) LP CMOS	~~10.25~~ 7.95
6514	1024x4	350ns CMOS	~~3.75~~ 3.49
43256-10L	32,768x8	100ns (256K) Low Power	23.95
43256-15L	32,768x8	150ns (256K) Low Power	22.95
62256LP-85	32,768x8	85ns (256K) LP CMOS	26.95
62256LP-10	32,768x8	100ns (256K) LP CMOS	24.95
62256LP-12	32,768x8	120ns (256K) LP CMOS	24.25

DYNAMIC RAMS

THM91000L-10	1,048,576x9	100ns 1MEGx9 SIP	~~399.95~~ 329.95
THM91000S-10	1,048,576x9	100ns 1MEGx9 SIM	~~399.95~~ 299.95
THM91000L-80	1,048,576x9	80ns 1MEGx9 SIP	~~419.95~~ 349.95
THM91000S-80	1,048,576x9	80ns 1MEGx9 SIM	~~419.95~~ 339.95
TMS4416-12	16,384x4	120ns	~~6.75~~ 5.95
TMS4416-15	16,384x4	150ns	~~6.25~~ 5.49
4116-15	16,384x1	150ns (MM5290N-2)	~~1.39~~ 1.25
4128-15	131,072x1	150ns (Piggyback)	5.29
4164-100	65,536x1	100ns	3.49
4164-120	65,536x1	120ns	2.95
4164-150	65,536x1	150ns	2.59
41256-60	262,144x1	60ns	~~11.99~~ 10.99
41256-80	262,144x1	80ns	~~10.19~~ 8.95
41256-100	262,144x1	100ns	~~9.75~~ 8.49
41256-120	262,144x1	120ns	~~8.95~~ 7.95
41256-150	262,144x1	150ns	~~8.49~~ 7.49
41264-12	64Kx4	120ns Video RAM	19.95
41464-10	65,536x4	100ns	~~14.49~~ 11.95
41464-12	65,536x4	120ns	~~11.95~~ 9.95
41464-15	65,536x4	150ns	~~10.95~~ 8.95
51258-10	262,144x1	100ns Static Column	~~13.95~~ 11.95
85227 10PL	262,144x9	100ns 256x9 SIP	~~149.95~~ 105.95
85227-10PS	262,144x9	100ns 256x9 SIM	~~149.95~~ 105.95
511000P-10	1,048,576x1	100ns (1 Meg)	~~25.95~~ 21.95
511000P-80	1,048,576x1	80ns (1 Meg)	~~35.95~~ 24.95
514256P-10	262,144x4	100ns (1 Meg)	~~34.95~~ 29.95
514258-10	262,144x4	100ns Static Column	31.95

EPROMS

TMS2516	2048x8	450ns (25V)	~~6.95~~ 5.95
TMS2532	4096x8	450ns (25V)	~~5.95~~ 4.95
TMS2532A	4096x8	450ns (12.5V)	~~4.49~~ 3.25
TMS2564	8192x8	450ns (25V)	~~6.95~~ 4.95
TMS2716	2048x8	450ns (-5V, +5V, +12V)	~~6.95~~ 6.49
1702A	256x8	(1μs)	4.95
2708	1024x8	450ns	6.95
2716	2048x8	450ns (25V)	3.75
2716-1	2048x8	350ns (25V)	~~4.25~~ 3.95
27C16	2048x8	450ns (25V) CMOS	~~4.25~~ 3.75
2732	4096x8	450ns (25V)	3.95
2732A-20	4096x8	200ns (21V)	4.25
2732A-25	4096x8	250ns (21V)	3.95
27C32	4096x8	450ns (25V) CMOS	~~4.95~~ 4.25
2764-20	8192x8	200ns (21V)	4.25
2764-25	8192x8	250ns (21V)	3.59
2764A 25	8192x8	250ns (12.5V)	3.69
27C64 15	8192x8	150ns (12.5V) CMOS	5.95
27128-20	16,384x8	200ns (21V)	~~6.95~~ 6.49
27128-25	16,384x8	250ns (21V)	5.95
27128A 15	16,384x8	150ns (12.5V)	7.75
27128A 20	16,384x8	200ns (12.5V)	~~5.75~~ 5.25
27C128-25	16,384x8	250ns (21V) CMOS	5.95
27256 15	32,768x8	150ns (12.5V)	8.95
27256 20	32,768x8	200ns (12.5V)	~~6.95~~ 6.25
27256 25	32,768x8	250ns (12.5V)	5.49
27C256 15	32,768x8	150ns (12.5V) CMOS	7.95
27C256-25	32,768x8	250ns (12.5V) CMOS	~~6.25~~ 5.49
27512-20	65,536x8	200ns (12.5V)	10.95
27512-25	65,536x8	250ns (12.5V)	9.95
27C512 25	65,536x8	250ns (12.5V) CMOS	~~10.25~~ 9.49
27C1024	131,072x8	200ns (12.5V) CMOS (1 Meg)	27.95
68764	8192x8	64K 450ns (25V) (Chip Enable)	19.95
68766	8192x8	64K 350ns (25V) (Output Enable)	19.95

