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FEBRUARY 1989

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The battle for acceptance heats up

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Practical circuits put downcounters to work

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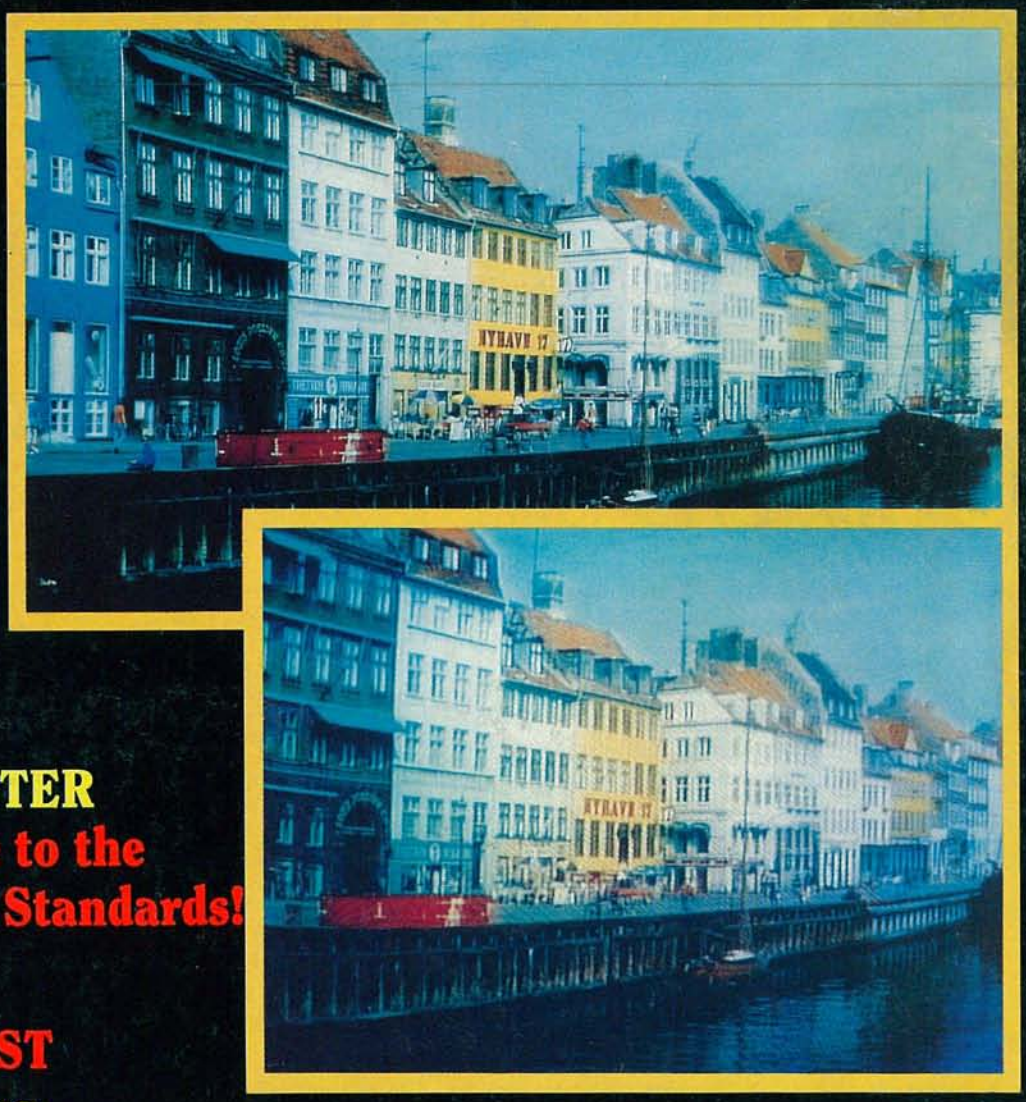
It's really traceable to the National Bureau of Standards!



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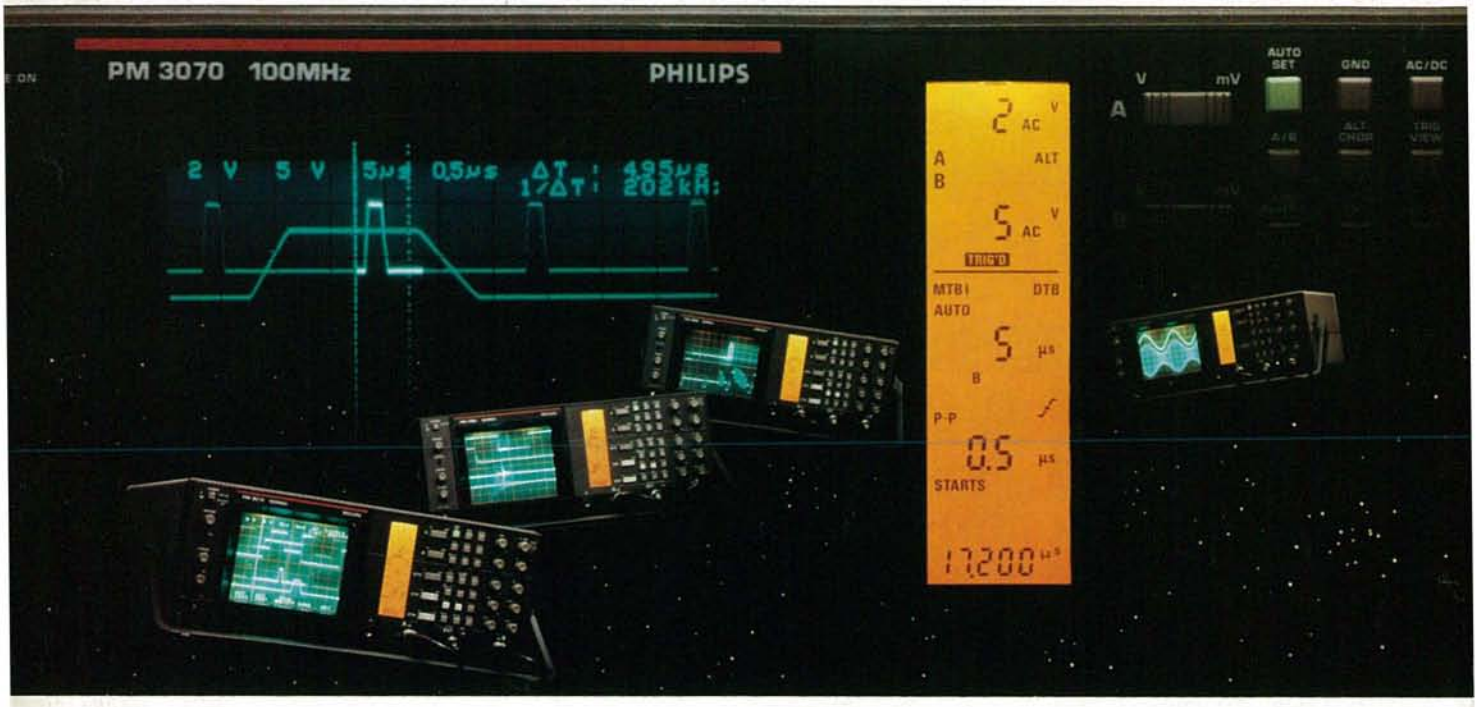

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February 1989 Radio-Electronics

Vol. 60 No. 2

BUILD THIS

TECHNOLOGY

CIRCUITS

PAGE 95

PAGE 51

DEPARTMENTS

AND MORE

ON THE COVER

The technology exists for high-definition TV; in fact, you could say that too much technology exists. Before HDTV can become a viewing reality, a consensus must be reached on one HDTV standard. There are currently close to 20 separate proposals vying for that position. Some are fully-compatible with NTSC standard and will display a picture on a conventional television. Other systems are "semi-compatible," requiring extra bandwidth for HDTV broadcasts; still others are completely incompatible with NTSC television. We take a look at all three categories, explain their pros and cons, and introduce you to the major contenders in the HDTV ring, beginning on page 35.

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Advertising Sales Offices listed on page 132.

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- 2225B HP-IL ThinkJet Printer
- HP-75D Portable Computer/RAM/Pod Package

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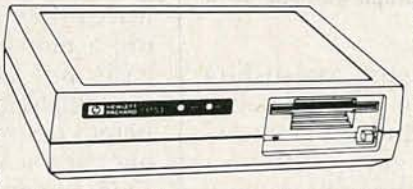
This liquidation means you can have that IL Disc Drive or ThinkJet that you've wanted, and that full-memory HP-75 to experiment with—these units are really affordable! But **do not delay**—we must limit these fantastic savings to stock on hand. Let us know right away that you want one.

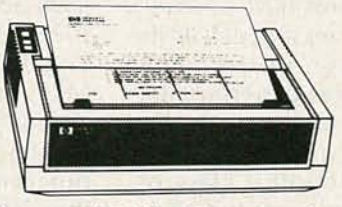
3½" Disc Drive— this is the current model (HP-9114B), and it comes with everything: rechargeable batteries, recharger, disc, HP-IL cable, manual.



It is HP-IL driven, so you can use it with the the HP-75D and also with the HP-41, HP-71 or HP-110. **Easily portable,** it weighs only 6 lb, is battery powered, 3" high and its footprint is the size of typewriter paper. 2-sided flexible discs hold 630K, and the drive automatically monitors wear and checks for defects at each use. Data access time is ½ sec and transfer rate is 6K/sec. List price new is $695, so you buy this used unit at a **whopping 57% discount!**

Stock # 9114BU [Used 3½" Disc Drive]..... $295

IL ThinkJet Printer— this is the current production model (HP-2225B) that is so popular.



It prints 80 columns and is **HP-IL driven**, so you can use it with the HP-75D and also with the HP-41, HP-71 or HP-110. **Completely portable**, it weighs only 5½ lb and it's battery operated. Yet it's so **quiet** and so **robust** that you see it as a public-access printer in many libraries, and it has a life of 100,000 pages! It's **fast**, 150 characters per second. and has **high quality print** with an 11×12 dot matrix (bidirectional, logic-seeking, 1K buffer, and it does underlining or boldface in 1 pass). There's no ribbon—you simply replace the printhead for $11.

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Stock #2225BU [Used ThinkJet Printer].....$195

Portable Computer/ RAM/Pod Package— loaded with extras! You get the HP-75D computer, plus the 8K RAM Expansion Module that plugs into its battery compartment, plus the Expansion Pod that adds a modem, barcode decoders, and a huge 64K RAM disc full of super-fast memory, plus the Barcode Wand! That's a lot, so I'll display the list here for you (remember, you are getting the whole package)—

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2. (HP-82700) 8K RAM Memory Module
3. (HP-82718B) Expansion Pod
4. (HP-92267B) Barcode Wand

HP-75D is 5×10×1¼ inches, 26 oz, with 16K RAM built in. It has a card reader, wand interface and port, touch-type keyboard (the keyboards on these units have never been used). Comes with manual, battery pack and adapter/recharger, IL cables.

Expansion Pod fits as a cradle on your 75, has 300 baud, direct-connect modem and decoders for 3 of 9 Code and Code 11.

Barcode Wand is medium resolution (0.19 mm min width of narrow element) for code produced on dot-matrix printers.

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WHAT'S NEWS

Longer CD recordings with new blue laser

Matsushita scientists report the development of industry's first ultra-compact blue laser, using a unique technology that combines a second harmonic generation element and a semiconductor-diode laser. The device will permit higher recording density for information-memory devices, as well as potential size reductions for data-processing equipment—such as laser-color printers and projection TV's—that are currently equipped with large gas lasers.

Low recording density has been a critical problem in compact-disc and optical-memory equipment. Increased recording density requires a shorter wavelength for the beam that writes to or reads from optical-memory discs. Present equipment uses a semiconductor laser with a wavelength of about 780–840 nanometers. By using the ultra-compact blue laser, with a wavelength of 390–420 nm, an optical disc's memory can be quadrupled. (That shorter wavelength—one-half as long—cuts the size of an optical disc's pits by 50 percent.)

THE PANASONIC ULTRA-COMPACT blue laser device will quadruple the memory of optical discs.

To achieve the lightest and most compact equipment, Matsushita has combined an infrared semiconductor laser and the new second harmonic generator in a single module, thus obtaining a blue-laser output of 420 nm from an infrared laser operating at 840 nm. Beam power is 1 milliwatt.

Samples of the new laser—to be marketed under the Panasonic name—should be available by the time you read this.

Microbial batteries seem a possibility

Fuel cells—those in which the electrolyte is continuously being used up and replaced—are well known. Unfortunately, fuel cells have their own difficulties; one is that most of them have to operate at high temperatures.

It has been known almost from the turn of the century that microorganisms such as bacteria can generate a voltage or produce a current. As the organisms break down (or catabolize) the large molecules in their food, they produce intermediate substances that are rich in electrons. The problem is that the organisms have a "skin" of liquid membranes and cell walls that block passage of the electrons. Currents from experimental cells have been low.

Now scientists from Kings College in London report a class of chemicals that "connect" the electron-rich interior of the cell to the negative terminal. Those "mediators" are chemicals—such as resorutin, thionin, and others—that are well known to biochemists. In effect, they penetrate the outer layer of the microorganism and make it possible for the electrons to get through.

Experimental bacterial cells fed with various sugars have been made with outputs as high as 2 amperes, and researchers are already talking of running cars with sugar in their tanks. At the other end of the scale, there is much interest in cells that would deliver milliwatts or even microwatts of power. (Less than one tenth of a gram of carbohydrate would power a watch for a year.) Another possible application is power from an abundant, inexpensive agricultural or industrial waste, such as sugar cane.

New editing technology harmonizes tape and film

Video-program producers have long wished to be able to shoot on film, edit on video tape, and release prints in both media, including a matching sound track for each. But film and videotape are incompatible—film operates at 24 frames per second, and videotape operates at 30—so that dream has always been thought of as being impossible.

Now engineers from CMX Corp., a leading designer of computerized film- and television-editing systems, have solved that problem with a revolutionary new patented software technique that is called MC² (Matched Computer Cut). MC² works within the CMX 6000 editing system that transfers film or videotape to laser videodiscs for editing purposes. With MC², editors are now able to prepare a film cut and a videotape master—including the audio portion for each of them—and they have them both "frame accurate" at 24 frames and 30 frames per second.

MC² also solves an international problem. Many foreign standards for video, such as PAL and SECAM, differ from the American NTSC. MC² can be used as an easy alternative to create high-quality PAL or SECAM masters from standard NTSC tapes. **R-E**

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V-1100A	100MHz	Q.T., 1mV sens, Delayed Sweep, CRT Readout, DVM, Counter	$2,295	$1,995	$300
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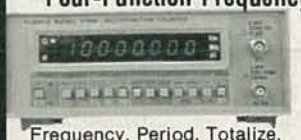

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VIDEO NEWS

DAVID LACHENBRUCH,
CONTRIBUTING EDITOR

• **An HDTV tube.** Just as semiconductor manufacturers are pushing for government grants or consortiums to lay the foundations for a "new consumer-electronics industry" in the United States, the last surviving major American-owned television manufacturer is pushing for government aid to keep it afloat. Zenith Electronics has asked for a grant (believed to be in the neighborhood of $60,000,000) to develop its unique *F*lat *T*ension *M*ask (FTM) tube as a high-definition, giant-screen picture tube. Zenith says that FTM is ideally suited for HDTV and can be made cheaply after further development. (FTM tubes currently are being made in the 14-inch size for data display only.) The FTM differs from conventional tubes in that its faceplate is completely flat—it can be made of conventional window glass—and the shadow mask is stretched just behind the faceplate and bonded into the glass, preventing any significant change in its contours as the tube heats up.

The display on the FTM tube is unique. Because there need be virtually no reflection, the picture looks more like a 35mm slide than a TV image. However, Zenith has had difficulty manufacturing the tube, and some members of the industry doubt that it can ever be produced economically.

While Zenith pleads for government aid in developing its tube into a consumer device, it is also seeking either to sell its consumer-electronics operation or enter into some kind of joint venture—developments that may have occurred by the time you read this. Zenith's problems and those of the semiconductor manufacturers, however, still underline the problems of the low-profit consumer-electronics industry.

• **Creating an industry.** Some of the semiconductor and related Silicon Valley manufacturers now pushing for a bailout to "revive the American consumer-electronics industry" were formerly engaged in the manufacture of TV sets and other consumer-electronic products, and left the industry voluntarily or sold out to Japanese manufacturers. They are now seeking government money to get back into a field they once quit because the profits were too low. However, those same manufacturers point out that the lack of a consumer-electronics industry as a major consumer of chips could imperil American defense.

A major campaign is on. Although there is a score of TV-assembly plants in the United States, the vast majority are foreign-owned, and many depend on imported parts and subassembly. The question is whether the supply of consumer-electronics products will continue to be the province of overseas manufacturers as the world enters the age of high-definition TV.

• **HDTV in spotlight.** High-definition television is getting increasing attention in Washington and elsewhere, as the public imagination is captured by the concept of a TV picture that looks like a movie, both in width of screen and in detail. Semiconductor manufacturers are urging the U.S. government to finance a major program to develop "a new consumer-electronics industry" as a stimulus to the development and sale of IC's. They claim that only 6% of the semiconductors used in consumer-electronics products sold in this country are made in the United States, and they insist that HDTV provides a good opportunity for the development of a new American consumer-electronics industry.

In the background is an FCC directive to American broadcasters that any new HDTV system be compatible with existing NTSC transmissions and channels. That virtually rules out the Japanese 1,125-line HDTV system that actually is designed for direct broadcasting from satellites and not for terrestrial-TV transmission. (In fact, the first Japanese HDTV transmissions will be to receivers in public places rather than in consumers' homes.) The FCC's compatibility ruling has cleared the air and helps to quell the rumors that the Japanese will export an incompatible system here with no opposition. **R-E**

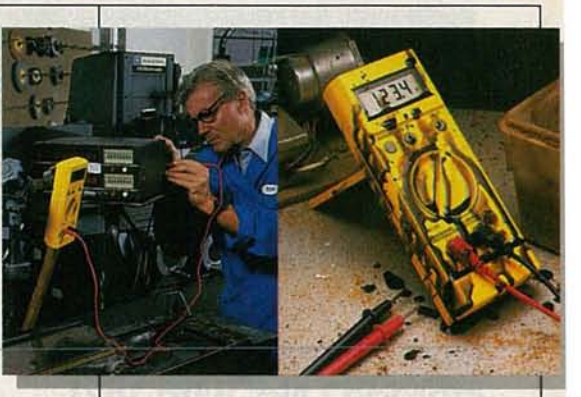
Intermittents. We Hear You.

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

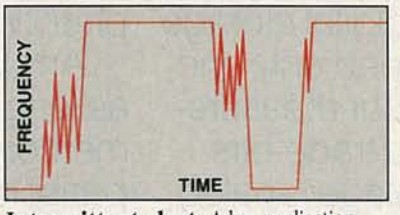
Intelligent design and solid construction make the new HD 150 Series the best DMMs in their class.

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

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



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



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

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

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

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

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

Key Specifications

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

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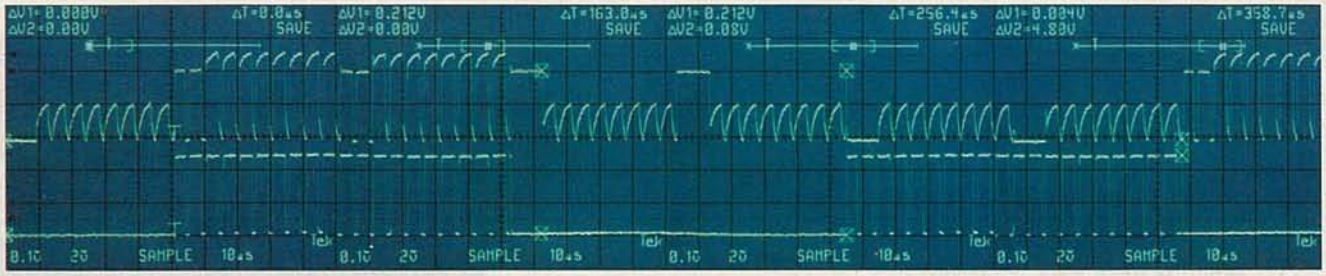

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Glitch Capture	100 ns	100 ns	100 ns	No	No
CRT Readout/ Cursors	Yes	Yes	No	No	No
GPIB/RS-232-C Options	Yes	Yes	Yes	No	RS-232-C Hardcopy
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TIME-BASE CORRECTOR

Can you explain exactly what a "time-base corrector" does? I want to be able to mix two video sources together, and I'd like to know if I need one of those to do it. Also, what other equipment do I need to do video mixing?—S. V., Okinawa, Japan

In order to understand what the time-base corrector does, you first have to understand what the time-base corrector corrects. The drawing in Fig. 1 is a typical line of video. The horizontal sync on the line is what makes the beam zip back to the left edge of the picture and start a new line of video. Although you only see what occurs on the line during the picture portion of the line, Fig. 1 should make it clear that there's a lot of other stuff going on during the blanking interval as well—behind the scene, so to speak.

When you record on a VCR, all the control signals (including sync) have to be recorded as well—that's obvious; but what's not obvious is that they're not recorded as part of the picture. The circuitry in the VCR separates the sync from the picture and records it all on a separate track called, appropriately enough, the control track.

When you play back a tape, things like bobble, misalignment, and jitter, often cause the control track to be read either a bit early or a bit late. All VCR's suffer from that to some degree, even high-quality professional ones. There's just no way to avoid it, since the VCR is only a mechanical device and mechanical devices are built with mechanical tolerances.

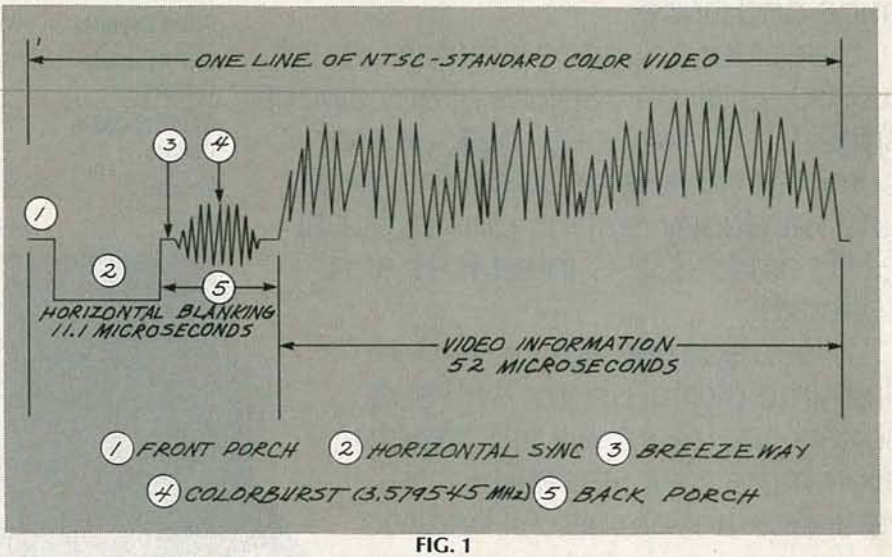

FIG. 1

Even if you managed to get a VCR in super-duper alignment, so that there was no jitter on the drum to misalign the control and video tracks, it wouldn't be long before normal mechanical wear caused it to fall out of alignment.

Now that we've seen what causes the problem, we can start talking about a time-base corrector. Since the picture's horizontal jitter is caused by timing errors in synchronizing the control and video tracks, they can be eliminated by synchronizing the video to a sync source that's independent of the recorded sync.

A time-base corrector takes the incoming video signal, strips sync from it, and remixes it with a new set of sync signals. The video is processed line by line, and the original sync is just used as a trigger to mark the correct position on the line for injecting the new sync. The actual circuitry that does the job can be designed several ways. You can have something similar to the auto-triggering circuitry found on an oscilloscope, or it can use a phase-locked loop to lock the old and new sync together.

You don't need a separate time-base corrector to mix several video sources together because most consumer video mixers will separate sync signals from video and inject new control signals on the output of the mixer anyway. It's possible to build your own video mixer, but even a basic mixer needs fairly complex circuitry.

If your interest is primarily in electronic design, designing one of those would be an interesting thing to do. If, on the other hand, you're more interested in having one to use, you'll probably find it a more efficient use of your time to go out and buy one.

DIGITAL METERS

I've built the digital oil-temperature gauge, temperature gauge,

and voltmeter that appeared in the July, August, and September 1983 Radio-Electronics, and I'm looking for some other ones. Do you know of any other digital meters I could build?—S. Salisbury, Omaha, NB

If you've already built the three gauges you've mentioned, you've also already built all the gauges that you need. That isn't meant as any sort of editorial judgment on the place of digital electronics in cars; it just means that you've already got all the circuitry you need to build as many digital gauges as you can fit between the driver's door and the cigarette lighter. If you look at the block diagram in Fig. 2, you'll see what I mean.

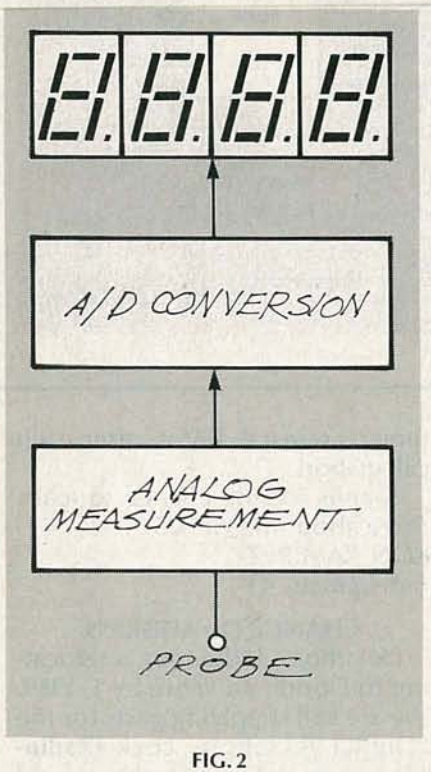

FIG. 2

Most digital gauges either count pulses per time unit or measure a standard electrical unit (usually volts). An electronic tachometer is an example of the former, and your digital voltmeter is an example of the latter. If you think of the meter as a sealed unit, there's a big difference between a digital temperature gauge and a digital oil-pressure gauge, but if you look at the illustration, you'll realize that the two meters are more alike than they are different.

The difference between the two gauges is only in the sensor and the conditioning circuitry. Both meters are actually measuring the same electrical parameter. To make the point clearer, let's suppose that you wanted to make a digital fuel-flow meter. That could come in handy because it would be calibrated and gated to show fuel economy. In any event, the design of a meter like that would revolve mostly around the device that you were using to measure fuel flow, and not on the meter that was measuring it.

The first place you would begin looking as you built up the design is in a catalog of rotary transducers, as they are good for measuring fuel flow. The deal here is that the most important part of the meter is the device that gives you something to measure. In this example, the rotary transducer would produce a voltage proportional to the fuel flow. Once you've got that signal available, you can measure it with the digital voltmeter that you built. **R-E**

LETTERS

NOT QUITE TRUE RMS

It has come to our attention that there are a couple of errors in the schematic diagram (Fig. 2) for the article "True RMS Converter for your DMM," that appeared in the December 1988 issue of **Radio-Electronics**. Neither pin 4 of IC1 nor the anode of D2 should be connected to ground, as the schematic indicates. Instead, as shown here in Fig. 1, pin 4 of IC1 should be connected directly to the anode of D2, and the connection from J4 to pin 4 should be removed.—*Editor*

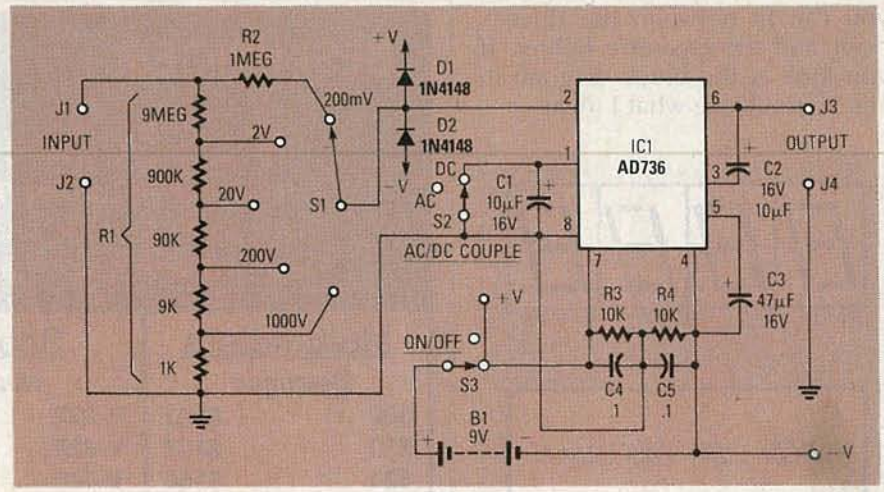

FIG. 1

DIGITALKER AVAILABILITY

Your readers will be interested to know that the National Semiconductor Digitalker system you described in "Build This Speech Synthesizer (**ComputerDigest**, December 1988) is no longer being produced by National Semiconductor, nor is there any plan to begin production again. While many distributors (including some of your advertisers) stock the part, anyone contemplating using the Digitalker in a new design should be aware that once current stocks are depleted, no more will be available.

FRED WICKERSHAM
Product Mkting Manager
Telecommunication IC's
National Semiconductor
Santa Clara, CA

COPING WITH BASIC

I read with interest the article, "Coping with Coils," in the November 1988 issue of **Radio-Electronics**. As a beginner in computers, and knowing very little about coils, I felt that it would be a good way to learn something about BASIC on a Hewlett-Packard 125.

I'm writing to inform you that the program, as it is presented in the article, will not work on the HP 125. Every time I tried to run the program, it displayed "Syntax Error on line 110." After some experimentation I found that it would work when line 110 was changed to read:

110 pi = 3.1415926545

Removing "cls:" from line 110 took care of the syntax error. I ran the program and it worked as described—until the end. After briefly displaying the calculations, it exited the BASIC mode. So I modified lines 540 and 1000 as follows:

540 if n 9999 then print "ERROR - turns count larger than 1000": END

1000 END

Changing "system" to "END" lets the calculations remain on the screen, so that I can read them and print them out if I want to. I can calculate other coils, one after the other, without having to take the time to reinstall BASIC after each calculation.

Thanks for the chance to learn more about the HP 125.

RON RAMIREZ
Providence, KY

CHANGE OF ADDRESS

Del-Phone Industries is relocating to Florida on February 1, 1989. We are still supplying parts for the "Digital Telephone Lock (**Radio-Electronics**, October and November 1988). The new address is: Del-Phone Industries, 4487 Plumosa Street, Spring Hill, FL 34606.

There have been no price changes; however, Florida residents must add the appropriate sales tax.

STEVE SOKOLOWSKI

COIL CORRECTION

I enjoyed David Powell's article, "Coping with Coils"—especially converting the IBM BASIC program to run on a modern computer. The program certainly makes RF-coil calculations easy.

There is one error in the program listing as printed. Line 855 should read:

PRINT INT (W.LENGTH-INT(W.LENGTH/12)*12

With the values given in the article's Fig. 2, the length of wire is 99.868 inches, or 8 feet 3.868 inches, not 8 feet 10 inches as shown.

RUSSELL K. PRATER
Parker, FL

DATA-CARRYING CAPABILITY AND BANDWIDTH

Referring to "Communications Corner" in the October 1988 issue of **Radio-Electronics**, the frequency ratio of 5.5:1 does not necessarily indicate a high data-carrying capability. For example, the range from 1 Hz to 5.5 Hz would have a very low data-carrying capability.

What counts is the frequency bandwidth. The above example has a bandwidth of only 4.5 Hz. In the range Herb Friedman is discussing, the 200 nm UV has a frequency of 1500 TeraHz, and the 1100 nm IR has a frequency of 270 TeraHz. The bandwidth is then 1230 TeraHz.

That bandwidth would give the theoretical potential of far more signal-carrying capability in a single fiber than all radio frequencies combined. However, it is the frequency *bandwidth* that counts, and *not* the ratio between the high and low.

MARION E. WOLFE
Glendale, CA 91202

PATENT PROBLEMS

I'd pretty much agree with Don Lancaster's observations on patents ("Hardware Hacker," **Radio-Electronics**, October 1988), particularly that industry does not want inventions from outside, and that fewer than 1% of patents earn the cost of getting them.

In my younger (and hungrier) days I got patents for some people who hoped to sell them. They were enthusiastic; the inventions looked good. Then I went over the old files and listed (a) the patentees who were actually in the business of making and selling the stuff invented, and (b) those who just hoped to sell or license the patent to some forward-looking company. It turned out that there was not one single success in category (b). Not one.

Were I to advise someone with an invention—or what he thinks is an invention—it would go like this: First, if you aren't already in the business or preparing to go into it, forget it. Second, a preliminary search in the patent literature is a must.

LAWRENCE FLEMING
Registered Patent Agent
Pasadena, CA 91106

THE DANGERS OF RADIATION

Leslie P. McCarty's letter in the September 1988 issue accuses **Radio-Electronics** of "yellow journalism" concerning the health effects of radon and radiation. To support his contentions, he makes several or misleading statements.

Dr. McCarty's statement that there is a "negative correlation between the presence of radon and lung cancer" is at odds with multi-

year epidemiologic studies of data from the U.S., Sweden, and Canada. In 1984 the National Council on Radiation Protection and Measurements estimated that among every one-million people exposed over a lifetime to a relatively low dose of radon, there would be an average of 130 lung-cancer deaths above those normally occurring. That risk estimate was recently raised by nearly a factor of three, to 350 additional lung-cancer deaths, following a 3-year study by the National Research Council of the National Academy of Sciences.

That new figure falls into the middle of the EPA-estimated range of 5,000 to 20,000 lung-cancer deaths per year linked to radon exposure—making radon the second leading cause of lung-cancer deaths after smoking. The study also found that the separate risks of lung cancer from radon and smoking are not additive, as some experts have believed. Radon exposure multiplies smokers' lung-cancer risk by at least a factor of ten.

Dr. McCarty also states that there is nothing to support the EPA-set action level for radon exposure of 4-picoCuries per liter (pCi/l), implying that the level has been set too low. Establishing environmental-exposure limits for even well-recognized public-health hazards can be very difficult. Estimates of the risk to the general population have been characterized through evaluations of lung-cancer mortality rates and radon-exposure data for uranium miners working in environments with typically high levels of radon gas.

In the above-mentioned study, risk estimates calculated by the National Research Council were referenced to a measurement called *W*orking *L*evel *M*onths (WLM). A WLM exposure is based on a specific amount of alpha-particle energy per liter of air over a 170-hour work month. A person staying at home an average of 12 hours per day, and exposed to a radon level of 4 pCi/l, would receive about 0.5 WLM annual exposure. Rather than too low, that level may be too high. That study found that people exposed each year to radon levels at or slightly above the present EPA limit have a 50% greater risk of contracting lung cancer than people who are exposed only to the extremely low, normal levels of radon in outdoor air. Living with a 4-pCi/l level of radon is equivalent to smoking eight cigarettes a day, or undergoing 200 chest X-rays in a year.

With respect to detecting radon with a Geiger counter, Dr. McCarty guesses "that alpha particles do not penetrate" the window of the Geiger-Mueller tube. Alpha particles are indeed characterized by shallow penetration depths. (The short penetration depth is associated with the higher linear-energy transfer of such particles as compared to X-rays and gamma rays, and reflects the generally more-damaging nature of particulate radiation.) However, a typical halogen-quenched Geiger-Mueller tube, having a thin mica end window (on the order of 1.4 milligrams per centimeter squared) is quite capable of detecting alpha particles down to 2.5 MeV directly. Detection sensitivity is generally greater than 80% at energies above 3.6 MeV. Radon decays predominantly through emission of particles at energies in excess of 5 MeV.

I also find it interesting that, after his comments concerning the detection of alpha particles, Dr. McCarty concedes that a "Geiger counter can measure some of the radon daughters." Of the six direct and indirect radioactive daughters of radon, four are predominantly alpha-particle emitters.

While I cannot personally judge the extent of Dr. John Gofman's objectivity, Dr. McCarty appears willing to accept a court statement that "Dr. Gofman's...conflict with all the world's radiation experts...destroys his credibility as an objective witness." I would tend to suspect any statement containing the phrase "all the world's...experts." The "experts" in radiation health risks not only have had difficulty estimating the exact national magnitude of indoor-radon pollution, but continue to debate risk assessments. Dr. McCarty apparently has his own bias in that area—as we all probably do.

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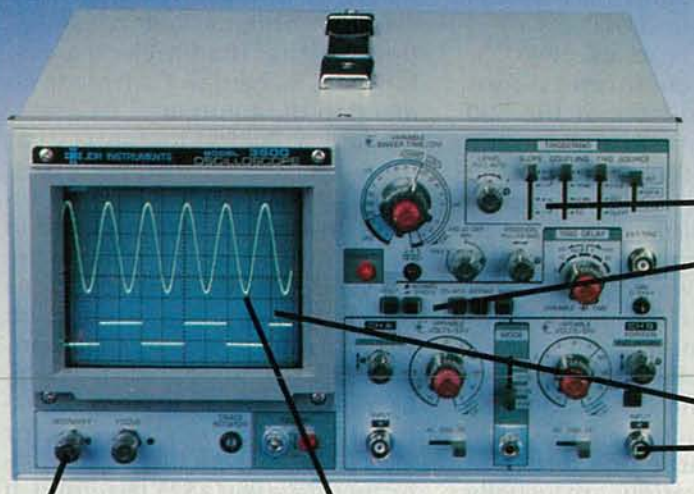

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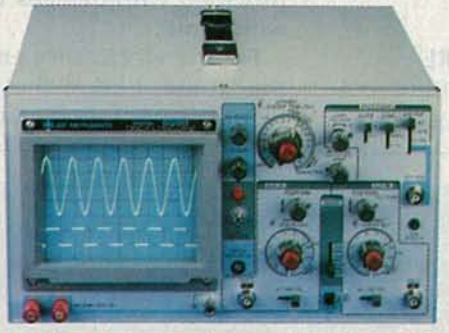

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I will agree that the *Journal of Health Physics* can probably consider the biological effects of ionizing radiation better than **Radio-Electronics** can. The public majority, however, does not subscribe to the former publication; that should not exclude them from the debate. Public exposures to radon far exceed those from the more widely reported Three Mile Island accident. I believe that the data supports the conclusion that radon is a significant health hazard, and long-term exposure should be viewed with some degree of alarm. Only an informed and educated public can rationally address health-risk problems of that nature. **Radio-Electronics** has not engaged in the cheaply sensational reporting of "yellow journalism"—nor has it strayed from what is "technically correct."

TIM M. SHARON, Ph.D.
El Toro, CA

CABLE-HUM CURE

In the August 1988 "Letters" column, Melvin Zion suggested a "cure"for cable-TV converter hum. I have used the same volume-adjustment solution, but I would consider it only a temporary "fix." I, and several of my friends, have experienced the problem of 60-Hz hum on various cable systems, and I have always been able to get rid of it.

My solution is to use two 75-to-300 ohm transformers connected back-to-back at the 300 ends. That seems to provide the isolation from the hum. Each of the transformers provides electrical isolation but allows the signal to be passed inductively, via the ferrite core. I use two transformers to ensure that the 75-ohm impedance is maintained.

I suppose that a single isolation transformer (with 1-to-1 windings) would be sufficient. I have not tried that, because one or two of the 75-to-300 variety are usually provided with devices to be used with cable.

For the electronics engineers in the crowd: I know that the use of transformers can cause other problems. However, I have only noticed the elimination of the 60-Hz hum when using that particular arrangement.

KIRK JOHNSON
Santa Clara, CA

ANTIQUE CAR-RADIO MEMORIES

In his "Antique Radios for Antique Autos" (**Radio-Electronics**, July 1988) Richard D. Fitch made no mention of Motorola.

I had a Radio-Operators First Class license, and I worked part-time for radio station WIBO in Chicago until they went off the air in June, 1933. I remember that in the early 1930's Motorola had a sales room and installation shop on Washington Blvd. in Chicago. They had a promotion deal whereby you could have a Motorola radio installed in your car for $125.00. If you sent them a customer, they gave you a $25.00 refund. If you referred five customers to have radios installed in their cars, your radio was free.

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The *AR-6400P* is a microprocessor-based instrument; it consists of a main unit with two 64-pin ports and an optional test fixture which is connected to the main unit by two 64-pin ribbon cables. The test fixture offers convenient access to the I/O ports of the tester. Various connectors can be attached to the test fixture to allow convenient testing of generic cable assemblies. The test jig comes equipped with various D-type and Centronics-type connectors, which you might expect to come across when servicing computers. It is possible to add other connectors to the test fixture, but we would assume that most users would want to make their own test jigs.

Cables can be tested for opens, shorts, and mis-wiring. Intermittent connections can be detected and latched as you squeeze and wiggle the cable. The integrity of the cable's insulation can also be verified.

Non-standard cables present no problems to the tester, as long as you have a good cable that the tester can learn from. To teach the

continued on page 24

Canon FAX-L920 Laser Facsimile

The future of facsimile is here today.

CIRCLE 40 ON FREE INFORMATION CARD

THE FACSIMILE REVOLUTION IS HERE, and it shows no signs of slowing down. Many radio stations across the country are now accepting music requests by fax, and local take-out restaurants accept lunch orders by fax. Fax is the fastest growing item in the fast-growing home office market. But don't expect the fax machines of tomorrow to be like the ones you're now familiar with. Expect them to be like the *FAX-L920* plain-paper laser facsimile from Canon U.S.A. (One Canon Plaza, Lake Success, NY 11042).

The *FAX-L920*, which consists of a main unit and a printer, doesn't look like a fax machine. In fact, we originally intended to show the machine on the cover of our November 1988 issue, which focused on fax technology. We thought the Canon machine would be a great choice because it was the most technically sophisticated fax we knew of. We eventually decided against using it on the cover because we didn't think that people would recognize it as a fax—the machine looks more like an office copier than a fax. (It is, incidentally, a full-featured laser copier, too.)

Advanced features

The *FAX-L920* features a 32-megabit memory that makes the machine's advanced features possible, including batch transmission, relay broadcast, confidential mailboxes, delayed transmission, and more.

Batch transmission is the ability to collect documents bound for any of up to 24 locations, and to send them at programmed times. In a real-life situation, a head of-

fice could collect, throughout the day, documents for its 24 salesmen stationed throughout the world. At pre-programmed times—which could correspond to the opening of each branch office—the documents would be sent to their destinations. In a high-volume operation, the savings in telephone costs could be dramatic.

Relay broadcast is a way of reaching hundreds of locations quickly and cheaply. An originating unit can be programmed to send a fax document to up to 151 relay units, each of which can be programmed to send them on to 150 additional locations. The main benefits are speed and, again, the ability to dramatically cut long-distance telephone costs. For example, a large corporation with several hundred stores nationwide could send a fax document to its regional offices. Each regional office could then relay the document to the stores in its area.

Confidential mailboxes can collect incoming documents and store them in memory. The contents of the mailboxes are printed only when the correct password is entered. Of course, only other Canon units can input data to the password-protected mailboxes. The confidentiality (or its lack) of faxed documents is an important issue that is only now beginning to be recognized.

A host of other convenient features are offered by the *FAX-L920*. For example, memory polling allows other Canon machines to request documents that have been stored in memory. Also, while the unit is receiving documents, you can still store documents in memory for transmission after reception is complete. Even running out of paper is less of a problem with the *FAX-L920*—up to 24 pages are automatically stored in memory until paper is supplied.

The fax features a flat-plate scanner, so sending images from books is not a problem. For paper documents, an automatic 50-sheet feeder is standard. The one thing missing from the *FAX-L920* is a computer interface. However, according to Canon, an RS-232 interface will be available in the future. When that becomes available, the fax will be able to work as a laser printer and a page scanner for the computer, as as well as a laser facsimile and copier.

Some of the unit's specifications are impressive. In a proprietary mode, a page can be sent to another Canon machine in about 12 seconds. In standard G3 mode, that increases to 18 seconds, and in a G2 mode things slow down considerably. Its scanning density is impressive as well. In its ultra-fine mode, the machine's horizontal resolution is 406 dots per inch, and its vertical resolution is 392 lines per inch. A halftone mode differentiates 16 shades of gray for reproducing photographs.

As you might expect, such advanced features and such impressive specifications do not come cheaply. The suggested retail price of the *FAX-L920* laser facsimile is $8395. **RE**

EQUIPMENTS REPORTS

continued from page 22

tester about a new cable, you must simply plug the good cable into the ports and press the READ key twice. The *AR-6400P* will then scan the cable's configuration, and store its characteristics in memory. When similar cables are tested, they are simply plugged into the ports. If the characteristics match, then PASS is displayed on the unit's LCD, and a two-tone beep is heard from the speaker. You can then wiggle and squeeze the cable to search for any intermittents. If one shows up, it will be latched, and the display will show BAD CONNECTION. The SHOW keys can be used to get an exact description of the pins presenting the problems on the LCD. Alternatively, the pin data can be output to a printer via the *AR-6400P*'s Centronics parallel printer port. To test another cable, the TEST key must be pressed. If any shorts or mis-wiring exist, the LCD will display ERROR. As before, the exact problem can be displayed on the LCD or output to a printer.

The cable tester features a STEP mode that allows it to memorize a sequence of up to 99 cable tests. That would be very useful to a manufacturer who wants to test all of the wiring harnesses of a piece of equipment before assembly. Each harness could be connected, in turn, to the tester; as long as they were tested in the proper order, the *AR-6400P* would know what configuration to expect. The STEP mode could also be used to test switching systems.

The *AR-6400P* features two additional modes, TOUCH and SEARCH, that can make a simple matter out of finding what's what in a rat's nest of wiring. Let's say, for example, that you have a cable with a connector on one end, but only wires on the other. You can plug the connector into the test fixture, and touch the bare wires with your hand. (You must be connected to the tester via a wrist strap.) The LCD will display the number of the pin you touched. The SEARCH mode is essentially the same. However, instead of relying on body conductance, a probe is used to touch the test points.

We liked the unit's two battery backups; one of which keeps the memory non-volatile for more than two weeks. A separate rechargeable battery acts as a uninterruptable power supply for the tester. We do have a couple of minor complaints. We'd like to see a backlight for the LCD, and we'd like to see a carrying handle on the unit even though it's really a little too heavy (almost 15 pounds) and big (about 14×12×5 inches) for field service. We'd also like to see a new, clearly written instruction manual.

All in all, we found the *AR-6400P* an easy-to-use special-purpose tool. In a manufacturing environment, the tester could be easily used by a non-skilled worker. A skilled technician could cut his troubleshooting time dramatically. In each case, the time saved and problems solved would quickly make up for the unit's $995 price.

The optional test fixture sells for $99.95. **R-E**

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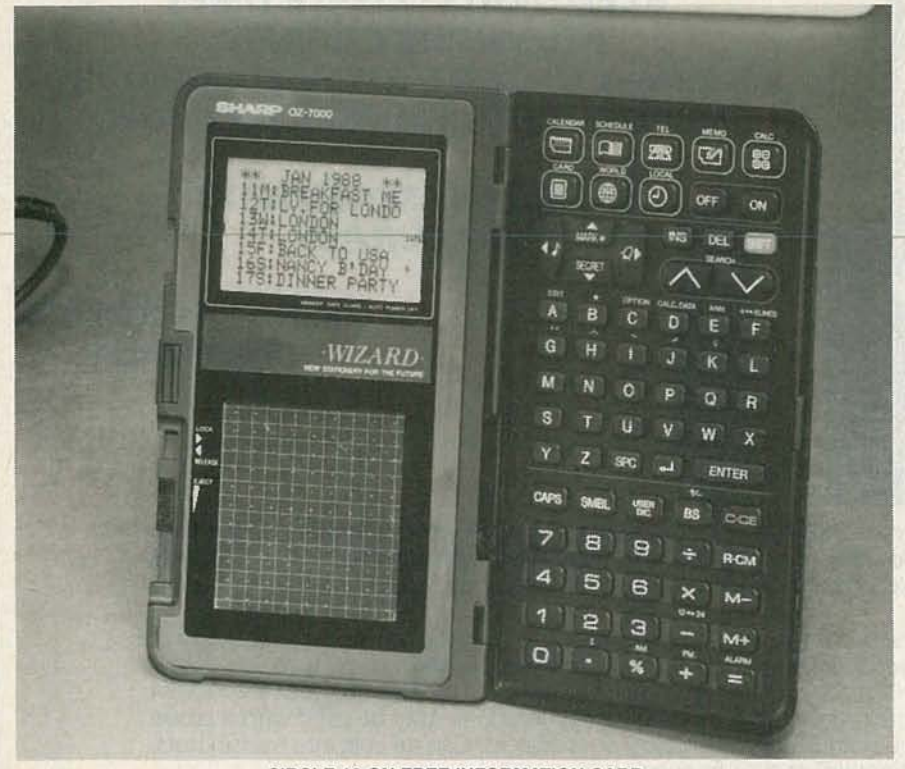


CIRCLE 10 ON FREE INFORMATION CARD

ELECTRONIC ORGANIZER. A recent survey conducted by *Sharp Electronics* revealed that 50 percent of business executives spend half their work time out of their offices, traveling or meeting with business associates or customers. To help them—and busy people in all walks of life—keep organized, Sharp has introduced the *Wizard*, a hand-held instrument that combines a personal computer, phone directory, calculator, appointment diary, calendar, and world clock in a 4 × 6-inch unit weighing only 8 ounces. Information can be transferred between two Wizard units, and bi-directionally between the Wizard and a PC. It also connects to a printer to produce hard-copy documents.

The unit (model *OZ-7000*) is menu-driven and user-friendly, requiring virtually no computer or programming knowledge. The Wizard has raised keypads, separate alpha and numeric keys, and a 16 × 8-line LCD display. A software card enhances the command keypad and allows the user to access the Wizard's seven built-in capabilities at a glance. Other integrated-circuit software cards—a time-management system, thesaurus/dictionary, and 8-language translator at present, with more planned for the future—are available as options. The addition of those cards will increase the Wizard's 32K RAM memory up to 96K.

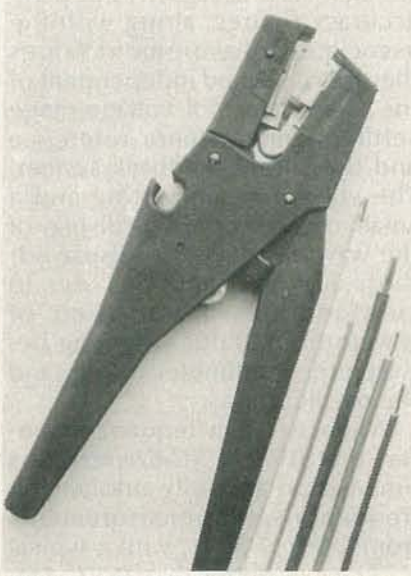
The seven built-in functions include the calendar mode that features daily and weekly display, with 200-year capability; the schedule mode that allows the user to insert names, notes, and comments for each appointment; the telephone mode that permits customized storage and retrieval of entries by name, company, phone/fax number, and address; and world/local mode that tells the time in over 200 cities. Up to 16 pages of typed information can be stored in the Wizard's memo mode. As a calculator, the *OZ-7000* offers 10-digit ciphering with 3-key memory and can function as a paperless printer for up to 50 entries. For confidentiality, the secret mode prevents unauthorized access to password-protected information. All of those built-in OZ-7000 functions can be edited and updated continuously.

The Wizard has a suggested retail price of $299.—**Sharp Electronics Corporation**, Personal Home Office Electronics Division, Sharp Plaza, Mahwah, NJ 07430.

WIRE STRIPPERS. *Paladin's PA-1101 Maxi-Stripax* simplifies the stripping and cutting of 10- to 22-gauge wire. Its increased-leverage design and cam system reduce hand-pressure requirements by up to 30% and allow the tool to strip up to eight conductors simultaneously. The *PA-1101* also features a built-in wire stop, insulation to 600 volts, front feed for close-in work, and a built-in wire cutter to speed your work.

The tool is designed to cut flexible and solid PVC, and hard PVC insulation, as well as 10- to 12-gauge wire. When used for multicore ribbon cables, several conductors can be stripped in one operation. Double-insulated or fiber-optic cable can be stripped in two operations with no adjustment.

The lightweight, but rugged, fiberglass-reinforced *PA-1101* has 66



CIRCLE 11 ON FREE INFORMATION CARD

stainless-steel stripping blades that are rated for a service life of 200,000 strips. Those blades will not cut or nick the internal wire while stripping.

The *PA-1101 Maxi-Stripax*, with cleaning brush, has a suggested list price of $52.95.—**Paladin Corporation**, 3543 Old Conejo Road, Suite 102, Newbury Park, CA 91320.

MENU-DRIVEN MULTIMETER.

Simpson's Model 560 menu-driven multimeter was designed for serious engineers and designers in audio, communications, and computer, as well as industrial-control fields. All of the unit's features and capabilities are accessible through front-panel, menu-driven programming.

The *Model 560* features very fast auto-ranging, a 500-kHz frequency counter, relative readings, and continuity and diode checks with audible beeper. Centronics-printer or RS-232 interfaces are available. The unit has data-logging capability on any selected range with 2,150-measurement memory and battery back-up. The dual-LCD format has a 5-digit, 52-segment measurement display and a 4-line menu/programming display.

The unit's functions include DC volts, true-RMS AC, or AC-plus-DC coupled volts, low and high power resistance; DC, and true-RMS AC or AC-plus-DC coupled amps; 5-Hz to 500-kHz frequency; dBm on any voltage range; diode and continuity tests; differential-peak hold; Rel; and Zero.

The available Centronics-compatible printer port is fully isolated for 8-bit data with strobe and busy. The isolated RS-232C serial port offers 300- to 9600-baud rates. Nonvolatile RAM, with battery back-up, retains the last user selections and readings.

The *Model 560* menu-driven multimeter, including operator's manual, test-lead kit, and calibration certificate, costs $2,195.00 with RS-232C interface, and $2,395.00 with Centronics inter-

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face.—**Simpson Electric Company**, 853 Dundee Avenue, Elgin, IL 60120.

PORTABLE OSCILLOSCOPE. *Createc's SCOUT SC-02* is a complete analog-to-digital, digital-to-analog measurement system. Surface-mount production technology allows benchtop features to be packed into a durable 25-ounce, handheld package that functions as an oscilloscope, a digital multimeter, a frequency counter, and a signal computer.

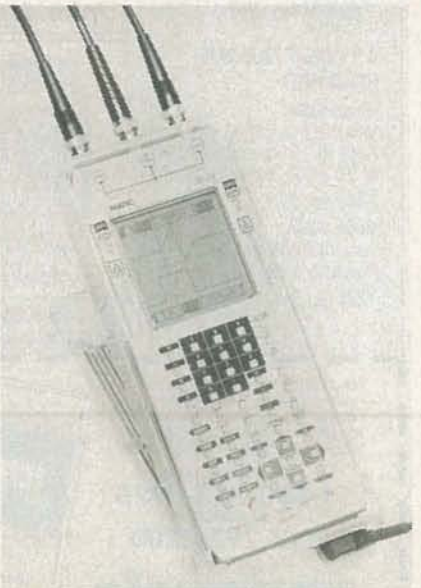
The oscilloscope's two independent 20-MHz digital-to-analog converters permit full-speed and parallel capture of periodic or single-shot waveforms. The *SCOUT SC-02* presents time, voltage ranges, cursor measurements, and trigger positions on the waveform display. It has 46 storage memories for storing and recalling waveforms and all related data. Other features include dual-timebase viewing, precise trigger placement, and an additional 10 complete setup memories. One saves the current set of setup parameters when the unit is shut off; the other nine are fully user-programmable.

