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WHAT'S NEWS

New range opens for spectroscopy

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 photoconducitvely 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. This dual generation is said to convert 50% of the coal's energy into electricity, as compared with 34% achieved conventionally.
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**VIDEO NEWS**

- **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 FCM 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, SE/AM, 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 15 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 videodisc 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.
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How loud is real?

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 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.

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 Psychophysics*, that attempted to establish a specific relationship between the outer objective world and the inner subjective one in all areas of sensation. Fechner's 19th-century 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

![Graph of sound pressure levels vs frequency](image-url)
about 1,000 feet overhead—is about 30 times greater than 50 dB."

After much research effort, starting in the 1930s 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 loses 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
**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.

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.

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, get-
...ing the circuit working is only half
the battle—you also have to calib-
rate 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 pad-
ding the output, but regardless of
the method you use, you have to
take into account the offset intro-
duced 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 ac-
curacy 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. Psychoacousti-
cians 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 inter-
nal processing. I doubt that it’s
possible to design a loudness con-
tral 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

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CIRCLE 86 ON FREE INFORMATION CARD

Includes flight simulation for
helicopters, too!
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—shuffie 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
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 onboard 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.
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

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CIRCLE NO. 123 ON INQUIRY CARD
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

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THE MODEL WTT-2015 IS ONLY THE SIZE OF A DIME, yet transmits both sides of a telephone conversation to any FM radio with crystal clarity. Telephone line powered - never needs a battery! Up to 1/4 mile range. Adjustable from 70-130 MHZ. Complete kit $29.95 + $1.50 S + H. Free Shipping on 2 or more! COD add $.4. Call or send VISA, MC, MO. DECO INDUSTRIES, Box 607, Bedford Hills, NY 10507. (914) 232-3678.

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**Equipment Reports**

**Tektronix 222 Handheld Digital Storage Oscilloscope**

10-MHz performance in a compact package.

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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 $3\frac{1}{2} \times 6 \times 10$ 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 time-base is adjustable from 50 nanoseconds to 20 seconds per division.

The scope’s $8 \times 10$-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 its 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 all 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.
AFFORDABLE, COMPACT, AND ULTRA-SENSITIVE. MORE AND MORE PEOPLE ARE USING CC SERIES INSTRUMENTS THAN EVER BEFORE FOR RF DETECTION. NOW WIDELY USED FOR PERSONAL SECURITY, SAFETY AND PEACE OF MIND, THESE INSTRUMENTS CAN LOCATE, IDENTIFY, ISOLATE, AND COUNTER LOW POWER RADIO FREQUENCY TRANSMITTERS THAT MAY BE CONCEALED IN OFFICES, AUTOMOBILES, CONFERENCE ROOMS OR ARE BEING CARRIED INSIDE CLOTHING, POCKET BOOKS, ETC.

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via a headphone jack. The light-
weight 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-
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The front-loading CD player
uses 3-beam, 1-laser pick-up, and
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smaller CD singles can be played
with the use of an adapter.
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maining, program number, pause,
and repeat are displayed on a 6-
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The 4955’s dual tape deck, with
high-speed or normal dubbing, al-
 lows 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 ad-
justable with slide controls on the
3-band graphic equalizer. The ra-
dio has automatic frequency con-
trol for improved reception, and
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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 individu-
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amplitude, time, frequency, duty
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simultaneously.

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

The 9202 and 9204 oscilloscopes
cost $865.00 and $1095.00 respec-
tively.—Beckman Industrial Corpo-
ration, Instrumentation Products
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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.

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The Model PSA-65A from Avcom is a portable microwave spectrum analyzer that covers frequencies from 1,000 MHz in one sweep, 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 11 1/2 x 5 1/2 x 13 1/2 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.

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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, 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- x 3- x 1 1/2-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 $10.00. —Electron Processing, Inc., Sales Department, P.O. Box 708, Medford, NY 11763.

2400-BAUD MODEM. The MET 2400X "Smart Modem" eliminates 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 II (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 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 molding. 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 Azelee St., Tampa, FL 33609; 813-876-6789.
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.

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 Accessories—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 features 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.
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.