6500/6800 68000 Series

Part No.	Price
6402	3.95
6502	2.65
6502A	2.75
65C02 (CMOS)	7.75
6520	1.95
6522	2.95
65C22	4.25
6532	~~5.49~~ 4.95
6551	2.95
65C802 (CMOS)	~~15.95~~ 14.75
6800	~~1.95~~ 1.49
6802	2.95
6808	1.95
6810	~~1.25~~ .99
6820	2.49
6821	1.75
68B21	1.95
6840	~~3.49~~ 2.95
6845	~~2.75~~ 2.49
6850	~~1.95~~ 1.49
6852	~~.75~~ .59
MC68000L8	9.95
MC68000L10	~~11.95~~ 10.95
MC68010L10	~~49.95~~ 39.95
MC68020RC12B	99.95
MC68701	14.95
MC68705P3S	~~9.95~~ 8.95
MC68705U3L	10.95
MC68705U3S	10.95
MC68450L10	49.95
MC68881RC12A	129.95
MC68881RC16A	149.95

Commodore

WD1770	~~8.95~~ 7.49
SI3052P	~~1.25~~ .99
6504A	1.19
6510	12.95
6526	~~14.95~~ 13.95
6526A	15.95
6545-1	3.95
6560	~~10.95~~ 8.95
6567	24.95
6572	~~10.95~~ 7.95
6581 (12V)	~~12.95~~ 10.49
6582 (9V)	~~14.95~~ 12.95
8502	7.95
8564	~~4.95~~ 2.95
8566	~~9.95~~ 7.95
8701	9.95
8722	~~13.95~~ 10.95
*82S100PLA**	15.95
901225-01	~~15.95~~ 13.95
901226-01	~~15.95~~ 13.95
901227-02	4.95
901227-03	15.95
901229-05	15.95
901460-03	1.95
901486-06	2.95

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

74C/CMOS

74C00	Sale	.19	74C174	Sale	.39
74C02	Sale	.19	74C175	Sale	.59
74C04	Sale	.19	74C192	Sale	.99
74C08	Sale	.19	74C194	Sale	.49
74C10	Sale	.15	74C221	Sale	1.79
74C14		.49	74C240	Sale	.75
74C32	Sale	.19	74C244		1.79
74C74		.49	74C373	Sale	1.49
74C85		1.49	74C374	Sale	1.49
74C86	Sale	.19	74C911		6.95
74C89		2.95	74C912	Sale	7.95
74C90		.99	74C915	Sale	1.19
74C151	Sale	1.49	74C917	Sale	3.95
74C154	Sale	2.75	74C920	Sale	3.95
74C157	Sale	1.25	74C921	Sale	2.95
74C160	Sale	.49	74C922		3.95
74C161	Sale	.49	74C923		3.95
74C162	Sale	.49	74C925		5.49
74C173		.59	74C926		5.95

MISC. COMPONENTS

TANTALUM CAPACITORS

TM.1/35 .1μf @ 35V	.19	TM4.7/35 4.7μf @ 35V	.45
TM1/35 1μf @ 35V	.19	TM6.8/35 6.8μf @ 35V	.49
TM2.2/35 2.2μf @ 35V	.25	TM10/35 10μf @ 35V	.59

POTENTIOMETERS

Values available (insert ohms into space marked "XX")
500Ω, 1K, 2K, 5K, 10K, 20K, 50K, 100K, 200K, 1MEG

43PXX 3/4 Watt 15Turn **.99** | **63PXX** 1/2 Watt, 1Turn **.89**

TRANSISTORS AND DIODES

PN2222	.13	PN2907	.13	1N4004	.12
2N2222A	.29	2N4401	.12	1N4148	.07
2N3055	.65	1N270	.25	1N4735	.29
2N3904	.12	1N751	.15	C106B1	.49

SWITCHES

JMT123 SPDT, On-On	1.19	206-8 SPST 16-pin DIP	1.25
MPC121 SPDT On-Off-On	1.19	MS102 SPST Momentary	.39

D-SUB CONNECTORS

DB25P Male, 25-pin	.69	DB25S Female, 25-pin	.75

LEDS

XC556R T1 3/4 Red	.13	XC556Y T1 3/4 Yellow	.17
XC556G T1 3/4 Green	.17	XC556C T1 3/4 Clear/Red	.17

IC SOCKETS

Low Profile		Wire Wrap (Gold) Level #2	
8LP	.11	8WW	.59
14LP	.12	14WW	.65
16LP	.13	16WW	.69
24LP	.25	24WW	1.19
28LP	.27	28WW	1.39
40LP	.29	40WW	1.89

Soldertail Standard (Gold & Tin) & Header Plug Sockets Also Available

74HC HI-SPEED CMOS

Part No.		Price	Part No.		Price
74HC00	SALE	.17	74HC175		.59
74HC02	SALE	.17	74HC221	SALE	.69
74HC04	SALE	.17	74HC240	SALE	.59
74HC08	SALE	.17	74HC244		.79
74HC10	SALE	.19	74HC245	SALE	.69
74HC14		.29	74HC253	SALE	.39
74HC30	SALE	.19	74HC259		.49
74HC32	SALE	.19	74HC273	SALE	.49
74HC74	SALE	.25	74HC373		.69
74HC75	SALE	.29	74HC374	SALE	.59
74HC76	SALE	.29	74HC595		1.29
74HC85		.55	74HC688	SALE	1.25
74HC86	SALE	.25	74HC943	SALE	7.95
74HC123	SALE	.49	74HC4040	SALE	.79
74HC125		.49	74HC4049	SALE	.25
74HC132	SALE	.39	74HC4050	SALE	.25
74HC138		.45	74HC4060	SALE	.69
74HC139	SALE	.35	74HC4511	SALE	.99
74HC154		1.49	74HC4514		1.79
74HC163	SALE	.39	74HC4538	SALE	.99
74HC174		.59	74HC4543	SALE	.99