As a multimeter, the *SCOUT SC-02* measures true-RMS voltages to 1 MHz with full-range accuracy of 1% or better. It also measures the DC-component, zero-to-peak, and peak-to-peak values. The unit can be fully DC-compensated for DC-voltage measurements of better than 0.5% accuracy. It displays accuracy figures, along with the associated measurement values that are calculated independent of the temperature of voltage-range setting, using a zener reference and the D-to-A feedback system. The voltage-range setting and a small, oscilloscope-type display of the waveform are also displayed; those features allow the user to view and measure a variety of waveforms without switching between the multimeter display and the oscilloscope.

When used as a frequency counter, the *SCOUT SC-02* performs time-period and fully autoranging frequency-setting measurements from DC to 7 MHz, with a typical accuracy of better than 0.5%. Frequency and time measurements, with associated accuracy figures, are displayed in the multimeter mode.

The signal computer tracks all incoming waveforms and automatically adjusts the timebase, trigger, trace, and cursor positions. It provides sophisticated past-processing and analysis functions on captured data. In addition, the signal computer constantly calibrates the system for changes caused by age and temperature drift of the components. For volume users with special requirements, the *SCOUT SC-02* can be custom programmed by the manufacturer.

The *SCOUT SC-02* costs $2,995.00.—**Createc Signal Computer**, 3337 Kifer Road, Santa Clara, CA 95051.



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SYNTHESIZERS GENERATORS. *Philip's* series of synthesizers/function generators, combining full-GPIB programmability with high resolution and a wide choice of functions, consists of the Models *PM 5191 SM*, *PM 5192 SM*, and *PM 5193 SM*, and the *PM 5193 VM* that provides an additional video-modulation facility.

The series is designed for use in applications where two or more instruments, such as generators and counters, must be synchronized. The function generators can be synchronized at 10 MHz or any sub-harmonics of that frequency (i.e., 1 MHz, 2 MHz, 5 MHz), allowing a complete setup of different instruments to be synchronized

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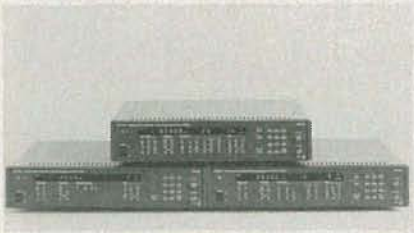
with a single central clock. In addition to all standard-bus functions, all four models support bus-learn mode and can transmit status and setting information to the controller at any time; the units are thus suitable for flexible, bus-based automatic-test systems.



CIRCLE 14 ON FREE INFORMATION CARD

The *PM 5193 SM* is a 50-MHz unit with 20-volt peak-to-peak output. It offers crystal-controlled frequency, 8-digit resolution, and comprehensive modulation facilities. Eight waveforms are available: Sine wave, square wave, negative and positive sawtooth, haversine, triangle, and positive and negative pulse. The modulation modes—AM, FM, sweep, burst, and gating—can be controlled internally or by an external signal source. Voltage can be set in peak-to-peak, RMS, or dBm.

The *PM 5191 SM*—a 2-MHz instrument with 30-volt peak-to-peak output—and the *PM 5192 SM*—with a 0.1-mHz to 20-MHz range and 20-volt peak-to-peak output—both feature high-output accuracy and repeatability. Five waveforms are standard on both models: Sine wave, square wave, triangle, and positive and negative ramps. The output voltage on both can be set in RMS, peak-to-peak, or dBm. The *PM 5191 SM* provides AM modulation; the *PM 5192 SM* offers AM/FM/gating modulation and full sweep facilities.

The *PM 5193 VM* synthesizer/function generator adds video modulation to the wide range of standard facilities of the *PM 5193 SM*. The former's video-modulation mode replaces the AM-external mode of the latter. In the video mode, the carrier frequency can be adjusted up to 50 MHz, with high accuracy and an 8-digit maximum resolution.

Suggested list prices are $3,695.00 for the *PM 5191 SM*, $4,295.00 for the *PM 5192 SM*, $4,895.00 for the *PM 5193 SM*, and $5,895.00 for the *PM 5193 VM*.—**John Fluke Mfg. Co., Inc.**, P.O. Box C-9090, Everett, WA 98206; phone 800-443-5853, ext. 77.

DIGITAL AUDIO TAPE PLAYER. *Mitsubishi's DT 10*—one of the first car DAT players to hit the American market—delivers the remarkable sound reproduction of digital audio for car audio systems. Its chassis is designed for easy installation in American, Japanese, and European cars, and an auxiliary radio/tape input switch permits the use of an RCA-type preamp output radio with the DAT player.

The *DT 10's* advanced full-logic tape transport has extremely fast track-to-track scanning and rewind time (it is much faster than a regular cassette deck). Its dynamic range is rated at 85 dB, and signal-to-noise ratio is 90 dB with a frequency response of 20 to 20,000 Hz. The unit also features a moisture-protection circuit, with temperature sensor and automatic heater, that extends tape life and maximizes tape-player performance by preventing condensation build-up on the internal components.

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Other features include program skip, sequential program scan, four repeat modes (one-program, all-program, non-repeat, and selected program), tape-in indicator, automatic power off, and a large, multi-function LCD display. *DT 10* dealers also offer a fairly decent selection of European digital-audio tapes—including jazz, classical, and pop formats—supplied by Delta Music Inc./Capriccio (Los Angeles, CA).

The *DT 10* DAT player has a suggested retail price of $1650.00.—**Mitsubishi Electric Sales of America Inc.**, Mobile Electronics Division, 800 Biermann Court, Mt. Prospect, IL 60056-2173. **R-E**

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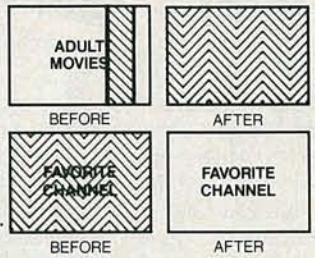

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72 Channel

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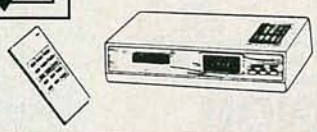

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HIGH DEFINITION TELE-VISION

The many ways of HDTV

LEN FELDMAN

AT LAST COUNT THERE WERE NEARLY 20 separate and distinct proposals for high-definition television systems. They generally fall into three major categories: fully compatible, semi- or backward-compatible, and those not compatible.

There are systems that are fully compatible with our presently used NTSC TV standards. Such systems display a conventional picture when tuned to on an older television receiver. Tuned to on receivers of the future, such systems would, generally speaking, offer increased resolution or picture detail as well as a new, preferred aspect ratio of either 5:3 or 16:9. Present NTSC picture displays have an aspect ratio of 4:3. That explains why many wide-screen motion pictures, when broadcast by TV stations, often have the edges of the picture cut off, forcing motion picture producers to concentrate the major action of their stories towards the center of the screen. Those systems that claim full compatibility with NTSC require no additional bandwidth or spectrum space, beyond the 6 MHz presently assigned to over-the-air-broadcast TV stations.

A second category of high-definition television systems might well be described as semi-compatible or "backwards compatible." Such systems will deliver a standard NTSC picture for those owners who tune in with older NTSC sets. Transmission of those types of HDTV signals, however, would require additional bandwidth beyond the standard 6 MHz—anywhere from 8 MHz to 12 MHz, which is two full channel widths. As was true of the first category, the benefits of such semi-compatible systems will only be realized by owners of new sets designed specifically for those systems.

The drastic difference in size and clarity between an NTSC TV's picture (inset) and the HDTV picture surrounding it, spells the demise of the aged NTSC format.

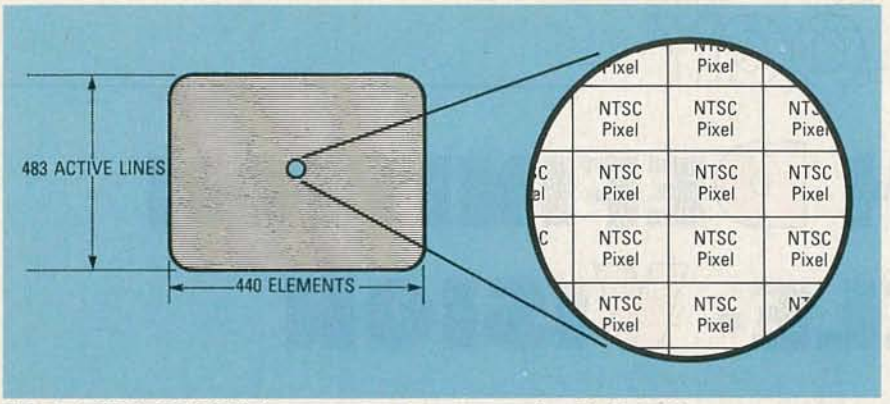

FIG. 1—THE NTSC PIXEL is represented as a rectangle of 1.46:1 ratio, corresponding to the present 4:3 NTSC aspect ratio.

The third category of the HDTV system is one that can be best categorized as the "no compromise" approach. That is, systems in this category are totally incompatible with the existing NTSC system used in this country. Generally speaking, these systems require extended bandwidth, but provide the greatest number of scan lines (1050 or 1125) and the greatest picture detail, both horizontally and vertically.

Any attempt to describe fully all of the proposed systems in all three categories would require more pages than are in this entire magazine. To give you some idea of the complexity and diversity of the ongoing HDTV debate, we will instead describe, briefly, one or two systems in each category.

HD-NTSC

An interesting and fully compatible system for a new high-definition NTSC broadcast system was proposed more than two years ago the The Del Rey Group, of Southern California. The system, dubbed HD-NTSC, can best be understood by regarding the smallest resolvable area of the NTSC picture as a "pixel," much as that term is used in referring to computer-screen resolution. In Fig. 1, the NTSC pixel is represented as a rectangle of 1.46:1 ratio, corresponding to the present 4:3 NTSC aspect ratio. A pixel, however, does not have to be rectangular or square in shape. It could be triangular, or even diamond shaped as shown in Fig. 2. One way to increase the number of addressable points of an image (and therefore the image detail) is to subdivide the pixels into smaller units, which might be called sub-pixels, as shown in Fig. 3.

Now, suppose a TV camera is able to scan only sub-pixel 1 during its first pass. After completing that frame 1/30 th of a second later, the camera scans again, this time hitting only sub-pixel-2 areas, and finally sub-pixel-3 areas. That approach is called a "Tri-Scan" technique. At the receiving end, a conventional NTSC receiver would not be aware of "sub-pixels" and would simply paint areas 1, 2 and 3 on top of each other as they come across in successive frames. A new, specially designed HD-NTSC TV set would reconstruct the same, higher detail image seen by the camera, placing the sub-pixels in their correct offset positions on the CRT. To change the aspect ratio, The Del Rey Group would simply "chop off" a few lines at the top and bottom of the existing NTSC line format, as illustrated in the comparison of Fig. 4. That arrangement would result in an aspect ratio of 14:9, as opposed to the present 4:3. As a side benefit, the HD-NTSC system creates 69 horizontal lines per frame that are no longer needed for the transmission of picture information. That new "data window" might well be made available for other information, such as encoded stereo digital audio!

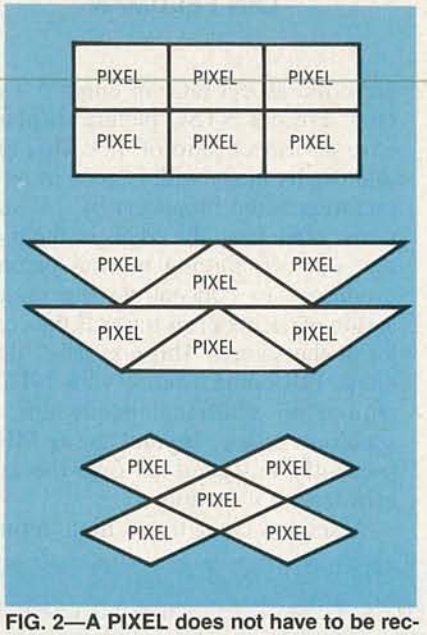

FIG. 2—A PIXEL does not have to be rectangular or square in shape. It could be triangular, or even diamond shaped.

ACTV

Originally introduced through the joint efforts by RCA, NBC, GE, and The David Sarnoff Research Center, ACTV was another system that was fully compatible with NTSC, in that it required only a single 6-MHz channel width for its implementation. Since then, the system has been divided into two systems, ACTV-1 (the original 6-MHz wide channel proposal) and ACTV-2, a system that remains compatible with NTSC but requires two full 6-MHz channels of bandwidth for its implementation. Here is how ACTV works: An original wide-

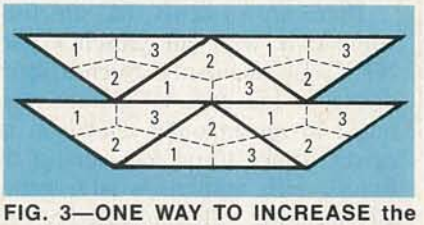

FIG. 3—ONE WAY TO INCREASE the number of addressable points of an image is to subdivide the pixels into smaller units, which might be called sub-pixels.

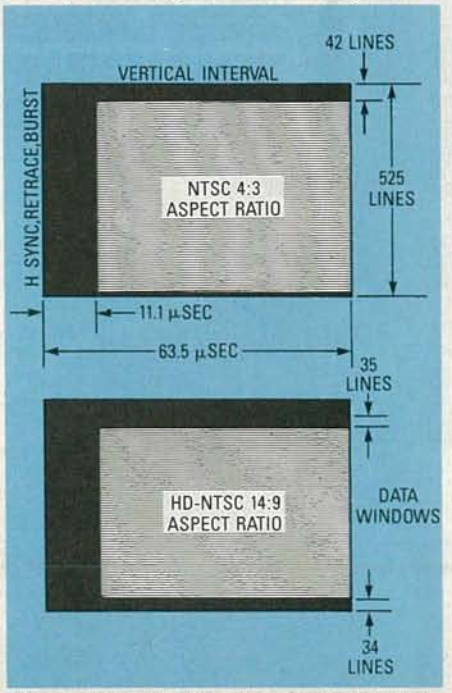

FIG. 4—TO CHANGE THE ASPECT RATIO, The Del Rey Group would chop off a few lines at the top and bottom of the existing NTSC line format.

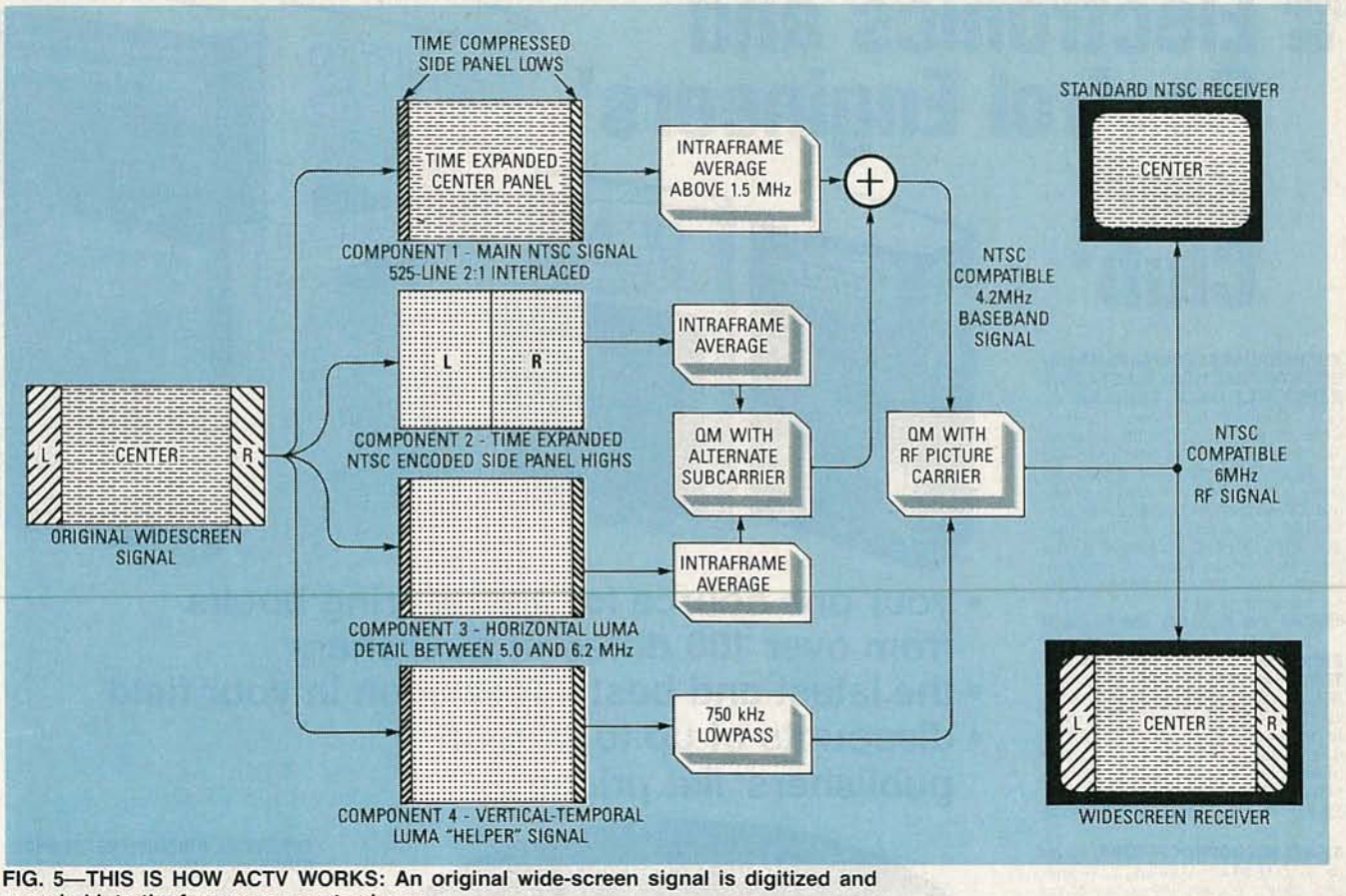

FIG. 5—THIS IS HOW ACTV WORKS: An original wide-screen signal is digitized and encoded into the four components shown.

screen signal, provided from any high-definition source, is first digitized at the studio and encoded into the four components shown in Fig. 5.

1: The first component is a main, NTSC-compatible, interlaced signal with the usual 4:3 aspect ratio. It consists of the central portion of the picture that has been time-expanded to nearly the entire active line time plus the side panel low-frequency horizontal information that has been time compressed into left and right horizontal overscan regions, where they would be hidden from view on most standard home receivers. This signal is color encoded in standard NTSC format.

2: There is an auxiliary 2:1 interlaced signal consisting of side panel high-frequency horizontal information that has been pre-comb-filtered, NTSC encoded, and time expanded to half the active line time. The time expansion reduces the horizontal bandwidth of this component to a little over 1 MHz.

3: The third component is an auxiliary 2:1 interlaced signal consisting of horizontal luminance detail between approximately 5.0 and 6.2 MHz. This band of frequencies is first shifted downward to the range of from 0 to 1.2 MHz.

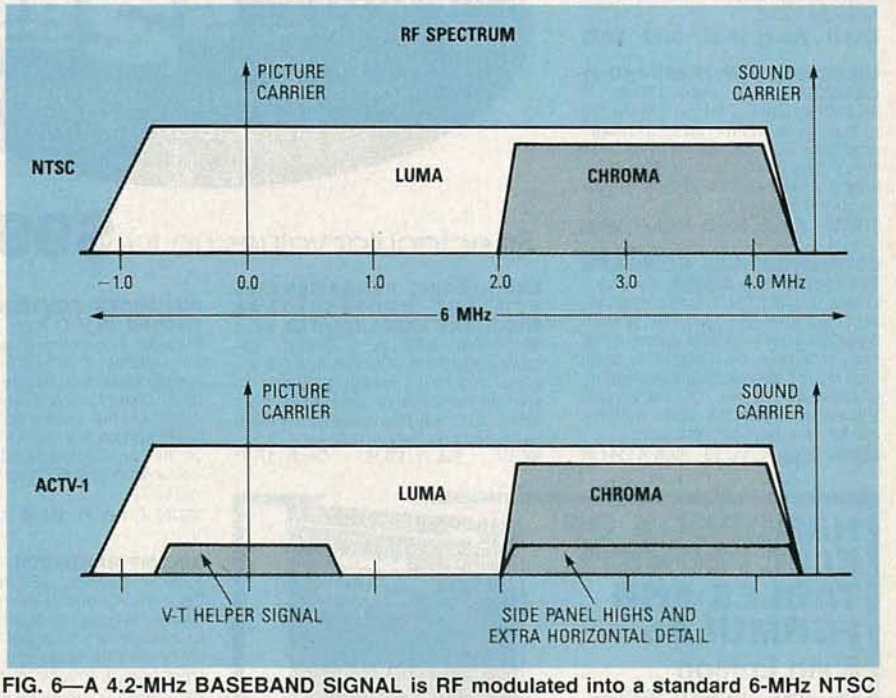

FIG. 6—A 4.2-MHz BASEBAND SIGNAL is RF modulated into a standard 6-MHz NTSC channel.

4: The fourth and last component is an auxiliary 2:1 interlaced "helper" signal, consisting of vertical-temporal (V-T) luminance detail that would otherwise be lost in the down conversion to 525-line interlace. On new, wide-screen receivers, this signal helps to reconstruct missing lines and to reduce or eliminate line flicker artifacts.

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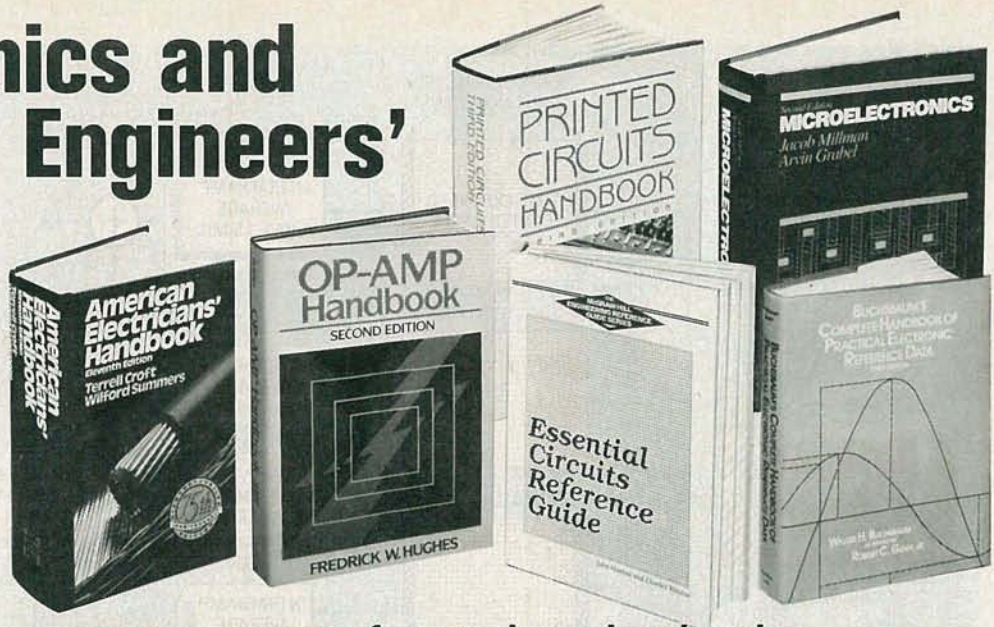

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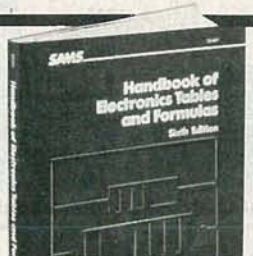

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FIG. 7—A WIDE-SCREEN RECEIVER recovers and equalizes the picture components and reconstructs the original wide-screen progressive scan signal.

Signal-components 1, 2 and 3 are passed through a special time-variant filter to eliminate V-T crosstalk between the main and auxiliary signals on a wide-screen receiver. The main signal is intra-frame averaged over all horizontal frequencies. Components 2 and 3 are amplitude-compressed in a non-linear manner, quadrature modulated on a phase-controlled subcarrier at 3.108 MHz, and added to component 1. The result is a 4.2-MHz baseband signal that is RF modulated into a standard 6-MHz NTSC channel, as shown in Fig. 6. Component 4, the VT "helper" signal, is modulated in quadrature with the main RF picture carrier.

When received on an existing NTSC receiver, only the central portion of the main signal is seen. A wide-screen receiver, such as that shown in Fig. 7, recovers and equalizes components 1–4 and reconstructs the original wide-screen signal. Relative to NTSC, the reconstructed signal has left and right side panels offering standard NTSC resolution and a central portion with superior horizontal and vertical luminance detail in the stationary sections of the picture.

While ACTV-1, just described, is delivered within the existing 6-MHz broadcast channel, a second version of the system, known as ACTV-2 is envisioned as well, when and if additional spectrum space is allocated. ACTV-2 would require an additional 6-MHz channel of bandwidth. As illustrated in Fig. 8, a TV station might someday transmit both ACTV-1 and ACTV-2 signals. Both systems would offer an aspect ratio (on new sets) of 5:3 or 16:9, and both would have 1050 lines per frame and 29.97 frames per second. However, ACTV-2 would offer still greater improvements in luminance resolution (650 horizontal and 800 vertical, as compared to 410 horizontal and 480 vertical for ACTV-1) and a doubling of chrominance resolution, which, in ACTV-1 is no better than in standard NTSC. The photos in the opening of this article show how a typical scene, transmitted in ACTV-2, would be viewed on a standard NTSC receiver (left) and how it would be seen on a new receiver equipped for ACTV-2 (right).

Philips HDS-NA

The abbreviation stands for *H*igh *D*efinition *S*ystem for *N*orth *A*merica, and the system, developed specifically for NTSC-TV based countries, would be usable on an equal basis for over-the-air broadcasting, CATV, direct-broadcast satellite or even fiber-optic transmission. The signal suitable for broadcasting or CATV has been dubbed HDNTSC and it consists of two major components. The first component carries the standard NTSC signal, while the second carries the additional information required to create the HDTV viewing experience.

As pointed out by Philips and others, an ideal HDTV system with double the present horizontal and vertical resolution and an increased aspect ratio would require about five times the bandwidth or spectral space of the current NTSC signal, or as much as 300 MHz! To reduce those impractical bandwidth requirements, various signal-processing schemes have been proposed by the various HDTV proponents. One class of signal processing is based upon combining several picture frames from both the "past" and "present" in the scene captured by the video camera. In our article last month, we discussed such basic picture-enhancement schemes under the general heading of IDTV, or *I*mproved *D*efinition *T*ele*V*ision systems. Philips has chosen a second approach that applies signal processing without the need for inter-frame picture information. The HDS-NA system can deliver 1.5 times the normal horizontal and vertical resolution of NTSC, wide aspect ratio, plus multiple channels of CD-quality digital sound.

The main HDNTSC signal carries NTSC and is a standard 6-MHz channel. The extra information needed to create the HDTV viewing experience can be transmitted eventually as a digital bit stream with a bandwidth of 3 MHz (or one half the extra width of a present-day NTSC channel). Philips has suggested that the signal energy

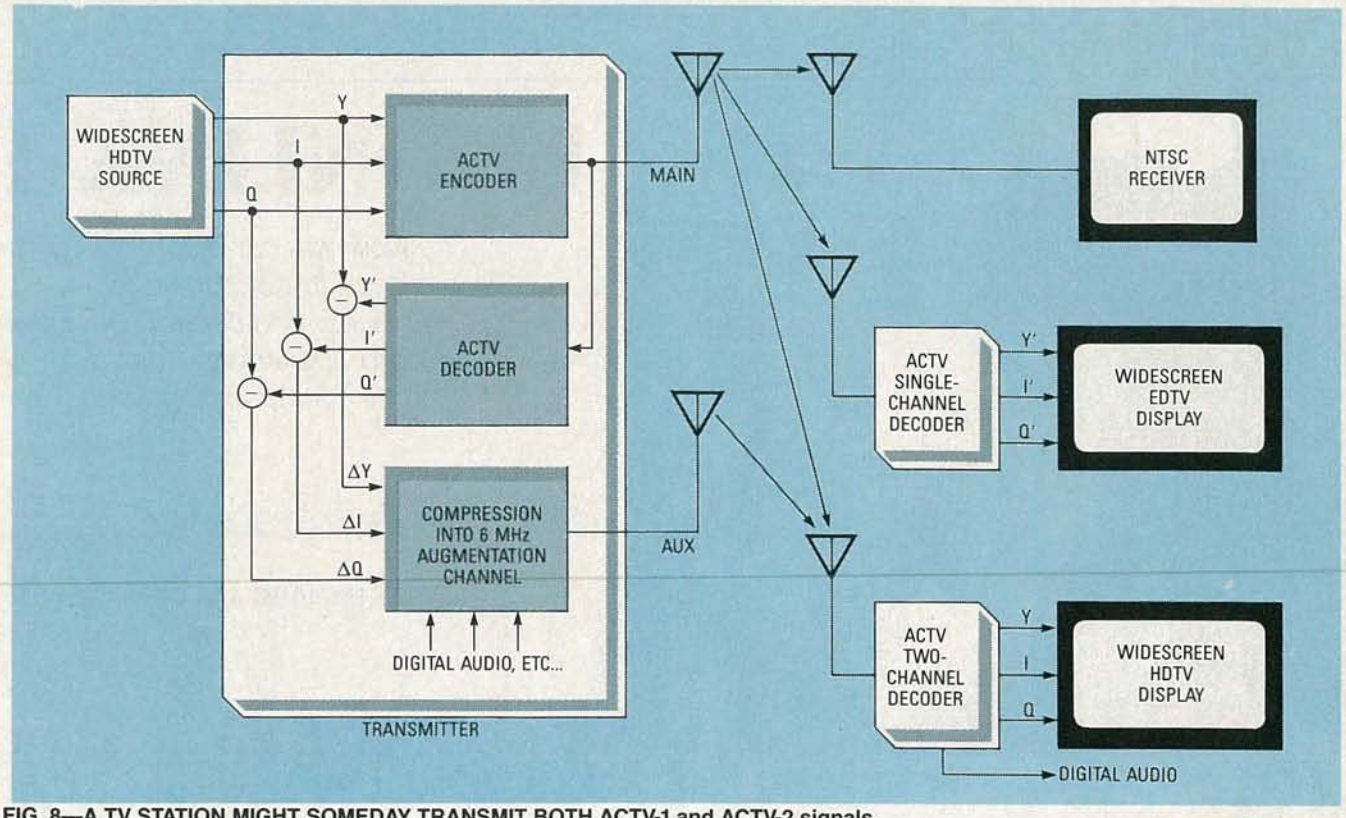


FIG. 8—A TV STATION MIGHT SOMEDAY TRANSMIT BOTH ACTV-1 and ACTV-2 signals. Both systems would offer an aspect ratio (on new sets) of 5:3 or 16:9, and both would have 1050 lines per frame and 29.97 frames per second.

of that extra augmenting channel can be well below the main NTSC signal level. That being the case, the extra signal might even be transmitted via the so-called "tabu" channels in each geographical area.

By "tabu" channels, we mean the TV channels that normally remain unassigned in a given area because they are adjacent to used channels. For example, if Channel 2 is assigned in a given city, Channel 3 remains unassigned. The same holds true for Channel 5 and 6, etc. (Channels 4 and 5, in the New York area, for example, are not really adjacent, as there is a 4-MHz space between them.) If Philips is correct about that, then in the New York area, for example, both Channel 2 and 4 might "share" Channel 3 for their augmentation channel; each using one half (3 MHz) of the otherwise unassigned channel spectrum. Using the tabu channels is not a necessary requirement for the Philips system—it is just one possibility. The augmentation channels could just as easily be positioned at other, noncontiguous frequencies which would have to be assigned for that purpose by the FCC if the Philips system were to prevail. As was true of ACTV, the Philips system is "backward compatible." Owners of older NTSC TV sets will continue to receive "normal" pictures while owners of newer sets designed for the HDS-NA system will receive the benefits of higher definition and a wider aspect ratio.

Battle Of Incompatibles

Finally, we come to the group of HDTV systems that are totally incompatible with our present day NTSC system (and, for that matter, with the PAL and SECAM systems used in other parts of the world). Aside from the incompatibility problems of these systems, there is also the problem of attempting to establish a world-wide

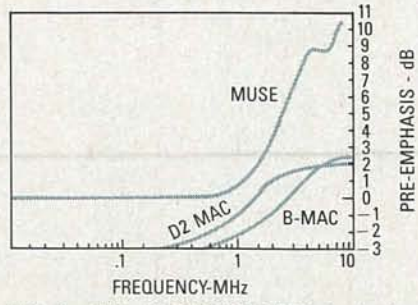


FIG. 9—ALL FORMS OF MAC, including MUSE, employ various amounts of pre-emphasis for the video signals.

standard for a no-compromise HDTV system. That problem arises primarily because of the fundamental difference in TV frame rates between U.S. (and Japanese) NTSC and European PAL. The European frame rate is 25 frames per second while the NTSC frame rate is 30 frames per second.

That difference is a throwback to the early days of TV, when scanning fields were synchronized to the power-line frequencies used (50 Hz in Europe, 60 Hz in North America and many sections of Japan). Today, much more sophisticated systems of vertical synchronization are in use, but, unfortunately, the standard frame rates are well entrenched in their respective counties. Thus, it may well be that two "world" standards may evolve for no-compromise, incompatible HDTV. The European proposal is for a 2:1 increase in number of lines per picture and a doubling of the pixel density or horizontal resolution with respect to their present broadcast systems. The Europeans would retain their present frame rate of 25 Hz. However, much work has already been done to reduce the large area flicker problem that is so noticeable to

continued on page 111

BUILD THIS

PHONLINK II

Now you can telephone home, listen to household voices, and control your lights and appliances—using any Touch-Tone *phone.*

JANET McNABB and GENE ROSETH

THE ORIGINAL PHONLINK WAS INTRODUCED in the May and June 1987 issues of **Radio-Electronics**. Back then, the Phonlink allowed you to control anything electrical by using a *Touch-Tone* telephone. The only drawback was having to run separate wires to each electrical device to be controlled. The Phonlink II improves on the original design by encoding the *Touch-Tone* commands (from any telephone) onto your household 120-volt AC power line, thereby eliminating the need for external wiring. Those encoded commands are received by any of the common AC plug-in control units that use the *X-10* system, (such as those from Radio Shack, Sears, Leviton, and others) which then switch the desired equipment on or off—thereby eliminating the need for clumsy homemade relay assemblies. Here's an example to illustrate how the Phonlink II works.

Let's suppose you're working late at the office and wish to turn on the exterior security lights of your home. You pick up the telephone, dial your home number and wait for Phonlink II to answer the phone. As its speech synthesizer prompts you, *Touch-Tone* enter your access code, then enter the control codes that instruct Phonlink II to turn on the security lights. Phonlink II verbally acknowledges your request, and outputs a control signal

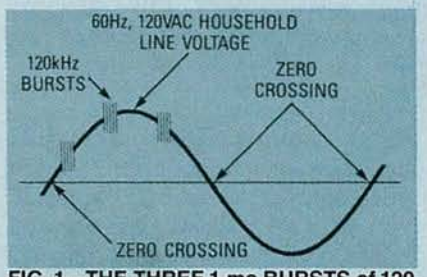


FIG. 1—THE THREE 1-ms BURSTS of 120-kHz frequency are precisely timed to coincide with the 60-Hz line-voltage zero-crossover points.

over the 120-volt AC power line in your home. That signal is received by the standard *X-10* AC plug-in module, which connects power to the security lights.

X-10 plug-in modules

The Phonlink II output signals are compatible with the standard *X-10 Powerhouse* code format, the *de facto* home-control communications standard. Most, if not all, of the household (power-line carrier) home-control systems use the *X-10* modules developed and manufactured by X-10 (USA), Inc., 185A LeGrand Ave., Northvale, NJ 07674, phone (201) 784-9700 or 1-800-526-0027. Compatible systems manufactured and supplied by X-10 (USA) are sold under the name of Radio Shack's *Plug'n Power system*, Sears' *Home Control System*, Leviton's *Decora Electronic Controls*, and Stanley's *LightMaker Home Controls*, and many others.

X-10 Code transmission

Notice that there are two Phonlink II communication paths: First, there's

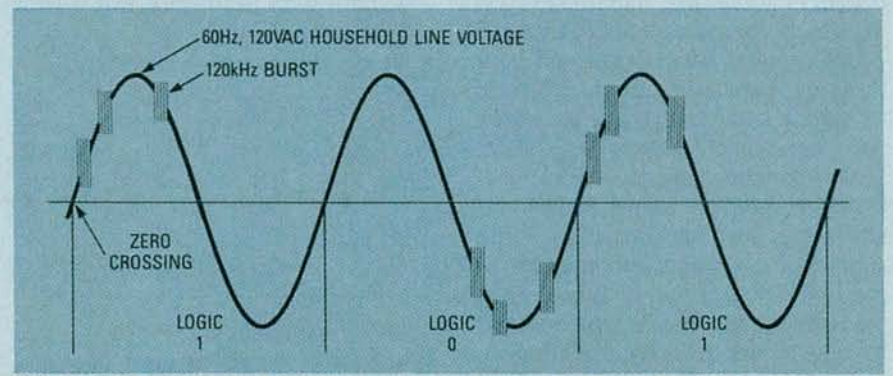
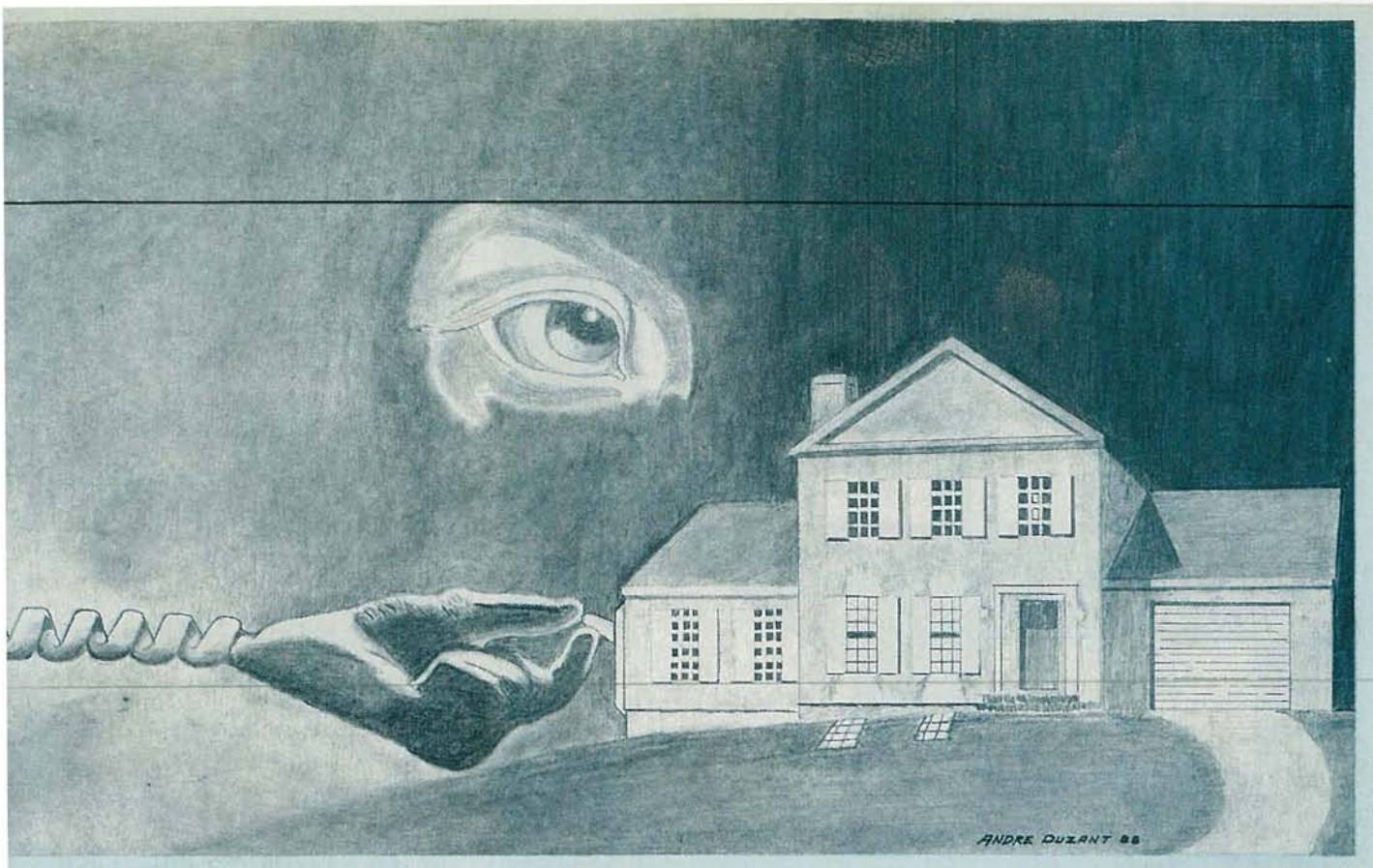


FIG. 2—THE ENCODED LOGIC depends on whether the three 120-kHz bursts are impressed on the positive or negative side of the household voltage.



the communication between you and the Phonlink II system (which includes *Touch-Tone* telephone codes, and Phonlink II's voice-synthesized statements); then there's the control signals between the Phonlink II and the standard *X-10* plug-in modules over the AC wiring. Let's now go into more detail on how the Phonlink II interacts with the *X-10* plug-in modules.

As shown in Fig. 1, the Phonlink II encoded signals consist of a series of three 1-ms 120-kHz bursts, which are impressed onto the household single-phase 60-Hz power line. Even though a typical residential home uses a single-phase electrical system, the *X-10* PLI-513 module will impress a 120-kHz burst at what would be the zero-crossover points in a three-phase system; that's why the actual *X-10* code has three 1-ms 120-kHz bursts. In a three-phase electrical system, each phase is 120 degrees apart. However, a closer study of the three 60-Hz phases will show that the actual zero-crossover points occur every 60 degrees—for example, at exactly 0°, 60°, again at 120°, and so on.

Figure 2 shows a practical scheme for encoding data onto the single-phase 60-Hz power line. A logic "1" is represented by three 1-ms 120-kHz bursts on the positive half cycle, followed by no bursts on the negative half cycle. A logic "0" is represented by just the opposite. As shown in Fig. 3, a complete instruction sequence consists of 11 cycles of the power line: 2 cycles for a *start* code, 4 cycles for the *house* code, followed by 5 cycles of *number* code, or 5 cycles of a *function* code. Each sequence is repeated to ensure reliability.

When Phonlink II transmits a complete command it takes a total of 44 cycles: two 11-cycle sequences of number code, and two 11-cycle sequences of function code. That selects the particular plug-in module, and what the module should do. The *X-10* receiver modules require a silence of 3 cycles of the power line between each 11-cycle sequence of code.

Table 1 lists all the house codes, the number codes, and the function codes defined by the *X-10* standard. Phonlink II uses house code F, number codes 1–5, and function codes ON and OFF. The software allows the house code to be changed easily if necessary.

The PLI Module

Figure 4 shows the PLI-513 (*P*ower *L*ine *I*nterface) module. The *X-10* code transmissions must be synchronized to the zero-crossing point of the AC-power line. How that's done is quite simple. The PLI provides a zero-crossing reference signal (60-Hz square wave) through the black wire at pin 1, which is derived from an opto-coupler directly con-

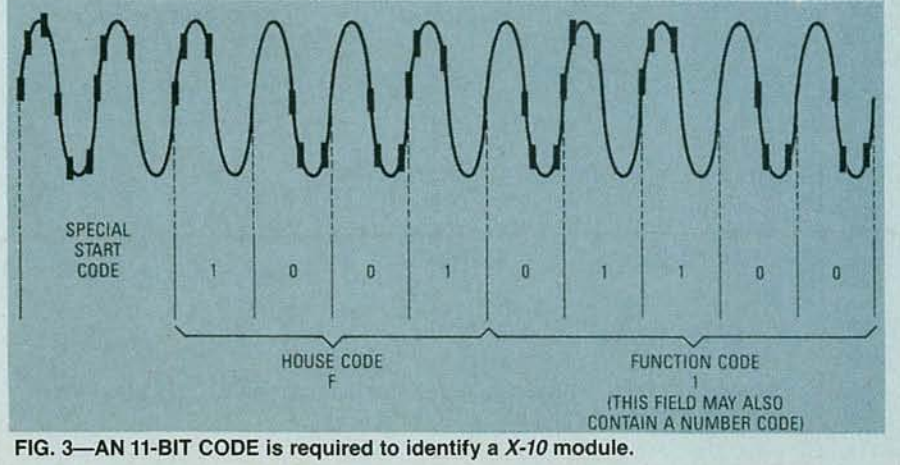


FIG. 3—AN 11-BIT CODE is required to identify a *X-10* module.

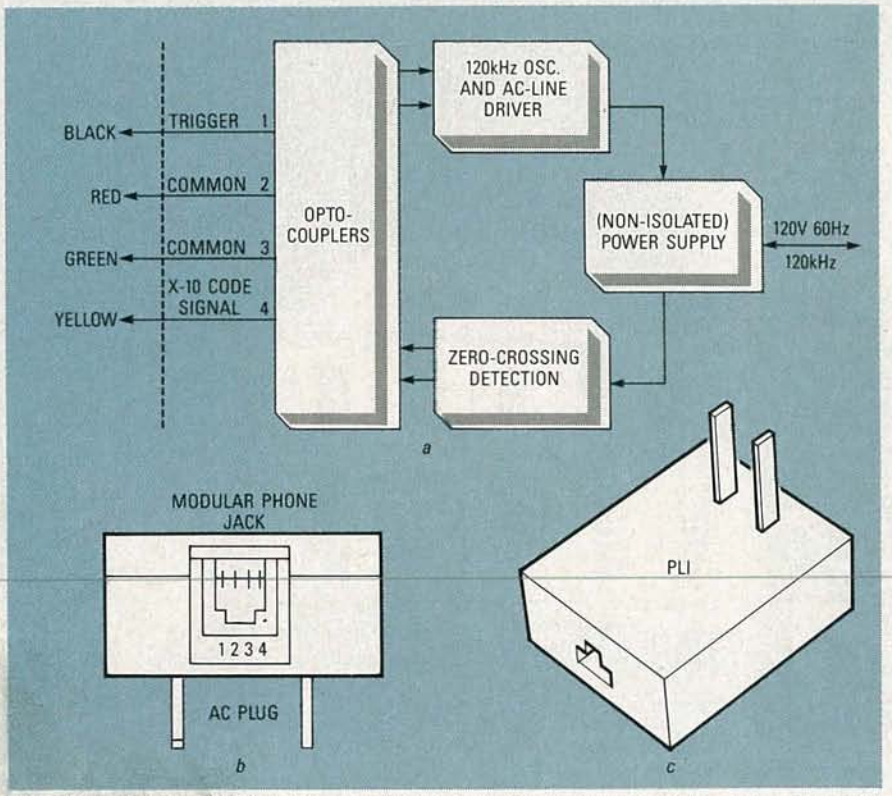


FIG. 4—In *(a)*, the PLI (*P*ower *L*ine *I*nterface) module impresses the *X-10* code onto household voltage, and communicates with the Phonlink II; *(b)* shows the PLI's modular phone-jack and AC wall plug, and *(c)* shows the PLI as viewed from the back.

nected to the AC line. (It is not desirable to derive the zero-crossing from a power-transformer's secondary because some phase shifting is likely to occur.) When Phonlink's II microprocessor detects the zero-crossing trigger, the software-generated *X-10* code will be sent through the yellow wire to pin 4 of the PLI module. The PLI 120-kHz oscillator is free-running, and is gated onto the AC line voltage (through an isolating tuned circuit) by the *X-10* code signals.

The PLI has a power-on LED that also doubles as a transmission-status LED. The LED is normally *on* to indicate the presence of power, and blinks off to indicate that a signal is being transmitted.

The power supply for the PLI is derived from a rectifier and capacitor filter that is directly referenced to the 120-volt AC power line. The zero ref-

TABLE 1

HOUSE CODES	NUMBER CODES	FUNCTION CODES
A– 0110	1– 01100*	ON– 00101*
B– 1110	2– 11100*	OFF– 00111*
C– 0010	3– 00100*	ALL ON– 00011
D– 1010	4– 10100*	ALL OFF– 00001
E– 0001	5– 00010*	DIM– 01001
F– 1001*	6– 10010	BRIGHT– 01011
G– 0101	7– 01010	
H– 1101	8– 11010	
I– 0111	9– 01110	
J– 1111	10– 11110	
K– 0011	11– 00110	
L– 1011	12– 10110	
M– 0000	13– 00000	
N– 1000	14– 10000	
O– 0100	15– 01000	
P– 1100	16– 11000	

*Code used by PHONLINK II

NOTE: Receiver modules require a "silence" of at least 3 cycles of the power line between each instruction sequence.

PARTS LIST

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

R1—100,000 ohms
R2—250 ohms, 1%
R3—10,000 ohms, 1%
R4, R17, R24, R27, R32, R34, R35—10,000 ohms
R5–R9, R19, R36, R40, R42, R44, R46, R48, R50, R52—33,000 ohms
R10, R15, R38—47,000 ohms
R11, R12, R14—1000 ohms
R13, R20, R21—220,000 ohms
R16, R28, R54, R55—1 megohm
R18, R25—22,000 ohms
R22—330,000 ohms
R23, R30, R31, R33,—100,000 ohms
R26—100 ohms
R29—100 ohms, ½-watt
R37—470 ohms
R39, R41, R43, R45, R47, R49, R51—51,000 ohms
R53—39,000 ohms
R56—150 ohms

Capacitors

C1, C6, C13–C15, C17–C22—.1 μF, ceramic disc
C2, C8, C10—1 μ, molded monolithic ceramic
C3, C4—0.022 μF, dipped-polyester film
C5, C11—10 μF, 16 volts, dipped tantalum
C7—2.2 μF, 35 volts, dipped tantalum
C9, C26—33 μF, 16 volts, solid tantalum
C12—0.1 μF, 200 volts, orange-drop polyester film
C16—4700 μF, 16 volts, electrolytic
C23—470 μF, 16 volts, electrolytic
C24, C25—22 pF, ceramic disc

Semiconductors

IC1—TMPZ84COOP, CMOS Z80 (Toshiba)
IC2—8255A, PIO
IC3—SPO256-AL2, speech synthesizer
IC4—74C04, hex CMOS INVERTER
IC5—74C02, quad CMOS NOR
IC6—27C64, 8K CMOS EPROM
IC7—74C32, quad CMOS OR gate
IC8—ADC0809CCN, A/D converter
IC9—LM324Z, precision current reference
IC10—M-956, DTMF decoder (Teltone)

PARTS LIST

IC11, IC22—unused
IC12, IC15—TLC271, programmable op-amp
IC13—LM324, quad op-amp
IC14—4066, quad analog switch
IC16–IC19—4N32A, opto-isolator
IC20—LM7805CK, 5-volt regulator, TO3 case
IC21—LM7805CT, 5-volt regulator, TO220 case
BR1— 200 volts, bridge rectifier, ½ amp
BR2—50 volts, bridge rectifier, ½ amp
LED1—(*L*ight *E*mitting *D*iode) red
D1, D3–D5—1N914, switching diode
D2—unused
D6–D8—1N5245B, 15 volt, ½-watt Zener diode
Q1—2N2222, NPN small-signal transistor

Other components

F1—125 volts, ½ amp, pigtail leads
MIC1— electret microphone (Radio Shack 270-092B or equivalent)
RY1—relay, 5 volts, 70 mA, (Radio Shack 275-243 or equivalent)
SO1—32-pin edge-card connector
SO2—16-pin DIP socket
T1—12.6 volts, 0.6 amp (Tria F-158XP)
XTAL1, XTAL2—3.58 MHz

Modification parts

Q2—2N2222A transistor
R57—5600 ohms, ¼-watt resistor
R58—3300 ohms, ¼-watt resistor
IC6—27C64 EPROM (KPL-3A)
PLI—(*P*ower *L*ine *I*nterface) *X-10* (USA) Model PL513

Note: The following items are available from STG ASSOCIATES, 2705-B Juan Tabo Blvd., N.E. # 117, Albuquerque, NM 87112: modification kit to update PHONLINK to PHONLINK II (MKPL-1), $30; PHONLINK II complete updated kit, all parts, cabinet and documentation (KPL-1A), $220; updated PC board only (KPL-2A), $36; programmed EPROM (KPL-3A),$19; source code print out (KPL-4A), $10; Please add 5% for postage and handling (10% Foreign). New Mexico residents add appropriate sales tax.

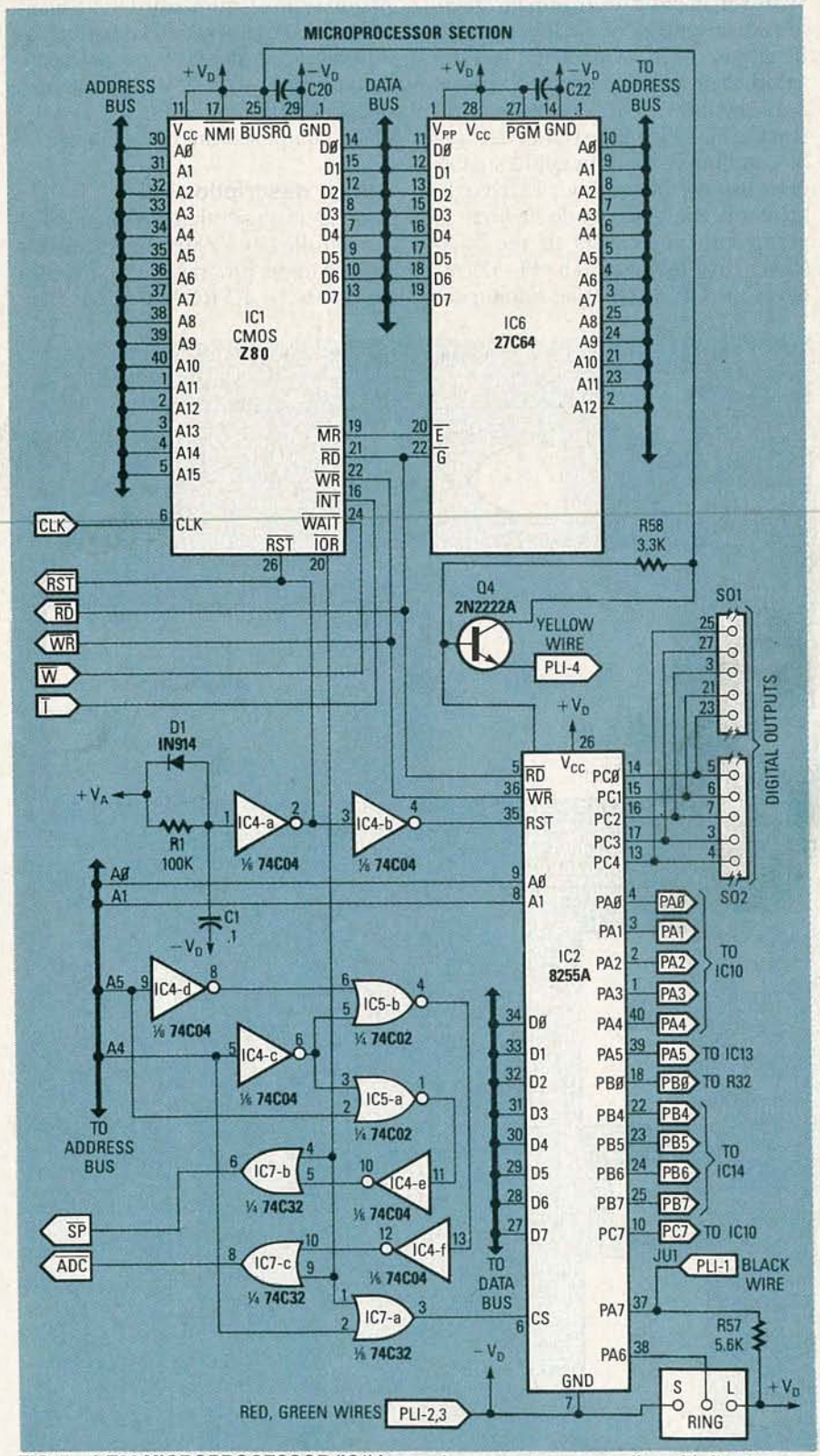


FIG. 5—A Z80 MICROPROCESSOR (IC1) is used as a system controller with its programming contained in an EPROM (IC6).

erence in the PLI is directly connected to the 120-volts AC. DC isolation is one reason why opto-couplers are used between the PLI and Phonlink II connections. Therefore: For safety, an isolating transformer must be used (between the PLI and the AC line) when attempting any internal PLI measurements. The isolating transformer, together with the PLI's diode rectifier and capacitor filter will provide a stable reference ground; that way, there can be no confusion as to which side is ground and which side is power. It's easy to be confused about which side is ground, because the PLI-513 module can easily be plugged in upside down, or your household wiring to that outlet may be wired backwards.

