

# NUTS & VOLTS

M A G A Z I N E



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VOL. 17 NO. 7  
JULY 1996

*Exploring Electronics And Technology For The Hobbyist And Professional*

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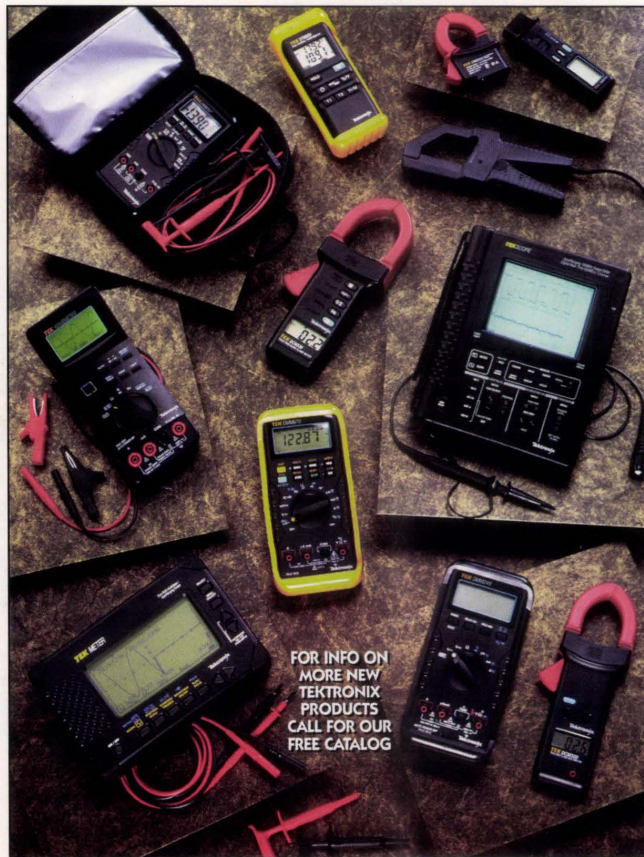
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- Verifying product specifications for manufacturing testing.
- Calibrating and servicing electronic equipment.



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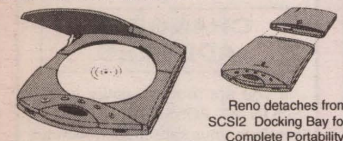
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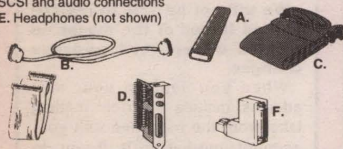
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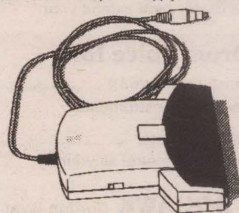


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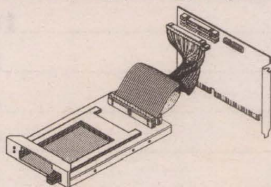
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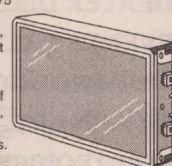
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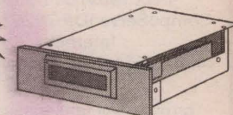
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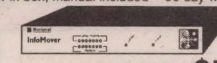
- Matsushita M-A101BUS CCD Color CCD-Camera
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- Servo-controlled mechanical iris for auto exposure, surprisingly good picture!
- Made by Matsushita for IBM Videoconferencing System
- Unit measures under 5" long - 90-day warranty, new in box!



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## Network Hub for Less

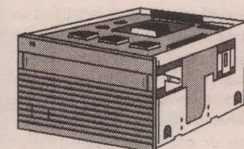
- National Semiconductor's "InfoMover"
- 6-port 10BaseT Twisted Pair Ethernet Hub
- Measures 9" x 6" x 1.5"
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All submissions should be on 5-1/4 or 3-1/2 inch diskettes and include hard copy as well. If return of materials is requested, include a SASE with your submission.

Deadlines should be discussed in advance with the editor, but generally all material should be submitted by the 1st of the month for the next month's issue.

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# reader FeedBack

Dear Nuts & Volts:

I would like to comment on Dave Dage's "Acoustically Coupled DTMF Receiver" project, Apr. '96 p. 41.

If someone decided to "modify the program performing the task," as suggested, to include all 16-tone combinations, it would not work properly. The hardware is not designed to cater for the "D" or 0000 case. Since the game port is looking for a change from zero to something in its upper four bits, the "D" is ignored. The change from zero to nothing does not register.

The Digit Valid output "Std. pin 15" must be included, via a seventh cable core, into one of the lower four-bit port inputs, going from Vss to Vdd.

Now reprogramming can work! IF VALUE = 0 THEN PRINT "D"; (cont) IF VALUE = 13 THEN PRINT "A"; (etc 14, 15).

**Dave Reynolds**  
Paddington NSW, Australia

Response:

The circuit uses the Digit Valid output to gate the four signal lines via U2 (74HC08). Monitoring the Digit Valid signal as it goes high, indicates a valid DTMF tone is present. If you can monitor Digit Valid, then you can eliminate U2; however, this will require five inputs.

Unfortunately, there are only four input pins available on the 15-pin game connector. The lower four bits which are read at the game port address are not inputs through the game connector, but are the output from four one-shot multivibrators. You can vary the time of the pulses produced by these multivibrators by feeding signals into the game connector. Digit Valid, if properly conditioned, could be used. You must initialize the multivibrator with an output to address 513 and then measure the pulse length. Depending on the pulse length, you can determine when Digit Valid is active and then capture the DTMF code. Sure, it can be done if you need that elusive "D," but why not make life easier by using the parallel port?

At the parallel port's base+1 address, there are five inputs just waiting for these DTMF codes. Connect the DTMF signals D0, D1, D2, and D4 to pins 15, 13, 12, and 10 respectively. Connect Digit Valid to pin 11. Note that pin 11 is inverted by the parallel port circuitry which translates into an active low in your program.

The only problem with the parallel port is that there is no power available at its connector. Power must be supplied

from a battery or from another connection to the computer's power supply.

**Dave Dage**  
DAGE Scientific

Dear Nuts & Volts:

I have nothing against the Zippa Dee-Doo product reported in your Jun. '96 issue. I believe any back-up system for any computer to be an essential part of today's computing world. However, the author's figures of math cost comparison are grossly inaccurate.

The back-up system that he proposes would only start to become equitable if you were backing up several gigs of memory, and then it would only be a savings with space, and not so much money.

Floppy disks aren't 75 cents a piece, but rather they start at 25 cents for used disks and 40 cents for no-name brand via many mail order magazines. This equates to approximately \$28.00 per 100 megs of memory compared to the \$20.00 per disk with the back-up unit.

This unit's \$200.00 purchase price would allow you to buy 720 megs worth of memory in floppies for the same start-up price that you would need to purchase just the unit alone without shipping or handling! After you spend \$200+ for the back-up, you then would require seven more disks at \$20.00 each, which comes to an additional \$140.00, and when added to the original \$200.00, adds up to \$340.00; this still doesn't include shipping, handling, or other possible required pieces such as cables!

\$340.00 worth of floppy disks amount to 850 floppies, or 1.2 gigs worth of memory which, by the way, take up less than a cubic foot of space! If you really want to be frugal, \$39.00 buys you a brand new 250 meg tape back-up unit from the advertisers in this magazine, and this equates pennies per meg.

Yes, back-up equipment might save some transfer time, but only if you are in the business of computer crashing. The high-transfer speed of this unit pays off only if you expect to crash every other week!

**Chris Bieher, CA**

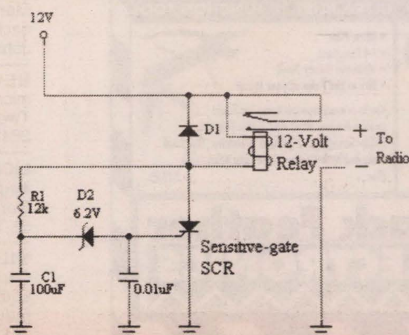
Response:

The writer and I agree on one important point: back-ups are very important. By what means and how often is, of course, a personal decision. For my part, I wouldn't do a full 1.06 gigabyte back-up onto 736 floppy

continued on page 119

## CORRECTION:

There was an error in the Delayed Action schematic in the June Electronics Q & A column. The correct circuit is shown here. Sorry for the error. — TJ Byers



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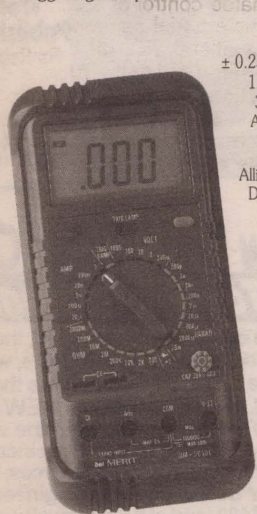
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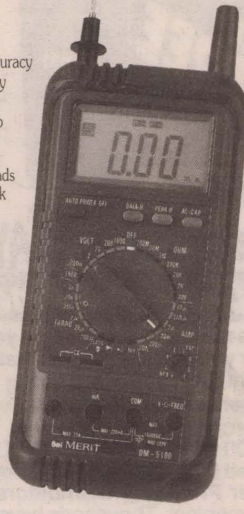
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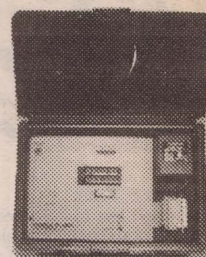
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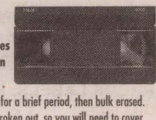
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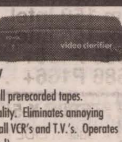
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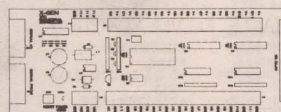
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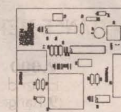
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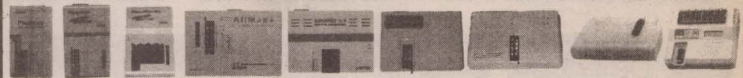
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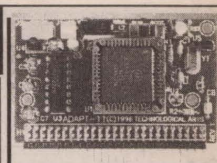
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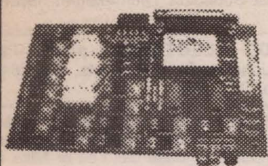
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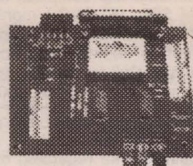
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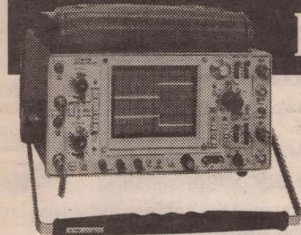
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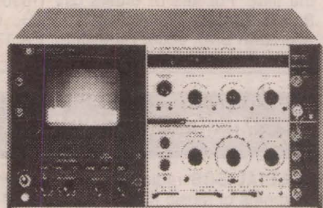
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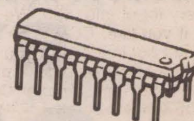
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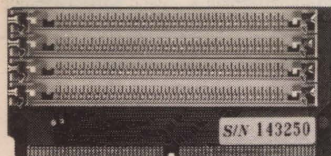
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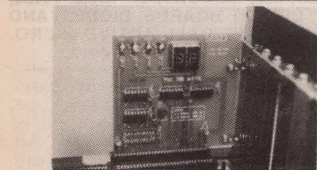
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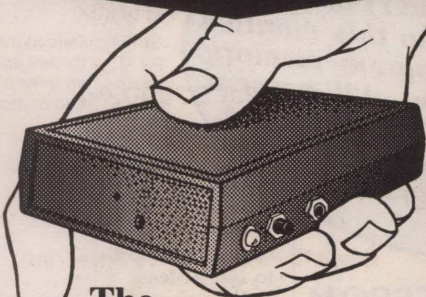
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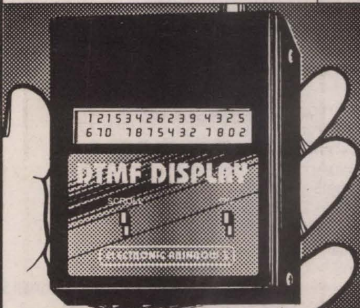


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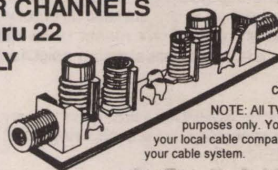
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# Stamp Applications!

Putting  
the Spotlight on  
BASIC Stamp Projects,  
Hints, and Tips

by Scott Edwards

**It ain't much, that 256 bytes of storage, but it's arguably the most important aspect of the BASIC Stamp I (BS1) or its kit brother, the Counterfeit. So this month's column will focus on program memory. After a little background, I'll present techniques for viewing and modifying data stored in memory using a free QBASIC program on your PC.**

## Exploring the BS1 EEPROM With a Homemade Browser Viewing and Modifying Long-Term Data

### A place for your programs

When you program a BS1 or Counterfeit, the host software on your PC converts your BASIC program into tokens — digital shorthand that the interpreter chip understands. It sends the tokens through the downloading cable to the Stamp, which writes them into its EEPROM (electrically erasable, programmable, read-only memory). The neat thing about EEPROMs is that they retain their contents with the power turned off, but can be reprogrammed over and over. Those virtues make EEPROMs a great place to store programs and

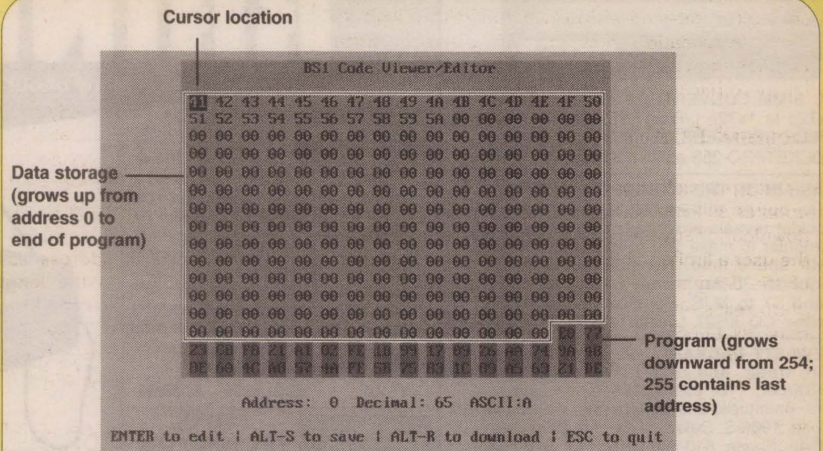
long-term data. EEPROMs eventually wear out after many programming cycles. The devices used in the Stamps are currently specified to last at least 1 million programming cycles. (Some parts of the documentation still say 100,000 programming cycles, which was true at the time they were written. Improved manufacturing processes continue to increase programming endurance, so I wouldn't be surprised to find out that they're now rated at 2 million cycles or more.)

The particular EEPROM used in the BS1 and Counterfeits is the 93LC56. It holds 256 bytes of data, enough for a BASIC program 70+ instructions long, or a mixture of instructions and data.

There are two ways to get data into the BS1's EEPROM: (1) You can tell the host program, STAMP.EXE, to store the data at the same time it

is downloading the program by using the EEPROM directive; or (2) You can have your program store data into the EEPROM using the WRITE instruction.

A quick note about the language of the previous paragraph: I called EEPROM a directive because it tells the host software what to do (put bytes into the EEPROM), but does not change the actual PBASIC program. WRITE is an instruction because it does become part of the program. Directives work at compile time, when the host computer is setting up to download your program.



**Figure 1 - Screen shot of BS1 object-code browser graphically illustrates how the Stamp stores data and programs in EEPROM.**

### Listing 1. QBASIC Browser for BS1 Object Code

\* QBASIC (PC) Program: BS\_PEEK.BAS  
\* This program allows you to view, modify, save, and download Stamp I (BS1) object-code files created by the BSAVE directive. It provides examples of techniques for reading and writing BS1 object files. To use the downloading capability, you must have the BSLOAD utility on your computer and either in the current directory, or in your PATH statement. This program is not meant to be the ultimate in object-code editing — just a suitable starting point for more elaborate programs.

```

SUBROUTINES
DECLARE FUNCTION screenSays% (searchString AS STRING)
DECLARE SUB acceptEntry ()
DECLARE SUB goHome ()
DECLARE SUB goEnd ()
DECLARE SUB saveFile ()
DECLARE SUB rightKey ()
DECLARE SUB upKey ()
DECLARE SUB downKey ()
DECLARE SUB leftKey ()
DECLARE SUB makeBkgd ()
DECLARE SUB readFile ()
DECLARE SUB updateCell (cell AS INTEGER)
DECLARE FUNCTION HEXX$ (NUM AS INTEGER)
DEFINT A-Z

CONSTANTS
CONST black = 0: CONST blue = 1
    
```

```

CONST green = 2: CONST cyan = 3
CONST red = 4: CONST magenta = 5
CONST brown = 6: CONST white = 7
CONST foreground = white
CONST background = blue
CONST lockout = red
enter$ = CHR$(13)

SCAN CODES
leftArrow$ = CHR$(0) + CHR$(75)
rightArrow$ = CHR$(0) + CHR$(77)
upArrow$ = CHR$(0) + CHR$(72)
downArrow$ = CHR$(0) + CHR$(80)
home$ = CHR$(0) + CHR$(71)
end$ = CHR$(0) + CHR$(79)
altS$ = CHR$(0) + CHR$(31)
altR$ = CHR$(0) + CHR$(19)
esc$ = CHR$(27)

GLOBAL VARIABLES
DIM SHARED code(255) AS INTEGER
DIM SHARED attribs(255) AS INTEGER
DIM SHARED cursPos AS INTEGER
DIM SHARED filename AS STRING

MAIN PROGRAM
' Load the file specified by COMMAND$ (QuickBASIC compiler only)
' or get the user to enter a file path.
start:
CLS
    
```



# Stamp Applications:

Instructions work at run time, when the program is actually running.

There are also two ways to get data back out of the EEPROM: (1) You can use the BSAVE directive to tell STAMP.EXE to create a file on your PC's disk drive containing a copy of all 256 bytes as it is preparing to download them to the EEPROM; or (2) You can use the instruction READ in your program to examine any EEPROM byte.

The Stamp programming disk includes a utility called BSLOAD that takes the file created by BSAVE (called an object file) and downloads it to a Stamp connected to the PC. It's most often used to keep a PBASIC program private; someone can download a BSAVED program to a Stamp without seeing (or messing with) the actual BASIC instructions. Application note no. 16 available from Parallax (and included with the Counterfeit) gives a bit more background on BSAVE.

## Beyond BSAVE

It's all well and good to distribute program updates as PBASIC object code and allow a user to download them with BSAVE, but how about giving the user a limited ability to customize the operation of the Stamp-based device? If your PBASIC program relies on values stored in EEPROM to determine its behavior (like the rotating message display from April's column) it's a piece of cake.

The trick is to understand how the BSAVE object file is structured, and how to read, modify, and save it using familiar PC tools. I'll demonstrate using QBASIC — the free and surprisingly modern dialect of BASIC that Microsoft has given away with every version of DOS since 5.0.

The program, called BS\_PEEK.BAS, is available from the Parallax BBS or FTP site (Sources). Figure 1 shows a sample screen from the program; Listing 1 is the program itself.

• *Loading the File.* PBASIC object code files

consist of 256 bytes of data arranged backwards with respect to the BS1's READ/WRITE addressing system. In other words, the address that you call 255 for the sake of a READ or WRITE is actually the very first byte contained in an object file. In order to preserve the BS1's addressing scheme, our QBASIC program for the PC will load the file backwards, as shown in this subroutine:

```
SUB readFile
OPEN filename FOR INPUT AS #1
FOR i = 255 TO 0 STEP -1
    code(i) = ASC(INPUT$(1, 1))
NEXT i
CLOSE #1
END SUB
```

These instructions load the file specified by the string "filename" into a 256-byte array called "code(n)." You can readily see the backwards part; the file is read one byte at a time from start to end, but it's stored into the code(n) array starting at index 255 and working down to 0.

You may remember from the PBASIC manual entry on the WRITE instruction that program memory starts at address 254 and works downward, depending on the length of the program. Address 255 contains the lowest address used by the program; everything below that may be used to store long-term data. By long-term, I mean data that doesn't go away when the power is disconnected.

Our browser program uses the value stored in address 255 to display the program memory in a different color (red) and to prevent users from changing it. The logic is the same as for a PBASIC program:

```
IF cursPos >= code(255) THEN BEEP
```

In other words, if the user has the cursor on

one of the program memory bytes and wants to change the value of that byte, the program beeps and refuses to do it. Since PBASIC is stored in variable-length tokens whose coding is not documented, no good could come of letting users mess with program memory.

• *Modifying the File.* Once the code is in memory, modifying it is just a matter of changing the content of the code(n) array. Write a value to index 0 of that array, and it'll later be written to address 0 of the Stamp's EEPROM. Simple as that.

• *Saving the File.* Since we loaded the file in reverse order, we've got to reverse it again when we save it:

```
SUB saveFile
OPEN filename FOR OUTPUT AS #1
FOR i = 255 TO 0 STEP -1
    PRINT #1, CHR$(code(i));
NEXT i
CLOSE #1
END SUB
```

The subroutine that does this is almost identical to the readFile subroutine.

• *Downloading.* Rather than ask the user to run BSLOAD on the newly saved file, I thought it would be neat to permit downloading from within the browser program. QBASIC offers a method for executing DOS commands or other programs called SHELL. The jargon is that you "shell out to DOS" to take care of some business, then return when done. All you have to do is execute the instruction SHELL, followed by a text string containing the stuff you would have typed at the DOS prompt:

```
CLS: theShell$="BSLOAD "+filename
SHELL theShell$
```

The first line above clears the screen and creates the string that SHELL is to execute; the second line carries out the instruction.

If you've ever used BSLOAD, you know that it presents a few lines of text indicating that a download is in progress, then prints a message to indicate whether or not it was successful using the terms "OK" or "ERROR." It does not tell the user what to do in the event of an ERROR. Since BSLOAD is not really designed for use by other programs, it doesn't use the DOS error-reporting method, so QBASIC isn't informed of the problem, either.

For the program to be useful by non-technical people, it should be aware of a problem with the download and suggest solutions (check cable, battery, etc.). The program gets this information the same way you would: by reading the

Continued on page 83

```
LOCATE 5, 1: INPUT "Enter pathname of BS1 object file: ", filename
IF filename = "" THEN GOTO start
continue:
CLS
makeBkgd
readFile
' Assign attributes to each screen cell (byte of data) depending on
' whether it's program or data. The last program-memory address is
' stored in location 255.
FOR i = 0 TO 255
    IF i < code(255) THEN
        attribs(i) = 0
    ELSE
        attribs(i) = 2
    END IF
NEXT i
' Display the data on the screen. Place the cursor at 0.
FOR i = 0 TO 255
    updateCell (i)
NEXT i
cursPos = 0: attribs(cursPos) = 1
updateCell (cursPos)
' Scan for keys pressed by the user and respond accordingly.
scanit:
k$ = INKEY$
IF k$ = "" THEN GOTO scanit
SELECT CASE k$
    CASE leftArrow$
        leftKey
    CASE rightArrow$
        rightKey
    CASE upArrow$
        upKey
    CASE downArrow$
        downKey
    CASE home$
        goHome
    CASE end$
        goEnd
    CASE enter$
```

```
acceptEntry
CASE alt$
    saveFile
CASE altR$
    CLS : theShell$ = "BSLOAD " + filename
    SHELL theShell$
    IF screenSays%("ERROR") THEN
        CLS : PRINT "Download failed!": PRINT
        PRINT "Check cable for correct connection."
        PRINT "Ensure that power supply is connected."
        INPUT "Press ENTER to continue.", dummy$
        GOTO continue
    ELSE
        CLS : PRINT "Download successful."
        INPUT "Press ENTER to continue.", dummy$
        GOTO continue
    END IF
CASE esc$
    END
END SELECT
GOTO scanit
```

```
SUB acceptEntry
' Let the user enter a new decimal value for cell that the
' cursor is now on. If it's in program memory, beep and
' ignore the entry.
IF cursPos >= code(255) THEN
    BEEP: EXIT SUB
ELSE
    LOCATE 22, 22: INPUT "new value (decimal): ", newVal$
    code(cursPos) = (VAL(newVal$) AND 255)
    updateCell (cursPos)
    LOCATE 22, 22: PRINT SPC(58);
END IF
END SUB
```

```
SUB downKey
' Respond to down-arrow key by moving the cursor to the next row.
attribs(cursPos) = attribs(cursPos) - 1
```



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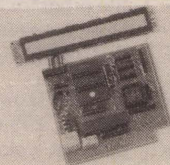
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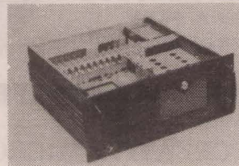
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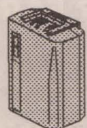
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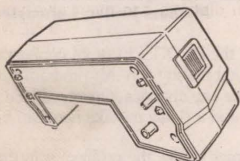
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# ELECTRONICS

## Q & A

With TJ Byers

In this column, I answer questions about all aspects of electronics, including computer hardware and software. This column doesn't displace the Tech Forum that you've grown to love and support. Instead, it will supplement it, so feel free to participate as always with your questions and answers. You can reach me on America Online at TJBYES, on the Internet at TJBYES@aol.com or by mail at *Nuts & Volts Magazine*, 430 Princland Ct., Corona, CA 91719.

### AST SixPack Plus

**Q.** I have acquired several AST SixPack Plus boards (part number 201177-004) and need to know where I can obtain technical information and/or software for them. I understand these were very popular expansion boards for the IBM PC and PC/XT. The boards are supposed to have a real-time clock on them. After doing some research at my local library, though, I found out that the board came with a floppy that had the programs "SuperSpool" (a print spooler) and "TIC" (a real-time clock manager). It is my suspicion that other programs were also included on that disk.

My problem is that AST no longer makes this product, and has no information on it. Neither does Dallas Semiconductor, the maker of the U28 real-time clock chip. How can I access and program this chip? Also, what 16-pin DIP chip plugged into U37? What 20-pin DIP chip plugged into U38? Regarding SW1 on these boards, I understand that switches 5 through 8 are for addressing, similar to the Intel Above Board. Any idea what positions 1 through 4 are for? Any information on these IBM PC-type circuit boards would be of great help.

**Daniel S. Mouradian, Countryside, IL**

**A.** My first PC had an AST SixPack Plus board, and it was a lifesaver. The board hails from 1983 and its primary purpose was to let you upgrade your system's memory. The motherboards in those days topped out at 512K (some of the earlier ones had only 64K). The SixPack Plus board, which plugged into an empty expansion slot, let you increase your RAM up to 1.5MB. The memory was added in 64K (using 2K DRAM chips) or 256K (using 32K DRAM chips) increments. SW1 positions 1 through 4 told the system how much memory was installed. (I don't have this information anymore, but you can experiment with different combinations to discover the RAM values.) Also missing from the motherboard was a parallel, serial, and game port. They came at the expense of another adapter card or two. The SixPack Plus included these I/O ports, which is the purpose of U37 and U38; U38 was for the game port chip (an extra-cost option) that I haven't seen in the catalogs for a while now. Finally, there was the matter of a real-time clock. The SixPack Plus was the first to offer one for the PC. Altogether, the board provided six functions: RAM, four I/O ports (one parallel, two serial, and one game), and a real-time clock — hence its name, SixPack.

The Plus part of the SixPack's name is the included software you mentioned. At the time, Microsoft DOS was the only game in town (Windows hadn't been invented, yet) and it was a bare bones operating system. It lacked most of the utilities we now take for granted. For example, a print spooler that takes over print jobs from applications so you can continue working while a file prints in the background was provided by SuperSpool. Today, you can find print spoolers packaged with both DOS (PRINT) and Windows. Ditto for the AST hard disk cache and I/O port utilities. In fact, the only software you need from the original SuperPak diskette is the real-time clock program. This utility, which works with most Dallas Semiconductor clock chips, can be found on the *Nuts & Volts Magazine* WEB site at <http://www.nutsvolts.com> under the name AST-CLOCK.COM.

### Car Works

**Q.** Does anyone know how to obtain the schematic and source code for the ECM (electronic control module) for a Nissan 1992 Z34?

**Lloyd Romeo, Temecula, CA**

**A.** Sure, but you're not gonna like the answer. You can buy repair manuals for virtually any car ever made from Autobound (510-521-8630). The problem is that the ECM is encapsulated, which means you can't get to its guts short of a jack hammer. If you're a DIY (do it yourself) person, take your car to a smog station and have a readout done. This will tell you whether the ECM module is good or bad. If it's bad ...

### Phony Antenna

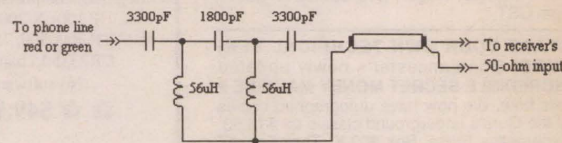
**Q.** Has anybody reverse engineered an 11-inch diameter piepan-shaped device to be placed next to an AM broadcast band radio, no connections or power, one knob tuning, which uses "mutual inductive coupling" to improve selectivity/volume by a factor of 75X? I saw it advertised in a slick catalog for \$55.00. Surely one can be built for less than \$10.00. Our problem is that we want to listen to a 250-watt AM station that's 45 miles away, but our office is on the sixth floor on the wrong side of a concrete and steel building. We have a medium quality portable (no external antenna hook-up point) and a Realistic DX-160 communications receiver. We built a passive LC circuit to put in-line with a short antenna. It helps the DX-160 some, but even wrapping the output wire around the ferrite rod antenna doesn't help the portable. I'm tired of buying off-the-shelf "black-boxes," only to discover they don't work. Does anyone have a schematic, parts list, or pub reference on this newest gadget?

**Anonymous**

**A.** The gadget you speak of is a tuned pick-up coil. Basically, it consists of a large-diameter coil of wire in parallel with a variable capacitor. The inductance of the coil and the capacitance of the capacitor are selected so that the circuit resonates at frequencies in the 640 KHz to 1600 KHz range — the frequency span of the broadcast band. Because the coil is large in diameter, it acts like an antenna, in the same way an unshielded microphone cable picks up all the noise around it. Twisting the knob connected to the variable capacitor tunes the resonant frequency to that of a desired radio station. Like all inductors, the coil radiates a strong, local magnetic field. This concentrated magnetic field is what increases the "volume" of a portable, ferrite-rod radio.

Unfortunately, I doubt this device would do you and your friends any good because of your building's location and construction. It's like trying to receive a radio station inside a tunnel. What you need is an outside antenna. Since you can't open a window and dangle a wire, I suggest you use your phone lines as an antenna. To block the ringer and voice signals, you'll need to insert a high-pass filter between the phone line and the receiver input, as shown below.

This will increase the sensitivity of your DX-160. To boost the reception of your portable, wrap several turns of 26-gauge magnet wire (you can buy small spools of magnet wire from Radio Shack, part number 278-1345) around the ferrite rod and connect it to the output of the filter through a 47-ohm resistor. While some readers may suggest using the power lines instead of the phone line, they present a shock hazard and aren't as effective as the phone line.



### All About Floppies

**Q.** I have a PC/XT dinosaur that will not recognize my old 3 1/2-inch floppy drive, nor my new (that is unused, so far) 5 1/4-inch floppy drive. Before I installed the 5 1/4-inch drive, the 3 1/2-inch drive was working. Now neither one works separately or together, although the drive's LEDs flash at boot-up. I have even tried another controller card. I just would like to get the information off the hard disk (if I can afford a 286 or better someday).

**Michael Keller, Lancaster, PA**

**A.** Unlike today's PCs, which have a built-in set-up routine, the PC/XT's EPROM configuration has to be done from a floppy disk diagnostic program. If you haven't run this program yet, do so now — but write down your current settings before you make any changes. Once you load the program, you're given a long list of items to change or verify, and a single mistake here can be disastrous.

If you have run the program and everything but the floppies works, the problem is in the way you have the data ribbon cable connected to the floppy drives. First, make sure the cable is plugged in properly and not reversed. The cable has a color stripe running along one side of the cable. The stripe is usually red, but it can be dark gray or blue. This stripe denotes pin 1 of the cable, and the cable must be plugged in with the stripe closest to the power plug. Also make sure you haven't reversed the connector on your controller card, now that you've changed it. Second, the data cable is A: and B: drive sensitive. See that twist in the cable halfway between the two drive connectors? The controller uses that twist to identify the drives. The drive A: connector is at the end of the cable and the drive B: connector is in the middle. If you switched these connectors when you installed the new drive (I've had to do it when the cable wouldn't reach), they're backwards in the eyes of the computer. Go back into your diagnostic set-up program and make the swap there, too. In other words, if you moved the 3 1/2-inch A: connector to the 5 1/4-inch drive, make that change in the EPROM configuration table. One last thought: The floppy drive cable uses the same connector as early ST506 (MFM) hard disk drives did, and to save money on inventory, some vendors would use the untwisted ST506 cable to connect the diskette drive in their single floppy systems. If your floppy drive cable doesn't have a twist, replace it with one that does. BTW, when you upgrade, target a 486 system. They're cheap and fast.