74HCT-CMOS TTL

74HCT00	SALE	.15	74HCT139	SALE	.29
74HCT02	SALE	.15	74HCT157	SALE	.19
74HCT04	SALE	.17	74HCT174	SALE	.25
74HCT08	SALE	.15	74HCT175	SALE	.25
74HCT14	SALE	.29	74HCT240	SALE	.59
74HCT32	SALE	.17	74HCT244	SALE	.49
74HCT74	SALE	.25	74HCT245	SALE	.49
74HCT86	SALE	.15	74HCT373	SALE	.45
74HCT138		.39	74HCT374	SALE	.45

LINEAR

TL071CP	.59	LM1489N	.45
TL072CP	.79	DS14C89N (CMOS)	1.19
TL074CN	.99	LM1496N	.69
TL081CP	.49	LM1871N	1.95
TL082CP	.49	LM1872N	1.95
TL084CN	.89	ULN2003A	.75
LM301N	.35	XR2206	3.95
LM307N	.39	XR2211	2.95
LM308N	.59	XR2240	1.49
LM309K	1.25	26LS29	2.95
LM310N	1.29	26LS31	.99
LM311N	.39	26LS32	.99
LM317T	.65	26LS33	1.49
LM318N	.99	ULN2803A	1.19
LM319N	1.29	LM2901N	.25
LM323K	3.49	LM2907N	1.29
LM324N	.35	LM2917N (8 pin)	1.79
LM335Z	1.39	MC3470P	1.19
LM336Z	.99	MC3479P	3.95
LM337T	1.09	MC3486P	1.19
LM3371	1.09	MC3487P	.99
LM338K	4.49	UDN3613M	.39
LF347N	1.49	LM3900N	.49
LM348N	.69	LM3905N	1.19
LF351N	.39	LM3909N	.89
LF353N	.49	LM3914N	1.79
LF356N	.79	NE5532	.69
LF357N	.89	NE5534	.69
LM358N	.49	7805K (LM340K-5)	1.29
LM380N	.89	7812K (LM340K-12)	1.29
LM386N-3	.89	7815K (LM340K-15)	1.29
LM393N	.39	7805T (LM340T-5)	.45
LF398N	1.95	7812T (LM340T-12)	.45
LF411CN	.79	7815T (LM340T-15)	.45
LF412CN	1.29	7905K (LM320K-5)	1.35
NE555V	.29	7905T (LM320T-5)	.49
XRL555	.59	75113	1.19
LM556N	.45	75150	1.19
LM565N	.89	75154	1.19
LM566CN	1.19	75174	2.95
LM567V	.75	75175	2.95
LM723CN	.39	75176	2.29
LM741CN	.29	75451	.39
LM747CN	.49	75452	.39
LM1458N	.35	75492	.79
LM1488N	.45	MC145406P	2.95
DS14C88N (CMOS)	1.19		

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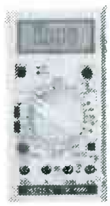
15th ANNIVERSARY YEAR 1974 - 1989

TEST EQUIPMENT

Metex Digital Multimeters



Metex General Specs:
• Handheld, high accuracy • AC/DC Voltage, AC/DC Current, Resistance, Diodes, Continuity, Transistor hFE • Manual ranging w/overload protection
M3650/B & M4650 only:
• Also measures frequency and capacitance
M4650 only:
• Data Hold Switch
• 4.5 Digit

M4650 Pictured

M3610	3.5 Digit Multimeter	$49.95
M3650	3.5 Digit w/Freq. & Capacitance	$69.95
M3650B	Same as M3650 w/Bargraph	$79.95
M4650	4.5 Dig. w/Freq., Capacitance and Data Hold Switch	$99.95

Metex Autoranging Jumbo Readout DMM

• AC/DC Voltage, AC/DC Current, Resistance, Diodes, Continuity and Frequency
• 3.75 Digit (.8" High)
• Ruggedized, Water-resistant case
• Easy-to-use pushbutton switches

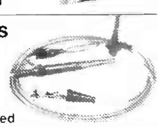
M80....................$59.95

A.R.T. EPROM Programmer

• Programs all current EPROMs in the 2716 to 27512 range plus the X2864 EEPROM • May be operated by any RS232 port w/ terminal emulation • Fully intelligent • ASCII command driven • Menu driven software included

EPP...............$179.95

Oscilloscope Probes



• Attenuation: x1 / x10
• Capacitance (LF180): 180pF / 22pF; (LF210): 40pF / 17pF