The *X-10* code format is patented.

However, in order to encourage others to take advantage of the large installment base of *X-10* modules, and develop their own systems to control *X-10* modules, X-10 (USA), Inc. offers the PL-513 as a cost-effective way of coupling *X-10*-compatible signals onto the AC power line. License to transmit the *X-10* code format is granted to purchasers of the *X-10* Power Line Interface. The PL-513 relieves the OEM (*O*riginal *E*quipment *M*anufacturer) from any UL (*U*nderwriters *L*aboratory) considerations as all power-line connections are taken care of by X-10 (USA), and all connections between the PL-513 and the OEM equipment are opto-coupled.

Circuit description

Figure 5 shows that the Phonlink II is controlled by a Z80 microprocessor (IC1) with its program code stored in an 8K-byte EPROM (IC6). The 8255A PIO (*P*arallel *I*nput *O*utput) contains three 8-bit ports that interface digital I/O circuits from the real world to the microprocessor.

In Fig. 6, the speech synthesizer SPO256 (IC3) works by storing the fundamental sounds of speech called phonemes. The microprocessor causes the speech synthesizer to output individual phonemes along with their appropriate delays to form complete words and phrases. The speech synthesizer, DTMF (*D*ual *T*one *M*ulti-*F*requency) M-956 (IC10), and also the built-in electret microphone (MIC1) all interface to the telephone line via a 4066 analog switch (IC14), and a few op-amps, opto-isolators, and a bridge rectifier.

The ADC0809 (IC8) analog-to-digital converter has eight analog inputs: Seven inputs are user-definable; however, the eighth is connected to a built-in temperature reference, IC9, an LM334. Just call your home, ask Phonlink II for the room temperature by keying in the correct function code, and a digitally synthesized voice will tell you the temperature. That's a great feature if you're worried about your water pipes freezing in the winter; or better yet, keeping a certain room in your home cool during the summer months for your loving pet, who you'd like to pamper. It's a comfort to know that you can control almost everything while away from home through any *Touch-Tone* phone.

The A/D converter is a successive-approximation type with a resistor voltage-divider connected to each of the first seven inputs (pins 1–4 and 26–28). The divider ratio will allow the Z80 to translate a 0–5-volt input to a 1–100 percent output. For other input-voltage ranges, those resistors must be changed accordingly.

In Fig. 7, the bridge-rectifier BR1 will provide a positive and negative voltage output in the proper orientation regardless of whether the tip and ring phone lines are connected in backward or forward. Relay RY1 serves as the hook switch, which is equivalent to the cradle switch on any telephone. The relay is controlled by Q1, which in turn is controlled via the PIO by the Z80. When the relay is engaged, the output of the speech synthesizer is optically coupled through IC19, which impresses an audio signal onto the DC-biased bridge rectifier. The audio then travels out the phone line.

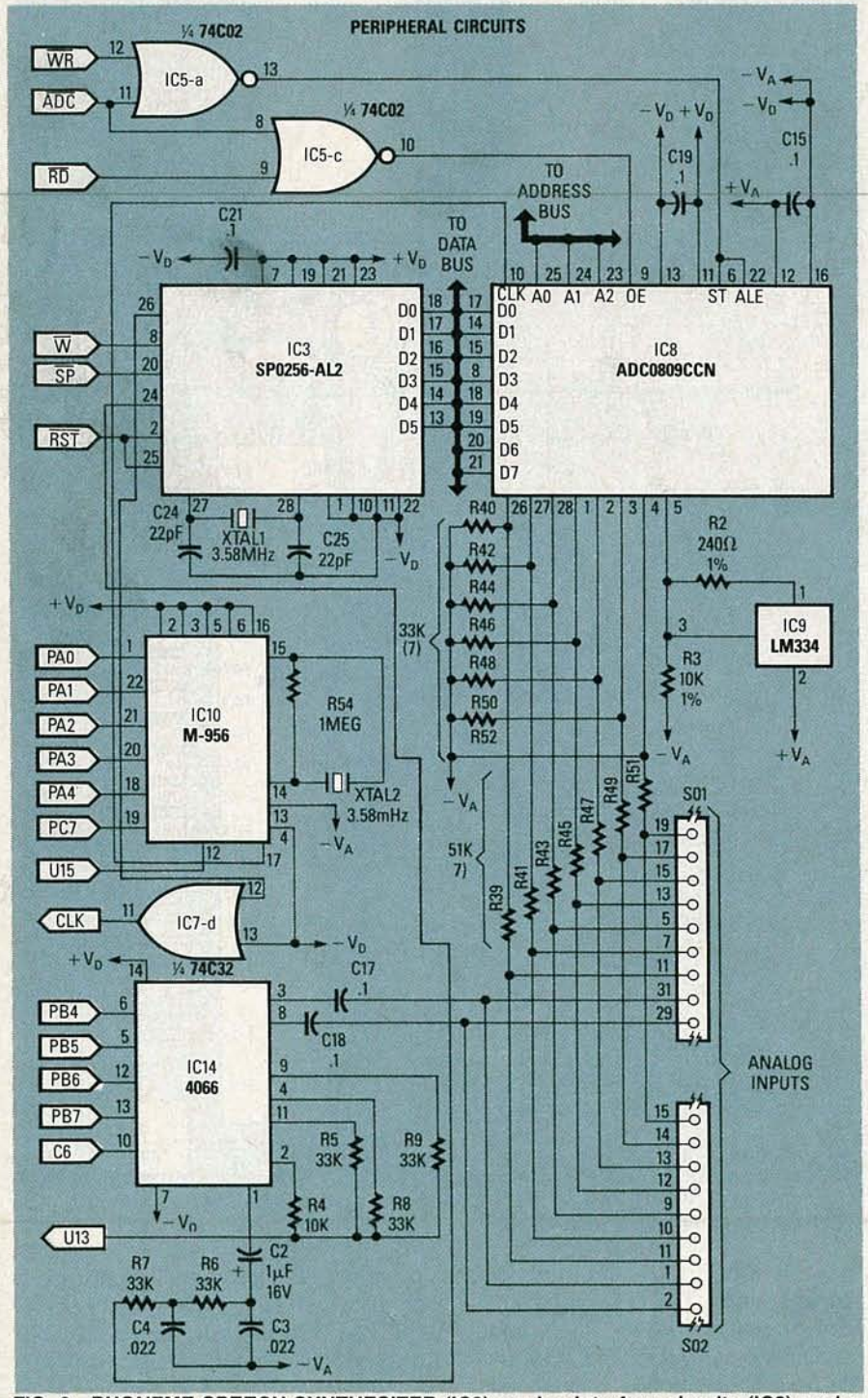


FIG. 6—PHONEME SPEECH SYNTHESIZER (IC3), analog interface circuits (IC8), and a DTMF decoder (IC10) are shown here.

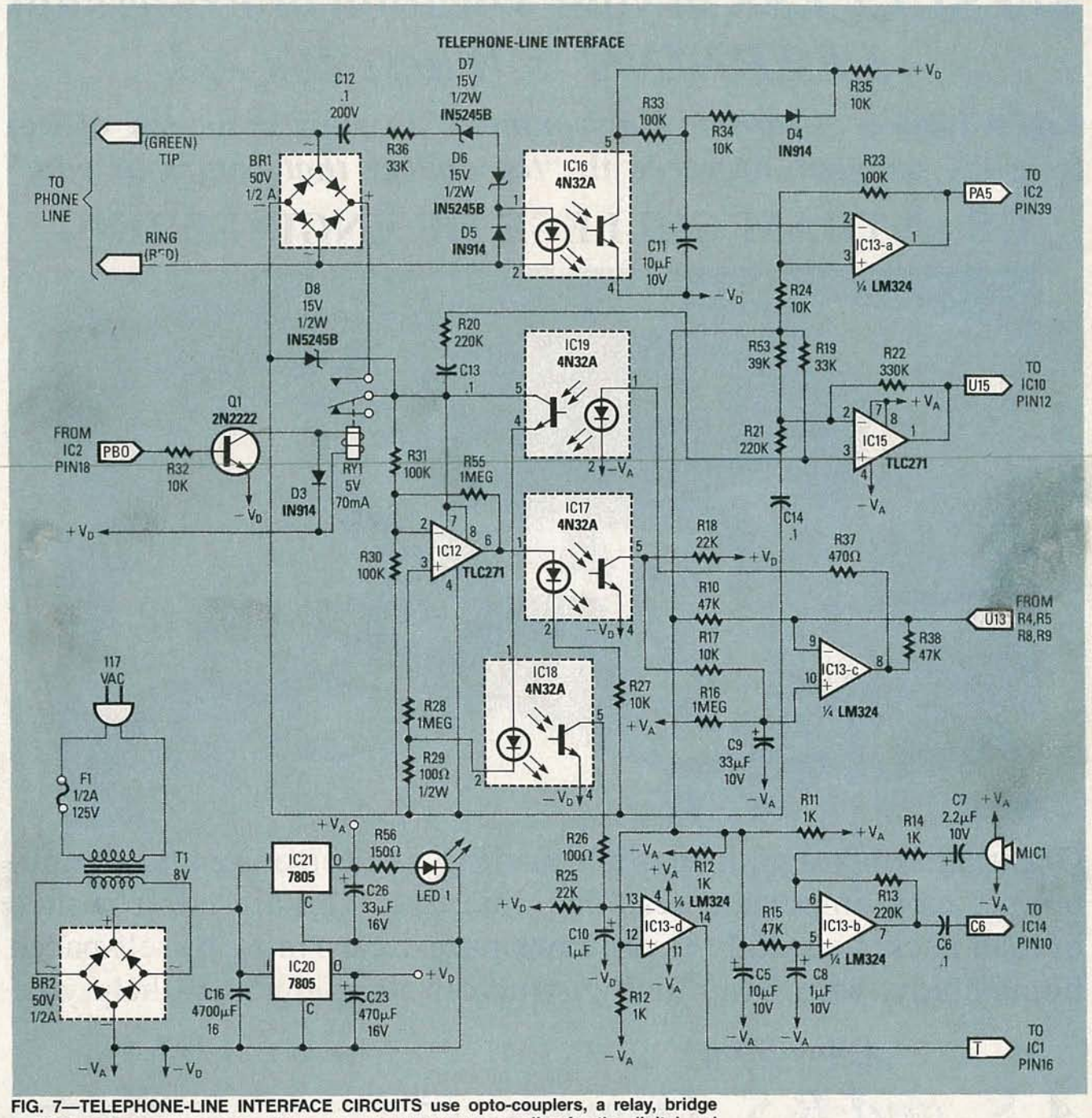


FIG. 7—TELEPHONE-LINE INTERFACE CIRCUITS use opto-couplers, a relay, bridge rectifier, and several op-amps. There are separate power supplies for the digital and analog circuits.

Telephone-line isolation is achieved through using opto-isolators. For example, opto-isolator IC16 and its associated passive components comprise the ring detector. Each time a ring occurs, it causes a negative-going pulse at IC16 pin 5, which is applied to IC13 pin 2. The output of that op-amp is then applied to the PIO, where it can be detected by the Z80 microprocessor.

The purpose of opto-coupler IC18 is to detect the disconnect pulse from the telephone exchange if the caller decides to hang up. That pulse sends an interrupt to the microprocessor, which then terminates the communication.

A closed-loop feedback circuit is composed of IC12, IC17, IC19, IC13-c, and the C9/R16 low-pass filter helps stabilize the sensitive op-amp circuitry and compensate for changes in circuit parameters that may be caused by slight variations in component temperatures.

Notice that there are two separate 5-volt power supplies: one for the analog and one for the digital circuits. Now you know why the power connections to some IC's in the previous figures are labeled $\pm V_D$ and others labeled $\pm V_A$. The analog and digital ground are connected together only at one point; otherwise, the analog and digital grounds use separate runs around the board.

That's all we have space for now. However, we'll continue next month with a discussion on the software, and the modifications necessary to get Phonlink II up and running. **R-E**

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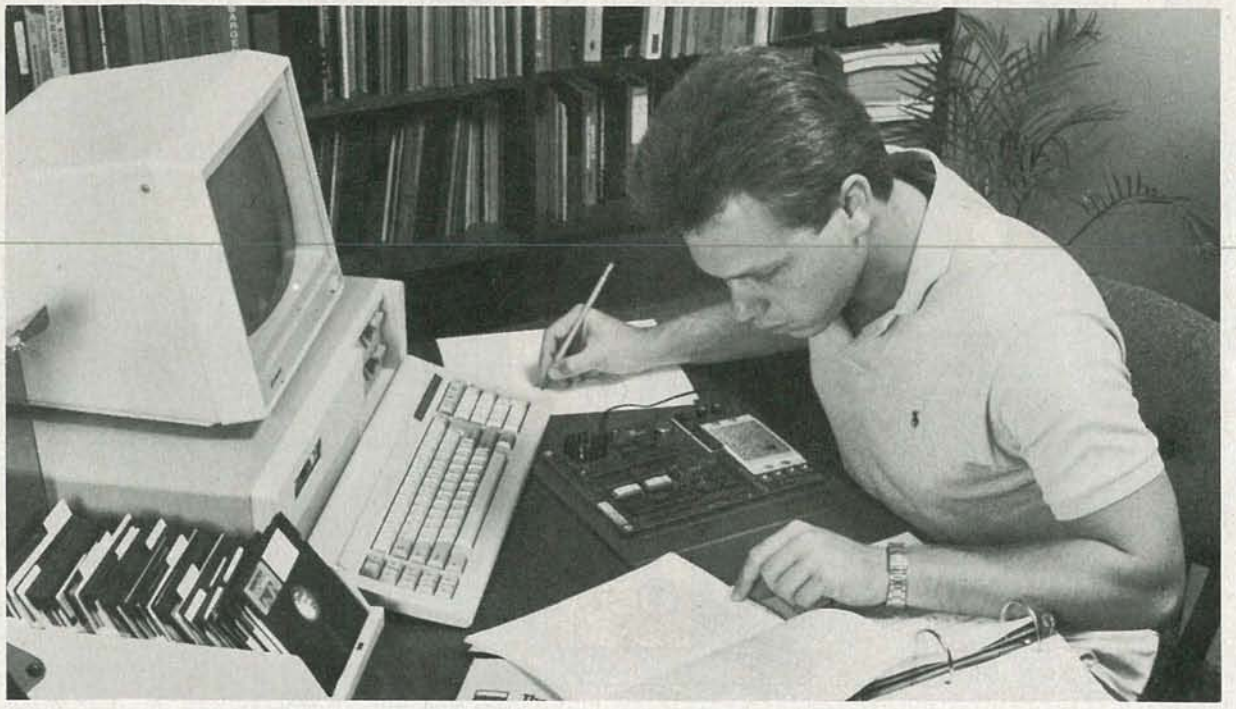

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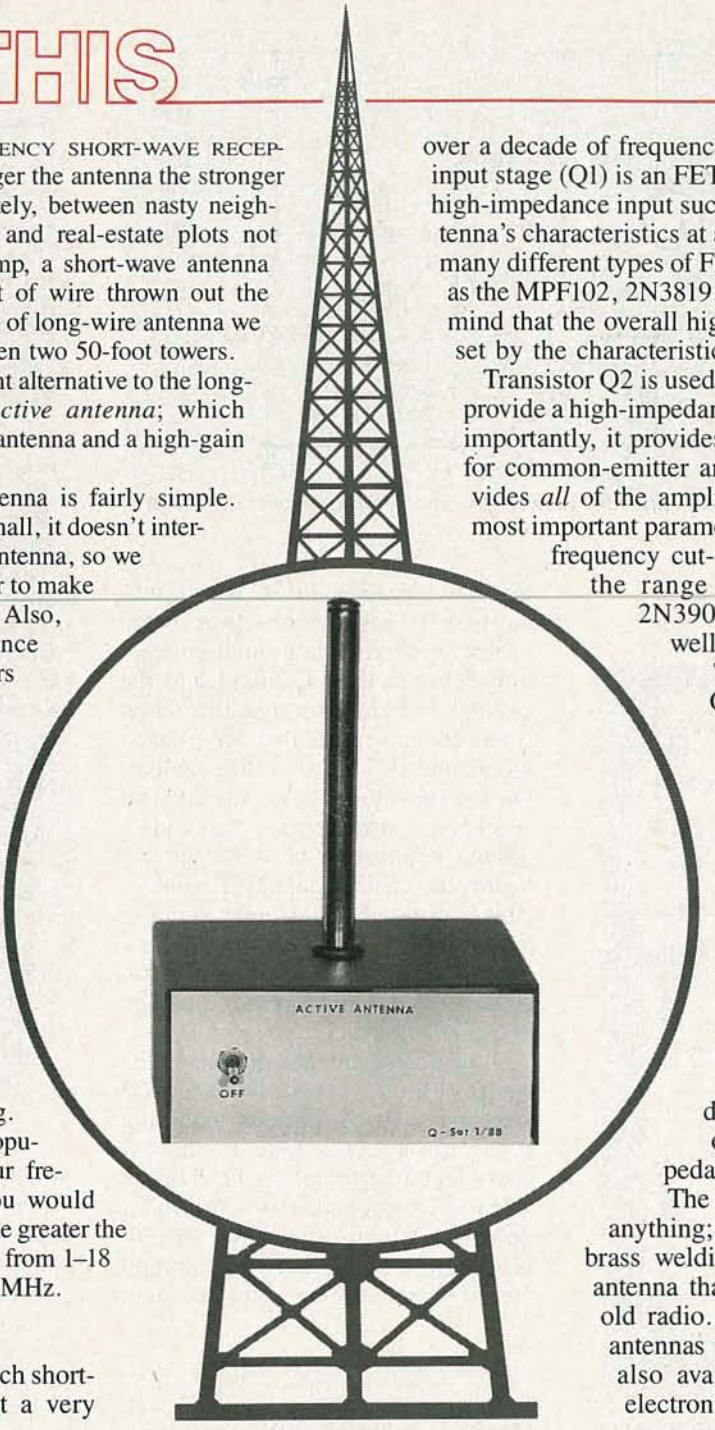

FOR CONVENTIONAL ALL-FREQUENCY SHORT-WAVE RECEPTION, the general rule is "the longer the antenna the stronger the received signal." Unfortunately, between nasty neighbors, restrictive housing rules, and real-estate plots not much larger than a postage stamp, a short-wave antenna often turns out to be a few feet of wire thrown out the window—rather than the 130 feet of long-wire antenna we would really like to string between two 50-foot towers.

Fortunately, there's a convenient alternative to the long-wire antenna, and that's an *active antenna*; which basically consists of a very short antenna and a high-gain amplifier.

The concept of an active antenna is fairly simple. Since the antenna is physically small, it doesn't intercept as much energy as a larger antenna, so we simply use a built-in RF amplifier to make up for the apparent signal "loss." Also, the amplifier provides impedance matching, because most receivers are designed to work with a 50-ohm antenna.

Active antennas can be built for any frequency range, but they are more commonly used from VLF (10 kHz or so) to about 30 MHz. The reason for that is because full-size antennas for those frequencies are often much too long for the available space. At higher frequencies, it is quite easy to design a relatively small high-gain antenna.

The active antenna shown in Fig. 1 provides 14–20 dB gain at the popular short-wave and radio-amateur frequencies of 1–30 MHz. As you would expect, the lower the frequency the greater the gain. A gain of 20 dB is typical from 1–18 MHz, decreasing to 14 dB at 30 MHz.

Circuit design

Because antennas that are much shorter than ¼ wavelength present a very small and highly reactive impedance that is dependent on the received frequency, no attempt was made to match the antenna's impedance—it would prove too difficult and frustrating to match impedances over a decade of frequency coverage. Instead, the input stage (Q1) is an FET source-follower, whose high-impedance input successfully bridges the antenna's characteristics at any frequency. Although many different types of FET's may be used—such as the MPF102, 2N3819, or the 2N4416—bear in mind that the overall high-frequency response is set by the characteristics of the FET amplifier.

Transistor Q2 is used as an emitter-follower to provide a high-impedance load for Q1, but more importantly, it provides a low drive impedance for common-emitter amplifier Q3, which provides *all* of the amplifier's voltage gain. The most important parameter of Q3 is f_T, the high-frequency cut-off, which should be in the range of 200–400 MHz. A 2N3904, or a 2N2222 works well for Q3.

The most important of Q3's circuit parameters is the voltage drop across R8: The greater the drop, the greater the gain. However, the passband decreases as Q3's gain is increased.

Transistor Q4 transforms Q3's relatively moderate output impedance into a low impedance, thereby providing sufficient drive for a receiver's 50-ohm antenna-input impedance.

The antenna can be almost anything; a long piece of wire, a brass welding rod, or a telescopic antenna that was salvaged from an old radio. Telescopic replacement antennas for transistor radios are also available from most retail electronic-parts distributors.

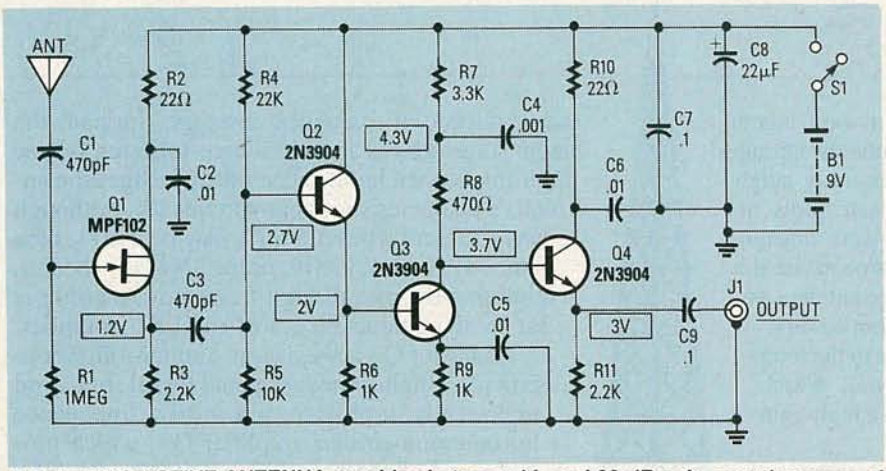

FIG. 1—THIS ACTIVE ANTENNA provides between 14- and 20-dB gain over the range of 1–30 MHz.

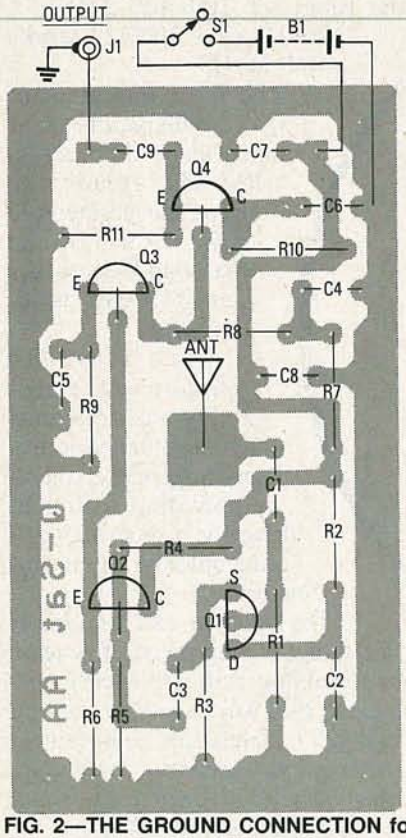

FIG. 2—THE GROUND CONNECTION for J1 is the metal cabinet. The cabinet is connected to the PC board's ground by the metal spacers at each mounting screw.

Construction

The amplifier for the prototype unit uses a printed-circuit board, for which a template is provided in "PC Service." The amplifier can be assembled on a perforated wiring board, but because there is *some* sensitivity to the parts layout, we strongly suggest that you use a PC board for best results.

The parts-placement diagram is shown in Fig. 2. Take note that although the battery's negative (ground) lead is returned to the PC board, output-jack J1 has a connection to the cabinet ground. The ground connection between the PC board and the cabinet is made through the metal standoffs or spacers that are used to mount the PC board in the cabinet. Do not substitute plastic standoffs or spacers because they won't provide a ground connection between the PC board, the cabinet, and J1. If you decide to use a plastic cabinet to house the amplifier, make certain that J1's ground connection is returned to the ground foil running around the edge of the PC-board.

A telescopic antenna mounts in the center of the PC board. From the foil side of the board, pass its mounting screw through the hole in the PC board and then solder the head of the screw to its foil pad. For both insulation and support, use a plastic or rubber grommet between the antenna and the hole in the cabinet's cover through which the antenna passes. In a pinch, several turns of a good-quality plastic tape wrapped around the antenna's shaft can be substituted for the rubber grommet.

If you decide to make provision for a wire antenna, install a 5-way binding post on the cabinet. Then, be sure to connect a short length of wire between the antenna's foil pad and the binding post.

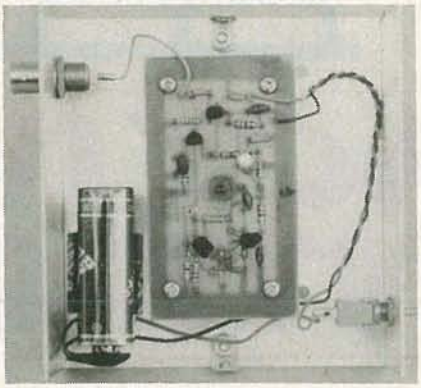

FIG. 3—THE AMPLIFIER IS SO SMALL that it almost gets lost in a 4-inch × 4-inch metal cabinet. The battery is held in place with a U-clamp. The output jack is anything that matches the receiver's antenna connection.

PARTS LIST

Resistors ¼-watt, 10%
R1—1 megohm
R2, R10—22 ohms
R3, R11—2200 ohms
R4—22,000 ohms
R5—10,000 ohms
R6, R9—1000 ohms
R7—3300 ohms
R8—470 ohms
Capacitors rated at least 16-WVDC
C1, C3—470 pF
C2, C5, C6—0.01 µF
C4—0.001 µF
C7, C9—0.1 µF
C8—22 µF, electrolytic
Semiconductors
Q1—FET, MPF102 or 2N3918 (see text)
Q2, Q3, Q4—NPN transistor, 2N3904, or equivalent
Other components
B1—9-volt battery
J1—Jack to match receiver cable
S1—SPST switch
ANT—Telescopic antenna or wire
Miscellaneous: Cabinet, printed-circuit materials, solder, etc.
Note: The following can be ordered from Q-Sat, P.O Box 110, Boalsburg, PA 16827: A printed-circuit board, $6 plus $1 shipping and handling; a complete kit (less case, switch, battery, and connectors), $15 plus $2 shipping and handling. Pennsylvania residents must add appropriate sales tax.

Modifications

If you are interested in a smaller frequency range than 1–30 MHz, resistor R1 can be replaced with an LC circuit tuned to the center of the desired range. The LC circuit will also improve the rejection of signals outside your range of interest, but remember that it won't improve the gain of the amplifier.

If your particular interest is the very-low frequencies (VLF), the amplifier's low-frequency response can

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be improved by increasing the values of capacitors C1 and C3. (You'll have to experiment with the values.)

Although a 9-volt battery is the recommended power source, the amplifier should work well using 6–15 volts. The inside of the cabinet of the completed prototype, using a 9-volt battery as the power supply, is shown in Fig. 3.

Troubleshooting

Circuit voltages for a 9-volt power supply are shown in Fig. 1. If the voltages in your unit differ by more than 20% from those in the schematic, try changing resistor values to get the voltages in their proper range. For example, if the voltage drop across R8 measures only 0.3 volt, you must decrease R4's value (the exact value is up to you to figure out) in order to increase Q3's base voltage and collector current.

The only critical voltages are those across R3 and R8. Performance should be fine if they are even close to the values on the schematic. If you decide to operate the amplifier from other than 9 volts, the values of R3 and R4 must be modified to obtain the indicated voltages.

Since it's almost impossible to measure the voltage from the gate to the source (VGS) of an FET, you can measure the voltage that is present across R3, because it is the same as VGS. Adjust R3's value accordingly, if the voltage is not within the range of 0.8–1.2 volts.

Limitations

Use of the amplifier above 30 MHz is not recommended because of sharply reduced gain. While operation above 30 MHz can be accomplished by using tuned circuits in place of the resistive loads, that modification is beyond the scope of this article. Therefore, such modifications are purely experimental.

Take care when handling the FET (Q1). A common belief is that FET's and CMOS devices are safe from static damage after having been installed in a circuit, or after being mounted to a PC board. Although it's true that they are better protected from static electricity when installed in a circuit, they are still susceptible to damage by static; so never touch the antenna before discharging yourself to ground by touching some grounded metallic object. **R-E**

BUILD THIS

CARRIER CURRENT RECEIVER

WILLIAM SHEETS and RUDOLF F. GRAF

LAST MONTH WE WENT OVER the operating theory of a carrier-current transmitter, and then showed you how to build one. Now we will describe two receivers that can be used with that transmitter. One receiver is a simple AM unit, best suited for applications where some noise can be tolerated (such as speech), and the other one is for wideband FM use. Both receivers have an output that can be connected directly to a speaker.

AM receiver

Figure 1 shows the AM-receiver schematic. It is a TRF- (*T*uned *R*adio *F*requency) type receiver, meaning that there is no signal mixing or heterodyning; the unit is tuned only once upon calibration, and then left alone. It has a sensitivity of about 1 millivolt at the input for an audio output of ½-watt.

Capacitor C22 couples audio signals from the power line to the PC board—it *must* be rated at 600-volts DC. R8 will cause F1 to blow if C22 shorts. As another safety precaution, the chassis of the unit must be grounded. If an older two-wire electrical system is used, the receiver must be grounded to a cold-water pipe.

The signal from C22 goes to a tuned network (C1–C5 and L1 and L2) that has a 20-kHz bandwidth, which allows only the desired signal to pass through. A jumper (J) between the line (antenna) and the input network can be removed for reception of very strong signals if distortion (overload) becomes a problem.

IC1 is a "gain block" IF chip, normally used for TV IF applications, but it is useful at low frequencies as well. It has AGC (*A*utomatic *G*ain *C*ontrol) capability and approximately 60 dB of gain. Components C8, C9, and L3, which are placed across the output of IC1, are broadly resonant around 280 kHz. C10 couples RF to detector-diode D1, which is used as an envelope detector.

AGC, which keeps the receiver output relatively constant, is obtained in the following manner: The cathode of D1 is connected to the variable resistor R5. A voltage from 4 to 6 volts appears on the cathode of D1 even with no received signal. When a signal is received, the DC voltage at the anode of D1 increases. That DC voltage appears across C14 (the detector output), and is then fed through R3 and C13, which remove audio components, to the base if Q1. The voltage at the emitter of Q1 is fed to pin 5 of IC1. A more positive voltage tends to reduce the gain of IC1, which in turn reduces the signal fed to D1 and subsequently the DC voltage at pin 5.

Complete your carrier-current audio system with an AM or FM receiver.

The detector output is taken from C14, which sets the upper frequency limit at about 10 kHz or so. By reducing the value of C14, a higher frequency response can be obtained; but using the FM receiver, which will be described later, is a better approach. The detector output is connected to an external jack. Audio components are fed to audio-gain control R6, through C16 to IC2, an audio amplifier. C18 couples up to ½-watt of audio to an external speaker.

Power for the AM receiver is supplied via T1, D2, and IC3. The power supply formed by those components provides a regulated 12-volts DC across C19.

FM receiver

The schematic of the FM receiver is shown in Fig. 2, and it operates as follows: Input signals from the power line are coupled through C23 and R19 to the input filter network. As with the AM transmitter, C23 *must* be rated at 600 volts. Switch S2 is used as an attenuator. It is provided to prevent receiver overload in case it is located too close to the transmitter. Signals above about 500 kHz are rejected by C1, which reduces the tendency for the filter network to "leak" signals at frequencies far above the passband. Components C2–C7, L1–L3, and R1 and R20 form a triple-tuned bandpass filter having a passband from 220–340 kHz. Signals from the filter are fed to pin 4 of IC1, an MC1350P "gain block" IC, which is used as a tuned RF amplifier. C8 and C9 provide internal bypassing for the chip. R2 biases IC1 so that it operates at maximum gain. An amplified signal appears at pin 8 of IC1. L4 provides DC bias and high RF impedance to pin 8, and D1 and D2 provide amplitude

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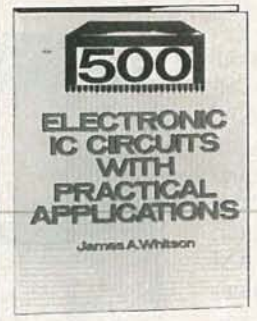

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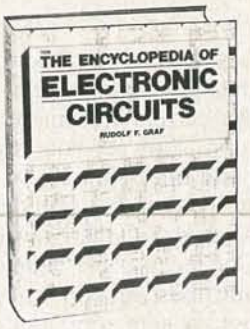

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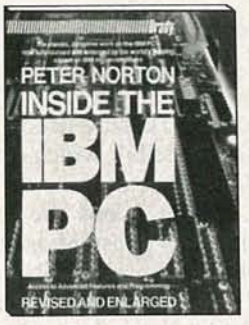

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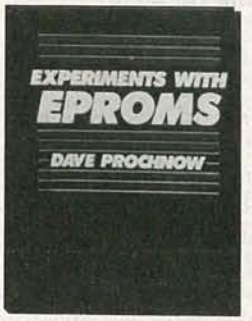

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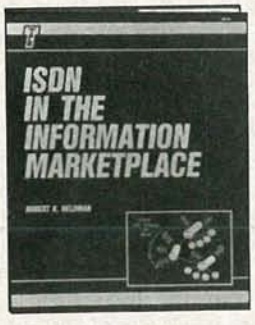

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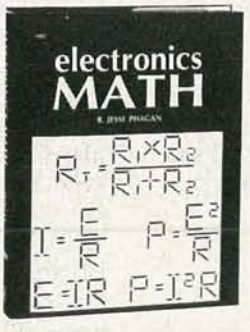

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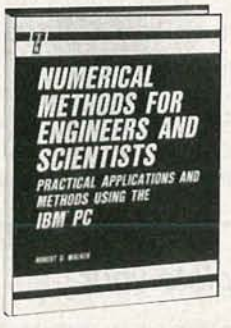

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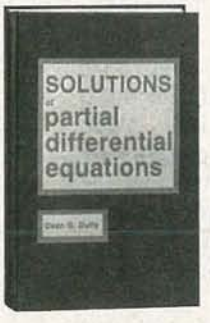

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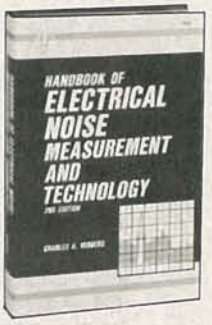

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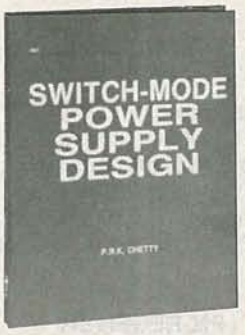

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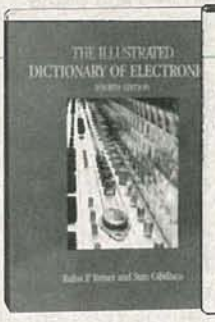

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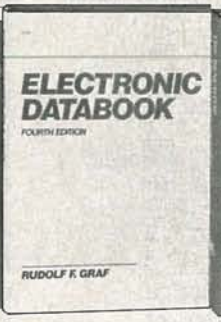

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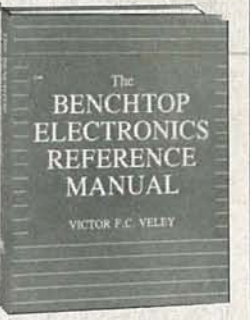

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PARTS LIST

AM RECEIVER

All resistors are ¼-watt, 10%, unless otherwise noted.
R1—4700 ohms
R2—1000 ohms
R3—47,000 ohms
R4, R8—47 ohms
R5—10,000 ohms, potentiometer
R6—50,000 ohms, potentiometer
R7—10 ohms
R9—680 ohms
Capacitors
C1, C5—33 pF, NPO
C2, C4—3–40 pF trimmer
C3—3 pF, NPO
C6, C7, C17—0.1 μF, 50 volts, Mylar
C8, C9—330 pF, NPO
C10, C14, C21—0.01 μF, disc
C11, C15—10 μF, 16 volts, electrolytic
C12, C13, C16—1 μF, 50 volts, electrolytic
C18—470 μF, 16 volts, electrolytic
C19, C20—2200 μF, 16 volts, electrolytic
C22—0.1 μF, 600 volts
Semiconductors
IC1—MC1350P gain block IF
IC2—LM386 audio amplifier
IC3—LM7812 12-volt regulator
D1—1N914B silicon diode
D2—1N4002 or 1N4007 rectifier diode
LED1—red light-emitting diode
Q1—2N3565 NPN transistor
Other components
L1, L2, L4—4.7 mH inductor
L3—470 μH inductor
F1—1-amp fuse
S1—SPST switch
T1—12-volt, 450-mA transformer
J1–J4—RCA jack
Miscellaneous: PC board, cabinet, hardware, grounded AC line cord, etc.

PARTS LIST
FM RECEIVER

All resistors are ¼-watt, 10%, unless otherwise noted.
R1, R10—15,000 ohms
R2, R4–R7, R17—4700 ohms
R3, R19—47 ohms
R8, R15—10,000 ohms
R9—10,000 ohms, potentiometer
R11—2200 ohms
R12—22 ohms
R13—10 ohms
R14, R20—22,000 ohms
R16—100,000 ohms
R18—50,000 ohms, potentiometer
R21—680 ohms
Capacitors
C1—0.0015 μF, 50 volts, Mylar
C2, C4, C6—56 pF, NPO
C3, C5—24 pF, NPO
C7—150 pF, NPO
C8, C9, C22—0.1 μF, 50 volts, Mylar
C10, C17, C18—1 μF, 50 volts, electrolytic
C11, C24, C26, C27—0.01 μF, disc
C12, C13—10 μF, 16 volts, electrolytic
C14, C29—0.001 μF, 50 volts, Mylar
C15—47 pF, NPO
C16—0.01 μF, Mylar
C19, C20—470 μF, 16 volts, electrolytic
C21—0.0033 μF, 50 volts, Mylar
C23—0.1 μF, 600 volts
C25, C28—2200 μF, 16 volts, electrolytic
Semiconductors
IC1—MC1350P gain block IF
IC2—LM565 PLL detector
IC3—LM386 audio amplifier
IC4—LM7812 12-volt regulator
D1, D2—1N914B silicon diode
D3–D6—1N4002 rectifier diode
LED1—red light-emitting diode
Q1, Q2—2N3565 NPN transistor
Other components
L1–L4, L6—4.7 mH inductor
L5—470 μH inductor
F1—1-amp fuse
S1, S2—SPST switch
T1—12-volt, 450-mA transformer
J1, J2—RCA jack
Miscellaneous: PC board, cabinet, hardware, grounded AC line cord, etc.

Note: The following items are available from North Country Radio, P.O. Box 53, Wykagyl Station, New Rochelle, NY 10804. A kit of parts containing a PC board and everything that is installed on it; For the AM receiver: $28.50. For the FM receiver: $38.50. A PC board for either receiver is available for $10.00 each. Add $2.50 to any order for postage and handling. NY residents must include sales tax.

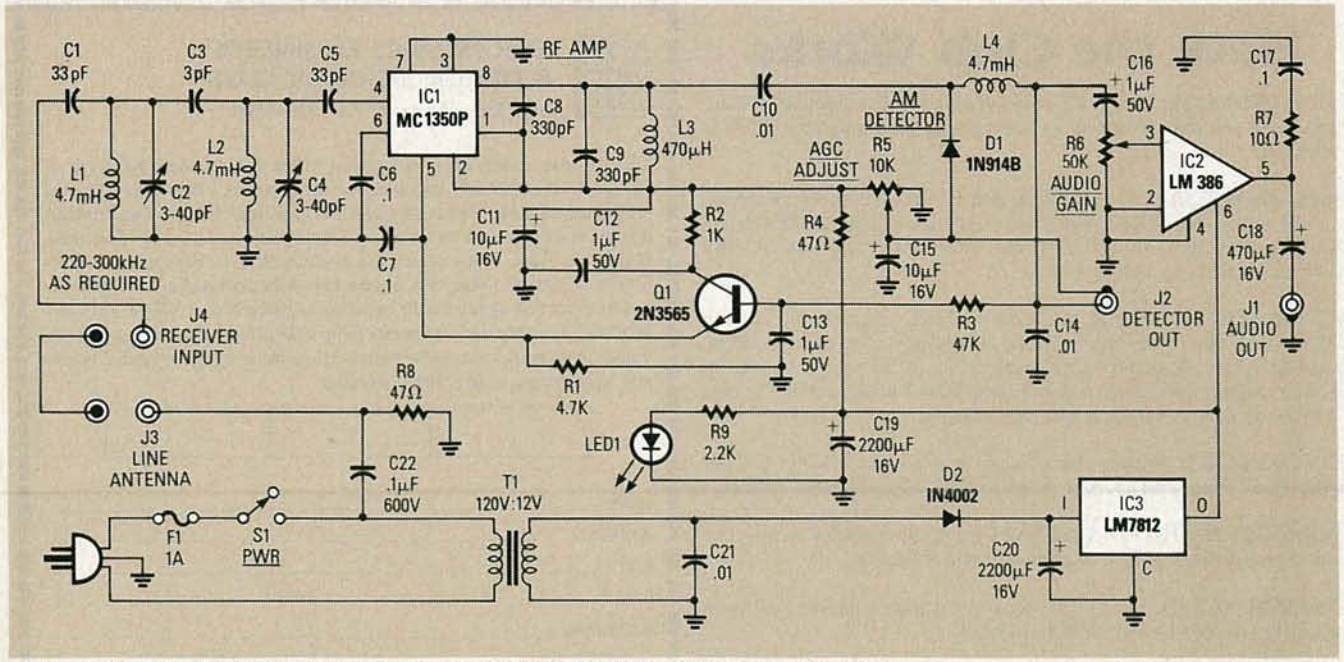


FIG. 1—THE AM RECEIVER. Shown here is the complete, and rather simple circuit, which is best suited for receiving speech.

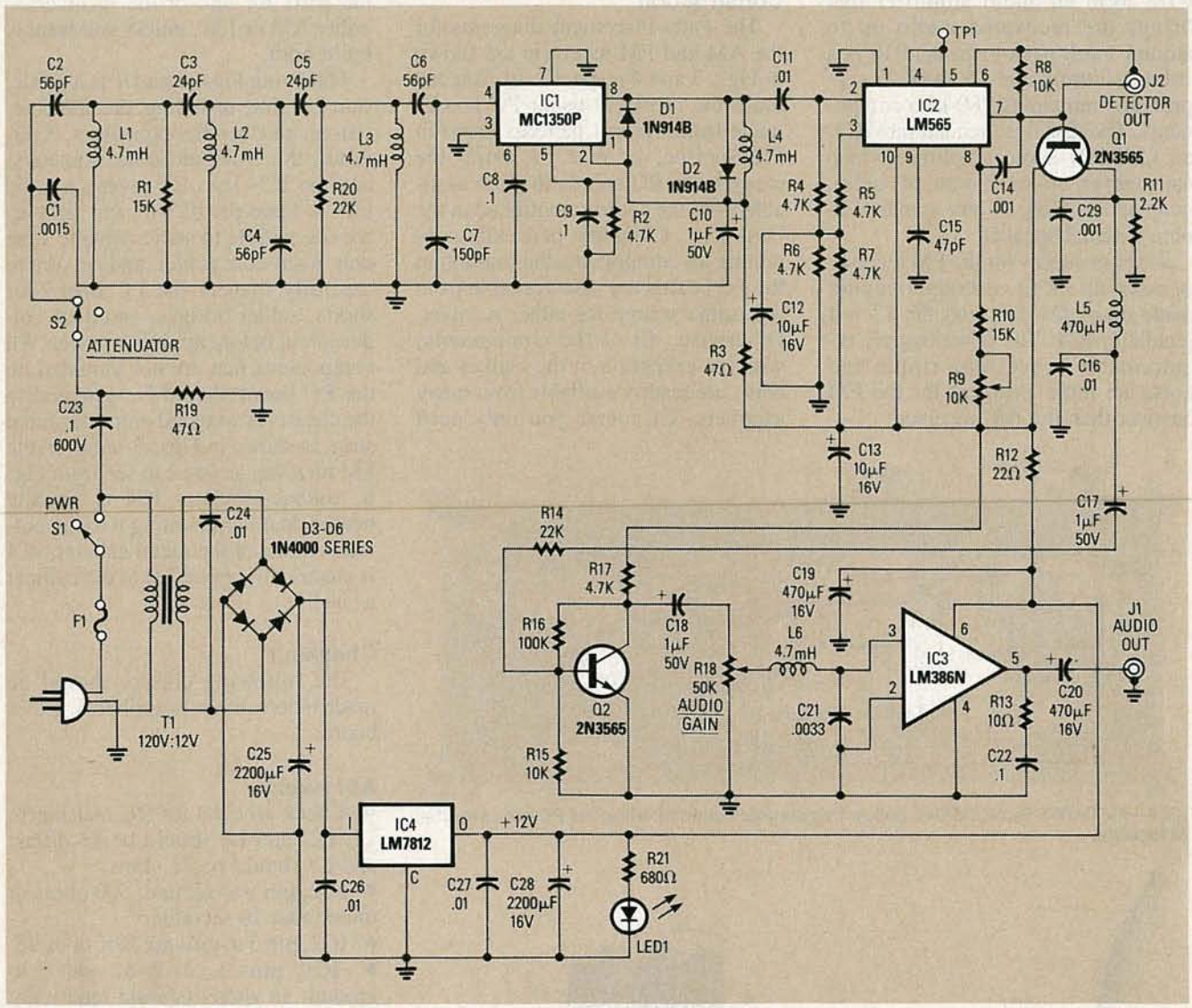


FIG. 2—THE FM RECEIVER. This receiver is slightly more complex than the AM receiver.

limiting of the FM signal. C10 and R3 form a decoupling network, and C11 couples the signal from IC1 to IC2, and also blocks DC.

IC2, an LM565 PLL, is used as an FM demodulator. Pins 8 and 9 are connected to an internal VCO (*V*oltage *C*ontrolled *O*scillator), and components R9, R10, and C15 set the VCO's free running frequency. The output of the VCO appears at pin 4, and is fed right back in to pin 5, which is the input to the internal phase detector (the test point between those two pins is used for setting the PLL's VCO frequency—280 kHz in this application). The VCO signal and the input signal (from pin 2) are compared in the phase detector. The output from the phase detector is internally amplified, and then appears at pin 7. The output at pin 7 is a replica of the original modulation on the FM input

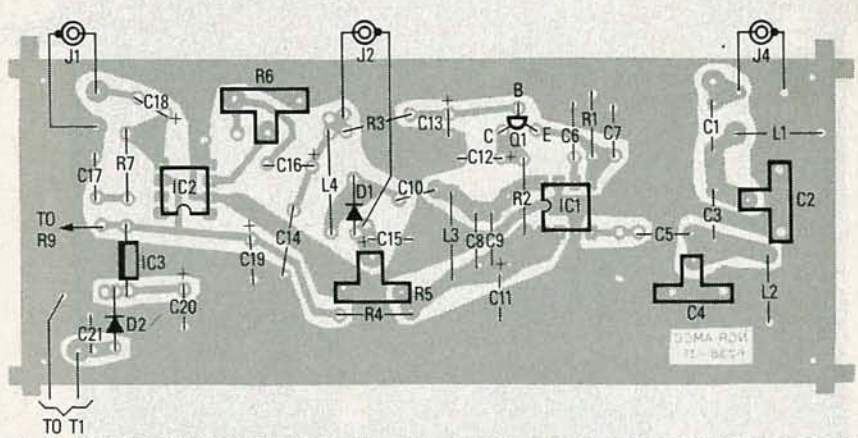


FIG. 3—AM PARTS PLACEMENT. Follow this diagram when building the PC board for the AM receiver.

signal to the receiver; the output (pin 7) is therefore the recovered audio. (The outputs from pins 6 and 7 are externally available for future interface purposes.)

The detector output at pin 7 is coupled to Q1 and R11. Components C16, C29, and L5 form a low-pass filter that eliminates 280-kHz components from IC2's output. C17 and R14 couple audio to the base of Q2, which, in conjunction with R15, R16, R17, and

C18, form an audio amplifier that brings the recovered audio up to around 1-volt peak-to-peak. R18 is a volume control, and L6 and C27 suppress any remaining 280-kHz components. The signal is then fed into IC3, an LM386N audio amplifier, which can deliver up to ½-watt of audio, coupled via C20, to any standard 8-ohm external speaker.

A power supply for the FM receiver is made up of T1, a bridge rectifier made up of D3–D6, and the 12-volt regulator, IC4. The power-supply requirements concerning ripple and noise are more stringent for the FM receiver than the AM receiver.

Construction

The Parts-Placement diagrams for the AM and FM receivers are shown in Figs. 3 and 4 respectively. You can build the receivers using PC boards made from the foil patterns given in PC Service, or else by using the ready-made PC boards that are available from the source mentioned in the Parts List. Complete parts kits containing all components that mount on the PC boards are also available from that same source for either receiver. Otherwise, all of the components, with the exception of the chokes and coils, are readily available from many suppliers. Of course you only need the parts for one of the receivers—either AM or FM, unless you want to build both.

Following Figs. 3 and 4 as a guide, start by first installing the fixed resistors, and then the capacitors. Next, install the coils and potentiometers, and the IC's last. It's always a good idea to leave the IC's for last, as they are susceptible to static damage. Use only rosin-core solder, and be sure to carefully inspect the PC board for shorts, solder bridges, and poor solder joints before applying power. All components that are not mounted on the PC board should be mounted to the chassis or soldered onto a terminal strip, as shown in Figs. 5 and 6. In the FM receiver, as you can see from Fig. 6, voltage-regulator IC4 is actually heat-sinked by mounting it to the bottom surface of the metal cabinet; IC4 is electrically grounded to the cabinet as well.

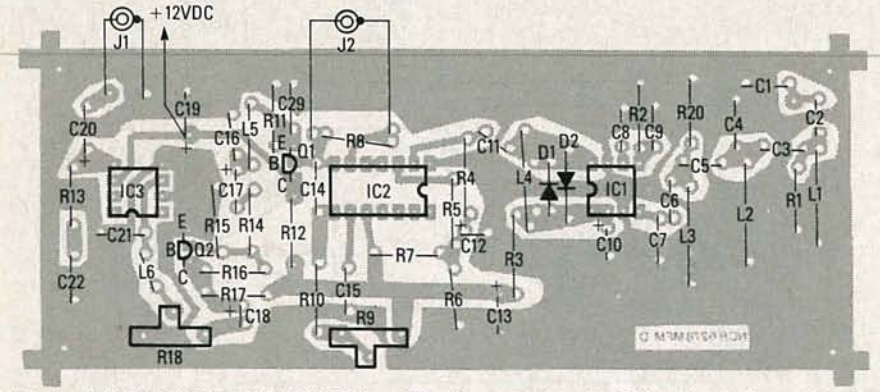


FIG. 4—FM PARTS PLACEMENT. Follow this diagram when building the PC board for the FM receiver.

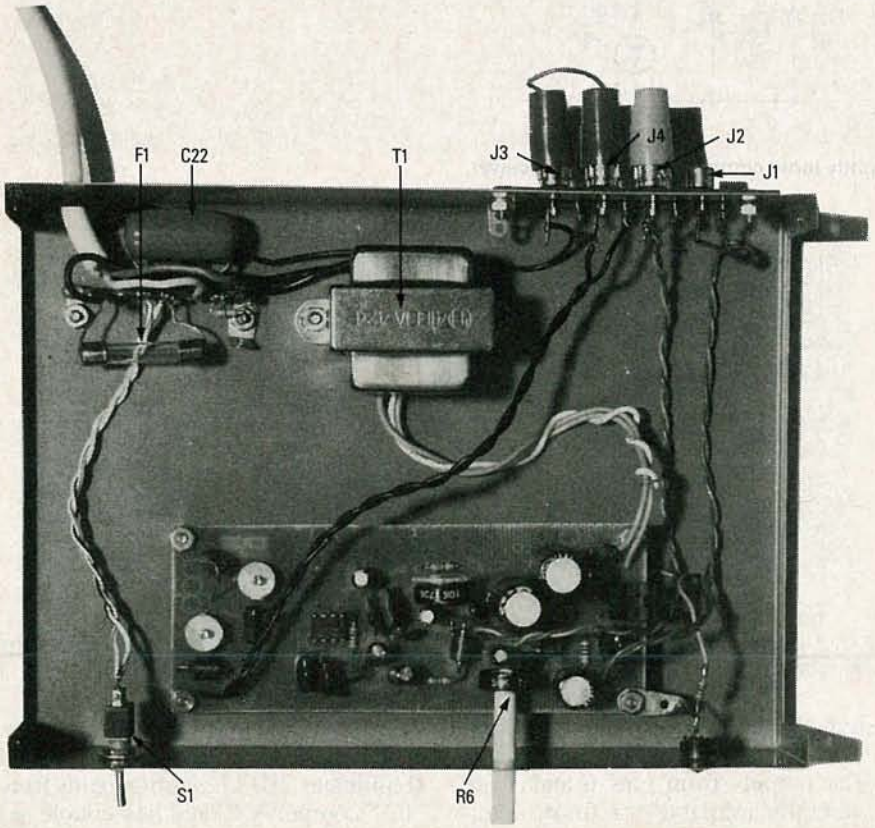


FIG. 5—THE PC BOARD for the AM receiver is installed inside the cabinet as shown. Notice the components that are *not* on the PC board.

Checkout

The following checks should be made before power is applied to either board:

AM receiver

- Check all coils for DC resistance: L1, L2, and L4 should be 48 ohms, and L3 should be 22 ohms.
- IC2, pin 6 to ground: 500 ohms or more (after 10 seconds).
- IC2, pin 5 to ground: 10K or more.
- IC1, pins 1, 2, 4–6, and 8 to ground: no shorts (should read more than 500 ohms).
- Make sure that D1 and D2 are correctly polarized.

Set all potentiometers at halfway, apply DC power, and check for the following positive voltages (all measurements are made with respect to ground):

- Across C20: 16 volts.
- Across C19: 12 volts.
- IC2 pin 5: 6 volts.
- IC1 pins 1, 2, and 8: 11.8 volts.
- Q1 collector: 11 volts.
- Q1 emitter: 6 volts (varies with R5).
- IC1 pin 5: 5 volts (varies with R5).

FM receiver

- Check all coils for DC resistance: L1–L4 and L6 should be 48 ohms, and L5 should be 22 ohms.
- IC3 pin 6 to ground: more than 500 ohms (after 10 seconds).
- IC3 pin 5 to ground: more than 10K.