### SCSI Makes The Way

**Q.** I have a 386DX machine which has both 8- and 16-bit slots open. What kind of controller card do I need to utilize a Seagate ST2209 SCSI hard disk drive? The disk would be installed as the D: drive.

**John W. Lippert, Menomonee Falls, WI**

**A.** Just about any SCSI controller card will work. The only caveat is that it has to be an ISA card; you can't use a VL or PCI controller in your system. Now which one to buy depends on your pocketbook and future needs. If all you want to do is add a second hard disk to your system, you can buy a basic SCSI controller, like those made by Future Domain, for \$50.00 or less. If you plan on adding a sound card in the future, then I suggest a SCSI sound card, like one from Adaptec, with a built-in SCSI controller port. This saves a slot, and eliminates a lot of hardware clashes later down the road. And if you ever plan to boot the system from the SCSI, choose a SCSI controller with an on-board BIOS chip. By now, though, you're in the \$250.00 price range.

After you've picked a card, you need to set it up before plugging it in. I recommend that you don't change the IRQ and Address settings, but that you set the ID switch to 5 or 6. This allows you to add a CD-ROM or other SCSI device in the future with the least hassle. Most importantly, make sure the ST2209 is properly terminated; it should be, but if you're not sure, now is the time to check. Plug in the card, mount your drive, and connect the cables. Next you'll need to install the software driver that came with the ST2209 or SCSI controller card. The instructions will be on the disk. I doubt you'll have to make changes to your CMOS setup, but if you do, set the D: drive type to None or Not Installed; don't enter the drive's parameters into the CMOS table. A final word of advice: Be forewarned that SCSI devices aren't easy to install. There are a lot of pitfalls, so hang in there and be patient.

### Obsolete Monitors

**Q.** I have a Silicon Graphics 20-inch monitor, model CM2073A, which has four BNC connectors: R, G, B, and composite sync, that I want to use with an IBM PC running in the VGA or 800 x 600 mode. I built a breakout box from a diagram that I saw in a *Circuit Cellar* INK article which lets me use the monitor in the 800 x 600 mode. Unfortunately, the screen colors are off and the image wraps slightly on the left side. Also, if the monitor loses sync for a even moment, the power supply cuts off and the monitor must be powered off and on again to resync. Has any-



one ever gotten one of these monitors to work with a PC clone? Does anyone have a schematic for an adapter?

Phillip R. Combs, Kettering, OH

**A.** Before I answer, let's take time out for a short history lesson. In the early days of computers, the video mode of a monitor was permanently programmed in the monitor itself. CGA monitors could display only 320 x 200 screens, and VGA monitors would display only 640 x 480 screens. It wasn't until the 8514A monitor came along that we had a choice. The 8514A monitor supported both the VGA and 1024 by 768 modes. Here's a table of the popular video modes.

Resolution	Refresh Rate	Horizontal Scan Rate
VGA 350	70 Hz	31.5 KHz
VGA 480	60 Hz	31.5 KHz
800 x 600	56 Hz	35 KHz
800 x 600	60 Hz	38 KHz
8514A (1024 x 768)	43 Hz	34.5 KHz
Mac IICx	72 Hz	35 KHz
VESA 1 (800 x 600)	72 Hz	48 KHz
VESA 2 (1024 x 768)	60 Hz	48 KHz
1024 x 768	75 Hz	60 KHz
1152 x 870	75 Hz	69 KHz
1280/64K	60 Hz	64 KHz
1280/75K	70 Hz	74.4 KHz
1280/81K	76 Hz	81 KHz

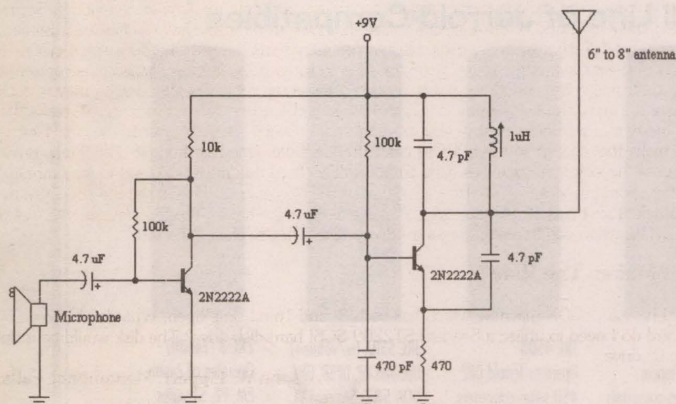
Now about your Silicon Graphics monitor. This monitor was originally made to work with a Silicon Graphics workstation, and its sync modes are set accordingly. Which video mode it was made for, I don't know, and Silicon Graphics can't remember, either. So I can't give you the exact specs. The fact that you can get it to momentarily work at 800 x 600 leads me to believe it's trying to sync with the Mac IICx video mode, which has a refresh rate of 67 Hz and a scan rate of 35 KHz. The VESA 800 x 600 standard is 60 Hz at 38 KHz. Close indeed, but no cigar. I've seen this many times where a reader gets a big-screen monitor for free, mostly Sun workstation monitors, and want to adapt it for use with the IBM PC clone. Sometimes I can give you a clue how it can be done, but mostly it'll cost you more than the monitor is worth. You're better off buying a 20-inch multiscan monitor from ViewSonic or other vendor that can handle any video mode tossed at it.

### Swing Your Partner To An FM Beat

**Q.** Do you know of a low-cost, xtal-stabilized 88-108 MHz FM transmitter as a commercial product? Or a simple circuit? The intended application is as an audio augmentation of square-dance music for the hearing impaired (using cheap standard FM receivers) indoors with a maximum range of 100 feet.

G. Frank Humiston, Santee, CA

**A.** If you browse the pages of *Nuts & Volts Magazine*, you'll discover several advertisers who sell FM transmitter kits for \$10.00 to \$40.00 that fit your specifications. Xandi (800-336-7389), for example, has a good assortment to choose from, as does Electronic Rainbow (317-291-7262). If you wish to roll your own, try this circuit.



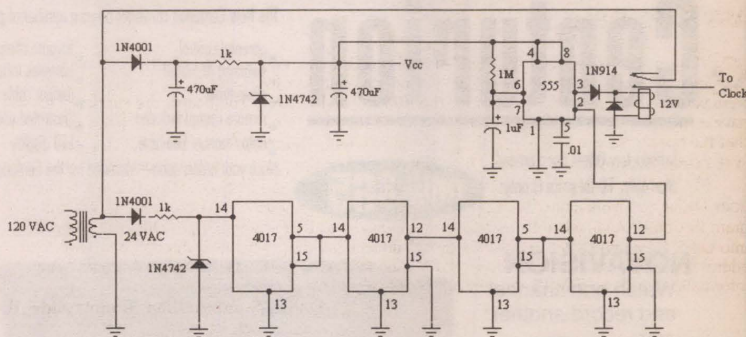
While this transmitter uses a condenser microphone for its input, you can replace the mike with a high-impedance, one-volt audio signal source, like that from a PA system. A short piece of wire six- to eight-inches long will provide a clear FM signal somewhere in the range of 88 to 95 MHz (adjusted by L1) with a range of about 100 feet. Call a dose-e-doe for me.

### School Time

**Q.** I have an old school clock that requires a 24 VAC pulse every minute that lasts about a second in duration. I need a schematic for a pulse generator or a relay that will trigger a 24-volt circuit.

Harold Summers, Oak Park, MI

**A.** Boy, do I have fond memories of those old wall clocks. There was many a time all class activities would grind to a halt as the Principal corrected the "school" time because of a power outage or whatever. We all cheered when, finally, all the clocks were back in sync — a time-out period the teachers often used to synchronize their own wrist watches, secretly hoping the new hour was closer to recess or a cigarette break. It usually was. What I would do is buy a cheap battery-powered wall clock from some place like Wal-Mart and use the second hand to mechanically trip a switch that would trigger your clock. But this is an electronics magazine, so here's an electronic solution that does the same thing at about the same cost.



Now realize that I haven't tested this circuit, but it should work. In other words, you may have to do some fine tuning on the 555 portion of the design. Basically, I've rectified the output of a 24-volt transformer and fed it into a series of 4017 CMOS dividers to arrive at a one-pulse-per-minute output. The 555 triggers off this pulse, and closes the relay, which provides a 1 second shot to your clock. If you want to simplify the circuit, you can eliminate the dividers and just go with the 555 timer (change the 1 uF capacitor to 100 uF, insert a 1 uF capacitor between pins 6 and 7, and make the 1M resistor a variable), but you'll find that the clock's time will drift a lot.

### Donate, Don't Upgrade

**Q.** I have a 386/486 Vesa LB Opt. 1 motherboard with a 386 ISA BIOS. How can I make it run 486DX (says no IRQ 13 handler) and LB? Will a 486 Vesa BIOS (with Opt.1) work?

Travis Brackeen, St. Louis, MO

**A.** What I would do is donate that motherboard to a good cause (community or family) and buy a new 486DX4 motherboard. Why you ask? Because the new BIOS chips will cost you \$75.00 and the 486DX CPU is another \$50.00. And after all that work and expense, you still have a slow, out-of-date PC. For \$200.00 you can buy a 100-MHz, state-of-the-art PCI motherboard with a 486DX4 CPU. Just yesterday, while pestering my favorite computer store salesperson, I noticed a sign on the door that advertised a 100-MHz Pentium system with a 850MB hard disk and everything sans a monitor for just \$599.00. It has come to the point where it's not economical to upgrade old motherboards.

### Netscape With America Online

**Q.** I recently added Netscape Navigator to my system, but I can't get it to work. A friend told me that Netscape Navigator won't work with America Online, and that I would have to subscribe to a different Internet service. Is he right?

Jeanne Goodman, via America Online

**A.** Well, yes and no. To begin with, you must have a direct Internet connection before you can use Netscape Navigator. The ability to send and receive E-Mail doesn't necessarily mean you

Continued on page 91

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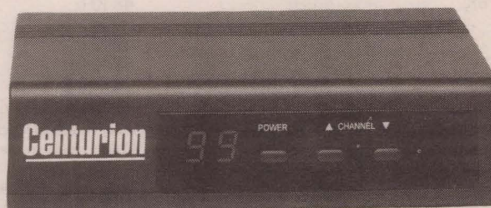
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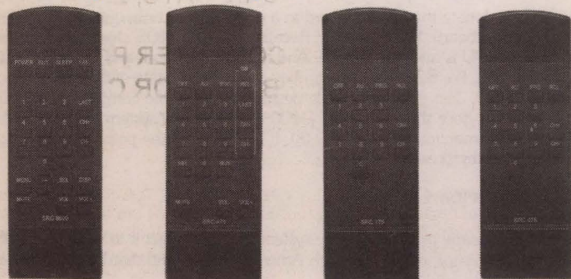
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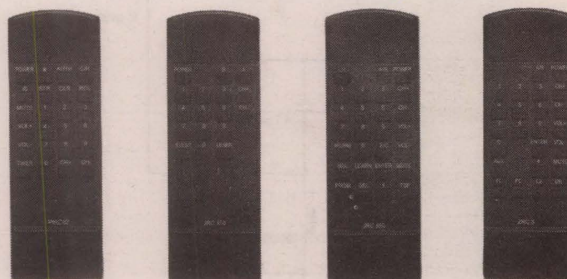
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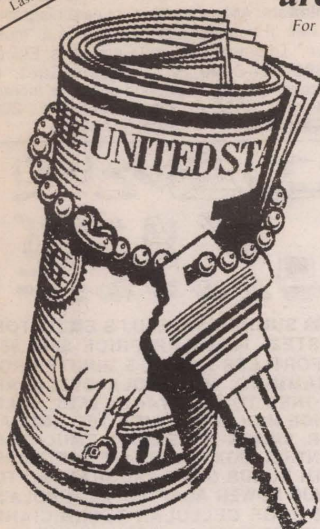
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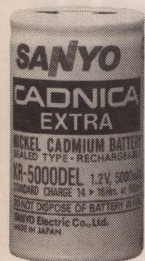


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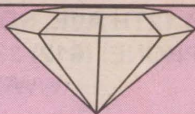
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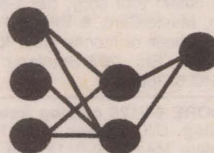


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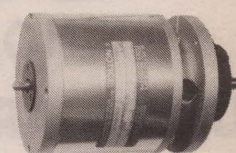
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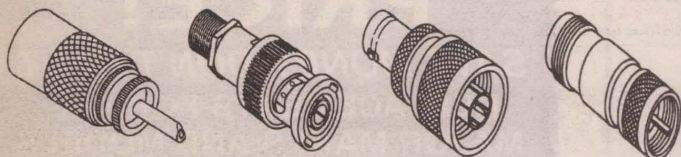




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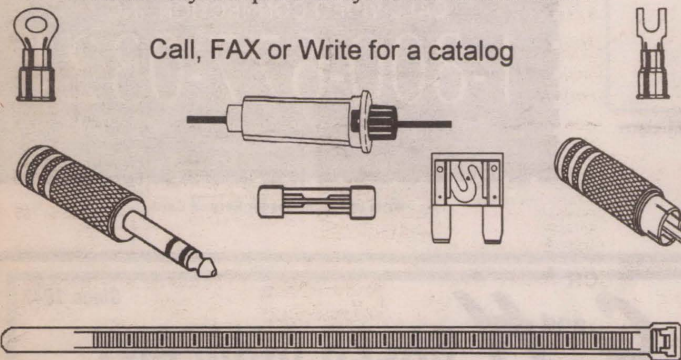
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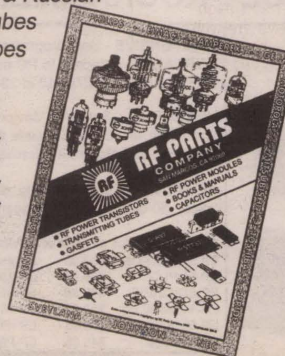
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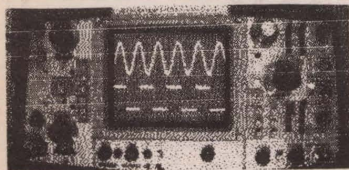
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by Ronald Reis

**Y**ou would be hard pressed to find a single electronic circuit, past or present, that didn't include at least one. Most contain dozens. Whether in a huge wire-wound case, a small color-coded cylinder, or, increasingly, as a tiny surface mount fly spec, the ubiquitous resistor is forever with us. As one of three passive components (the other two being the capacitor and inductor), it submissively works to suck up voltage, limit current, control the charge and discharge of a capacitor, and, in general, support the operation of active components such as transistors and integrated circuits.

In this article, we'll get to know the omnipresent resistor in detail. We'll find out why circuits just can't live without them. We'll examine the various resistor types, fixed and variable. We will learn the infamous resistor color code. We will see how a single resistor both limits current flow and drops voltage. Then, we will explore how resistors combine with

their "fellows" to divide voltage and split up current. Finally, we will investigate the workings of the "mighty bridge" — the Wheatstone bridge, that is.

### Resistors: In the Circuits Everywhere

Most circuits start out with too much of a good thing. Getting all the voltage and current they need is not their problem. Power supplies, even battery packs, are ready to give to the maximum. Problems occur because many parts of a circuit — particularly around active components — don't want the full supply voltage or large amounts of current.

For example, while the emitter-collector of a transistor might need close to the 12-volt supply voltage, its emitter-base region may require but 2 or 3 volts. A comparator might demand 9 volts at its power pins, but 4.5 volts at its non-inverting reference input. The triac in a circuit might be able to handle 1 ampere, but the LED used to indicate it's on, "wants" no more than 20 mA.

In other words, circuits begin with the maximum amount of voltage and current. However, various ele-

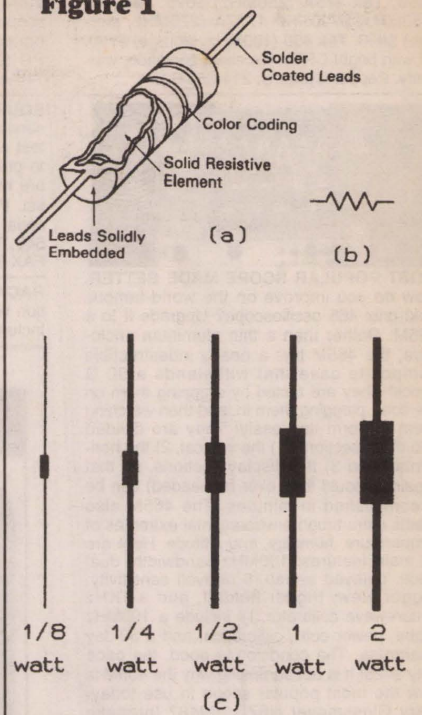
ments in the circuit often need less of either one or both. How do we reduce the power supply voltage and current at key points in a circuit? Enter the resistor. It is a simple component, designed to do two critical things: limit current flow and drop (use up) voltage. As we shall see shortly, being able to accomplish these two tasks has made it virtually indispensable.

### Resistor Types

The resistor, a component with a certain opposition to current flow, measured in ohms, is of two types: fixed and variable. The former — the most common of the two — has a value of resistance that cannot be changed. The variable resistor, on the other hand, has a range of values that can be selected by mechanical, thermal, or optical adjustment or variation.

Fixed resistors are of many types, carbon composition being the most common. As shown in Figure 1A, this

Figure 1



# The Ubiquitous Resistor:

## All About the Most Widely Used Electronic Component of All Time

COLOR	DIGIT VALUE	MULTIPLIER
Black	0	1 one
Brown	1	10 one zero
Red	2	100 two zeros
Orange	3	1000 three zeros
Yellow	4	10000 four zeros
Green	5	100000 five zeros
Blue	6	1000000 six zeros
Violet	7	10000000 seven zeros
Gray	8	
White	9	
Silver		0.01
Gold		0.1
None		

TABLE 1. General purpose and precision resistor color code.

resistor consists of a solid resistive element, solder coated leads, and an outer ceramic coating color-coded with the resistor's ohmic value. The resistive element is a mixture of powdered carbon and powered insulator bounded together. The ratio of the two substances determines the ohmic value: more carbon, lower resistance; more insulator material, higher resistance. Within a given size, resistance values can range from less than 2 ohms to 10 megaohms. The schematic symbol for a fixed resistor is shown in Figure 1B.

The physical size of the resistor tells us how much power in the form of heat it can dissipate. That dissipation is measured in watts. In Figure 1C, we see the relative size of resistors ranging from 1/8 to 2 watts. You can always use a higher wattage resistor than is called for, but never a lower value.

Of the variable resistors, the

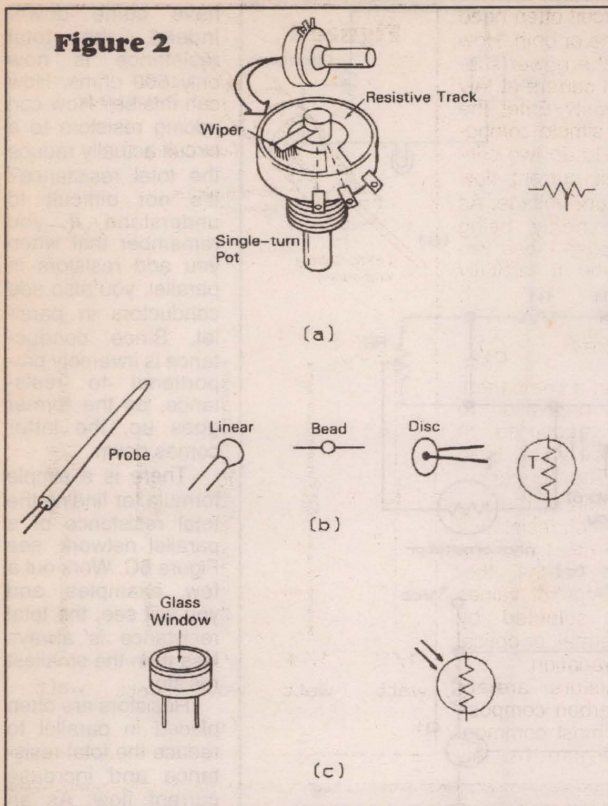
potentiometer (pot, for short) is probably the most familiar. User adjustable, the pot consists of a rotatable shaft to which is attached a wiper that traverses a resistive track. A terminal attaches to each end of the track, with a third, center, terminal affixed to the wiper. The physical appearance and schematic symbol for a potentiometer is shown in Figure 2A.

The total resistance of the potentiometer remains fixed between the outer terminals. Thus, the 10 kilohm pot in Figure 2A measures 10 kilohms between terminals A and C. Between the center terminal (B) and either outer terminal, however, the resistance can vary from zero ohms to 10 kilohms, depending on the position of the shaft. We'll see the potentiometer in use a little later.

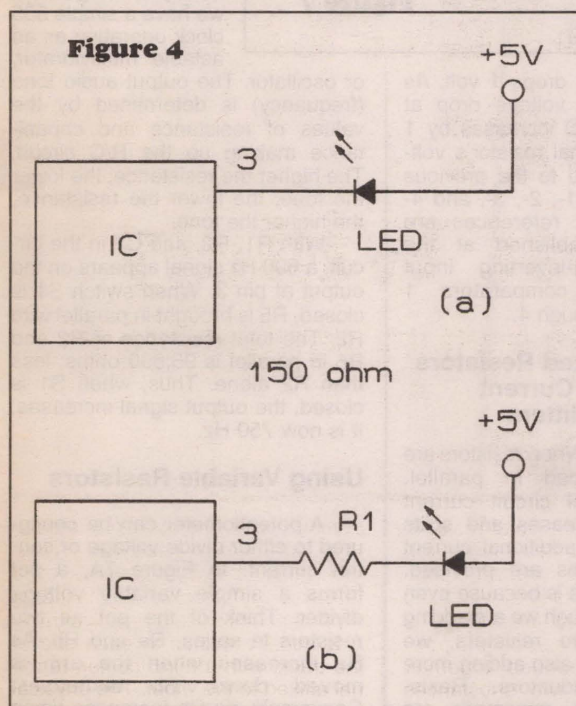
When it comes to thermal resistors — those that change their resistance with heat — the thermistor is



**Figure 2**



**Figure 4**



the most common. It produces extremely large changes in resistance for very small changes in temperature. The thermistor is constructed by bonding wire to various semiconductor materials. A variety of thermistors are shown in Figure 2B, along with their schematic symbol.

Most thermistors have a negative temperature coefficient, which means their resistance decreases as their temperature increases. We say the thermistor's resistance is inversely proportional to heat. Positive temperature coefficient thermistors do exist, but they are rare.

Resistors that vary their resis-

electricity. Thus, the component's resistance goes down. In the dark, however, few valence electrons are created; the photoresistor's resistance goes way up.

Shortly, we'll look at interesting applications for the potentiometer, thermistor, and photoresistor.

## The Resistor Color Code

Before we examine how resistors (fixed and variable) are used in electronic circuits, we need to introduce the infamous resistor color code.

Fixed resistors, all general pur-

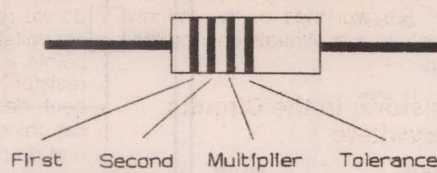
pose and some precision, have colored bands surrounding their body. The bands are used to indicate the resistor value in ohms and the tolerance, or deviation, from the specified resistance. General purpose resistors have four bands; precision resistors, five. See Figure 3.

In a four-band resistor, the first colored band (the band closest to the edge) represents the first significant figure of the resistor value. The second colored band represents the second significant figure. The third colored band is the multiplier to be applied to the two significant numbers. It will range from 0.01 to 100,000. The fourth band indicates the resistor's tolerance. Gold represents +5%, silver +10%, and if no fourth band is present (rare today), +20%. See Table 1.

For example: What would be the nominal ohmic value, tolerance range, and plus and minus deviation of a resistor with red, violet, orange, and silver bands? The answer is a nominal value of 27,000 ohms, a tolerance of +10%, a minus value of 24,300 ohms, and a plus value of 29,700 ohms. The manufacturer guarantees this resistor will be somewhere between the minus and plus values.

A precision resistor has five bands. The first three colored bands represent significant numbers, the fourth colored band is the multiplier, and the fifth colored band is the resistor's tolerance (see Table 1). What is the nominal ohmic value, tolerance range, and plus and minus deviation of a resistor with red, red, green, gold, and brown bands? The answer is a nominal ohmic value of 22.5 ohms, a tolerance of +1%, a minus value of 22.27 ohms, and a plus value of 22.72 ohms. The manufacturer will guarantee that this resistor falls somewhere between the minus and plus values.

General Purpose Resistor

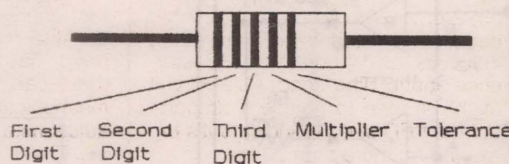


Tolerance--General Purpose

Resistor	
Gold	±5%
Silver	±10%
No Band	±20%

(a)

Precision Resistor



Tolerance--Precision

Resistor	
Red	±2%
Brown	±1%
Green	±0.5%
Blue	±0.25%
Violet	±0.1%

**Figure 3**

(b)

and the fifth colored band is the resistor's tolerance (see Table 1). What is the nominal ohmic value, tolerance range, and plus and minus deviation of a resistor with red, red, green, gold, and brown bands? The answer is a nominal ohmic value of 22.5 ohms, a tolerance of +1%, a minus value of 22.27 ohms, and a plus value of 22.72 ohms. The manufacturer will guarantee that this resistor falls somewhere between the minus and plus values.

## Limiting Current and Dropping Voltage

Let's begin our exploration of resistor usage by seeing how a single resistor can both limit current and drop voltage.

In Figure 4A, we have an LED (light emitting diode) connected directly to a five-volt supply. Assume the LED has an internal resistance of 100 ohms. If the IC's output, pin 3, goes low, according to Ohm's law, 50 mA will flow through the LED ( $I = V/R$ ;  $= 5/100$ ;  $= 50$  mA). Since the LED is rated at 2 volts and 20 mA, it will surely burn out.

We need to add a resistor in series with the LED that will reduce current flow to 20 mA while dropping 3 volts ( $5V - 2V = 3V$ ). See Figure 4B. Using Ohm's law, a 150-ohm resistor will drop 3 volts and limit current through it to 20 mA ( $R = V/I$ ;  $= 3/0.020$ ;  $= 150$  ohms).

## Fixed Resistors as Voltage Dividers

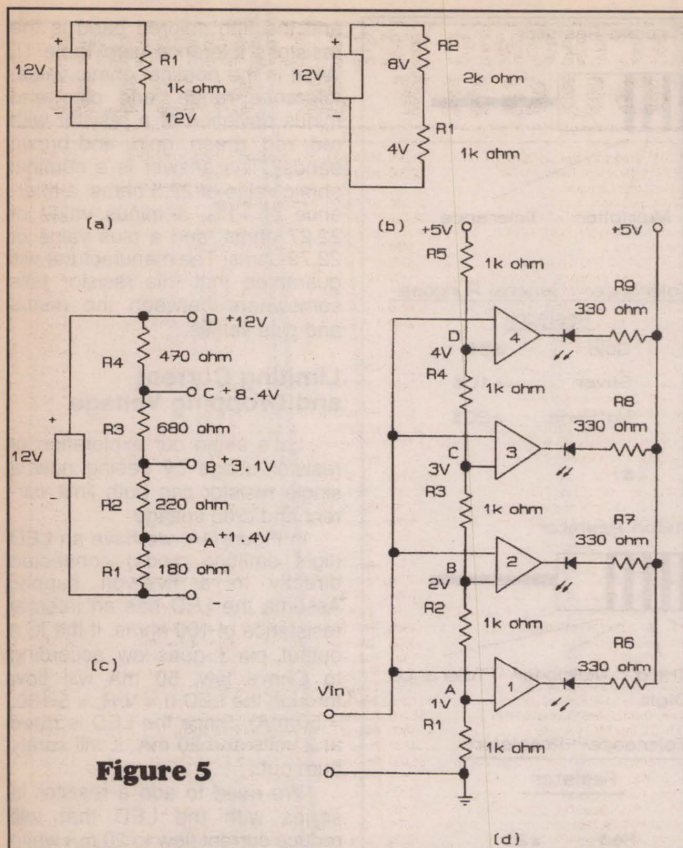
In Figure 5A, we see a simple circuit consisting of a voltage source, a resistor, and a path for current flow. In this circuit, the 1,000-ohm resistor limits current to 12 mA. In pushing 12 mA through the resistor, the entire 12 volts from the source is used up. We say the resistor "needs" 12 volts to push 12 mA through it.

If we place two resistors in series, each resistor "demands" a share of the supply voltage in getting circuit current through. In the circuit of Figure 5B, the two resistors add to equal 3,000 ohms of opposition to current flow. As a result, 4 mA flows everywhere in the circuit. But resistor R2 "says" to resistor R1: "Since I have twice the resistance, to get 4 mA through me, I need twice as much voltage as you do." Thus, resistor R2 gets (drops) 8 volts from the supply, resistor R1 gets the remaining 4 volts.

We can find the voltage drop "demanded" by any resistor in a series circuit with the use of a simple formula:  $VRX = (RX/RT)VS$ , where VRX is the voltage drop across the selected resistor, RX is the value of that resistor, RT is the total resistance of the circuit, and VS is the supply voltage.

Since resistors in a series circuit divide the voltage, series resistor circuits form voltage dividers. Hence, we have a simple way of developing a lower voltage from a higher volt-

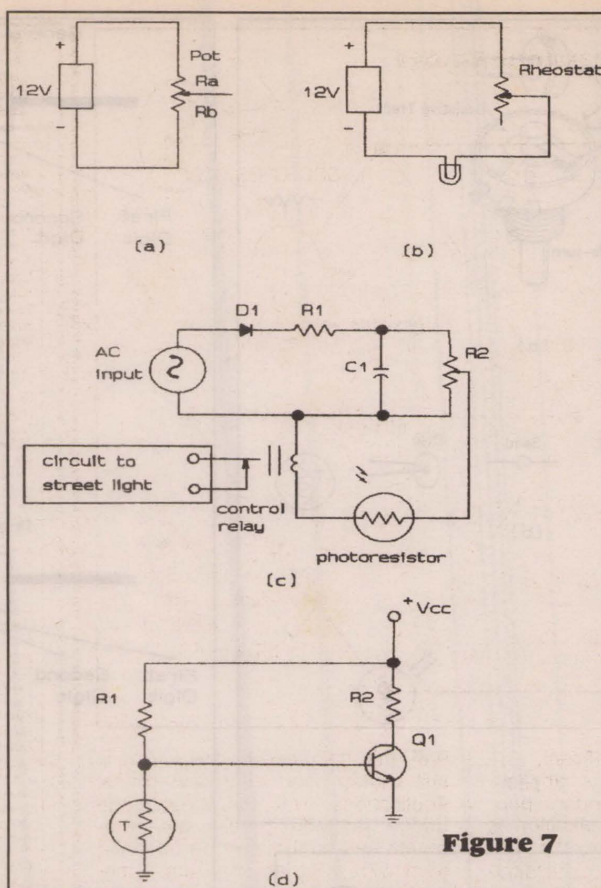




**Figure 5**

age. In Figure 5C, we have such a voltage divider consisting of four resistors. Resistor R1 drops approximately 1.4 volts (point A). Resistors R1 and R2 together drop approximately 3.1 volts (point B). Resistors R1, R2, and R3 together drop

spread throughout countless electronic circuits. Any time you see resistors in series, you know they are there to divide up voltage. In Figure 5D, we see an example of resistors working as voltage dividers in a flash analog-to-digital converter. Resistors R1 through R5



**Figure 7**

have come down. Indeed, the total resistance is now only 500 ohms. How can this be? How can adding resistors to a circuit actually reduce the total resistance? It's not difficult to understand if you remember that when you add resistors in parallel, you also add conductors in parallel. Since conductance is inversely proportional to resistance, as the former goes up, the latter comes down.