LF180 Pictured

LF180	40MHz Oscilloscope Probe	$19.95
LF210	100MHz Oscilloscope Probe	$29.95

Digital Logic Probes and Logic Pulser

PRB20 Pictured

Logic Probes:
• High, low and pulse indication • 20MHz and 50MHz versions available • Circuit powered w/ over/undervoltage indicators
Logic Pulser (LP540):
• Generates "one-shot" pulse or continuous 5Hz pulse train • Audible tone • Compatible with: TTL, DTL, RTL, HTL, HINIL, MOS and CMOS ICs

PRB20	20MHz Logic Probe	$26.95
PRB20A	20MHz Audible Logic Probe	$33.95
PRB50	50MHz Logic Probe	$47.95
LP540	Logic Pulser	$19.95

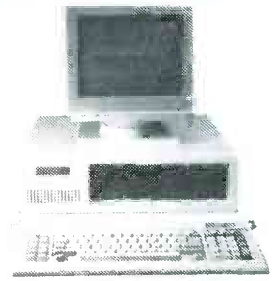
RS232 Tester and Breakout Box

Make Your Own Custom Cables!

• Complete cable breakout and reconfiguration exists with 24 in-line switches and 54 in-line machine tool sockets • Bi-color LEDs tell you if a line is hi, low or off • Male to female DB25 pin connectors • Includes device wiring chart

MLA1..............$29.95

JAMECO IBM PC/XT 8MHz Turbo Compatible Kit With 256K RAM



- *Free! QAPLUS Diagnostic Software Included!*
- *Free! PC Write Word Processing Software Included!*
- *256K RAM Included, Expandable to 640K*
- *AMI BIOS ROMs Included*
- *4.77 or 8MHz Operation*
- *Regular $592.01 value for only $479.95!*
- *Flip-Top Case w/150 Watt Power Supply*
- *360K Disk Drive*
- *Parallel Printer Port*
- *84-Key Keyboard*
- *Monochrome Amber Monitor*

JE3002	IBM Compatible PC/XT 8MHz Turbo Kit	~~$499.95~~ **$479.95**
EZDOS	Digital Research MS/PC-DOS Comp. Operating System	$49.95
EZDOSP	Same as above with TrueBASIC	$69.95

IBM COMPATIBLE DISPLAY MONITORS

NEW

QC1478 Pictured

AMBER	12" Amber Mono		$99.95
HD55H	14" RGB 640x240		$249.95
TM5154	EGA 14" 720x350	~~$399.95~~	$369.95
JE1059	EGA Monitor & Card	~~$519.95~~	$499.95
TM5155	14" Multiscan 800x560	~~$549.95~~	$499.95
QC1478	14" VGA 720x480	~~$449.95~~	$399.95
JE2055	VGA Monitor & Card	~~$649.95~~	$599.95

JAMECO IBM PC/XT/AT COMPATIBLE CARDS

JE1050	Monochrome Graphics Card w/Parallel Printer Port (PC/XT/AT)	$59.95
JE1052	Color Graphics Card w/Parallel Printer Port (PC/XT/AT)	$49.95
JE1055	EGA Card w 256K Video RAM (PC/XT/AT)	$159.95
JE1071	Multi I/O Card w Controller & Monochrome Graphics (PC/XT)	$119.95
JE1060	I/O Card w Serial, Game, Printer Port & Real Time Clock (PC/XT)	$59.95
JE1061	RS232 Serial Half Card (PC/XT)	$29.95
JE1062	RS232 Serial Half Card (AT)	$34.95
JE1065	I/O Card w Serial, Game and Parallel Printer Port (AT)	$59.95
JE1081	2MB Expanded or Extended Memory Card (zero-K on-board) (AT)	$119.95
JE1041	20/40MB Hard Disk Controller Card (PC/XT)	$79.95
JE1043	360K/720K/1.2MB/1.44MB Floppy Disk Controller Card (PC/XT/AT)	$49.95
JE1044	360K Floppy Hard Disk Controller Card (PC/XT)	$129.95
JE1045	360K/720K/1.2MB/1.44MB Floppy Hard Disk Controller Card (AT)	$149.95

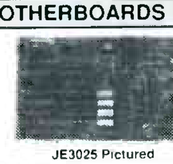
SEAGATE HALF-HEIGHT HARD DISK DRIVES

ST225XT Pictured

ST225	20MB Drive only (PC/XT/AT)	$224.95
ST225XT	20MB w Controller (PC/XT)	$269.95
ST225AT	20MB w/Controller (AT)	$339.95
ST238	30MB Drive only (PC/XT/AT)	$249.95
ST238XT	30MB w/Controller (PC/XT)	$299.95
ST238AT	30MB w/Controller (AT)	$389.95

Seagate 40MB and 60MB Hard Disk Drives Also Available!