![Diagram of a circuit](image)

**FIG. 1**

**FIG. 2**

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
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 first 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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ROGER SONNTAG

IF YOU'RE LOOKING FOR A purely fun project, then this light beam communicator is for you. It is not only contains the usual electronics, it also has an ingenious mechanical assembly whose operation is interesting in its own right. You're sure to find it a refreshing change from the usual board-in-a-box project. But don't think that this light-beam communicator is just for fun. The powerful transmitter and extremely sensitive receiver take this project out of the realm of toys—you can do some pretty serious work with our device!

A complete Light-Beam Communicator (LBC) consists of a transmitter and a receiver, installed into 2 tube-like assemblies, along with various optical components. Two complete LBCs 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 a narrow beam that narrow light beam travels a surprisingly long distance. The standard unit has about a 1/4-mile range. The high-power unit has an amazing range of better than 1/2-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-candlepower (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-candlepower (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.

www.americanradiohistory.com
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.

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, DI. 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...
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), 1/2-inches long, and then separate and strip the ends. (Any thin,}

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.

in a circuit with so much gain.

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FIG. 7—TRANSMITTER parts-placement diagram.

FIG. 8—RECEIVER PARTS-PLACEMENT DIAGRAM.

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

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; Siemens BPW-33 photodiode, $3.50; HLMP-8150 12-volt battery clips, LED price to be determined (call GSE for information); Assembled and tested communicator, $198. Note: The spotting scope is not available from GSE.

PARTS LIST—RECEIVER

All resistors are 1/2-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 µF, 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—Siemens 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.

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; Siemens BPW-33 photodiode, $3.50; HLMP-8150 12-volt battery clips, 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 polarity indicated by a painted dot on the anode.

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

Well, the boards are finished, but that’s all we have room for this month. Next month we’ll finish the project by detailing the mechanical assembly.

We’ll also present a list of the necessary mechanical components.
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The CIE Microprocessor Trainer helps you to learn how circuits with microprocessors function in computers.
Any test bench would love to have our hand-held 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. 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 $C_X$. 

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The diagram shows a detailed schematic of the capacitance meter circuit, including various components and connections. The text provides a theoretical explanation of how the circuit operates to measure capacitance.
The 555 is the most versatile IC timer ever developed for astable/monostable operating modes, and it needs very few external components to use. 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 VCC, 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 VCC; pin 5 is bypassed by C2 for added stability. In either mode, C1 charges through at least R4 toward VCC, 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 VCC. When C1's voltage reaches 2/3 VCC, the threshold comparator resets the flip-flop, turning Q on, discharging C1 through R5 until its voltage reaches 1/3 VCC, 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 trigger comparator to reset the flip-flop, turning Q off, charging C1 from the saturation voltage of Q (effectively ground) through R4 to 2/3 VCC. The threshold comparator sets the flip-flop, turning Q on, discharging C1, driving pin 3 low, ending the timing pulse.

Frequency and periods

To determine the astable frequency and monostable period, you have to know how C1 charges and discharges in the 555's operation. Figure 2 shows the relation between the output on pin 3 and C1's voltage on pin 6.

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, DSPl.

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
charged. Let \( R_{\text{EFF}} \) be the effective charging/discharging resistance in either mode. In an astable mode, \( R_{\text{EFF}} \) is equal to \( R_4 + R_5 \) when charging, and \( R_{\text{EFF}} \) is equal to \( R_5 \) when discharging. The duty cycle in the astable mode must be the ratio of those, or the duty cycle is equal to \( [(R_4 + R_5)/R_5] \times 100\% \), or equal to \( [1+(R_4/\ R_5)] \times 100\% \).

In a monostable mode, \( R_{\text{EFF}} \) equals \( R_4 \) when charging; there is no discharge path. If \( C_1 \) is discharged and in series with \( R_{\text{EFF}} \), with both connected to \( V_{\text{CC}} \), \( C_1 \) charges "exponentially" from ground toward \( V_{\text{CC}} \). That basically means that \( C_1 \)'s voltage never reaches \( V_{\text{CC}} \), but gets very close.

The "time constant" is always: \( \tau = R_{\text{EFF}} \times C_1 \), in seconds. 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 difference between its initial and target voltages in one \( \tau \), and essentially fully charges/discharges to a target voltage within \( 5\tau \) (99.33%).