There is a simple formula for finding the total resistance of a parallel network, see Figure 6C. Work out a few examples and you will see, the total resistance is always less than the smallest resistor.

Resistors are often placed in parallel to reduce the total resistance and increase current flow. As an example, in Figure 6D we have a simple 555 clock operating as an astable multivibrator,

or oscillator. The output audio tone (frequency) is determined by the values of resistance and capacitance making up the R/C circuit. The higher the resistance, the lower the tone; the lower the resistance, the higher the tone.

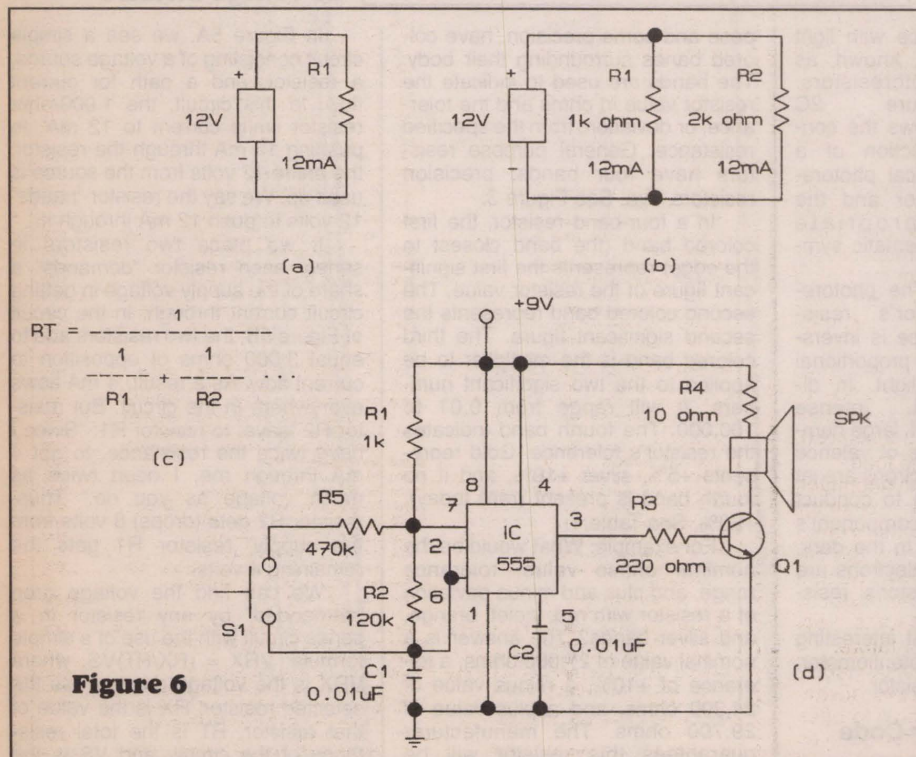
With R1, R2, and C1 in the circuit, a 600 Hz signal appears on the output at pin 3. When switch S1 is closed, R5 is brought in parallel with R2. The total resistance of R2 and R5 in parallel is 95,590 ohms; less than R2 alone. Thus, when S1 is closed, the output signal increases. It is now 750 Hz.

### Fixed Resistors as Current Splitters

When resistors are placed in parallel, total circuit current increases and splits as additional current paths are provided. This is because even though we are adding more resistors, we are also adding more conductors. Resistors, remember, are conductors, too.

As shown in Figure 6A, with only resistor R1 in the circuit, 12 mA flows. When we place a second resistor of equal value, R2, in parallel with R1 (Figure 6B), it too allows 12 mA to flow through it. Thus, a total of 24 mA is now

flowing through the circuit. If, in Figure 6B, the source voltage remained the same — 12 volts — and the current increased, the total resistance of the circuit must



**Figure 6**

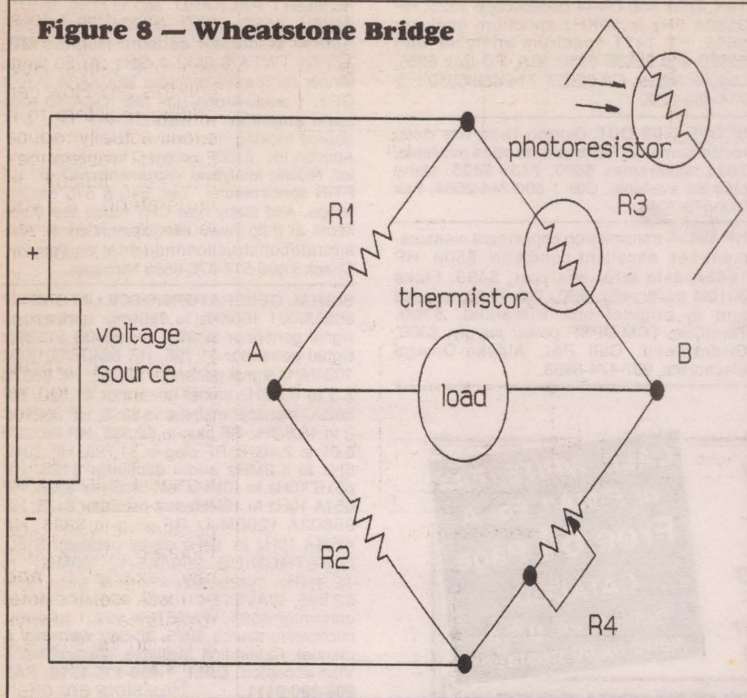
approximately 8.4 volts (point C). All four resistors must drop the entire supply voltage, 12 volts (point D).

Voltage dividers made up of two or more resistors in series are

are connected in series across the five-volt source. Since each resistor is 1K ohms, each resistor "demands" an equal share of the supply voltage in pushing current through it. Each



**Figure 8 — Wheatstone Bridge**



age, the latter controls current.

There are numerous applications for the light-dependent photoresistor. One such application is shown in Figure 7C. Here, the photoresistor is used to determine when the street light should turn on or off. Diode D1, resistor R1, and capacitor C1 form a halfwave rectifier that supplies power to the coil of the control relay. Resistor R2 — a potentiometer — taps off an appropriate power supply voltage and delivers it to the relay coil.

Now, an increase of light at the photoresistor results in a decrease in resistance. Thus, current is increased through the coil, the coil is energized, and the normally closed (NC) contacts are held open. The street lights are off. When darkness falls, the resistance of the photoresistor increases, the coil de-energizes, and the NC contacts return to their original position. The lights go on.

In Figure 7D, we see an interesting use for the thermistor — a heat-dependent variable resistor. The thermistor forms a voltage divider with R1 to provide a fixed bias for the base of the transistor. As temperature increases with an increase in base bias current, the resistance of the thermistor decreases. With less resistance, the thermistor drops less voltage for the base, and the base bias decreases. With a properly designed circuit, the thermistor will change the base current to compensate for changes in temperature.

## The Mighty Wheatstone Bridge

No article on resistor usage would be complete without a discussion of the Wheatstone bridge, named after Charles Wheatstone, who invented it in 1850. Though it's been around for a century and a

half, this balanced bridge circuit is still widely used in a few critical applications. With the Wheatstone bridge, far more precise measurements and control can be obtained than with a series or parallel connection.

In Figure 8, we have four resistive elements arranged to form a bridge circuit. R1 is in series with R2, as is R3 in series with R4. Both series circuits are connected across the voltage source.

If R1 is equal to R2, and R3 is equal to R4, then the voltage at point A equals the voltage at point B. In that case, no voltage difference exists between the two points, and no current flows through the load. We say the bridge is balanced.

Assume a sensing device (photoresistor or thermistor) replaces R3, and is situated such that it can detect light or heat, respectively. Potentiometer R4 (connected as a rheostat) will be used to balance the bridge by making its resistance equal to that of R3.

Any change in light or temperature will change the resistance of R3, and the bridge becomes unbalanced. With the bridge unbalanced, current flows through the load.

If the load is a galvanometer, the circuit becomes an extremely sensitive light meter or thermometer. If R3 is a photoresistor, the circuit can then measure minute changes in light. If a thermistor is used, the bridge measures very minute changes in temperature.

The Wheatstone bridge represents another way to take advantage of what resistors have to offer. Though the resistor is often seen as a lowly, passive component, it deserves more respect. Its longevity, alone, should give one pause to admire. By limiting current and dropping voltage, the resistor has made itself indispensable to almost every electronic circuit. NV

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HP 3300A, Function Gen. with 3302A Phase Lock	\$150	Tek 475, Scope, 200MHz, Dual Trace	\$600
HP 3320A, Frequency Synthesizer	\$250	Tek 485, Scope, 350MHz Dual Trace	\$800
HP 3320B, Frequency Synthesizer	\$350	Tek 624, XY Monitor	\$200
HP 3325A, Synthesized Function Generator	\$2,000	Tek 7403N, Scope Mainframe, Rack Mount	\$200
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HP 3400A, RMS Voltmeter 1mV-300V, 10Hz-10MHz	\$150	Tek 7A29/04, 1GHz Vert. Amp Variable Delay	\$500
HP 3455A, High Accuracy Voltmeter 6.5 Digits	\$400	Tek 7B10, Delayed Time Base, 2ns-2s/Div, 10Hz	\$300
HP 3456A, Digital Voltmeter, 6.5 Digits	\$700	Tek 7B85, 400MHz Delaying Time Base	\$150
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HP 3575A, Phase Gain Meter, Opt. 01, Dual Displays	\$600	Tek 7L18/7603, Spectrum Anz. 1.5-18GHz	\$3,000
HP 3580A, Spectrum Anz., 5Hz-50KHz, 1Hz Res	\$1,000	Tek 7512, TDR/Sampler	\$400
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HP 3586C, Selective Level Meter, 50 Ohm	\$1,000	Tek AM503, Current Probe Amp	\$400
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HP 4270A, Automatic Capacitance Bridge	\$800	Tek DC503A, Universal Counter, 125MHz TM500	\$200
HP 432A/478A, Power Mtr., Cable, Mount, 10MHz/10GHz	\$300	Tek DC504, Counter/Timer TM500	\$100
HP 432B, Power Meter, Digital Display	\$250	Tek DC508A, Counter, 1.3GHz Opt. 01	\$500
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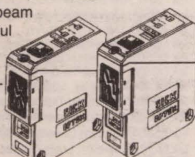
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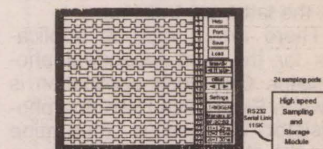
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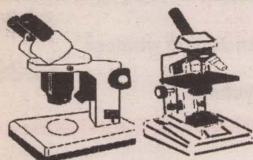
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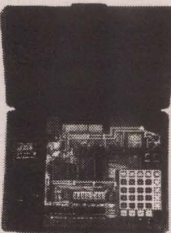
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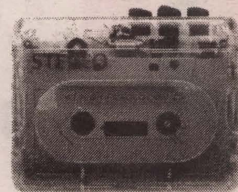
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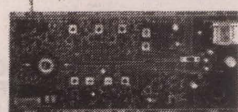
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\$39.95

### TK-1000



### M-2665K

#### Deluxe Full Function Digital Multimeter Kit

Extra large 1 1/4" x 2 1/2" LCD display area, 3 1/2 digit display, 34 ranges (cap., trans. test, diode test).

\$54.95



### M-1005K

#### Digital Multimeter Kit

Low cost, 3 1/2 digit LCD, 18 ranges, transistor test, diode test, overload protection and pocket size.

\$19.95



### FG-500K

#### 100KHz Function Generator Kit

Provides sine, square or saw tooth waveforms continuously variable 1Hz to 100KHz. Amplitude adjustable to 2.5V peak to peak. Complete with all parts, PC board, schematic, deluxe case with handle and extensive assembly manual.

\$34.95



### FO-30K Fiber Optics Technology with training course



Learn the basics of fiber optics data communications while you build this exciting kit. Comes complete with all necessary components.

\$19.95

### Robotic Arm Y-01

The Movit Robotic Arm is an educational kit that teaches the fundamentals of a basic robotic arm as well as your own motor skills.



\$59.95

### Sound Activated Switch

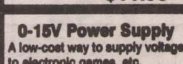
Clap and the light comes on, clap again and off it goes.



\$8.95

### Temperature Adapter Kit Model K-40

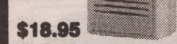
This easy and fun-to-build kit converts any 2VDC range multimeter into a temperature probe.



\$11.95

### Motion Detector Kit SS-50K

Compact and portable. Adds safety to your home & office.



\$18.95

### Telephone Line Analyzer Kit Model TT-400K

A telephone line analyzer that provides fast indication of telephone line polarity, ring and line voltage levels.



\$19.95

### Telephone Kit Model PT-223K

Build this high-tech see-thru plastic telephone. Learn theory on how telephones work and then proudly show off your work with the transparent phone case. Complete with all parts and manual. Neon lamps flash when the phone rings.



\$15.95

### Telephone Hold Button

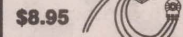
Put all incoming and outgoing calls on hold at the press of a button.



\$6.50

### Strobe Light

Produces a bright flash via xenon flash tube. The flashing rate is adjustable.



\$8.95

### 0-15V Power Supply

A low-cost way to supply voltage to electronic games, etc.



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### Telephone Bug

Size of a dime yet transmits both sides of a phone conversation to any FM radio. No battery needed.



\$8.95

### FM Mic

Transmit your voice on any FM radio. Range up to 1000'. Case incl.



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





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



## King of Combos Panasonic TCPC175DG2

-  Volume Control
-  Sleep Timer
-  Last Channel Recall
-  Favorite Channel Memory
-  Parental Lockout
-  STD/HRC/IRC Switchable
-  Channel 2/3 Switchable
-  Infrared Remote Control



- Model SP+** **\$239**  
A 100% replacement for all Pioneer, all Scientific Atlanta (except baseband), Oak, Hamlin, and Eagle Systems
- Model T** **\$239**  
Perfect for all TOC xx03/07/08 systems including wireless
- Model Z** **\$239**  
The one for all Zenith and Zenith/Oak systems.





## G7 Combo

-  Last Channel Recall
-  Favorite Channel Memory
-  STD/HRC/IRC Switchable
-  Infrared Remote Control



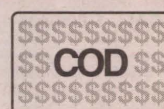
- Timeless Products TPI550PC w/G7** **\$139**  
Timeless Products TPI550PC with all new G7 Tri-Mode decoder installed. This brand new one piece system is a real crowd pleaser. Easy to install and operate.

## SSA-TV86

-  Last Channel Recall
-  Parental Lockout
-  STD/HRC Switchable
-  Infrared Remote Control
- Manual Fine Tuning**



- SSA-TV86** **\$149**  
This updated SSA-TV86 replaces all SA8500-8580 and PIO 5xxx-61xx.



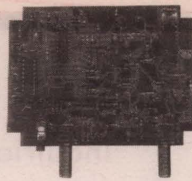
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6325-9 FALLS OF THE NEUSE ROAD, RALEIGH, NC 27615



## Decoders

	QTY 10	QTY 20
<b>STEALTH 1000-P</b> 5 x 4 Plastic Case w/Toggle	\$49	\$45
<b>TNT</b> 6 x 9 Metal Case w/Toggle	\$45	\$42
<b>TVT-3G</b> 6 x 9 Metal Case	\$42	\$39
<b>MINI-TVT</b> 3 x 6 Metal Case	\$42	\$39
<b>GOLD</b> 3 x 6 Plastic Case	\$42	\$39
<b>APOLLO-J</b> 3 x 6 Metal Case Replaces Purple & SIP	\$49	\$45
<b>FTB-3</b> 6 x 9 Metal Case	\$43	\$39
<b>G7</b> 4 x 4 Board Only	\$39	\$35



	QTY 10	QTY 20
<b>PIO-6300</b> 6 x 9 Metal Case w/Toggle	\$69	\$59
<b>PIO+/TNT</b> 6 x 9 Metal Case w/Toggle	\$69	\$59
<b>PIO RED</b> 3 x 6 Metal Case Replaces Green & Apollo-P	\$69	\$59
<b>STEALTH 80-P</b> 5 x 4 Plastic Case w/Toggle	\$55	\$49
<b>M-80</b> 6 x 9 Metal Case w/Toggle	\$65	\$59
<b>S-BLUE</b>	\$65	\$59

## Converters

	QTY 10	QTY 20
<b>Stargate Elite</b>	\$59	\$55

- Last Channel Recall
- Favorite Channel Memory
- Parental Lockout
- STD/HRC Switchable
- Infrared Remote



<b>Stargate 550XL</b>	\$99	\$89
-----------------------	------	------

- Volume Control
- Sleep Timer
- Last Channel Recall
- Favorite Channel Memory
- STD/HRC Switchable
- Channel 2/3 Switchable
- Infrared Remote Control



<b>Panasonic TZPC1453G2</b>	\$79	\$69
-----------------------------	------	------

- Sleep Timer
- Last Channel Recall
- Favorite Channel Memory
- Parental Lockout
- STD/HRC Switchable
- Infrared Remote Control



<b>TPI 550</b>	\$60	\$57
----------------	------	------

- Last Channel Recall
- Favorite Channel Memory
- Parental Lockout
- Infrared Remote Control



<b>Centurion</b>	\$65	\$61
------------------	------	------

- Sleep Timer
- Last Channel Recall
- Favorite Channel Memory
- STD/HRC Switchable
- Infrared Remote Control
- 100 Channel Capability
- Fine Tuning



<b>Millennium<sup>3</sup></b>	\$69	\$59
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- Sleep Timer
- Last Channel Recall
- Favorite Channel Memory
- Parental Lockout
- STD/HRC Switchable
- Infrared Remote Control
- 100 Channel Capability



Build your own one piece combo unit. This converter is perfect for installing a descrambler into. No soldering required, all cable included.

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1. COURTEOUS AND PROFESSIONAL SERVICE.
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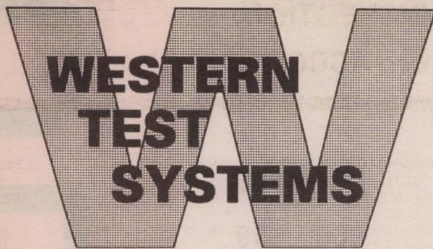


All prices are for 10 pieces, subject to change without notice. Some quantities may be limited. 30-Day Money Back Guarantee. One year parts and labor warranty.

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SAT 10-3 EST  
FAX 1-800-854-7118

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## OSCILLOSCOPES & ACCESSORIES

### TO 100 MHz

TEK 7A18A 75 MHz Dual Trace Amplifier .....	\$125.00
TEK 7A22 1 MHz High CMRR Differential Amplifier .....	\$300.00
TEK 7B53A 100 MHz Dual Time Base .....	\$175.00
TEK SC502 15 MHz Dual Trace Oscilloscope, TM500 series .....	\$375.00

### ABOVE 100 MHz

TEK 475 200 MHz Dual Trace Oscilloscope .....	\$850.00
TEK 485 350 MHz Dual Channel Oscilloscope .....	\$1,100.00
TEK 7104 1 GHz Oscilloscope, .....	\$5,000.00
with 7A29, 7A29-04, 7B10, 7B15	
TEK 7854 400 MHz Waveform Processing Oscilloscope frame .....	\$1,250.00
TEK 7904 500 MHz 4-slot frame .....	\$500.00
TEK 7904 500 MHz System, with 7A24, 7A26, 7B92A .....	\$1,000.00
TEK 7904 500 MHz System, with 7A24, 7A26, 7B80, 7B85 .....	\$1,000.00
TEK 7904A 500 MHz Oscilloscope Frame .....	\$750.00
TEK 7A13 105 MHz Differential Comparator .....	\$300.00
TEK 7A19 600 MHz Single Trace Amplifier .....	\$125.00
TEK 7A19-opt.4 600 MHz Single Trace Amplifier, variable delay line .....	\$175.00
TEK 7A24 400 MHz Dual Trace Amplifier .....	\$200.00
TEK 7A26 200 MHz Dual Trace Amplifier .....	\$350.00
TEK 7A29 1 GHz Single Trace Amplifier .....	\$175.00
TEK 7A29-opt.4 1 GHz Single Trace Amplifier, variable delay line .....	\$550.00
TEK 7B15 1 GHz Delaying Time Base .....	\$650.00
TEK 7B80 400 MHz Delayed Time Base .....	\$450.00
TEK 7B85 400 MHz Delta Delaying Time Base .....	\$175.00
TEK 7B85 400 MHz Delta Delaying Time Base .....	\$200.00

### STORAGE

TEK 7834 400 MHz Storage Oscilloscope, .....	\$1,250.00
w/7A24, 7A26, 7B80, 7B85	
TEK SC503 10 MHz Dual Trace Storage .....	\$700.00
Oscilloscope, TM500 series	

### SAMPLING

TEK 7S11 Sampling Unit .....	\$300.00
TEK 7T11 Sampling Sweep Unit .....	\$750.00
TEK R7903/7S11/7T11/S-4 12 GHz .....	\$1,750.00
Sampling Oscilloscope System	
TEK S-4 14 GHz Sampling Head .....	\$300.00

### PROBES

TEK 1101 Accessory Power Supply, for FET probes .....	\$250.00
TEK P6045 230 MHz 1X/10X/100X FET Probe .....	\$225.00
TEK P6046 100 MHz Differential Probe .....	\$750.00
TEK P6101A 34 MHz 1X Modular Probe, 2m length "NEW" .....	\$25.00
TEK P6108A 100 MHz 10X Modular Probe, 2m length "NEW" .....	\$50.00
TEK P6201 900 MHz 1X/10X/100X FET Probe .....	\$500.00
TEK P6203 10X 1 GHz Active Probe, for 11000 series .....	\$450.00
TEK P6205 750 MHz 10X FET Probe, .....	\$275.00
for TDS/DSACSA/11000 series	
TEK P6701-opt.01 O/E Converter, .....	\$675.00
450-1050 nm/0.1-mV: DC-700 MHz, FC conn.	

### CALIBRATION

TEK 067-0587-01 Signal Standardizer .....	\$300.00
Calibration Plug-in, 7000 series	
TEK CG5001-opt.01/TM5006 Programmable .....	\$7,000.00
Oscilloscope Calibration, with power module	
TEK CG551/AP/TM5006A Oscilloscope .....	\$3,500.00
Calibrator, with pulse head & power module	

## WAVEFORM GENERATORS

### FUNCTION

HP 3310A 5 MHz Function Generator .....	\$325.00
HP 3310B 5 MHz Function Generator, .....	\$425.00
monocycle & var. phase trigger	
HP 3312A 13 MHz Function Generator, sweep, AM, FM .....	\$850.00
HP 8015A 50 MHz Dual Output Pulse Generator .....	\$650.00
TEK DD501 Digital Delay & Burst Gen., for function & pulse gen's .....	\$375.00
TEK FG502 11 MHz Function Generator, TM500 series .....	\$325.00
TEK FG503 3 MHz Function Generator, TM500 series .....	\$275.00
TEK FG504 40 MHz Function Generator, TM500 series .....	\$875.00
TEK RG501 Ramp Generator, TM500 series .....	\$225.00
WAVETEK 188 4 MHz Sweep/Function Generator, 20Vp-p .....	\$275.00

### PULSE

HP 214B 10 MHz Pulse Generator, .....	\$1,650.00
50V/50 Ohms, auto duty cycle	
HP 8005B 20 MHz Dual Output Pulse Generator .....	\$450.00
HP 8012B 50 MHz Pulse Generator, variable Tr .....	\$600.00
HP 8013B 50 MHz Dual Output Pulse Generator, 3.5 nS fixed Tr .....	\$600.00
HP 8015A-002 50 MHz Dual Output .....	\$750.00
Pulse Generator, burst mode option	
HP 8080A/81A/82A/83A 300 MHz Word Generator .....	\$600.00
HP 8080A/91A/92A/93A 1 GHz Single Channel Pulse Generator .....	\$950.00
HP 8080A/91A/93A 1 GHz Clock Generator .....	\$600.00
HP 8082A 250 MHz Dual Output Pulse Generator .....	\$1,400.00
PHILIPS PM5785B 125 MHz Dual Output Pulse .....	\$875.00
Gen., burst mode, 1 nS Tr	
TEK PG501 50 MHz Pulse Generator, TM500 series .....	\$250.00
TEK PG502 250 MHz Pulse Generator, Tr=1nS, TM500 series .....	\$700.00
WAVETEK 801 50 MHz Pulse Generator .....	\$450.00

## PROGRAMMABLE

HP 3314A Multi-Waveform Generator, 0.001 Hz-19.99 MHz, HPIB ....	\$3,500.00
HP 3325A Synthesizer / Function Generator, 1 uHz-21 MHz .....	\$2,250.00
HP 3325A-002 Synth./Function Gen., .....	\$2,400.00
1 uHz-21 MHz, 40V out 1 uHz-1 MHz	
HP 8160A 50 MHz Programmable Pulse Generator, HPIB .....	\$2,500.00
HP 8165A Programmable Signal Source, 1 mHz-50 MHz .....	\$2,600.00
TEK AWG5102 Arb. Waveform Gen., 20 MS/s, .....	\$1,400.00
12 bits, 50ppm synthesis <1MHz	
TEK AWG5105 Arbitrary Waveform Generator, 50 MS/s, 12 bits .....	\$1,700.00
TEK AWG5105-opt.02 Arbitrary Waveform .....	\$2,200.00
Generator, dual channel option	
TEK PFG505 Programmable 12 MHz Pulse/Function Generator .....	\$900.00

## VOLTAGE & CURRENT

### VOLTMETERS

HP 3456A 6-1/2 Digit Voltmeter .....	\$850.00
HP 3458A 8-1/2 digit Voltmeter .....	\$5,000.00
HP 3468A-001 5-1/2 digit Voltmeter, battery power option .....	\$375.00
KEITHLEY 181 6-1/2 digit Nanovoltmeter, 10 nV sensitivity, GPIB .....	\$1,500.00
SOLARTRON 7150 5-1/2 digit Multimeter, GPIB .....	\$450.00

### CALIBRATION

DATA PRECISION 8200-488 DC Voltage/Current .....	\$1,375.00
Calibrator, 0-100V/0-100 mA, GPIB	
FLUKE 332B/AF DC Voltage Calibrator, .....	\$675.00
0-1111V, 0-50 mA, 7 decades	
FLUKE 343A DC Voltage Calibrator, .....	\$1,375.00
0-1100V, 7 decades, 20 ppm acc.	
FLUKE 515A Portable Calibrator, .....	\$1,500.00
DC/AC/Ohms, line & battery power	
FLUKE 5220A Transconductance Amplifier, DC-5 kHz, 0-20 A .....	\$3,750.00
FLUKE 720A Kelvin-Variety Voltage Divider, 7 decade .....	\$2,250.00
FLUKE 731B DC Reference Standard .....	\$400.00
HP 11049A AC Thermal Converter, 3V, 20 Hz-100 MHz .....	\$175.00
VALHALLA 2703 AC Volt. Std., .....	\$2,500.00
0-120V/10 Hz-100 kHz; 120-1200V/10 Hz-1 kHz	

### VOLTAGE SOURCES

HP 6114A Precision Dual Range Power Supply, .....	\$875.00
20 V 2 A / 40 V 1 A	
HP 6115A Precision Dual Range Power Supply, .....	\$875.00
50 V 0.8 A / 100 V 0.4 A	

### CURRENT METERS & SOURCES

DRANETZ 656A (3) TR2019A Current Density Analyzer, .....	\$5,000.00
w/(3) current probes 300A max.	
FLUKE Y5020 Current Shunt, to 20 A, 0.01 ohm, DC-5 kHz .....	\$400.00
HP 6177C DC Current Source, to 50V, 500mA .....	\$600.00
HP 6181C DC Current Source, to 100V, 250 mA .....	\$675.00
HP 6186C DC Current Source, to 300V, 100mA .....	\$750.00
KEITHLEY 414A Picoammeter, 0.1 nA-10 nA .....	\$325.00
KEITHLEY 617 Programmable Electrometer .....	\$2,750.00
KEITHLEY 642 Electrometer .....	\$2,900.00
LEEDS & NORTHRUP 4360 Precision .....	\$650.00
Current Shunts, 15-500 Amp	
TEK CT-5-opt.05 High Current .....	\$500.00
Transformer for P6021/A6302, to 1000A	
VALHALLA 2301 Programmable Single Phase Power Analyzer .....	\$1,250.00
VALHALLA 2575A AC/DC Active Current Shunt, .....	\$1,000.00
20 mA-100 A, DC-10 kHz	

## IMPEDANCE & COMPONENT TEST

### L.C.R.

BOONTON 62AD 1 MHz Inductance Meter, 2-2000 uH .....	\$550.00
E.S.I. 296V 4-1/2 Digit LCR Bridge, 120 Hz & 1 kHz .....	\$700.00
GR 1689-M 5 digit Precision RLC Digitbridge, 12 Hz-100 kHz .....	\$2,000.00
HP 4261A 3-1/2 digit LCR Meter, 120 Hz/1 kHz .....	\$1,000.00
HP 4274A-001 5-1/2 digit LCR Meter, 100 Hz-100 kHz, inL DC bias .....	\$4,250.00

### STANDARDS

E.S.I. RS-925 9-Decade Resistor, 0.01 ohm-1.2 Megohm .....	\$1,600.00
E.S.I. SR1010 Resistance Transfer Standards, 1 ohm-100 K/step .....	\$700.00
FLUKE 5450A Programmable Resistance Standard, 2 & 4 wire .....	\$1,750.00
GR 1409-SERIES Standard Mica Capacitors, 0.05% accuracy .....	\$150.00
GR 1432-N 5-Decade Resistor, to 11,111 ohms, 0.1 ohm res. ....	\$175.00
GR 1432-U 4-Decade Resistor, 0-111.1 ohms, 0.01 ohm resolution .....	\$125.00
GR 1433-X 4-Decade Resistor, 0-111.0 ohms, 0.01 ohm resolution .....	\$475.00
GR 1433-X 6-Decade Resistor, to 111,111.0 ohms, 0.1 ohm res. ....	\$550.00
GR 1434-G 7-Decade Resistor, 0-111,111.0 ohms, 0.1 ohm res. ....	\$400.00
HP 16380A Standard Air Capacitor Set; 1, 10, 100, 1000 pF .....	\$1,675.00
VALHALLA 2724A Programmable Resistance .....	\$1,675.00
Standard, 0-11 Gigaohms, GPIB	

### HI & LO RESISTANCE

GR 1666 DC Resistance Bridge, 1 micro-ohm - 100 kilohms .....	\$750.00
HP 4329A High Resistance Meter, .....	\$1,350.00
5E5-2E16 Ohms, 10-1000V test	
VALHALLA 4150-ATC 4-1/2 digit Ohmmeter, .....	\$1,000.00
20 milliohms-2 kilohms, 4-wire	

### CURVE TRACERS

TEK 576 Curve Tracer, with standard test fixture .....	\$2,350.00
TEK 577D/1177 Storage Curve Tracer, with standard test fixture .....	\$2,250.00

TEK 7CT1N Curve Tracer, to 0.5W, 7000 series .....	\$400.00
--	----------

### T.D.R.

TEK 1503-opt.04 Time Domain Reflectometer, .....	\$2,000.00
0-50,000 feet, chart recorder	
TEK 7S12S-S/S-52/7854 T.D.R., 0-375 feet, .....	\$2,750.00
45 pS Tr, w/digital storage display	

## POWER SUPPLIES

### SINGLE OUTPUT

HP 6031A Autoranging Supply, .....	\$2,000.00
to 20V / 120 A / 1000W max., HPIB	
HP 6201B 20V at 1.5A CV/CC Power Supply .....	\$200.00
HP 6206B Dual Range 0-60V 0.5 A / 0-30V 1 A CV/CL Supply .....	\$250.00
HP 6207B 160V at 200 mA CV/CC Power Supply .....	\$300.00
HP 6260B-027 10V at 100A CV/CC Power Supply .....	\$675.00
HP 6261B-027 20V at 50 A CV/CC Power Supply .....	\$675.00
HP 6263B 20V at 10 A CV/CC Power Supply .....	\$400.00
HP 6266B 40V at 5 A CV/CC Power Supply .....	\$400.00
HP 6267B 40V at 10 A CV/CC Power Supply .....	\$550.00
HP 6268B-027 40V at 30 A CV/CC Power Supply .....	\$850.00
HP 6284A 20V at 3 A CV/CC Power Supply .....	\$250.00
HP 6299A 100V at 750 mA CV/CC Power Supply .....	\$250.00
HP 6384A 4.0-5.5V at 8 A CV/CL Power Supply .....	\$175.00
HP 6448B 600V at 1.5 A CV/CC Power Supply .....	\$850.00
KEITHLEY 240A HV Power Supply, 0-1200V, 0-10 mA, CV/CL .....	\$250.00
SOERENSON DCR 110-45T 110V at 45 A CV/CC Power Supply .....	\$2,200.00
SOERENSON DCR 300-6B 300V at 6 A CV/CC .....	\$950.00
Power Supply, 120VAC 30 A line	
SOERENSON DCR 300-8A 300V at 8 A CV/CC .....	\$950.00
Power Supply, 208/230VAC line	
SOERENSON SRL 60-80V at 8 A CV/CC Power Supply, low noise .....	\$950.00
TEK PS501-1 Power Supply, 0-20V, 2 mV res., .....	\$175.00
400 mA, TM500 series	