IBM PC/XT/AT COMPATIBLE MOTHERBOARDS



JE3025 Pictured

JE1001	4.77 8MHz (PC/XT)		$89.95
JE1002	4.77/10MHz (PC/XT)	~~$109.95~~	$99.95
JE3005	Baby 8/12MHz (AT)	~~$329.95~~	$299.95
JE3010	Baby 8/16MHz *NEAT* (AT)	~~$469.95~~	$399.95
JE3020	Baby 16MHz 80386 (AT)		$1199.95
JE3025	Baby 20MHz 80386 (AT)		$1499.95
JE3026	Full-Size 25MHz 80386 (AT)		$2299.95

IBM PC/XT/AT COMPATIBLE 3.5"/5.25" DISK DRIVES

JE1022 Pictured

352KU	3.5" 720KB (PC/XT/AT)	$109.95
356KU	3.5" 1.44MB (PC/XT/AT)	$129.95
JE1020	5.25" 360KB (PC/XT/AT) Black	$89.95
JE1021	5.25" 360KB (PC/XT/AT) Beige	$89.95
JE1022	5.25" 1.2MB (PC/XT/AT) Beige	$99.95

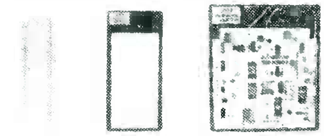
IBM PC/XT/AT COMPATIBLE INTERNAL MODEMS

1200H	1200/300 Baud Internal Modem w/MaxiMite Comm. Software (PC/XT/AT)	$69.95
2400H	2400/1200/300 Baud Internal Modem w/MaxiMite Comm. Sftwr. (PC/XT/AT)	$129.95

External Modems and Pocket-Size Modem Also Available!

PROTOTYPING PRODUCTS

Jameco Solderless Breadboards



JE23 JE24 JE27

Part No.	Dim. L" x W"	Contact Points	Binding Posts	Price
JE20	6.5x.75	200	0	$1.95
JE21	3.25x2.125	400	0	$4.95
JE22	6.5x1.325	630	0	$5.95
JE23	6.5x2.125	830	0	$7.95
JE24	6.5x3.125	1,360	2	$12.95
JE25	6.5x4.25	1,660	3	$19.95
JE26	6.875x5.75	2,390	4	$24.95
JE27	7.25x7.5	3,220	4	$34.95

DATAK Photo Etch PCB Kit

Make your own circuit boards!

The ER4 photo etch kit contains all the chemicals necessary for any hobbyist, engineer or student to create professional circuit boards. Contains: Print frame, photo copy film, resist developer, etch resist, 2 copper circuit boards, concentrated etchant, film developer and fixer, resist patterns and complete instructions.

ER4 Photo Etch PCB Kit.....................$34.95

Jameco Prototype PC Boards

Specs: Laminated glass epoxy .062" thick 2 oz. copper clad with solder tin finish. All holes are .042" dia. on .10" x .10" grid pattern.

JE401 Pictured

JE401	4.5"x6.5" 1-sided 3 hole pad pattern	$9.95
JE403	4.5"x6.5" 1-sided pwr & gnd busses	$9.95
JE405	4.5"x6.5" 1-sided general purpose	$9.95
JE407	5"x13.25" 2-sided general purpose	$19.95
JE417	4.2"x6.5" PC/XT 1/2 card proto board	$19.95
JE421	4.75"x3.7" IBM PC/XT Card Extender	$19.95

ENGINEERING/DATA BOOKS

21035	Sams TTL Cookbook (88)	$14.95
21398	Sams CMOS Cookbook (88)	$19.95
22453	Sams Op-Amp Cookbook (88)	$21.95
270645	Intel 8-bit Controller Hndbk. (89)	$19.95
270646	Intel 16-bit Controller Hndbk. (89)	$19.95
270647	Intel 32-bit Controller Hndbk. (89)	$19.95
400041	NSC Linear Data Book Vol. 1 (88)	$14.95
400042	NSC Linear Data Book Vol. 2 (88)	$9.95
400043	NSC Linear Data Book Vol. 3 (88)	$9.95
ICM89	1989 IC Master (3 Volume Set)	$129.95

EDUCATIONAL KITS

JE2206 Pictured

JE310/315: Fiber optics kits demonstrate the principles of fiber optic system design. Complete step-by-step instructions, theory of operation and tutorial info. incl.
JE2206: Function generator kit provides three basic waveforms: sine, triangle and square wave. Frequency range: 1Hz to 100kHz

JE310	Fiber Optics Experimenter Kit	$19.95
JE315	Advanced Fiber Optics Kit	$29.95
JE2206	Function Generator Kit	$19.95

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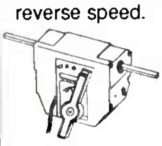
ALL ELECTRONICS CORP.

3 to 6 Vdc MOTOR with GEARBOX

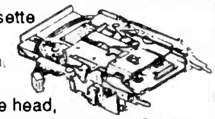
Probably designed for childs toy. Lever selects 2 forward and one reverse speed. 1st gear aprox. 120 rpm/6vdc, 2nd gear aprox. 300 rpm/6vdc, Reverse aprox. 120 rpm/6vdc.



3.35" X 1.75" X 3.25"
CAT# DCM-10 $6.00

CASSETTE MECHANISM

Alpine cassette transport mechanism. Includes stereo tape head, Mitsubishi # MET-3RF2B 13.2 Vdc motor, belt, pulleys, capstan, fast-forward, rewind and eject actuator. Does not include amplifier section. 6 1/2" X 5 1/4" X 1 3/4".