The voltage divider partitions the charge/discharging cycle so that there are two sets of target voltages; those created by the divider, and those of \( V_{\text{CC}} \) and ground. The \( C_1 \) voltage stays between \( \frac{1}{3} \) and \( \frac{2}{3} \) of \( V_{\text{CC}} \) in the astable mode. Since \( C_1 \) either charges toward \( V_{\text{CC}} \), or discharges toward ground, the \( V_{\text{CC}}/\text{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 \( C_1 \) can only charge/discharge arbitrarily close to a target voltage.

In the astable mode, \( C_1 \) cycles between \( \frac{1}{3} \) and \( \frac{2}{3} \) of \( V_{\text{CC}} \), always charging/discharging to halfway between an initial and target voltage. When charging, the initial voltage is \( \frac{1}{3} V_{\text{CC}} \) and the target voltage is \( V_{\text{CC}} \). When discharging, the initial voltage is \( \frac{2}{3} V_{\text{CC}} \) and the target voltage is ground.

For \( C_1 \) to charge/discharge through \( R_{\text{EFF}} \) from one divider voltage to the other, it always takes: \( T = 0.693 \times \tau = 0.693 \times R_{\text{EFF}} \times C_1 \).

In the astable, the charging interval is:

\[
T_{\text{AC}} = 0.693 \times (R_4 + R_5) \times C_1.
\]

The discharge interval is:

\[
T_{\text{AD}} = 0.693 \times R_5 \times C_1.
\]

The total period is:

\[
T_A = T_{\text{AC}} + T_{\text{AD}} = 0.693 \times [R_4 + (2 \times R_5)] \times C_1.
\]

And the frequency is:

\[
f_A = 1/T_A = 1.44/(R_4 + (2 \times R_5))C_1.
\]

In the monostable mode, \( Q \) holds \( C_1 \) at ground. After triggering, \( C_1 \) charges through \( R_4 \) to \( \frac{2}{3} V_{\text{CC}} \). Both the charging cycle and the pulse are now ended by the threshold comparator, as mentioned earlier. For reasons too lengthy to discuss in the space we have, pulse duration will be:

\[
T_m = 1.1 \times R_4 \times C_1.
\]

Figure 4 is a nomograph of \( C_1 \) vs. \( f_A \) in the monostable mode for different values of \( R_4 + (2 \times R_5) \). Figure 5 is a nomograph of \( C_1 \) vs. timing-pulse width \( T_m \) in the monostable mode for different values of \( R_4 \).
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 DSPI 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 1–0.001 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 μF is displayed as 0100, 0.001 μF is displayed as 0001, and 4.7 μF is 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.

---

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

---

**All resistors are 1/2-watt, 5%, unless otherwise indicated.**

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1, R8, R12, R16-R22—100 ohms</td>
<td></td>
</tr>
<tr>
<td>R2, R4, R5, R27—100,000 ohms</td>
<td></td>
</tr>
<tr>
<td>R3—10,000 ohms</td>
<td></td>
</tr>
<tr>
<td>R6, R28—560 ohms</td>
<td></td>
</tr>
<tr>
<td>R7—1000 ohms, PC-mount potentiometer</td>
<td></td>
</tr>
<tr>
<td>R8—250,000 ohms, PC-mount potentiometer</td>
<td></td>
</tr>
<tr>
<td>R9—2.5 megohms, PC-mount potentiometer</td>
<td></td>
</tr>
<tr>
<td>R10—4.7 megohms</td>
<td></td>
</tr>
<tr>
<td>R11—2.2 megohms</td>
<td></td>
</tr>
<tr>
<td>R12—7.1 megohms</td>
<td></td>
</tr>
<tr>
<td>R13—15,000 ohms, PC-mount potentiometer</td>
<td></td>
</tr>
<tr>
<td>R14—150,000 ohms, PC-mount potentiometer</td>
<td></td>
</tr>
<tr>
<td>R15—2200 ohms</td>
<td></td>
</tr>
<tr>
<td>R23, R26, R29—1000 ohms</td>
<td></td>
</tr>
</tbody>
</table>

**Capacitors**

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1, C7—0.1 μF, ceramic disc</td>
<td></td>
</tr>
<tr>
<td>C2, C3, C5—0.01 μF, ceramic disc</td>
<td></td>
</tr>
<tr>
<td>C4, C6—0.001 μF, ceramic disc</td>
<td></td>
</tr>
<tr>
<td>C9—1 μF, tantalum electrolytic</td>
<td></td>
</tr>
</tbody>
</table>