### MULTIPLE OUTPUT

HP 6227B Dual 25V at 2 A CV/CC Power Supply, tracking .....	\$550.00
HP 6253A Dual Output 20V 3 A CV/CC Power Supply .....	\$500.00
HP 6255A Dual Output 40V 1.5 A CV/CC Power Supply .....	\$500.00
TEK PS5010 Programmable Triple Power Supply, TM5000 series .....	\$800.00

### MISCELLANEOUS

HP 59501A HPIB Isolated DAC/Power Supply Programmer .....	\$175.00
HP 6824A Bipolar Power Supply/Amplifier, to 50V, 1 A .....	\$400.00
HP 6827A Bipolar Power Supply/Amplifier, to 100V, 500 mA .....	\$800.00
KEPCO BOP-100-4M 100V, 4 A Four .....	\$1,000.00
Quadrant Bipolar Supply / Amplifier	

## TIME & FREQUENCY

### UNIVERSAL COUNTERS

HP 5314A 100 MHz/100 nS Universal Counter .....	\$225.00
HP 5315A-001 100 MHz/100 nS Universal Counter, TCXO reference .....	\$650.00
HP 5315A-001,003 100 MHz/100 nS .....	\$800.00
Universal Counter, TCXO, 1 GHz C-channel	
HP 5316A-003 100 MHz/100 nS Universal Counter, .....	\$1,000.00
HPIB, 1 GHz C-channel	
HP 5316A-003,006 100 MHz/100 nS Counter, .....	\$1,100.00
1 GHz C-ch., offset/normalize	
HP 5316B 100 MHz/100 nS Universal Counter, HPIB .....	\$950.00
HP 5335A 200 MHz Universal / Statistical Counter .....	\$1,500.00
HP E1420A-010,030VXI card 200 MHz/2 nS .....	\$900.00
Univ. Counter, TCXO & 2.5 GHz C-ch	
PHILIPS PM665A/056 120 MHz/2 nS .....	\$850.00
Programmable High Res. Counter, OCXO, GPIB	
RACAL-DANA 1992-04, 55 100 MHz/1 nS .....	\$850.00
Univ. Counter, 1.3 GHz C-channel, OCXO, GPIB	
TEK DC5004 Programmable 100 MHz/100nS .....	\$350.00
Counter/Timer, TM5000 series	
TEK DC5009 Programmable 135 MHz .....	\$600.00
Univ. Counter/Timer, TM5000 series	
TEK DC5010 350 MHz/3.125 nS Univ. Counter, TM5000 series .....	\$1,000.00
TEK DC503A 125 MHz Universal Counter/Timer, TM500 series .....	\$450.00
TEK DC509 135 MHz High Resolution .....	\$550.00
Universal Counter/Timer, TM500	

### FREQUENCY COUNTERS

EIP 575 18 GHz Source Locking Counter, GPIB .....	\$3,250.00
EIP 578-opt.02, 06 26.5 GHz Source Locking .....	\$7,500.00
Counter, power meter & MMW opt's	
FLUKE 7220A-opt.01 111.1 3 GHz .....	\$650.00
Communications Counter, TCXO option	
HP 5305B/5300B-001 1.3 GHz Counter .....	\$450.00
Package w/TCXO ref., high res. audio	
HP 5340A-001,011 18 Hz Frequency .....	\$1,900.00
Counter, OCXO reference, HPIB	
HP 5340A-005,011 23 GHz Frequency Counter, HPIB .....	\$2,000.00
HP 5342A 18 GHz Frequency Counter .....	\$2,350.00
HP 5342A-001,011 18 GHz Frequency .....	\$2,750.00
Counter, OCXO, HPIB	
HP 5342A-003,011 18 GHz Freq. Counter, .....	\$2,750.00
+22 dBm, -20 dBm dynamic range, HPIB	
HP 5342A-01,04,05,11 24 GHz .....	\$3,900.00
Frequency Counter, OCXO, DAC, and HPIB	
HP 5382A 225 MHz Frequency Counter .....	\$200.00





# 90 DAY WARRANTY PARTS AND LABOR • 10 DAY INSPECTION TEST EQUIPMENT WANTED CALL OR FAX LIST • OPEN ACCOUNTS



## STANDARDS

HP 105A Quartz Oscillator, 0.1/1.0/5.0 MHz	\$750.00
HP 5087A-031 Distribution Amp.	\$1,250.00
0.1/1.0/5.0 MHz x 4 channels each	
HP 5359A Time Synthesizer, pulse width 5 nS-160 mS, jitter <200pS	\$2,000.00

## AUDIO & BASEBAND

### SPECTRUM ANALYZERS

HP 8556A LF Section, 20 Hz-300 kHz	\$500.00
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### DISTORTION ANALYZERS

HP 334A Distortion Analyzer, 5 Hz-600 kHz, -60 dB, auto nulling	\$550.00
HP 339A Distortion Analyzer, built-in low distortion osc.	\$2,400.00
TEK DA4084 Programmable Distortion Analyzer, 0.0025% THD, w/frame	\$1,500.00

### RMS VOLTMETERS

FLUKE 8920A True RMS Voltmeter, 180 uV-700V, 10 Hz-20 MHz	\$700.00
FLUKE 8921A True RMS Voltmeter, 180 uV-700V, 2 Hz-2 MHz	\$700.00
HP 3400A RMS Voltmeter, 10 Hz-10 MHz	\$250.00
HP 400FL AC Voltmeter, 100 uV-300V f.s., 20 Hz-4 MHz	\$200.00

### OSCILLATORS

FLUKE 8011A Synthesized Generator, 10 Hz-11 MHz, 10 Hz res.	\$1,200.00
HP 204D Oscillator, 5 Hz-1.2 MHz, 5V RMS, 80 dB step attenuator	\$200.00
HP 209A Sine/Square Wave Generator, 4 Hz-2 MHz, 5V RMS max.	\$225.00
HP 652A Test Oscillator, 10 Hz-10 MHz	\$300.00
ROCKLAND 5100 Synthesizer, 1 mHz-1.999999999 MHz	\$350.00
TEK 067-0938-00 Calibration Fixture, for SG505 Oscillator	\$500.00
TEK SG502 Sine/Square Osc.	\$350.00
5 Hz-500 kHz, 70 dB step atten., TM500	
TEK SG505-opt.01 Low Distortion Oscillator, 10 Hz-100 kHz, intermod.opt.	\$1,000.00

### MISCELLANEOUS

HP 3575A-001 Phase-Gain Meter, 1 Hz-13 MHz, dual display	\$900.00
HP 4437A Step Attenuator, 0-119.9 dB, DC-1 MHz, 600 ohms unbal.	\$200.00
KROHN-HITE 3202/3202R Dual High-Pass/Low-Pass Filter, 20 Hz-2 MHz, 24 dB/oct	\$600.00
KROHN-HITE 3342 Dual HP/LP Filter, 0.001 Hz-99.9 kHz, 48 dB/octave	\$1,100.00
KROHN-HITE 3750 LP/HP/BP/BR Filter, 0.02 Hz-20 kHz, 61/21/18/24 dB/oct	\$700.00
ROCKLAND 852 Dual Highpass/Lowpass Filter, 0.1 Hz-111 kHz	\$1,000.00
TEK AM502 Differential Amplifier, 0.1 Hz-1 MHz, TM500 series	\$575.00

## RF & MICROWAVE

### SPECTRUM ANALYZERS

HP 11517A/18A/19A/20A Mixer, 12.4-40 GHz, w/adapters, for 8555A, 8565A, etc.	\$675.00
HP 11970A/WR28 Harmonic Mixer, 26.5-40 GHz	\$1,100.00
HP 11970Q/WR22 Harmonic Mixer, 33-50 GHz	\$1,400.00
HP 11970U/WR19 Harmonic Mixer, 40-60 GHz	\$1,400.00
HP 11971A/WR28 Harmonic Mixer, 26.5-40.0 GHz, for 8569B	\$1,100.00
HP 11971K/WR42 Harmonic Mixer, 18.0-26.5 GHz, for 8569B	\$1,100.00
HP 5371A Modulation Domain Analyzer, 125 MHz-500 MHz	\$4,000.00
HP 8406A Comb Generator, 1/10/100 MHz increments, to 5 GHz	\$450.00
HP 8444A Tracking Generator, 0.1-1300 MHz, for 8554B	\$800.00
HP 8444A-059 Tracking Generator, 0.5-1500 MHz, for 8554, 8568, etc.	\$1,500.00
HP 8445B Preselector, 1.8-18.0 GHz, for HP 8555A	\$800.00
HP 8552B IF Section	\$750.00
HP 8553B RF Section, 1 kHz-110 MHz	\$500.00
HP 8554B RF Section, 0.1-1250 MHz	\$800.00
HP 8554B/8552B/141T Spectrum Analyzer, 100 kHz-1250 MHz, 100 Hz resolution	\$2,000.00
HP 8555A RF Section, 0.01-18 GHz	\$950.00
HP 8555A/8552B/141T Spectrum Analyzer System, 10 MHz-18 GHz, 100 Hz res.	\$2,250.00
HP 8555A/8552B/8445/141 As above, w/1.8-18 GHz Preselector, opt.003 freq display	\$3,000.00
HP 8558B/181TR Spectrum Analyzer, 0.1-1500 MHz, 1 kHz res., w/display	\$2,250.00
HP 8559A/853A Spectrum Analyzer, 10 MHz-21 GHz, 1 kHz res., w/display	\$5,500.00
TEK 492-opt.1,2,3 Spectrum Analyzer, 50 kHz-21 GHz, 100 Hz min.res.bw	\$8,000.00
TEK 496P Spectrum Analyzer, 10 kHz-1.8 GHz, 30 Hz res., GPIB	\$5,500.00
TEK 7L13/7613 Spectrum Analyzer, 1 kHz-1.8 GHz, 30 Hz min.res., w/frame	\$2,250.00
TEK TR503 Tracking Generator, 0.1-1800 MHz, for 492/4/5/6	\$1,375.00

### NETWORK ANALYZERS

HP 11590A Bias Network, 1.0-12.4 GHz, N(f/f)	\$375.00
HP 11590A-001 Bias Network, 1.0-18.0 GHz, APC7	\$450.00
HP 11665B Modulator, 0.15-18.0 GHz, for use with 8755/6/7	\$375.00
HP 11666A Reflectometer Bridge, 0.04-18 GHz, for 8755/8756	\$1,200.00
HP 8407A/8412A/8601A Network Analyzer, 100 kHz-110 MHz, with sweep generator	\$1,250.00
HP 85027E Directional Bridge, 10 MHz-26.5 GHz, for 8757 series	\$2,000.00
HP 85050D APC7 Calibration Kit, for 8510 series	\$1,100.00
HP 8505A-005/8503A Network An., 0.5-1300 MHz, w/S-Parameter & phase lock	\$5,000.00
HP 8755C(3)/11664A/182T Scalar Network An. w/3 detectors, 10 MHz-18 GHz & frame	\$1,750.00
HP 8756A(3)/11664A Scalar Network Analyzer,	\$3,750.00

w/(3) detectors, 0.01-18 GHz	
NARDA 7000A/7202/7206 Microwave Multimeter System: scalar analysis 0.1-18 GHz	\$1,950.00
WILTRON 640/G50/E(2)/7850(2) Network An., w/1-1500 MHz source, (2) log amp, (2) det.	\$1,675.00

### SIGNAL GENERATORS

FLUKE 6060A/AN Synthesized Signal Gen., 10 kHz-520 MHz, 10 Hz res., GPIB	\$2,000.00
GIGATRONICS 600/10-18, opt.06 Synthesized Source, 10-18 GHz, 1 MHz res., OCXO, GPIB	\$3,000.00
GIGATRONICS 605/01-8-0, opt.3 Synthesized Source, 10 MHz-8 GHz, 1 kHz res., GPIB	\$3,000.00
GIGATRONICS 875/50 Levelled Multiplier, x4, 50.0-75.0 GHz output, -3 dBm	\$3,500.00
GIGATRONICS 875/86 Levelled Multiplier, 26.5-40.0 & 50.0-75.0 GHz outputs	\$7,000.00
GIGATRONICS 910/12-18, opt.6, 14.16 Synthesized Source/Sweeper, 12-18 GHz, 1 Hz res., OCXO	\$3,500.00
HP 85100V Frequency Mult., 10-15 GHz in/50-75 GHz out >0 dBm	\$4,250.00
HP 8616A Signal Generator, 1.8-4.5 GHz	\$450.00
HP 8640B-001,002,003 Signal Gen. 0.5-1024 MHz, AM, FM, var. audio osc.	\$2,750.00
HP 8654A Signal Generator, 10-520 MHz, calibrated AM & uncal. FM	\$625.00
HP 8656A Signal Generator, 0.1-990 MHz, AM, FM, HP1B	\$2,900.00
HP 8660C/86603A/86632B Synth. Sig. Gen., 1-2600 MHz, AM, FM, digital sweep	\$4,500.00
HP 8672A Synthesized Signal Generator, 2-18 GHz	\$10,000.00
WAVETEK 907 Signal Generator, 7.0-11.0 GHz, 0 dBm levelled	\$1,000.00
WILTRON 6742A Synthesizer/Sweep Generator, 18.0-26.5 & 26.5-40.0 GHz	\$9,000.00

### SWEEP GENERATORS

GIGATRONICS 900/0.05-12, opt.3 Synthesized Sweep/Sig. Gen., 50 MHz-12 GHz, 1 kHz res.	\$4,500.00
HP 8350A/86290B-H08 Programmable Sweep System, 2.0-22.0 GHz, +4 dBm f/d	\$5,500.00
HP 8600A Digital Marker, for HP 8601A	\$400.00
HP 8601A Generator/Sweeper, 0.1-110 MHz, +20 dBm levelled	\$500.00
HP 8620C Sweep Oscillator Frame	\$550.00
HP 8620C-011 Sweep Oscillator Frame, HP1B programmable	\$675.00
HP 86220A RF Plug-in, 10-1300 MHz, +10 dBm levelled	\$800.00
HP 86222B-002 RF Plug-in, 10-2400 MHz, crystal markers, 0-70 dB atten.	\$1,750.00
HP 86230B RF Plug-in, 1.8-4.2 GHz, +10 dBm unlevelled	\$675.00
HP 86240A RF Plug-in, 2.0-8.4 GHz, +16 dBm levelled	\$1,000.00
HP 86240A-002 RF Plug-in, 2.0-8.4 GHz, +14 dBm lvd., 70 dB step att.	\$1,200.00
HP 86240B RF Plug-in, 2.0-8.4 GHz, +13 dBm levelled	\$1,000.00
HP 86241A-001 RF Plug-in, 3.2-6.5 GHz, +8 dBm levelled	\$500.00
HP 86242D-004, 008 RF Plug-in, 5.9-9.0 GHz, +10 dBm levelled	\$500.00
HP 86245A RF Plug-in, 5.9-12.4 GHz, +16 dBm levelled	\$1,100.00
HP 86260A RF Plug-in, 12.0-18.0 GHz, +10 dBm unlevelled	\$800.00
HP 86260A-H04 RF Plug-in, 10.0-15.0 GHz, +10 dBm unlevelled	\$800.00
HP 86290A RF Plug-in, 2.0-18.0 GHz, +7 dBm levelled	\$1,750.00
HP 86290B RF Plug-in, 2.0-18.6 GHz, +10 dBm levelled	\$2,250.00
HP 86290C RF Plug-in, 2.0-18.6 GHz, +13 dBm levelled	\$2,500.00
WAVETEK 962 Sweep Generator, 1.0-4.0 GHz, markers, +12 dBm unlvld.	\$2,000.00
WILTRON 6647A-04,02 Sweep Gen., 0.01-18.6 GHz, +14 dBm levelled, 70 dB atten.	\$6,500.00

### POWER METERS

ANRITSU MP-81BWR10 Power Sensor, 75-110 GHz, for ML83A or ML4803A	\$1,875.00
ANRITSU MP-82BWR8 (Pin Flange) 90-140 GHz Power Sensor	\$2,500.00
BOONTON 4200-01B/4G Power Meter w/sensor, 1 MHz-26.5 GHz, -60 to +10 dBm, GPIB	\$1,500.00
BOONTON 42B/41-4E Analog Power Meter, with 1 MHz-18 GHz sensor	\$500.00
BOONTON 42B/42A-S3 Analog Power Meter, with 1 MHz-8.4 GHz N(f) sensor	\$375.00
GENERAL MICROWAVE 476/4240A Power Meter & Sensor, 0.01-18 GHz, -35 to +10 dBm	\$375.00
HP 11683A Range Calibrator, for HP 435/6/7/8	\$750.00
HP 432A/8478B Power Meter, 0.01-18 GHz, -20 to +10 dBm f.s.	\$500.00
HP 432C Autoranging Digital Power Meter, 10 uW-10 mW f.s.	\$425.00
HP 435A/8481A Power Meter, 10 MHz-18 GHz, -30 to +20 dBm	\$1,000.00
HP 435A/8482H Power Meter, 0.1-4200 MHz, -15 to +34 dBm	\$1,150.00
HP 435A/8483A Power Meter, 0.1-2000 MHz, -30 to +20 dBm, 75 ohms	\$1,000.00
HP 435A/8484A Power Meter, 10 MHz-18 GHz, -70 to -20 dBm	\$1,000.00
HP 436A-022 Digital Power Meter, HP1B option	\$1,400.00
HP K486A/WR42 Thermistor Mount, 18.0-26.5 GHz, for 432 series	\$400.00
HP Q8486A Power Sensor, 33.0-50.0 GHz, WR22, for 435/6/7/8	\$1,500.00
HP R486A/WR28 Thermistor Mount, 26.5-40.0 GHz, for 432 series	\$400.00

### RF MILLIVOLT METERS

RACAL 9303 TRMS Level Meter, 12-20 GHz-2 GHz, -77 to +23 dBm, GPIB	\$875.00
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### AMPLIFIERS, MISCELLANEOUS

ALITECH 7618E Noise Source, 10 MHz-18 GHz, SMA(m), 15 dB ENR	\$500.00
BOONTON 82AD FM/AM Modulation Meter, 10-1200 MHz	\$800.00
HP 11715A AM/FM Test Source, 11-13.5/88-108/352-432 MHz	\$1,375.00
HP 11720A Pulse Modulator, 2-18 GHz, >80 dB on/off ratio	\$950.00
HP 8447A-001 Dual Amplifier, 0.1-400 MHz	\$500.00

HP 8901A-002,010 Modulation Analyzer, 150 kHz-1300 MHz, OCXO, int. cal.	\$5,500.00
HUGHES 1177H02R000 TWT Amplifier, 30 dB, 4-8 GHz, 10 Watts	\$1,750.00
M.P.D. LAB2-1020-2A Amplifier, 34 dB, 1.0-2.0 GHz, 2 Watts	\$800.00
M.P.D. LAB2-714-3A Amplifier, 34 dB, 0.7-1.4 GHz, 3 Watts	\$800.00
MARCONITF2304 AM/FM Modulation Meter, 18-1000 MHz, FM dev. 1.5-150 kHz	\$500.00
MICROWAVE SEMI.CORP MC5112 Noise Source, 25.5 dB ENR, 1.0-12.4 GHz, N(m), +28VDC	\$325.00

## COAXIAL & WAVEGUIDE

AMERICAN NUCLEONICS AM-432 Cavity Backed Spiral Antenna, LHC, 2-18 GHz, TNC(f) "NEW"	\$95.00
FXR/MICROLAB S3-02N Triple Stub Tuner, 200-1000 MHz, 100 Watts max., N(m/f)	\$90.00
GR 874-LT Constant Impedance Trombone Line, 0-44 cm, DC-2 GHz	\$450.00
GR 900-Q GR900 14mm Inlet Series Adapters	\$125.00
HP 11691D Directional Coupler, 22 dB, 2-18 GHz	\$450.00
HP 11692D Dual Directional Coupler, 22 dB, 2-18 GHz	\$800.00
HP 7750 Dual Directional Coupler, 20 dB, 450-940 MHz	\$275.00
HP 7760 Dual Directional Coupler, 20 dB, 940-1900 MHz	\$275.00
HP 7770 Dual Directional Coupler, 20 dB, 1.9-4.1 GHz	\$275.00
HP 7780 Dual Dir. Coupler, 20 dB, 100-2000 MHz, N(m/f/f/f)	\$550.00
HP 7780-011 Dual Dir. Coupler, 20 dB, 100-2000 MHz, APC7/N(f/f/f)	\$400.00
HP 8472A Crystal Detector, 10 MHz-18 GHz, neg. pol., SMA(m)	\$150.00
HP 8497K-004 Programmable Step Atten., 0-90 dB, DC-26.5 GHz, APC3.5	\$750.00
HP 8498A-030 30 dB Attenuator, 25 Watts, DC-18 GHz, N(m/f)	\$600.00
HP K422A/WR42 Flat Broadband Detector, 18.0-26.5 GHz	\$350.00
HP K532A/WR42 Frequency Meter, 18.0-26.5 GHz	\$500.00
HP Q752D/WR22 Directional Coupler, 20 dB, 33-50 GHz	\$650.00
HP R375A/WR28 Variable Attenuator, 0-20 dB, 26.5-40 GHz	\$375.00
HP R422A/WR28 Flat Broadband Detector, 26.5-40 GHz	\$400.00
HP R532A/WR28 Frequency Meter, 26.5-40.0 GHz	\$500.00
HP R914B/WR28 Moving Load, 26.5-40 GHz	\$300.00
M/A-COM 3-19-300/10WR19 Directional Coupler, 10 dB, 40-60 GHz	\$450.00
NARDA 26298 20 dB Attenuator, 150 Watts, DC-1 GHz, N(f/f)	\$200.00
NARDA 3000-SERIES Directional Couplers	\$150.00
NARDA 3090-SERIES Precision High Directivity Couplers	\$225.00
NARDA 369BNF/369BN High Power Termination, 175 Watts, 0.7-18 GHz, N	\$325.00
NARDA 3752 Coaxial Phase Shifter, 0-180 deg./GHz, 1-5 GHz	\$1,250.00
NARDA 4000-SERIES SMA Miniature Directional Couplers	\$75.00
NARDA 4203-6 Directional Coupler, 6 dB, 2-18 GHz, SMA(f/f/f)	\$225.00
NARDA 4246B-10 Directional Coupler, 10 dB, 6-18 GHz, SMA(f)	\$100.00
NARDA 4317-2 Power Divider, 18.0-26.5 GHz, 3.5mm	\$175.00
NARDA 5070-SERIES Precision Reflectometer Couplers	\$300.00
NARDA 765-20 20 dB Attenuator, 50 Watts, DC-5 GHz, N(m/f)	\$135.00
NARDA 768-20 20 dB Attenuator, 20 Watts, DC-11 GHz, N(m/f)	\$125.00
NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz	\$375.00
PAMTECH KYG 1014/WR42 Junction Circulator, 18.0-26.5 GHz	\$250.00
SPACEK LABS Q-1 WR22 Flat Broadband Detector, 33-50 GHz	\$550.00
TRGV510WR15 Precision Rotary Vane Atten., 0-50 dB, 50-75 GHz	\$1,000.00
TRGV551WR15 Frequency Meter, 50-75 GHz	\$600.00
TRGV559-10WR15 Directional Coupler, 10 dB, 50-75 GHz	\$400.00
TRGV510WR10 Precision Rotary Vane Atten., 0-50 dB, 75-110 GHz	\$1,000.00
TRGV551 WR10 Frequency Meter, 75-110 GHz	\$900.00
WILTRON 60NF50 SWR Bridge, 5-2000 MHz, N(f) test port, 40 dB dir.	\$475.00
WILTRON 87A50VSWR Bridge, 2-18 GHz, 35 dB dir., APC7 test port	\$750.00

## LOGIC

HP 5005A Signature Multimeter	\$350.00
HP 8170A-002 Logic Pattern Generator, 2 MB/s, address driver option	\$1,200.00
TEK 1240 Logic Analyzer, w/(36) 50 MHz channels	\$1,500.00

## COMMUNICATIONS

HP 4972A/18182A LAN Protocol Analyzer, with software	\$2,500.00
HP 59401A HP1B Bus Analyzer	\$700.00
TEK 1410R-opt.04 NTSC Test Signal Gen. w/SPG2, TSG1, TSP1, TSG3, TSG5, TSG6	\$2,750.00
TEK 1411R-opt.04 PAL Test Signal Gen. w/SPG12, TSG11, TSP11, TSG13, TSG15, TSG16	\$2,750.00
TEK 144 NTSC Test Signal Generator	\$675.00
TEK 147A NTSC Test Signal Generator, with noise test signal	\$800.00
TEK 520A NTSC Vectorscope	\$1,200.00

## MISCELLANEOUS

P.A.R. 5202 Two-Phase Lock-In Amplifier, 0.1-50 MHz	\$3,000.00
P.A.R. 5205-94, 95, 96, 98 Lock-In Amp, 20 Hz-20 kHz, int. osc., intlog, GPIB	\$2,750.00
P.A.R. 5206 Two-Phase Lock-In Amplifier, 2 Hz-200 kHz	\$2,500.00
P.A.R. 5208-92, 94, 97, 98 Two Phase Lock-In Amp., 5 Hz-20 kHz or 200 kHz, GPIB	\$3,250.00
TEK TM5006 5000-series 6-slit Programmable Power Module	\$600.00
TEK TM503 500-series 3-slit Power Module	\$175.00
TEK TM504 500-series 4-slit Power Module	\$175.00
TEK TM506 500-series 6-slit Power Module	\$250.00
TEK TM515 500-series 5-slit Traveller Power Module	\$275.00



Preserve  
Your  
Sanity!

### PHONE LINE MANAGER

Better than Caller ID! This device detects an incoming call. If you subscribe to caller ID, the unit will automatically receive and display the caller's telephone number. If not, the unit will ask the caller to enter their telephone or personal ID number. The device will then display and compare this telephone or personal ID number to a memory bank of numbers that you've installed. If the system finds a match your phone will ring. If the system does NOT find a match, the caller will be directed to leave a message. All messages are digitally recorded. No tape or answering machine necessary. New, in factory cartons, with documentation.

96U001 \$59.95 each

### PRECISION EYEPiece

21mm f:3.5. Four coated glass lenses in black aluminum case measuring 1.15625" long by 1.0" diameter. Excellent correction of all aberrations for an angle of 35° without vignetting. Resolution in focus is 385 lines/mm when the image of object is in focus (D=6mm), or 500 lines/mm when object is in focus (numerical aperture 1.41). Possible applications include: objective lens for scanners; photographic objective enlarging nearly 10X; objective for a handheld microscope, enlarging from 30X to 120X (numerical aperture=1.41); lens working with light sensor or emitter as a precise focusing element; or lens for shaping a laser beam.

92L031 \$12.50 each

### SUPER- POWERFUL MAGNET ASSEMBLY

Two magnets approx 1.75" x 2.25" mounted in a metal frame. Strength is approx. 1300 Gauss each. These magnets are epoxied in place and are not easily removed. Makes excellent clamping/holding assembly.

92N001 \$15.95 Pair

### HEAVY DUTY INSTRUMENT CASE

Unit splits apart for ease of access. Self-adhesive feet and screws included. ABS plastic used for flexibility and strength. Grey body complete with black front and rear panels. IC115B includes ventilation slots and speaker recess.

Order #	Price	Dimensions (HxWxD)
IC115A	6.20	2.5" x 8" x 6.4"
IC115B	8.20	3.1" x 10" x 7.4"

### LASER POINTER

This solid-state laser emits a red light up to 5mW at 670nm that will produce a spot on objects up to 100 ft. away. Use as a pointer/instructional aide, tease your cat, or use as a sight for your peashooter. Buy two so you and a friend can have lightsaber battles on foggy nights. Runs on two AAA cells and comes in a hard, protective case. Batteries included.

94L007 \$49.95 each

### LIQUID CRYSTAL SHUTTER/ VARIABLE DENSITY FILTER

0.5" x 1.625" active area. 0% to 23% transmission. Switching rate up to 4 KHz. Specs included.

92L012 Only \$9.95 each

### MINIATURE TOGGLE SWITCHES

Specifications:  
• Contact rating: 6A @ 125VAC,  
3A @ 250 VAC  
• Mounting hole: 0.25"

Order #	Price	Action	Type	Wt.
CT21	1.09	On/-/On	SPDT	0.1 oz.
CT24	1.39	On/-/On	DPDT	0.2 oz.

### 12VDC 140mA BRUSHLESS FAN

3.125" square by 1" thick.

94F001 \$2.99 each

### 9 VDC 500 mA WALLWART

Center negative co-axial connector.

96E008 \$4.95

### AIRPAX STEPPER MOTOR

12 Volt, 15°/step, 2.125" diameter by 0.875" deep.

95M003 \$3.95 each

### INTERNAL SCSI CABLE

50-conductor ribbon cable, 29" long. Will allow connection to two SCSI hard drives.

94C014 \$4.95 each

### 12" SCSI CABLES

For external cases. Two 50-pin Centronics female, one IDS50 connectors.

96W003 \$2.95 each

### UHF LINEAR AMPLIFIER

For 870-895MHz. 45W output. 1 Watt input. VCC 20 to 30 VDC @ 6 A. Class A, low intermodulation distortion. New, with spec sheets.

96A003 \$149.00 each

### 3" SPEAKER

6 Ohm speaker with heavy magnet and foam-edged paper cone.

95V015 \$4.95

### STANDOFF ASSORTMENT

Popular sizes and styles used in electronics.

92J007 100 for \$4.95

### CAPACITORS BY THE POUND

Lytics, tants, discs, computer grade. A good variety of all kinds of caps.

92P088 5 Lbs. for \$5.00

### TRANSISTORS!

MTH35N05 - MTH7N50  
Your Choice \$2.49 each

### BI-COLOR LED

Red/green, 3 lead, common cathode 5/32" (4mm) square flat top. Shown actual size.

SE57122C 79¢ each

### ULTRA BRIGHT LED!

T1-3/4 yellow, 2000 MCD. Shown actual size.

SE5034H 69¢ each

### EXTRA-BRIGHT FLASHING RED LED

T1-3/4 size, 750 mcd, 3-12 VDC, water clear

SE5012G 69¢ each

### TIP110 TRANSISTOR

2A, NPN Darlington.

49¢ each - 100 for \$39.95

94S003 1000 for \$250.00

### STEPPER MOTOR DRIVER IC

UCN5804. Drives a unipolar stepper in one of three operating modes: single phase, two phase or half step. Up to 1.25 Amps per phase. Step and direction input. Drive with a 555 oscillator, parallel port, etc. Build your own robot turntable for model trains, anything that requires precision positioning.

93I002 \$4.50 each

• Above, packaged with 5V stepper motor (92M010) and schematics.

93I003 \$9.95 each



### CYBERSAUCE - Virtual Pain

At 120,000 Scoville units your tongue's gonna think somebody dropped an overheated Pentium on it. Stir a drop or two in your bloody mary. Dip a fork in it and stab your scrambled eggs. That's enough. This stuff ain't for wimmin, sissies, or little kids. Never joke with it. If you don't kaphis 120,000 Scoville let's put it this way: a hot bottle of Tabasco is about 50 Scoville. 5 fl. oz. (150 ml) bottle.

96U006 \$6.95 each

### MINIATURE C-BAND LNB

Low-noise block converter. Better than 40°K noise temperature. Spec sheet included.

94G001 \$49.95

### UHF LINEAR AMPLIFIER

890 to 940 MHz. Gain: 17dB. Bias: 18V @ 100mA. Used in cellular communications equipment.

96V001 \$14.95 each

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# Using The IC Voltage Comparator

From time to time, we will look at particular classes of circuit, especially those that are useful in electronic instrumentation circuits, and the analog front-ends of digital electronic instruments. This month, we will look at the voltage comparator.