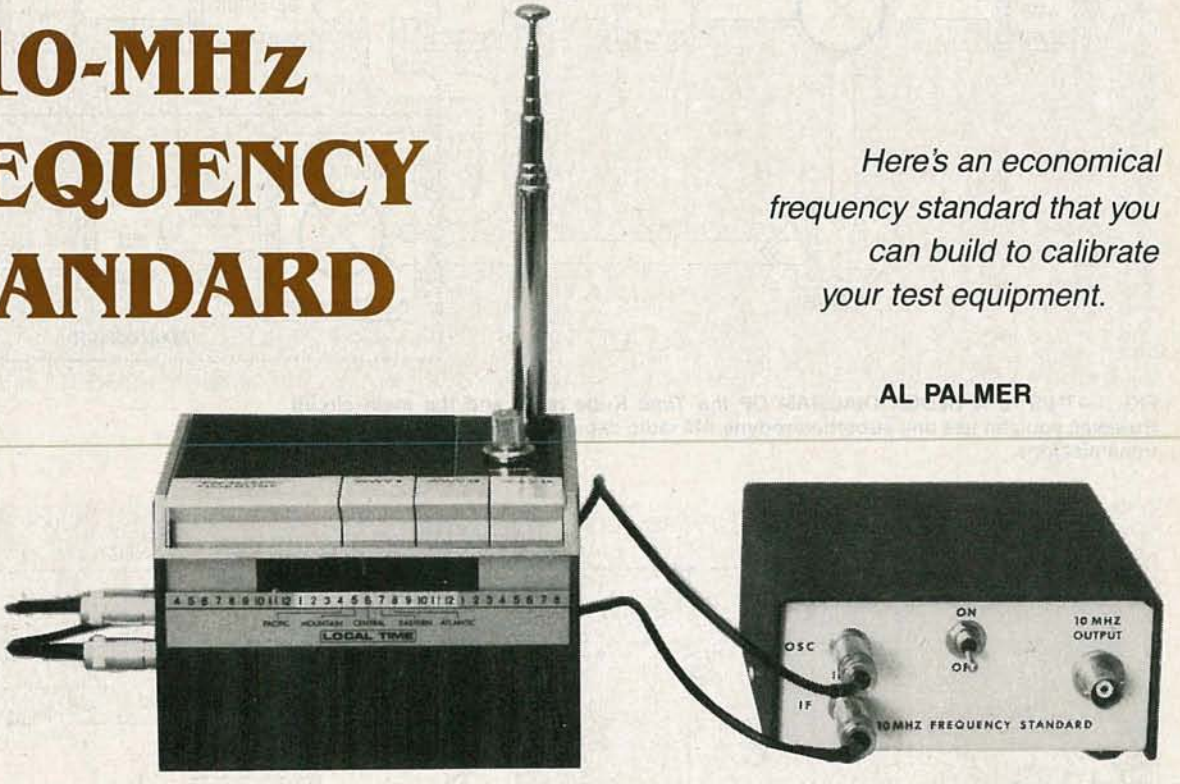
continued on page 94

BUILD THIS

10-MHz FREQUENCY STANDARD

Here's an economical frequency standard that you can build to calibrate your test equipment.

AL PALMER



YOUR FREQUENCY COUNTER IS GOING TO need calibration—if not today, then in the near future. That's also true for any test instrument that uses a built-in reference oscillator, such as an oscilloscope or signal generator. Calibration means adjusting the instrument's built-in reference oscillator until it matches a known frequency standard. Unfortunately, a highly accurate frequency standard, such as one traceable to the *N*ational *B*ureau of *S*tandards, NBS, is far beyond the budget of most technicians and electronics hobbyists.

With the absence of an NBS-traceable standard, hobbyists usually decide to calibrate their frequency counters against a similar working model. After several calibrations, usually one against another, the law of averages dictates that eventually a frequency counter will end up calibrated to itself. The end result is that no standard at all is being maintained.

The frequency standard detailed in this article resolves the dilemma by providing a calibrator that is accurate, inexpensive, and simple enough to build. The calibrator's output is a 10-MHz square wave that is phase-locked to the WWV 10-MHz radio transmission that's traceable to the NBS in Boulder, Colorado. And, if you want more versatility, later on we'll show you how to modify the unit to phase-lock on to the WWV 2.5-MHz and 5-MHz radio transmission.

Theory of operation

Figure 1 is a block diagram of our 10-MHz frequency standard. It consists of a *Time Kube* superheterodyne AM radio which contains an RF amplifier, a mixer, a local oscillator, two IF amplifiers, a detector, and an audio amplifier. We add to that a circuit containing a mixer and PLL. (We'll call that circuit our "main circuit.")

Let's take a closer look at each stage of the radio receiver. The incoming WWV 10-MHz signal is amplified in the RF amplifier stage, and then sent to the mixer stage where it is combined with the 10.455-MHz output from the local oscillator. Because the mixer is a non-linear device, the two frequencies are heterodyned together creating two additional frequencies in the output; the sum frequency of 20.455 MHz, and the difference frequency 0.455 MHz (or 455 kHz), which is the one we are most interested in (see Table 1). The IF frequency is chosen to be 455 kHz, and the local oscillator is designed to operate 455 kHz above the frequency that's being received.

The purpose of the IF amplifiers is to select out, and amplify, only the difference signal at 455 kHz. The output of the second IF amplifier will be a narrow band of frequencies centered around 455 kHz, which contains all of the audio information present in the original transmission. The IF is then detected, amplified, and heard over the speaker.

Although the WWV 10-MHz incoming frequency to the RF amplifier is extremely accurate, the 455-kHz IF frequency is only as stable as the local oscillator. That means: If the local oscillator drifts 100 Hz off frequency, the center frequency of the IF will also drift 100 Hz off frequency. Although that amount of drift is acceptable as far as listening to audio is concerned, the IF frequency is not accurate enough to be used as a frequency standard unless the drift is compensated for.

As shown in Fig. 1, the main circuit

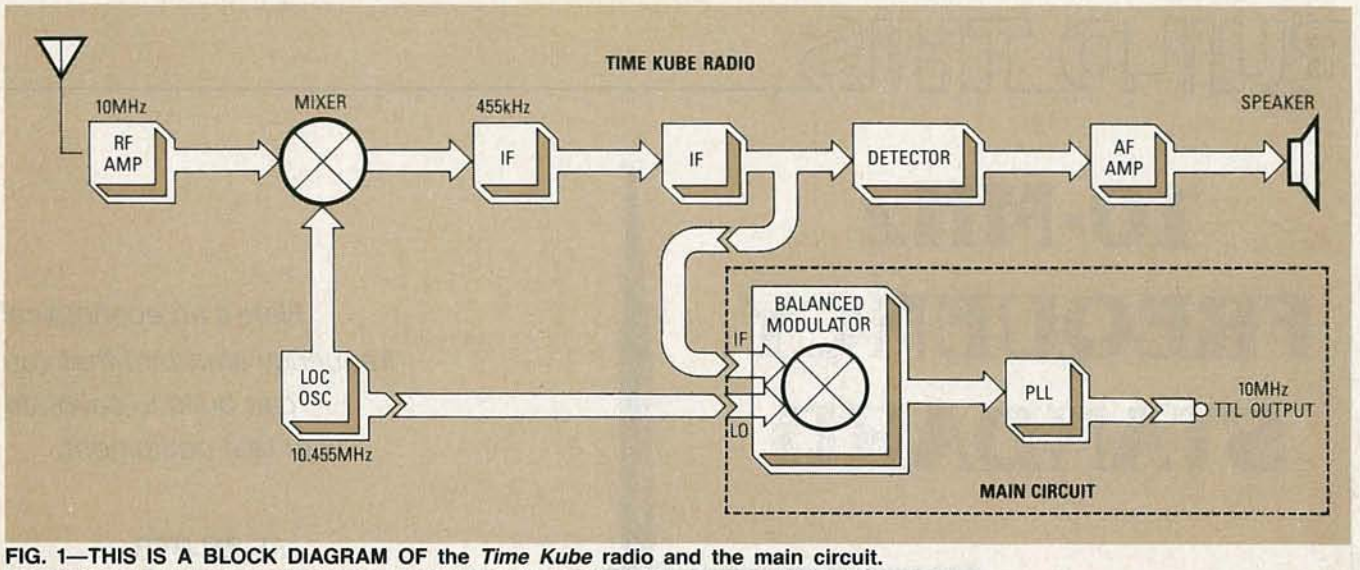


FIG. 1—THIS IS A BLOCK DIAGRAM OF the *Time Kube* radio and the main circuit. However, you can use any superheterodyne AM radio capable of receiving WWV's radio transmissions.

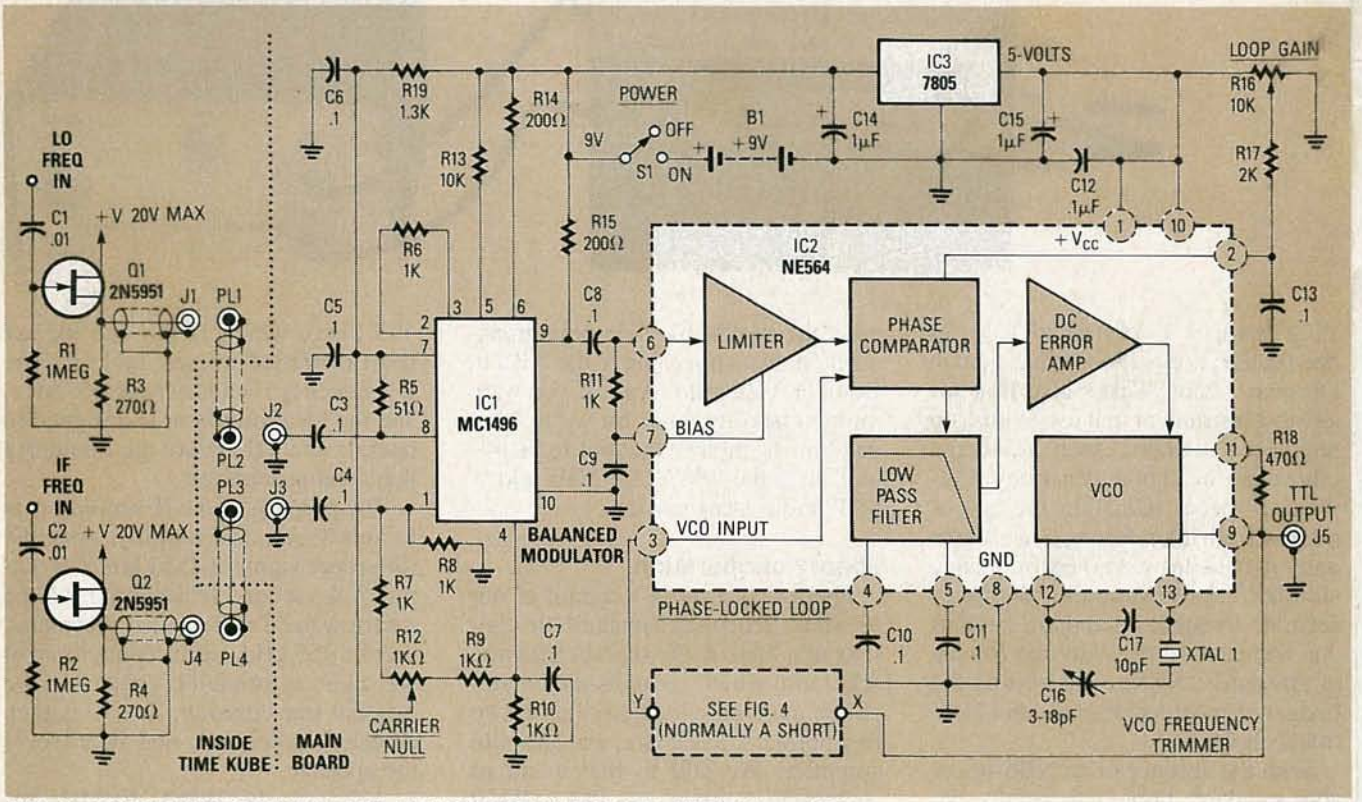


FIG. 2—SCHEMATIC OF THE 10-MHz FREQUENCY STANDARD. FET's Q1 and Q2 are installed inside the radio, and the rest of the components are installed on the main board.

consists of a balanced modulator, which is a type of mixer, and a phase-locked loop. Those two stages cancel any frequency error caused by drifting of the local oscillator, and recreates a signal as accurate as the original WWV 10-MHz signal. For example, if the local oscillator drifts up 100 Hz (10.456 MHz), and then heterodyned with the 10-MHz WWV signal, the IF-difference frequency will now be 456 kHz. When the new IF and local oscillator frquency are heterodyned in the balanced modulator (10.456 MHz − 0.456 MHz), the result is still 10 MHz. In that manner, the balanced modulator will cancel out any drifting in the radio's local oscillator.

The advantage of that approach lies in its simplicity. Any single-conversion superheterodyne short-wave receiver will work, even one where the local oscillator is not crystal-controlled. But the Radio Shack *Time Kube* is self-contained, and relatively inexpensive.

10-MHz frequency standard

Figure 2 is the schematic for the 10-MHz frequency standard. The two FET transistors are installed inside the *Time Kube*, and are used to pick

up the IF and the output of the local oscillator without loading down the radio's circuitry. The balanced modulator (IC1) and phase-locked loop (IC2) are part of the main circuit board that we are going to assemble.

Instead of a diode or other nonlinear device, a balanced modulator is used, because that type of mixer produces only two frequencies instead of the usual four; it outputs only the sum and difference frequencies. The two original input frequencies are balanced out and do not appear at the output.

By using a balanced modulator, neither the 10.455-MHz input from the local oscillator, nor the 455-kHz input from the IF amplifier will be present at the output. The closest output frequency of any magnitude will be the 10.91-MHz sum frequency, but 10.91 MHz is far enough away from 10.0 MHz so as not to cause any interference. The phase-locked-loop will lock onto the 10-MHz output of the balanced modulator, and produce a 5-volt peak square wave at the WWV 10-MHz carrier frequency.

A rather unconventional crystal-controlled phase-locked loop is used for two reasons: **1**—the crystal-controlled VCO will not lock up on the wrong frequency (ie. 10.91 MHz); and **2**—even if the WWV-propagated signal is too weak for the PLL to frequency-lock, the output frequency's stability would be controlled by the crystal. (The crystal's accuracy is at least ±0.005%, or 50-parts-per-million, a viable reference for low accuracy of calibration when propagation of WWV is poor.)

Figure 3 shows an AC power supply that you can use in place of the 9-volt battery shown in Fig. 2. Simply connect the 12-volt output to S1, instead of the battery. The foil pattern that we'll show you shortly already has the power-supply components incorporated into it. If you want to use the foil pattern, but would prefer to use a bat-

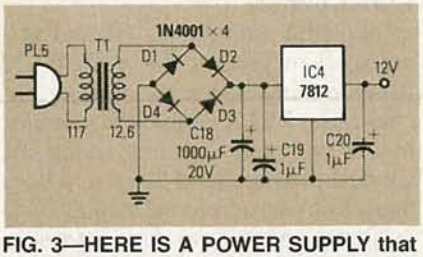


FIG. 3—HERE IS A POWER SUPPLY that you can use if you would prefer not to use a battery.

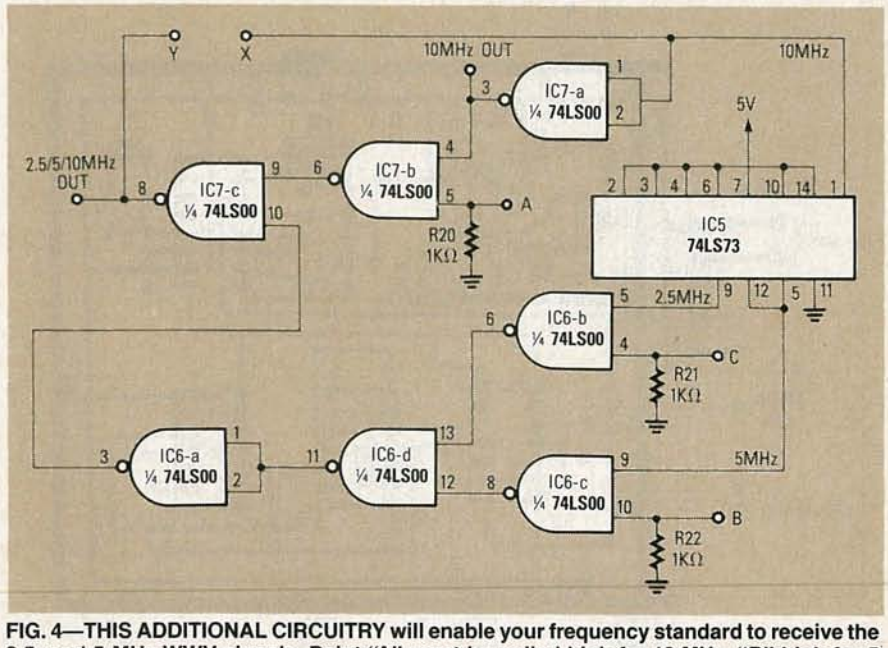


FIG. 4—THIS ADDITIONAL CIRCUITRY will enable your frequency standard to receive the 2.5- and 5-MHz WWV signals. Point "A" must be pulled high for 10 MHz, "B" high for 5 MHz, and "C" high for 2.5 MHz.

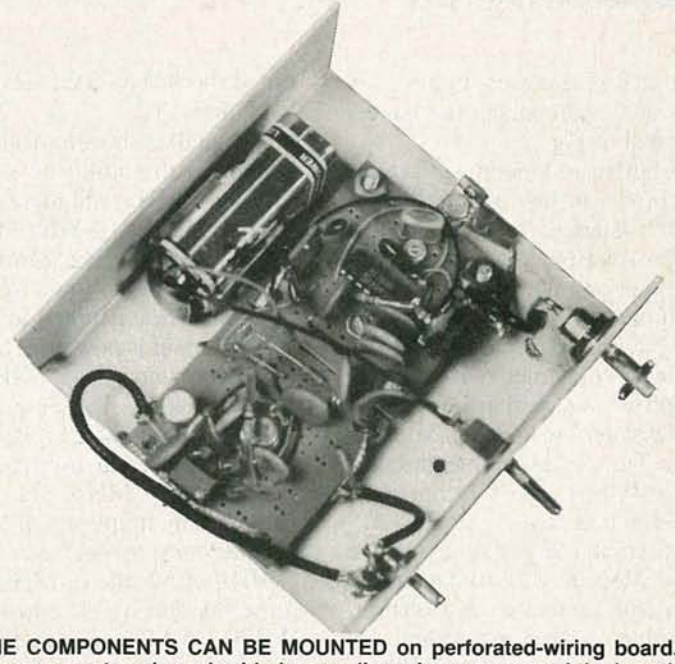


FIG. 5—THE COMPONENTS CAN BE MOUNTED on perforated-wiring board. To help shield the components, a large braided grounding wire runs around the board.

TABLE 1—IDEAL MIXER OPERATION
MIXER

INPUT	OUTPUT
10.0000 MHz RF CARRIER	10.0000 MHz (ORIGINAL)
10.4550 MHz LOCAL OSCILLATOR	10.4550 MHz (ORIGINAL)
	20.4550 MHz SUM
	.4550 MHz DIFFERENCE (IF)

BALANCED MODULATOR

INPUT	OUTPUT
.4550 MHz IF FREQUENCY	10.9100 MHz SUM
10.4550 MHz LOCAL OSCILLATOR	**10.0000 MHz DIFFERENCE**

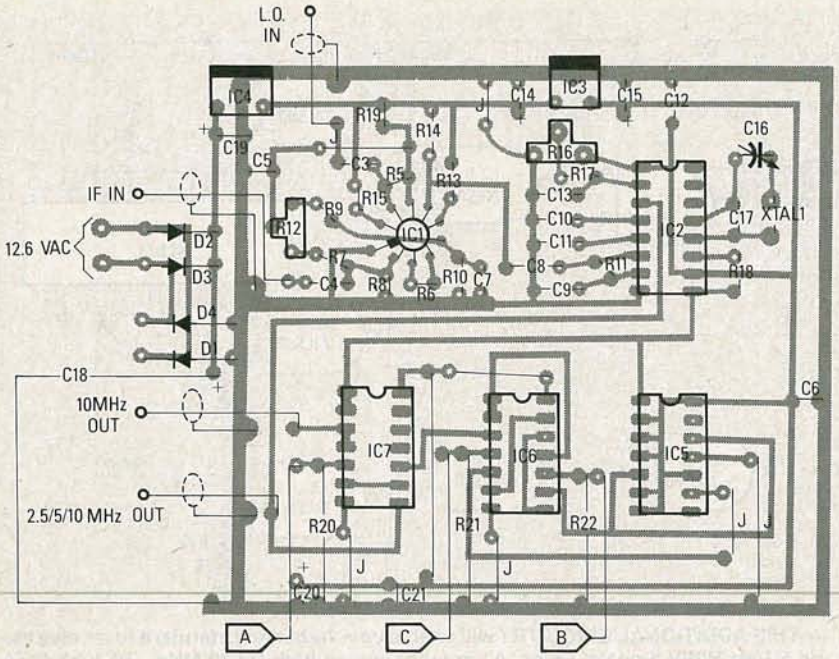


FIG. 6—PARTS PLACEMENT DIAGRAM. The foil pattern in PC Service is being used here, but the parts inside the dashed box are optional. If you don't use them, be sure to put a jumper between pins 9 and 3 of IC2.

tery, just leave the power-supply components out, and connect the battery as indicated in Fig. 2.

We mentioned before that we would show you how to modify the frequency standard to receive other WWV broadcasts. If your radio has trouble receiving the 10-MHz signal, WWV broadcasts the same information on 2.5, 5, 10, 15, and 20 MHz (we're only concerned with 2.5, 5, and 10 MHz), and perhaps either 2.5 or 5 MHz is coming in better. You will notice in Fig. 2, the connection between pins 9 and 3 of IC2 contains a dashed box that says "see Fig. 4." Normally (if you only want to receive WWV 10-MHz broadcast)that dashed box would be a direct short. However, if you want to have the added versatility of being able to receive three WWV frequencies, the circuitry in Fig. 4 should be added between points "X" and "Y."

An ancillary benefit from the modification is the ability to select a 2.5 MHz or 5-MHz calibrated output, instead of just the 10-MHz PLL output.

With the modifications, the unit will operate as follows: Assume that the *Time Kube* is tuned in to 5 MHz. The RF input is now 5 MHz, the local oscillator is now 5.455 MHz, and the IF is 455 kHz. The output from the balanced modulator is the difference between the local oscillator and the IF—exactly 5 MHz. The PLL has a free-running frequency of 10 MHz, so in order for it to lock on to the WWV 5-MHz signal, the 10-MHz signal has to be divided by two; to receive the WWV 2.5-MHz signal, the 10-MHz signal has to be divided by four.

When you wish to receive the WWV 10-MHz signal, point "A" must be pulled high; when you wish to receive the 5-MHz WWV signal, point "B" must be pulled high; and when you wish to receive the WWV 2.5-MHz signal point "C" must be pulled high. At the same time, the corresponding frequency must be selected on the *Time Kube* radio. (Note that not all radios can receive the three mentioned frequencies.) Use Fig. 4 as a wiring guide for the additional switches that are required, and mount the board and switches in a cabinet as you see fit.

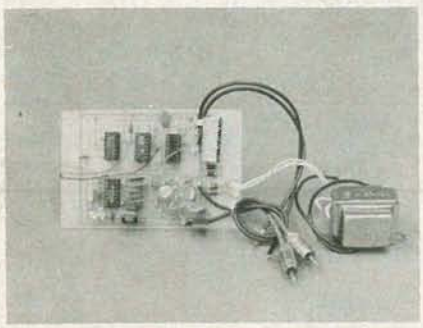


FIG. 7—SHOWN HERE is the completely assembled PC board. Note that this board contains all of the components.

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.
R1, R2—1 Megohm
R3, R4—270 ohms
R5—51 ohms
R6–R11—1000 ohms
R12—1000 ohm potentiometer
R13—10,000 ohms
R14, R15—200 ohms
R16—10,000 ohm potentiometer
R17—2000 ohms
R18—470 ohms
R19—1300 ohms

Capacitors
C1, C2—0.01μF, ceramic disc
C3–C13, C21—0.1μF, ceramic disc
C14, C15—1μF, 35 volts, tantalum
C16—3–30pF trimmer
C17—10pF, 5%, silver-dipped mica

Semiconductors
IC1—MC1496, balanced modulator, metal-can package
IC2—NE564, phase-locked loop
IC3—7805, 5-volt regulator
Q1, Q2—2N5951, FET transistor

Other components
XTAL1—10 MHz
B1—9-volt battery
S1—SPST toggle switch
J1–J4—phono jacks
J5—BNC jack
PL1–PL4—phono plugs
Miscellaneous: Perforated-construction or PC board, hardware, metal chassis, 50-ohm coax cable, and battery clip.

The following components are for the optional power supply.
C18—1000μF, 20 volts, electrolytic
C19, C20—1μF, 35 volts, tantalum
D1–D4—1N4001 rectifier diode
IC4—7812, 12-volt regulator
T1—117/12.6 volt, 1 amp transformer
PL5—AC plug and line cord

The following components are optional. They are to be used only if you would like to be able to receive all three of the WWV frequencies.
R20–R22—1000 ohms
IC5—74LS73, dual JK flip flop
IC6, IC7—74LS00, quad nand gate

Construction

Two FET transistors, Q1 and Q2, are used to prevent the main board from loading down the radio's circuits. The FET's should be mounted inside the radio cabinet, using the shortest possible lead lengths to keep them from de-tuning the radio's local oscillator and IF amplifier. Terminate the outputs with RCA jacks mounted on the radio's cabinet. (See the pho-

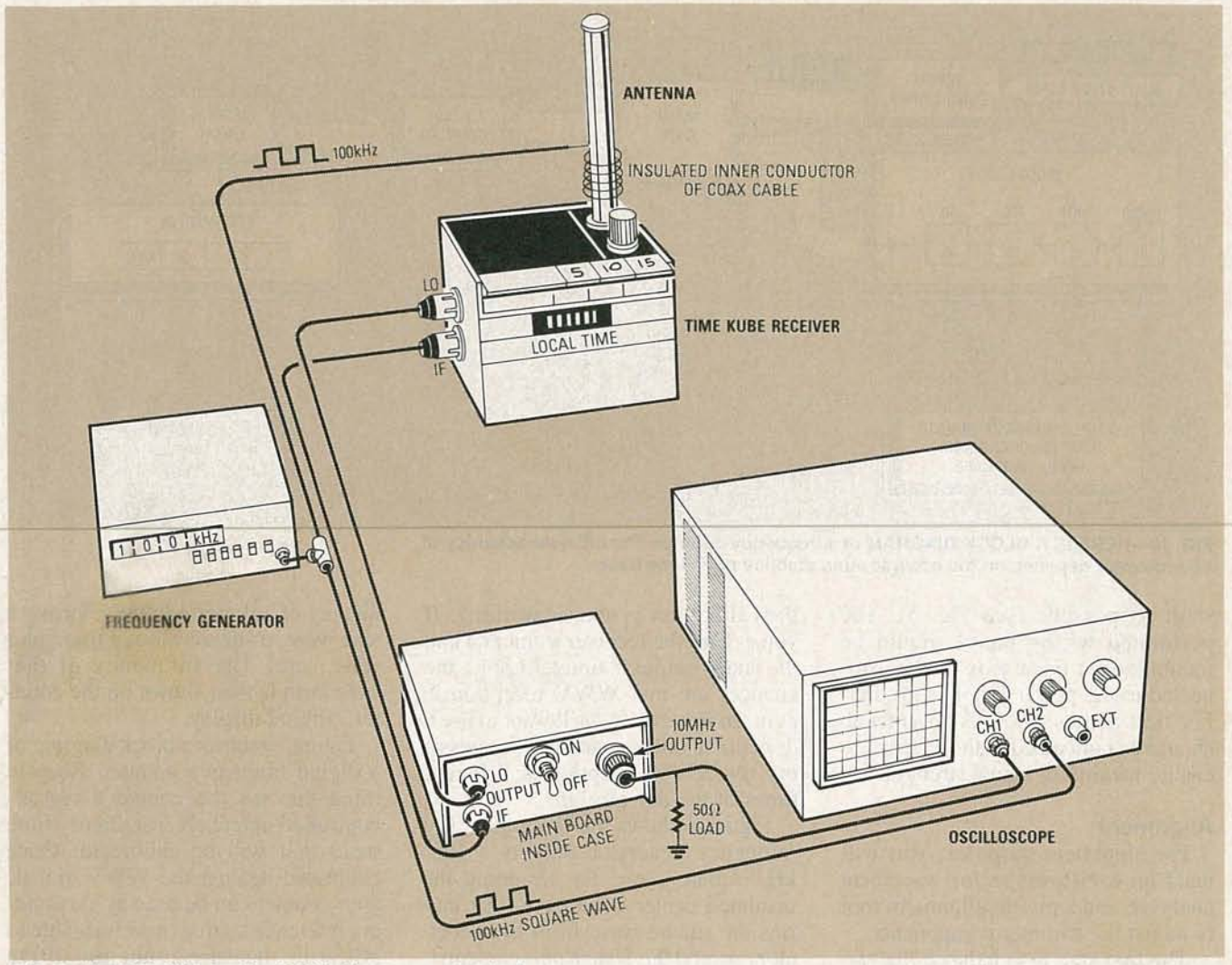


FIG. 8—TEST SETUP for the 10-MHz frequency standard.

tograph in the opening of this article.) The power consumed by the FET transistors is minimal, and can be tapped from the radio's power supply as long as it's less than 20 volts.

Now you have to figure out where to tap off the *Time Kube's* local oscillator and IF frequencies. Whether you use Radio Shack's *Time Kube 12-158*, or the *Weather Time Kube 12-148*, the local oscillator and IF connection points are the same. The points are easy to locate if you have Radio Shack's service manual showing the schematic and the parts layout. In both radios, the local oscillator is a single-transistor and crystal-controlled. The transistor's emitter is the best point to tap off the local-oscillator frequency. In both radios, the IF signal can be tapped off from AM-detector D1's cathode, which immediately follows the second (last) IF transformer.

In constructing the main board, you can use perforated construction board and point-to-point wiring (if you wish) as shown in Fig. 5. However, another alternative is to use the foil pattern shown in PC Service. That pattern is for the 3-output frequency standard, and if you want to use it for the 1-output unit you have to connect a jumper between pins 9 and 3 of IC2, and leave the additional components off the board.

A Parts-Placement diagram is shown in Fig. 6. Note that the parts specified in the Parts List for use only with the 3-output unit are optional. If you leave them out, just be sure to put a jumper between pins 9 and 3 of IC2. Also note, that the 3–30 pF variable capacitor, C16, may need a bit of customizing in order to make it fit on the board. Just make sure that the middle terminal, and one of the side terminals, are soldered to the appropriate pads. Figure 7 shows a photograph of the fully assembled PC board.

If you use point-to-point wiring, it

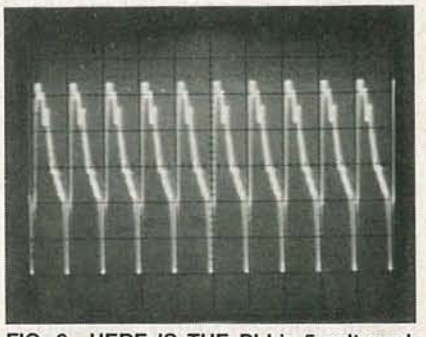


FIG. 9—HERE IS THE PLL's 5-volt peak TTL-compatible output.

is important to ensure that a good ground is available all around the board. That is best accomplished by running a piece of thickly braided shielding around the edge of the perforated circuit board. The braiding is attached to the metal chassis by heavy screws at both ends, and at the center of the perforated wiring board. The component layout is not critical; however, lead lengths should be kept as

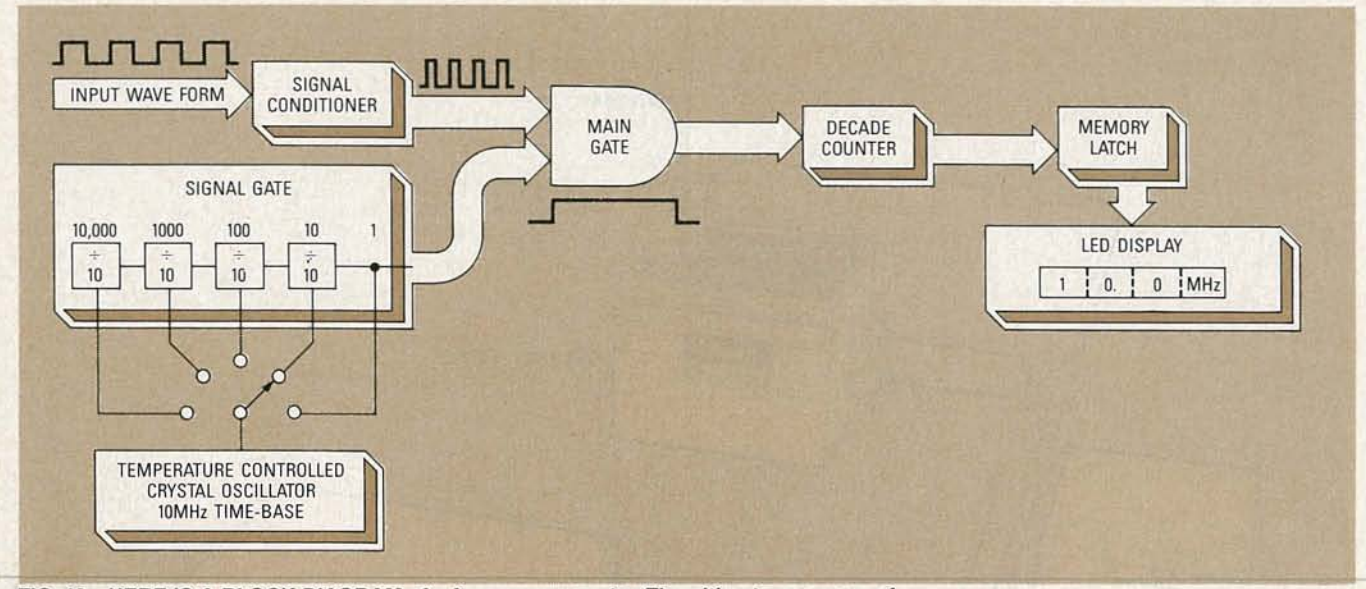


FIG. 10—HERE IS A BLOCK DIAGRAM of a frequency counter. The ultimate accuracy of your counter depends on the accuracy and stability of its time base.

short as possible (see Fig. 5). The perforated wiring board should be mounted in a metal box that is connected to the power supply's ground. For best results, an outside antenna should be connected to the receiver to ensure maximum signal strength.

Alignment

For alignment purposes, you will need an oscilloscope for waveform analysis, and a plastic alignment tool to adjust the trimmer components.

The first step is to balance the two inputs to IC1. Connect the radio's local-oscillator output, *but not the IF output*, to the main board via 50-ohm coax cable. Adjust the balance potentiometer (carrier null), R12, for a minimum-amplitude signal at pin 9 of IC1. The reasoning behind that adjustment is quite simple. When only one signal is input to a balanced modulator there is no heterodyning—therefore, no sum-and-difference output frequencies—and the original input frequency is highly attenuated.

The second step is to adjust the free-running frequency of the PLL's VCO to as close to 10 MHz as possible. That can be done using an oscilloscope, by adjusting trimmer-capacitor C16 so that the period of one complete output cycle is 0.1 μs.

Testing

Before attempting to lock onto the actual 10-MHz WWV signal, let's first test the 10-MHz *Time Kube* receiver and the locking ability of the PLL circuitry. That way you know that the calibration system is working. If you extend the receiver's antenna and the audio output is unintelligible, the chances are that WWV reception is poor. In that case, you'll want to use a directional outdoor antenna, or possibly try WWV reception at different times of the day or night.

Figure 8 shows the test setup. The frequency generator outputs a 100-kHz square wave. By wrapping the insulated center conductor (that carries the square wave from the generator) around the *Time Kube's* antenna, the 100th harmonic will be inductively coupled to the radio's antenna input, which is tuned to 10 MHz. Connect the *Time Kube's* local oscillator and IF outputs, via 50-ohm coax cable, to the main board's inputs. The Phase-Lock-Loop 10-MHz square-wave output is then coupled to CH-1 of your oscilloscope using a 50-ohm termination.

While triggering off the frequency generator's 100-kHz square wave on CH-2, tune the generator in and out a little. Eventually you will find a spot where the 10-MHz harmonic is picked up and the PLL output will lock-up (the 10-MHz signal will be displayed on CH-1). Adjust the PLL's loop-gain trimmer, R16, until the calibrator output can most easily lock onto the 10-MHz input signal. The PLL's 10-MHz output is a 5-volt square wave, as shown in Fig. 9.

Your frequency counter

A digital frequency counter is an instrument that can measure the frequency of any periodic waveform—a sine wave, a square wave, a triangular wave, etc. The frequency of that waveform is then shown on the counter's digital display.

Figure 10 shows a block diagram of a digital frequency counter. Keep in mind that it's the counter's crystal-controlled reference oscillator (time base) that will be calibrated. Once calibrated against the WWV signal, your counter can be used as a secondary reference source (now traceable to NBS) to measure other repetitive waveforms.

The input to the counter is fed into a signal conditioner that outputs one electrical pulse per input cycle. Those pulses having a constant amplitude and width drive the decade counters that follow. The signal-gate output controls the length of time that the main gate will allow the input pulses to pass into the decade counters. For example, when you set the counter for 0.1μs divisions, you're adjusting the length of time that the signal gate asserts the main gate. The frequency counter's time-base oscillator is used as a clock, and therefore must be as accurate as possible.

A counter's accuracy is dependent upon several factors, but it's the time-base generator that determines the ultimate accuracy of your measurement. Quite often, the difference in cost of one counter over another depends on the quality of the time base. You can consult the time-base specifications of your counter for its performance data.

Counter calibration

Now it's time to calibrate your frequency counter. First, connect the calibrator's 10-MHz square-wave output to the input of your counter, just as if you were going to measure the frequency of any other signal. Adjust the counter's time-base trimmer until the digital readout displays 10 MHz. That's it! Your frequency counter is now calibrated to the National Bureau of Standards WWV 10-MHz radio transmission, and is accurate enough to be used to calibrate your other test equipment.

Parts-per-million

Oscillator accuracy is usually expressed in parts-per-million (ppm), or sometimes as a percentage. One ppm is equivalent to 1×10^{-6}, or 1 divided by 1,000,000. That is equal to ± 0.000001. To get the accuracy in percentage, simply multiply by 100; that gives you $\pm 0.0001\%$. If the time-base has a frequency of 1 MHz, and an accuracy of 1 ppm, then it can be off by ± 1 Hz and still be within specifications.

As another example, suppose that a time base is specified as having an accuracy of 5%. That percentage represented as a decimal is equal to 0.05, or 5 parts per hundred, or 50 parts per thousand, or 50,000 parts per million. If you have a 1-MHz time base with an accuracy of 5%, then your oscillator's frequency can be off by ± 50 kHz, and still be within specifications. That doesn't sound too good for a 1-MHz oscillator, but if the time base is an audio oscillator, then 5% accuracy might be acceptable. In that case, the accuracy is 50 parts per thousand, or ± 50 Hz at 1 kHz.

The WWV radio transmission

The most obvious sounds heard on WWV are the pulses that mark the seconds in each minute. At alternate minutes during most of each hour, a 500-Hz or 600-Hz tone is broadcast. A 440-Hz tone (the musical note "A" above middle "C") is broadcast once each hour, and can provide an hourly marker for chart recorders.

There has been a controversy over the years regarding whether the WWV signal, as received via ionospheric propagation, is accurate enough to calibrate the reference oscillators used in today's moderately priced frequency counters. A letter from John Henning that appeared in the "Letters" column of the June 1982 issue of **Radio-Electronics** takes the position that: "WWV as received via ionospheric propagation is not accurate enough to adjust the standard contained in many of today's moderately priced frequency counters." In contradiction to that statement, contacts at the Oscillator Characterization, Time and Frequency Division, Center for Basic Standards at NBS in Boulder Colorado say: "The WWV signal as received via ionospheric propagation is accurate enough to calibrate moderately priced (below $250) commercial frequency counters." Let's examine the reasoning behind that statement.

The RF transmission at WWV, which is controlled by their cesium atomic clock, is transmitted on 2.5, 5, 10, 15, and 20 MHz, and has an accuracy of at least 1 part per 100 billion at the time of transmission. However, the RF wave propagates by skipping between Earth and the ionosphere. The ionospheric skip is principally caused by the F_2 layer, whose height and density above Earth varies at different times of the day and night. The most stable propagation occurs during the daylight hours and during nighttime. (Most signal corruption occurs at sunrise and sunset, when the ionosphere's height above Earth is moving either up or down.) That movement causes a Doppler shift in the WWV RF-carrier as it is refracted back to Earth. The worst case would yield an RF-carrier accuracy of 0.1 parts-per-million (± 1 Hz per 10 MHz), but usually the accuracy would be much better.

Let's assume the WWV carrier's worst-case accuracy is 0.1 part per million. As a rule of thumb, to calibrate any device, your frequency standard should have an accuracy one order of magnitude better than the oscillator your calibrating. Therefore, because most moderately priced frequency counters have a reference-oscillator accuracy from 1 to 10 parts-per-million, the 10-MHz WWV RF transmission is useful as a calibration signal. On the other hand, if your reference oscillator is accurate to 0.1 part per million, or better, then the WWV signal is not accurate enough for your purposes. **R-E**

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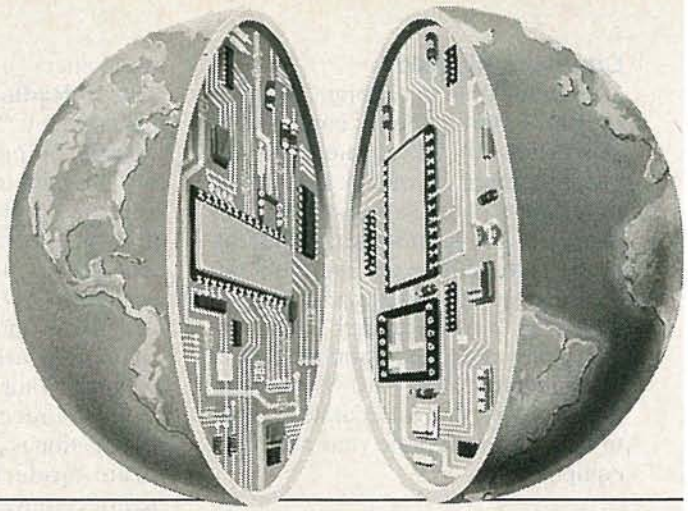

Look at the world as it was 20 years ago and as it is today. Now, try to name another field that's grown faster in those 20 years than electronics. Everywhere you look, you'll find electronics in action. In industry, aerospace, business, medicine, science, government, communications—you name it. And as high technology grows, electronics will grow. Which means few other fields, if any, offer more career opportunities, more job security, more room for advancement—if you have the right skills.

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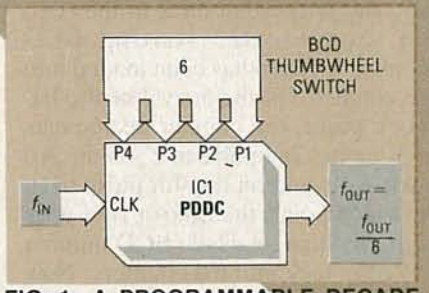


FIG. 1—A PROGRAMMABLE DECADE down-counter (PDDC) can count/divide by any BCD number fed into its PRESET pins.

LET'S EXAMINE PRESETTABLE DOWN-counters; how to design frequency dividers, frequency synthesizers, and alpha-numeric displays.

Jam inputs

By feeding a binary number into their PRESET pins—often called JAM pins—those counter IC's can be externally programmed to divide-by any binary number: either *B*inary *C*oded *D*ecimal (BCD), or straight binary form. For example, Fig. 1 shows a *P*rogrammable *D*ecade *D*own *C*ounter (PDDC) having a BCD code fed into its PRESET inputs via a thumbwheel switch.

The unique feature of the PDDC is known as *programmable cascadability*. As shown in Fig. 2, the *hundreds* counter is set to divide-by-2, the *tens* counter is set to divide-by-6, and the *units* counter is set to divide-by-3, which has an overall division ratio of 200 + 60 + 3, or 263. On the other hand, Fig. 3 shows that when conventional counters are cascaded with the same division ratios they would, of course, have a resultant of 200 × 60 × 3, or 36,000. We see that the presettable-types output the sum of the division ratios, while the conventional-types output the product of the division ratios.

Practical PDDC's can be programmed by a variety of methods. The two most common are electromechanical programming via thumbwheel switches, and there's electronic programming via microprocessor control.

Preset truth table

Figure 4-*a* shows a PDDC 4-stage synchronous down-counter, which shifts down one count for each positive transition of the CLOCK signal. Note however, as shown in Fig. 4-*b*, that when the down count reaches BCD 0 (ØØØØ), the next arriving clock pulse causes the counter to jump to BCD 9 (1ØØ1).

Other features of the PDDC include the following: The CLOCK signal can be disabled by a high level on the INHIBIT control. A decoded ZERO OUTPUT goes high only when the Q4-Q1 outputs are in the ØØØØ state. Also, by applying a high level to the LOAD pin, the counters are forced to take up the BCD states of the PRESET inputs.

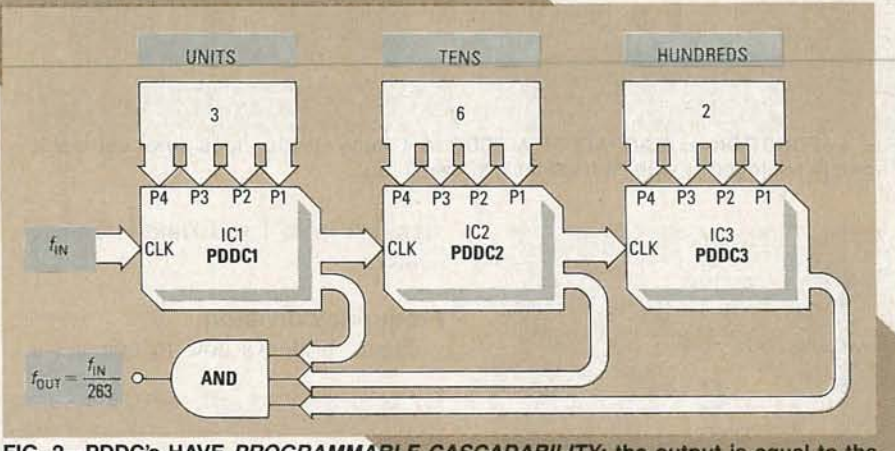


FIG. 2—PDDC's HAVE *PROGRAMMABLE CASCADABILITY*; the output is equal to the sum of the individual division ratios.

Programmable down-counter

Figure 5 shows a PDDC hookup that will count down from a BCD number loaded into the PRESET pins, by depressing the *start* button. For example, suppose the BCD number 6 (Ø11Ø) is loaded via the *start* button. On the arrival of each CLOCK pulse, the IC counts down one step, going through the numbers 5, 4, 3, 2, 1 and, finally, on the arrival of the 6th pulse, to 0, at which point the ZERO OUTPUT pin goes high. That logical high is fed back to the INHIBIT pin, causing all further CLOCK pulses to be ignored. The count sequence is now completed, but can be restarted only by depressing the *start* button once again.

Figure 6 shows how two PDDC's can be cascaded to make a down-counter having a count of 26. Notice that the ZERO OUTPUTS of both IC's are inputs to a logical AND gate that triggers the INHIBIT control of PDDC1. Also, the CLOCK signal of PDDC2 comes from the Q4 output of PDDC1. When the *start* button is depressed, counting action of the circuit is as follows: The BCD number 2 (ØØ1Ø) is loaded into the *tens* counter; the BCD number 6 (Ø11Ø) is loaded into the *units* counter; after which, the CLOCK input signal is initiated. PDDC1 counts down from 6 to 0 through the first six clock pulses. But then, because both IC's ZERO OUTPUTS are not high, PDDC1 is not inhibited. Instead, it starts acting as a divide-by-10

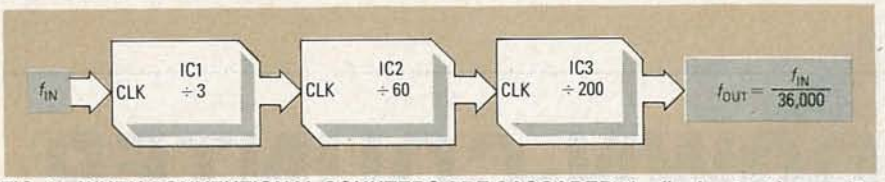
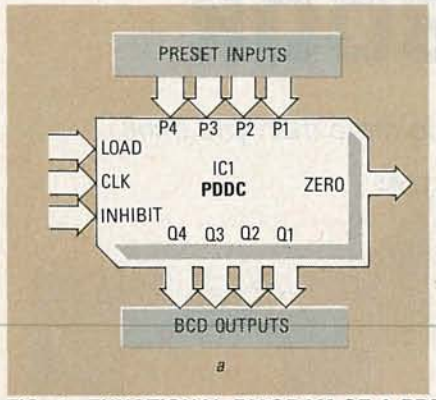


FIG. 3—WHEN CONVENTIONAL COUNTERS ARE CASCADED, the final output is equal to the product of the individual division ratios.



COUNT SEQUENCE	OUTPUTS Q4	Q3	Q2	Q1	BCD NUMBER
►n+1	1	0	0	1	9
n+2	1	0	0	0	8
n+3	0	1	1	1	7
n+4	0	1	1	0	6
n+5	0	1	0	1	5
n+6	0	1	0	0	4
n+7	0	0	1	1	3
n+8	0	0	1	0	2
n+9	0	0	0	1	1
n	0	0	0	0	0

b

FIG. 4—FUNCTIONAL DIAGRAM OF A PDDC. A 4-stage synchronous down counter is shown in (*a*), together with its truth table shown in (*b*).

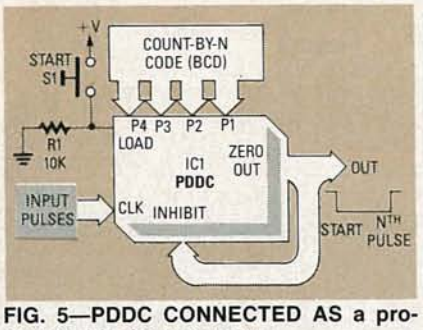


FIG. 5—PDDC CONNECTED AS a programmable down-counter.

counter, and counts down from BCD number 9 (code 1ØØ1) on the arrival of the 7th pulse, simultaneously sending a single CLOCK pulse to PDDC2 as Q4 output switches high. Ten pulses later (on the 17th pulse), PDDC1 sends another CLOCK pulse to PDDC2, causing its ZERO OUTPUT to go high. Nine pulses later (on the 26th pulse), the ZERO OUTPUT of PDDC1 also goes high, at which time the output of the AND gate goes high, inhibiting further counting action.

Figure 7 shows how to connect a single PDDC as a programmable timer. The output goes high as soon as the *start* button is depressed, but goes low again after a programmed amount of time. The circuit is the same as Fig. 5, except that the final output is inverted, and the CLOCK signal is taken from a fixed time-reference source (1 pulse/second). Looking back, Fig. 6 can also be made to act as a programmable timer by similarly inverting its final output, and taking the CLOCK signal from a fixed time-reference source.

Frequency division

Figure 8 shows how to connect a PDDC as a programmable frequency-divider. The divide-by-N code is fed to the PRESET pins. The output of the counter is taken from the ZERO OUTPUT pin, and is coupled back to the LOAD pin. Suppose the starting BCD number 4 (Ø1ØØ) has been loaded into the counter. On the arrival of the 1st CLOCK pulse, the counter decrements to 3, on the 2nd pulse to 2, on the 3rd pulse to 1, and on the 4th pulse to 0. At which point, the ZERO OUTPUT goes high, and that loads the BCD number 4 (Ø1ØØ) back into the counters. Now the whole sequence starts over again, and the ZERO OUTPUT switches back low. Thus, the counter repeatedly counts by the number set on the PRESET inputs, and the output (from the ZERO OUTPUT pin) takes the form of a narrow pulse only a few hundred nanoseconds wide.

Figure 9 shows a PDDC connected as a simple divide-by-10 counter/divider. The LOAD pin is grounded, so the PRESET codes have no effect and the counter repeatedly cycles through its basic BCD count from 9 to 0, and then back to 9 again, and so on. The output is taken from the ZERO OUTPUT

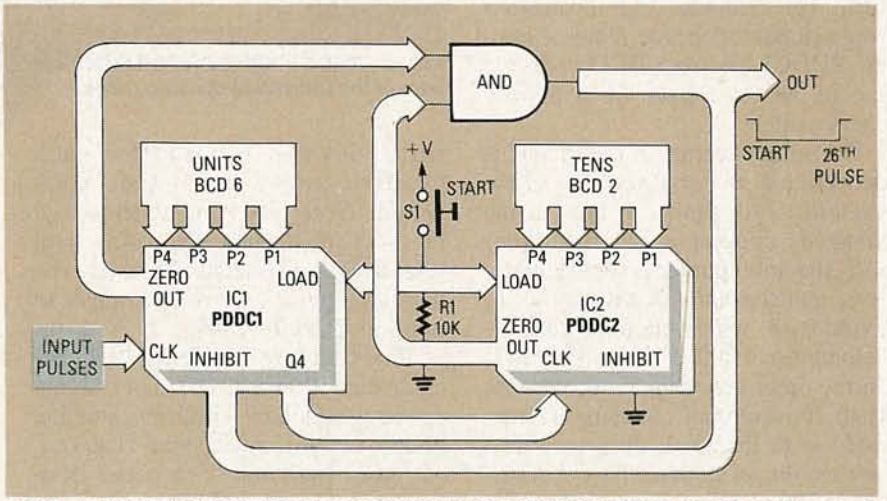


FIG. 6—TWO-IC (CASCADED) PROGRAMMABLE DOWN-COUNTER that is set for count 26 operation.

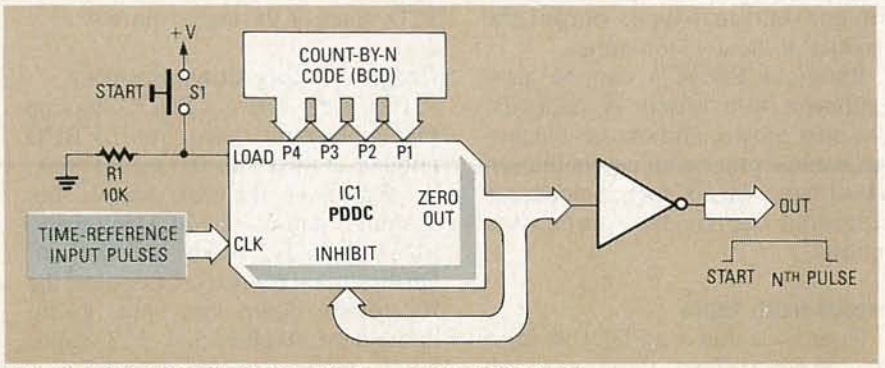


FIG. 7—PDDC CONNECTED AS A programmable timer.

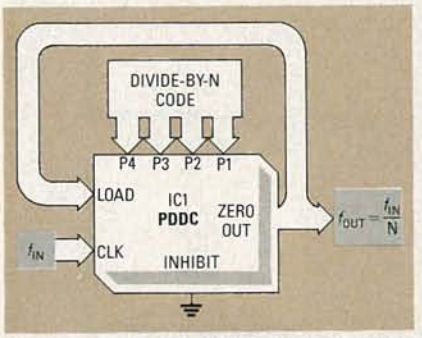


FIG. 8—PDDC CONNECTED AS A PROgrammable frequency-divider. The PDDC counts down to 0000 from the PRESET inputs—the ZERO OUTPUT pin is a narrow pulse of a few nanoseconds.