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**PARTS LIST**

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

**Other components**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL1—8-pin SIP plug</td>
<td></td>
</tr>
<tr>
<td>S1—S3—board-mounted 3-pushbutton DPDT switch array, 1/8-inch lead spacing, with PC-contact pins and solder lugs for wires</td>
<td></td>
</tr>
<tr>
<td>S4—board-mounted pushbutton 4P2T switch, 1/4-inch lead spacing, with PC-contact pins and solder lugs for wires</td>
<td></td>
</tr>
<tr>
<td>S5—board-mounted momentary pushbutton, 1/8-inch lead spacing</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1—9-volt alkaline battery or optional 7.2-volt rechargeable Ni-Cd (see text)</td>
<td></td>
</tr>
<tr>
<td>J1—Subminiature jack matching the plug of the charger/adapter (optional, see text)</td>
<td></td>
</tr>
<tr>
<td>T1—optional charger/adapter, 117/12-volts AC, 300 mA</td>
<td></td>
</tr>
</tbody>
</table>

**Miscellaneous:** Pacific 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 Tri-stat 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 1/8 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 nonprecision capacitors for each range, of the same nominal value. For the 999-1 µF range, test an unknown capacitor at random, adjusting R7 until Cx's nominal value appears on the display, and then set the capacitor aside. Next, without adjusting R7, test the capacitor again. 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.

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 is 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, Cx 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.
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Followed, coil with available materials, the components, handle lead lengths become critical. The 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 1/2-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 capacities. Don’t use paper-base phenolic materials; they’re too lossy at UHF frequencies.
7. Transistor Q12 must be heat-sunk 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-sunk 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.
1. Wind No.22 wire in threads the required No. of turns. Clean, tin, and form leads as shown.

2. Remove the screw from coil by rotating it.

3. Insert slug into coil by rotating it.

4. Install in PC board.

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 construct-
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.

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

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.
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 that will be 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...
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 readjusting 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.

Semiconductors
Q1, Q2—2N3563, transistor
Q3—Q5—MPS3866, transistor
Q6—MRF559 or MRF627 transistor
Q7—MRF550, 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—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.

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 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 (Alternate) with respect to J9 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 it’s 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 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. 6—IF YOU FOLLOW THESE STEPS when soldering the chip components to the PC board, you’ll have no problems with them.

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

**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, \( f_0 \), which can be calculated using this formula:

\[
f_0 = \frac{1}{2\pi CR}
\]

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

**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 \( f_0 \), 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 Negative Temperature Coefficient (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.
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 Positive Temperature Coefficient (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 in 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 amplitude (minimum distortion) at which oscillation can be maintained across the frequency band.

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

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

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

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

**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.**
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 (f0), 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 f0.

By critically adjusting R4 to slightly unbalance the network, the twin-T gives a 180° inverted phase shift with a small-signal f0. 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. 10—RELAXATION SQUARE-WAVE oscillator.](image1)

![FIG. 11—500 Hz-5 kHz SQUARE-WAVE oscillator.](image2)

![FIG. 12—IMPROVED 500 Hz-5 kHz square-wave oscillator.](image3)

![FIG. 13—FOUR DECADE 2 Hz-20 kHz SQUARE-WAVE generator.](image4)

![FIG. 14—SQUARE-WAVE GENERATOR with variable duty-cycle, and frequency.](image5)

![FIG. 15—VARIABLE FREQUENCY narrow-pulse generator.](image6)
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 1:1 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.

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 is shown to a "dark-activated" oscillator by transposing the position of LDR and R1. Figure 18 uses a NTC thermistor, RT, as the resistance-activating element, and is a precision over-temperature oscillator. The circuit can be converted to an under-temperature oscillator by transposing RT and R1.

The LDR or R1 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. 21—100 Hz–1 kHz FUNCTION GENERATOR with variable slope and duty cycle.

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 1/100 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; then 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 then switches 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.

2 ¼ INCHES
THE LBC’S TRANSMITTER BOARD.