A voltage comparator is basically an operational amplifier that has no negative feedback network (Figure 1A). The open-loop gain (i.e., no feedback gain) of the operational amplifier is very large, being on the order of 200,000 to 300,000 for many common devices, and over 1,000,000 for some premium devices. Thus, with no negative feedback, the operational amplifier functions as a very high-gain DC amplifier with an output that saturates at a very tiny input potential. A few microvolts or millivolts of differential input voltage (depending on the circuit) is enough to saturate the op-amp.

So what use is an amplifier that saturates with only a few microvolts of input signal voltage? Such an amplifier can be used as a voltage comparator. The voltage comparator is used to compare two input voltages and issue an output signal that indicates their relationship ( $V_1 = V_2$ ,  $V_1 > V_2$ , or  $V_1 < V_2$ ). In Figure 1A, potential  $V_1$  is applied to the inverting input, and  $V_2$  is applied to the noninverting input. If  $V_1 = V_2$ , then  $V_o = 0$ . Otherwise, the output voltage obeys the relationships shown in Figure 1B, which is the transfer function of the comparator. According to the normal rules for operational amplifiers, making  $V_1$  larger than  $V_2$  (see Figure 1A) looks like a positive input to the inverting input, so the output potential is saturated just below  $V_-$ . Alternatively, when  $V_1$  is smaller than  $V_2$ , it looks like a negative input potential, so the output is saturated just below  $V_+$ .

In Figure 1B, there is a small hysteresis band around zero where no output changes

occur. This is an unfortunate defect in practical operational amplifiers. It is possible to measure the hysteresis of operational amplifiers and IC comparators in a laboratory experiment.

In one experiment involving operational amplifier and IC comparator (LM-311) devices, hysteresis bands of 1 to 25 mV were found. Not surprisingly, the low-cost 741-family of operational amplifiers had high hysteresis levels (on the order of 25 mV). The LM-311 devices had 8 to 10 mV hysteresis. Certain other devices had 10 to 20 mV of hysteresis.

The overall best device in the experiment was the CA-3140, a BiMOS operational amplifier. The CA-3140 device uses the industry standard "741" pinouts:

FUNCTION	PIN NO.
-IN	2
+IN	3
OUT	6
$V_-$	4
$V_+$	7

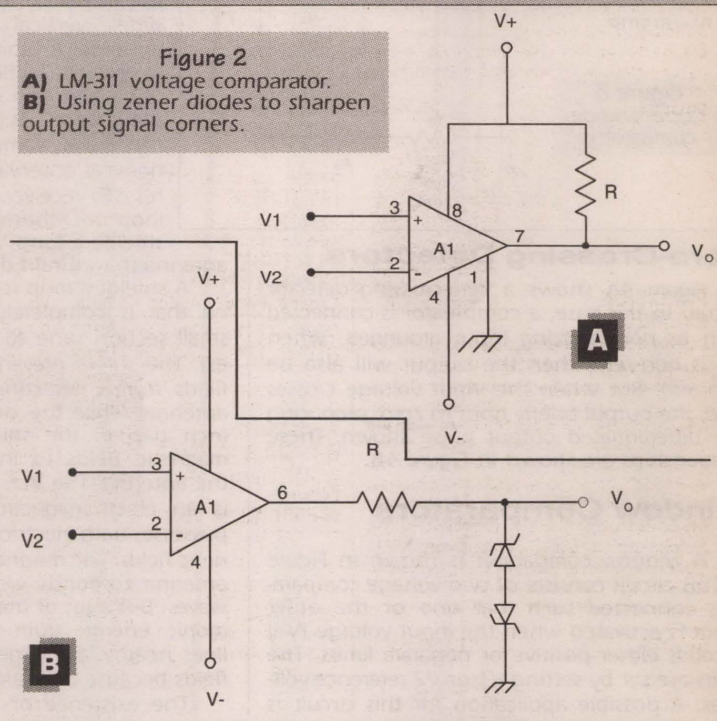
The LM-311 device (Figure 2A) is a low-cost voltage comparator in IC form. Although based internally on op-amp circuitry, this device is specifically designed as a voltage comparator. It has a ground terminal (pin 1), contrary to op-amp practice, and requires an output pull-up resistor (R) to a positive power supply voltage. The output terminal can drive loads such as relay coils, lamps, and LEDs operated at potentials up to 40 to 50 volts (depending upon category of device) and current loads of 50 milliamperes. If the LM-311 is operated to be compatible with TTL digital logic, then the pull-up resistor is terminated in a +5 VDC potential, and usually has a value of 1.5 to 3.3 kohms.

A means for limiting the output level, improving the sharpness of the transfer function corners (see Figure 1B), and improving speed by reducing latch-up problems, is shown in Figure 2B. In this circuit, a pair of back-to-back zener diodes are connected across the output line. When the output voltage is HIGH, it is limited to  $V_{z1} + 0.7$  volts; and when LOW, it

# Open Channel

by Joseph J. Carr  
K4IPV

**Figure 2**  
**A)** LM-311 voltage comparator.  
**B)** Using zener diodes to sharpen output signal corners.

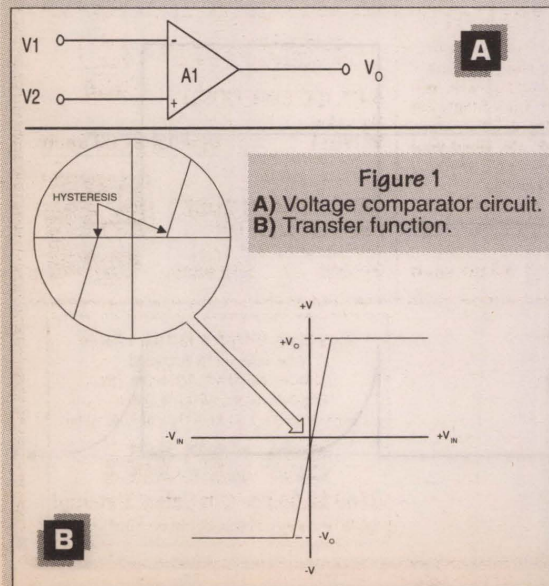


is limited to  $V_{z2} + 0.7$  volts. These potentials represent the reverse bias zener voltages of D1 and D2, plus the normal forward bias voltage drop of the other diode (which is forward biased).

## Current Mode Comparator

Figure 3 shows two comparator circuit techniques applied to the same circuit. One technique is a zero offset control used to reduce the effects of the hysteresis band, while the other technique is the current mode configuration. The offset control (R4) biases one input to a small, but non-zero level so that it is ready to trip when the other input is also non-zero. In this particular case, the non-inverting input is grounded ( $V_2 = 0$ ), but could as easily be connected to a non-zero voltage.

Current mode operation is usually faster and less prone to latch-up than voltage mode operation. For this reason, current mode comparators are sometimes used in high speed analog-to-digital converters (A/D). Assume that the noninverting input is grounded. In this case, the output potential  $V_o$  will reflect the relationship of the two currents. If  $I_1 = I_2$ , then  $V_o = 0$ . This circuit is, to the outside observer, a voltage comparator in that  $I_1 = V_1/R_1$  and  $I_2 = V_2/R_2$ . Of course, the circuit is also useful for accommodating current output devices such as the LM-334 temperature monitor IC, as well as voltages as shown.





# Open Channel

age meets both criteria.

## Other Matters

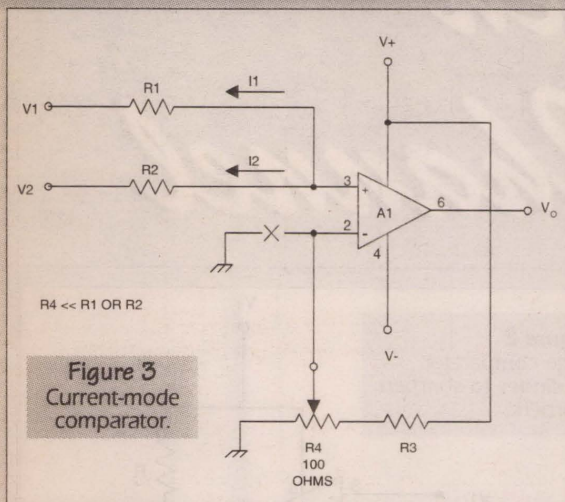
Now let's take a look at some other matters. One reader wrote to me via E-Mail and asked about the use of shielded loop antennas in VLF receivers. We've discussed VLF receivers operating in the 15 to 35 KHz region for hunting solar flares and detecting Sudden Ionospheric Disturbances (SIDs). Some people use a simple vertical aluminum pipe for the antenna. A pipe of two to three meters length will suffice. A few have reported using the rain gutter or downspout of their homes. At least one SID hunter uses the metal dome of his backyard astronomical observatory as the antenna for his SID receiver. So why use a shielded loop for these receivers? After all, a shielded loop is a lot more complex

antenna than a rain downspout or metal pole. A shielded loop is a multi-turn loop antenna that is completely shielded except for a

the untuned voltage at the same frequency). *The ARRL Antenna Book*, as well as my own *Practical Antenna Handbook — 2nd Edition*, both give details on how to calculate this inductance. Alternatively, you can order my Windows software LoopMaker (\$20.00) or Antlers (\$30.00). The LoopMaker is used only for loop antennas, while Antlers covers a much wider variety of antennas from VLF through HF bands.

Another reader wrote to ask about a "storm finder" receiver. These were popular many years ago, and a project was published in the ARRL magazine *QST*. The storm finder looks for the RF burst of energy generated when a lightning bolt strikes, and provides directional information to tell where the storm is located. The storm finder antenna consists of a pair of 24-inch loop antennas, similar to the antenna discussed above, set at right angles to each other. For best results, the loops should be interleaved so as to form a cubical structure (even if made from sticks).

The output signals from the loop (which is untuned) are amplified in identical amplifiers,



**Figure 3**  
Current-mode  
comparator.

## Zero-Crossing Detectors

Figure 4A shows a zero-crossing detector circuit. In this case, a comparator is connected with its non-inverting input grounded. When  $V_{in}$  is non-zero, then the output will also be non-zero. But when the input voltage crosses zero, the output briefly goes to zero, producing the differentiated output pulse shown. These relationships are shown in Figure 4B.

## Window Comparators

A window comparator is shown in Figure 5. This circuit consists of two voltage comparators connected such that one or the other input is activated when the input voltage ( $V_{in}$ ) exceeds either positive or negative limits. The limits are set by setting  $V1$  or  $V2$  reference voltages. A possible application for this circuit is alarm systems (for example, over- and under-temperature alarms), and other applications where a range of permissible values exists between two forbidden regions.

An example of an application for the window comparator is the coincidence threshold detector shown in Figure 6; the circuit is shown in Figure 6A, while the operation is shown in Figure 6B. The coincidence threshold detector passes pulses with amplitudes that fall within the upper and lower limits (i.e., the "window"), but rejects pulses outside these limits. One use of this type of circuit is to reject noise and other spurious signals.

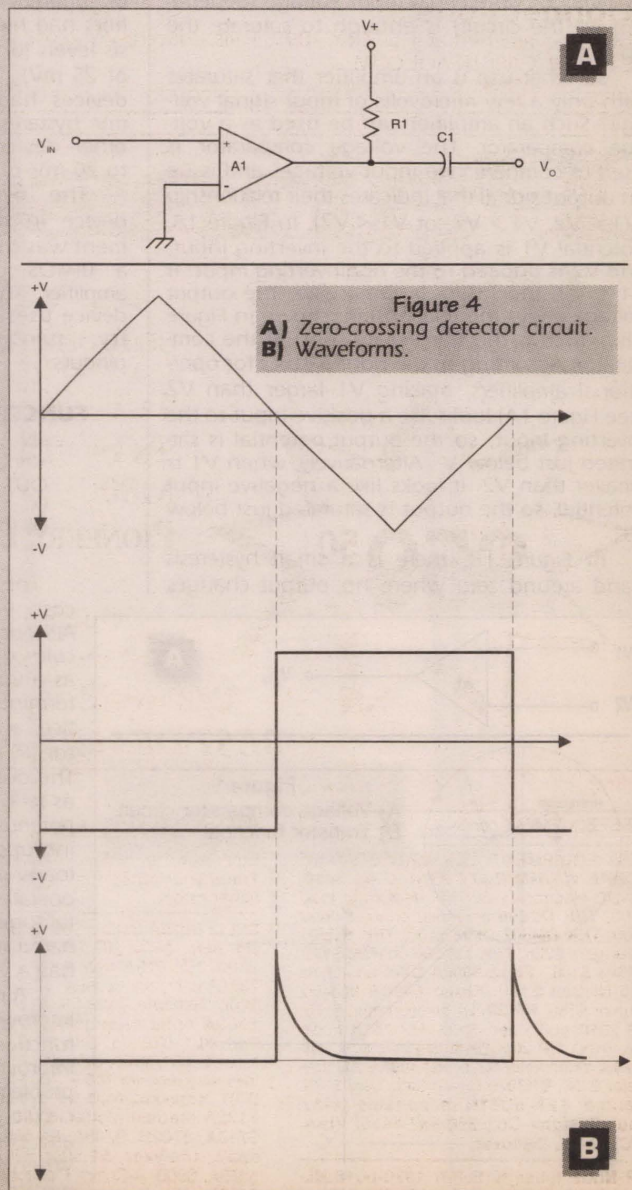
The circuit consists of the window comparator shown earlier, A1 and A2. The voltage levels at which the two comparators trip are set by a pair of potentiometers connected between the  $V+$  power supply and ground. For best results, make  $V+$  a regulated source, and bypass it to ground with at least  $0.1 \mu F$  at the top of each potentiometer. The values of the potentiometers are not critical, and can be anything from 1000 ohms to 100,000 ohms. They should both be the same value, however.

The outputs of the operational amplifiers are fed to an AND gate. The two-input AND gate produces an output if, and only if, BOTH inputs are HIGH. If either input is LOW, then the output of the AND gate is also LOW. The outputs of the comparators are HIGH only when the voltage relationship to the input voltage is correct. Thus, the two inputs of the AND gate are both HIGH only when the input volt-

age meets both criteria. The existence of 60 Hz harmonics doesn't seem to be so much of a big deal on first blush. After all, 15 KHz is a lot higher in the spectrum than 60 Hz, so what's the big deal? Well, it's the high power levels involved in the power mains, combined with the high sensitivity of the VLF receiver, that causes the problem. Even a small percentage of the 60 Hz energy radiating as harmonics is sufficient to interrupt a receiver operating close to the power lines.

For VLF reception, the loop should be 24 to 36 inches on a side if square, or about the same diameter if circular. Use about 50 to 125 turns of wire to form the loop. One approach that I've used is to use 50, 60, or 64 conductor computer ribbon cable to form the loop. Adjacent turns are connected together, forming a continuous loop.

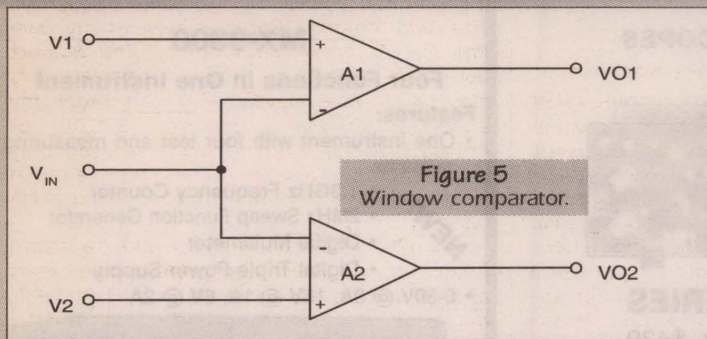
If you want to tune the loop, it's necessary to find the inductance of the loop, and then find a capacitance value to resonate it to the desired frequency. The advantage of tuning the loop is that the output signal is much larger, being increased by the Q of the capacitor (about 100 times



**Figure 4**  
A) Zero-crossing detector circuit.  
B) Waveforms.



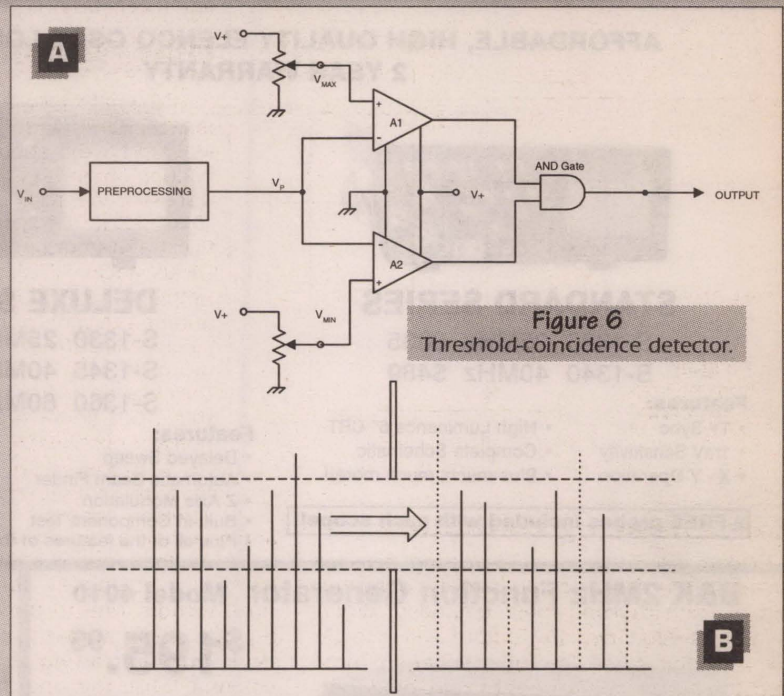
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**Figure 5**  
Window comparator.

and carried to an X-Y oscilloscope through identical lengths of coaxial cable. One loop signal is applied to the X-input of the 'scope, while the other signal is applied to the Y-input. The resulting pattern on the 'scope is a Lissajous figure that shows the direction to the lightning strike. If the 'scope is calibrated using a compass, then you can get the bearing by noting the way the signal is oriented. If you think your

'scope is not an X-Y model, be sure to make sure — look at the vertical controls and see if there is any button marked "X-Y" or "A-B" or something similar. **NV**



**Figure 6**  
Threshold-coincidence detector.

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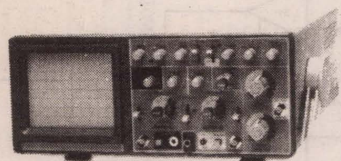
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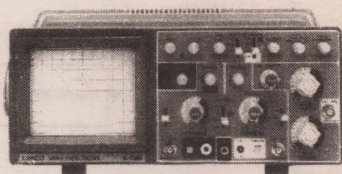
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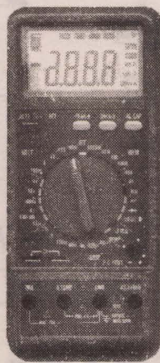


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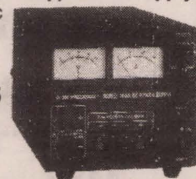


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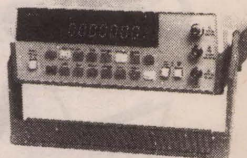
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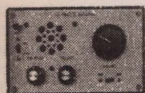
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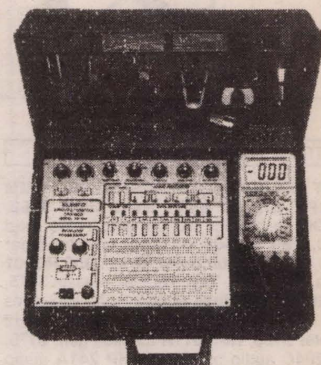
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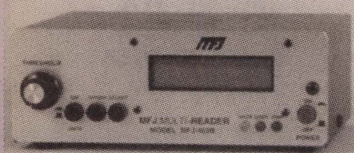
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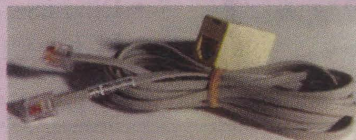
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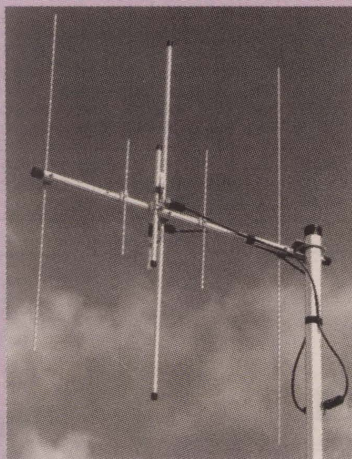
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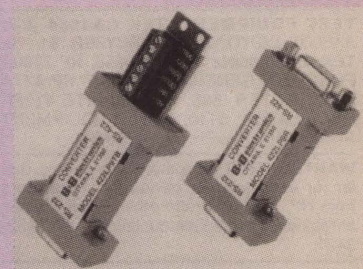
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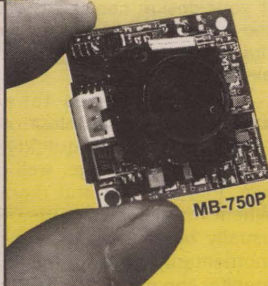
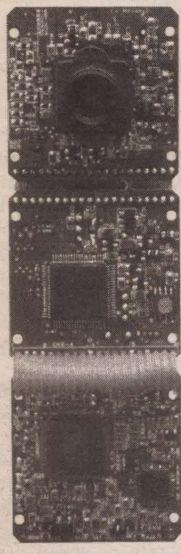
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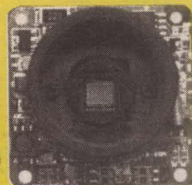
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by Karl Lunt

## Step out with a stepper motor robot

I've never built a stepper motor robotics platform before, but there's never any time like the present. So I asked others in the Seattle Robotics Society (SRS) for some pointers, spent a few evenings in the workshop, and built up the two-tiered machine you see here. I enjoyed the construction, and picked up a few tips that I'd like to pass along.

I'll leave a discussion of stepper motor theory and design to others, and focus instead on building the actual platform. You can find excellent information on steppers through many channels, including a Web search using Alta Vista, or a browse through back issues of the popular electronics magazines, including *Nuts & Volts*. Also check the application notes from major chip makers such as National Semiconductor and SGS-Thomson. These app notes usually include some excellent material on the physics of steppers, as well as info on designing driver electronics.

I approached my platform design from the premise that stepper motors are very much like the usual DC gearhead motors I've used so often before. You bolt them to the chassis, wire them up to a driver board, write some software to give them the electrical signals they want, and your robot goes. As it turns out, this is pretty close to correct, but the differences between steppers and DC gearheads proved interesting.

### Drive that motor

A stepper motor, such as the Vexta PXB44H that I used, consists of a magnetized rotor element that spins within a cylindrical field of alternating electromagnetic coils. When one coil is magnetized, the rotor moves slightly to align itself to the field. If that coil is de-energized and the second coil energized, the rotor again moves slightly, or steps, to realign itself. If the motor's coils are energized rapidly and in sequence, the rotor will rotate around its axis in a series of steps, with each step corresponding to the distance between coils.

This very simplistic explanation shows the major difficulty in using stepper motors. You don't just apply current and watch the motor spin; you have to have some fairly complex driving circuitry. Luckily, owing to the widespread use of steppers, companies such as SGS-Thompson have developed ICs that ease the design of stepper driver boards.

Stepper driver boards come in two major designs: the L/R type and the chopper type. Both designs try to deal with the same problem when supplying voltage to a stepper's coils, namely, forcing the maximum rated current into the coils as quickly as possible. The faster you can get the maximum current into the coils, the sooner you will have full torque available. But the inductance (L) and resistance (R) of the motor's coils combine to place an upper limit on how quickly current can build up at a given voltage.

I'll use the Vexta motor above as an example. The motor runs at a rated 6 VDC. The two coils are center-tapped (the motor has six leads), and the resistance across each full coil is 15 ohms. This means each full coil, when driven by 6 VDC, will pull 0.4 amps.

# AMATEUR ROBOTICS

The motor will show maximum torque when the coils carry the rated current. However, sticking 6 VDC on the coils just locks the motor in place. Remember, to move a stepper, you have to energize its coils in a sequence. This implies a sequence of squarewaves, with 0 VDC (and hence, zero torque) when a coil is off, and 6 VDC (and maximum torque) when a coil is on.

This brings us back to the L and the R. Current does not build up instantly in a coil simply because you switch on the juice. The rate at which the current builds is determined by the L/R constant, where L is the coil's inductance in henrys, and R is its resistance in ohms. For a full explanation of this relationship, refer to any copy of the *ARRL Handbook*.

For now, I'll stay with a general discussion of the problem. You want to bring the current in the

efficiency, with half of the applied power going into the coils and the other half into the air as heat. As you boost the resistance of the series resistor, the efficiency drops accordingly. An L/4R driver board in our example would use 45-ohm resistors, require 24 VDC to reach rated current, and dissipate a whopping 7.2 watts per resistor. This yields an efficiency of just 25%.

This characteristically low efficiency makes the L/R design a true bow-wow for robotics. Most robots have enough problems hauling batteries around to let them run at all, without having to carry extra juice just to run the onboard room heater.

Besides the obvious problems with efficiency, this example points out another weakness to the L/R design. The current eventually applied to the coils depends directly on the voltage you use. Put

another way, your L/R design must specify both the series resistor value AND the applied voltage. This becomes obvious when you think of the resistor and the coil forming a divider. You have to balance the resistance and the applied voltage so the motor's coil ultimately sees the rated voltage and current when fully energized.

So why do so many L/R designs still exist? Because they're cheap. About all you

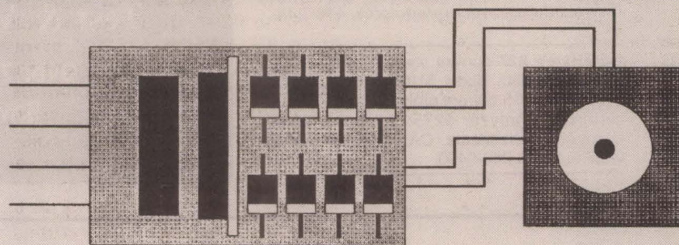
really need is a set of power transistors or MOSFETs, the series resistors, and some type of electronics to create the correct sequence of steps. If your design can use a wall outlet for power, all the better. Not having to worry about the battery drain just leaves you with the problem of venting all the built-up heat.

Chopper drives take a more intelligent approach to the problem of getting the rated current into the coils quickly. Here, the idea is to dump a high voltage, well beyond the rated voltage, into the coil and monitor the coil's current. Whenever the coil's current reaches some set limit, usually below the rated value, the chopper drive momentarily shuts off the voltage, but continues to monitor the current. When the current drops below a lower bound, the driver turns the voltage back on and the process starts over. This repeated cycle of sample and switch lets the chopper drive maintain full current in the coils longer than would be possible with a simple L/R drive. This, in turn, lets you run a stepper faster, with more high-end torque.

The increase in speed and torque over an L/R drive can be considerable. National Semiconductor's application note AN-828 cites a typical comparison of torque between a standard L/R drive and a chopper drive based on the company's LM18200 chopper IC. Using a motor rated at 18 oz-in of torque, the torque using an L/R drive dropped to 10 oz-in at a step rate of about 400 steps per second. Compare this to the chopper drive, where the torque didn't drop that low until the motor hit 2,000 steps per second.

A chopper drive usually consists of logic circuitry to create the proper stepping pulses, a current monitor for sampling the current flowing

CLOCK  
HALF/\*FULL  
ENABLE  
CW/\*CCW



The L297/L298 chopper driver

motor's coils to the rated value as quickly as possible, to get the maximum torque, but the L/R time constant gets in the way. You need a driver board that somehow gets past this L/R time constant, or at least helps you mitigate its effects.

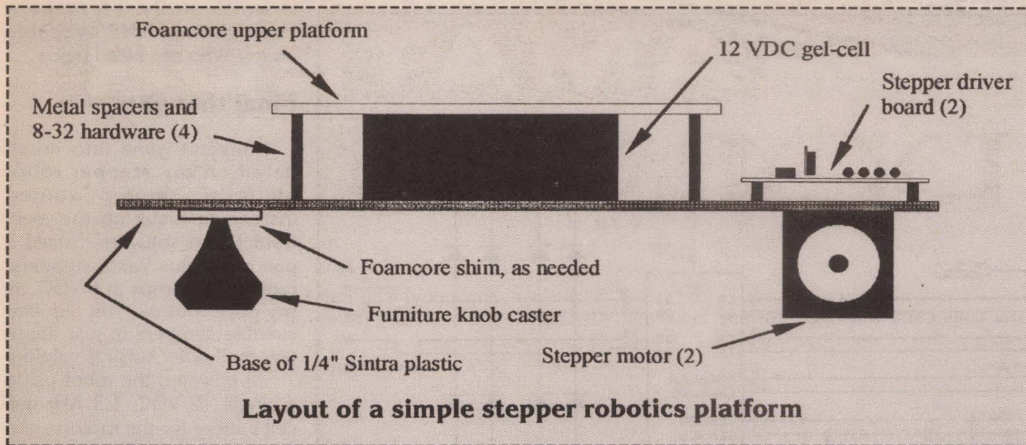
The L/R driver tries to offset this time constant by increasing the R value. If each coil measures out at 15 ohms, and you were to somehow double that, the time constant would suddenly become L/2R, or half its original value. This would let you reach the rated current in the motor's coils twice as fast. Rewinding the motor's coils with smaller wire wouldn't be practical, so most L/R drivers simply stick a hurking power resistor in series with each coil.

Assume you add a resistor equal to the coil's resistance in series with each coil. For my example, this would take a pair of 15-ohm resistors. The added resistance means that in a holding situation, with a coil fully energized, the coil will only see half the applied voltage. So right off, we know that we have to double the driving voltage if we want the coil to ever see its rated voltage. Thus, we would have to supply 12 VDC to our L/2R driver board to run a 6 VDC stepper motor.

Next, we need to look at the power rating of the resistor. In the worst case, with the coil fully energized, the resistor will carry the coil's rated current of 0.4 amps. This means the resistor must dissipate  $I^2 \cdot R$  watts, or  $(0.4 \cdot 0.4 \cdot 15)$  watts, or 2.4 watts. Since each stepper motor has two coils, you need two resistors, which will dissipate a total of 4.8 watts.

Because the stepper coils have the same resistance of 15 ohms, each coil will also use up 2.4 watts. This means that an L/2R drive shows 50%





through the motor's coils, and a set of high-current switches. These usually consist of an H-bridge made of power bipolar or MOSFET transistors, though many companies now offer a single package containing one or two high-current H-bridges.

One of the older chopper drive systems on the market is the SGS-Thomson L297/L298 combination. The L297 stepper controller chip comes in a 20-pin DIP format. It accepts a set of digital signals from some host device and generates the proper switching signals for a high-current driver. The L297 works well with the L298 dual high-current H-bridge driver, which comes in a 15-pin multiwatt power package. This driver can handle up to 46 VDC and a total of three amps of current (intermittent).

## Real electronics

A single L297/L298 combination can drive one stepper motor. The two chips plus supporting circuitry fit comfortably on a PCB 2.75 x 2 inches. I know this because Bill Bailey, one of the SRS stalwarts, designed just such a circuit board. Rather

coils. If ENABLE is low, however, the H-bridge removes all current from all coils. This latter condition can serve as a power-saving feature, since you can shut off the current when the robot is at rest.

The HALF/\*FULL line determines whether the stepper moves in half-step or full-step increments. Using half-step mode lets you double the resolution of your stepper system, though your motor will run half as fast for the same pulse rate.

The schematic shows a 1K trimpot, R4, which you use to set the maximum current the chopper will deliver to a coil. You simply hook a voltmeter to pin 15 (VREF) of the L297, then read the voltage as you adjust R4. The voltage you read, in millivolts, corresponds to the amount of current the chopper will deliver to each coil, in milliamps. Thus, setting VREF to 200 mV causes the driver to maintain 200 mA of current in any energized coil.

Note that the L298 power H-bridge only uses the motor's voltage; it does not need a source of 5 VDC. You can drive the L298 with anything up to 46 VDC, though you may have to provide a heatsink at higher currents.

You do need, however, to provide 5 VDC to the

You need to pay attention to some of the components when building your own L297/L298 stepper driver board. Most important, be sure to use Schottky diodes for the snubbers; these are CR1 through CR8 in Bill's schematic. I used 1N5822 devices, as suggested by Bill, but other three-amp, 50 V fast-recovery diodes will work as well.

Also, the two sense resistors, R7 and R8, should be non-inductive devices. This means you cannot use wirewound resistors. Bill's circuit calls for 0.5 ohms each, but he notes that 0.47 ohms will work as well.