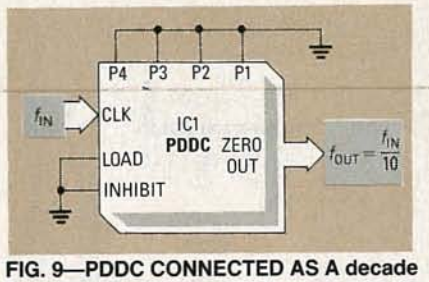


FIG. 9—PDDC CONNECTED AS A decade frequency-divider. The LOAD pin is grounded, so the PRESET pins have no effect on the circuit, consequently, the counter cycles through its basic decade count, from 9 to 0.

pin, which remains low until the all-zero count, when it pulses high for a few nanoseconds.

Figure 10 shows how to cascade two PDDC's to make a programmable frequency-divider. The ZERO OUTPUTS of the two counters are inputted to an AND gate to provide the LOAD action, and the CLOCK signal of PDDC2 is derived from the Q4 output of PDDC1. For example, assume that at the start of the count cycle the BCD number 24 (ØØ1Ø,Ø1ØØ) is loaded into the counters. For the first few counts, PDDC1 counts down from 4 to 0, and then the ZERO OUTPUT goes high. However, because PDDC2's ZERO OUTPUT is low, the AND gate's output does not go high; that would reload the counters. But instead, PDDC1 reverts to the normal divide-by-10 mode, jumping to the 9 state, simultaneously feeding a clock pulse to PDDC2 as Q4 output switches high. That action continues until the arrival of the 24th pulse, when the ZERO OUTPUTS of both IC's go high together. At that time, the output of the logical AND gate goes high (for a few nanoseconds), and reloads the BCD number 24 back into the counters. The whole sequence then starts over again.

Frequency synthesis

The main application of programmable frequency-dividers, as shown in Fig. 11, is in frequency synthesizers when used in conjunction with a (PLL) *P*hase *L*ocked *L*oop. Notice that the output of a *V*oltage *C*ontrolled *O*scillator (VCO) is fed, via the programmable divide-by-N counter, to one input of a phase detector. The other phase-detector input is taken from a (fixed frequency) crystal-controlled reference generator. The phase detector produces an output voltage proportional to the difference between the two input frequencies. That voltage is filtered into a DC voltage, and fed to the VCO's control input that automatically adjusts the VCO's frequency. When the output of the divide-by-counter is the same as the reference generator, the PLL is said to be locked.

Notice that in Fig. 11, the output frequency of the VCO is N-times the value of the frequency reaching the input of the phase detector. Consequently, when the PLL is locked, the output frequency of the VCO is equal to N-times the reference frequency; for example, if N = 236, and the reference frequency = 1 kHz, then the VCO frequency output equals 236 kHz, and also has crystal accuracy.

4522B/4526B down counters

The best-known family of CMOS programmable (cascadable) down-counters is shown in Fig. 12; it is composed of the 4522B (decimal) and the 4526B (binary) 4-bit IC's, which both have the same pinout. Those IC's are almost identical to Fig. 4, except that the counters can be synchronously set to the zero state by forcing the MR (master reset) pin high. The AND gate is built into the ZERO OUTPUT line, so the ZERO OUTPUT can only go high if the CF (cascade feedback) pin is also high; that enables cascading without external gates.

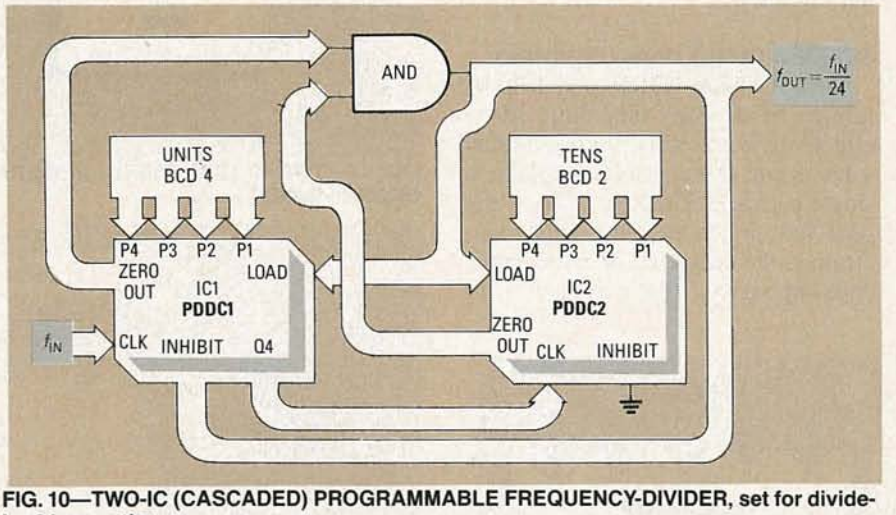


FIG. 10—TWO-IC (CASCADED) PROGRAMMABLE FREQUENCY-DIVIDER, set for divide-by-24 operation.

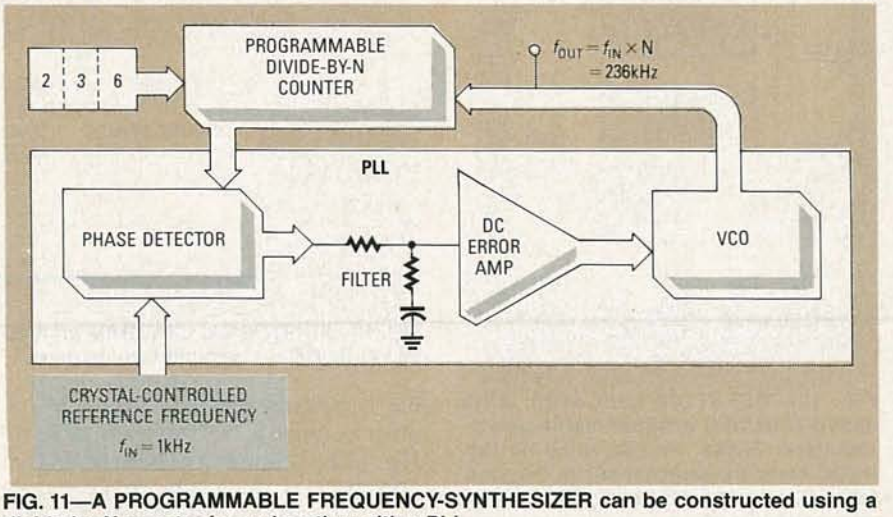


FIG. 11—A PROGRAMMABLE FREQUENCY-SYNTHESIZER can be constructed using a divide-by-N counter in conjunction with a PLL.

The 4522B and 4526B can be used in the same ways as the counters shown in Figs. 5 to 11, except that the MR pin is normally grounded, and the AND gate is built into the IC. When those IC's are used alone, the CF pin must be tied high to enable the ZERO OUTPUT. When cascading two or more IC's, tie the ZERO OUTPUT of the *M*ost *S*ignificant *D*igit (MSD) IC to the CF pin of the IC that is used for the next most significant digit, repeating the process until the *L*east *S*ignificant *D*igit (LSD) IC is reached. Figure 13 shows the hookup for making a 2-stage programmable down-counter, and Fig. 14 shows the connections for a 2-stage programmable frequency-divider.

When using those IC's, notice that all unused inputs, including PRESETS, must be tied high or low, as appropriate. Also, the outputs of all internal counter stages are available through the Q output pins, enabling the counter states to be decoded by using external circuitry.

40102B/40103B down counters

Each IC in the 40102B and 40103B family of devices (see Fig. 15-*a*) effectively act as a pair of presettable 4-bit down counters, cascaded in a single package. The ZERO OUTPUT that goes low under the zero-count condition is the only externally available counting signal. That's in contrast to the Q outputs typically available on other counter IC's. The truth table in Fig. 15-*b* is common to both IC's. The 40102B is a 2-decade BCD down-counter, while the 40103B IC is an 8-bit (or two 4-bit words) binary counter. Both types of counters clock down on the positive transition of the CLOCK signal.

Codes that are applied to the eight

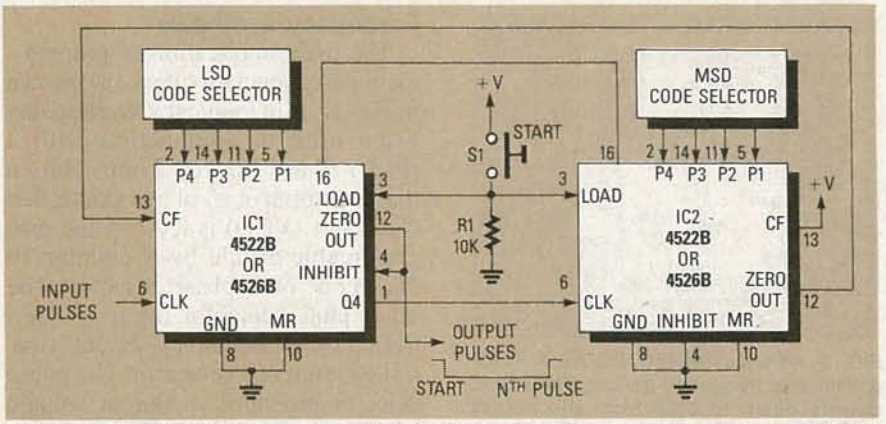


FIG. 13—TWO-IC (CASCADED) PROGRAMMABLE DOWN-COUNTER using the 4522B or 4526B.

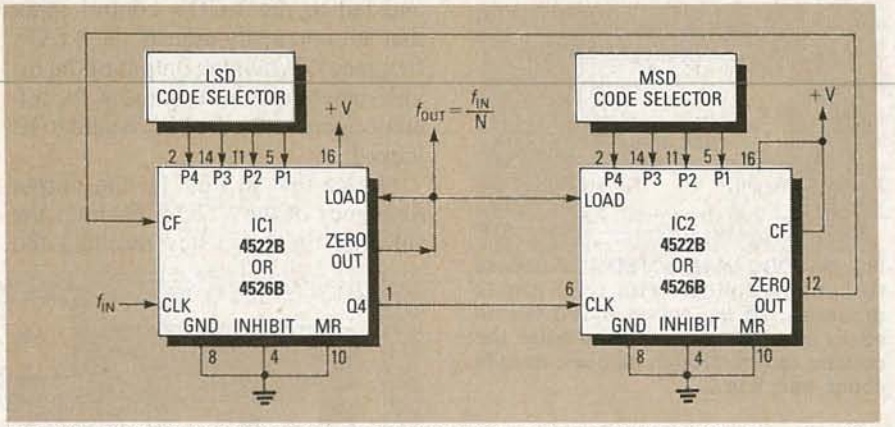
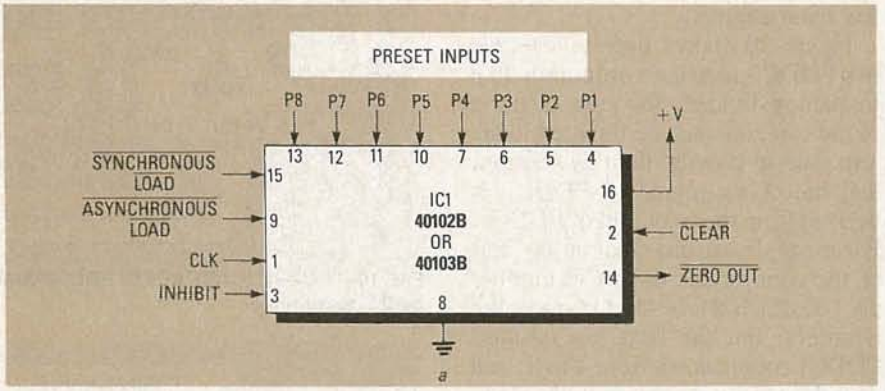


FIG. 14—TWO-IC (CASCADED) PROGRAMMABLE FREQUENCY-DIVIDER using the 4522B or 4526B.



CONTROL INPUTS				LOAD MODE	ACTION
CLR	AL	SL	INH		
1	1	1	1	SYNC	INHIBITS COUNTER
1	1	1	0	SYNC	COUNT DOWN
1	1	0	X	SYNC	LOAD ON NEXT CLK PULSE
1	0	X	X	ASYNC	LOAD ASYNCHRONOUSLY
0	X	X	X	ASYNC	CLEAR TO MAXIMUM COUNT

b

FIG. 15—FUNCTIONAL DIAGRAM *(a)* AND TRUTH TABLE *(b)* of the 40102B dual-decade and 40103B 8-bit binary down-counters.

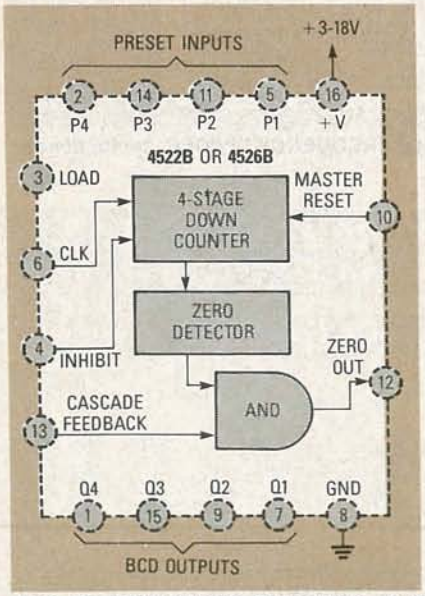


FIG. 12—THE 4522B (DECADE), AND 4526B (BINARY) programmable down-counters. Those are the same as the PDDC counters except that the AND gate that's used when cascading IC's is integrated into the IC.

PRESET pins of those IC's can be loaded asynchronously by pulling the $\overline{AL}$ pin low, or synchronously on the arrival of the next CLOCK pulse by pulling the $\overline{SL}$ pin low. When the $\overline{CLR}$ input is pulled low, the counter asynchronously clears to its maximum count. When the INH control is pulled high, it inhibits both the CLOCK counting action, and the ZERO OUTPUT action. The INH control thereby acts as a CARRY-IN pin for cascading counter IC applications.

Figures 16 to 19 show four ways of using that family of presettable down-counters. Figure 16 shows the connection for making a programmable 8-bit, or 2-word timer, or down-counter. Figure 17 shows the circuit of a programmable frequency-divider that has divide-by-(N + 1) operation. Its ZERO OUTPUT going low for one full clock cycle under the zero-count condition. True divide-by-N operation can be obtained by tying $\overline{SL}$ high and connecting ZERO OUTPUT to $\overline{AL}$; the output pulses will have widths of only a few hundred nanoseconds.

Finally, Figs. 18 and 19 show the basic connections that are used to cascade 40102B or 40103B stages in large-word programmable applications. Figure 18 shows the counter hookup for the fully synchronous clocking that's needed when used for high-speed applications.

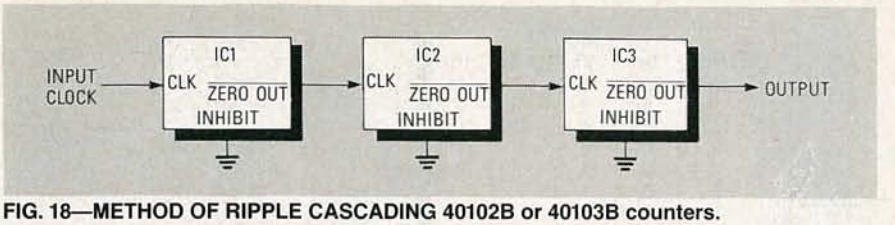


FIG. 18—METHOD OF RIPPLE CASCADING 40102B or 40103B counters.

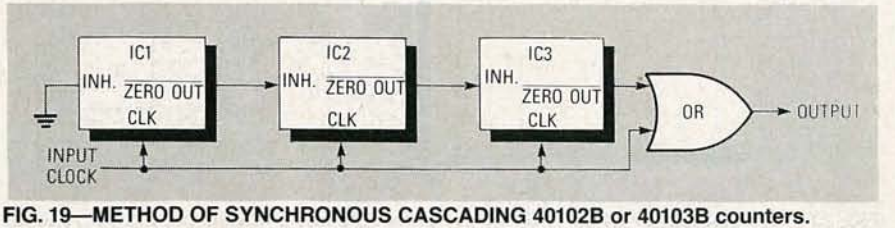


FIG. 19—METHOD OF SYNCHRONOUS CASCADING 40102B or 40103B counters.

Decoders

Most of the counter/dividers that we've looked at have 4-bit coded outputs, which take the standard code forms shown in Fig. 20-*a*. Thus, when the counters are in the BCD-5 state, they have an output code of Ø1Ø1. When in the BCD-7 state, they have an output code of Ø111 (read with Q4 to the left). Individual output states of the counters can easily be decoded and used for driving external display units or control lines, by using the basic logic technique shown in Figs. 20-*b* and 20-*c*. The decoder outputs that are high (logic-1) in the desired code state are fed directly to the inputs of a 4-input AND gate, and those that are low are fed through an inverter. If BCD numbers are to be decoded, and the numbers fall between 2 and 7 inclusive, the Q4 code can be ignored, and a 3-input AND gate can be used.

If more than three code states are to be decoded, it's economical to use dedicated CMOS decoder IC's, such as the 4028B, 4514B or 4515B. The 4028B in Fig. 21 is a 4-bit BCD-to-Decimal decoder that has direct decoding of the ten possible input BCD numbers 0 to 9 inclusive. Only one of the ten decoded outputs will go high with the remaining outputs low. The 4514B and 4515B in Fig. 22 are full 4-bit binary decoders having an individual output for each of the sixteen possible code numbers. The 4514 has *active high* outputs; that means that all outputs are low except the decoded line, which is high. The 4515B has *active low* outputs. Those IC's are considerably more sophisticated than the 4028B type, and they have their FOLLOW/$\overline{\text{LATCH}}$ control on pin-1, and they have a DECODE INHIBIT control on pin-23.

When the DECODE INHIBIT pin is brought high, all decoding functions are disabled; it drives all outputs low in the 4514B, or all outputs high in the 4515B, irrespective of the states of all other pins. When the FOLLOW/$\overline{\text{LATCH}}$ pin is high, the IC's act as straight decoders; but when the pin is pulled low, it latches the prevailing input code into memory and retains it, irrespective of the subsequent states of the input code.

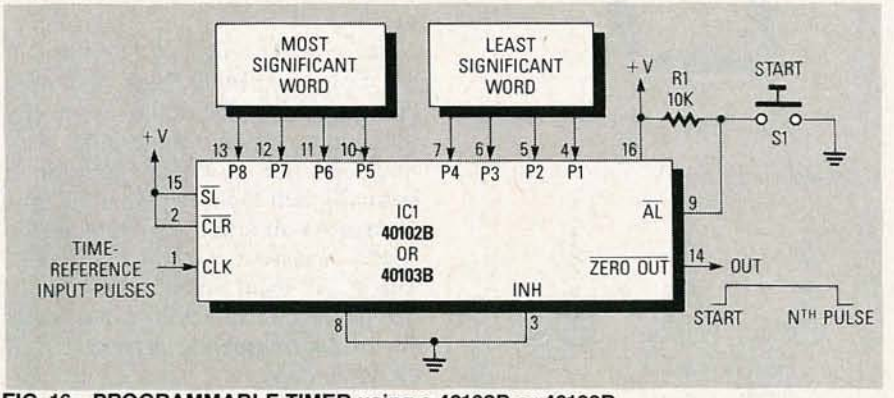


FIG. 16—PROGRAMMABLE TIMER using a 40102B or 40103B.

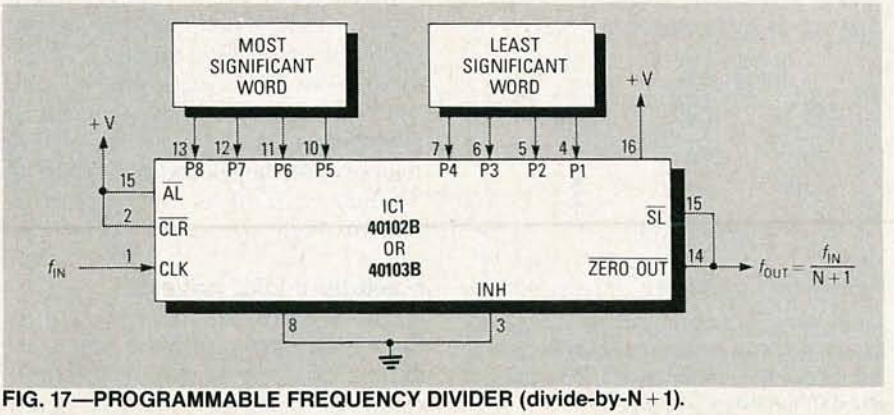


FIG. 17—PROGRAMMABLE FREQUENCY DIVIDER (divide-by-N + 1).

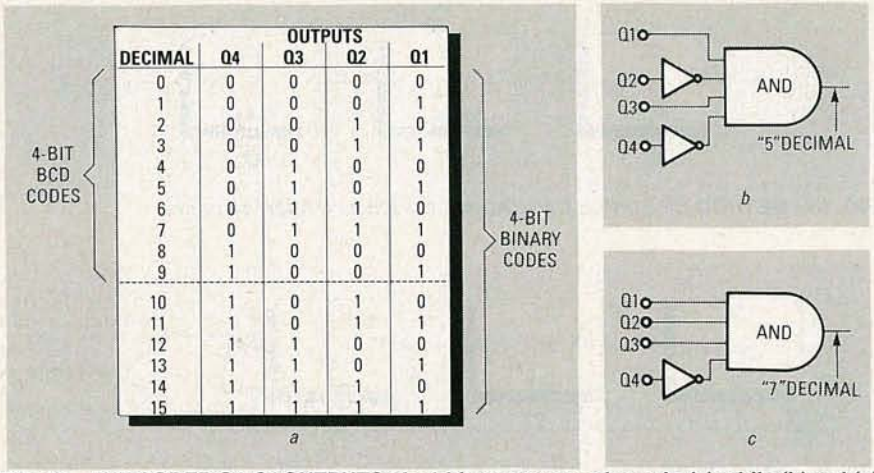


FIG. 20—THE CODED Q4-Q1 OUTPUTS of a 4-bit counter are shown in *(a)*, while *(b)* and *(c)* show how to decode the numbers 5 and 7, respectively.

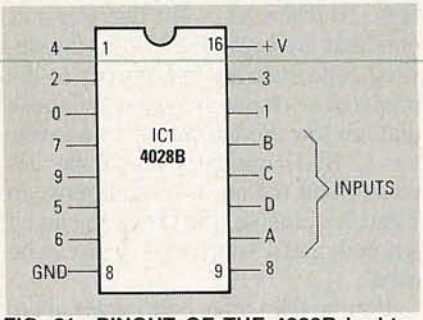


FIG. 21—PINOUT OF THE 4028B bcd-to-decimal (1-of-10) decoder.

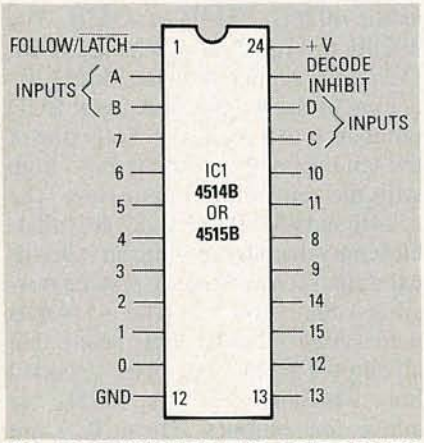
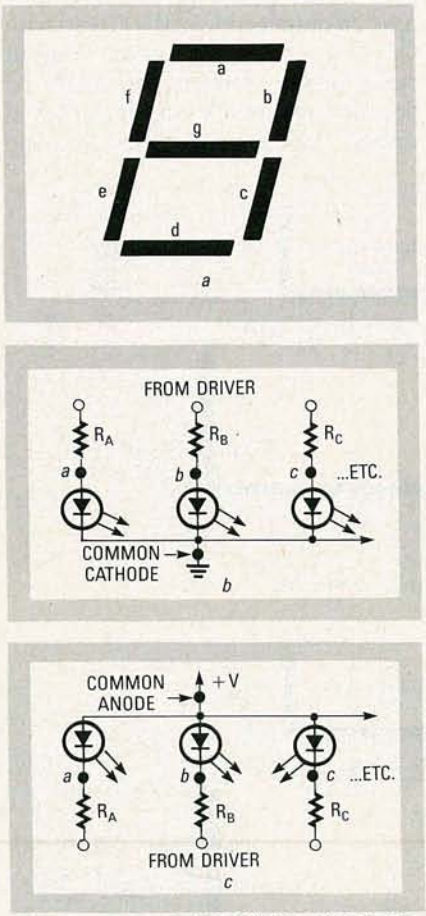


FIG. 22—PINOUT OF THE 4-BIT BINARY (1-of-16) decoders, the 4514B (active-high output) and the 4515B (active-low output).

BCD-to-7-segment decoder

The BCD outputs of decade counters can easily be decoded and used to drive 7-segment (*l*ight *E*mitting *D*iodes) LED's, or (*L*iquid *C*rystal *D*isplays) LCD's, by using suitable decoder/driver IC's. The 7-segment displays have the standard format and pin notations shown in Fig. 23-*a*, with each LED segment having its own individual pin. LED 7-segment displays are available in either common-cathode form shown in Fig. 23-*b*, or common-anode form shown in Fig. 23-*c*. Common-cathode types must be driven by IC's that can source significant current, while common-anode types must be activated by devices that can sink a significant amount of current. Notice that a current-limiting resistor must be wired in series with each LED segment.



IG. 23—THE 7-SEGMENT LED (OR LCD) DISPLAYS have the standard segment format shown in *(a)*. The LED types are available as either common-cathode *(b)*, or commom-anode *(c)* types.

The most popular CMOS IC for driving 7-segment LED displays is the 4511B BCD-to-7-segment decoder/LED-driver, shown in Fig. 24. That IC is ideally suited for driving common-cathode displays because its outputs can each source up to 25 milliamperes of current.

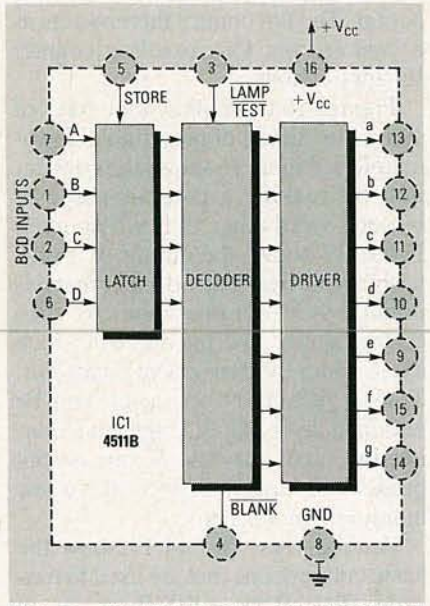


FIG. 24—THE 4511B BCD-TO-7-SEGMENT Latch/Decoder/LED-Driver. This single IC has the combined capability of a 4-bit data latch, a BCD-to-7-segment decoder, and a transistor-driver output for LED displays.

The 5411B is an easy IC to use. It has 4 pins as a BCD input, an output driving pin for each of the seven LED segments, and only three input control pins. The $\overline{\text{LAMP TEST}}$ input pin is normally tied high; when pulled low, it turns on all seven segments of the display, irrespective of the input code. The $\overline{\text{BLANK}}$ input pin is also normally tied high; when pulled low, it turns off all display segments, irrespective of the input code. The STORE control enables the IC to have either transparent or latched decoder operation. When STORE is low, the IC has transparent decoding of the BCD inputs. When STORE is switched high, the BCD input that is present at the moment of switching is latched into an internal memory and then decoded. That BCD number is held as long as STORE remains high.

7-segment LCD drivers

The 7-segment LCD's (*L*iquid *C*rystal *D*isplays) have the same format as LED types, except that their common pin is known as the *back-*

plane (BP). LCD's must be driven by AC signals that have virtually no DC components. In practice, the AC signal takes the form of a square wave with a frequency in the 30-Hz to 200-Hz range.

Old-style LCD drivers relied on the use of dual power supplies to provide the AC drive. Modern types, however, use the bridge-supply technique, shown in Fig. 25-*a*, to provide the necessary AC drive. When a segment is turned on using the bridge supply, the segment and backplane are driven by antiphase square waves. The resulting voltage across the LCD is AC as far as the display is concerned; it's the value of segment voltage relative to the backplane voltage that is important. Lets examine how that works. In Fig. 25-*b*, part **A** of the waveform shows the segment to be 10-volts positive to the backplane; in part **B**, it is 10-volts negative to the backplane. Therefore, the LCD is effectively driven by an AC signal with a peak-to-peak value of 20 volts, and with no DC component. In that LCD driving system, when a segment is turned off, it is simply shorted to the backplane of the display.

The most popular CMOS IC for driving 7-segment LCD's is the 4543B BCD to 7-segment decoder/LCD-driver, which uses the bridge power-supply technique. Figure 26 shows the 4543B. That device has to have its PHASE pin connected to the backplane of the display, and must be driven form a symmetrical external square wave. The BLANK pin is normally grounded; that pin blanks the entire display when pulled high. The $\overline{\text{STORE}}$ control causes transparent decoding when pulled high, or causes latched decoding when pulled low.

In conclusion, all of the devices that we have discussed in this article are intended for use in fairly simple applications such as the ones shown. For dedicated applications such as frequency meters, or digital clocks, you should consider the potential applications for the special VLSI IC's. **R-E**

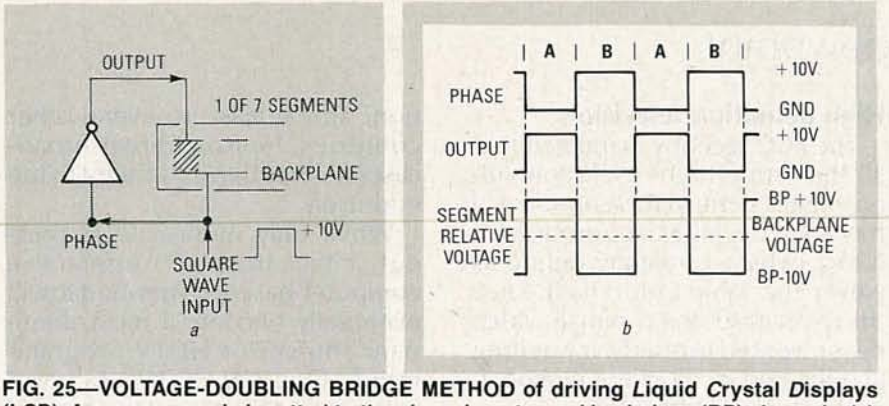


FIG. 25—VOLTAGE-DOUBLING BRIDGE METHOD of driving *L*iquid *C*rystal *D*isplays (LCD). A square wave is inputted to the phase inverter and backplane (BP) shown in *(a)*. That creates an AC voltage across the backplane shown in *(b)*.

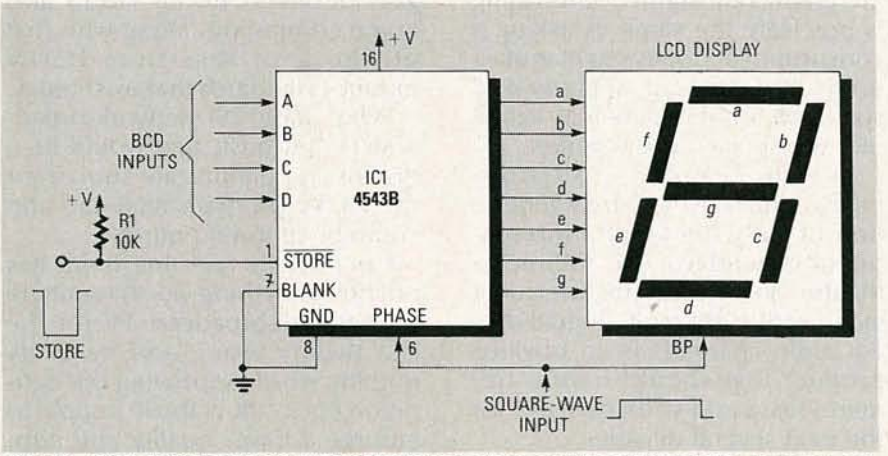


FIG. 26—THE 4543B BCD-TO-7-SEGMENT Latch/Decoder/LCD-Driver. The decoder outputs (*a-g*) are connected directly to the LCD display.

HARDWARE HACKER

White noise software
Top octave generators
High definition television
Pseudorandom sequences
Electronic music resources

HDTV—an alternative viewpoint

MANY THANKS FOR ALL THOSE CALLS and letters I got on the patents and patenting topics that we covered back in the October issue. Of the 415 responses to date, far and away the majority were in the "right on" or else the "if only I had known that six years ago" category, and I thank you for them.

You'll be seeing other viewpoints on that from time to time over in the letters column. Since arguing one-on-one in the letters column is just not my usual style, I'll repeat our key point here—For most of you hardware hackers most of the time, any involvement whatsoever with patents and patenting will almost certainly prove to be a monumental waste of time, energy, and money—not to mention the resulting headaches.

The overwhelming evidence for that is based on (A) my lifetime of experience directly involving inventions, patenting, creativity, design, and product development; (B) the independent and very thoroughly documented third-party studies of patent productivity; and above all, (C) the dozens of horror stories from current **Radio-Electronics** hardware hackers who have already gotten ground into hamburger by all of the absurdities that surround the patent process today.

I am sorry if I did offend one or two patent attorneys, and one or two others who seem to be personally profiting from this very sorry state of affairs. I also extend my apologies to their BMW dealers.

Well, now that we got that hornet's nest kicked out of the way, let's take a swipe at another one. Which involves...

High definition television

The FCC recently mandated that all the future high-resolution video images done in this country will have to be NTSC-compatible. NTSC (which I jokingly define as *N*ever *T*he *S*ame *C*olor) has been a thirty-year-old compromise which never worked properly. It was long ago flushed by all of the personal-computer manufacturers.

Besides its being monumentally stupid, insanely protectionist, and incredibly hindsighted, this ruling is precisely the same as asking a consortium of trolley-car manufacturers to dictate a mandatory new standard for the personal vehicular transport of the nineties.

Any disinterested outsider might conclude that a new generation of fully digital and internationally standard "35 millimeter theater quality" interactive home video with eight multi-lingual stereo audio channels is an obvious product that should have a tremendous world-wide demand for the next several decades.

Where would the programming for true HDTV come from? Well (1) from local cable systems; (2) from upcoming generations of video-tape rentals; (3) from video-tape ownership; (4) from home video cameras; (5) from satellite reception; and at least in several other countries, (6) from direct-broadcast satellites that go straight to the end-user.

While only minuscule at present, I feel that a (7) interactive computer-based Hypermedia will eventually become a most dominant source for HDTV programming. Once a HDTV standard exists, all of those major personal computers suppliers are likely to adopt it, eliminating the artificial gulf between home video and home computing, along with that plethora of less-than-HDTV monitor standards that exist today.

What about (8) network-broadcast TV? At best, that would be a distant and eighth-rate source for the HDTV program material, and could be ignored entirely.

I personally feel that there has not been anything worth watching on network-broadcast TV for the last twenty years, and certainly nothing worth improving the definition of. To allow those people to enforce a lower quality and non-international poor patchwork "unstandard" at the expense of the ultimate videophile is unthinkable, inexcusable, and an outright atrocity.

As with streetcars, there comes a time when it is a good idea to tear up the tracks.

Further, virtually all of the HDTV receivers will now include a microprocessor, a new frame grabber, great heaping bunches of additional RAM memory, and possibly even a digital signal processor.

Which means that real-time video compression and decompression should be fairly cheap and simple to add to virtually any trans-

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mission medium. Thus, we might easily end up with HDTV transmission bandwidths that are ridiculously *lower* than the present NTSC standards.

Most newer HDTV displays will probably be able to accept older NTSC, PAL, RGB, or SECAM program inputs, and even spruce them up a tad before displaying them. The key question is whether an older NTSC television set that inadvertently got plugged into some HDTV program source has to be able to display something viewable. The present ruling makes about as much sense as requiring that all CD-ROM disks be able to output low-fidelity audio when played with a cactus needle on a 78-RPM turntable.

As per usual, I do welcome your comments on this. In fact, let's have us another contest. Write me with your thoughts on HDTV. There will be all the usual *Incredible Secret Money Machine* books for the best dozen or two entries, with an all expense paid (FOB Thatcher, AZ) *tinaja quest* for two for the best entry of all. Naturally, you do not have to agree with me, but the more thought-out and the more coherent your written response, the better will be your odds of winning.

Do send your entries directly to me per the *Need Help?* box, rather than over to the **Radio-Electronics** editorial offices. And, hey, no fair sending the "right on" responses to me and the "up yours" ones over to the letters column.

Pseudo-random sequences

I have long been fascinated with both random and pseudorandom numbers and their generation.

Truly random numbers are quite difficult to generate, and it is very easy to introduce all sorts of subtle bias into them. One fact that many hardware hackers refuse to accept is that virtually any and all attempts at making something more random will nearly always have the exact opposite of the intended effect.

A *pseudorandom* sequence is some long string of numbers that eventually will exactly repeat, but any short portion of which will appear totally random, and apparently obey all the rules of random number distributions. The concept of "noise that repeats" is especially handy for industrial testing, for military radars, for security systems, and for such things as a re-deal of the same card hand in a computer game or simulation.

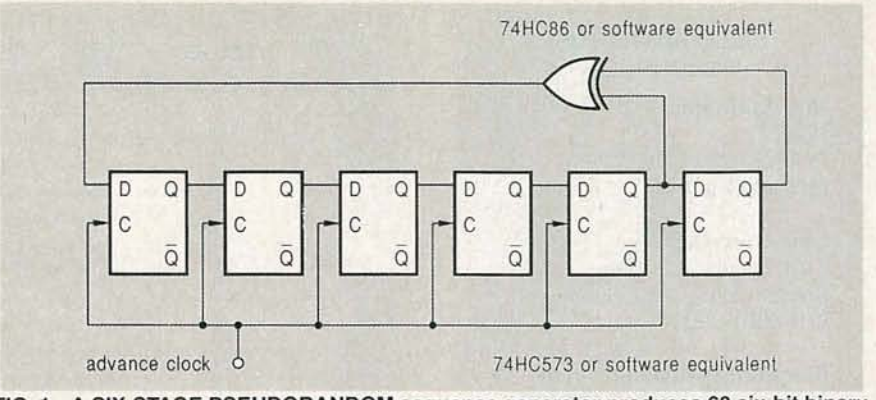

FIG. 1—A SIX-STAGE PSEUDORANDOM sequence generator produces 63 six-bit binary numbers in an apparently random, yet exactly repeating order.

To generate a new pseudorandom sequence, you can use, of all things, a *pseudorandom sequence generator*. Golly gee, Mr. Science.

To do that, you take a plain old hardware or software shift register. You then will choose a few of the outputs and XOR (exclusive-OR) them together and use the resulting one or zero as an input for the next clocking cycle.

One of two things is likely to happen. If you pick the wrong feedback combinations, then the shift register will shortly hang in its all-ones or all-zeros state. But with just the right combination, the shift register will become some sort of a counter of some length, that goes through a series of count values in a repeating and predictable order.

The trick is to pick out the longest possible sequence length for any shift register by finding just the right "magic" feedback combinations.

That is called a *maximal length sequence* and it's always *one less than* the total possible number of states in the register. Shorter groupings within one of those maximal length sequences will appear to be random and obey most of the properties of real random numbers.

Figure 1 shows you a six-stage pseudorandom generator that will generate a sequence that is 63 counts long. You might like to list all of the states to prove that, sure enough, short samples do appear random, even though the whole sequence does repeat once each 63 clocks. I used that back in my *Psyctone* project, which seems like eons ago, in the "golden age" of **Popular Electronics**.

You can create up to four related maximal-length sequences, a "forward" one and its complement, and a "backward" one and its complement. There is one big gotcha: You must never start with the "all

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STAGES	LENGTH	FEEDBACK
2	3	1, 2
3	7	2, 3
4	15	3, 4
5	31	3, 5
6	63	5, 6
7	127	6, 7
8	255	4, 5, 6, 8
9	511	5, 9
10	1023	7, 10
11	2047	9, 11
12	4095	6, 8, 11, 12
13	8191	9, 11, 12, 13
14	16,383	4, 8, 13, 14
15	32,767	14, 15
16	65,535	4, 13, 15, 16
17	131,071	14, 17
18	262,143	11, 18
19	524,287	14, 17, 18, 19
20	1,048,575	17, 20
21	2,097,151	19, 21
22	4,194,303	21, 22
23	8,388,607	18, 23
24	16,777,215	17, 22, 23, 24
25	33,554,431	22, 25
26	67,108,863	20, 24 25, 26
27	134,217,727	22, 25, 26, 27
28	268,435,455	25, 28
29	536,870,911	27, 29
30	1,073,741,823	7, 28, 29, 30
31	2,147,483,647	28, 31

FIG. 2—HERE ARE THE "MAGIC" FEEDBACK connections for many maximal length pseudorandom sequences. If two feedback numbers are shown, you XOR (exclusive-or) them together. If four numbers are shown, you XOR by pairs and then XOR the two intermediate results. Either hardware or software may be used.

zeros" state or your generator will hang, permanently outputting zeros.

For many uses, you'll want to use much longer sequences. Figure 2 lists the magic feedback combinations needed for various maximal-length sequences. A very few of the longer ones aren't "quite" maximal, but they are the best that anyone has ever found so far.

A very interesting pseudorandom generator for computer use appears in Fig. 3. This is a 31-stage register, giving you a sequence length of 2,147,483,687 before it repeats. Yet, it is able to deliver an apparently random one or zero in 40 microseconds or less with most personal computers.

The all time whiz-bang expert on random or pseudorandom anything is Donald Knuth in his *Art of Computer Programming* volumes. They are available at any large technical library. I've also gotten into that rather extensively in my *Apple Assembly Cookbook*, where you will find several ways around the fatal flaws in that Applesloth random-number generator, along with lots of useful ways to generate and test random and pseudorandom numbers of any size.

A white noise source

As a quick and dirty example of a 31-stage pseudorandom generator, Fig. 4 shows you a short machine-language routine that makes an Apple IIc, IIe, or IIgs sound as if it is frying itself in its own grease. I'll leave it up to you to dream up some of the more fiendish and unusual uses for this short code module.

On every binary one, the speaker cone gets whapped, while it stays where it is on a zero. As shown, the code is very slightly pinkish, rather than a pure white

noise. I'll let you add the few extra bytes needed to equalize the timing so each loop takes exactly the same time, regardless of when the cone gets moved.

You can use similar code to explore other pseudorandom lengths. As the lengths get shorter, you will first note some structure. For even shorter lengths, actual tonal color will result.

And here's something not quite related that you might like to play with: If you take any old 30-bit digital word and whop the speaker on the ones and not whop it on the zeros, different *timbre*, or tonal values will result depending on the strengths of the harmonics you are listening to.

For instance, getting a very strong fundamental and no low harmonics should result in a flute-like sine wave, while any waveform with a strong third, fourth, and fifth, but a weak first and second should give a major chord, *although you are only pushing a speaker cone all the way in or out.*

Thus, you can easily generate a pure tone, as well as two or three apparent notes at once by using that simple technique.

Now, it is easy to pick words at random and listen to the results, but how do you *purposely* design your selected word for the desirable harmonic structure?

Fourier series anyone?

Resources for electronic music

As with any other field, the bookstores, tech journals, and popular magazines that service electronic music interests are your starting place. It also helps if you can carry a tune in a bucket.

The *Electronic Music Resources* sidebar lists some of the more important and more interesting places to go to get started.

Probably the best collection of the electronic music, synthesizer, MIDI, audio, and video production books in the world is available through the *Mix Bookstore*. Their free catalog is an absolute must.

Of all the publications that are listed though, I think the *Journal of the Audio Engineering Society* has the best long-term track record on both the tech fundamen-

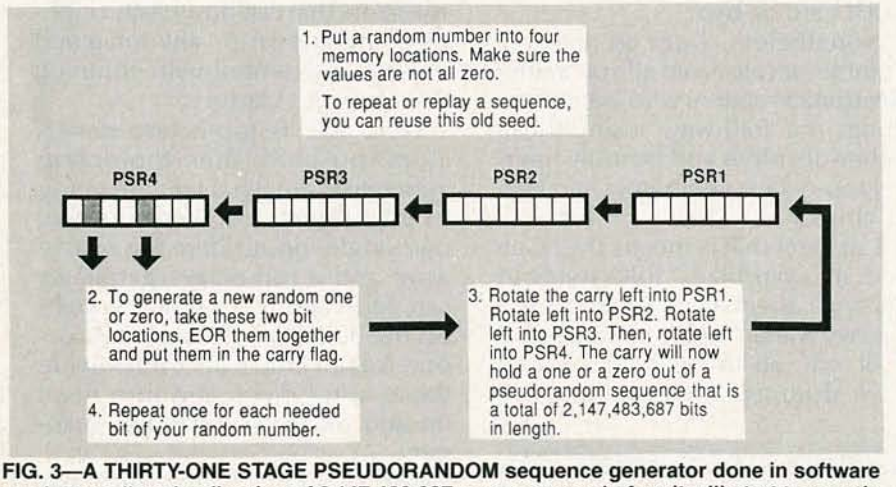

FIG. 3—A THIRTY-ONE STAGE PSEUDORANDOM sequence generator done in software produces a "random" string of 2,147,483,687 ones or zeros before it will start to exactly repeat. Typical execution time is under 40 microseconds.

(1) On an Apple II+, IIc, IIe, or IIgs, get into **BASIC.SYSTEM** and do a **CALL -151** to get into the monitor.

(2) Then, enter the following code:

```
0300:  4C 07 03 27 0C A1 C9 AD  <cr>
0308:  06 03 0A 0A 0A 4D 06 03  <cr>
0310:  0A 0A 90 03 2C 30 C0 2E  <cr>
0318:  03 03 2E 04 03 2E 05 03  <cr>
0320:  2E 06 03 4C 07 03 11 11  <cr>
```

(3) Finally, do a **BSAVE KFC.VIRUS, A$0300, L$28, D2**

(4) To test, use, or abuse your code, do a **BRUN KFC.VIRUS**

FIG. 4—THIS WHITE-NOISE GENERATOR makes an Apple computer sound as if it is frying itself in its own grease. A 31-stage pseudorandom generator is used. Except for stress-induced medical effects on the system owner, the code is more or less harmless.

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Erieville, NY 13061

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(414) 272-2060

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34 Foley Drive
Sodus, NY 14551
(315) 483-9122

Statek
512 N. Main Street
Orange, CA 92668
(714) 639-7810

Synergetics
Box 809
Thatcher, AZ 85552
(602) 428-4073

tals and on all the roots of the digital synthesis revolution, while Craig Anderton's *Electronic Musician* offers "hands on" coverage of the very latest and the very best.

Let me know if there is anything else that you think should be added. So far, we have done resource collections on handicapped aids and electronic music. Which others would you like to see?

Top-octave generators

If you wanted to design your own home, theater, or a church organ from the ground up today, far and away the simplest and the cheapest way to get the highest possible quality results would be to model what you are after on the *Ensoniq* synthesizer inside an *Apple IIgs* and later on tack on a MIDI card or two.

Nonetheless, I get an amazing number of calls from all you **Radio-Electronics** readers who want to do things the "old way," using those rather obsolete and horribly limiting top-octave generators and keyer chips.

I suspect that is mostly the "Gee dad, its a Wurlitzer" folks trying to distance themselves from all the "Heavy Metal" punk rockers. Like it or not, all those punk rockers have dumped many millions of dollars and hundreds of thousands of man hours into developing very simple, ultra cheap, and highly effective all-digital synthesizers that can now easily duplicate any known or any imagined musical instrument with stunning accuracy and clarity.

Well, if it is top-octave generators you want, then top-octave generators are what you are going to get. Figure 5 shows you how one single-input reference square wave and a top-octave generator can generate thirteen of the highest needed keyboard notes. A second keyer chip can then divide those notes down and turn them on and off in an organ-like manner.

Roy DeVault of *Devtronix* has lots of top-octave generators and keyer chips and boards available, and is more than glad to sell them to you at low cost in very small quantities. Roy provides everything from single chips up through new and used complete organs, besides being one incredible information source. He welcomes your calls.

If you do decide to build a top-octave generator for use as a pitch reference or a tuning instrument, just be sure to take into account these two big gotchas: Your output tones absolutely must be filtered to produce ultra-pure sine

continued on page 86

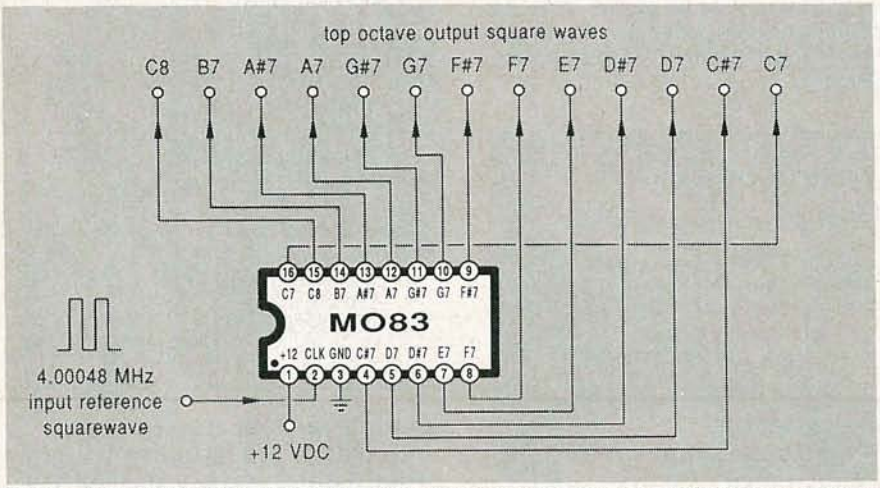

FIG. 5—A TOP-OCTAVE GENERATOR integrated circuit takes an input reference square wave and divides it down to approximate the thirteen uppermost notes on an electronic organ. Further binary division of each output can generate all the needed lower notes. This SGS part replaces the Mostek MK5083.

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continued from page 82

waves that can be used for tuning purposes; and you have to be able to vary your pitch by as much as 30 percent when tuning a piano. Because of the enharmonic lateral stiffness of piano strings, a piano keyboard has to be "stretched," rather than tuned to textbook frequencies. Otherwise it will sound awful.

New tech lit

Free samples of some low-cost connectors for pneumatic robotics are available from *Ark-Plas Products*, while one good and cheap source for custom photochemical etching of thin materials is *Fotocut*. Many thanks to *Model Railroader* magazine for that hard-to-find item. Besides absolutely outstanding tech writing, you might want to check out that magazine for very unusual tools, ideas, and materials.

By the way, if you ever do run across a model railroader, just tell him you are scratch-building an 0-2-0 articulated Camelsback, and watch his eyes light up.

International Rectifier now has a free *Microelectronic Relay Designer Manual*, mostly on their *ChipSwitch* solid-state interfaces.

Allied Electronics has a new free *#889* Catalog. Allied is one of the oldest of those "old line" electronics distributors and are at long last back to offering lots of products stocked in depth at tolerable prices.

The free *Hewlett-Packard Journal* is certainly worth a subscription to. The October 1988 issue has good stuff in it on SCSI interface fundamentals and on some cheap optical encoders. On the other hand, I simply cannot conceive of anyone ever actually buying one of those diskless workstations they're highly touting in the same issue.

Even when spelled correctly, I do feel that diskless workstations are both fascist and on the stupid side of dumb.

One good and low-cost source of miniature low-frequency crystals is *Statek*, who have a number of data sheets, price lists, and apnotes on hand. Ask for their literature list.

Two sources of low-cost infrared "people detectors" that operate using new pyro-electric sensors include *Amperex* and *Pace*. They both have several very detailed application notes and data sheets available.

Turning to my own products: Yes, we now have complete bound sets of reprints to all of the *Hardware Hacker* columns that you've seen here to date, along with volumes I and II of my sister *Ask the Guru* column that you'll find in *Computer Shopper*. And, of course, my classic *TTL Cookbook* and *CMOS Cookbook* remain available to those of you wanting to pick up the basics of digital integrated circuits.

As always, this is your column and you can get tech help and off-the-wall networking per the end box. You'll find two *Names and Numbers* lists this month, one for music stuff and one for everything else. Let's hear from you. **R-E**

SHORTWAVE RADIO

STANLEY LEINWOLL,
CONTRIBUTING EDITOR

Sunrise and sunset affect frequency propagation.

DURING THE WINTER MONTHS (JANUARY and February, 1989) propagation conditions change drastically around sunrise and sunset, local time. Those sharp "transition periods" occur because the sun is closer to Earth than at any other time of the year and, consequently, solar radiation is at its most intense levels. It's the sun's radiation that affects the ionization density of the ionosphere, which directly affects the range of useful frequencies.

For example, at sunset—when solar energy is abruptly removed—the range of frequencies that the ionosphere will support plunges rapidly. That effect is especially noticeable during the long winter nights in the northern hemisphere, when the ionosphere is weakened. The opposite effect takes place during the hours around sunrise. At that time, the sudden intense illumination of a weak ionosphere causes a rapid increase in the range of useful frequencies. And lastly, during the daylight hours, the range of useful frequencies is higher than at other times.

Radio conditions over long circuits are at their worst when part of the path is in daylight and part in darkness, because the frequencies that are optimum over part of the path are radically different from those over the remainder of the path. On circuits to the east, for example, conditions will be poor several hours before sunset; on circuits to the west, conditions will be at their worst several hours after sunset. That phenomenon, often referred to as following the gray line, will be discussed later.

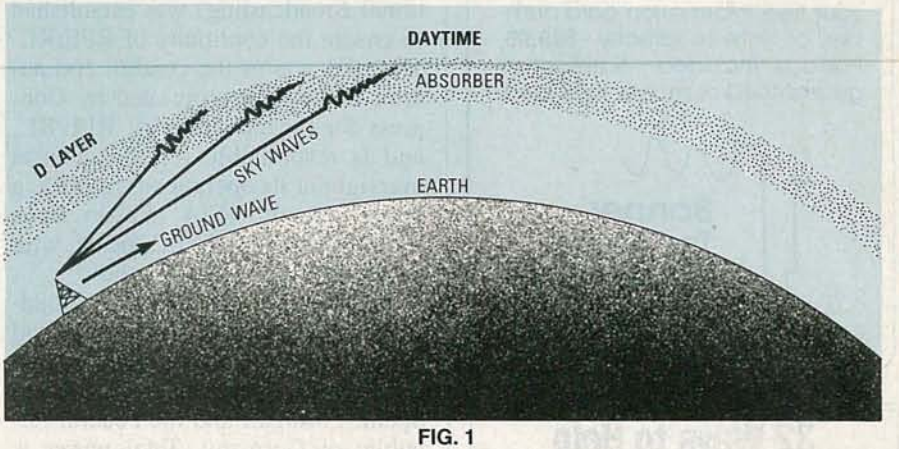

FIG. 1

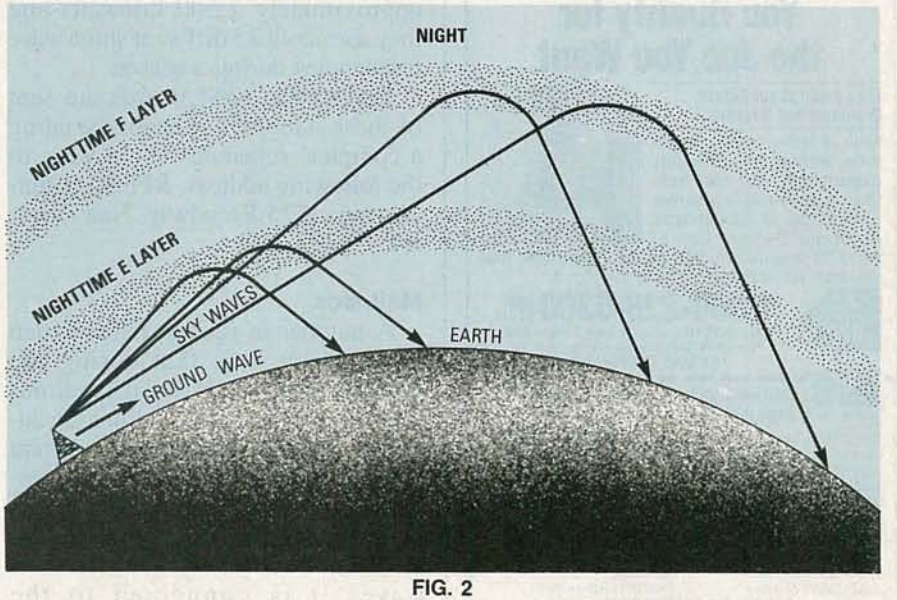

FIG. 2

General Conditions

Daytime conditions will be good to excellent throughout the forecast period, with DX openings possible from 15 to 28 MHz. The 10- and 11-meter bands will remain open for amateurs and CB DX-ers, and the seldom-used 26-MHz broadcast band will be open from early morning to around midday, local time in the eastern United States. The BBC (*B*ritish *B*roadcasting *C*orporation) and the Voice of America are the principal users of that band.