4 INCHES
FOIL SIDE OF TV TRANSMITTER.

MORE PC SERVICE ON PAGE 84
SERVICING

REPAIRING SICK AM/FM receivers is generally an easy, straightforward job; that can all change when tackling the newer digitally tuned models. It's bad enough having to work with densely packed circuitry sprouting unfamiliar components, no product documentation, and a matchbook-size schematic; now you have to cope with fixing digitally tuned (synthesized) radios, too.

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-fashioned 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
synthesizer monitors the AM- or FM-local oscillator and varies Vp, 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 ICs**

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 UB553 (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-
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 pre-sets has forced receiver manufacturers to return to separate controller and synthesizer IC combinations. Chrysler, for example, uses a National COP-series controller and a DS6908 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 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 key-boards 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 FM 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 stop that off with tips on where to obtain those tough-to-find parts.

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

R-E
CHOOSING THE RIGHT SHORTWAVE ANTENNA

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

JOSEPH J. CARR

M ost 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 shortwave listener (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.
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 high frequency (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 position- ing 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,
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 zipcord) as a twin-lead transmission line. Zipcord has an impedance that approximates the 75-ohm impedance of a dipole.

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
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.

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, and 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’s not. 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.

**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. 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.

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.
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 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 audio file 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 as hassle as going the other way. One obvious route is to use any CD player and intercept and overload 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 costs 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.

DON LANCASTER
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 2½ 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...
The 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
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 turned, or turned on and off with an external signal. The rule is that a +5 volt input will run

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**FIG. 4—THIS TWO-TONE ALARM produces a distinctive "twee-dee" 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.**

**A** - ADJUSTING THE DUTY CYCLE

**B** - VARYING THE FREQUENCY

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

\[ \text{C} = \frac{i \Delta t}{\Delta v} \]

where \( C \) is the capacitance in microfarads, \( \Delta t \) is the half time period in microseconds, \( i \) is the charging current in microamps and \( \Delta v \) is 1 for the one-volt triangular amplitude. The same formula will also work if \( C \) is in microfarads, \( i \) is in milliamps, and \( \Delta t \) 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) tina aja quest for two to the best entry...
we've the Hardware Hacker Toner box, rather than to 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 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, wood-working 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 Tyco 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 $1/2-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 butylate plastic is useful as the feeler gauge for recharging 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 Uniform Product Code. A complete set of standards is available from the UPC Council.

The leading bar-code trade association is called the AIM, short for the Association of Identification Manufacturers. 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. Surprisingly 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 Merrymaker 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.
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 8086/8088/80286/386 microprocessor. But on a 386, especially in conjunction with 386MAX (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.

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
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 Community becomes a reality. Developments such as these, however, could not represent the major excitement—there had to be more going on at CeBIT. You can't have a show this big without something new and unexpected to report. Macintosh Apples or Does the Recipe Call for Jonathan?

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 legal 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 ROMs. Of course, if you are familiar with US computer-component mail-order opportunities, you know you can buy Mac Plus 128K ROMs for about $890 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 useful 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 telecommunication solutions 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 (Integrated Services Digital Networks), 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 attenders. 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 Informatics 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.

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 longer and 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 NUL.EXE. It provides several functions for getting at the data on your disk at various levels. Depending on how you use NUL, you can get at physical tracks and sectors, logical (DOS-level) sectors, files, the FAT’s (File Allocation Tables), the partition table, and directories.

NUL 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 NUL is to unerase files. The program provides semi-automatic and manual ways of doing so: a separate, fully automated pro-

“Productivity has really jumped since we switched to the new computers with built-in coffee pots.”
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 Mace's program 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 (so, 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; and Ds, 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.

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.

Enclosures
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 often copy on-going projects to temporary disks during the day. Paranoid? You bet! I've lost too many files to the bit bucket.

DOS loads and controls PC operation thereafter: the second half consists of reference information on BIOS interrupts, DOS functions 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.

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

PRODUCTS REVIEWED
- "Circle 50 on Free Information Card"

- "Circle 49 on Free Information Card"

- "Circle 48 on Free Information Card"
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 hotkey 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 808886, the 286, and the 386. Extended memory is available only on 80286 and 80386 microprocessors; on the latter it can function as expanded memory.](image)

Internally, OmniView consists of five 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-
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\textsuperscript{MAX}. In addition to emulating EMS 4.0 memory using plain extended memory, 386\textsuperscript{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\textsuperscript{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 Page Directory Base Register (PDBR), entire memory-mapped "contexts" can be loaded into conventional memory nearly instantaneously.