After you have built your driver board, you can hook up a small 555 oscillator to generate a stream of square pulses at about 200 Hz. Temporarily tack jumpers to the input lines of your driver board to get this configuration:

- J2-1 Ground
- J2-2 N/C
- J2-3 N/C
- J2-4 Ground (HALF/\*FULL)
- J2-5 Pin 3 of the 555 (CLOCK)
- J2-6 Ground (CW/\*CCW)
- J2-7 VCC (ENABLE)
- J2-8 VCC (RESET)
- J2-9 See text (VCC)

If you installed the optional 5 VDC power supply shown in Bill's schematic, do not connect an external 5 VDC source to pin J2-9; that pin will already have 5 VDC on it. Instead, hook J2-7 and J2-8 directly to J2-9, to tie those signals high.

Turn on the driver electronics, then adjust R4 for a reading of 200 mA at pin 15 of the L297. Remove power, install a stepper motor on the connector J3, then turn on power to the motor board and to your 555 circuit. You should see the motor spinning smoothly. If you used a trimpot in your 555 circuit, you should be able to alter the pulse rate and see a corresponding change in the motor's step rate.

## Now, some software

Time to add some software, so you can put some intelligence behind your motors. I used one of Marvin Green's BOTBoards, complete with a 68hc811e2 MCU, to act as my robot's brain. I wrote all of the stepper driver code in SBasic, and the complete stepper library only takes up about 512 bytes of EEPROM. (See software listing elsewhere in this article.)

The heart of the stepper code is the two interrupt service routines (ISRs) used to generate step pulses on output pins OC4 and OC5. I will describe how OC4 works; OC5 behaves identically.

This simple routine begins by clearing the RMASK bit in the TFLG1 register. Clearing this bit rearms the TOC4 timer, acknowledging the interrupt that got us here in the first place. If you don't clear this bit, the interrupt will re-trigger as soon as you try to leave the routine, putting you in an infinite loop.

The code next checks the variable RSCNT, which holds the right-motor step count. This variable always holds the number of steps remaining before the current motor motion completes. If RSCNT does not already contain zero, then the code assumes another step is required. It prepares the step by first updating the timeout value in RTOC, which holds the timeout count for the next pulse. The code does this based on the value already in RTOC, which is just an equate for the 68hc11 TOC4 register. That register already holds the timer count that got us into this routine originally, so adding a delay to that value and storing the sum back into RTOC makes sure we get another interrupt at the right time. The delay we add to RTOC has already been stored in variable RSDLY, which stands for right-motor step delay.

The code then tests to see if RSCNT holds the

```

interrupt $ffe2
rtoc_isr:
pokeb TFLG1, RMASK
if rscnt <= 0
    pokeb RTOC, (peekb(RTOC) + rsdly)
    if rscnt <= $ffff
        rscnt = rscnt - 1
    endif
    pokeb PORTB, (peekb(PORTB) or RCLK1)
    pokeb PORTB, (peekb(PORTB) and RCLK0)
endif
end

' right motor ISR
' clear the interrupt flag
' if something to do ...
' set timer for next pulse
' if not running forever ...
' count this step

' bring clk high
' now bring it low
    
```

than design my own, I used his in my latest robot. Refer to the accompanying schematic of Bill's chopper driver board.

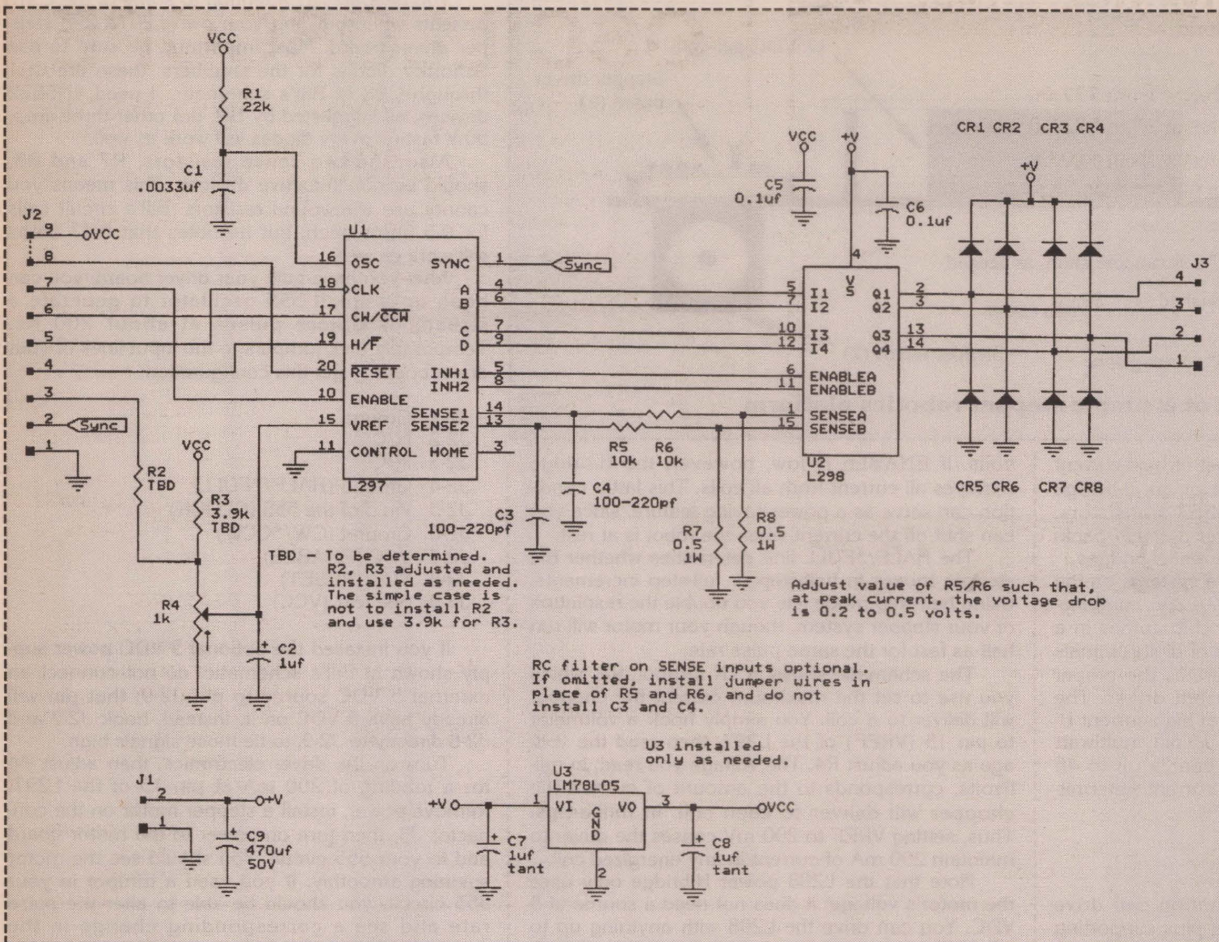
You can think of this chopper design as a black box. You plug a stepper motor into one end, add voltage, and hook up a computer to the other end. The computer provides a set of signals to the board's inputs, and the board, in turn, switches current into the motor's coil as required. Refer to the accompanying drawing of the L297/L298 chopper driver.

The host computer — a 68hc11 in my case — must provide a small set of control signals. The CLOCK signal acts as a step command; each low-going pulse causes the L297 to advance the motor one step in the current direction. The CW/\*CCW signal determines the direction of rotation; a high on this line causes the motor to step in one direction, while a low makes the motor step in the opposite direction. The ENABLE signal controls the overall operation of the H-bridge. If ENABLE is high, the bridge drives current into the selected

L297, since it is basically a logic device. Bill has added traces for a simple 78L05 voltage regulator supply that derives 5 VDC from the motor voltage, though you can also provide 5 VDC through the host computer connector, J2. If you do use the 78L05 regulator, make sure you keep the motor voltage at 12 VDC or below. Higher voltages will cause the 78L05 to dissipate too much heat, and it will thermally shut down.

Bipolar H-bridges, such as the L298, can suffer from thermal runaway and burn up if you pull excessive current. I strongly suggest you install a fuse in the motor voltage line coming into the board to protect the electronics. The fuse rating isn't too critical; just use one about twice your intended current draw. In my case, I had set both motor driver boards for about 300 mA, so I was drawing 600 mA per board or a total of 1.2 amps worst case from my 12 VDC battery. I chose a 1.75 A fuse, inserted it into a Radio Shack automotive in-line fuse assembly, and wired the harness into the power system of my robot.





is worth study. I'll make a copy of this code available on my Web site listed below.

## Final thoughts

I haven't gone into much detail on my stepper robot platform, since I wanted instead to focus on the electronics and software. I used a pair of surplus Vexta steppers, rated at 0.8 amps at 6 VDC, as my drive motors. You can find suitable steppers in just about any mail-order surplus catalog.

I powered the robot using a single 12 VDC, 1.3 Ahr gel-cell battery for the motors, and a set of four AA Renewal cells to run the 68hc11 MCU board. I used a separate MCU supply to keep as much stepper motor electrical noise out of the MCU's circuitry as possible. I also hooked up a charging jack on the gel-cell, so I can recharge the gel-cell in place, without having to pull wires and mess with connectors.

I took the easiest possible way out for mounting these motors onto my Sintra plastic base. I simply stuck them in place using double-sided foam tape. The tape has plenty of grip; in fact, I'm reluctant to change the arrangement, since it's such a pain pulling the motors off the base.

As for mounting the wheels

onto the motor, I used the wheel mounts described in last month's issue. Dan Mauch, one of the club's machinists, helped me with the design, and it really simplifies wheel mounts. Take a moment to leaf back through the last issue for details. **NV**

value \$ffff. This is a special value that means "move forever." If RSCNT holds \$ffff, the ISR does not decrement RSCNT. Thus, RSCNT stays non-zero and unchanging, so the right motor will spin continuously. If, however, RSCNT does not hold \$ffff, the ISR decrements it. This insures that eventually RSCNT hits zero and the motor pulses stop.

Finally, the time comes to actually provide the motor pulse. The code does this by toggling a selected bit in output port B. The constant RCLK1 defines an OR-mask for setting this bit to 1 and RCLK0 defines an AND-mask for clearing this bit to 0. The two POKEB statements each read the current value of port B, modify the proper bit, then write the new byte back to port B.

When control exits this routine via the END statement at the end of the ISR, the 68hc11 will

actually execute an RTI instruction, which returns from the interrupt back to the mainline code.

This ISR forms the bulk of the stepper motor code. All the other code in the stepper library exists only to support this routine in some way. For example, the routine InitSteppers sets up the TOC registers for the right and left ISRs, and initializes the variables used by these routines. Similarly, StartSteppers activates the motor interrupts so the first pulse can actually happen.

I've tried to provide good comments to all of this code, to make it easy to follow. This code should serve as a good starting point for more sophisticated routines, and

As always, you can reach me at:

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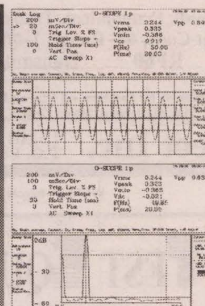
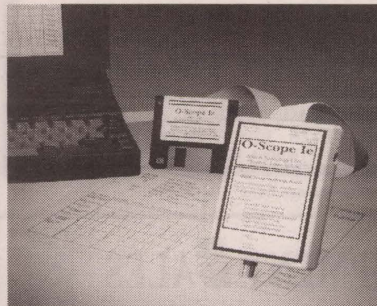
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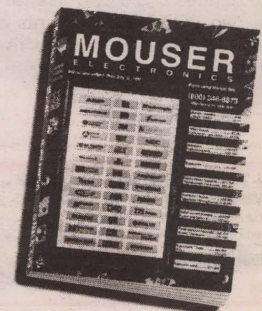
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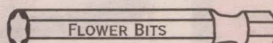
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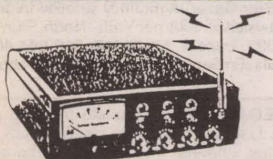
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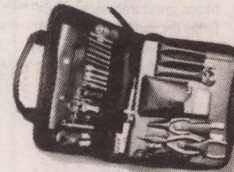
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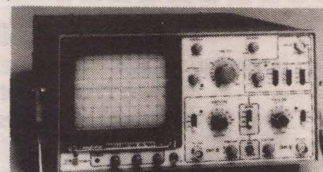


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# UNDERSTANDING PROGRAMMABLE LOGIC DEVICES

## PART 2

Last month, we introduced the Programmable Logic Device (PLD) and explained why it is fast becoming one of the most popular components used in complex digital circuits. This month, we continue with a discussion of Boolean Logic — the language used to program and test PLDs.

### Boolean Logic Primer

In 1854, the mathematician George Boole described a method whereby classical logic statements could be written in a mathematical form similar to algebra. In Boolean algebra, there are only two possible values for any element (TRUE or FALSE) and only three operators (AND, OR, and NOT). For compactness, we can represent TRUE by the number "1" and FALSE by the number "0." Similarly, we substitute {1} the symbols \*, +, and / for the operators AND, OR, and NOT, respectively. In the notation that follows, do not confuse these operators with the more familiar multiplication, addition, or division signs; these equations have nothing to do with decimal (or, for that matter, any other base system) arithmetic.

Another way to understand the basic principles of Boolean algebra is to represent operators and functions

using truth tables. Figure 1 shows the truth table for the AND operator. In our Boolean algebraic notation, we would write:

$$C = A * B$$

which is read as "C equals A AND B." From the table we can infer that:

- 1) If A is FALSE and B is FALSE, then C is FALSE;
- 2) If A is FALSE and B is TRUE, then C is FALSE;
- 3) If A is TRUE and B is FALSE, then C is FALSE and;
- 4) If A is TRUE and B is TRUE, then C is TRUE.

Likewise, we can define the OR operator by the truth table in Figure 2, and by the following notation:

$$C = A + B$$

or "C equals A OR B." Thus we see that:

- 1) If A is FALSE and B is FALSE, then C is FALSE;
- 2) If A is FALSE and B is TRUE, then C is TRUE;
- 3) If A is TRUE and B is FALSE, then C is TRUE and;
- 4) If A is TRUE and B is TRUE, then C is TRUE.

Note that the Boolean OR varies slightly from

the English usage of the word. In English, when we say that something is one thing or another, we usually refer to mutually exclusive possibilities. That is, we might say that a person is either at home or at work. On the other hand, a question such as "Do you have a nickel or a dime?" is clearly ambiguous. Does the question ask which type of coin is possessed or whether the person has either coin? If the person had both coins, would the answer be true or false? To avoid this confusion, we define the Boolean OR to mean, "either one or both." The exclusive-or (XOR) operator is used to represent "one and only one."

Finally, we show the truth table for the NOT operator in Figure 3. The notation:

$$B = /A$$

is read "B equals NOT A" which simply says that:

- 1) If A is FALSE, then B is TRUE and;
- 2) If A is TRUE, then B is FALSE.

Just as with ordinary algebra, we need to define a few more rules before we can begin to apply these principles and develop more complicated functions. For purely notational reasons, we need to define the precedence of our Boolean operators. As in arithmetic, the expression:

$$2 + 4 * 3$$

could be evaluated as either  $(2 + 4) * 3$  giving 18 or as  $2 + (4 * 3)$  yielding an answer of 14. While adding parenthesis

will always make the order of evaluation clear, we can also remove any ambiguity by defining a priority to each operator. In Boolean algebra, the

FIGURE 1.

INPUTS		OUTPUT
A	B	C
0	0	0
0	1	0
1	0	0
1	1	1

The AND operator.

FIGURE 2.

INPUTS		OUTPUT
A	B	C
0	0	0
0	1	1
1	0	1
1	1	1

The OR operator.

FIGURE 3.

INPUT	OUTPUT
A	B
0	1
1	0

The NOT operator.

NOT operator has the highest precedence followed by AND, and then OR.

In traditional circuit design using discrete gates, we start with a function we wish to have the circuit perform and then search for the appropriate ICs and pin connections to implement this design. With PLDs and their "sea of gates," this task is greatly simplified if we can express the design using Boolean equations. These equations can then be input into a computer program which will generate the appropriate "circuit connections" inside the PLD to obtain the desired result. These connections reside in a file which is then used to program the PLD. This process of turning a logic design into a set of Boolean equations is known as syn-

[1] Other symbols may be encountered in the literature for these functions, most notably the overscore symbol to signify a logic NOT. The symbols we shall use are more widely accepted because they are standard ASCII characters and thus simpler to typeset and input into PLD programming software.

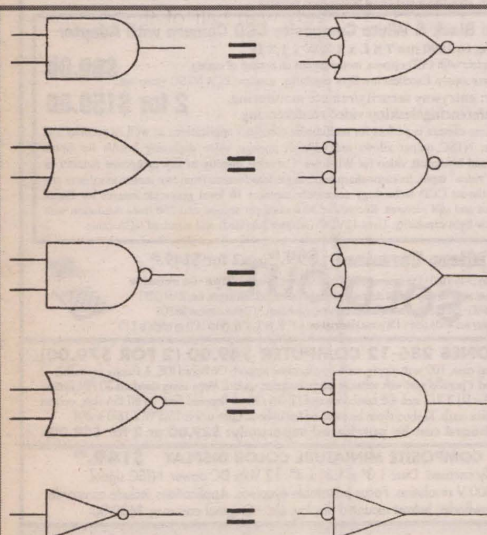


FIGURE 4.

Equivalent gates using "bubble logic" notation.

Inputs

A	B	C	D	F
0	0	0	0	0
0	0	0	1	1
0	0	1	0	1
0	0	1	1	1
0	1	0	0	0
0	1	0	1	1
0	1	1	0	1
0	1	1	1	0
1	0	0	0	0
1	0	0	1	1
1	0	1	0	1
1	0	1	1	0
1	1	0	0	1
1	1	0	1	1
1	1	1	0	1
1	1	1	1	0

FIGURE 5.

Sample truth table.



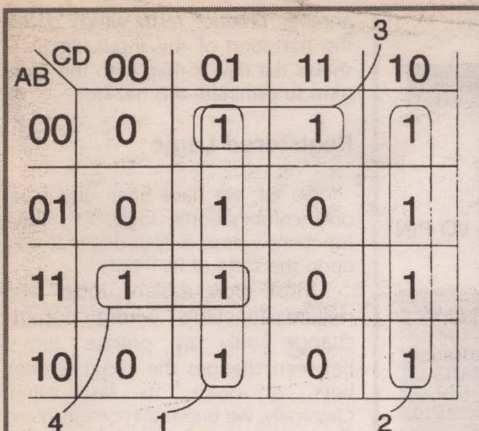


FIGURE 6.

Karnaugh map for function of Figure 5.

thesis. To aid in the process of synthesis, we shall explore a few more properties of Boolean algebra.

### Other Boolean Principles

Boolean operators obey the principles of commutation, association, and distribution. Like traditional algebra, the commutative property implies that the order in which two operands appear is not important, e.g.:

$$A + B = B + A$$

$$A * B = B * A$$

The associative property states that the order in which similar operators are evaluated is not important, e.g.:

$$A + (B + C) = (A + B) + C$$

$$A * (B * C) = (A * B) * C$$

Note that this principle only applies when the same operator is applied to all operands, i.e.:

$$A + (B * C) \neq (A + B) * C$$

The distributive property allows one variable acting on an expression to be distributed out to each element in the expression,

thus:

$$A * (B + C) = (A * B) + (A * C)$$

$$A + (B * C) = (A + B) * (A + C)$$

Finally, there is one more principle in Boolean algebra which has no analog in ordinary arithmetic. This is the principle of absorption, which allows redundant terms to be eliminated:

$$A + (A * B) = A$$

$$A * (A + B) = A$$

Another property of Boolean algebra is that every expression has an equivalent, but "opposite" form known as a dual. The dual of an expression is formed by inverting all values and swapping all ANDs and ORs in the expression. Thus the equation

$$A + B = \text{TRUE}$$

has a dual which says:

$$/A * /B = \text{FALSE}$$

In plain English, the first statement says simply that either A or B (or both) are TRUE. The second statement twists things around and says that A and B are not both FALSE. The principle of duality also leads to the famous theorem derived by Augustus DeMorgan and which bears his name:

$$/(A * B) = /A + /B$$

$$/(A + B) = /A * /B$$

You might also recognize DeMorgan's Theorem in the equivalence of the logic drawings in Figure 4. Many times these non-standard symbols are used (e.g., a NOR gate with inverted inputs instead of an AND gate) to make the logic flow of a circuit easier to follow.

One final principle of Boolean algebra has already been mentioned. It basically says that no matter how complicated a logic expression may be, and no matter how many variables may be involved, the expression can always be simplified into a form known as the sum of products. An expression in this form looks like:

$$(A * B) + (C * D * E) + (F * /G) + H \dots \text{etc.}$$

The expression consists of a number of ANDed terms which are ORed together. Each AND term is called a product term due to the similarity between the AND function and multiplication. The ORing of the terms is referred to as a SUM in view of the similarity to addition. Note that it is also possible to express any equation in a product of sums form as well. Consider the following example:

$$(A * /B) + ((A + C) * /B)$$

$$= (A * /B) + ((A * /B) + (C * /B))$$

$$= (A * /B) + (A * /B) + (C * /B)$$

$$= (A * /B) + (C * /B) \text{ (Sum of Products form)}$$

$$(A * /B) + ((A + C) * /B)$$

$$= (/B * A) + (/B * (A + C))$$

$$= /B * (A + (A + C))$$

$$= /B * (A + C) \text{ (Product of Sums form)}$$

### Karnaugh Maps

Another technique used to simplify logic equations is the creation of a Karnaugh map (also known as a K-map). By condensing the truth table of a logic function into a more compact array, patterns in the function can be found which allow it to be reduced to a simpler form. K-maps are very useful for minimizing functions with three to six variables; beyond that it gets too complicated and other methods must be used.

A K-map is produced by re-writing the truth table of a function into a matrix with half of the variables represented on each axis. The value of the function is placed into each cell according to the intersecting inputs at that cell. It is important to order the rows and columns of the matrix in such a way that only one variable changes at a time. Then, wherever we find two adjacent "1" cells, we can eliminate one variable from the equation for that cell by the rule:

$$(A * B) + (A * /B) = A$$

For example, consider the truth table shown in Figure 5. We could make a brute-force implementation of this function using 10 sum-of-product terms (one for each "1" value of F):

$$F =$$

$$+ /A * /B * /C * D$$

$$+ /A * /B * C * /D$$

$$+ /A * B * /C * D$$

$$+ /A * B * C * /D$$

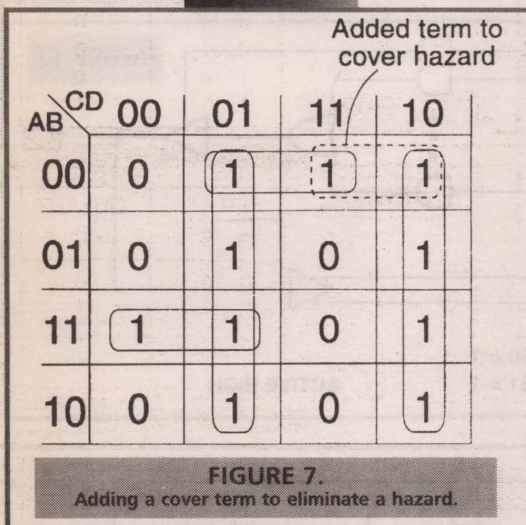


FIGURE 7.

Adding a cover term to eliminate a hazard.

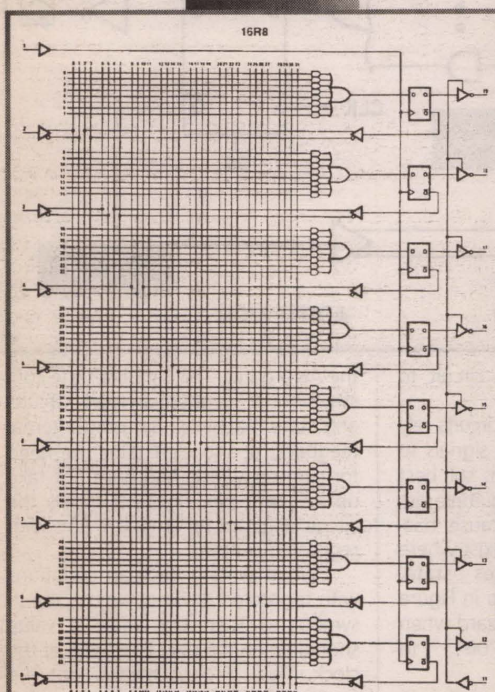


FIGURE 9.

Logic diagram of a 16R8 PAL.

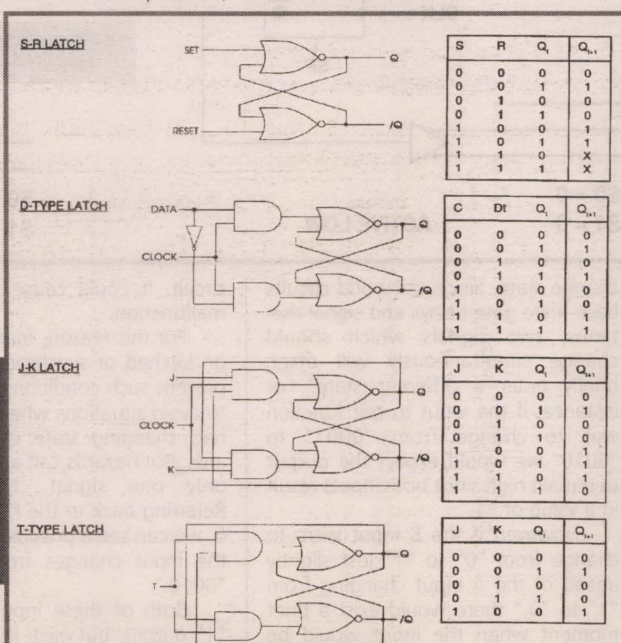


FIGURE 8.

Various latches and their truth tables.



### S-R Latch

SR	Q	0	1
00	0	1	
01	0	0	
11	X	X	
10	1	1	

$$Q_{t+1} = S + /R * Q$$

### D-Type Latch

CD	Q	0	1
00	0	1	
01	0	1	
11	1	1	
10	0	0	

$$Q_{t+1} = C * D + /C * Q$$

### J-K Latch

JK	Q	0	1
00	0	1	
01	0	0	
11	1	0	
10	1	1	

$$Q_{t+1} = J * /Q + /K * Q$$

### T-Type Latch

T	Q	0	1
0	0	1	
1	1	0	

$$Q_{t+1} = T * /Q + /T * Q$$

**FIGURE 10.**  
Logic equations for various latches.

$$\begin{aligned}
 &+ A * B * /C * D \\
 &+ A * /B * C * /D \\
 &+ A * B * /C * /D \\
 &+ A * /B * C * D \\
 &+ A * B * C * /D
 \end{aligned}$$

By creating the K-map as shown in Figure 6, however, we can easily identify several groupings of ones. For example, note that the function is true whenever C and D have the values "0" and "1" respectively (see group 1). In fact, all of the "ones" can be covered with just four circles. Thus we can express this function in a much simpler form:

$$\begin{aligned}
 F &= /C * D && \text{(group 1)} \\
 &+ C * /D && \text{(group 2)} \\
 &+ /A * /B * D && \text{(group 3)} \\
 &+ A * B * /C && \text{(group 4)}
 \end{aligned}$$

K-maps are also useful in discovering hazards. Hazards exist when one or more inputs to a logic design

change state. Since real-world circuits have finite gate delays and signal rise-times, two signals which should change simultaneously will often briefly enter a different state. For instance, if the input to our function was to change from "0001" to "0010" we would expect the output to remain high since both inputs result in a value of "1".

However, if the B input were to change from "0" to "1" just slightly ahead of the A input changing from "1" to "0," there would exist a brief moment when the input would be "0011" and thus the output would be high. However short this erroneous pulse (or glitch) might be, if this signal represented a clock or fed a counter

circuit, it could cause the circuit to malfunction.

For this reason, many circuits rely on latched or synchronous signals to prevent such conditions. It is still best to avoid situations where multiple signals changing state can cause hazards. But hazards can also exist where only one signal changes state. Referring back to the K-map in Figure 6, we can see a possible hazard when the input changes from "0011" to "0010."

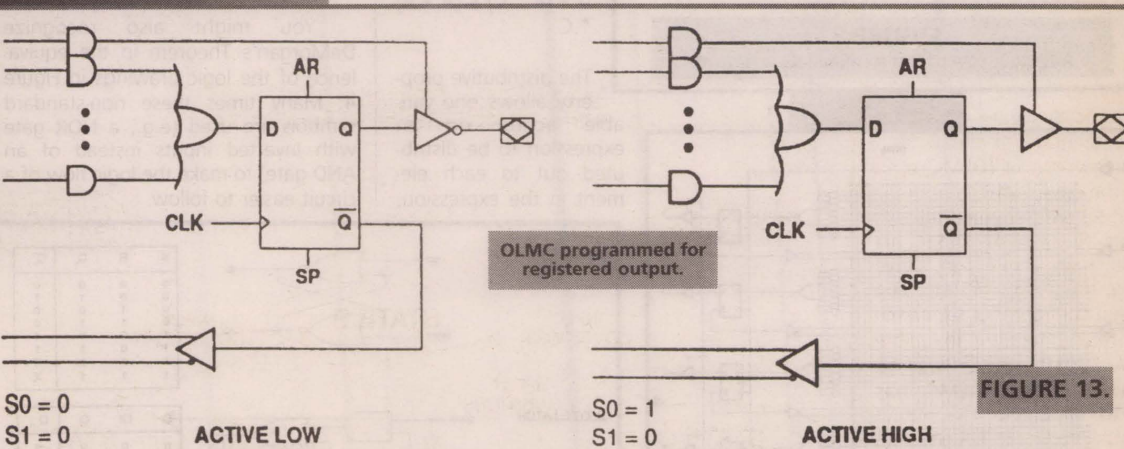
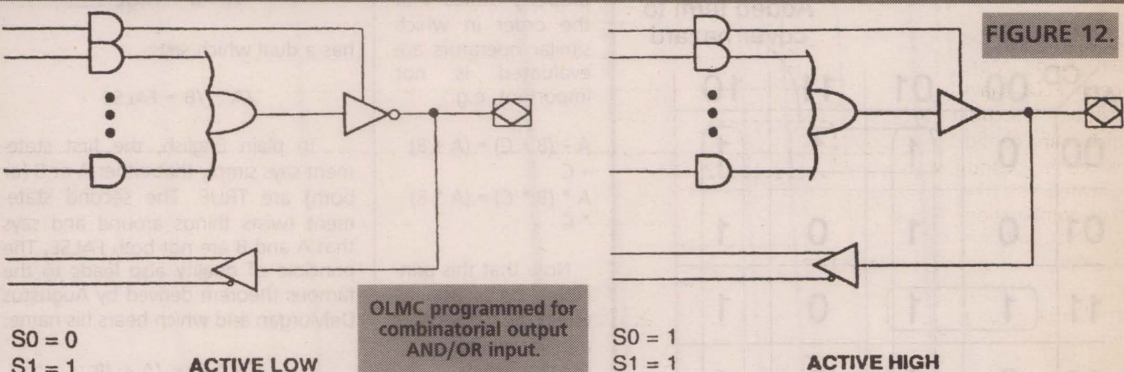
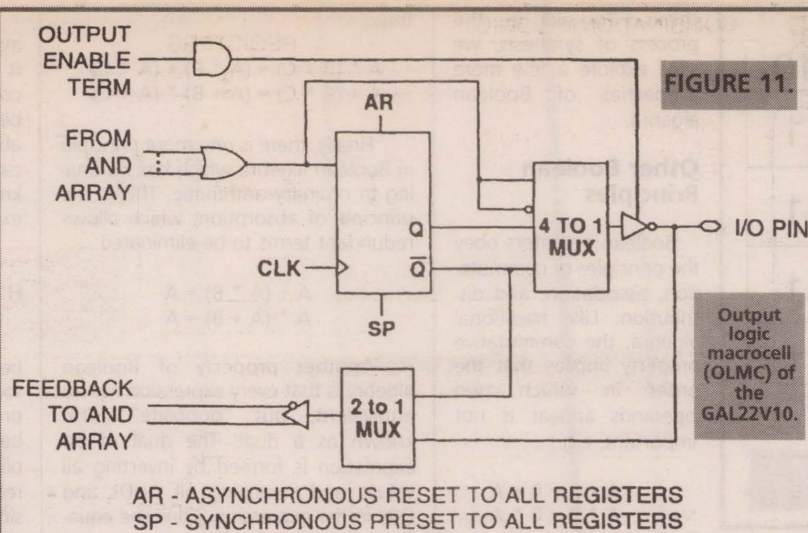
Both of these inputs result in a "1" output, but each is generated by a different "group" or product term. Thus, as one term is becoming true, the other is becoming false. A simple solution to this problem is to add

another product term which covers the transition of this input. Figure 7 shows the new K-map with the cover term to eliminate this hazard.