Nighttime DX conditions will be possible from 6 MHz up to 15 MHz over paths from the southern hemisphere. In general, the best DX will be in the 6- to 11-MHz bands.

Broadcast-band DX will be good to very good at night. During periods when the transmitter and receiver are both in darkness, openings from Europe will occur regularly

Chit-Chat

RFE (*R*adio *F*ree *E*urope) and RL (*R*adio *L*iberty) were founded in 1949 and 1951, respectively, as independent broadcasting stations. They originally received most of their financing from the CIA (*C*entral *I*ntelligence *A*gency). However, in 1971, all connections to the CIA were severed and the stations were temporarily financed by the U.S. State Department. By 1973, the BIB (*B*oard for *I*nternational *B*roadcasting) was established to ensure the continuity of RFE/RL. The BIB acts as the conduit and auditor of funds appropriated by Congress for the operation of RFE/RL, and is responsible for the general oversight of its operations. In 1985, a third station, RFA (*R*adio *F*ree *A*fghanistan) joined RFE and RL with broadcasts in Dari and Pashto.

In all, RFE, RL, and RFA broadcast in 23 languages of the USSR and Eastern Europe. Collectively, their 48 short-wave transmitters are located in Spain, Portugal, and the Federal Republic of Germany. Total power is approximately 7,500 kilowatts and they use about 85 different short-wave frequencies during a season.

Verification (QSL) cards are sent by those stations, and anyone wanting a complete schedule should write to the following address: RFE/RL Engineering, 1775 Broadway, New York, NY 10019.

Mail Box

A number of readers have written asking why it is that during the daylight hours only local medium-wave (broadcast band) stations are audible, whereas at night many distant United States and international stations can be heard by tuning across your AM-radio dial. Although the answer is not technically related to short wave, it is connected to the ionosphere so that interesting phenomenon will be treated here.

Those of you who have been reading this column regularly will remember that the ionosphere actually consists of several distinct layers, including the D, E, and F layers. The D layer is the lowest of the layers, and it exists only during the daylight hours. Although ionization in the D layer is not generally sufficient to absorb short-wave radio signals, its ionization is high enough to absorb medium-wave signals completely.

Figure 1 shows that during the day the broadcast band is absorbed by the D layer, while that part of the broadcast signal that travels along Earth's surface (the ground wave) contributes to the reception of the signal. Therefore, during the day, you get nothing but local stations.

However, at night the story is entirely different. As Fig. 2 shows, the D layer disappears because it's totally dependent upon solar radiation for its existence. And with that absorbing layer out of the way, the sky-wave signal travels to the E layer, which is present in residual amounts at night, and to the F layer, which is always present. Both the nighttime E layer as well as the F layer are capable of propagating medium-wave signals.

In general, the E layer will reflect signals at the lower end of the AM broadcast band (up to about 1000 kHz), whereas the F layer will reflect signals above 1 MHz (1000 kHz).

The maximum distance E-layer-reflected signals will propagate is about 1000 miles, whereas F-layer-reflected signals can cover twice that distance on the first hop. DX from more distant stations involves multiple-hop reflections between the ionosphere and Earth. Such multi-hop propagation can take place from a single layer, or from a combination of both E and F layers.

Those near the east coast of the United States will find that local sunset to several hours after are the best times to try for European medium-wave stations. During those hours it's dark across the Atlantic and still light to the west, minimizing the chances of interference from American stations. On the west coast, the hours immediately before sunrise to a little after are best because American stations are being absorbed in daylight while it is still dark across the Pacific Ocean.

If you are DX-ing European, African, or Asiatic stations, remember that the medium-wave bands in those regions are different from those in this hemisphere. The AM band in those areas extends from 531 kHz to 1602 kHz, and the separation between stations is 9 kHz, not 10 kHz as it is here. There are therefore 119 channels you can try for. **R-E**

AUDIO UPDATE

The question of reliability

LARRY KLEIN,
AUDIO EDITOR

QUESTIONS ABOUT THE RELIABILITY OF audio components turn up regularly in the reader mail at the major hi-fi magazines. And I'm sure that the salespersons at the audio showrooms are occasionally quizzed about the durability of the models or brands under consideration. Test labs are also taken to task for not commenting in their reports on a unit's construction and potential longevity. In general, the writers and editors probably seem unresponsive to such concerns and suggestions, and I'd like to explain why. (By way of citing my credentials for what is to come: I worked as a lab technician/troubleshooter in a audio/test equipment factory for five years, did free-lance hi-fi service work for several years, and for about 20 years I served as the Technical Director of a major hi-fi magazine where I supervised the work of the test laboratory.)

FIG. 1

Component longevity

Readers old enough to remember the days when all audio equipment had tubes are no doubt aware of the far greater reliability of today's transistor equipment. Vacuum tubes wear out through normal use; either their filaments blow out or their cathodes run out of electrons. In contrast, transistors have no inherent internal-wear mechanism, and can theoretically go on forever. In addition, one of the major causes of parts deterioration is heat; tube amplifiers run very hot, transistors amplifiers run merely warm.

Although transistors themselves may have a theoretically unlimited life span, we all know that transistor equipment does not. What determines whether an audio component will break down prematurely? One factor is the know-how of the designer. Example: Perhaps 10 years ago I received a press release (with schematic diagram) in my morning mail that announced the first amplifier product of a well-known loudspeaker-system manufacturer. Coincidentally, a friend who was the chief designer of a leading U.S. amplifier company chanced to drop in, spotted the diagram on my desk, and asked to see it. After a brief perusal of the schematic, my friend suggested that the amplifier was going to blow up in large numbers once it got into retail channels. His prediction proved accurate, and the product was subsequently withdrawn from production. Apparently the amplifier's designers hadn't included protection circuits to cope with some of the practical stress situations encountered in the "field." By the time they determined what was wrong, the amplifier's reputation was shot—along with dozens of output transistors.

But even knowledgeable designers occasionally find themselves in trouble. One best-selling power amplifier had a good reliability record for a year or so, then large numbers began to fail after a month or so of operation. I checked with the company's chief engineer, who told me this sad story: The source of the failure was a small-signal transistor at the input circuit of the amplifier. It seems that after X-number of hours of use, the transistor would develop enough leakage to upset the amplifier's direct-coupled circuit sufficiently to blow fuses. Although the same transistor type had been used without problems in similar circuits for years, there was some-

thing wrong with a recent batch supplied by the semiconductor manufacturer. Unfortunately, the defective batch (which passed incoming quality-control tests) had been mixed in with the other similar transistors and the manufacturer had no way of telling which of his finished amplifiers were OK and which had the built-in time bombs. A recall of the entire production run would have been inappropriate because less than 10 percent of the units had the potential problem. I don't know how the manufacturer and his dealers handled the problem but the model remained in the line and in the long run sold very well.

Incidentally, I've been told that the particular "timed" self-destruct problem resulted from manufacturing fault that causes a sort of electroplating process within the transistor. There is a slow transfer of material from one internal element to another until the transistor no longer operates. Capacitors, for different reasons, can also become timed destruct mechanisms. It's not uncommon for a specific brand and value of capacitor to have 75- to 100-percent failure rate, but only after months or even years of use.

Infantile mortality

Wouldn't the finished-product test procedures used by all reputable manufacturers have revealed those defective transistors? Unfortunately, no. In the absence of a special test, that kind of transistor problem only shows up after prolonged use. No manufacturer is going to tie up newly built equipment on the heat rack for hundreds of hours when his dealers are clamoring for shipment.

Luckily, most product failures take place during their first 24 hours of operation. Quality-control engineers refer to that as "infantile mortality." Obviously, any reasonable manufacturer would rather have a newly built component fail on his heat rack, than in the customer's home. The better heat racks enable amplifiers to be hooked up with appropriate line voltages, loads, and input signals, which are then automatically cycled to significantly stress the am-

continued on page 111

ANTIQUE RADIOS

Loudspeakers and things.

RICHARD D. FITCH,
CONTRIBUTING EDITOR

IN MOST INSTANCES, YOU WON'T BE able (or permitted) to plug in or make any tests on a set that you might want to purchase, so your decision must be based entirely on your visual inspection. Actually, being able to plug in a set isn't really that important—there have been only two sets that I was able to listen to before buying. If the set has a worn line cord, as practically all do, you wouldn't plug it in anyway. Suppose you plug in a prospective set and it doesn't light up at all. Would you reject it? If you did, you might be making a big mistake. I always prefer to repair a radio or TV that's "dead," rather than one with distorted or intermittent sound, or a wavy picture.

FIG. 1

Restoration

I've got a Philco Model 650, from about 1936. Over 50 years old, the set shows its age. Having a collection of antique radios, I bought the set (the left one in Fig. 1) just to get a part for another set (the right one in Fig. 1). I don't think that $20.00–$25.00 is too much to pay for a parts set to get a major component. What should we do with what's left over? Well, let's restore it! Sometime in the future, I'll bet that this derelict will be the antique radio of the month.

The cabinet has a lot of damage, especially to the veneer, but we won't get into any woodwork this month. We'll concentrate on getting it working.

Not only is the veneer damaged, but the frame is coming apart also. The grille cloth is worn and torn, there is a knob problem, and the escutcheon is missing. There's nothing I hate more than finding an antique radio with the escutcheon missing. It's like taking its identity away—and I won't be able to make one as easily as I have for some other radios.

Besides the multi-band dial, there's also the Philco shadowmeter tuner—that is going to be a tough escutcheon to make. I'll have to get a photo of the same model to copy it. As you can see, this Philco has every defect that an antique radio can have. It would take a true antique radioer to see any possibilities in that mess.

Dynamic loudspeakers

The Philco Model 650 has a component problem: the loudspeaker, or the lack of one. The set was purchased for the sole purpose of getting the electro-dynamic loudspeaker for another radio of mine in which the speaker had a damaged voice coil and cone, but the field coil was still intact. Since the field coil (or a substitute) must remain in the circuit (for the Philco 650, but not all antique radios), I think I'll put the damaged speaker in the bottom of the cabinet, so that I can at least connect the field coil.

The purpose of the field coil is primarily to create an electro magnet. On sets where the field coil gets its DC voltage from a separate source, or from a battery, as in most auto radios, it can be discon-

nected when replacing with a permanent-magnet loudspeaker. However, in most antique radios, the field voltage is taken right from the set's power supply, so the field coil is actually shown schematically as part of the power supply—removing it would disable the power supply.

In a way, using the field coil in that manner was an economy move by the early radio manufactures. For us antique radioers, we would rather see a separate choke coil installed. Then we could replace the electro-dynamic loudspeaker with a permanent-magnet type by just disconnecting the field leads. The field coil could then be discarded, even though it was rarely the cause of trouble.

The last time I made that statement about the durability of field coils, it drew considerable reader response from radiomen who were not in complete agreement. I thank all who took time to correspond, even just to disagree. Many of the readers' comments were very educational. However, looking at my collection of antique radios, there's not an open or shorted field coil in the lot.

Yes, an open can occur in the winding of the field coil; a resin block, corrosion, overloading, or even a faulty speaker plug can give that indication. If the field coil is part of the B supply, it will completely disable the receiver.

Often the field-coil winding gets its voltage from a separate source or rectifier. In that case, there may be a weak signal from the loudspeaker, even though there is an apparent open associated with the loudspeaker field-coil winding. The slight residual magnetism is the cause. So, when you make a cold continuity test on a suspected open field coil, be sure to include all of the connecting wires and plugs. Also, be sure to set your ohm meter to the proper range; some field coils have resistances up to 2000 ohms.

If an open is found, and it is definitely in the field winding, remove some of the insulation where the leads enter the coil. That is a vulnerable spot, and often the trouble is there. You can then make the necessary repairs and replace the insulation.

Now, if you can't repair the field coil, or if the cone or voice coil are beyond repair, a replacement loudspeaker must be found. You may have to buy a whole receiver just to get the proper electro-dynamic loudspeaker. All electro-dynamic loudspeakers are not interchangeable, so be sure to compare them before making substitutions. If you can't find a suitable substitute, you'll have to go with a permanent-magnet type.

On most units where the field coil is part of the B supply, you will be able to install a choke coil as a substitute. To do that, you will have to know the resistance of the field coil you are replacing. Then obtain a choke coil with about the same DC resistance. Usually a choke coil having an inductance of anywhere from 3–8 henrys will be suitable; even one that is slightly more or less might be OK. When a substitute choke coil has less resistance than the field coil, the operating voltages throughout the receiver may increase over what they normally were.

Besides the two aforementioned field-coil uses, they sometimes had another use. An extra wire from the field coil could be used to supply negative C bias voltage for the receiver. So you can see that there is no easy way to just remove an electro-dynamic loudspeaker and install a permanent-magnet unit. Each receiver will have to be studied to determine what will safely replace a unit that can't be repaired.

Going back to the Philco 650, that console was directed toward those who wanted all that was available in a radio at that time. Besides being a superhetrodyne, the set included the Philco shadow tuning. Also, there were provisions for short wave and tone control. That is a lot of radio. Everything appears to be in place and in fair condition. The multi-band superhetrodyne with eight tubes and push-pull output should have an excellent tone and provide some fine listening. How much will it be worth when restored? I'd say about $200.00. **R-E**

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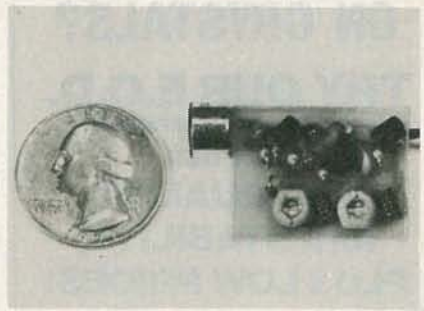

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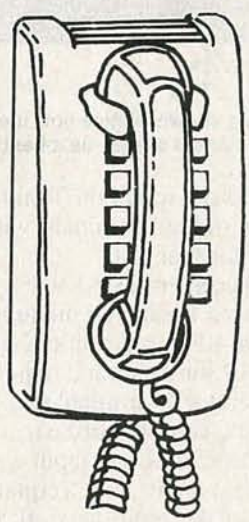

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CARRIER CURRENT

continued from page 64

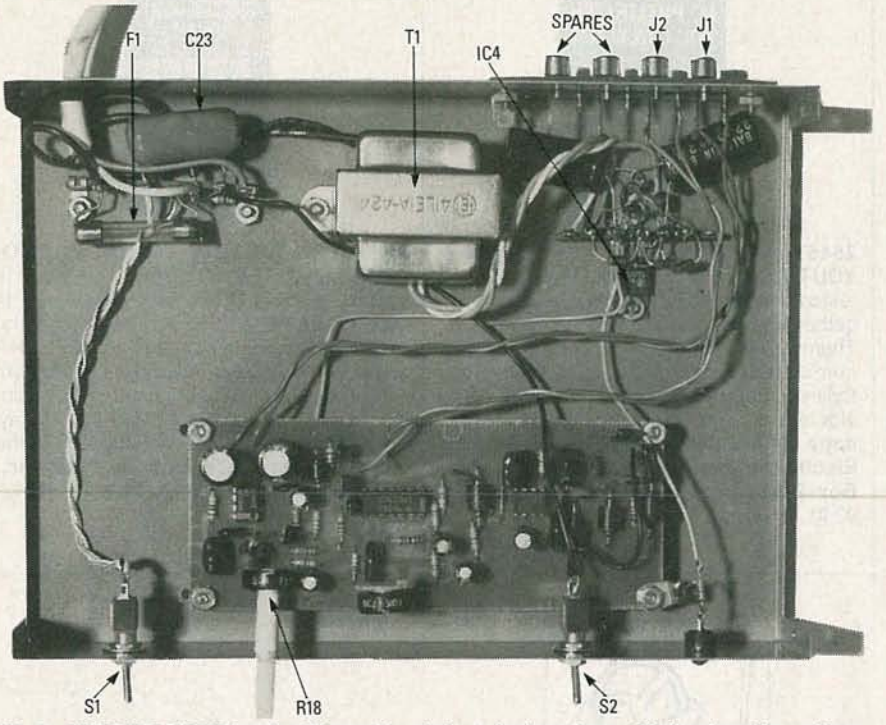

FIG. 6—THE PC BOARD for the FM receiver is installed as shown. Notice how the voltage regulator is mounted to the bottom of the cabinet; the cabinet serves as a heat sink.

- IC1 pins 1, 2, 4–6, and 8 to ground, and IC2 pins 2–10 to ground: no shorts (more than 500 ohms).

Set all potentiometers at halfway, apply DC power, and check for:

- Across C25: 16 volts (exact voltage depends on T1).
- IC3 pin 6: 12 volts.
- IC3 pin 5: 6 volts.
- Q2 collector: 7 volts.
- Q1 emitter: 9–10 volts.
- IC2 pin 7: 10–11 volts.
- IC2 pin 8: 10.5 volts.
- IC2 pins 2 and 3: 4 volts.
- IC1 pins 1 and 2: 11 volts.
- IC1 pin 5: 4 volts.

If everything's OK, connect a speaker to the output of either receiver. Apply power and continue:

AM receiver—Set R10 at about ⅔ open (to get between 6 and 7 volts across C15). Apply a 1-millivolt, 30% amplitude-modulated signal at 280 kHz between C1 and ground. If no signal generator is available, connect a long (25 feet or so) piece of wire to that point and try to pick up some noise from an appliance, etc. peak C2 and C4 for maximum audio output. Adjust R5 so that the audio output stays relatively constant over a range of inputs between 1 millivolt and 1 volt. R5 will affect the receiver's gain, so don't set it too high. Terminate the detector output terminals with a 1K resistor for that test.

FM receiver—Set R9 at midpoint and apply a 1-millivolt modulated signal with 40-kHz deviation, and then adjust R9 for minimum distortion. If no generator is available, set R9 at midpoint; you should hear a hiss in the speaker with no input signal. If possible, verify the frequency response of the input network by connecting a scope to pin 8 of IC1 and applying a CW signal (unmodulated) to the junction of C1 and C2. The signal should be low enough so that no more than 0.5 volts peak-to-peak appears at that pin, and also so that D1 and D2 do not conduct. Vary the signal frequency between 200 and 350 kHz, and plot the response (keep the input level constant). You should get ±1dB flatness or better between 240 and 330 kHz. If not, try adjusting the value of C3, C4, and C5 as required.

The boards are mounted as shown in Figs. 5 and 6. Another alternative is to install the receiver board and power supply inside an old speaker cabinet and use the existing speaker. Sometimes a speaker can be purchased for less than it might cost for just a project case alone. **R-E**

VOL. 6 NO. 2 FEB. 1989

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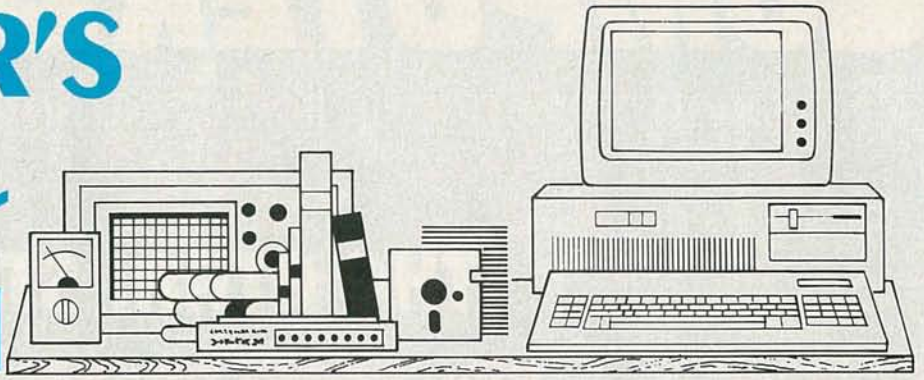


On-The-Go Computing

Z80 computing is not dead! British inventor Sir Clive Sinclair has introduced a new laptop to U.S. computer users. Sir Clive's Z88 features a CMOS Z80, 32K RAM, eight-line by 106-character supertwist LCD display, operation from four AA cells, a built-in serial port, and three slots for memory expansion.

The machine also contains 128K of ROM-based software, including several desktop accessories (clock, calendar, alarm, diary, etc.), and a combination spreadsheet/word processor called PipeDream.

Because of its extensive software, capacity for memory expansion, and wide screen, the Z88 is somewhat more powerful than the original laptop, Radio Shack's Model 100. However, the Z88 is incompatible with MS-DOS software, and has nowhere the storage capacity or expandability of typical DOS laptops.

Even so, the Z88 goes for a great price: just under $600 for the basic unit with 32K of RAM (only 20K of that is usable, however). Not coincidentally, that's Radio Shack's current price for the 32K Model 102 (a cosmetically upgraded Model 100).

For purposes of comparison, we examined a Z88, a Model 100, and a Toshiba T1000. The latter is an MS-DOS machine. Major features of the three are shown in Table 1.

The Z88

The Z88 has a rubberized keyboard that provides a surprisingly good feel. Using a setup utility, you can enable a keyclick that lets you know when you've pressed a key far enough. You can also vary the keyboard's repeat rate. However, the screen cannot keep up with the faster rates; the Z88 simply ignores keystrokes it can't process immediately. Also, the keyboard has no function keys, but it does have an embedded numeric pad. The Z88 also has several unique keys that allow you to use the software efficiently.

One key is labeled with a diamond; it is located in the spot traditionally reserved for the Control key (left of *A*), and functions with other keys as a Control key.

TABLE 1—FEATURES COMPARED

	Z88	T1000	Model 102
Hardware			
CPU	Z80 (CMOS)	80C88	80C85
Clock speed (MHz)	N/A	4.77	2.4
RAM (standard)	32K	512K	32K
RAM (maximum)	416K	1280K	32K
ROM	128K	(DOS 2.1)	32K
Keyboard keys	64	82	56
Display matrix size	8 × 106	25 × 80	8 × 40
Display area (sq in)	10.9	27.8	16.2
Tiltable display	No	Yes	No
RGB video port	No	Yes	No
Composite video port	No	Yes	No
Internal modem	No	Option	300 baud
Expansion slots	3	1	1
Disk drive	No	720K	Option
Weight (lb)	2	6.4	3
Battery life (hr)	20	5*	20
Low-power warning	Yes	Yes	Yes
Auto power off	Yes	No	Yes
Rechargeable	No	Yes	No
Serial port	Yes	Yes	Yes
Parallel port	No	Yes	Yes
Disk drive port	No	Yes	No
Software			
Word Processor	Yes	Yes**	Yes
Spreadsheet	Yes	No	No
Telecom	No	No	Yes
Clock, calendar, etc.	Yes	Yes**	Yes
DOS	No	Yes***	No
BASIC	Yes	No***	Yes

Notes:
*Without modem and memory card
**Borland's SideKick 1.5
***MS-DOS 2.11 in ROM. GW-BASIC not included

Another key is labeled Index; you can press it at any time to bring up a menu of the currently installed applications programs, along with a list of which applications are currently open. Installed applications include both those in the machine's built-in ROM and those in optional memory cartridges.

You open an application by navigating the Index list with the cursor keys and pressing Enter. Several programs can be open at once; in fact, several instances of the same application can be open at once. For example, you could have a spreadsheet open in one instance of PipeDream, and a business letter in another.

A third special key is labeled Menu; within a given application, pressing it brings up a menu of commands. For example, the PipeDream menu lists the following items: Blocks, Cursor, Edit, Files, Layout, Options, and Print.

Each time you press the Menu key, a new item is highlighted, and a sub-menu of available commands appears beside the menu. As with the Index list, you traverse the command list with the cursor keys, and select the desired item by pressing Enter.

A Help key brings up a brief context-sensitive help message in many situations, and a key marked with a square provides a quick way of switching between applications. For example, []-S brings up the Setup screen; []-P brings up PipeDream; etc. If more than one instance of a program is running, repeatedly pressing the box-key combination will switch among those instances.

The software provides some unusual features. For example, although PipeDream is basically a spreadsheet, it also functions fairly well as a word processor. One neat trick is to set up several columns with narrow margins; text typed in each column will wrap within its margins. In that way you can create multi-column documents with ease. 72 columns of text are shown in the middle of the screen; along the left side is the command menu; on the right is a miniature preview map of the current page, in which each pixel corresponds to a single character on the page.

PipeDream can read and write text files in WordStar format; it can also read and write Lotus 1-2-3 files, although a number of features are not implemented (macros and graphics, among others).

You can also use PipeDream as a miniature database; a sort command allows you to sort by column. Search and Replace commands are included.

The software also includes a simple calculator, a calendar display that can work with a diary to schedule appointments, and a flexible alarm that can alert you to single and repetitive events. (The Z88 has a battery-backed clock/calendar.) Another "pop-down" shows the current time and date. In addition, a file manager lets you manage files in the various memory banks.

A version of BASIC called BBC BASIC is also included. It's fairly powerful, but if you're used to any version of Microsoft (or Borland) BASIC, it'll take some getting used to, and you'll definitely have to work to convert programs to run on the Z88.

A dumb-terminal emulator lets you hook up to an external modem and access on-line services. To upload and download files, however, you'll need the special modem, to be discussed shortly. There is a way to send and receive files using just the built-in software, but it's kludgy.

You can print files on an Epson or compatible printer with no problem. The Z88 also includes a special editor for entering codes to activate various features in other types of printers.

Memory management

One inconvenience is that you must treat each bank of memory as a separate unit. For example, you refer to the built-in 32K bank of RAM as RAM.0. You can add 32K ($48) and 128K ($113) expansion modules; a RAM module in the first expansion slot is known as RAM.1, the second as RAM.2, etc. Three 128K modules could be added, provided a maximum of 32K + 3 × 128K = 416K.

Surprisingly, you can organize files into a hierarchical directory structure, as used by MS-DOS and UNIX. So, for example, you might refer to a file in the second expansion slot like this:

:RAM.2/FINANCE/1989/FEBRUARY/BUDGET

Two ROM modules are currently available. One (PC Link II, $78) contains a program for trading files with an IBM-compatible PC. The program comes with a special cable and a disk containing a program you run on the PC. The other ROM module ($264) contains a telecommunications program and comes with a miniature 1200-baud Hayes-compatible modem.

Several user-programmable EPROM modules are also available with capacities of 32K ($48) and 128K ($113). The Z88 contains a built-in EPROM programmer; using the Filer program, you can save data files to the EPROM. However, you can't access them from there directly; instead, you must copy a desired file from EPROM to RAM to use it.

With only three slots available, you must analyze your needs carefully to get the right combination of features and enough RAM.

The Tandy Model 100

Because for all practical purposes the Model 100 and the Model 102 are identical, we'll refer to both simply as the Model 100. This venerable machine includes an 8 × 40 line LCD screen, 300-baud modem, and five programs: BASIC, Text (editor), Telcom (communications), Addrss (address book), and Schedl (appointment scheduler). The first three provide the machine's real power.

The screen has fairly low contrast by today's standards, but its large characters are easier to read than those of the other machines discussed here. The editor is primitive, but functional. However, to print files, you must send them to another machine, write your own BASIC program, or obtain a commercial or public- domain program.

Because of the Model 100's longevity, there are numerous third-party expansion options, both hardware and software. There is also a wealth of public-domain software, especially on CompuServe. Several books have been written discussing its workings in minute detail, and several magazines devoted to the Model 100 have been published off and on.

Third-party expansion options include RAM and ROM switching systems that allow you to add as much as a megabyte of memory to the machine. Floppy-disk drives that operate off the serial port are available from Radio Shack and others.

The Model 100 is not as glitzy as the Z88, but it's a solid, bug-free product that is well supported. Many Model 100 users (including yours truly) refuse to upgrade to an expensive MS-DOS machine, even though they could easily justify doing so.

The Toshiba T1000

Based on list prices, this machine is not competitive with the others discussed here. At $1250, the T1000 costs twice what the others cost. However, it's regularly sold in big city computer stores and by mail order for about $750. That's 25% more than the Model 100 and the Z88, but you get more than 25% more computing power for your money.

For one, you get a full 25 × 80 screen. And no matter how much you love your Model 100, you lust for a bigger screen.

You also get 512K of contiguous memory. The other machines can't even count that high. However, that 512K is volatile—when you turn the machine off, the RAM contents are lost. (But there is a fix—we'll talk about that shortly.)

The T1000 also comes with a 720K floppy-disk drive. Although external drives are available for the Model 100, they are slow and buggy. Cambridge Direct advertises the Z88 saying: "No disks. No DOS." However, the user's manual mentions "disc" storage, suggesting that an upgrade may be available at some point. But it would have to run off the serial port also. And external drives are a pain to deal with when traveling.

No modem is included with the T1000, but there is an internal slot for one.

There is another slot for a 768K memory card. (List price = $399; street price = $270.) The memory card bridges the gap between typical MS-DOS portables, and the Model 100/Z88 crowd. The reason is that the memory on the card is not volatile, and may be used as a RAM disk (or as EMS 3.2 memory).

It's probably most useful as a RAM disk, because you can load your favorite DOS applications on the RAM disk, thereby providing the equivalent of the ROM-based software in the other machines.

The T1000 normally boots from DOS version 2.11, which is contained in ROM. If you need a later version, you can boot from floppy, or you can format the RAM disk with the DOS version of your choice, and boot from it.

Other than DOS, the only software that comes with the T1000 is SideKick. Most people think of SideKick as a utility program, but it has a fairly good text editor, and better desktop accessories (address book, scheduler, etc.) than either the Model 100 or the Z88. To provide a complete range of full-powered applications, you could install Microsoft Works or PFS: First Choice for about $100.

The choice

As a long-time Model 100 owner, I find choosing among the three excruciating. The Z88's screen provides many more characters per line than the Model 100, but it has only about 67% of the surface area. Consequently, characters are small. The T1000 provides a standard 25 × 80 work area, and the largest overall screen size. Even so, the Model 100's screen is easier to read.

The Z88 has much more built-in software than the Model 100. For example, even though the Model 100 has a built-in text editor, it provides no way to print files. And a spreadsheet costs an extra $150. The T1000 includes a copy of SideKick, whose features exceed those of the corresponding programs in the other machines, but SideKick has neither a spreadsheet nor a communications program.

The Model 100 has a built-in telecommunications program that works with both its built-in modem and its built-in serial port. There is no excuse for not providing a built-in communications program in the Z88. The T1000 is also weakened by that omission.

The big question is whether DOS compatibility is important. If it is, the T1000 is the best buy on the market. It's not as powerful as the 286 and 386 machines, but it costs one third as much.

Disadvantages of the T1000 include limited battery life (about four hours with the RAM card), about 50% more weight, and about 67% more volume.

If you can get by without a DOS machine, it's a tough decision. The Z88 includes more software, and has more usable screen space, but the Model 100's screen is more legible. The base Model 100 has more memory (a full 32K vs. 20K in the Z88), and built-in telecomm software. Upgrading the Z88 for 32K of RAM and the modem/software combo costs more than $300; in that price range, you may as well go for a T1000.

Another point to consider is third-party support. Only time will tell whether the Z88 will generate the kind of support that the Model 100 has.

If I were in the market now, I'd probably go for the T1000 with RAM card, and put up with the squashed screen. But as a Model 100 owner, neither the Z88 nor the T1000 represents a significant enough improvement in design and utility to retire my old machine.

The New Norton

In any field less than ten years old, it's hard to refer to any printed work as a classic. But Peter Norton's *Programmer's Guide To The IBM PC* comes as close as anything can. The venerable guide to PC hardware and software has been reissued and renamed the *Programmer's Guide To The IBM PC and PS/2*.

As you can guess from the title, the update includes much information on hardware and software introduced with and since the PS/2: DOS (3.3 and 4.0), new hardware (VGA, enhanced keyboards, the PS/2 mouse interface), and new BIOS functions. To make room for all the new information, the update drops some information about the PCjr, the PC Convertible, and the XT/286.

The book is both a good read and a good reference. If you're new to the PC world and curious about what's going on inside the box, several introductory chapters give the proper background quickly. If you're an old hand, the multitude of reference charts can help you locate necessary information quickly.

The book isn't perfect; for example, the discussion of keyboards fails to mention that late-model IBM XT's have BIOS support for the enhanced keyboard. And although it provides a good discussion of scan codes, etc., no mention is made of the dedicated keyboard controller used in AT's. So for the most complete information, you'll want to examine IBM's Technical Reference manuals.

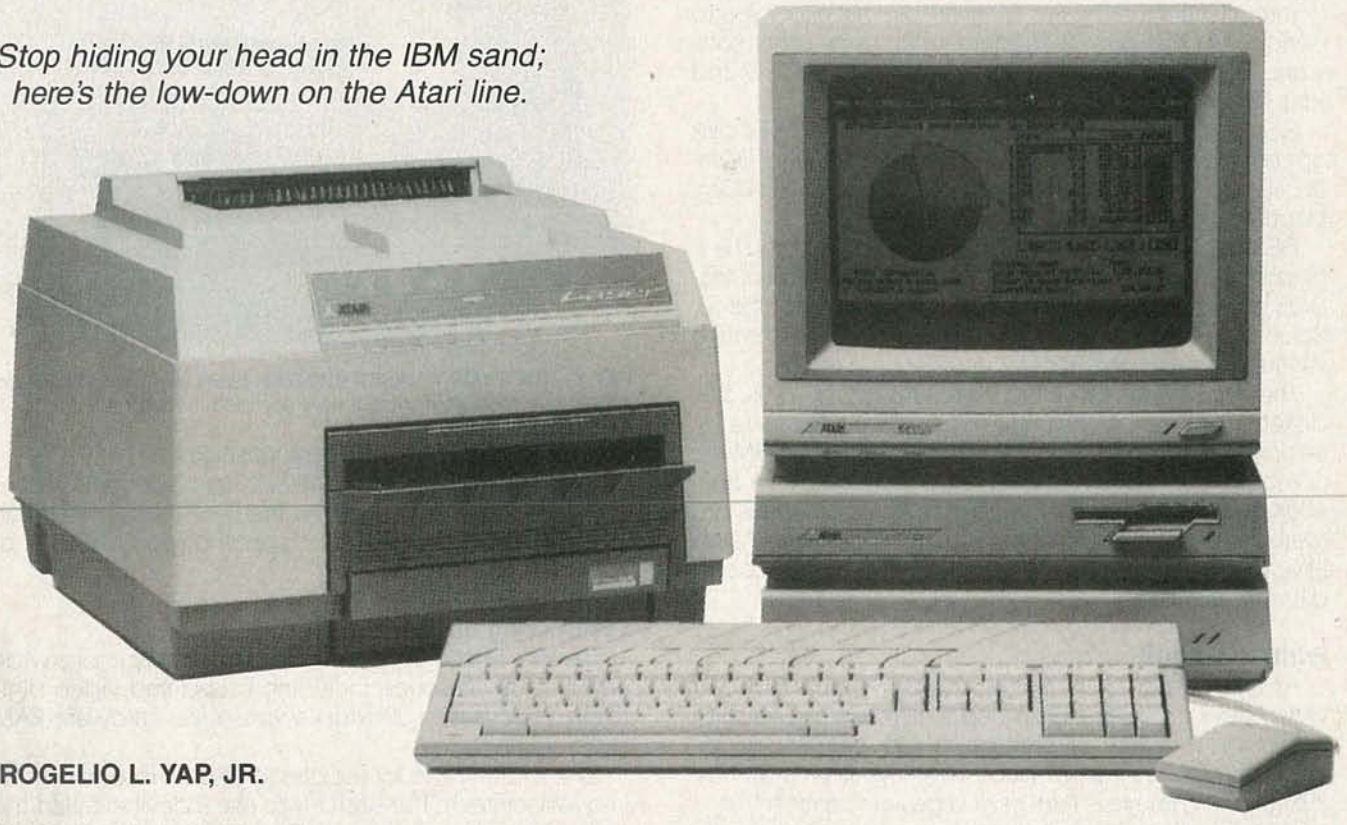
The book's co-author, Richard Wilton, is also author of the excellent *Programmer's Guide To PC And PS/2 Video Systems*. Both books have found permanent places in my reference library.

PRODUCTS REVIEWED

- Z88 ($599), Cambridge Direct, 1419 Lake Cook Rd., Suite 300, Deerfield, IL 60015. (800) 435-7729. (312) 940-1554.
  CIRCLE 45 ON FREE INFORMATION CARD
- Toshiba T1000 ($1249), Toshiba America, Inc., Information Systems Division, 9740 Irvine Blvd., Irvine, CA 92718. (714) 583-3000.
  CIRCLE 46 ON FREE INFORMATION CARD
- Model 100 ($599), Radio Shack.
  CIRCLE 47 ON FREE INFORMATION CARD
- *Programmer's Guide To The IBM PC and PS/2* ($22.95), *Programmer's Guide To PC And PS/2 Video Systems* ($24.95), Microsoft Press, 16011 NE 36th Way, Box 97017, Redmond, WA 98073-9717. (206) 882-8080.
  CIRCLE 48 ON FREE INFORMATION CARD

THE ATARI ST

Stop hiding your head in the IBM sand; here's the low-down on the Atari line.



ROGELIO L. YAP, JR.

In the July 1988 issue, we published a letter that berated us for our lack of coverage of machines outside the MS-DOS family. (See page 16 of that issue.) Actually, in Computer Digest, 50% of the articles published in the past year dealt with a 68000 system; much of the other 50% consisted of articles that had no machine-specific orientation.

Anyway, the author of that letter sang the praises of the Atari line. So we decided to take a look. What follows is an introduction to the Atari family and several of the more interesting hardware and software products available for it.—Editor

Atari's ST was formally introduced at the Winter 1985 Consumer Electronic Show. With 512K of RAM, a 512-color video system, an 8-MHz 68000, and an under-$1000 price tag, the 520 ST caused quite a stir.

Other standard features include a graphical user interface, support for both monochrome and RGB color monitors, a full-function keyboard with function keys and numeric keypad, a two-button mouse, serial and parallel interfaces, a 360K/720K 3.5" disk format, second-drive port, and ROM-cartridge port. The ST also includes a blazingly fast (10 MHz) DMA port, and a built-in MIDI (*M*usical *I*nstrument *D*igital *I*nterface) port for attaching electronic musical instruments.

The ST line includes four models: the 520 ST, the 1040 ST, the Mega 2, and the Mega 4 of those models. Features are summarized in Table 1.

The four models are highly compatible with one another; in fact, they're nearly identical, with the exception of memory. However, all ST's are upgradable to 4 megabytes of directly addressable RAM.

The major differences between the 520 and the 1040 on one hand, and the Mega machines on the other is that the Mega machines offer detached keyboards, an expansion bus that allows direct access to the 68000 CPU, and a graphics processor (named the "blitter") that provides lightning-fast text and graphics screen updates.

User interface

The ST comes with a graphical operating environment called GEM (*G*raphic *E*nvironment *M*anager); GEM was written by Digital Research, the company that designed the CP/M operating system a decade ago. GEM is also available for IBM machines.

If you have used Windows or a Macintosh, you'll find working with GEM familiar. Drop-down menus, movable and re-sizable windows, icons, and desk accessories are found on the GEM desktop.

The Mac and the ST handle desktop accessories in slightly different manners. On the ST, all desk accessories are loaded into RAM when you boot, so the system disk is no longer required. By contrast, the Mac must load an accessory from disk each time it is needed.

TABLE 1—SYSTEM CONFIGURATIONS

Model	Standard Memory	Monochrome System	Color System
520	512K	$799	$999
1040	1024K	$999	$1199
Mega 2	2048K	$1699	$1899
Mega 4	4096K	$2399	$2599

GEM does not support multitasking, but "switching" programs are available that allow you to load as many as eight programs in RAM simultaneously. And several telecommunications programs are available that allow you to perform file transfers by modem while using other software. If you need real multitasking, versions of OS/9 and Idris (a UNIX look-alike) are available.

GEM, along with the BIOS and GEMDOS (the ST's disk operating system), are contained entirely in 192K of ROM. Because the entire operating system is contained in ROM, booting an Atari takes only about five seconds.

GEMDOS is quite similar to MS-DOS. In fact, if you hate graphical interfaces, you'll be glad to know that an MS-DOS style command-line interface is available for the ST. Batch files, I/O redirection, etc., are all available through various software packages.

The Atari ST can read and write IBM-format 720K 3.5" diskettes, as well as 360K and 720K 5.25" diskettes using an optional external 5.25" drive. If you don't need IBM file compatibility, you can squeeze even more data on a disk: 400K and 800K 10-sector/track formatting programs are available commercially and in the public domain. As on IBM systems, floppy-disk drives have a 250 kilobit/second data-transfer rate.

Printed output

An external part of the ST's operating system is GDOS, a virtual device interface designed to provide high-quality output on a variety of printers. In use, GDOS can, for example, map a desktop-publishing layout on a 32K by 32K grid. The image is then scaled down to a form that is suitable for either Atari's laser printer, or an inexpensive 9- or 24-pin dot-matrix printer. Figure 1 shows a sample output from a 9-pin Panasonic KX-P1091i printer. The image was created using Timeworks Desktop Publisher.

FIG. 1—SAMPLE OUTPUT created in Timeworks desktop publisher and printed on an inexpensive Panasonic dot-matrix printer.

The Atari laser printer provides high-quality 300 DPI output at low cost ($1899 list). The SLM804, shown in Fig. 2, was the first "dumb" laser printer, a concept subsequently imitated by Apple.

Most laser printers have built-in intelligence, and are usually built around 68000 or 68020 microprocessors and a big chunk of RAM. In order to keep costs down, Atari let the RAM and the CPU in the computer do the "thinking" for the printer too. That keeps the cost down.

FIG. 2—THE SLM804 LASER PRINTER costs less than $2000 and provides a resolution of 300 dots per inch.

One reason for the SLM804's high speed is that it connects to the computer via the DMA port, rather than an RS-232 port. That increases speed by about a factor of ten.

Connecting up

The ST's cartridge port provides an interface for a wide variety of accessories, including sound and video digitizers, ROM-based desktop accessories, hardware RAM disks, scanners, etc.

One exciting use for the cartridge port is to turn an ST into a Macintosh. The secret is to use a device called the Magic Sac, which lists for $149.00. (A set of Apple ROM's is also required.)

The Magic Sac consists of a standard ST cartridge with two empty sockets for the Mac's 64K operating system in ROM. You can buy the ROM's at your local Atari dealer for $40–$60 (or $80–$120 from an Apple dealer). A new version of the Sac should be released by the time you read this; the new version will allow use of the new 128K ROMS, thereby making it possible to run HyperCard on the ST! The Magic Sac works by disabling the ST's operating system and replacing it with the Macintosh operating system contained in the ROM's.

Getting the Magic Sac up and running is as simple as plugging the cartridge in and running the ST software that activates it. The difficult part is transforming Macintosh software to the ST disk format. To help solve that problem, the Magic Sac includes a null modem cable and file-transfer software for both the Mac and the ST. The software allows you to transfer any unprotected Mac disk onto a custom-format (called "Magic format") ST disk. Of course, to transfer files by that means, you must have a real Mac physically present (but see below). A "Magic" disk can only be recognized by the Atari when the Sac cartridge is activated.

The Mac is extremely picky about when you can remove a disk from a drive; in fact, you must explicitly ask the machine to eject a disk, or you risk irrecoverable damage to the data on the disk.

The ST does not have the ejection hardware, so the Magic Sac software informs you when it is safe to remove a disk by flashing a large *A* or *B*, depending on which drive the disk is to be ejected from.

It took more than a year to develop the Magic Sac

software, and the software has been revised numerous times. The software is so well done that the ST can now run programs that will not work on the $5000 Mac II! In fact, some Macintosh developers test their programs on Magic Sac equipped ST's as a test of compatibility! Overall, the Magic Sac is approximately 90% compatible with a Mac SE.

The Magic Sac has several advantages over a real Mac. For one, the ST's 640 × 400 screen provides almost 50% more resolution than the Mac's 512 × 342. The difference is noticeable in MacWrite, for example, where the on-screen ruler is visible only up to the 6" mark on a real Mac, but goes past 8" on the ST.

FIG. 3—ATARI'S MEGA 4 includes four megabytes of RAM, an 8-MHz 68000, 3.5" floppy-disk drive, and the GEM operating system.

Another advantage is the ST's increased speed, which makes mouse movement and scrolling faster.

Use of available memory is another improvement. A four-megabyte Mega 4, shown in Fig. 3, will function effectively as a 3.8-megabyte Mac. In addition, the Mac's modem port is fully supported and properly written telecommunications programs (Red Ryder, for example) will run normally.

As mentioned earlier, the ST cannot read or write Macintosh-format disks. However, in addition to the Magic Sac, Data Pacific markets a product called The Translator that allows the ST to read Mac disks via an external disk drive. The biggest advantage of the Translator is that a Mac need not be physically present to transfer software.

The problem with reading Mac disks in an ST is that Macintoshes have variable-speed disk drives, whereas the ST uses constant-speed drives. So rather than vary the speed of the drive, the Translator varies the rate at which bits of data are sent to the drive. The variable data-transfer rate even allows you to run copy-protected programs on an ST. The Translator is completely invisible to the ST when turned off, and it won't interfere with any ST software. The Translator is rather expensive at $279.95 list, but it's still cheaper than buying a Mac.

The Macintosh simply won't work with non-Apple printers. Another Data Pacific product called Epstart ($45) allows you to use an Epson (or compatible) printer to print Macintosh text and graphics. Epstart is a Macintosh desk accessory that can be installed and forgotten. Epstart works by fooling the Mac into thinking that an Imagewriter is present; the program intercepts and correctly formats all printer output, including screen dumps, graphics, and text. In fact, I think my Panasonic printer produces output superior to the Apple printer, which costs more than twice as much. As for compatibility, programs including MacPaint, MacDraft, Microsoft Word, and PageMaker produce good, clean output without problem.

The Atari in Europe

Because of Atari's past connection with game machines, the company has concentrated (and continues to concentrate) on the European market. Those efforts have been so successful that the Atari ST is a top-selling computer in West Germany, and is consistently in the top three in England, France, and the Scandinavian countries.

In all of those places, the ST is viewed as a professional system; it enjoys widespread use in businesses and universities. In fact, the number of ST computers sold in West Germany (roughly 400,000) outnumbers American sales significantly. But the company is now starting to focus on the American market.

IBM emulation

Using an $89 product called PC Ditto, the ST can also run IBM software. PC Ditto turns the ST into a 99% compatible IBM clone that can run Lotus 1-2-3, Flight Simulator, DESQview, the Norton Utilities, GW-BASIC, and most other programs. Mouse drivers are included to let the ST mouse emulate a Microsoft mouse.

Because the PC and the ST are based on microprocessors from totally different families, PC Ditto is a software emulator. Every 8088 machine instruction must be translated into an equivalent 68000 instruction or series of instructions. Because of that translation, PC Ditto generally runs at about 80% of the speed of an XT. For that reason, PC Ditto works best with non-graphics software. Figure 4 shows PC ditto running Lotus 1-2-3 and SideKick.

At least two companies are working on hardware emulators based on 8088-compatible microprocessors; these emulators have expansion slots that can accept IBM cards.

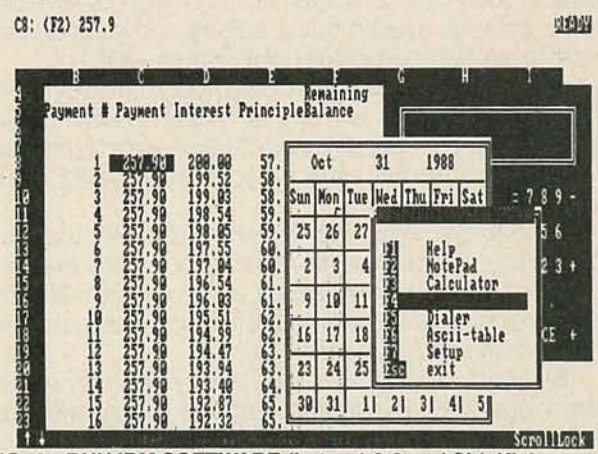


FIG. 4—RUN IBM SOFTWARE (Lotus 1-2-3 and SideKick, among others) on an Atari using PC Ditto.

Software outlook

If you're concerned about the so-called lack of business software for the ST, file-compatible Lotus and dBase III+ clones are available; the clones also provide full support for mice and windows.

On the desktop publishing front, several powerful programs are available that can drive PostScript and HP LaserJet laser printers.

Of course, a multitude of games is available, and entertainment software for the ST meets or beats that found in the arcade. The ST has a joystick port in addition to the mouse port, but for two-player games, the mouse port can also be used as a joystick port. Many of the recent games that have become available use the ST's large RAM size to store digitized graphics and sound to provide a new level of sophistication.

Musical applications

One of the ST's strongest areas is music. Popular rock groups (The Pointer Sisters and Fleetwood Mac, among others) use Atari computers; the computer's low price make computerized musical editing and creation available to budget-conscious hobbyists as well.

The ST's musical abilities come about through its MIDI port, which allows as many as sixteen different instruments to be controlled. That includes synthesizers, drum machines, special effects generators, and digital samplers.

For example, Atari and Yamaha Music teamed up to produce a home electronic music system consisting of an Atari 520ST, a Yamaha keyboard, and software that allows composing, tapeless multi-track recording and playback. The system lists for under $1000.

To get up to speed in music theory, you may want to check out Alfred Publishing's Practical Theory and Music Achievement Series. It runs on the 1040ST.

Conclusion

In this article, we have tried to indicate why the Atari line of personal computers should be taken seriously by serious computerists. The ST combines high quality, low price, and extensive third-party support. Add-on products allow it to run software from the IBM and Macintosh families.

Vendors

Atari Computer Corporation
1196 Borregas Avenue
Sunnyvale, CA 94086
(408) 745-2000

Yamaha Music Corporation, USA
Consumer Products Division
6600 Orangethorpe Avenue
Buena Park, CA 90620
(714) 522-9240

Alfred Publishing Co., Inc.
16380 Roscoe Blvd.
Van Nuys, CA 91410
(818) 891-5999

Timeworks Inc.
444 Lake Cook Road
Deerfield, Illinois 60015
(TimeWorks Desktop Publisher, $129.95)

Data Pacific Inc.
609 Speer Blvd
Denver, Colorado 80203
(Magic Sac, $149)
(Translator, $279)
(Epstart, $45)

Avante Garde Systems
381 Pablo Point Drive
Jacksonville, Florida 32225
(PC Ditto, $89.95)

Word Perfect Corp.
288 West Center ST.
Orem, UT 84057
(Word Perfect 4.1, $395)

Antic Software
524 Second St.
San Francisco, CA 94107
(CADD 3-D 2.0, $89.95)

INSIDE INTEL's 80386

How the 80386 supports operating systems.

NEAL MARGULIS, INTEL CORP.

An operating system is like the foundation of a house: it provides a base on which the entire structure rests. In a house, several sub-systems (plumbing, electrical, heating and cooling) interact to provide an environment for living. When we flip a switch to turn on a light, for example, we don't need to understand or even know about the electrical circuits involved.

Likewise, an operating system has both visible and invisible components. For example, when you copy a file from a hard disk to a floppy disk, a complex system of software functions provide low-level (raw serial data), mid-level (track and sector), and high-level (file) access to data on the disk.

More visible, but no less important, is an operating system's user interface. It translates your COPY command into something the underlying components can understand, so that you don't have to keep track of the tracks and sectors that comprise a file yourself. Thus, copying a file is like flipping a switch.

In this article we'll show how architectural features of the 80386 microprocessor make efficient multi-tasking operating systems possible.—Editor

Time slicing is a technique by which a number of tasks appear to execute on a computer simultaneously. In a simple time-slicing system, each of several tasks is allowed to execute sequentially for a specific amount of time—a time slice. If the time slices are of the proper duration, all tasks appear to execute simultaneously.

Time-slicing has been used, on mainframes and minicomputers, since the 1960's. It is only recently, however, that microprocessors became powerful enough to make time-slicing multi-tasking operating systems practical.

Depending on the operating system, the tasks themselves may be parts of a single program, different programs run by the same user, or different programs run by different users. It is up to the operating system to provide each task with the illusion that it can use any and all resources of the machine throughout the duration of its time slice.

The size of each slice (i.e., the frequency at which tasks are switched) has a great affect on system performance. If you switch tasks too often, system overhead becomes so great that the tasks don't have enough time to do any useful work. But if you don't switch often enough, the responsiveness of a system suffers. For example, if you switched tasks every 10 seconds, typing in a word processor would be frustrating, to say the least!

For the duration of each time slice, the operating system assigns the real processor to a "virtual processor." Each virtual processor has a complete environment consisting of a set of microprocessor registers and information describing that task's use of memory. That information is specified in a *Task State Segment* (TSS).

Task state segments

A TSS is shown in Fig. 1. It is one of several data tables defined by the 80386. The data tables are sometimes referred to as task control blocks. The purpose of the TSS is to save the state of a task's virtual processor while it is not actually running on the microprocessor.

The task control block consists of two parts. The lower part holds the values contained in the virtual microprocessor's registers. The upper part is defined by the operating system, and holds task-related information, including I/O privilege level (discussed shortly), and other information.

To create a new task, the operating system creates a TSS and initializes each slot in the table to the values the task should have when it begins execution.

The processor keeps a selector for the current task's TSS in an on-chip *Task Register* (TR). The TR has a visible 16-bit selector and an invisible selector cache. The selector cache is loaded automatically when the selector is changed. We described selector-cache loading in Part 1 of this article (last month).