CAT# CMEC-5 $7.50 each
10 for $65.00

6 VOLT D.C. 9.5 AMP/HOUR GEL-CELL

Elpower# 695
6 volt, 9.5 amp/hour rechargeable gel-cell battery.
4.25" X 2.75" X 5.5".
Quick connect terminals.

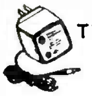
CAT# GC-695
$15.00 each

12-36 VDC GEAR-HEAD MOTOR

Brevel#
780-953075

Rated for 36 Vdc: 95 rpm. 0.5 amps no load. 65 rpm, 1.5 amp @ 12 lb/in torque. Gearbox is 3 1/4" X 3 1/4" X 1 15/16" deep. Motor is 1 1/2" diameter X 3 1/2" long with double flatted 5/16" X 1" shaft. Ideal for pumps, lift mechanisms, robotics and other high torque applications. **CAT# MOTG-11**
$15.00 each • 2 for $25.00

WALL TRANSFORMERS



ALL PLUG DIRECTLY INTO 120 VAC OUTLET

6 Vdc @ 200 ma.	CAT# DCTX-620	$2.25
6 Vdc @ 750 ma.	CAT# DCTX-675	$3.50
9 Vdc @ 250 ma.	CAT# DCTX-925	$2.50
12 Vac @ 930 ma.	CAT# ACTX-1293	$3.50
18 Vac @ 1 amp.	CAT# ACTX-1885	$3.50

SWITCHES

ITT PUSH BUTTON

ITT MDPL series. 3/4" X 1/2" gray rectangular key cap. S.P.S.T. N.O. Push to close. RATED: 0.1 amp switching, 0.25 amp carry current. P.C. mount. **CAT# PB-8**
65¢ each • 10 for $6.00 • 100 for $50.00

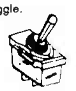
10 POSITION MINI-ROTARY

Grayhill# 56P36-01-1-10N-C
Mini rotary switch. Non-shorting. 1 deck, 10 positions. .125" dia. shaft X .375" long. .377" behind the panel depth. P.C. pins.
CAT# MRS-10 WAS $2.50 NOW $1.50 each

SPDT PUSHBUTTON

Marquardt# 1843
Rated 6 amps @ 125/250 Vac. Black plastic pushbutton. Switch body: .92" X .94" X .65".
CAT# PB-18 $1.65 each • 10 for $1.50 each

S.P.S.T. (ON-OFF)



All plastic body. Standard size toggle. 7/16" threaded mounting bushing. Copper contacts. Rated: 10 amp @ 125 Vac.
CAT# STS-1 $1.00 each
10 for $8.50 • 100 for $75.00

LED'S

STANDARD JUMBO

DIFFUSED T 1-3/4 size
RED CAT# LED-1
10 for $1.50 • 100 for $13.00
GREEN CAT# LED-2
10 for $2.00 • 100 for $17.00
YELLOW CAT# LED-3
10 for $2.00 • 100 for $17.00

FLASHING LED

with built in flashing circuit operates on 5 volts...
RED $1.00 each
CAT# LED-4 10 for $9.50
GREEN $1.00 each
CAT# LED-4G 10 for $9.50

BI-POLAR LED

Lights RED one direction, GREEN the other. Two leads.
CAT# LED-6 2 for $1.70

LED HOLDER

Two piece holder.
CAT# HLED 10 for 65¢

RELAYS

12 VOLT D.C. COIL S.P.D.T.

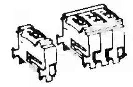
Omron# G2E-184P 4 Amp contacts 335 ohm coil. Sugar cube size. .61" X .42" X .44" high. P.C. mount with pins on DIP spacing.
CAT# RLY-787 $1.50 each

5 VOLT DC SIP RELAY

Gould, Allied Control# SR-1A-5VDC
SPST-normally open SIP reed relay. 95 ohm coil. 2 amp contacts. .9" X .29" X .39" high. Housing resists flesists fluorocarbon and chlorinated commercial solvents. **CAT# RLY-SIP6**
$1.00 each • 10 for $8.50

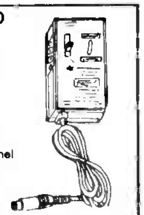
MINIATURE BCD THUMBWHEEL SWITCHES

SMK# J-D0001 #01



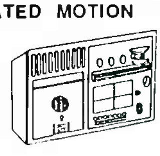
Each switch has digits 0-9. Snap together to make up any necessary configuration. Designed to mount directly to P.C. board. Pins on .1" centers. Each switch is .64" high X .59" wide X .235" thick.
CAT# SWTH-5 2 for $1.00
10 for $4.50 • 100 for $40.00

SOUND AND VIDEO MODULATOR



TI# UM1381-1. Designed for use with T.I. computers. Can be used with video cameras, games or other audio/video source. Built in A/B switch enables user to switch from T.V. antenna without disconnection. Operates on channel 3 or 4. Requires 12 Vdc. Hook up diagram included.
CAT# AVMOD $5.00 each

LIGHT ACTIVATED MOTION SENSOR



This device contains a photocell which senses sudden change in ambient light. Could be used as a door annunciator or modified to trigger other devices. 5 1/2" X 4" X 1". Operates on 6 Vdc. Requires 4 AA batteries (not included)
CAT# LSMD $5.75 per unit