## Registered Logic

So far, we have been discussing only combinational logic, i.e., logic functions whose output depends only upon the state of its inputs.

Most logic designs today also require functions whose outputs change only at precise times; between changes the circuit remembers, or holds, its last value. Classically, we build such circuits using cross connected gates, or flip-flops. Figure 8 shows some typical circuits used for latches or registers. When registers are added to the output circuit of a PLD, the latched outputs are typically fed back to the input array of



the AND gates. This simplifies the construction of sequential logic circuits and state machines. By using internal feedback, it also eliminates the need for external wiring and does not take up an input pin. Figure 9 shows the circuit diagram for a typical PAL with registered outputs.

When writing Boolean equations with registered devices, we use the := symbol to represent what a value should be on the next transition of the clock. Thus, F := A means that the function F will take on the value of A after the next clock transition.

The output of a registered device can also depend upon its previous value; e.g., F := /F \* A will cause the output to toggle on each clock as



long as A is TRUE. Such an equation might also be written as  $F_{t+1} = F_t * A$ .

PLDs typically contain only D-type flip-flops. However, we have just seen how feedback can be used to implement a toggle, or T-type, flip-flop. Figure 10 shows K-maps for all of the common types of flip-flops and gives the PLD equations to implement each type using the D-type flip-flops available.

## Macrocells

PALs had outputs which were either combinational or registered. Some even had a fixed number of each kind. More recent PLDs have output circuits which can configure each output separately to be either combinational, registered, tri-stateable, etc. Unused outputs can also be configured as additional input pins.

All of this is accomplished by adding a programmable output structure commonly referred to as a macrocell. Figure 11 shows the diagram of the Output Logic Macrocell (OLMC) used in the GAL22V10.

By programming the various "fuses" in the OLMC, we can create active high, active low, registered, tri-state, and input configurations for each output pin. In the GAL22V10, there are 10 OLMCs. Each OLMC has between 8 and 16 product terms feeding its OR gate. An additional product term is dedicated to allow output enable (tri-state) control. Each of the macrocells has two primary functional modes (registered and combinational I/O). The mode and output polarity are set by two bits, S0 and S1.

In the combinational mode (S1 = 1), the output pin is driven by the output of the sum term OR gate. Polarity of the output signal may be selected as either active low (S0 = 0) or active high (S0 = 1). Figure 12 depicts how the output structure looks when the macrocell is programmed this way.

Feedback into the AND array is provided from the pin side of the output buffer in both true and inverted

polarities. Since the output enable control comes from its own product term, we can choose to dedicate the pin as either an output or input by turning the enable on or off. We can also use inputs from the product array to tri-state the output or even change it from an output to input on-the-fly.

When S1 = 0, this selects the registered mode of the OLMC. In this mode, the output comes from a D-type flip-flop in the macrocell as shown in Figure 13. S0 again deter-

mines the output polarity and the output enable term can still be used as a tri-state control. Note that the feedback, however, comes from the /Q output of the flip-flop; therefore a pin designated as registered can be used for output only.

## State Machines

Many digital designs require circuits that perform a sequence of functions in a very specific order. Although

microprocessor control is often used to implement very complex tasks, simpler designs can be built with just a few chips. The sequential control logic required to build these state machines is ideally suited to the architecture of PLDs.

A state machine, or more formally a Finite State Machine (FSM), is a digital circuit which moves through a predetermined sequence of states in an orderly fashion.

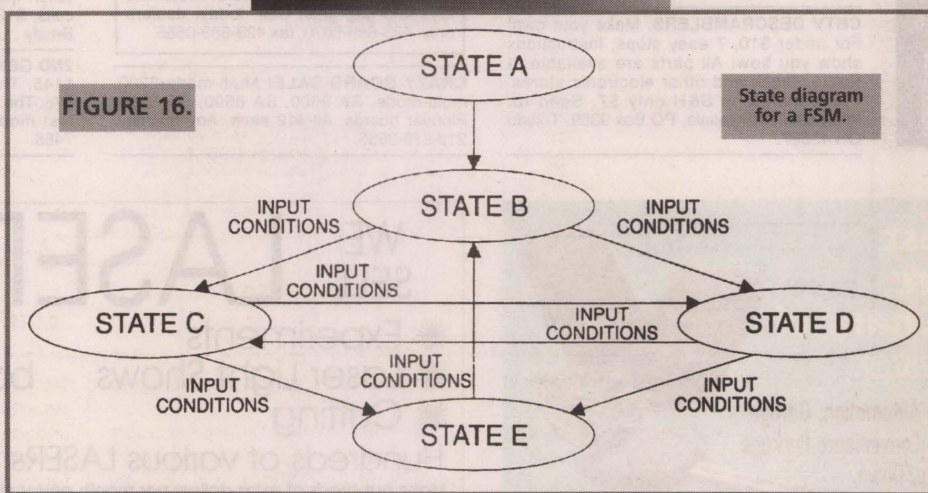
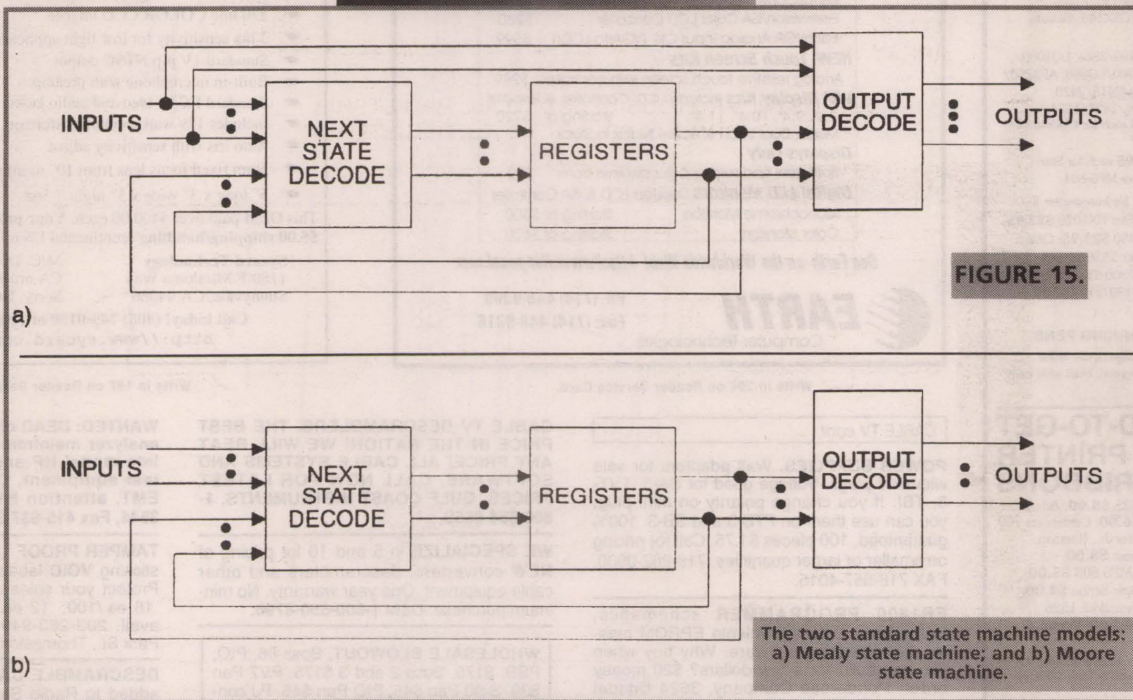
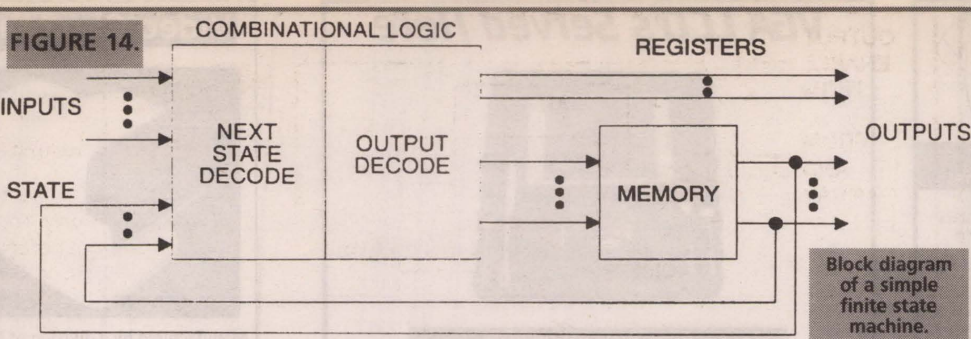
A state is simply defined by the value of certain output signals, which, in turn, determine which state the FSM will travel to next. Figure 14 shows a general block diagram of an FSM. The next state decode and output decode sections are comprised of combinational logic. The memory section consists of registers.

There are two basic models of FSMs: the Mealy State Machine and the Moore State Machine (see Figure 15). In a Mealy State Machine, the outputs are a function of both the current state and the inputs. The outputs of a Moore State Machine, however, depend only on the current state. For any given state, each set of input conditions will cause the FSM to move into another configuration, which we call the next state.

The behavior of an FSM can be seen more clearly by drawing a state diagram such as Figure 16. Each state is represented by an oval with arrows indicating what conditions will cause the FSM to move into another state.

Some transitions, such as from State A to State B in our figure, follow a direct sequence. Other transitions, however, can depend upon the input conditions, allowing conditional sequencing, or branching.

Now that we have a firm background in the language of Boolean logic, we can begin to discuss how to use and program PLDs. Next month, we will continue with a discussion of the hardware and software tools needed to program these devices. We will then conclude with a real-world example of a circuit design using PLDs. **NV**





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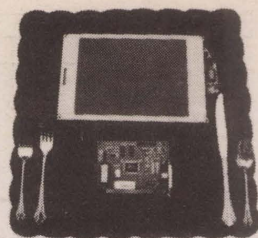
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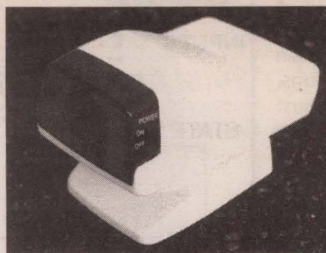
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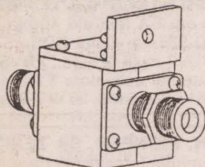
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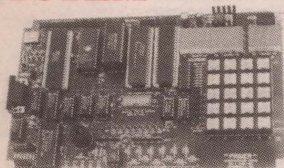
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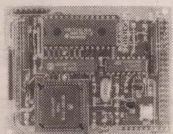
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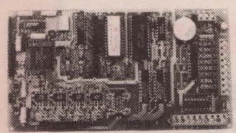
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# THE LASER

## EXPERIMENTER

Conducted by  
Anthony Charlton

**W**elcome! Last time, we covered several subjects including the possibility of laser-based communications with other star systems in the possible search for other intelligent life-forms. This could be done by firing lasers through space-based remote collimator/beam steerers. It occurred to me this would be a good project for use on the proposed space station. For those of you who don't know it, the manufacturing of space station components is occurring now in the United States and the former Soviet Union (who will help pay for the staggering \$27 billion cost of this structure).

An article in the June '96 issue of *Scientific American* paints a negative picture of this monumental task. It says basically many of the experiments designed for use on the station won't work; that manufacturers who want to have technology done in space are backing out, etc., etc. Let's take a different viewpoint. If I wanted to invest significant money in a process to be done in space — like growing a specialized medical drug — I'd, of course, follow the ongoing progress of the station carefully. If I saw the station passed in Congress by one vote (ridiculous!), naturally I'd hesitate to pre-commit funds.

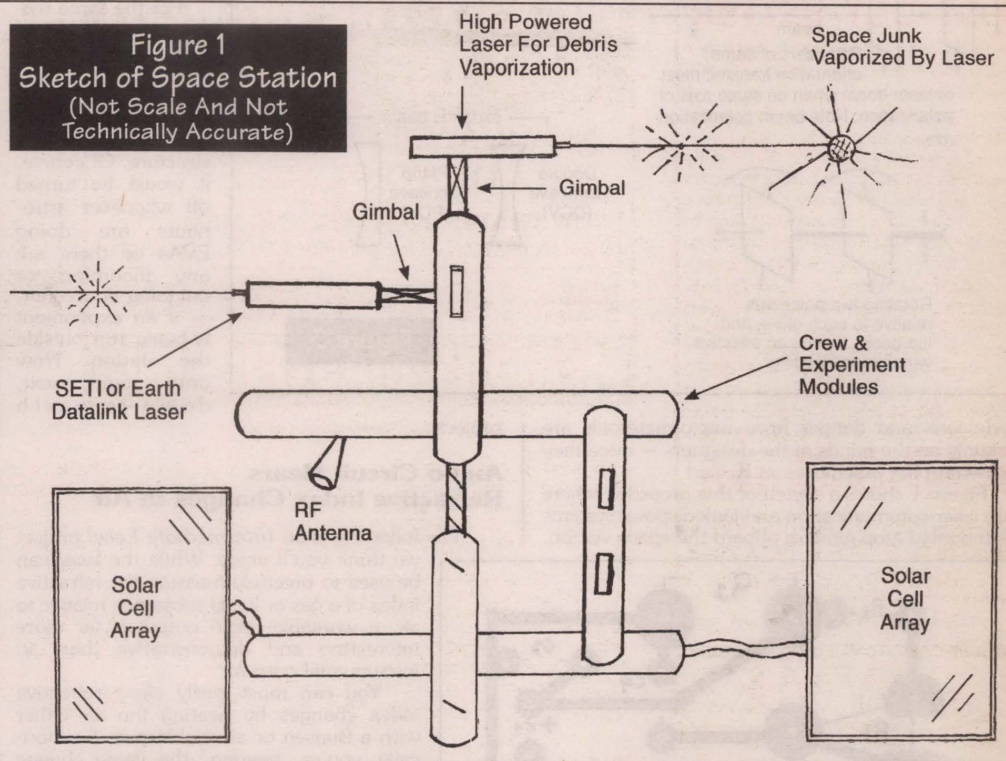
So, you have a developing situation that self-propagates. It's a lot like the coach telling your football team they're going to lose! The prophecy can fulfill itself. (Remember the superconducting supercollider boondoggle.) So a much better approach, I believe, is to boost morale about this project. A plausible idea would be to assemble a "think tank" of minds who dream up many more practical uses for the station and get the ball rolling! NASA, Congress, et al, are you listening? Following is one modest proposal ...

### Cleaning Up Space Junk

Space is relatively full of junk. From nuts and bolts, to larger parts, to a thermal glove that floated out of Gemini 4 in 1965. The problem is that it all represents a danger to the space station and, of course, other spacecraft. Depending upon the orbit of the junk versus the object of orbital reference, one can have quite a problem, if say a small metal chunk hits the station at 20,000 mph. Remember that a high-powered rifle bullet which weighs only a fraction of an ounce travels at a relatively slow 2,000 mph or so. That bullet can do a lot of damage at even 1/10th the velocity of the junk.

Radar and LIDAR (Laser Radar) can pick up much of this junk, at least once it's close enough. Imagine now an integrated system whereby a high-sensitivity LIDAR system is hooked up to a small, but powerful, laser. An incoming piece of junk is detected. A fast computer quickly determines the trajectory of the object, adjusts the

**Figure 1**  
**Sketch of Space Station**  
(Not Scale And Not Technically Accurate)

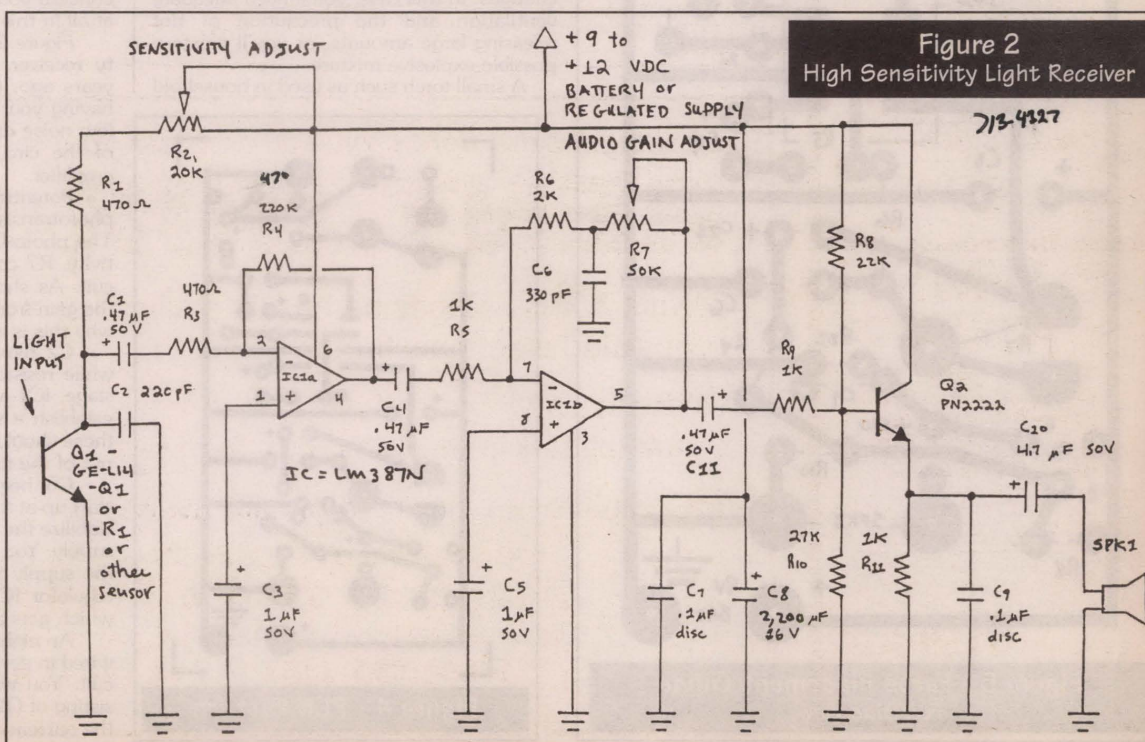


optics of the laser, and fires it as many times as needed to vaporize the object. ZAP! One more nuisance piece of junk in space is gone.

The procedure might be useable on some

micro-meteroids as well. Components of the space station will be sheathed in Kevlar, the same super-tough plastic used in law enforcement bulletproof vests. So, the reality of threats from errant man-

**Figure 2**  
**High Sensitivity Light Receiver**





# THE LASER

## EXPERIMENTER

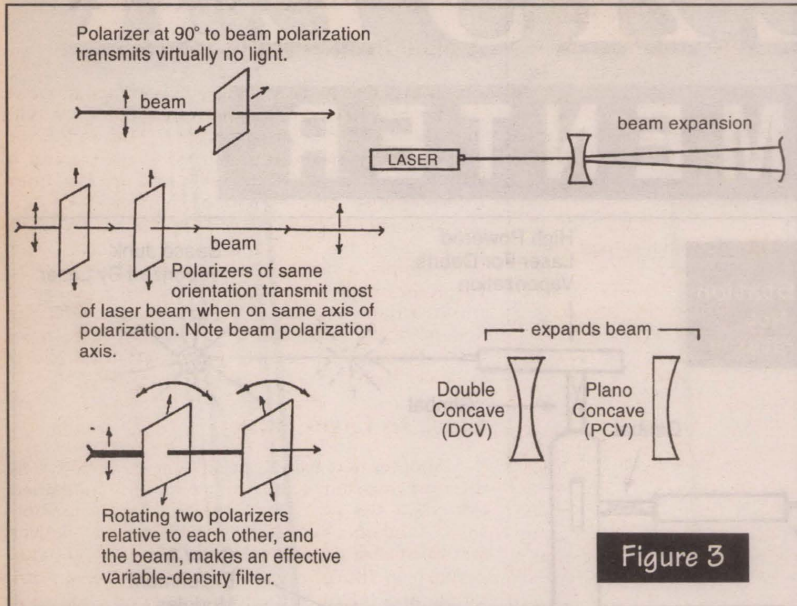


Figure 3

made junk and danger from micro-meteroids are certainly on the minds of the designers — once they start wrapping assemblies in Kevlar!

Figure 1 shows a sketch of this proposal, where both laser communication and junk disposal systems are mounted atop gimbals aboard the space station.

project ...

### Audio Circuit Hears Refractive Index Changes In Air

The following is an *Intermediate Level* project we think you'll enjoy. While the laser can be used to precisely measure the refractive index of a gas or liquid substance relative to air, a workable audio output is far more interesting and demonstrative than an instrumental output.

You can most easily effect refractive index changes by heating the air either with a Bunsen or alcohol burner. So, basically, you're "hearing" the flame change the index.

Another method is to release a bottled gas such as propane or butane, and shine the laser beam through that gas to hear the changes. In this case, you'll need adequate ventilation and the precaution of not releasing large amounts, or you'll create a possible explosive mixture.

A small torch such as used in household

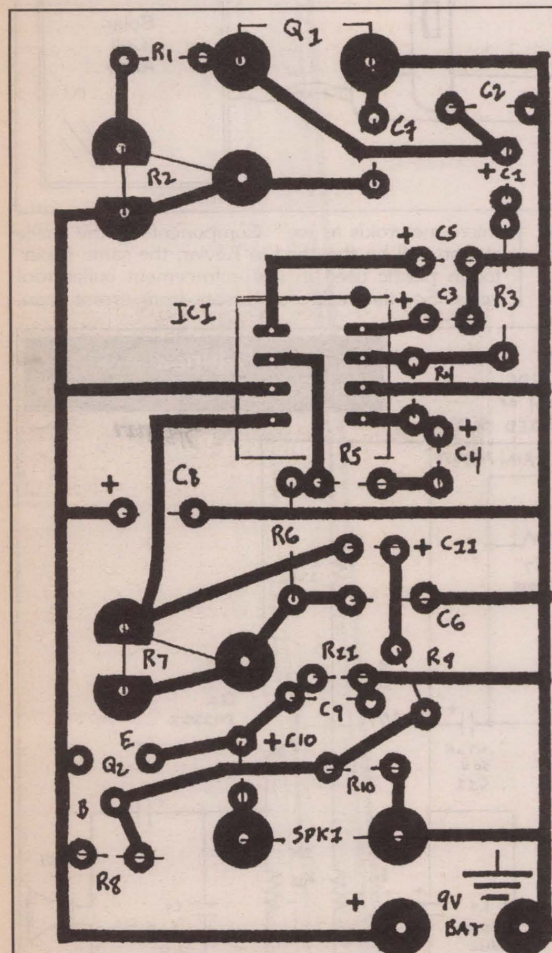


Figure 5 - Parts Placement Guide  
Foil Side View

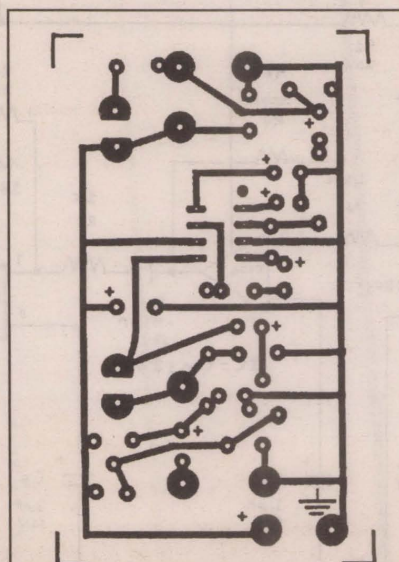


Figure 4 - PCB Pattern

The junk-zapping laser occupies the highest point of the station where it would have an unobstructed view and not accidentally zap any part of the station.

For the same reason, its field of movement would be mechanically limited so that it couldn't accidentally fire across any part of the structure. Of course, it would be turned off whenever astronauts are doing EVAs or there are any incoming or outgoing spacecraft, or if an experiment is being run outside the station. Now onto our next, down-to-earth

### PARTS LIST

**Resistors** — All resistors are 1/4 watt, 5% carbon film unless otherwise indicated

- R1 — 470-ohm
- R2 — 470-ohm
- R3 — 220,000-ohm
- R4 — 20,000-ohm trimmer potentiometer
- R5 — 1,000-ohm
- R6 — 2,000-ohm
- R7 — 50,000-ohm trimmer potentiometer
- R8 — 1,000-ohm
- R9 — 22,000-ohm
- R10 — 27,000-ohm
- R11 — 1,000-ohm

**Capacitors** — Voltages other than those given are usable, provided they are 16 WVDC or higher

- C1 — 220 pF disc capacitor
- C2 — .47 uF, 50 WVDC electrolytic
- C3 — 1 uF, 50 WVDC electrolytic or tantalum
- C4 — .47 uF, 50 WVDC electrolytic
- C5 — 330 pF disc capacitor
- C6 — 1 uF, 50 WVDC electrolytic or tantalum
- C7 — .47 uF, 50 WVDC electrolytic
- C8 — .1 uF disc capacitor
- C9 — 4.7 uF, 35 WVDC electrolytic
- C10 — 2,200 uF, 16 WVDC electrolytic
- C11 — .1 uF disc capacitor

### Other Parts:

- IC1 — LM387N dual low-noise preamp integrated circuit in 8-pin case
- Q1 — GE-L14Q1-ND NPN phototransistor or GE-L14R1-ND photo-Darlington
- Q2 — PN2222 NPN transistor
- 1 — 8 pin IC socket
- 1 — 8-ohm headphones, preferably full cover or a small 8-ohm speaker
- 1 — Appropriate headphone jack

**NOTE:** All the parts are available from Digi-Key except for a PC board. Consult their catalog for exact part numbers and current pricing.

soldering and heating jobs is adequate, and doesn't release large amounts of gas. So you don't have to concern yourself with creating an explosive mixture at all in this case.

Figure 2 shows a schematic of a high-sensitivity receiver that first appeared here about 2-1/2 years ago. (We thought we'd reprint it instead of having you chase down an old issue.) The LM387 low noise dual audio preamplifier chip is the heart of the circuit. It is configured as a variable-gain amplifier.

Potentiometer R2 controls the sensitivity of the phototransistor or photo-Darlington used for Q1. The photo-Darlington will offer much greater sensitivity. R7 controls the overall audio gain of the circuit. As shown, the two potentiometers can vary the gain from 935 to 23,300 times. So you can see why this is a "high-sensitivity" circuit.

C2 filters out high-frequency light fluctuations while resistors R3 and R4 set the gain of the first stage, IC1-a, to about 470. Capacitors C3 and C5 establish a stable bias on the amp's input. Ideally, these should be solid tantalum. C4 couples the output of the first stage through R5 to IC2-b.

C6 helps suppress any oscillations that may start up at the control potentiometer R7. C7 and C8 stabilize the power supply, which ideally is a battery supply. You may have to increase the value of C8 if the supply is regulated, despite the evenness of a regulator IC's output. This is to reduce any hum, which gets amplified along with the desired signal.

An eight-ohm speaker, or a pair of headphones wired in parallel, provide the audio output of the circuit. You will recognize the current amplifier consisting of Q2 and associated components that boost the current output of the LM387 to a level capable



## SOURCES

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**Geo-Monitor**, 65 Washington Street, #400, Santa Clara, CA 95050; ph: (408) 749-6770, FAX: (408) 249-3780. Publishes a technical newsletter about earth science, and may be useful to those interested in using lasers to record seismic activity.

Be sure and mention Nuts & Volts when you contact the above suppliers so your request goes to the right department.

## A New Project Rating System

In order to assist the laser experimenter, we've developed a new rating system in conjunction with the editorial staff of this magazine. That rating system applies to projects only, not to discussions of laser technology or news. The ratings are *Beginner*, *Intermediate*, and *Advanced*, corresponding to approximate categories describing the level of learning a person has accomplished in our forum here. For example, a simple lens demo would be classified *Beginner*, while our project this month is labeled as *Intermediate* because it requires some electronic and assembly expertise. Anything more complex than this month's project (either electronically or optically) would fit into the *Advanced* category.

## Back To Laser Basics

Another new feature which will commence with the next installment, is a return to laser fundamentals. Over the past three years, we've gone from super fundamental optical principles, to relatively advanced laser concepts, but lost some people intellectually in the process. So, we'll be doing some simple and interesting experiments too, from now on, for the people who are just getting into the laser field. Look for a section in future columns titled "Laser Basics" for you guys and gals who are becoming acquainted with this technology for the first time. And don't be shy about dropping us a postcard with your thoughts and suggestions to The Laser Experimenter's P.O. box listed elsewhere. We genuinely appreciate your ideas! People who follow this column regularly may find some repetition in Laser Basics, however, but we'll re-write every project so you don't read the same words and it won't exactly follow the outlay of anything published in this forum before.

## Conclusion

Next month, we'll be taking a look at plasma acoustics and how a laser can be modulated by a plasma, plus do some other interesting, simpler experiments. NV

## Closing Quote:

"He who wishes to see how much nature and the heavens can do among us should come to gaze upon her." — Francesco Petrarch, Italian Poet/Scholar (1304-1374)

Anthony Charlton is an active electronics and science "do-it-yourself" project designer, does custom R & D, and writes technical articles. Previous work experiences include design of hardware & software for microprocessor-based process control systems and electronic design. His hobbies include lasers, gardening, target shooting, model rocketry, and radio-controlled model airplanes.

The Laser Experimenter is a reader-interactive column. We like to hear from the reader and, in many cases, the best projects have come directly from your suggestions. If there is some particular facet of laser science that interests you, we would welcome hearing from you at: The Laser Experimenter, P.O. Box 74, Cornwall Bridge, CT 06754. Questions, comments, suggestions, and material relating to lasers are all welcome. We would like to publish letters in Reader Feedback occasionally. Indicate whether using your name and address is okay. We can now respond to your letters personally on an "as time permits" basis. Your FAX number, which will be kept confidential, will speed replies.

of driving a low-ohm speaker or headphones. After all, we are dealing with a PRE-AMP chip here which is not designed to directly drive a low-ohm load.

Ideally, you will operate the apparatus in an area of reduced light. That way, you'll get the maximum effect from the refractive changes and the minimum effect from ambient light. To adjust the intensity of the laser for maximum effect, you'll want to use an expanding lens and a variable polar-

izer. Both are shown in Figure 3.

Plastic polarizing sheets are available from Edmund Scientific at very reasonable prices. By rotating the polarizers relative to one another, the admitted light can be adjusted from approximately 20% of the original intensity to near zero. The combination of adjustment of the expander lens, the controls of the amplifier, and the variable polarizer will enable you to hear refractive index changes at their best. Keep this circuit away from artificial lighting and sunlight. The first will always cause an annoying buzz in the earphones, and the second will saturate the amplifier with "popcorn" noise.

Figure 4 shows a life-size PCB pattern for the amplifier. Figure 5 shows a blown-up parts placement guide. This guide shows the component placement from the FOIL side of the PC board, not the COMPONENT side. Albeit different from most diagrams depicting component placements, perhaps this protocol is better once a person gets used to it.

## Laser Helpline

This is a free service to the readers of The Laser Experimenter who wish to get in touch with one another by whichever medium they mutually prefer. To place your "free ad" (no commercial products, please), send your abstract and communication protocol to: The Laser Experimenter, Laser Helpline, P.O. Box 74, Cornwall Bridge, CT 06754.



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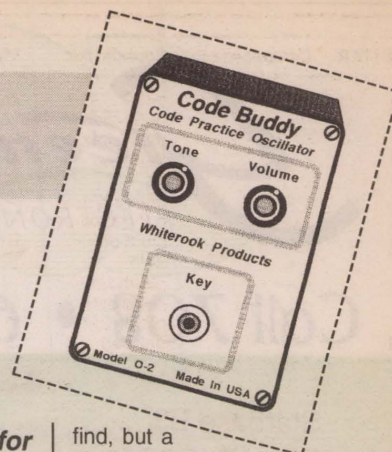
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# Build a Code Practice Oscillator

by  
Fred Blechman

**This article will describe how you can build your own simple "Code Buddy" code practice oscillator, either from scratch or from a kit. Using the Code Buddy, you'll be able to get up to the required code speeds to qualify for all amateur radio operator licenses, instead of being limited to the no-code frequencies. The schematic, parts list, and basic instructions are provided, as well as a source for the Code Buddy kit and two different kinds of code transmission keys.**



**S**o you want to join the over two million "hams" (amateur radio operators) around the world, but you don't want to learn the International Morse Code? Well, as of a few years ago, you no longer need to pass an International Morse Code test to become a US ham (although you still need to pass a written examination) — but your transmission privileges will be limited to the mostly-short-range higher frequency bands, six-meters and above. And you won't be able to communicate by code with the large percentage of hams that use code either exclusively or frequently on the lower frequency bands.