To switch tasks, the operating system executes a JMP or CALL instruction; the target of the instruction is a selector for the new task. For example, the processor executes the Jump TSS instruction by storing its registers in the current TSS and then loading the TR with the selector specified in the instruction. The microprocessor can now determine

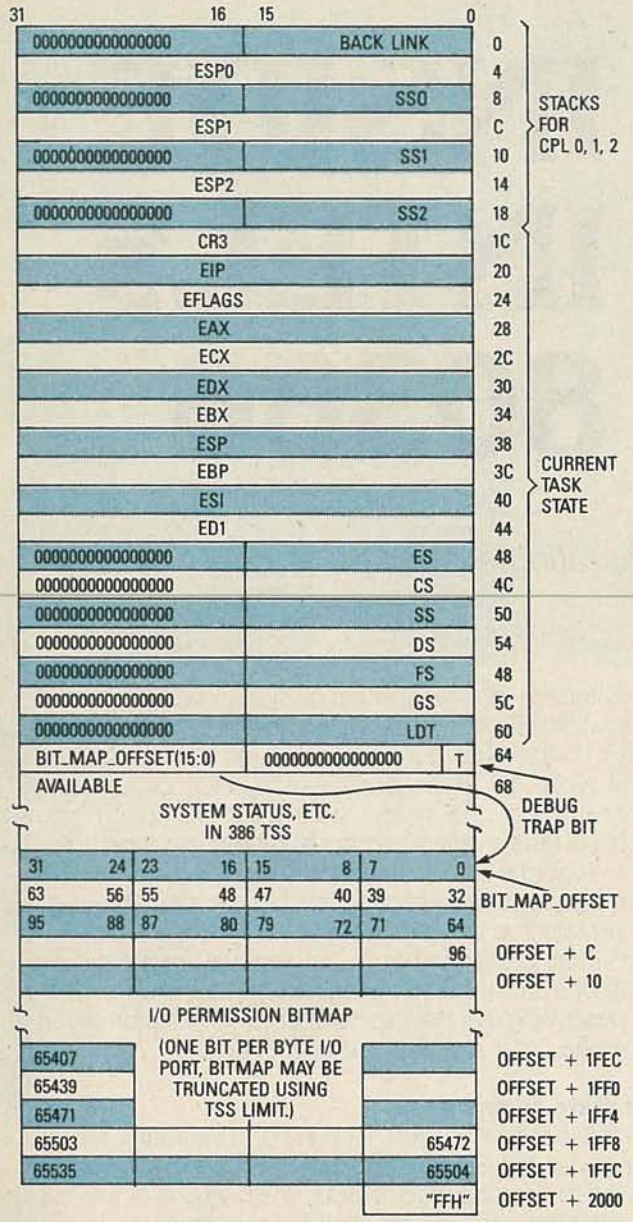


FIG. 1—A TSS IS ONE OF SEVERAL data tables defined by the 80386. The purpose of the TSS is to save the state of a task's virtual processor while it is not actually running on the microprocessor.

the actual memory address of the new TSS, because that address is part of the TR descriptor.

The processor then loads its memory registers with the values in the new TSS. Execution continues with the instruction that is pointed to by the new task's instruction pointer. The old task, including the pointer to the next instruction to be executed in that task, have been stored in that task's TSS. Execution of the old task can resume in the same manner; it is done by issuing a JMP to that task's TSS selector.

In addition to the jump method of loading descriptors described above, two instructions are available for loading and storing the Task Register directly: LTR and STR, respectively. LTR is used to load the TR with a pointer to the TSS data area prior to the first use of JUMP TSS. That ensures that the execution of JUMP TSS stores the current processor state in a valid area of memory.

Memory management

The physical address space of most computers is organized as a simple array of bytes. However, with the development of *M*emory *M*anagement *U*nits (MMU's), computer architectures began to distinguish between the physical address space implemented in hardware, and the logical address space seen by a programmer. It is the MMU's job to translate the logical addresses seen by programs into physical bus addresses. (The 376 embedded processor does not need virtual-memory management so some MMU features are not included.)

The address space of the 386 Microprocessors can be viewed in several ways: flat, segmented, paged, and paged segments.

Flat: The address space is an array of bytes with no additional structure. The logical address is equal to the physical address, so no MMU translation occurs.

Segmented: The logical address space consists of a number of segments, each of which can vary in size. Each segment is specified by a selector and a descriptor, as discussed in Part 1 of this article.

Paged: The logical address space consists of many relatively small fixed-size pages.

Paged segments: The logical address space consists of a segment and an offset. The logical address specifies a linear address; however, each linear address is translated into a page and an offset into that page.

Each type of address space is suitable for a different type of task. A one-to-one correspondence between physical and logical addresses requires the least operating system overhead. A paged-segmented structure is more complicated, but more flexible.

The 386 and 386SX microprocessors can support any of the four models, but the 376 supports only the flat and the segmented models.

Segments

A task's logical address space consists of one or more segments. The 80286 allowed segments with a maximum length of 64K bytes, but the 80386 allows four-gigabyte segments.

Each segment is defined by a descriptor. Descriptors are stored in the shared *G*lobal *D*escriptor *T*able (GDT), which all tasks can access, and in a *L*ocal *D*escriptor *T*able (LDT), where they are more private.

Swapping is a method of sharing memory, when there is more code, data, or both, than physical memory. An operating system that employs swapping keeps track of how often each segment is used. When there is a memory shortage, the least-used segments are stored on disk; the freed-up space can then be used by the current task. OS/2, for example, currently uses segment swapping as the basis for its virtual memory management.

Because 80286 segments are limited to 64K, it is possible to perform memory management by swapping segments. With the 386, however, segments can be extremely large, so swapping on a segment basis is not feasible. That is the origin of paging.

Paging

In the 386 family, there are three kinds of address space: logical, linear, and physical. Depending on which mode the microprocessor is operating in, all three may be identical, two of the three may be identical, or all three may

differ. As discussed above and in Part 1, the logical address space is what the programmer sees; in protected mode, selectors in the microprocessor's segment registers refer to the logical address space by way of descriptors, special tables in RAM.

When paging is not enabled, the linear and physical addresses are identical. When paging is enabled, any given 4K chunk of linear memory may correspond to any 4K chunk of physical memory.

The 4K page size is convenient. The reason is that the small page size prevents a common memory-management problem: memory fragmentation that occurs when variable-sized segments are used for memory allocation. When a segment-based operating system needs to make room for a large segment, and only small areas of free memory are available, the operating system must rearrange the programs and data currently in memory to provide one contiguous chunk for the desired segment. Doing so takes time that degrades system performance.

Another complication that a segment-based operating system must contend with is whether to place a new segment into the first memory area the operating system finds, or into an area that is close in size to the new segment. Those strategies are known as first-fit and best-fit management, respectively. With a paging system, memory contents don't actually have to be moved; rather, tables that indicate the linear-to-physical mapping are updated—a much quicker process.

An 80386 operating system enables paging by setting the PG bit in control register CR0. When paging is enabled, the processor translates a linear address to a physical address with the aid of page tables. As on mainframes, page tables are arranged in a two-level hierarchy, as shown in Fig. 2.

Control register CR3 is also known as the Page Table Directory Base; it points to the first entry in a Page Table Directory. A Page Table Directory is one page (4K) long and contains entries for 1024 page tables. Each page table is one page long; each page table describes 1024 pages. Referring back to Fig. 1, you'll notice that CR3 is stored in the TSS. Therefore, each task may optionally have its own page table directory.

Figure 3 shows the complete mechanism that the 80386 uses to translate a linear address into a physical address when paging is enabled. The processor uses the upper ten bits of the linear address as an index into the directory. The selected directory entry contains the address of a page table. The processor adds the next ten bits of the linear address to the page table address. That is then used to select the entry in the page table corresponding to the desired address. Last, the lower twelve bits of the linear address select the desired location in the 4K page.

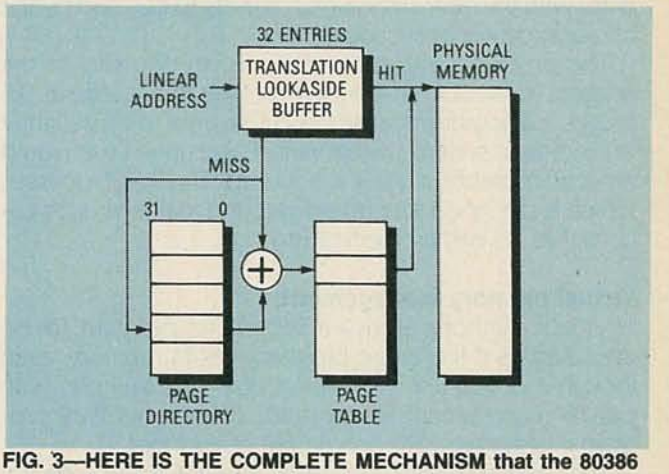


FIG. 3—HERE IS THE COMPLETE MECHANISM that the 80386 uses to translate a linear address into a physical address when paging is enabled.

Note that all of that paging information is stored in memory. If the microprocessor had to access the page tables every time it needed to access memory, performance would suffer greatly. So to reduce the overhead of the page-table lookups, the processor automatically caches mapping information for the 32 most recently used pages in an on-chip *T*ranslation *L*ookaside *B*uffer (TLB), shown in Fig. 3. Only when it does not find the mapping information for a page in the TLB does the processor perform a page table lookup from information stored in memory. Fortunately, 98–99% of all address references are TLB hits (i.e., are found in the TLB). When a TLB miss does occur, the processor replaces an older TLB

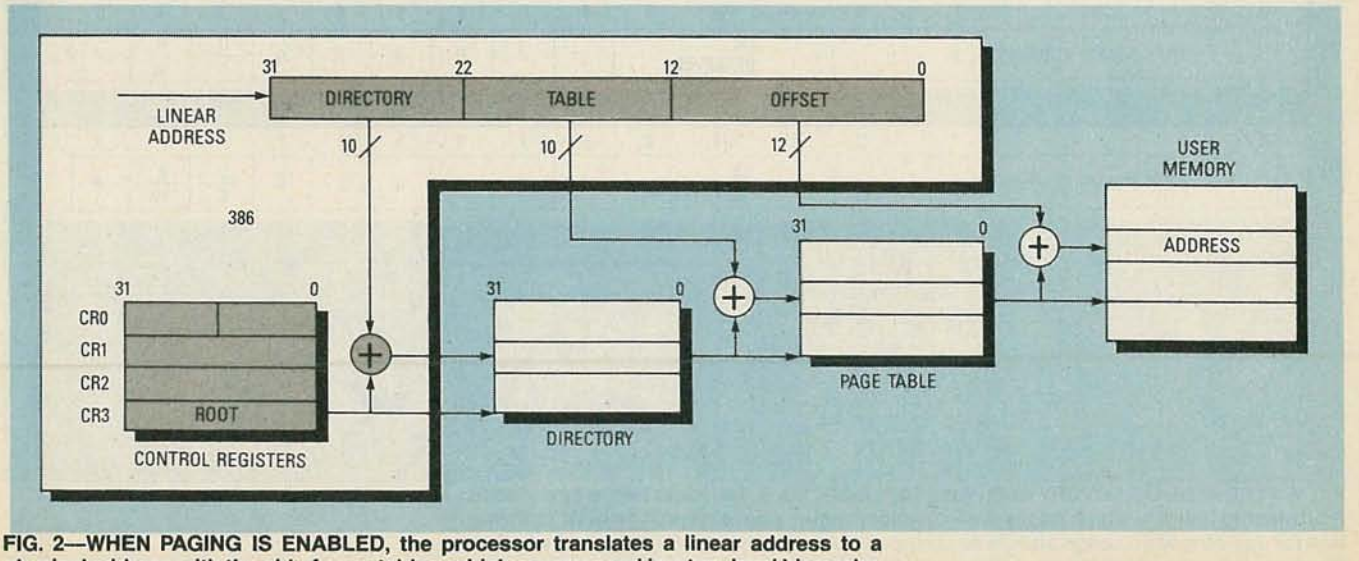


FIG. 2—WHEN PAGING IS ENABLED, the processor translates a linear address to a physical address with the aid of page tables, which are arranged in a two-level hierarchy.

entry with the new entry, which is likely to be used by the microprocessor again soon.

The on-chip page table lookups do not add to the address translation time. However, due to occasional TLB misses, paging does cause execution time to vary slightly. In a real-time system, where varied execution time would be unacceptable, paging is not used. The 376 processor, which is designed for embedded and real-time applications, has no paging mechanism.

Virtual memory management

Virtual memory allows a very large program to be executed as if the entire program was in memory, even though a portion of it is still on disk. For example, with proper management, a computer could run a 2MB program in a system with only 1.5MB of memory.

The page directory and page table entries provide the mechanism. As shown in Fig. 4, the lower twelve bits of each type of entry indicate which pages are in memory, which pages are still on disk, information for deciding which page should be swapped out in favor of a new page, and whether the swapped page needs to be written back to disk or merely overwritten.

The P (present) bit, if set to 1, indicates that the entry is present in memory. If the P bit is 0, then any attempt to access the page will cause a page fault. When a page fault occurs, the microprocessor passes control to a special handler via interrupt fourteen. The interrupt-fourteen handler must read the needed page into memory and return execution to the program. To accomplish that, the handler first determines which page caused the fault. Doing so is easy, because the processor stores that information in CR2.

But what happens if there is no room in physical memory to load another page? Then the handler must decide which page of those presently in memory may be discarded. The handler can't know whether a given page will be needed later on, so it makes an educated guess, based on which page was used least recently.

The A (accessed) bit and the bits available for OS use determine which pages have not been recently used. The A bit is automatically set whenever the processor accesses any location on a page; the A bit is only cleared by software. By periodically clearing A bits, the operating system can keep track of which pages are used often, and which aren't.

After the operating system determines which page will be discarded, it must decide whether it must be written back to disk. It does that via the D (dirty) bit, which is set each time the page is written to. So when a page is to be discarded, if the D bit is set, the operating system knows that that page must be written back to disk. If the D bit is not set, then the contents of the page in memory and the page on disk are the same, so the memory image needn't be written to disk.

That method of swapping pages in and out of memory when needed is called demand paging. Demand paging is used, for example, by UNIX System V for the 80386. And Phar Lap software offers a set of tools for developing large applications that rely on demand paging.

Paging is useful in applications other than virtual-memory management. For example, paging can be used to remap memory. Remapping can be used to fill in gaps in physical memory, or to emulate one type of memory with another.

For example, a program called 386^{MAX} allows you to fill out 512K motherboards to the 640K MS-DOS limit by using paging. The program also allows you to emulate LIM EMS 4.0 memory using extended (physically linear) memory. Similar programs are available from a number of vendors, including Compaq, Quarterdeck Office Systems, and others.

Protection and privilege

The 80386 provides several mechanisms that an operating system can use to protect tasks from one another. We've already discussed one form of protection; that is, the separation of address spaces by segment descriptor tables.

Other protection facilities are based on the notion of privilege hierarchy. At any instant, a task's privilege level is equal to the privilege level of the code segment in which it is executing. A two-bit protection field found in each

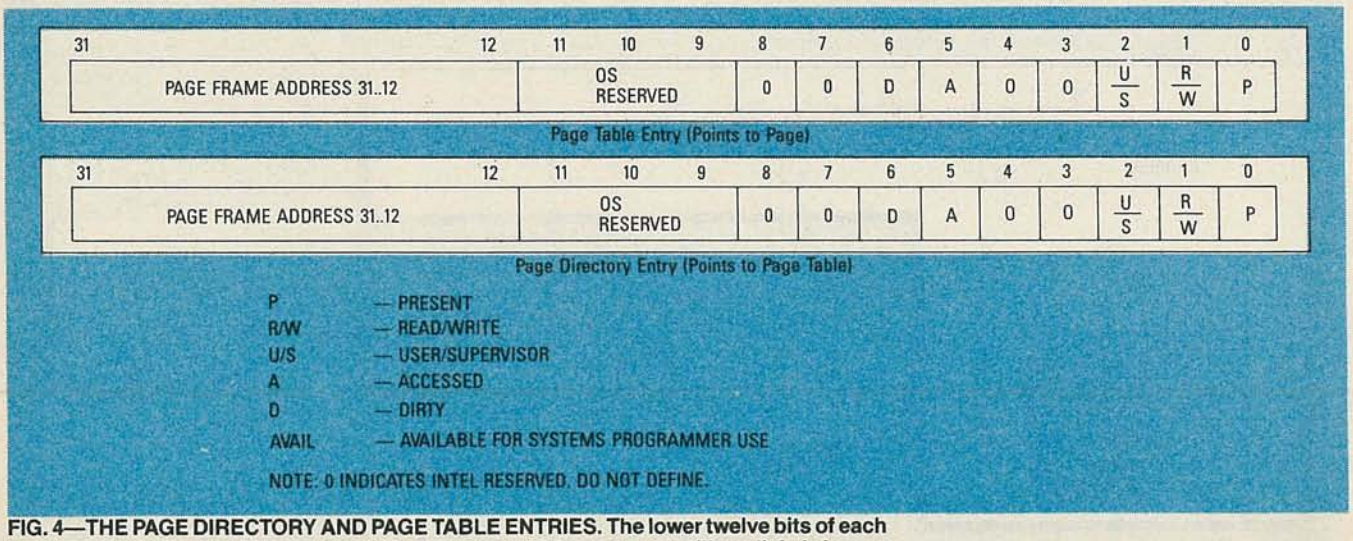


FIG. 4—THE PAGE DIRECTORY AND PAGE TABLE ENTRIES. The lower twelve bits of each type of entry indicate which pages are in memory, which pages are still on disk, information for deciding which page should be swapped out in favor of a new page, and whether the swapped page needs to be written back to disk or merely overwritten.

descriptor and selector specifies four privilege levels. Level 0 is most privileged; level 3 is least privileged. Level 0 is for the operating system; level 3 is for user code. The middle levels can be used for other types of code. For example, OS/2 uses level 2 for device drivers. Figure 5 shows how the different privilege levels can be used to form "rings" of protection.

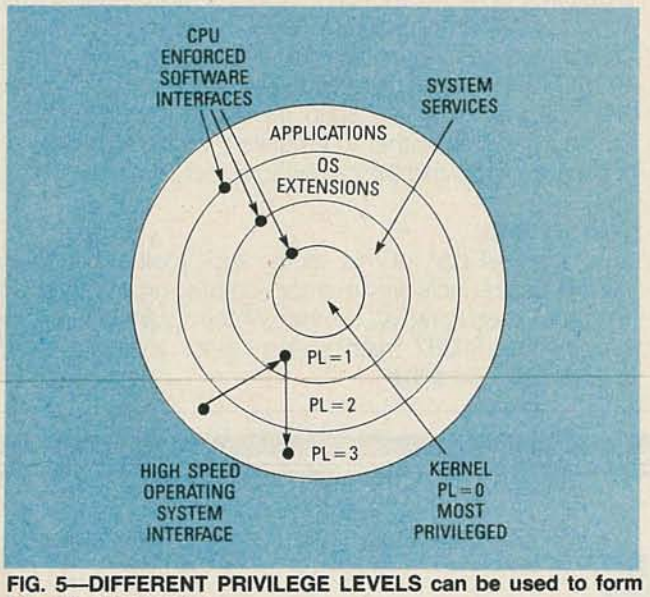


FIG. 5—DIFFERENT PRIVILEGE LEVELS can be used to form "rings" of protection.

When paging is enabled, there is a separate mechanism for protecting user and operating-system memory. That mechanism is governed by the U/S (User/Supervisor) and R/W (Read/Write) bits, which are found in each page directory and page table entry. Those bits control access to individual pages; the operating system manipulates those bits to allow a user program read and write, read only, or no access at all to a given page. That type of control is especially useful for systems that do not use segmentation.

I/O has its own privilege-control mechanism. The flags register contains a field called *I/O Privilege Level* (IOPL), which defines the minimum privilege level at which the currently running task can execute I/O instructions. Because the IOPL is updated during task switches, different tasks can have different IOPLs.

In addition, each task has an I/O Permission Bitmap for controlling access to each port address. That RAM-based table consists of a variable number of bytes, each bit of which corresponds to one of the 64K I/O ports available on the 80386.

Virtual 8086 environment

The 386 microprocessor can execute 8086 applications in two modes: real mode and virtual 86 mode. In real mode, the 80386 functions just like an 8086: the data bus is accessed sixteen bits at a time, as are the microprocessor's registers; memory is limited to one megabyte; and the 80386 paging and protection mechanisms are unavailable.

Virtual mode combines the best of real and protected modes; a simulated real-mode environment that enjoys the full benefits of paging and protection. When the processor is executing in virtual mode, the segment registers are used as in real mode. The contents of the segment register are shifted left four bits and added to the offset to form a linear segment address.

However, by using paging in virtual mode, 8086 ap-

WHAT IS AN OPERATING SYSTEM?

When it comes to operating systems, what you see is not the operating system. The user interface and the functions it performs—formatting disks, for example—is not the operating system. The user interface is really just another program that runs on the operating system. Many companies that sell operating systems include a user interface. Other companies sell just the operating system and include an interface specification so that programmers can write their own user interfaces. The user interface in MS-DOS is contained in COMMAND.COM.

An operating system is not a language or a compiler. Although an operating system must be written in some language, the language is not the operating system. Nor is the compiler, although one is often included with an operating system.

Utilities (FORMAT.COM and DEBUG.COM, for example) and commands (DIR and COPY, for example) are also not the operating system.

Then what is an operating system? An operating system is a program that provides orderly access to computer hardware by applications programs: word processors, spreadsheets, databases, etc. Without an operating system, every application would have to define its own disk-file structure and write its own code to access that structure. Different applications would undoubtedly have different file structures, so they would be unable to coexist on the same disks. Chaos would result if users had to use a different disk for every application.

Likewise, the operating system provides orderly access to the other resources: keyboard, video display, serial and parallel ports, etc.

Operating systems vary greatly in the services they provide. A single-tasking operating system (MS-DOS, for example) provides capabilities for loading and executing programs, reading and writing disk files, etc. A multitasking operating system is more complex because it must allow multiple tasks to share a machine simultaneously, prevent them from corrupting one another, and prevent them from trying to access the hardware simultaneously.

An operating system is the most complex program a programmer can write. Because of that complexity, typical operating systems are designed in layers. The services needed to implement a given layer are found in the layer below. The lowest level of an operating system is the one that interacts with the hardware directly.

Multitasking operating systems were developed in the 1960's to allow multiple users to share a central computer. This is called time sharing. In time sharing, relatively inexpensive terminals connect each user to an expensive central computer. From his terminal, each user seems to have the central computer all to himself, but as the number of users increases, performance decreases.

Many of the advantages of time-shared central computers are disappearing. Personal computers and workstations offer much less expensive processing power than mainframes. And advances in networking allow users to share information with inexpensive network file servers.

Although the popularity of time-shared computers is decreasing, the number of multitasking computer systems is increasing. Multitasking is showing up in both real-time control systems and in personal workstations.

plications can be executed anywhere in physical memory, not just the lower one megabyte. As discussed above, the paging hardware allows the 20-bit linear address produced by a virtual-mode program to be divided into 256 4K pages. Each page can be located anywhere in physical memory.

All virtual-mode programs execute at privilege level 3, the lowest level. If a virtual-mode task attempts to execute a privileged instruction, a microprocessor exception will occur. IN and OUT instructions are not sensitive to I/O privilege level when executed in virtual 8086 mode. Instead, I/O port access is controlled using the I/O permission bit map.

A virtual-machine monitor program such as Windows 386 can provide a virtual-8086 environment that is totally transparent to normal applications programs. The main requirement is that operating-system calls and I/O instructions are intercepted and emulated by the virtual-machine monitor.

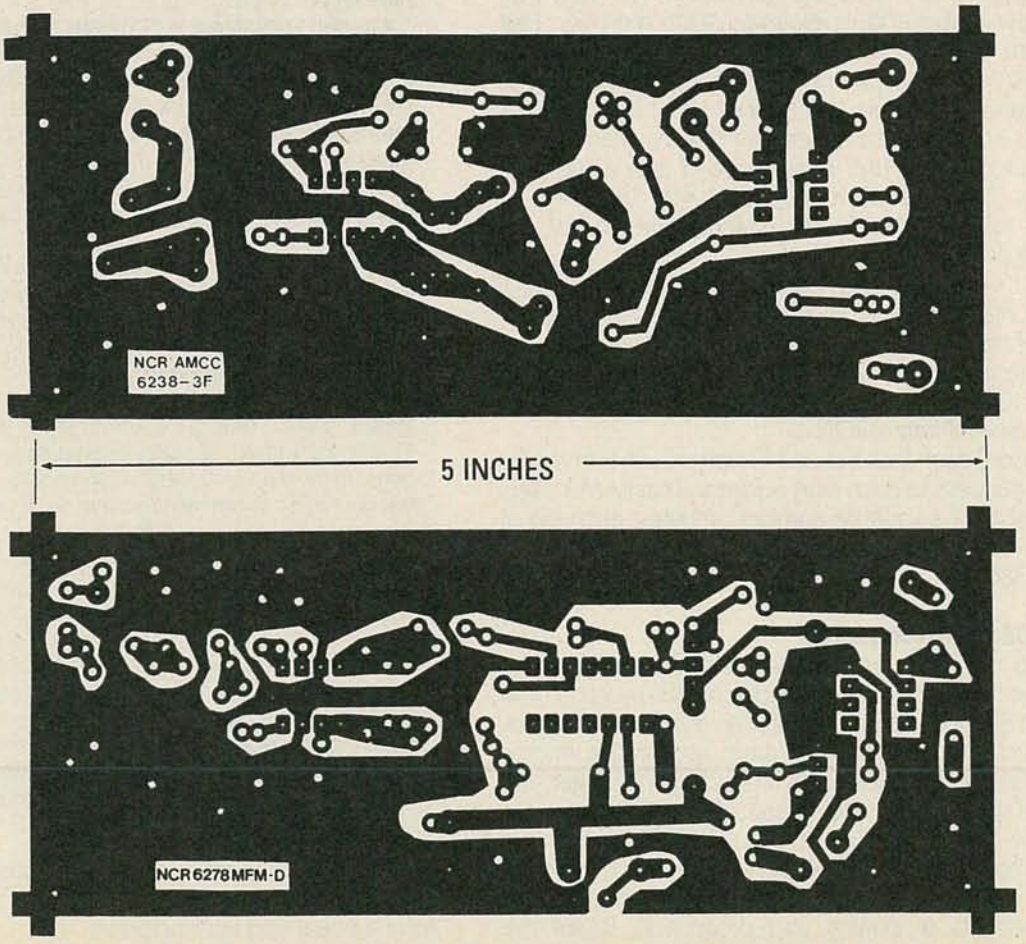
One of the biggest advantages of virtual mode is the ability to run several MS-DOS programs simultaneously. OS/2 cannot multitask DOS applications because OS/2 was designed specifically for the 80286, which does not provide a virtual 86 mode. On the other hand, Windows/386, OmniView, VM/386, and other programs use virtual mode to run several DOS programs simultaneously.

Other products use virtual mode to run DOS applications under UNIX. DOS uses interrupt 21h to provide operating-system functions: opening and closing disk files, etc. When a program issues an interrupt 21h, the operating system examines the VM bit in the image of the EFLAGS register that is stored on the stack. If that bit is set, the task was a virtual 8086 task. It is then up to the operating system either to emulate the call using its own resource, or to send the call on to an actual copy of DOS.

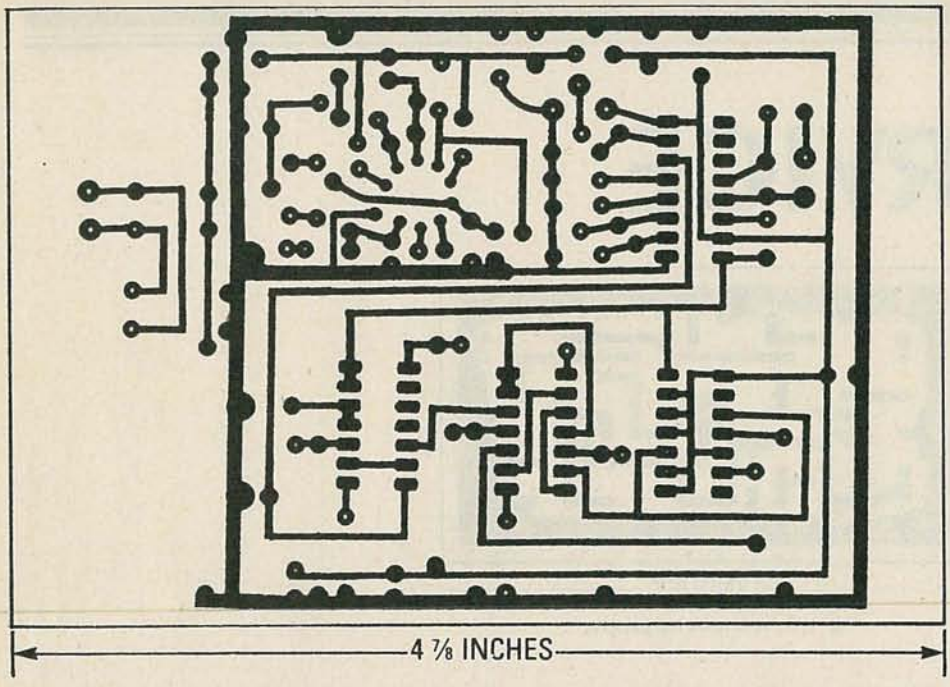
Next month

In the final part of this series, we'll look at hardware design issues, including memory interfacing, I/O interfacing, and interfacing with other system components, including the 80387 math co-processor and the 82386 cache controller.

PC SERVICE



THE FOIL PATTERNS for the AM (top) and FM (bottom) carrier-current receivers.



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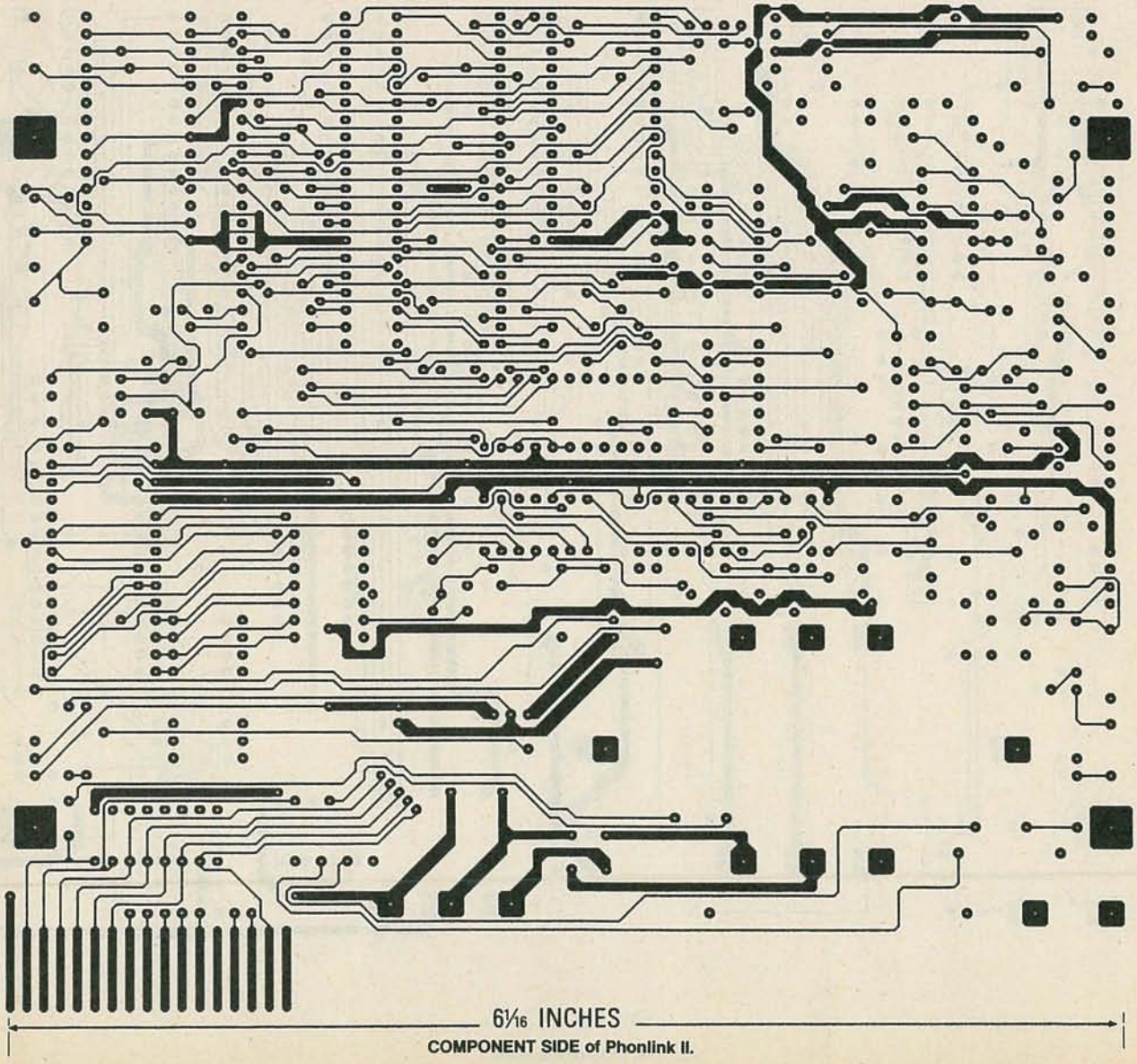
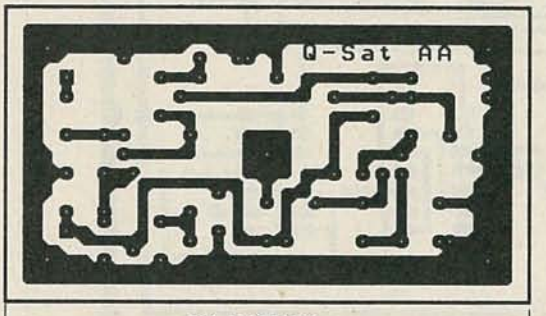
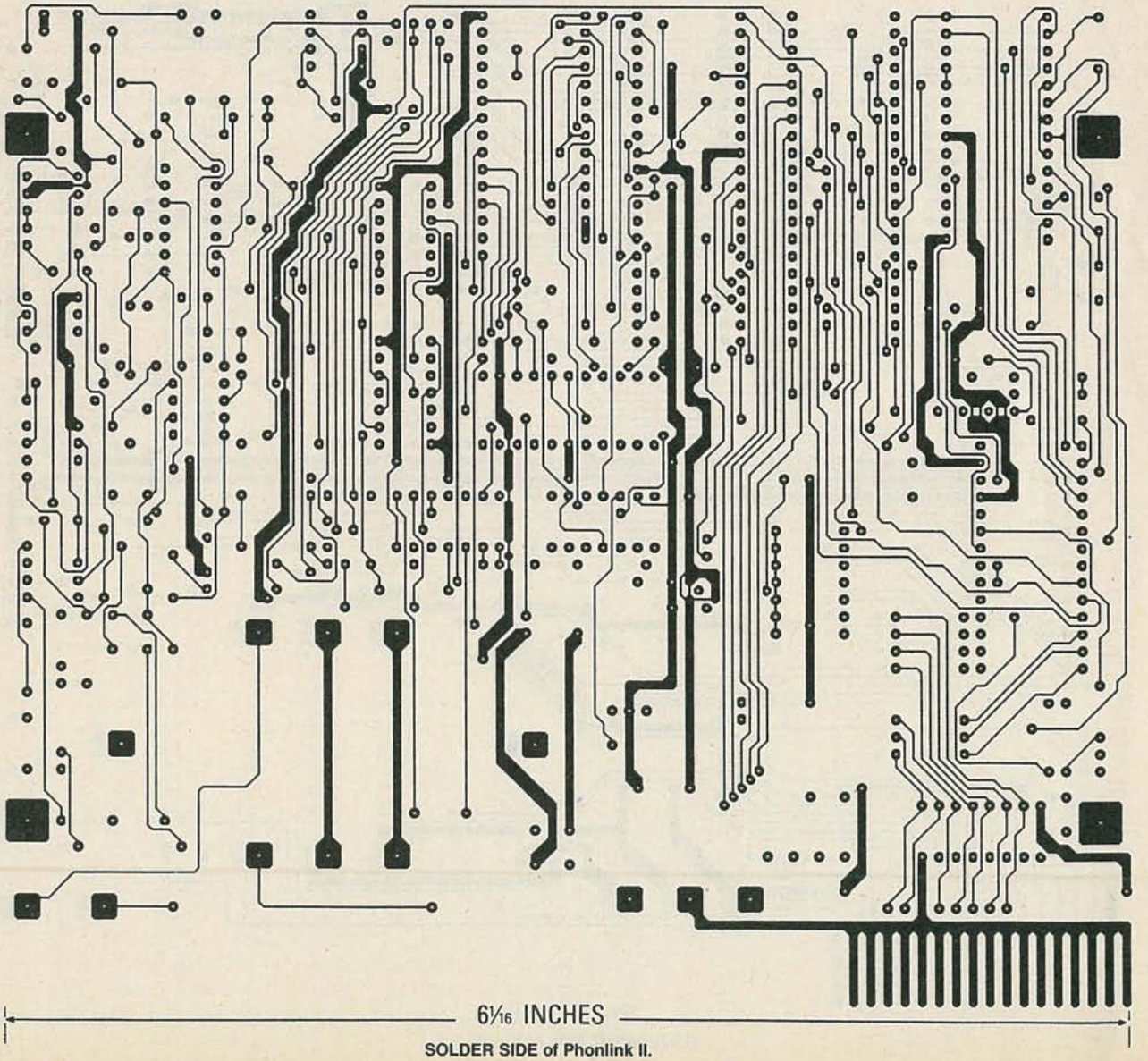


COMPONENT SIDE of Phonlink II.

PC SERVICE



ACTIVE ANTENNA foil pattern.



SOLDER SIDE of Phonlink II.

HDTV

continued from page 43

those of us who travel to Europe and watch TV there. It is planned that future displays would be refreshed from the frame storage memory at a 75- or 100-Hz rate.

The HDTV system that seems to be favored for North America has a more complex relationship to NTSC. The line ratio would be 15:7. A down-conversion from HDTV to broadcast NTSC would require either a digital interpolation of 15:7 or the cropping of 69 lines at top or bottom or both to give 966 active TV lines, so that a simple 2:1 digital interpolation could yield 483 active lines per the NTSC standard (the remaining lines of the so-called 525 line NTSC system are not visible on screen, but are in the vertical blanking interval). Many of the HDTV systems that are currently under consideration are known as MAC systems, which is an acronym that stands for Time *M*ultiplexed *A*nalog *C*omponents. MAC systems, it should be noted, are inherently free of the color artifacts that have always plagued both NTSC and PAL broadcast pictures.

In Europe, the consensus seems to be that the HDTV production standard used in studios will be fully compatible with a version of MAC called D-2 MAC which is intended to be used shortly as the *D*irect *B*roadcast *S*atellite (DBS) transmission signal of the *E*uropean *B*roadcast *U*nion (EBU). The emphasis there is on compatibility with D-2 MAC, and not necessarily with PAL or SECAM. Some see the eventual use of D-2 MAC for terrestrial transmission with the eventual replacement of the existing PAL and SECAM.

B-MAC, a system developed by Scientific Atlanta, while not a true HDTV system in that it transmits an interlaced 525-line picture and is therefore limited in vertical resolution, might more properly be called an Enhanced Definition System. NHK, the Japanese government-sponsored broadcast authority, has taken a totally different approach to the transmission of HDTV pictures. Since their 1125-line picture is not designed to be compatible with any existing broadcast standards, they have developed a special form of MAC for HDTV transmission. It's called MUSE, which is an acronym for *MU*ltiple *S*ub-Nyquist *E*ncoding." MUSE sub-samples the 1125-line picture, transmitting every other pixel of every other line in a first field. The missing samples of the line are transmitted next, followed by alternate samples of the missing lines and, finally, the samples previously omitted. MUSE has two resolution specifications. One resolution is for static pictures where the full information content of the 1125-line system is delivered via one 8.1-MHz baseband video signal. The other is the resolution that is provided when the picture contains motion; that is the resolution of current NTSC pictures. All forms of MAC, including MUSE, employ various amounts of pre-emphasis for the video signals, as shown in Fig. 9. In MAC systems, the 0-dB crossover frequency for the emphasis curve is much higher than for NTSC, and the low-frequency gain reduction is only about 3 dB for the B-MAC and D-2 MAC systems. MUSE employs a very elegant form of pre-emphasis that provides substantial improvement in signal-to-noise ratios. The MUSE pre-emphasis characteristic applies a large high-frequency gain boost for small-amplitude high-frequency components, and much less emphasis for large high-frequency components. That is possible only with a signal format that has no color subcarrier mixed in with it.

There are other variations on the MAC HDTV idea, but by now it should be clear that the path towards a standard is going to be a long and tortuous one. There seems to be an increasing tendency, in this country at least, to favor some sort of NTSC compatible approach to enhanced definition TV, so that millions of TV's don't become obsolete. It is entirely possible that the first delivery of HDTV may not be via broadcasting or cable TV at all. It could well be that we will see first examples of HDTV delivered to us in the form of software (new laser optical-disc formats or even new VCR formats based upon Super VHS or ED-Beta technology). Of course, such software will require new video monitor/receivers and other new hardware. Still, you should hold on to those NTSC receivers for the moment, since the current multiplicity of HDTV systems could well delay over-the-air HDTV for many years to come. **R-E**

AUDIO UPDATE

continued from page 90

plifier. If an amplifier survives 24 hours of such rough treatment, then the statistical probability is that it is not likely to break down in a customer's home in the foreseeable future. (See Onkyo's product-life test facilities in Fig. 1.)

Physical examinations

How much will a physical examination reveal about an electronic component's reliability? Unfortunately, not much. In the past, some very expensive audiophile components sporting ½-inch thick front panels, beautifully laid out wiring on military glass-epoxy circuit boards, computer-grade parts, etc., have had a far higher breakdown rate than some other unpretentious and far less expensive mass-produced products. That is not to say that pushing the state of the art results in unreliable products, but rather that some designers in their pursuit of the will-of-the-wisp of ultimate fidelity seem to neglect (or have never understood) some essential ground rules of amplifier design. For example, at one point many of the high-end limited-production amplifiers seemed to suffer from instability and to be unable to withstand standard slew-factor testing without blowing fuses.

I don't mean to imply that cheaper is better. An overzealous pursuit of lower manufacturing costs will almost always have negative consequences. Reducing the size and thickness of the front panel won't affect longevity, but cutting back on the heat sinks might. It appears, however, that when the economies of large production runs are possible, the manufacturer gains very little in the way of cost by scrimping on parts quality—particularly considering the ill will engendered by premature failures.

As someone who grew up with audio during the unlamented mono tube days, I continue to be impressed with the extended longevity—and sound—of today's audio equipment. Of course, failures still occur, but they are rarer than ever before. **R-E**

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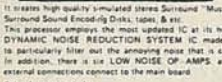

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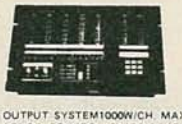
SPECIFICATIONS:
Frequency Response: 20Hz - 20KHz (± 5dB) • Total Harmonic Distortion: 0.05% 20Hz - 20KHz (front channel), <0.25% (surround channel) • Input Signal Voltage: 0.1V - 3.5V • Output Voltage: 0.1V - 3.5V (front channel), 6.6V Max. (surround channel) • Delay Time: 5ms - 50ms • Input Impedance: 47K Ohms, Power: AC 110V 60Hz • Dimensions: 4 3/16in (W) X 4 13/16in (D) X 2 1/16in (H) •
KIT/ASSM. AND TESTED $62/83

SUPER SALE

PROFESSIONAL COLOR LIGHT CONTROLLER SM—328



FEATURES:
1. FOUR GROUPS OF INDEPENDENT OUTPUT SYSTEM 1000W/CH. MAX. 4680W (100-117V) 2. PROFESSIONAL COLOR CONTROL SYSTEM (KEY-BOARD TYPE) 3. INDEPENDENT INPUT SIGNAL ADJUSTMENT 4. FOUR GROUPS OF INDEPENDENT DIMMER CONTROL 5. SPEED CONTROL CHASER 6. AUTOMATIC CHASING CONTROL SYSTEM 7. FOUR KINDS OF SPECIAL CHASING PROGRAM 8. COMBINATION OF PROGRAM AND MUSIC CHASING EFFECT 9. FORWARD/BACKWARD CHASING CONTROL
SM-328 color light controller is specialized for ballroom, night club disco and advertisement lighting. It consorts with several color control characteristics, which employ professional color control system and keyboard program selection. Therefore, it is capable of producing lighting effects by using chasing program and fluctuating music signal. There are two kinds of lighting effects. The first type is controlled by "music" signal. In order to adjust the brightness of four groups of lightings, each music signal will be separated into high, medium low A, and low B frequency range. Furthermore, each group of lightings is incorporated with an independent signal adjustment. The second kind is composed of electrical circuits and this is the main part for creating a special lighting effect. It has four chasing programme.
Dimensions: 14 5/16" x 8 15/16" x 3 3/16"
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300W HQ HI-FI POWER AMPLIFIER (MONO) TA-3600 △△△

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2450W (P.M.P.O.) INTO 8 OHMS
540W (MUSIC POWER) INTO 8 OHMS
*LOAD IMPEDANCE: 4 OHMS OR 8 OHMS
*FREQUENCY RESPONSE : 10Hz-200,000Hz
*TOTAL HARMONIC DISTORTION LESS THAN 0.05%
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• It uses "CR", RIAA EQ pre-amplifier to minimize TIM distortion and to obtain high fidelity.
• The power supply is based on by pass coupling DC stabilizer which uses class A design to obtain low internal impedance at high frequency and to greatly reduce transient distortion.
• Professional relay delay circuit prevents noise which may occur during power on and off.
• All FETs were tested and paired in the factory so no problem is likely to occured during building.
• It can be directly connected to any power amplifier. The best partner is TA-477 120W MOS FET power amplifier & TA-3600
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METAL CABINET $20.16

120W MOSFET POWER AMPLIFIER TA-477 △△

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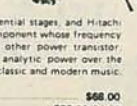

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This amplifier consists of three super low TIM differential stages, and Hitachi 2SJ49/2SK 134 match pair "MOSFET" as output component whose frequency response and transient response is superior to the other power transistor. Therefore this amplifier has high fidelity and superior analytic power over the entire Audio Spectrum. It is suitable for reproducing classic and modern music. Heavy Duty Heat Sink with 28 radial fins is included!
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DC current DC±1uA ±20A
*Accuracy DC±0.025% ± 2 digit
*Power DC5-6V at 200mA
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A.C. VOLTAGE: 1mV — 1000V
DIGITAL THERMOMETER: 0°C — 100°C
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CAPACITOR METER: 1 pF — 2 uF
DIMENSIONS: 3 3/4" x 1 7/8" x 4 1/16" ASSM. AND TESTED & CAL. $43

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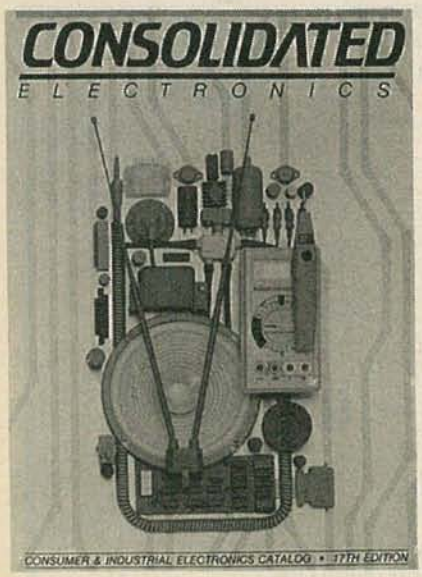

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100 .35	.40	1.40	
200 .40	.50	1.80	
400 .60	.70	2.40	9.00
600 .80	1.00	3.60	12.00

TRIAC's

PRV	1A	10A
100	.35	.60
200	.50	.80
400	.70	1.00
600	1.00	1.20

LINEAR CIRCUITS

TL062C	.95	LM393	.40	MC1391	1.00
TL064CN	1.00	LF398A	3.00	1456	.80
TL072	1.00	LF411	1.25	1458	.50
LM79BCT	.60	AD506JH	2.50	LM1808	1.75
TL062	.90	537	1.50	ULN2003A	.75
TL084	1.00	LM555	.29	AD2700LD	4.95
DG201BP	1.40	LM556	.45	LM2901	.95
LM201	.75	558	1.10	CA3018	1.95
LM301	.35	AD561	3.00	CA3045	1.20
LM307	.45	564	1.75	CA3078AT	1.50
LM308	.65	565	.90	CA3089E	1.75
LM311	.45	566	1.25	CA3094	1.30
LM318	1.00	567	.75	CA3130	.90
LM319	1.10	NE570	2.50	CA3140	.75
LM324	.35	NE592	.95	SG3543	.70
LM339	.50	709CN	.80	SG3544	1.00
LM348	.65	711CH	.60	UNL3701E	1.75
LF351	.45	733	.95	LM3900	.50
LF353	.75	739	1.50	4136	.85
LF355	.35	741CV	.29	SD5000	1.75
LF356	.85	747	.50	N5534	.75
LM358	.45	DAC0808	2.95	NS598A	1.50
LM370	1.60	ADC0809		SD6000	1.00
LM380	.85	CNN	8.95	8038	3.95
LM384	1.00	MC1310	1.00	8700CJ	5.95
LM386	.85	MC1350	.90	LM13080	.95
		MC1355	1.25	76477	2.95

C/MOS

74C00	.25	74C915	1.10	4027	.35	4072	.20
74C04	.25	4001	.19	4028	.65	4076	.55
74C08	.25	4002	.20	4029	.65	4077	.28
74C10	.25	4006	.65	4030	.35	4081	.20
74C14	.55	4007	.20	4034	1.40	4082	.20
74C20	.25	4008	.85	4035	.65	4093	.45
74C32	.35	4009	.35	4040	.65	4099	1.40
74C42	1.10	4010	.35	4041	.75	4501	.95
74C74	.55	4011	.19	4042	.55	4503	.45
74C76	.60	4012	.25	4043	.85	4506	.75
74C85	1.25	4013	.35	4044	.65	4510	.65
74C86	.35	4014	.65	4045	.85	4511	.65
74C93	1.00	4015	.28	4046	.85	4512	.75
74C157	.95	4016	.28	4047	.65	4514	.95
74C161	.95	4017	.45	4049	.28	4515	1.60
74C174	.95	4018	.65	4050	.28	4516	.75
74C175	.95	4019	.35	4051	.65	4518	.85
74C193	1.25	4020	.55	4052	.65	4520	.75
74C245	1.75	4021	.65	4053	.65	4528	.75
74C901	.35	4022	.65	4060	.65	4529	1.40
74C902	.40	4023	.25	4066	.28	4538	.95
74C903	.80	4024	.48	4068	.35	4539	1.60
74C907	.75	4025	.25	4069	.19	45418	1.20
		4026	1.25	4070	.28	4583	.90
				4071	.20	4585	.75

PLEASE CALL FOR QUANTITY PRICING

74HC00	.35	**74HC SERIES**		74HC245	.80		
74HC02	.35	74HC125	.50	74HC257	.55		
74HC04	.35	74HC133	.50	74HC259	.60		
74HC08	.35	74HC137	.75	74HC273	.80		
74HC10	.35	74CH138	.70	74HC354	.95		
74HC11	.40	74HC139	.45	74HC373	.80		
74HC20	.35	74HC153	.55	74HC374	.80		
74HC30	.35	74HC154	1.75	74HC533	1.35		
74HC32	.35	74HC157	.50	74HC534	1.35		
74HC50	.45	74HC162	.55	74HC573	2.50		
74HC58	.50	74HC163	.55	74HC595	2.50		
74HC74	.40	74HC164	.80	74HC640	2.00		
74HC75	.40	74HC174	.60	74HC4002	.50		
74HC85	.70	74HC175	.60	74HC4020	1.10		
74HC86	.40	74HC194	.70	74HC4066	.60		
74HC107	.35	74HC221	.90	74HC4514	3.20		
74HC109	.40	74HC240	.75	74HC4538	1.40		
74HC112	.40	74HC242	.75	74HC4543	1.40		
		74HC244	.80				

74LS SERIES

74LS00	.17	74LS112	.29	74LS241	.65
74LS01	.17	74LS113	.33	74LS242	.65
74LS02	.17	74LS114	.33	74LS243	.65
74LS03	.17	74LS122	.70	74LS244	.65
74LS04	.17	74LS123	.45	74LS245	.75
74LS05	.17	74LS125	.35	74LS246	1.40
74LS08	.17	74LS126	.35	74LS247	.75
74LS09	.17	74LS132	.39	74LS248	.65
74LS10	.17	74LS136	.35	74LS251	.45
74LS11	.20	74LS137	.90	74LS253	.45
74LS12	.27	74LS138	.39	74LS257	.39
74LS13	.25	74LS139	.39	74LS258	.45
74LS14	.36	74LS145	.70	74LS259	1.20
74LS15	.25	74LS147	1.00	74LS260	.45
74LS20	.17	74LS148	.90	74LS266	.55
74LS21	.22	74LS151	.39	74LS273	.75
74LS22	.22	74LS153	.39	74LS279	.39
74LS26	.23	74LS154	1.50	74LS280	1.70
74LS27	.23	74LS155	.55	74LS283	.55
74LS28	.26	74LS156	.45	74LS290	.80
74LS30	.17	74LS157	.35	74LS293	.80
74LS32	.17	74LS158	.20	74LS298	.65
74LS37	.26	74LS160	.29	74LS299	1.25
74LS38	.26	74LS161	.49	74LS320	2.00
74LS40	.17	74LS162	.49	74LS322	3.00
74LS42	.35	74LS163	.49	74LS323	2.40
74LS48	.65	74LS164	.45	74LS365	.39
74LS51	.17	74LS165	.65	74LS366	.39
74LS54	.22	74LS166	.95	74LS367	.39
74LS73	.25	74LS169	.90	74LS368	.39
74LS74	.24	74LS170	.80	74LS373	.75
74LS75	.29	74LS173	.49	74LS374	.75
74LS76	.29	74LS174	.39	74LS377	.75
74LS83	.45	74LS175	.39	74LS386	.45
74LS85	.45	74LS181	1.40	74LS390	1.10
74LS86	.22	74LS190	.49	74LS393	.75
74LS90	.39	74LS191	.49	74LS398	2.50
74LS92	.45	74LS192	.65	74LS446	2.00
74LS93	.45	74LS193	.65	74LS541	1.40
74LS95	.48	74LS194	.65	74LS625	1.75
74LS96	.49	74LS195	.65	74LS645	.95
81LS98	1.40	74LS196	.55	74LS658	1.45
74LS107	.35	74LS197	.55	74LS670	.95
74LS109	.35	74LS221	.55	25LS2521	1.95
		74LS240	.65		

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16R4	1.95
16R6B	2.75
16L8A	3.50
16R8A	3.50
20R8A	3.95

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.22UF 35V	5/$1.00	15UF 16V	3/$1.00
.47UF 35V	5/$1.00	22UF 10V	$ .30
.68UF 35V	5/$1.00	30UF 6V	5/$1.00
1UF 20V	5/$1.00	33UF 15V	$ .50
2.2UF 20V	5/$1.00	47UF 20V	$ .85
3.3UF 20V	4/$1.00	68UF 20V	$1.00
4.7UF 20V	4/$1.00	100UF 16V	$1.10
6.8UF 20V	4/$1.00	330UF 10V	$1.75
10UF 20V	$ .40		

DISC CAPACITORS

.1UF 16V...	10/$1.00 ... 100/$8.00
.01UF 35V...	16/$1.00 ... 100/$5.00

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REGULATORS

LAS39U	$5.95	323K (LA1405)	$2.95
78L05 or 12	$ .30	LM337	$2.75
78MO5, 12 or 15	$ .40	LM338K	$3.75
LM305	$ .75	340T-5,6,8,12, 15,18 or 24V	$ .45
309K	$1.25	723	$ .45
LM317T	$ .90	320T-5,12,15 or 24	$ .55

L1411-IR Detector	3/$1.00
FP 100 Photo Trans	$ .50
Red LED's .2"	10/$1.00
Yellow, Green, or Amber Lg LED's .2"	8/$1.00
Red-Green Bipolar LED	$ .90
Red-Yellow Bipolar LED	$ .90
MLED92 IR LED	$ .40
MRD14B Photo Darl, XTOR	$ .60
IL-5 Opto Isolators or MCT-2	$ .60
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TTL SIZE RELAYS

5V DPST	.95
12V DPST	.95

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PRV	2A	6A	25A
100			1.40
200	.80	1.30	2.20
400	1.00	1.65	3.30
600	1.30	1.90	4.40

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CTS 206- 4	4 Position .75
CTS 206- 7	7 Position .95
CTS 206- 8	8 Position .95
CTS 206-10	10 Position 1.25

SILICON POWER RECTIFIERS

PRV	1A	3A	12A	50A	125A	240A
100	.05	.14	.35	.90	6.00	7.00
200	.06	.17	.50	1.30	8.00	10.00
400	.09	.25	.65	1.50	10.00	12.00
600	.11	.30	.80	2.00	13.00	15.00
800	.13	.35	1.00	2.50	16.00	18.00
1000	.20	.45	1.25	3.00	20.00	26.00

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1000 OHM
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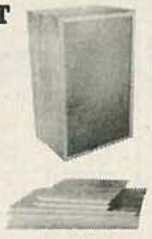
WALNUT SPEAKER CABINET KIT



Super quality, genuine walnut veneer cabinet. Kit includes: routed and mitred top, sides, and bottom in unfinished 3/4" walnut veneer. Cut your own custom holes in the front and rear to match your drivers. 15" x 24" x 11". Volume: 1.9 cu. ft.