PIEZO WARNING DEVICE

Murata Erie # PKB8-4A0
High pitched audible alarm. Operates on 3 - 20 Vdc @ 20 ma. 1" high x 7/8" dia. P.C. board mount.
CAT# PBZ-84 $1.75 each

NICKEL-CAD BATTERIES (RECHARGEABLE)

SPECIAL!! AAA SIZE
Panasonic# P-18AAA
1.2 volt @ 180 MAh
CAT# NCB-AAAX $1.50 each
10 for $13.50 • 100 for $125.00

AA SIZE $2.00 each
1.25 volts 500 mAh
CAT# NCB-AA

AA SIZE $2.20 each
WITH SOLDER TABS
CAT# NCB-SAA

C SIZE $4.25 EACH
1.2 volts 1200 mAh
CAT# NCB-C

D SIZE $4.50 each
1.2 volts 1200 mAh
CAT# NCB-D

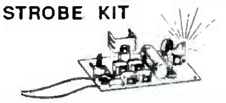
WIDE BAND AMPLIFIER

NEC# UPC1651G. 1200 Mhz @ 3 db. Gain: 19db @ f=500 hz. 5 volt operation. Small package 4mm dia. X 2.5 mm thick.
CAT# UPC-1651 2 for $1.00
10 for $4.50 • 100 for $35.00

N-CHANNEL MOSFET

IRF-511 TO-220 case
CAT# IRF 511
$1.00 each • 10 for $9.00
LARGE QUANTITY AVAILABLE

STROBE KIT

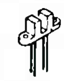


Variable rate strobe kit, flashes between 60 to 120 times per minute. Will operate on either 6 or 12 Vdc depending upon how you wire the circuit. Comes complete with P.C. board and instructions for easy assembly. **CAT# STROBE-1** $7.50 each

TELEPHONE COUPLING TRANSFORMER

Multi Products International# A19N-HO-1D/1
Primary 600 ohm
Secondary: 600/600 ohm
.77" X .61" X .63" high.
6 p.c. pins on .187" centers.
Primary inductance: 300 mH min., at 1kHz, 1 volt.
CAT# TCTX-1 $1.25 each
10 for $11.00 • 100 for $95.00

OPTO SENSOR



U shaped package with mounting ears. 1/8" opening. 3/4" mounting holes. **CAT# OSU-6** 50¢ each
10 for $4.50 • 100 for $40.00

LOOK WHAT $1.00 WILL BUY

200 ASSORTED 1/4 WATT RESISTORS
Bent leads, carbon comp. and carbon film.
CAT# GRES $1.00 per assortment

200 ASSORTED 1/2 WATT RESISTORS
Bent leads, carbon comp and carbon film.
CAT# GRABRE $1.00 per assortment

50 ASSORTED DISC CAPACITORS
Most are cut (p.c. leads). Some to 500 volts
CAT# GRABDC $1.00 per assortment

15 VALUES OF ELECTROLYTICS
Contains both axial and radial styles from 1 mfd.
CAT# GRABCP $1.00 per assortment

10 AMP SOLID STATE RELAY

ELECTROL# S2181
CONTROL: Rated 5.5 to 10 Vdc (will operate on 3-32 Vdc).
LOAD: 10 amp @ 240 Vac
2 1/4" X 1 3/4" X 7/8"
CAT# SSRLY-10B $9.50 each
QUANTITY DISCOUNT
10 for $85.00 • 25 for $175.00
50 for $300.00 • 100 for $500.00

XENON TUBE

1" long flashtube prepped with 3 1/2" red and black leads. Ideal for electronic flash or strobe projects.
CAT# FLT-3 2 for $1.00

1/4 WATT RESISTOR KIT

Ideal for the workshop, this 1/4 watt resistor kit contains 10 pieces each of 42 of the most popular values (420 pieces total). Includes a divided box and a parts locator.

VALUES in this kit are:
1 ohm, 10 ohm, 39 ohm, 47 ohm, 51 ohm, 68 ohm, 100 ohm, 130 ohm, 150 ohm, 180 ohm, 220 ohm, 330 ohm, 470 ohm, 560 ohm, 680 ohm, 1K, 1.2K, 1.5K, 2K, 2.2K, 2.7K, 3K, 4.7K, 5.1K, 5.6K, 10K, 15K, 22K, 30K, 33K, 39K, 47K, 56K, 68K, 100K, 120K, 150K, 220K, 470K, 1 MEG, 5.1 MEG, 10 MEG

The resistors alone would sell for $21.00.
Complete kit • **CAT# REKIT-14** $17.00

TRANSISTORS

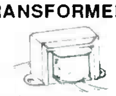
ORDER BY PART #

PN2222 NPN
TO-92 5 for 75¢
PN2907 PNP
TO-92 5 for 75¢
2N3055 NPN
TO-3 $1.00 each
MJ2955 PNP
TO-3 $1.50 each
MJE2955T PNP
TO-220 75¢ each
MJE3055T NPN
TO-220 75¢ each
TIP31 NPN
TO-220 75¢ each
TIP32 PNP
TO-220 75¢ each
TIP121 NPN
TO-220 75¢ each
TIP126 PNP
TO-220 75¢ each