386\textsuperscript{MAX} makes that function available to system-level software through the Alternate Mapping Register Set (AMRS) concept, which is part of the EMS 4.0 specification. 386\textsuperscript{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 (File Allocation Table) 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\textsuperscript{MAX} combination takes advantage of those mechanisms to tame most ill-behaved programs.

To facilitate protection, 386\textsuperscript{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 CRT (CRT Controller) hardware, and even from moving the cursor directly. By using the 386's I/O-port privilege map, all accesses to the CRT controller registers can be trapped and simulated without affecting the actual hardware.

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\textsuperscript{MAX} also supports the Virtual Control Program Interface (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\textsuperscript{MAX} into the realm of advanced, protected-mode operating systems (UNIX, OS/2).
However, under a fully 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 co-exist 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 multitaskinging 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 impact 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.

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.

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.

“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 ICs 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 band 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 ICs 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!
Fig. 1. MOTHERBOARD PARTS-PLACEMENT DIAGRAM.
### Parts List—80286 MOTHERBOARD

#### Resistors
- All resistors are 1/4-watt, 5%.

<table>
<thead>
<tr>
<th>Resistor</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1, R2</td>
<td>150 ohms</td>
</tr>
<tr>
<td>R3, R46</td>
<td>2 megohms</td>
</tr>
<tr>
<td>R5, R12, R21, R34, R55, R56, R900, R901, R905, R906</td>
<td>10,000 ohms</td>
</tr>
<tr>
<td>R6</td>
<td>51,000 ohms</td>
</tr>
<tr>
<td>R7, R23, R33, R47</td>
<td>1000 ohms</td>
</tr>
<tr>
<td>R8, R13</td>
<td>10 ohms</td>
</tr>
<tr>
<td>R9, R10</td>
<td>1 megohm</td>
</tr>
<tr>
<td>R11, R14, R16, R18, R19, R24-R28, R41, R44</td>
<td>33 ohms</td>
</tr>
<tr>
<td>R20, R50, R907</td>
<td>not used</td>
</tr>
<tr>
<td>R30</td>
<td>620 ohms</td>
</tr>
<tr>
<td>R31</td>
<td>51 ohms</td>
</tr>
<tr>
<td>R36, R45, R52, R57</td>
<td>330 ohms</td>
</tr>
<tr>
<td>R49</td>
<td>2200 ohms</td>
</tr>
<tr>
<td>R53, R54</td>
<td>470 ohms</td>
</tr>
</tbody>
</table>

#### Resistor packs
- RP1, RP2, RP4, RP5
  - 33 ohms x 8, 16 pins, DIP
- RP3
  - 33 ohms x 3, 8 pins, SIP
- RP6, RP10
  - 10,000 ohms x 9, 10 pins, SIP
- RP7, RP9, RP11, RP13
  - 10,000 ohms x 7, 8 pins, SIP
- RP8
  - 250 ohms x 7, 8 pins, SIP
- RP12
  - 4700 ohms x 7, 8 pins, SIP
- RP14-RP17
  - 330 (or 470) x 14, 16 pins, SIP

#### 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
  - 0.22 µF, 5%, 50 volts, mono

#### Semiconductors
- ICl-IC18, IC21-IC29, IC31-IC39
  - DRAM, 256K x 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, 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
- IC66, IC73, IC76
  - 74LS244
- IC67
  - 74F08
- IC68
  - PAL16L8A
- IC70
  - 74LS30
- IC72
  - 9.6-MHz oscillator
- IC74
  - 74LS00
- IC75
  - W530C65
- IC78
  - 8742AH
  - keyboard controller

#### Other components
- 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
- DI, D2
  - 1N4148
- DL1
  - 100-ns delay line
- SIMM0-SIMM3
  - DRAM, 30 pins, SIMM, 1024K x 9, 100 ns

#### Circuit board
- IC Sockets
  - 8-pin DIP 48 14-pin DIP 36 16-pin DIP 23 20-pin DIP 1 24-pin skinny DIP 2 28-pin DIP 3 40-pin DIP 168-pin PGA 1 58-pin PLCC 4 84-pin PLCC 4 30-pin SIMM (ANGLE)