#260-350 $22.50 (1-3) **$19.95** (4-up)

15" THRUSTER WOOFER

Thruster by Eminence. Made in U.S.A. Forward poly roll foam surround, 56 oz. magnet. 2-1/2", 2 layer voice coil. 150 watts RMS, 210 watts max. 4 ohm. fs = 23.5 Hz, QMS = 9.86, QES = .34, QTS = .33, VAS = 17.9 cu. ft. SPL = 94.8 dB 1W/1M. Net weight: 15 lbs.

#290-180 $43.50 (1-3) **$39.80** (4-up)

SUBWOOFER CROSSOVER

200 watts RMS. 12 dB per octave, 150 Hz at 8 ohm crossover point.

#260-220 $28.80 (1-5) **$24.40** (6-up)

12" POLY WOOFER

PIONEER

Super duty, 40 oz. magnet. Polypropylene cone. 100 watts RMS, 145 watts max. 4 and 8 ohm compatible (6 ohm). 2" voice coil. fs = 25 Hz. VAS = 10.8 cu. ft., QTS = .166. Response: 25-1,500 Hz. Net weight: 9 lbs.

#290-125 $36.80 (1-3) **$34.50** (4-up)

12" PIONEER SUB WOOFER

PIONEER

Dual voice coil sub woofer. 30 oz. magnet, 2" voice coil. 100 watts RMS, 145 watts max. fs = 25 Hz. 6 ohm (4 and 8 ohm compatible). SPL = 89 dB 1W/1M. Response: 25-700 Hz. QTS = .31, VAS = 10.3 cu ft. Pioneer #A30GU30-55D. Net weight: 6 lbs.

#290-145 $39.80 (1-3) **$36.80** (4-up)

15" 3-WAY, 125 WATT SYSTEM

Our "Top-of the Line" system. The system features elements specifically selected to produce a balanced output throughout the full frequency bandwidth of the system. System includes: (1) #290-155 15" polypropylene woofer rated at 145 watts max, (2) #280-020 cup midranges, (1) #270-035 4" soft dome tweeter, (1) #260-215 200 watt 3-way crossover, (2) #260-265 100 watt mid, tweeter "L" pad attenuators, (1) #260-300 speaker terminal, and (1) #260-340 grille cloth.

#15-125 **$99.95** Each

18" EMINENCE WOOFER

EMINENCE

MADE IN U.S.A.

100 oz. magnet, 3" voice coil. 250 watts RMS, 350 watts max. 8 ohm, 30 Hz resonant frequency. 22-2700 Hz response. Efficiency: 95 dB 1W/1M. Paper cone treated accordian surround. Net weight: 29 lbs.

#290-200 $98.80 (1-3) **$89.50** (4-up)

PIONEER HORN TWEETER

Mylar dome, 2.93 oz. barium ferrite magnet. 8 ohm. Response: 1,800-20,000 Hz. 35W RMS, 50W max. fs = 2,000 Hz, SPL = 106 dB. Pioneer #AHE60-51F.

#270-050 $6.50 (1-9) **$5.90** (10-up)

3-WAY 100W CROSSOVER

12 dB / octave rolloff. 800 Hz, 5000 Hz. 8 ohm. 100 watts RMS.

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(will operate on 3-32 Vdc).
LOAD: 10 amp @ 240 Vac
2 1/4" X 1 3/4" X 7/8"
CAT# SSRLY-10B $9.50 each
QUANTITY DISCOUNT
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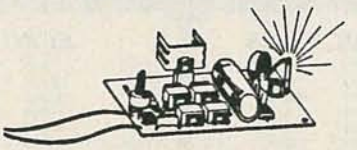
STROBE KIT



Variable rate strobe kit, flashes between 60 to 120 times per minute. Will operate on either 6 or 12 Vdc depending upon how you wire the circuit. Comes complete with P.C. board and instructions for easy assembly.
CAT# STROBE-1 $7.50 each

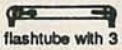
CASSETTE MECHANISM

Alpine cassette transport mechanism. Includes stereo tape head, Mitsubishi # MET-3RF2B 13.2 Vdc motor, belt, pulleys, capstan, fast-forward, rewind and eject actuator. Does not include amplifier section. 6 1/2" X 5 1/4" X 1 3/4".
CAT# CMEC-5 $7.50 each
10 for $65.00

PIEZO WARNING DEVICE

Murata Erie # PKB8-4A0
High pitched audible alarm. Operates on 3 - 20 Vdc @ 20 ma. 1" high x 7/8" dia. P.C. board mount.
CAT# PBZ-84 $1.75 each

XENON TUBE



1" long flashtube with 3 1/2" red and black leads. Ideal for electronic flash or strobe projects.
CAT# FLT-3 2 for $1.00

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SPECIAL!! AAA SIZE
Panasonic# P-18AAA
1.2 volt @ 180 MAh
CAT# NCB-AAAX $1.50 each
10 for $13.50 • 100 for $125.00

AA SIZE $2.00 each
1.25 volts 500 mAh
CAT# NCB-AA
AA SIZE $2.20 each
WITH SOLDER TABS
CAT# NCB-SAA
C SIZE $4.25 EACH
1.2 volts 1200 mAh
CAT# NCB-C
D SIZE $4.50 each
1.2 volts 1200 mAh
CAT# NCB-D

TRANSISTORS

CAT#	TYPE	CASE	PRICE
PN2222	NPN	TO-92	5 for 75¢
2N2904	PNP	TO-5	3 for $1.00
2N2906	PNP	TO-18	3 for $1.00
PN2907	PNP	TO-92	5 for 75¢
2N3055	NPN	TO-3	$1.00 each
PN3569	NPN	TO-92	5 for 50¢
2N3904	NPN	TO-92	5 for 75¢
2N3906	PNP	TO-92	5 for 75¢
2N4400	NPN	TO-92	5 for 75¢
2N4402	PNP	TO-92	5 for 75¢
2N5400	PNP	TO-92	4 for $1.00
2N5880	PNP	TO-3	$2.00 each
2N5882	NPN	TO-3	$2.00 each
MJ2955	PNP	TO-3	$1.50 each
MJE2955T	PNP	TO-220	75¢ each
MJE3055T	NPN	TO-220	75¢ each
TIP30	PNP	TO-220	75¢ each
TIP31	NPN	TO-220	75¢ each
TIP32	PNP	TO-220	75¢ each
TIP41	NPN	TO-220	75¢ each
TIP42	PNP	TO-220	75¢ each
TIP121	NPN	TO-220	75¢ each
TIP126	PNP	TO-220	75¢ each

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NEC# UPC1651G. 1200 Mhz @ 3 db.
Gain: 19db @ f=500 hz. 5 volt operation.
Small package 4mm dia. X 2.5 mm thick.
CAT# UPC-1651 2 for $1.00
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IRF-511 TO-220 case
CAT# IRF 511
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LARGE QUANTITY AVAILABLE

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U shaped package with mounting ears. 1/8" opening. 3/4" mounting holes. **CAT# OSU-6** 50¢ each
10 for $4.50 • 100 for $40.00

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ALL PLUG DIRECTLY INTO 120 VAC OUTLET

6 Vdc @ 200 ma.	CAT#	DCTX-620	$2.25
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12 Vac @ 930 ma.	CAT#	ACTX-1293	$3.50
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ITT PUSH BUTTON

ITT MDPL series. 3/4" X 1/2" gray rectangular key cap. S.P.S.T. N.O.
Push to close. RATED: 0.1 amp switching, 0.25 amp carry current. P.C. mount. **CAT# PB-8**
65¢ each • 10 for $6.00 • 100 for $50.00

10 POSITION MINI-ROTARY

Grayhill# 56P36-01-1-10N-C
Mini rotary switch. Non-shorting. 1 deck, 10 positions. .125" dia. shaft X .375" long. .377" behind the panel depth. P.C. pins.
CAT# MRS-10 $2.50 each

HALL EFFECT SWITCH

MICROSWITCH# 4BE3
Slanted keyboard switch with hall effect sensor. Snaps into 5/8" square chassis hole. Hall effect sensor slides easily from switch and can be used in other applications.
CAT# HESW 4 for $1.00
10 for $2.00 • 100 for $15.00

SPDT PUSHBUTTON

Marquard# 1843
Rated 6 amps @ 125/250 Vac.
Black plastic pushbutton.
Switch body: .92" X .94" X .65".
CAT# PB-18 $1.65 each • 10 for $1.50 each

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STANDARD JUMBO
DIFFUSED T 1-3/4 size

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CAT# LED-6 2 for $1.70

LED HOLDER

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CAT# HLED 10 for 65¢

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TMM2016-200	2048x8	200ns	3.25
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TMM2016-100	2048x8	100ns	4.29
HM6116-4	2048x8	200ns	4.95
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MK4332	32768x1	200ns	6.95
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4164-120	65536x1	120ns	3.19
4164-100	65536x1	100ns	3.95
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41128-150	131072x1	150ns	5.95
TMS4464-15	65536x4	150ns	10.95
TMS4464-12	65536x4	120ns	11.95
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41256-120	262144x1	120ns	12.95
41256-100	262144x1	100ns	13.45
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2716	2048x8	450ns	25V	3.49
2716-1	2048x8	350ns	25V	3.95
2732	4096x8	450ns	25V	3.95
2732A	4096x8	250ns	21V	3.95
27C64	8192x8	250ns	12.5V	4.95
2764	8192x8	450ns	12.5V	3.49
2764-250	8192x8	250ns	12.5V	3.69
2764-200	8192x8	200ns	12.5V	4.25
MCM68766	8192x8	350ns	21V	15.95
27128	16384x8	250ns	12.5V	4.95
27128A-200	16384x8	200ns	12.5V	5.95
27C256	32768x8	250ns	12.5V	7.95
27256	32768x8	250ns	12.5V	5.95
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8155-2	3.95
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7912T	.59	79L12	1.49
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74LS03	.18	74LS124	2.75	74LS244	.69
74LS04	.16	74LS125	.39	74LS245	.79
74LS05	.18	74LS126	.39	74LS251	.49
74LS08	.18	74LS132	.39	74LS253	.49
74LS09	.18	74LS133	.49	74LS257	.39
74LS10	.16	74LS136	.39	74LS258	.49
74LS11	.22	74LS138	.39	74LS259	1.29
74LS12	.22	74LS139	.39	74LS260	.49
74LS13	.26	74LS145	.99	74LS266	.39
74LS14	.39	74LS147	.99	74LS273	.79
74LS15	.26	74LS148	.99	74LS279	.39
74LS20	.17	74LS151	.39	74LS280	1.98
74LS21	.22	74LS153	.39	74LS283	.59
74LS22	.22	74LS154	1.49	74LS290	.89
74LS27	.23	74LS155	.59	74LS293	.89
74LS28	.26	74LS156	.49	74LS299	1.49
74LS30	.17	74LS157	.35	74LS322	3.95
74LS32	.18	74LS158	.29	74LS323	2.49
74LS33	.28	74LS160	.29	74LS365	.39
74LS37	.26	74LS161	.39	74LS367	.39
74LS38	.26	74LS162	.49	74LS368	.39
74LS42	.39	74LS163	.39	74LS373	.79
74LS47	.75	74LS164	.49	74LS374	.79
74LS48	.85	74LS165	.65	74LS375	.95
74LS51	.17	74LS166	.95	74LS377	.79
74LS73	.29	74LS169	.95	74LS390	1.19
74LS74	.24	74LS173	.49	74LS393	.79
74LS75	.29	74LS174	.39	74LS541	1.49
74LS76	.29	74LS175	.39	74LS624	1.95
74LS83	.49	74LS191	.49	74LS640	.99
74LS85	.49	74LS192	.69	74LS645	.99
74LS86	.22	74LS193	.69	74LS670	.89
74LS90	.39	74LS194	.69	74LS682	3.20
74LS92	.49	74LS195	.69	74LS688	2.40
74LS93	.39	74LS196	.59	74LS783	22.95
74LS95	.49	74LS197	.59	25LS2521	2.80
74LS107	.34	74LS221	.59	26LS31	1.95
74LS109	.36	74LS240	.69	26LS32	1.95

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LM301	.34	TL494	4.20	MC3470	1.95
LM309K	1.25	TL497	3.25	MC3480	8.95
LM310	1.75	NE555	.29	MC3487	2.95
LM311	.59	NE556	.49	LM3900	.49
LM311H	.89	NE558	.79	LM3909	.98
LM311K	3.49	NE564	1.95	LM3911	2.25
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LM318	1.49	LM567	.79	MC4024	3.49
LM319	1.25	NE570	2.95	MC4044	3.99
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HIGH SPEED CMOS LOGIC

74HC00	.21	74HC244	.85	74HCT138	.35
74HC04	.25	74HC245	.85	74HCT139	.55
74HC08	.25	74HC273	.69	74HCT157	.59
74HC14	.35	74HC367	.69	74HCT161	.79
74HC32	.35	74HC373	.69	74HCT240	.89
74HC74	.35	74HC390	.79	74HCT244	.89
74HC138	.45	74HC374	.69	74HCT245	.99
74HC139	.45	74HC4040	.89	74HCT273	.99
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STANDARD CMOS LOGIC

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4011	.19	4040	.69	4070	.29
4013	.35	4042	.59	4081	.22
4015	.29	4044	.69	4093	.49
4016	.29	4046	.69	14411	9.95
4017	.49	4047	.69	14433	14.95
4018	.69	4049	.29	14497	6.95
4020	.59	4050	.29	4503	.49
4021	.69	4051	.69	4511	.69
4023	.25	4052	.69	4518	.85
4024	.49	4053	.69	4528	.79
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7402	.19	74123	.49	74S00	.29
7404	.19	74125	.45	74S02	.29
7406	.29	74150	1.35	74S04	.29
7407	.29	74151	.55	74S08	.35
7408	.24	74153	.55	74S10	.29
7410	.19	74154	1.49	74S32	.35
7411	.25	74157	.55	74S74	.49
7414	.49	74159	1.65	74S86	.35
7416	.25	74161	.69	74S112	.50
7417	.25	74164	.85	74S124	2.75
7420	.19	74166	1.00	74S138	.79
7430	.19	74175	.89	74S153	.79
7432	.29	74367	.65	74S157	.79
7438	.29			74S158	.95
7442	.49	74F/74S		74S163	1.29
7445	.69	74F00	.35	74S175	.79
7447	.89	74F02	.35	74S195	1.49
7473	.34	74F04	.35	74S240	1.49
7474	.33	74F08	.35	74S241	1.49
7475	.45	74F10	.35	74S244	1.49
7476	.35	74F32	.35	74S280	1.95
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7485	.59	74F74	.39	74S288	1.69
7586	.35	74F86	.55	74S299	2.95
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10.738635	1.95
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18.432	1.95
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1.8432	5.95
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2.4576	5.95
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4.0	4.95
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5.0688	4.95
6.0	4.95
6.144	4.95
8.0	4.95
10.0	4.95
12.0	4.95
14.31818	1.95
15.0	1.95
16.0	4.95
18.432	4.95
20.0	4.95
24.0	4.95

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IN5402	.25	2N6045	1.75
IN4004	10/1.00	MPS-A13	.40
IN4148	25/1.00	TIP31	.49
KBP02	.55	4N26	.69
PN2222	.10	4N27	.69
2N2222	.10	4N28	.69
2N2907	.25	4N33	.89
2N3055	.79	4N37	1.19
2N3904	.10	MCT-2	.59
2N3906	.10	MCT-6	1.29
2N4401	.25	TIL-111	.99

CAPACITORS

TANTALUM

1.0µf	15V	.12
6.8	15V	.42
10	15V	.45
22	15V	.99
1.0µf	35V	.45
2.2	35V	.19
4.7	35V	.39
10	35V	.69

DISC

10pf	50V	.05
22	50V	.05
33	50V	.05
47	50V	.05
100	50V	.05
220	50V	.05
.001µf	50V	.05
.005	50V	.05
.01	50V	.07
.05	50V	.07
.1	12V	.10
.1	50V	.12

ELECTROLYTIC

RADIAL

1µf	50V	.14
4.7	50V	.11
10	50V	.11
47	35V	.13
100	16V	.15
100	50V	.23
220	35V	.20
470	25V	.30
2200	16V	.70
4700	25V	1.45

AXIAL

1µf	50V	.14
10	16V	.14
10	50V	.16
22	16V	.14
47	50V	.19
100	35V	.19
470	50V	.29
1000	16V	.29
2200	16V	.70
4700	16V	1.25

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JDR-PR16V	16 BIT FOR VIDEO APPLICATIONS	39.95
	FOR AT	
JDR-PR10	16BIT WITH I/O DECODING LAYOUT	34.95
JDR-PR10PK	PARTS KIT FOR JDR-PR10 ABOVE	12.95
	FOR XT	
IBM-PR1	WITH +5V AND GROUND PLANE	27.95
IBM-PR2	AS ABOVE WITH I/O DECODING LAYOUT	29.95

POWER SUPPLIES

APPLE TYPE SUPPLY

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

PS-A $49.95

FLOPPY DRIVE SUPPLY

- +5V @ 2.5A, +12V @ 2A, -12V @ .1A
- +5V @ 5A, IF +12 NOT USED

PS-ASTEC $24.95

75 WATT SUPPLY

- UL APPROVED
- +5V @ 7A, +12V @ 3A, -5V @ 300MA, -12V @ 250MA

PS-1558 $34.95

MICRO SUPPLY

- UL APPROVED, 144 WATTS
- +5V @ 18A, +12V @ 4A, -12V @ 500MA

PS-1554 $29.95

GENDER CHANGERS

GENDER-FF	FEMALE-FEMALE	7.95
GENDER-MM	MALE-MALE	7.95
GENDER-MF	MALE-FEMALE	7.95
GENDER-NM	NULL MODEM	8.95
GENDER-JB	JUMPER BOX	8.95
GENDER-MT	MINITESTER	14.95

BIT RATE GENERATORS

MC14411	9.95
BR1941	4.95
4702	9.95
COM5016	16.95
COM8116	8.95
MM5307	4.95

BYPASS CAPACITORS

.01xx	CERAMIC DISC	100/5.00
.01xx	MONOLITHIC	100/10.00
.1xx	CERAMIC DISC	100/6.50
.1xx	MONOLITHIC	100/12.50

CLOCK CIRCUITS

MC146818	5.95	MM58174	9.95
MM58167	9.95	MSM5832	2.95

DISK CONTROLLERS

1771	4.95	2797	29.95
1791	9.95	8272	4.39
1793	9.95	UPD765	4.39
1795	12.95	MB8876	12.95
1797	12.95	MB8877	12.95
2791	19.95	1691	6.95
2793	19.95	2143	6.95

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CAN BE SNAPPED APART TO MAKE ANY SIZE HEADER, ALL WITH .1" CENTERS

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1x40	RIGHT ANGLE LEAD	.49
2x40	2 STRAIGHT LEADS	2.49
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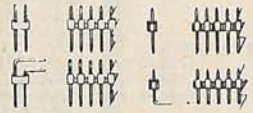
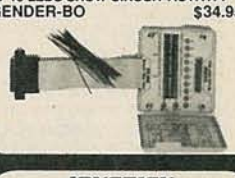


RS-232 BREAKOUT BOX

FOR TROUBLESHOOTING SERIAL COMMUNICATIONS

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

GENDER-BO $34.95



IDC CONNECTORS/RIBBON CABLE

DESCRIPTION	ORDER BY	CONTACTS					
		10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.31	2.72	3.39
WIREWRAP HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RIGHT ANGLE WIREWRAP HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	.63	.89	.95	1.29	1.49	1.69
RIBBON HEADER	IDMxx	--	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	.85	1.25	1.35	1.75	2.05	2.45
10' PLASTIC RIBBON CABLE	RCxx	1.60	3.20	4.10	5.40	6.40	7.50

FOR ORDERING INSTRUCTIONS, SEE D-SUBMINIATURE CONNECTORS BELOW

EPROM ERASERS

SPECTRONICS CORPORATION

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

DATARASE *$34.95*

- ERASES 2 EPROMS IN 10 MINUTES
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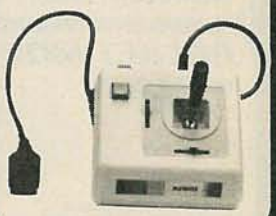

D-SUBMINIATURE CONNECTORS

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

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

MOUNTING HARDWARE 59¢

IC SOCKETS/DIP CONNECTORS

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

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE CONNECTORS ABOVE

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M2551A	5-1/4" FUJITSU DS/DD 360K	**$89.95**
M2553K	5-1/4" FUJITSU DS/HD 1.2M	**$119.95**
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N-MD2D	BOX OF 10 5-1/4" 360K DS/DD	**$6.95**
N-MD2H	BOX OF 10 5-1/4" 1.2 MB DS/HD	**$13.95**
N-3.5DS	BOX OF 10 3-1/2" 720K DS/DD	**$16.95**
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N-MD2DBULK	360K DS/DD (MIN. 50 DISKS)	**EA. 49¢**

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FD-ARAIL	MTG. RAILS FOR AT COMPATIBLE	**$2.95**
FD-55FP	BEIGE FACEPLATE FOR TEAC DRIVES	**$2.95**
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FD-5Y	Y-POWER ADAPTOR FOR DRIVES	**$2.95**

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30MB RLL	ST-238	65 ms	Half	$249	-	$299	-	$389
40MB	ST-251	40 ms	Half	$379	$419	-	$489	-
40MB	ST-251-1	28 ms	Half	$469	$509	-	$579	-
60MB RLL	ST-277	40 ms	Half	$449	-	$499	-	$589
30MB	ST-4038	40 ms	Full	$559	$603	-	$659	-
80MB	ST-4096	28 ms	Full	$629	-	-	$739	-

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SINGLE SLOT CONTROL OF 4 FLOPPIES
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ADD VERSATILITY AND CAPACITY TO YOUR XT
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- ALLOWS DATA TO FLOW FREELY FROM XT'S TO AT'S

MCT-FDC-1.2

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- SUPPORTS 16 DRIVE SIZES INCLUDING 10,20,30 & 40 MB
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TRANSFER DATA 50% FASTER
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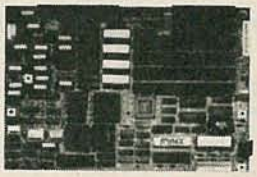

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#29-260

VCR Battery Pack

- Fits many RCA and Panasonic portable VCRs
- Replaces RCA battery #149722 and Panasonic #LCR1812 ■ Manufactured by Hitachi ■ 12V, 1.9Ah
- Used in Panasonic models #NV8410, #PV3100, #PV3200, #PV4510 and others

See pages 73-84 of Catalog #19 for more VCR parts and accessories

#20-220

Circuit Cooler

- Cools circuits instantly for rapid location of heat related problems ■ Will not leave residue

For more chemicals see pages 24-27 of Catalog #19

RS-232 Port Switches

For more port switches and computer equipment see pages 40-52

Two-Way
#83-605

Four-Way
#83-600

PYLE
15" Polypropylene Woofer

- Poly cone with polyfoam surround ■ Display packaged ■ Made in USA ■ Magnet weight: 60 oz. ■ Power handling: RMS/peak 100W/144W ■ Frequency response: 20-3500Hz

For more speakers and accessories see pages 94-109 of Catalog #19

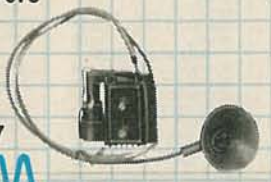
#55-445

Sharp Type Flyback

#33-975

- Popular flyback for Sharp color TVs
- Replaces Sharp #RTRNF0009

For more flybacks see page 57 of Catalog #19



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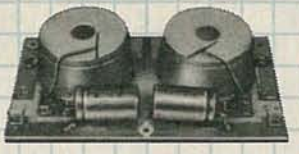


PYLE
Subwoofer Crossover

- To be used with one dual voice coil subwoofer or two single voice coil woofers ■ Crossover frequencies: Rolls off at 100Hz at 12dB per octave ■ 4ohm impedance ■ 150 watt RMS continuous — 220 watt peak ■ 4" (W) x 7" (L) x 1⅜" (D)

#50-220

TENMA
Soldering Station

#21-147

- Adjustable temperature range of 150° - 420° C (300° - 790° F) ■ Grounded tip for soldering static sensitive devices ■ Overheat protection with closed loop temperature control ■ Replaceable iron clad tip

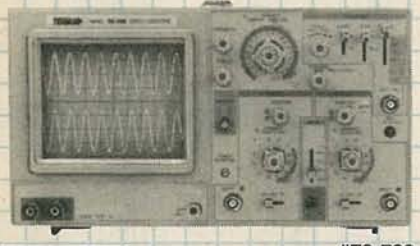
Catalog #19 contains other soldering equipment on pages 37-39

#75-010

Replacement Magnetron

- A quality replacement for many magnetrons on the market ■ Intended for use in microwaves of 600-700 watts, 950 watts maximum

Catalog #19 contains additional microwave oven parts on page 125



For more specifications and test equipment see pages 8-23 in Catalog #19

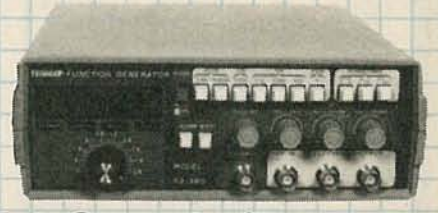
#72-720

TENMA
Dual Trace 20MHz Oscilloscope with Component Tester

This oscilloscope combines quality craftsmanship with ease and flexibility of operation. Specifications include 5mV/div. sensitivity and a frequency characteristic response with a smooth roll-off exceeding 20MHz.

The component tester is a valuable troubleshooting tool that gives a visual display of the characteristics, value and condition of resistors, capacitors, inductors and diodes; in or out of circuit.

#72-380



TENMA
Digital Function Generator/Frequency Counter

- A versatile function generator with a 10MHz frequency counter, to be used either externally or to measure the output frequency of the generator ■ Produces square, sine, triangle, ramp and pulse waveforms ■ Six digit frequency counter is switchable for internal or external use

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Part No.		Price
UPD70108-5	(5MHz) V20 Chip	$ 7.49
UPD70108-8	(8MHz) V20 Chip	$10.75
UPD70108-10	(10MHz) V20 Chip	$12.95
UPD70116-8	(8MHz) V30 Chip	$ 9.95
UPD70116-10	(10MHz) V30 Chip	$16.95

7400

Part No.	1-9	10+	Part No.	1-9	10+
7400	.29	.19	7485	.69	.59
7402	.29	.19	7486	.45	.35
7404	.29	.19	7489	1.95	1.85
7405	.35	.25	7490	.49	.39
7406	.39	.29	7493	.45	.35
7407	.39	.29	74121	.39	.29
7408	.35	.25	74123	.49	.39
7410	.29	.19	74125	.55	.45
7414	.49	.39	74126	.55	.45
7416	.35	.25	74143	4.95	4.85
7417	.35	.25	74150	1.35	1.25
7420	.29	.19	74154	1.35	1.25
7430	.29	.19	74158	1.49	1.39
7432	.39	.29	74173	.79	.69
7438	.39	.29	74174	.59	.49
7442	.49	.39	74175	.59	.49
7445	.79	.69	74176	.79	.69
7446	.89	.79	74181	1.95	1.85
7447	.89	.79	74189	1.95	1.85
7448	1.95	1.85	74193	.79	.69
7472	.39	.29	74198	1.85	1.75
7473	.39	.29	74221	.99	.89
7474	.39	.29	74273	1.95	1.85
7475	.49	.39	74365	.59	.49
7476	.45	.35	74367	.59	.49

74LS

74LS00	.26	.16	74LS165	.75	.65
74LS02	.28	.18	74LS166	.89	.79
74LS04	.28	.18	74LS173	.39	.29
74LS05	.28	.18	74LS174	.39	.29
74LS06	.59	.49	74LS175	.39	.29
74LS07	.59	.49	74LS189	3.95	3.85
74LS08	.28	.18	74LS191	.59	.49
74LS10	.26	.16	74LS193	.69	.59
74LS14	.49	.39	74LS221	.69	.59
74LS27	.35	.25	74LS240	.59	.49
74LS30	.28	.18	74LS243	.69	.59
74LS32	.28	.18	74LS244	.69	.59
74LS42	.49	.39	74LS245	.79	.69
74LS47	.89	.79	74LS259	.99	.89
74LS73	.39	.29	74LS273	.89	.79
74LS74	.35	.25	74LS279	.49	.39
74LS75	.39	.29	74LS322	3.49	3.39
74LS76	.39	.29	74LS365	.49	.39
74LS85	.59	.49	74LS366	.49	.39
74LS86	.29	.19	74LS367	.49	.39
74LS90	.49	.39	74LS368	.49	.39
74LS93	.49	.39	74LS373	.79	.69
74LS123	.49	.39	74LS374	.79	.69
74LS125	.49	.39	74LS393	.89	.79
74LS138	.49	.39	74LS590	5.95	5.85
74LS139	.49	.39	74LS624	1.95	1.85
74LS154	1.19	1.09	74LS629	2.49	2.39
74LS157	.45	.35	74LS640	1.09	.99
74LS158	.39	.29	74LS645	1.09	.99
74LS163	.49	.39	74LS670	.99	.89
74LS164	.59	.49	74LS688	2.39	2.29

74S/PROMS*

74S00	.25	74S188*	1.49
74S04	.25	74S189	1.49
74S08	.29	74S196	1.49
74S10	.25	74S240	1.39
74S32	.29	74S244	1.19
74S74	.29	74S253	.59
74S85	.89	74S287*	1.49
74S86	.29	74S288*	1.49
74S124	1.49	74S373	1.49
74S174	.49	74S374	1.49
74S175	.49	74S472*	2.95

74F

74F00	.25	74F139	.59
74F04	.25	74F157	.59
74F08	.25	74F193	2.95
74F10	.25	74F240	.69
74F32	.25	74F244	.69
74F74	.29	74F253	.59
74F86	.39	74F373	.79
74F138	.59	74F374	.79

CD—CMOS

CD4001	.19	CD4076	.59
CD4008	.59	CD4081	.22
CD4011	.19	CD4082	.22
CD4013	.29	CD4093	.35
CD4016	.29	CD4094	.89
CD4017	.49	CD40103	1.49
CD4018	.59	CD40107	.49
CD4020	.59	CD4510	.69
CD4024	.45	CD4511	.69
CD4027	.35	CD4520	.75
CD4030	.35	CD4522	.79
CD4040	.65	CD4538	.79
CD4049	.29	CD4541	.89
CD4050	.29	CD4543	.79
CD4051	.59	CD4553	3.95
CD4052	.59	CD4555	.79
CD4053	.59	CD4559	7.95
CD4063	1.49	CD4566	1.95
CD4066	.29	CD4583	.59
CD4067	1.49	CD4584	.49
CD4069	.19	CD4585	.69
CD4070	.25	MC14411P	7.95
CD4071	.22	MC14490P	4.49
CD4072	.22		

MICROPROCESSOR COMPONENTS

MISCELLANEOUS CHIPS

Part No.	Price
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WD9216	3.95

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Z80	1.19
Z80-CTC	1.29
Z80-PIO	1.29
Z80A	1.29
Z80A-CTC	1.65
Z80A-DART	4.95
Z80A-PIO	1.89
Z80A-SIO/0	3.95
Z80B	2.75
Z80B-CTC	3.95
Z80B-PIO	3.95

6500/6800/68000 SER.

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

6500/6800/68000 Cont.

6845	2.75
6850	1.95
6852	.75
6854	1.19
MC68000L8	9.95
MC68000L10	11.95
MC68010L10	49.95
MC68020RC12B	99.95

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8031	3.95
80C31	9.95
8035	1.49
8073	6.95
8080A	2.25
8085A	2.49
8086	3.95
8086-2	6.95
8087 (5MHz)	99.95
8087-1 (10MHz)	229.95
8087-2 (8MHz)	159.95
8088	4.95
8088-2	6.95
8116	4.95
8155	2.49
8155-2	3.49
8156	2.95
8203	6.95
8212	2.29
8224	2.25

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8228	1.95
8237-5	4.25
8243	1.75
8250A	4.95
8250B (For IBM)	5.95
8251A	1.69
8253-5	1.95
8254	3.95
8255A-5	2.95
8259-5	2.25
8272	3.95
8279-5	2.95
8741	9.95
8742	19.95
8748 (25V)	7.95
8748H (HMOS) (21V)	9.95
8749	9.95
8751 (3.5-8MHz)	39.95
8751H (3.5-12MHz)	44.95
8755	13.95

DATA ACQUISITION

ADC0804LCN	2.79
ADC0808CCN	5.95
ADC0809CCN	3.69
ADC1205CCJ-1	19.95
DAC0808LCN	1.75
DAC1008LCN	5.95
AY-3-1015D	4.95
AY-5-1013A	1.95

MICROPROCESSOR SALE!

Part No.		Price
8052AHBASIC	CPU w/BASIC Interpreter	$24.95
MC68000P12	16-Bit MPU (12MHz)	$12.95
MC68701	8-Bit EPROM Microcomputer	$14.95
MC68705P3S	8-Bit EPROM Microcomputer	$9.95
MC68705U3S	8-Bit EPROM Microcomputer	$10.95
80286-10	16-Bit Hi Performance MPU	$69.95
80287-8	Math Co-processor (8MHz)	$244.95
80287-10	Math Co-processor (10MHz)	$309.95
80387-16	Math Co-proc. (16MHz) GRID ARRAY	$474.95
80387-20	Math Co-proc. (20MHz) GRID ARRAY	$749.95

DYNAMIC RAMS

Part No.			Price
*4116-15	16,384 x 1	(150ns)	1.39
4128-20	131,072 x 1	(200ns) (Piggyback)	3.25
*4164-100	65,536 x 1	(100ns)	3.49
*4164-120	65,536 x 1	(120ns)	2.95
*4164-150	65,536 x 1	(150ns)	2.59
*4164-200	65,536 x 1	(200ns)	1.75
*TMS4416-12	16,384 x 4	(120ns)	7.75
*41256-80	262,144 x 1	(80ns)	13.49
*41256-100	262,144 x 1	(100ns)	12.49
*41256-120	262,144 x 1	(120ns)	11.95
*41256-150	262,144 x 1	(150ns)	11.49
*41464-15	65,536 x 4	(150ns) (4464)	14.75
*511000P-10	1,048,576 x 1	(100ns) 1 Meg	39.95
*514256P-10	262,144 x 4	(100ns) 1 Meg	59.95

STATIC RAMS

*2016-12	2048 x 8	(120ns)	4.49
2018-45	2048 x 8	(45ns)	6.95
2102	1024 x 1	(350ns)	.89
2114N	1024 x 4	(450ns)	.99
2114N-2L	1024 x 4	(200ns) Low Power	1.49
21C14	1024 x 4	(200ns) (CMOS)	.49
5101	256 x 4	(450ns) (CMOS)	2.95
*6116P-3	2048 x 8	(150ns) (CMOS)	4.95
*6116LP-3	2048 x 8	(150ns) LP CMOS	5.99
*6264LP-12	8192 x 8	(120ns) LP CMOS	10.49
*6264P-15	8192 x 8	(150ns) (CMOS)	9.95
*6264LP-15	8192 x 8	(150ns) LP CMOS	10.25
6514	1024 x 4	(350ns) (CMOS)	3.75
*43256-15L	32,768 x 8	(150ns) Low Power	16.49
*62256LP-12	32,768 x 8	(120ns) LP CMOS	17.95

EPROMS

TMS2516	2048 x 8	(450ns) 25V	6.95
TMS2532	4096 x 8	(450ns) 25V	5.95
TMS2532A	4096 x 8	(450ns) 21V	4.49
TMS2564	8192 x 8	(450ns) 25V	6.95
TMS2716	2048 x 8	(450ns) 3 Voltage	6.95
1702A	256 x 8	(1µs)	4.95
2708	1024 x 8	(450ns)	6.95
2716	2048 x 8	(450ns) 25V	3.75
2716-1	2048 x 8	(350ns) 25V	4.25
27C16	2048 x 8	(450ns) 25V (CMOS)	4.25
2732	4096 x 8	(450ns) 25V	3.95
2732A-20	4096 x 8	(200ns) 21V	4.25
2732A-25	4096 x 8	(250ns) 21V	3.95
27C32	4096 x 8	(450ns) 25V (CMOS)	4.95
2764-20	8192 x 8	(200ns) 21V	4.25
2764-25	8192 x 8	(250ns) 21V	3.59
2764A-25	8192 x 8	(250ns) 12.5V	3.69
2764-45	8192 x 8	(450ns) 21V	3.39
27C64-15	8192 x 8	(150ns) 12.5V (CMOS)	5.95
27128-20	16,384 x 8	(200ns) 21V	6.95
27128-25	16,384 x 8	(250ns) 21V	5.95
27128A-25	16,384 x 8	(250ns) 12.5V	5.25
27C128-25	16,384 x 8	(250ns) 21V (CMOS)	5.95
27256-20	32,768 x 8	(200ns) 12.5V	6.95
27256-25	32,768 x 8	(250ns) 12.5V	5.49
27C256-25	32,768 x 8	(250ns) 12.5V (CMOS)	6.25
27512-20	65,536 x 8	(200ns) 12.5V	10.95
27512-25	65,536 x 8	(250ns) 12.5V	9.95

EEPROMS

2816A-25	2048 x 8	(250ns) 5V Read/Write	6.25
2817A	2048 x 8	(350ns) 5V Read/Write	7.95
2865A-30	8192 x 8	(300ns) 5V Read/Write	9.95
52B13 (21V)	2048 x 8	(350ns) 5V Read Only	1.49

COMMODORE CHIPS

Part No.	Price
LAG570	9.95
WD1770	8.95
SI3052P	1.25
6504A	1.19
6507	2.95
6510	12.95
6522	2.95
6525	4.95
6526	14.95
6532	5.49
6545-1	3.95
6560	10.95
6567	24.95
6569	15.95
6572	10.95
6581 (12V)	12.95
6582 (9V)	14.95
8502	7.95
8564	4.95
8566	9.95
8701	9.95
8721	14.95
8722	13.95
*251104-04	12.95
310654-05	9.95
318018-03	12.95
318019-03	12.95
318020-04	12.95
325302-01	14.95
325572-01	17.95
*82S100PLA**	15.95
901225-01	15.95
901226-01	15.95
901227-03	15.95
901229-05	15.95

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

74C/CMOS

74C00	.29	74C174	.49
74C02	.29	74C175	.49
74C04	.29	74C221	1.79
74C08	.29	74C240	1.19
74C10	.19	74C244	1.79
74C14	.49	74C373	1.95
74C32	.29	74C374	1.95
74C74	.49	74C912	7.95
74C85	1.49	74C915	1.39
74C86	.29	74C920	4.95
74C89	3.95	74C921	4.95
74C90	.99	74C922	3.95
74C154	2.95	74C923	3.95
74C173	.59	74C925	5.49

MISC. COMPONENTS

TANTALUM CAPACITORS

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

POTENTIOMETERS

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

43PXX ¾ Watt, 15 Turn .99 | 63PXX ½ Watt, 1 Turn .89

TRANSISTORS AND DIODES

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

SWITCHES

JMT123 SPDT, On-On 1.19 | 206-8 SPDT, 16-pin DIP 1.25

MPC121 SPDT, On-Off-On 1.19 | MS102 SPST, Momentary .39

D-SUB CONNECTORS

DB25P Male, 25-pin .69 | DB25S Female, 25-pin .75

LEDS

XC556R T1¾, Red	.13	XC556Y T1¾, Yellow	.17
XC556G T1¾, Green	.17	XC556C T1¾, Clear/Red	.17

IC SOCKETS

Low Profile		Wire Wrap (Gold) Level #2	
8LP	.11	8WW	.59
14LP	.12	14WW	.65
16LP	.13	16WW	.69
24LP	.25	24WW	1.19
28LP	.27	28WW	1.39
40LP	.29	40WW	1.89

Soldertail Standard (Gold & Tin) & Header Plug Sockets Also Available

74HC HI-SPEED CMOS

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

74HCT — CMOS TTL

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

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DS0026CN	1.95	LM1458N	.35
TL074CN	.99	LM1488N	.45
TL084CN	.89	DS14C88N (CMOS)	1.19
AF100-1CN	8.95	LM1489N	.45
LM307N	.39	DS14C89N (CMOS)	1.19
LM309K	1.25	LM1496N	.69
LM311N	.39	MC1648P	2.95
LM317T	.65	LM1871N	1.95
LM318N	.99	LM1872N	1.95
LM319N	1.29	LM1896N-1	1.49
LM323K	3.49	ULN2003A	.75
LM324N	.35	XR2206	3.95
LM338K	4.49	XR2211	2.95
LM339N	.39	XR2243	1.95
LM347N	1.49	26LS29	2.95
LM348N	.69	26LS31	.99
LM350T	2.95	26LS32	.99
LF351N	.39	26LS33	1.49
LM353N	.49	LM2901N	.25
LF355N	.79	LM2907N	1.29
LF356N	.79	LM2917N (8 pin)	1.79
LF357N	.89	MC3419CL	3.95
LM358N	.49	MC3446N	.99
LM360N	1.95	MC3450P	.49
LM361N	1.49	MC3470P	1.19
LM380N-8	.99	MC3471P	.99
LM386N-3	.89	MC3479P	3.95
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LM393N	.39	MC3487P	.99
LM399H	3.49	LM3900N	.49
LF411CN	.79	LM3905N	1.25
TL497ACN	1.49	LM3909N	.89
NE540H (C540H)	.99	LM3914N	1.79
NE555V	.29	LM3916N	1.49
XRL555	.59	NE5532	.69
LM556N	.45	NE5534	.99
NE558N	.79	7805K (LM340K-5)	1.39
LM565N	.89	7812K (LM340K-12)	1.39
LM567V	.75	7815K (LM340K-15)	1.59
NE592N	.75	7805T (LM340T-5)	.45
LM741CN	.29	7812T (LM340T-12)	.45
LM747CN	.49	7815T (LM340T-15)	.45
MC1350P	.89	7905K (LM320K-5)	1.49
MC1377P	2.29	7905T (LM320T-5)	.49
MC1398P	4.95	75472	.89
LM1414N	.99	75477	1.29
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Jameco IBM PC/XT/AT Compatible Computer Cases

JE1019 Pictured

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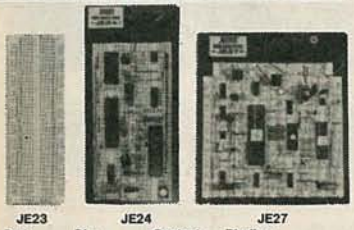

JE23 JE24 JE27

Part No.	Dim. L" x W"	Contact Points	Binding Posts	Price
JE20	6½ x ¾	200	0	$ 2.95
JE21	3¼ x 2⅛	400	0	$ 4.95
JE22	6½ x 1⅜	630	0	$ 5.95
JE23	6½ x 2⅛	830	0	$ 7.95
JE24	6½ x 3⅛	1,360	2	$14.95
JE25	6½ x 4¼	1,660	3	$22.95
JE26	6⅞ x 5¾	2,390	4	$27.95
JE27	7¼ x 7½	3,220	4	$37.95

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JE1001	4.77/8MHz Turbo Motherboard (Zero-K RAM — includes AMI BIOS ROM)	$89.95
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JE1015	XT/AT Compatible Keyboard	59.95
JE1020	5.25" DSDD Disk Drive (Black Bezel)	89.95
JE1030	150 Watt Power Supply	59.95
JE1040	360K Floppy Controller	29.95
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CTX2410

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TM5155. . . . . $549.95

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JEVGA. $649.95

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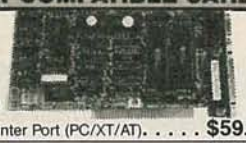
Graphic Display Cards — MGA, CGA or EGA!



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JE1050	Mono Graphics Card w/Printer Port (PC/XT/AT)	$59.95
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JE1062	RS232 Serial Half Card (AT)	$34.95
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JE1081	2MB of expanded or extended memory (zero-K on-board) (AT)	$119.95
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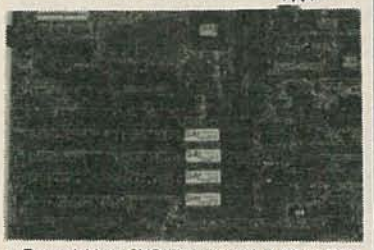
JE1043	360K/720K/1.2MB/1.44MB Floppy Disk Cont. (PC/XT/AT)	$49.95
JE1044	360K Floppy/Hard Disk Controller Card (PC/XT)	$129.95
JE1045	360K/720K/1.2MB/1.44MB Floppy/Hard Disk Controller Card (AT)	$149.95

COMPUTER PERIPHERALS

AMI 80386 Motherboards



- Expandable to 2MB (Zero-K incl.) of 32-bit RAM with expansion board (included) • Expand an additional 8MB using the JE3030 (below, Zero-K incl.) • XT footprint-AT compatible • 80387-16/20 capability • Built-in set-up and diagnostics • Includes AMI BIOS ROMs • One-year warranty

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JE3025	20MHz 80386 (AT)	$1699.95
JE3030	8MB (Zero-K) Daughterboard	$299.95

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ST225XT (Pictured)

ST225	20MB Drive only (PC/XT/AT)	$224.95
ST225XT	20MB w/Controller (PC/XT)	$269.95
ST225AT	20MB w/Controller (AT)	$339.95
ST238	30MB Drive only (PC/XT/AT)	$249.95
ST238XT	30MB w/Controller (PC/XT)	$299.95
ST238AT	30MB w/Controller (AT)	$389.95
ST251	40MB Drive only (PC/XT/AT)	$429.95
ST251XT	40MB w/Cont. Card (PC/XT)	$469.95
ST251AT	40MB w/Controller Card (AT)	$539.95
ST251-1	40MB Fast 28ms (Drive only)	$499.95
ST277	60MB Drive only (PC/XT/AT)	$499.95
ST277XT	60MB w/Controller (PC/XT)	$549.95
ST277AT	60MB w/Controller Card (AT)	$639.95

40MB Tape Back-Up for IBM PC/XT/AT

DJ10	40MB Back-Up and Tape	$349.95
TB40	40MB Tape Cartridge	$24.95

Jameco 5.25" PC/XT & AT Compatible Disk Drives

JE1022 (Pictured)

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JE1021	360K Beige Bzl. (PC/XT/AT)	$ 89.95
JE1022	1.2MB Beige Bzl. (PC/XT/AT)	$109.95

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10Mb *(IBM® Compatible)*

Mfr – NEC #D5124

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20Mb *(ST225 Compatible)*

Mfr – Olivetti #EM5520/2 ***Tested—Like New!***

Item #20060 *New* – **$159.00**

5¼" FULL-HEIGHT DISK DRIVE *(IBM® Compat.)*

48 TPI,40 Track, Double Side/Double Density

Tandon #TM100-2 or equiv.

Item #7928 **$79.00** New

2 for **$150.00** New

3½" MICROFLOPPY DISK DRIVE

1 Mb (unformatted), 135 TPI, 3 ms. access time. Power requirements: +12, +5 volts. Removed from operational computers — ***TESTED — LIKE NEW!***

Mfr — NEC, model FD1035

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115 CFM MUFFIN®-TYPE FANS

115VAC; 60Hz.; 21W.; 28A.; 3100 RPM; 5-blade model; aluminum housing. Can be mtd for blowing or exhaust. Dimen.: 4 11/16" sq. x 1½" D. Mfr: Howard Industries or equiv.

Item #1864 *New* – **$9.95**

W/Adjustable Speed Control

Item #20611 **$12.95**

27VDC MINI FAN... (12VDC)

12VDC; .20A.; brushless fan motor. Can be mtd. for cooling or exhaust. 5 plastic blades; aluminum housing. Dim.: 3⅛" sq. x 1½" deep. ,Mfr – FlowMax #3115PL-04W-B30-90

Item #16540 *New* – **$12.95**

MAGNIFYING LAMP

Multi-position, 30", completely adjustable swing arm with 3-way metal C-clamp. Has 4" diopter magnifying lens, w/ruler. Porcelain lamp socket & on/off switch; uses up to a 60W bulb. Color: beige. UL listed.

Item #13136 *New* – **$29.95**

NICAD BATTERY PACKS *(Rechargeable)*

"AA" Cells

12V @ 450ma

Contains 10 "AA" cells, connected in series. Recharge rate: 45ma., 16–18 hrs. Case w/tab output connex. Dim.: 2 1/16" x 2¼" x 2 15/16" Mfr – GE #123233

Item #5443 **$5.95** RFE

"Sub C" Cells

12V @ 1.2Ah.

Consists of 10 "Sub C" cells. Connected in series. Case w/tab output connex. Recharge rate: 100 ma. for 14–16 hrs. Dim.: 4½" x 1¾" x 1⅞" Mfr – GE or equiv.

Item #19677 **$9.95** RFE

"C" Cells

7.2V @ 1.25Ah.

Consists of 6 "C" cells. Connected in series. Recharge rate: 80–100 ma. for 16 hrs. Dim.: 6" x 1⅞" x 1". Major Mfrs.

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EXTERNAL DISK DRIVE CHASSIS

With 60W power supply fan cooled).

Can accommodate any of the following:

2 full-ht. drives .....*ADC* Item #7928

2 floppy drives .....#10005/17171

1 hard drive .....#19704

& 1 floppy .....#10005

Input: 115/230V, 50/60 Hz. Orig. for Burroughs computer. Dim.: 11"W x 8"H x 12"D

Item #14541 **$59.50**

STEPPING MOTORS for ROBOTICS...

Precision steppers with increments from 1 to 7.5°. Speeds up to 5,000 steps.

Fig. 1

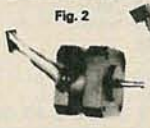

Fig. 2

Fig. 3

Item No.	Step Angle	DC Voltage	Torque oz/in.	Type	Mfr. & Part No.	Dimensions	Fig.	Price
5275	1.8°	1.8	72	PM 2Ø	Superior MO61-FF-6201B	2"L x 2¼"dia. x 2¼"H	1	$19.95 ea. 2 for $37.50
7630	1.8°	3.0	200	PM	Superior MO92-FT-402	2"L x 2¼"dia. x 2¼"H	1	$34.50 ea. 2 for $59.50
16410	1.8°	12.0	700*	PM	Applied Motion 4017-839	1½"sq. x 1¼"D	2	$9.95 ea. 2 for $14.95
16406	3.6°	12.0	700*	PM	Applied Motion 4017-838	1½"sq. x 1¼"D	2	$9.95 ea. 2 for $14.95
7014	7.5°	12.0	900*	PM	Mitsubishi 55SI-25DAYA	2⅛"sq. x 1"D	3	$10.95 ea. 2 for $19.95

*Grams per Cm.

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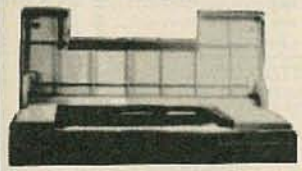

Print speed: 120 CPS; paper width: 8½". 80/132 columns/line. With RS-232 IBM serial interface. Operates on 115/230V, 50/60Hz. **Hewlett Packard #HP2671A**

Item #19705 **$79.00**

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NEON TRANSFORMER

(Hi-Voltage)

7300 VAC @ 5 Ma.

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75-Key, 8-Bit, Serial Output

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***ADAM*/*COLECOVISION* GAME CONTROLLERS...**

Can also be used w/Atari!

Set of 4...

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Incl. Smart Basic, Buck Rogers & blank cassette. Item #7786

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Item No.	Output Voltages (DC) +5V	+12V	-12V	+24V	Mfr. & Part No.	Dimensions (L x W x H)	Price
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17897*	8.0	2.0	1.5		Power Systems #11627AY52021	8½" x 5" x 2½"	24.95
17223	4.0	.8	.2		Power Systems #1556	8⅝" x 5½" x 2"	19.95
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*Mounted on base

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EXPANSION MODULE #2

Play arcade quality driving & racing games on your *ColecoVision*. Incl. ***Turbo*** cartridge.

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Gives you indiv. control of 4+ on-screen players. Includes ***Baseball*** cartridge.

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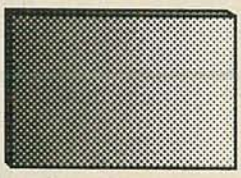

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20	7353	.18
22	16875	.19
24	1230	.20
28	12865	.22
40	7351	.30
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2114-150	1,024 x 4	1.25	6116LP-4	2,048 x 8	4.00
2114-200	1,024 x 4	.95	6264LP-12	8,192 x 8	10.50
2114L-2	1,024 x 4	1.00	6264LP-15	8,192 x 8	10.25
2148-55	1,024 x 4	3.49	6264LP-20	8,192 x 8	9.75
2149	1,024 x 4	2.49	62256LP-12	32,768 x 8	20.95
2167S-55	16,384 x 1	2.00	62256LP-15	32,768 x 8	19.95
MK4027N-4	4,096 x 1	2.00	6514	1,024 x 4	3.50
5101	256 x 4	4.95			

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4116-200	16,384 x 1	.69	4416-120	16,384 x 4	10.00
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41256	262,144 x 1	15.00	4464-15	65,536 x 4	18.95
41464	64,536 x 4	18.95	511000P-10	1,048,576 x 1	39.95
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4165-200	65,536 x 1	1.50	6665	65,536 x 1	1.50

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2708	1,024 x 8	4.50	27C128-25	16,384 x 8	6.95
27L08	1,024 x 8	7.50	27128-30	16,384 x 8	5.45
2716	2,048 x 8	3.75	27256-25	32,768 x 8	5.95
27C16	2,048 x 8	5.49	27C256-25	32,768 x 8	7.95
2732	4,096 x 8	3.95	27512-25	65,536 x 8	11.75
27C32	4,096 x 8	5.95	27C512	65,536 x 8	14.95
2732-35	4,096 x 8	4.45	68764	8,192 x 8	15.95
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3.6864	13501	14.31818	7359
4.0	7045	16.0	13425
4.32	13041	18.0	13617
4.9152	13666	18.432	19332
5.0	13043	19.6608	12112
5.0688	6786	20.0	12360
6.0	12362	24.0	14117
6.144	13226	32.768	13911
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8.0	1957	64.0	20093
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4.908	12118	18.432	13227
4.9152	9419	20.0	17262
5.0	10266	20.43468	12117
6.0	12113	22.2912	7357
7.0	12406	24.0	18005
7.3728	10181	28.0	18262
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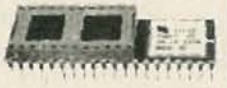

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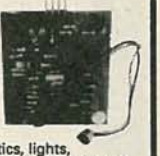

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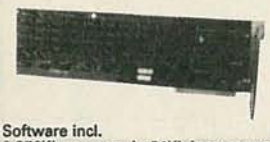

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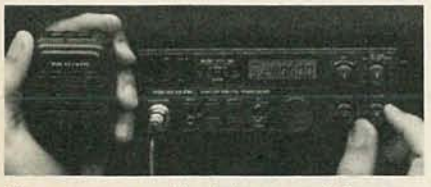

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