12 VOLT DC SOLID STATE BUZZER

Star# CMB-12 fits 14 pin DIP socket. CMOS compatible. Operates on 7 - 17 Vdc @ 1 ma. PC pins. Has trigger terminal. 70 dB @ 20 cm. 0.886" X 0.63" X .575" high.
CAT# CMB-12 $1.25 each

14.7 VOLT TRANSFORMER



Sprite Industries# CS-510A. 14.7 volt, 60 hz, 8.82 Va. 1.61" high X 1.95" X 1.47". Mounting holes on 2.32" centers.
CAT# TX-147 $3.00 each
10 for $27.00 • 100 for $250.00

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CIRCLE 107 ON FREE INFORMATION CARD

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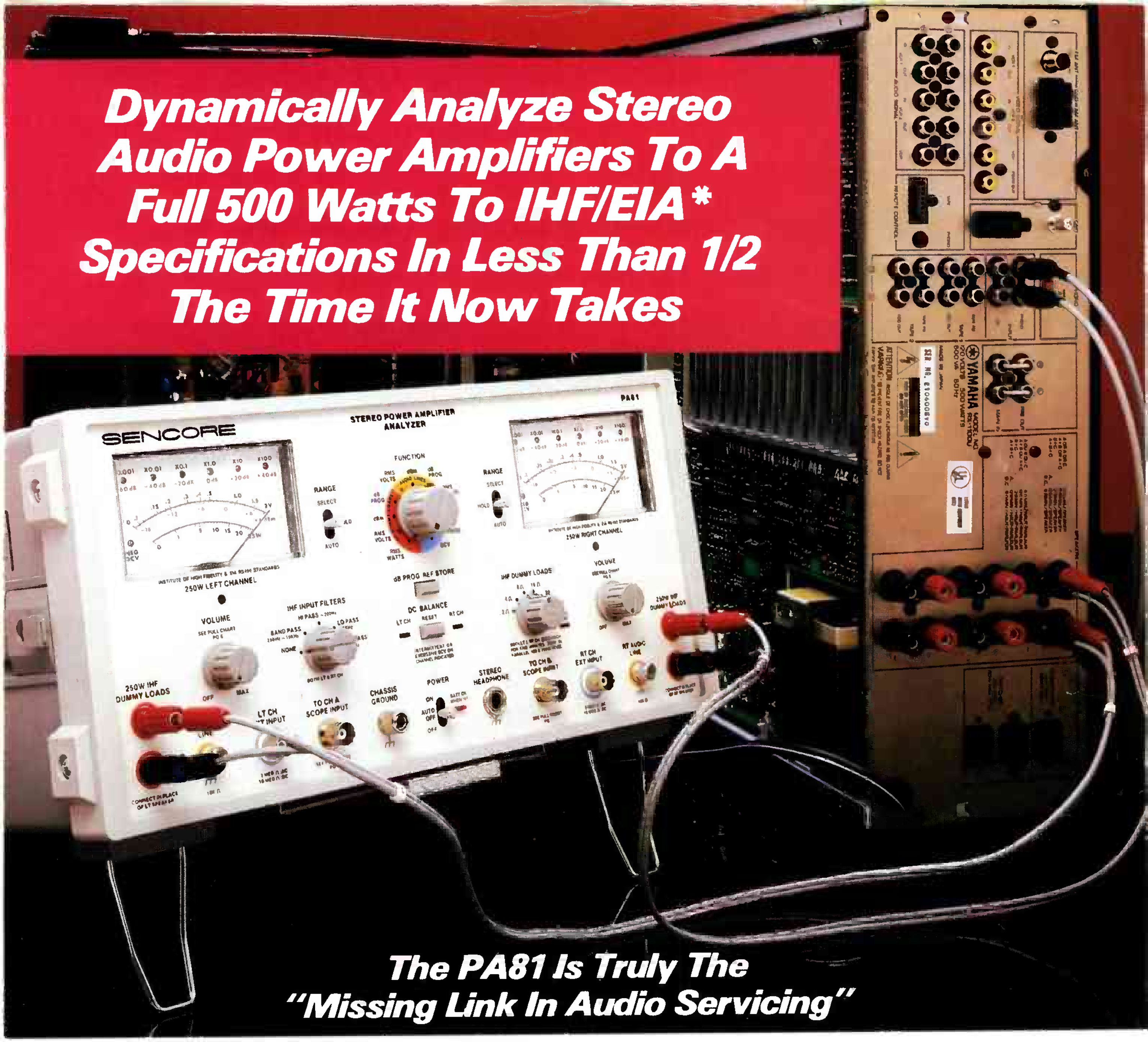

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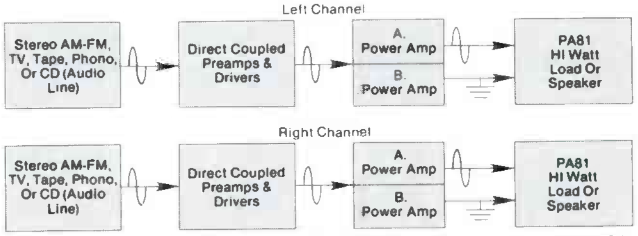

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