### Ordering Information
- Ordering information appeared in the June issue of Computer Digest and will be repeated next month.
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CIRCLE 183 ON FREE INFORMATION CARD

DRAWING BOARD
continued from page 29

together through an inverter and eliminate one column in the table. We can tie the two sin 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 74LS93, 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.
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JE1003: Baby Bitt 12MHz (AT)...
JE1004: Baby 12MHz 8503/AT...
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JE1006: Full-Speed 25MHz 8503/AT...
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21035: Sams TTL Cookbook (86)...
1398: Sams C MOS Cookbook (88)...
22453: Sams Co AMP Cookbook (89)...
27064: Intel Box Controller Handbook (89)...
27066: Intel 16/8 Controller Handbook (92)...
27067: Intel 32 Controller Handbook...
40004: NSC Linear Data Book Vol 1 (88)...
40012: NSC Linear Data Book Vol 2 (88)...
40003: NSC Linear Data Book Vol 3 (88)...
IC669: 1990 MOS Model (3 Volume Set)...

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Alpina cassette transport mechanism.
Includes stereo tape head, Mitsubishi # MET-3RF2B 15.2 Vdc motor, belt, pulleys, capstan, fast-forward, rewind and eject actuator.
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Each switch has digits 0-9. Snap together to make 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.
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WALL TRANSFORMERS
ALL PLUG DIRECTLY INTO 120 VAC OUTLET
6 Vdc @ 500 ma CATT DCTX-60  $2.75
6 Vdc @ 750 ma CATT DCTX-75  $3.50
6 Vdc @ 1000 ma CATT DCTX-100  $4.00
AC 120 V @ 1000 ma. CATT ACTX-125  $5.50
120 V @ 300 ma. CATT ACTX-330  $5.50

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(All Vdc)
74E175 ß 656 each
656 @ 930 Vac @ 1000 ma.
For $8.50 100 for $85.00

LED'S
STANDARD JUMBO DIFFUSED 3-1/4" size B000 CATT LED-1
10 for $1.05 - 100 for $10.00
12 for $1.60 - 100 for $13.00
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50 for $5.60 - 100 for $55.00

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Each switch has digits 0-9. Snap together to make 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.
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10 Volt. Operates with TV. Can be used with video cameras, game or video output. Insert in J block allows user to switch between video signals without deconnection. Operates on channel 3. Requires 12 Volt. Hook up diagram included.
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LIGHT ACTIVATED MOTION SENSOR
This device contains a phototransistor with sensor housed in an aluminum cylinder. The device will be triggered by a sudden change in light intensity. When light is detected, the sensor will trigger other devices. Some applications:
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2. Operates 12 Volt, requires 4 AA batteries (not included)
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I deal for the workshop, this 1/4 watt resistor contains 10 values each of 42 of the most popular values (1000 pieces) 5% tolerance includes a divided box and a parts selector.

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BRAND NEW
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BATTERY RESISTOR KIT
WATT RESISTOR KIT
107 ohm, 39 ohm, 16, 1.26, 1.5 k, 2 k, 2.2 k, 2.7 k, 4.7 k, 5.1 k, 5.6 k, 10 k, 20 k, 47 k, 56 k, 68 k, 100 k, 120 k, 220 k, 470 k, 560 k, 820 k, 1 M, 2 M, 3 M, 4 M, 5 M, 6 M,

CAT# MJK-07  $1.00 each
10 for $9.00  100 for $75.00

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WATT RESISTOR KIT
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CAT# MJK-07  $1.00 each
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CAT# BPF-5  $1.00 each
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SPECIAL AA SIZE
PARMY-0 AA
12 volt 180 Mah
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Variable color strobe light flashes between 60 to 100 flashes per second, operate on a 6 or 12 Volt battery, depending upon which type you wire the circuit. Comes complete with P.C. board and instructions for easy assembly.
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Secondary: 600 ohm 7/16 X 1/2 X 1/4 high.
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Primary impedance: 300 ohm, 3.8 at 445 KHz.
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Sprite Industries# CORP.
CAT# SB-12 3-12 Hz
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CAT# SBP-12  $3.00 each

14.7 VOLT TRANSFORMER
Sprite Industries# CORP.
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60Hz 80va.
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