Spend some time learning International Morse Code ("CW"), even at the slow speed of five-wpm (words per minute), and your CW radio horizon literally expands worldwide to the 80, 40, 15, and 10-meter bands, including voice communication on 10-meters. Increase your code skills together with passing tougher written exams and ALL amateur bands will be open to you!

## Sending Code

While you can listen to tapes or training broadcasts to learn to READ the code, only consistent use of a code practice oscillator (CPO) and key will allow you to learn to SEND the code. For the higher level ham licenses that permit broader transmission privileges, Federal Communications Commission (FCC) Rule 97.503 states that, in addition to a written examination, "A telegraphy examination must be sufficient to prove that the examinee has the ability to send correctly by hand and to receive correctly by ear texts in the International Morse Code at not less

than the prescribed speed ..."

For the specific details of getting a ham license, the operating bands and privileges, several books are available at your local Radio Shack store. I particularly recommend "No-Code Plus," by Gordon West WB6NOA (Radio Shack Cat. #62-2417, \$7.99), a complete study guide for the Novice, Technician, and Technician-Plus exams.

## Learning the Code

The main reason for learning the International Morse Code is to be able to pass a five-wpm code test so that you can qualify for ham Novice Class or Technician-Plus Class frequencies and privileges — and even greater expansion of your ham horizons when you qualify at 13-wpm and 20-wpm (plus additional written exams) for General Class, Advanced Class, and Extra Class licenses.

You can learn to READ Morse by listening to cassette tapes available from Radio Shack, you can listen to live code broadcasts on a ham or short wave radio, or you can attend a code class. You can even use available computer programs to learn and practice.

But when it comes to SENDING Morse, and developing what hams and telegraphy operators call "a good fist," you need to practice with a sending key and a code practice oscillator like the "Code Buddy."

A typical code key is shown in Figure 1. These are getting hard to

find, but a similar key (and many of the parts for building the Code Buddy from scratch) are available from Ocean State Electronics, P.O. Box 1458, 6 Industrial Dr., Westerly, RI 02891. Call them at (800) 866-6626 and ask them to send you their latest free 120-page chock-full-of-goodies catalog, and look on page 75 for their 70-378 Deluxe Code Key for \$12.75. Ameco Corp., 224 E. Second St., Mineola, NY 11501, (516) 741-5030, has several code keys. See the Code Buddy Parts List for an inexpensive "pocket-size" key.

So that you can practice with the proper "fist," Figure 2 shows the proper International Morse Code time intervals, and Figure 3 shows the actual codes and their sounds.

## Code Buddy Circuit Description

Figure 4 shows the schematic of the Code Buddy. As you can quickly see, the heart of the design is the popular 555 integrated circuit (IC) timer. Produced by several different manufacturers that vary the internal design somewhat, the most common version of this IC has 23 transistors, 2 diodes, and 16 resistors on the silicon chip within its package.

In block diagram form, as shown in Figure 5, these components form two comparators, a flip flop, an output stage, a reset transistor, and a discharge transistor. Supply voltage, Vcc, is applied to pin 8, and pin 1 is GROUND. Pin 2 is connected to an

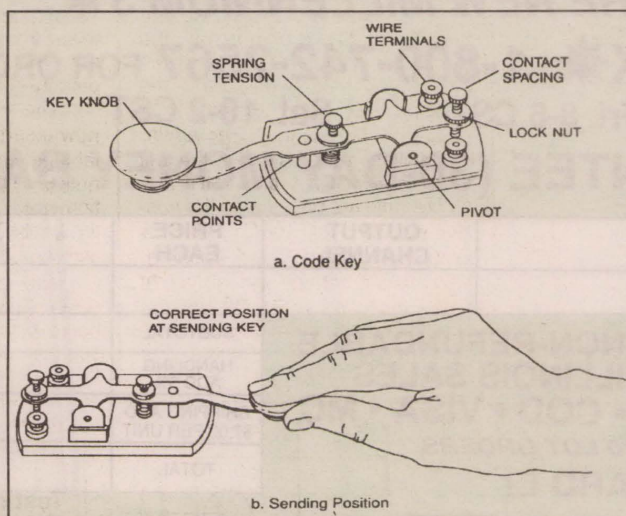


Figure 1. A typical code key (a), and the correct sending position for the hand (b). (From Radio Shack "No-Code Plus" book by Gordon West, Master Publishing, Inc.)



Assembled Code Buddy before placement in cabinet.

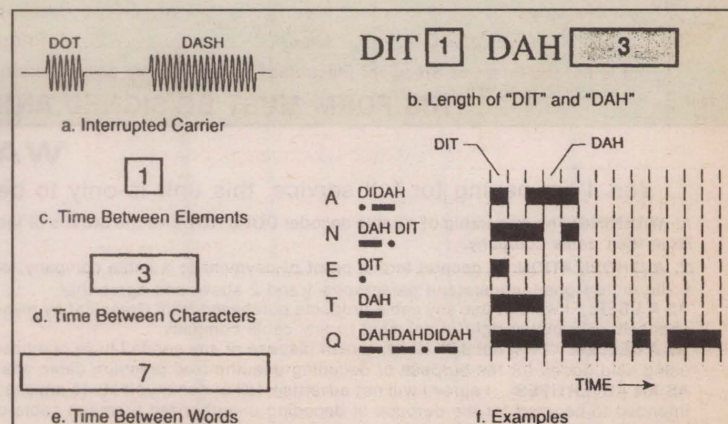


Figure 2. Time Intervals for Morse Code. (From Radio Shack "No-Code Plus" book by Gordon West, Master Publishing, Inc.)



LETTER	Composed of:	Sounds like:	LETTER	Composed of:	Sounds like:
A	• —	didah	N	— •	dahdit
B	— • • •	dahdididit	O	— — —	dahdahdah
C	— • • • •	dahdidahdit	P	• — — •	didahdahdit
D	— • •	dahdidit	Q	— — — •	dahdahdahdit
E	•	dit	R	• • • •	didahdit
F	• • — •	dididahdit	S	• • •	dididit
G	— — •	dahdahdit	T	—	dah
H	• • • •	didididit	U	• • —	dididah
I	• •	didit	V	• • •	dididah
J	• — — —	didahdahdah	W	• — —	ditdahdah
K	— • •	dahdidah	X	— • • —	dahdidah
L	• • • •	didahdidit	Y	— • — —	dahdidahdah
M	— —	dahdah	Z	— — • •	dahdahdidit

a. Alphabet

CHARACTER	Composed of:	Sounds like:
AR (end of message)	• — • • •	didahdidahdit
K invitation to transmit (go ahead)	— • •	dahdah
SK End of work	• • • • •	didididididid
SOS International distress call	• • • — • • • •	dididididididididit
V Test letter (V)	• • • —	didididah
R Received, OK	• • • •	didahdit
BT Break or Pause	— • • • •	dahdidididah
DN Slant Bar	— • • • •	dahdididahdit
KN Back to You Only	— • • • •	dahdididahdit
Period	• • • • •	didididididid
Comma	— • • • •	dahdahdididid
Question mark	• • • • •	didididididit

b. Special Signals and Punctuation

NUMBER	Composed of:	Sounds like:
1	• — — — —	didahdahdahdah
2	• • — — —	dididahdahdah
3	• • • — —	didididahdah
4	• • • • —	dididididah
5	• • • • •	dididididit
6	— • • • •	dahdidididit
7	— — • • •	dahdahdididit
8	— — — • •	dahdahdahdidit
9	— — — • •	dahdahdahdidit
0	— — — — •	dahdahdahdahdah

c. Numerals

Figure 3. Morse Code and its sound. (From Radio Shack "No-Code Plus" book by Gordon West, Master Publishing, Inc.)

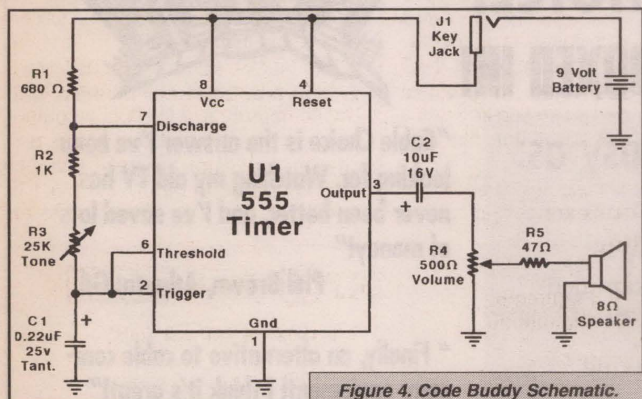


Figure 4. Code Buddy Schematic.

input to the TRIGGER comparator, and pin 6 is connected to an input of the THRESHOLD comparator.

Notice that three resistors of equal value are placed between Vcc and GROUND so that 1/3 Vcc appears as a reference voltage to an input of the TRIGGER comparator, and 2/3 Vcc is the reference voltage at an input of the THRESHOLD comparator. Since the resistors are all of the same value, the 1/3 Vcc and 2/3 Vcc points are relative to Vcc, and

therefore independent of actual Vcc variation.

The OUTPUT (either HI or LO) appears at pin 3, while a DISCHARGE transistor provides a path to GROUND at pin 7 whenever the OUTPUT is LO. When the RESET transistor at pin 4 is turned ON with a voltage below .4 volts, it makes the OUTPUT at pin 3 LO. When not intended to be used for RESET, pin 4 is connected to pin 8 to prevent spurious resetting. Pin 5 CONTROL

VOLTAGE is not used in this application.

The 555 has two principal operating modes: monostable (must be triggered to change state) and astable (changes state automatically — "oscillates" — depending on the external components used). In the Code Buddy circuit, the 555 is configured for use in the astable mode as a simple variable frequency audio oscillator with volume control.

When a key is plugged into the J1 key jack, it acts as a switch. When the key is closed, battery voltage, Vcc, appears at pin 8 and pin 4 to power the IC and prevent spurious resetting. Since capacitor C1 is uncharged, the voltage at pin 2 is below 1/3 Vcc and, therefore, the OUTPUT at pin 3 is HI.

Voltage begins to build up on capacitor C1 through resistors R1 and R2, and potentiometer R3. When the voltage on C1 reaches the THRESHOLD voltage (2/3 Vcc at pin 6), the OUTPUT at pin 3 goes LO, and the DISCHARGE transistor at pin 7 provides a path to GROUND.

Now C1 starts to discharge at pin 7 at a rate depending on the value of resistor R2 and the setting of potentiometer R3. When the voltage at C1 drops below the TRIGGER voltage (1/3 Vcc at pin 2), the OUTPUT goes HI and the DISCHARGE path at pin 7 is opened. C1 starts to charge again.

Oscillation occurs due to the fact that the TRIGGER and THRESHOLD inputs are both tied to the positive side of capacitor C1, which is continually charging and discharging between 1/3 Vcc and 2/3 Vcc at a rate controlled by R1, R2, and the setting of tone potentiometer R3.

Capacitor C2 couples the squarewave output of U1 to poten-

plate. I will describe the kit construction so that you can build your own from scratch if you prefer.

Figure 6 shows the printed circuit board, foil side, in actual size. Figure 7 shows the component layout using this board. Figure 8 shows side views with components installed so you can see the mounting of the speaker.

Use only rosin core solder and a 25-35 watt pencil-type soldering iron. When installing parts into the printed circuit board (PCB), be sure that capacitors C1 and C2 are installed with the positive leads oriented as shown, and that the U1 integrated circuit is plugged into its socket with the notch (pin 1 end) as shown. C2 will have to be installed flat against the board so it does not interfere with the front panel in later assembly. Similarly, the potentiometers will also have to lie flat against the board. When soldering the battery snap to the PCB, make sure the red wire is soldered to the plus (+) pad. Make sure the key jack you are using is an open circuit type.

A piece of double-sided foam tape holds the speaker to the foil side of the PCB in the boxed area centered between the potentiometers on the other side, as shown in Figure 8. You'll need to connect short hook-up wires from the PCB to the key jack and the speaker terminals — no polarity consideration in either case.

The PCB/speaker assembly is now inserted into the pre-drilled and labeled front panel. Washers and nuts hold the front panel to the potentiometers and key jack, after which the knobs are slipped onto the potentiometer shafts.

The cabinet provided with the Code Buddy Kit has a pattern of holes drilled in the bottom to allow the speaker sound to exit the cabinet. When installing the assembly into the cabinet, orient the cabinet so the holes appear opposite the speaker.

## Testing and Troubleshooting

For best results, always use an alkaline nine-volt battery. If you use a closed-circuit key jack by mistake, the Code Buddy will sound off when you connect the battery. This should not be! Power should not be applied to the circuit until an EXTERNAL key is closed.

No power is drawn from the battery until the external key is closed. The assembled Pocket Mini-Key (see Parts List) has a built-in 3.5 mm (1/8-inch) miniature phone jack, and makes a good mate for the Code Buddy.

To test the unit, simply connect an external key through a two-wire cable (with the appropriate plugs on each end) to the key jack on the Code Buddy front panel. When the external key is closed, you should hear a tone through the speaker. The frequency is controlled by the TONE

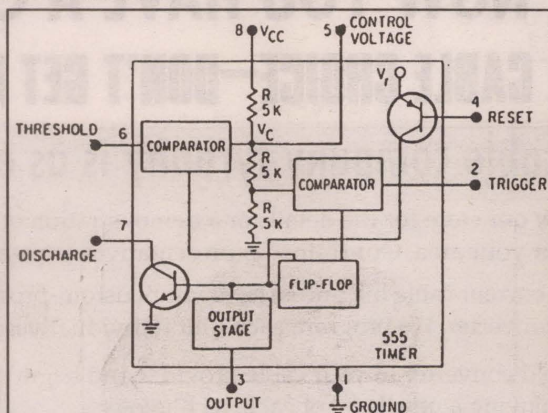


Figure 5. 555 Timer Block Diagram.

tiometer R4, which controls the signal volume through resistor R5 to the small speaker.

## Code Buddy Construction

You can build the Code Buddy circuit from parts you have or can obtain, but the Code Buddy Kit (see Part List) has everything you need, including a custom cabinet and face-



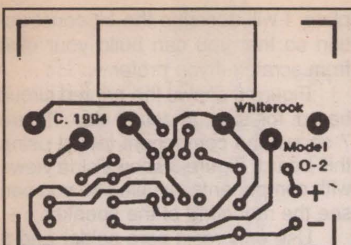


Figure 6. Code Buddy Printed Circuit Board — Actual Size.

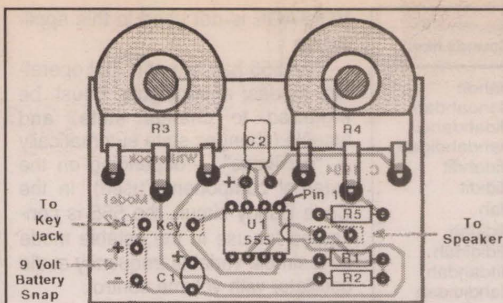


Figure 7. Code Buddy Parts Layout.

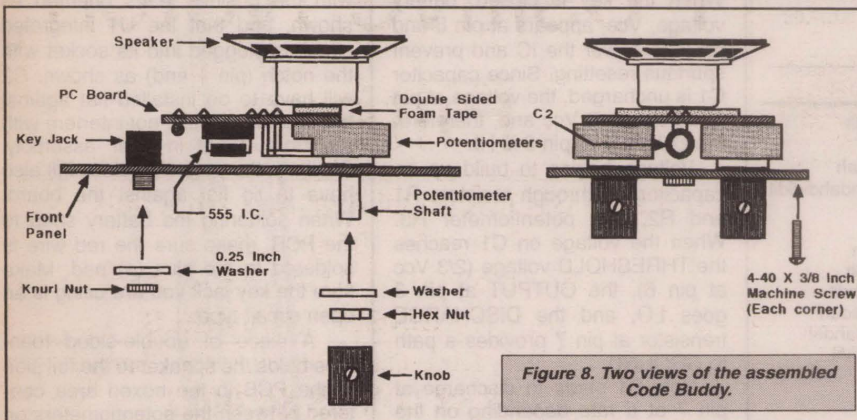


Figure 8. Two views of the assembled Code Buddy.

control, the loudness by the VOLUME control.

Have the speaker face you during operation. This reduces the need for higher volume levels, which use more battery power! If you use an

older key — such as a vintage WWII surplus type — make sure the contacts are clean and not corroded.

In troubleshooting, be aware that the majority of problems arise from construction errors. The most com-

mon problem, by far, comes from solder bridges between traces and pads on the PCB. Hold the PCB up to a light, compare it with the PCB drawing, and any bridges should be readily apparent.

Next, check all parts that involve polarity: C1, C2, battery snap, pin 1 of the IC. Make sure none of the pins of the IC were bent when inserting it into its socket. There should be nine volts between pin 8 (Vcc) and pin 1 (ground.) If the tone seems unstable or scratchy sounding, clean your key contacts, since they are likely corroded or dirty.

### Special Thanks

My thanks to Gordon West WB6NOA, for his help with this article. Over 15,000 Southern California amateur radio operators have passed their ham licensing examination and upgrades through Gordon West Radio School weekend courses. Throughout the country, one out of two newly-licensed hams use Gordon West training materials. For reservations or

more information, call Radio School 24 hours at (714) 434-0666 or speak directly with Gordon West Radio School, 10am-4pm Pacific time, by calling (714) 549-5000. NV

## Code Buddy Parts List

C1 — .22 uF (10WVDC or higher) tantalum capacitor  
C2 — 10 uF (10WVDC or higher) electrolytic capacitor  
R1 — 680 ohm 1/4W 5% carbon resistor  
R2 — 1K 1/4W 5% carbon resistor  
R3 — 25K potentiometer with mounting hardware and knob  
R4 — 500 ohm potentiometer with mounting hardware and knob  
R5 — 47 ohm 1/4W 5% carbon resistor  
J1 — 3.5 mm (1/8-inch) miniature open-circuit phone jack  
U1 — 555 timer integrated circuit  
SPEAKER — 8 ohm 2-inch diameter  
SNAP — 9-volt battery snap connector  
SOCKET — 8-pin IC socket for U1  
Miscellaneous: printed circuit board, double-sided tape, hook-up wire, solder.

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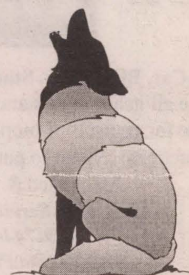
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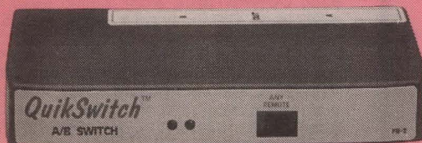
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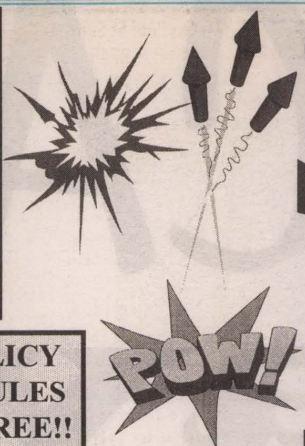
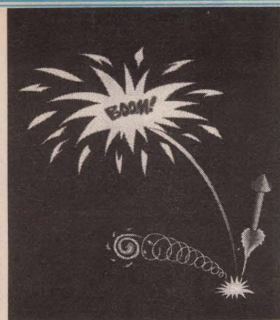


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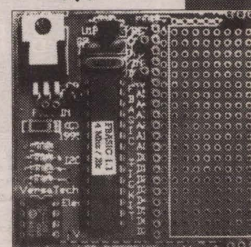
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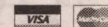
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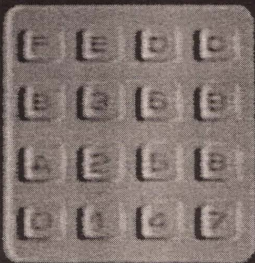
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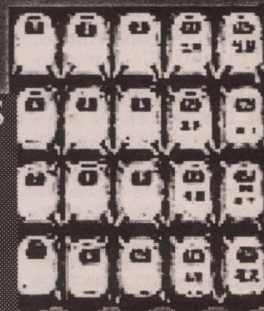
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by  
Thomas Henry and  
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# BUILD THE ADV-SNARE:

## AN ANALOG DRUM VOICE FOR PERCUSSIVE MUSICAL EFFECTS

**T**he ADV-SNARE is an exceedingly versatile analog drum voice you can construct using a handful of common electronic components. It is perfect for use on stage during live musical performances, but is equally useful at home in the recording studio. The ADV-SNARE has no commercial

gear. Although a bit subjective in nature, claims are made that analog voices sound warmer or more natural.

But whatever your audio philosophy, one thing is clear: The ADV-SNARE can simulate a staggering array of percussive instruments. Realistic snare and bass drum sounds are all easily within reach, as well as many techno-pop effects like tunable

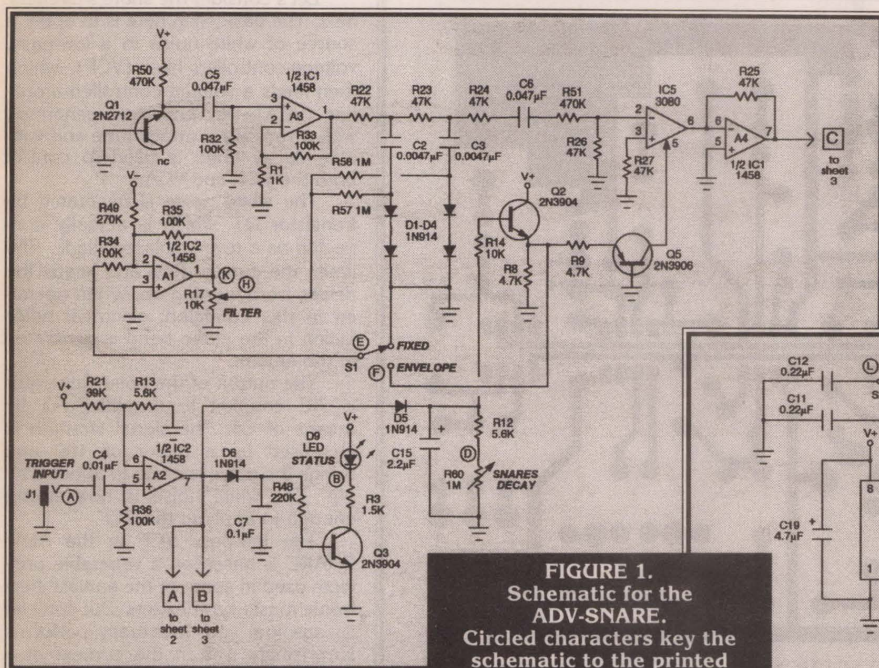
making a realistic snare drum sound. Later sections will explain the circuit behavior, then show you how to build and play the ADV-SNARE.

### ANALYSIS OF A SNARE DRUM

While the ADV-SNARE is capable of many different percussive effects, it was designed to do an especially good job of snare drum sounds. Now, to synthesize a decent snare drum requires close attention to three particular sonic components. These are called the impact, shell resonance, and snares. To understand these parameters, consider what happens when a real snare drum is struck.

drum is an air-filled hollow body, and so has a certain basic frequency at which it resonates. This depends upon its volume, as well as the tightness of the skins. When the head is struck, a damped sinusoidal wave results. Complicating the issue is the fact that the impact of the stick deforms the head slightly at the outset, and hence alters the volume of air within the drum. This causes the shell resonance to change slightly. The basic tuning rises momentarily and then settles back to normal.

Finally, the third component of a snare drum sound is the effect created by the vibration of metal wires which lie against the bottom head. Musicians, not surprisingly, call these wires "snares." They will rattle and shake about briefly whenever the drum head is in motion. At the outset, the snares produce a sound richer in high-frequency components, but as



**FIGURE 1.**  
Schematic for the  
ADV-SNARE.  
Circled characters key the  
schematic to the printed  
circuit board.

equivalent, and sports a number of front panel controls which let you dial in a full range of realistic or surrealistic percussive sounds. Best of all, the device can be triggered by hand or computer with equal ease.

In this day and age of digital sampling, you may wonder what the appeal of an analog drum voice might be. Let's compare the two approaches and see. With sampling, the sound of a real drum is recorded, digitized, and then stored in computer memory from where it can be later recalled. One limitation is obvious: You're pretty much stuck with the basic drum sound that the manufacturer thought was worth recording. This may or may not appeal to your musical taste!

On the other hand, an analog voice offers continuous control over a number of the parameters affecting the final sound. And, somewhat surprisingly, after the initial hubbub of the so-called digital revolution, many musicians are returning to analog

tom-toms and explosions.

While simple to build and use, the ADV-SNARE includes a number of professional features, such as:

- Individual controls for every sound parameter.
- Built-in three-channel audio mixer and waveform blend control.
- Ability to be tuned over a wide range.
- Versatile input stage which can be triggered by switches, sensors, or computers.
- Status LED.
- Bipolar 15V operation which is compatible with most analog synthesizer gear.
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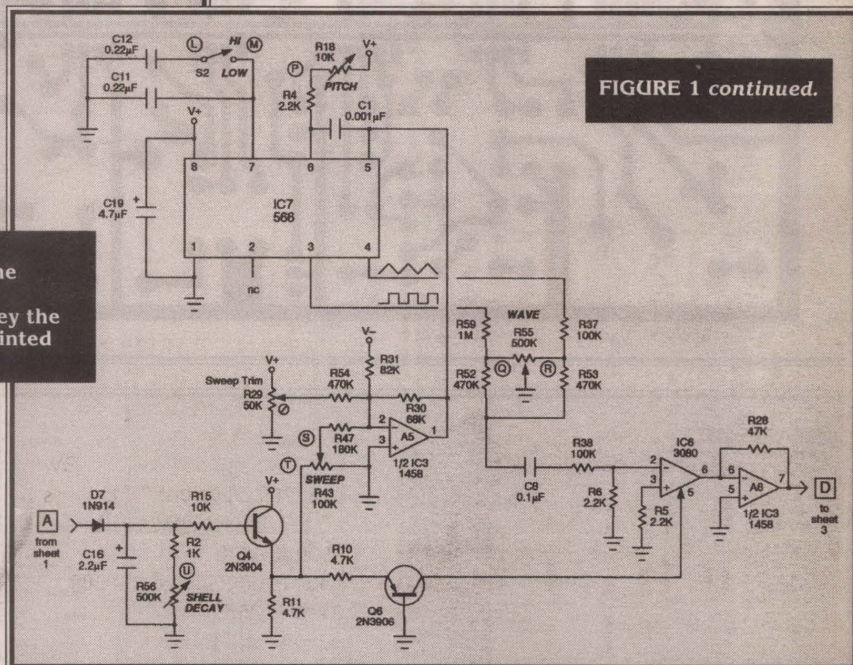
If this all seems appealing to you, then read on to learn what goes into

The sound of the stick hitting the taut skin grabs your attention first. This is the impact. Depending on the tightness of the drum head, the material from which the drum stick is made, and how the head is struck, the sound may range from a fierce click to a more mellow thud.

Almost immediately after hearing the impact (which is quite short in nature), you will notice the softer boom of the shell resonance. Now a

they lose energy, the high end falls away.

Snare drum circuits from the past often garnered bad reputations, musically speaking, since they typically failed to take all three sound components into account. For example, the earliest attempts used gated white noise to simulate the sound of the snares vibrating. By itself, this gives little more than a splatty hiss and only vaguely suggests a real drum. Later



**FIGURE 1 continued.**



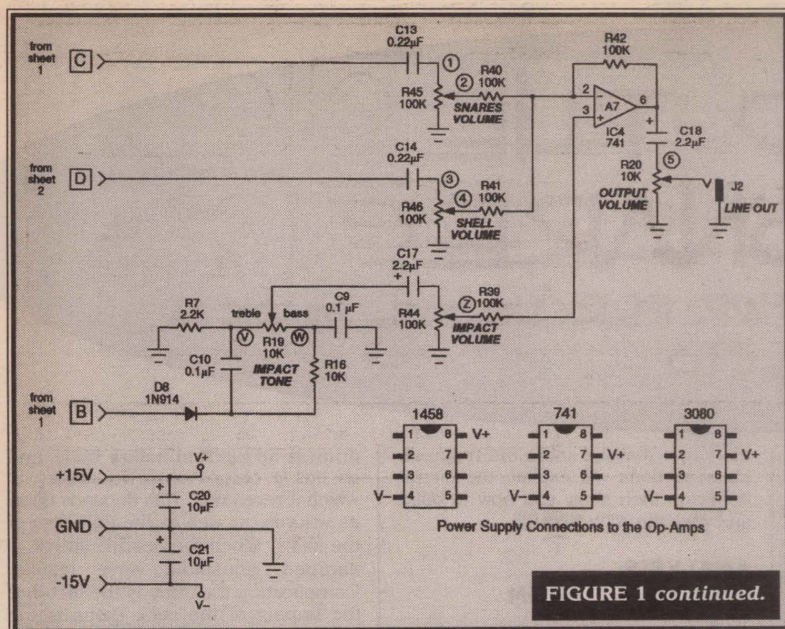


FIGURE 1 continued.

designers added in shell resonance. This certainly improved the situation, but lacking the initial detuning described above, the sound was still a bit static and artificial. Moreover, without the impact tone, it was next to impossible to convince the listener that something was really being struck.

By using proven analog techniques, the ADV-SNARE recreates all of these sonic components and then some. And unlike many earlier stabs, it does so without recourse to exotic or hard-to-find music synthesizer chips. In short, while perfect for professional and amateur musicians alike, the ADV-SNARE is also inexpensive and easy to build.

## CIRCUIT OPERATION

At first glance, the ADV-SNARE circuit appears to be quite complicated. However, when considered in light of the general acoustical analysis given above, its operation is straightforward. Refer to Figure 1,

which shows the complete schematic for the ADV-SNARE.

We'll start with the trigger input, which is applied to jack J1. The input signal is differentiated by C4 and R36, and then squared up by comparator A2. R13 and R21 set a threshold of about 1.8V. Due to the versatility and reliability of this input structure, the ADV-SNARE can be fired by most any switch, transducer, or computer port line.

The output of A2 is a crisp pulse, about 1 millisecond wide for most input sources. It is then applied to several diodes — D5 through D8 — which route the pulse to various portions of the circuit. Consider the Status LED circuitry first. D6 dumps the pulse onto capacitor C7, which will hold the charge long enough to light an LED efficiently. (Without this pulse stretcher, the LED would flicker too rapidly to be useful.) The voltage is then applied to the buffer configured around R48 and Q3. When the transistor turns on, current passes through LED D9 and illuminates it. R3 limits the current to a reasonable level.

Let's consider the snare's circuitry next. The basic idea here is to apply a source of white noise to a low-pass, voltage-controlled filter (VCF), which then feeds a voltage controlled amplifier (VCA). An envelope generator, with a very short attack time and variable decay time, is used to control both the VCF and VCA.

The white noise is generated by transistor Q1, which is actually connected as a reverse-biased diode. R50 limits the current flow and keeps the device from burning up. When operated in this condition, electrical noise falling in the audio band is generated at the emitter.

The output of the noise generator is AC coupled to amplifier A3 by means of C5. The signal strength is increased by a factor of 100 and brings the noise level up to about 0.5V p-p. The white noise is now strong enough to apply to the VCF.

The low-pass VCF in the ADV-SNARE is based on a venerable principle used in some of the earliest electronic music synthesizers. But don't let its age fool you; it actually performs surprisingly well in the context of a percussion unit. At the heart of it is the pi-section filter composed of resistors R22 through R24, capacitors C2 and C3, and diodes D1 through D4. If you pretend that the diodes are resistors, then this really is just an ordinary pi-section filter which will pass lower frequencies while attenuating the higher ones. But notice that R57 and R58 tap into the legs of the pi-section. When a voltage is applied to these, a current will flow through the diodes. As more current flows, the effective impedance of the legs changes, altering the cut-off frequency of the filter. More specifically, when the control voltage sent to R57 and R58 increases from 0V to about +5V, the corner frequency of the VCF will drop lower and lower. The sound, thus transmitted, will become more bassy in nature.

Incidentally, one of the reasons

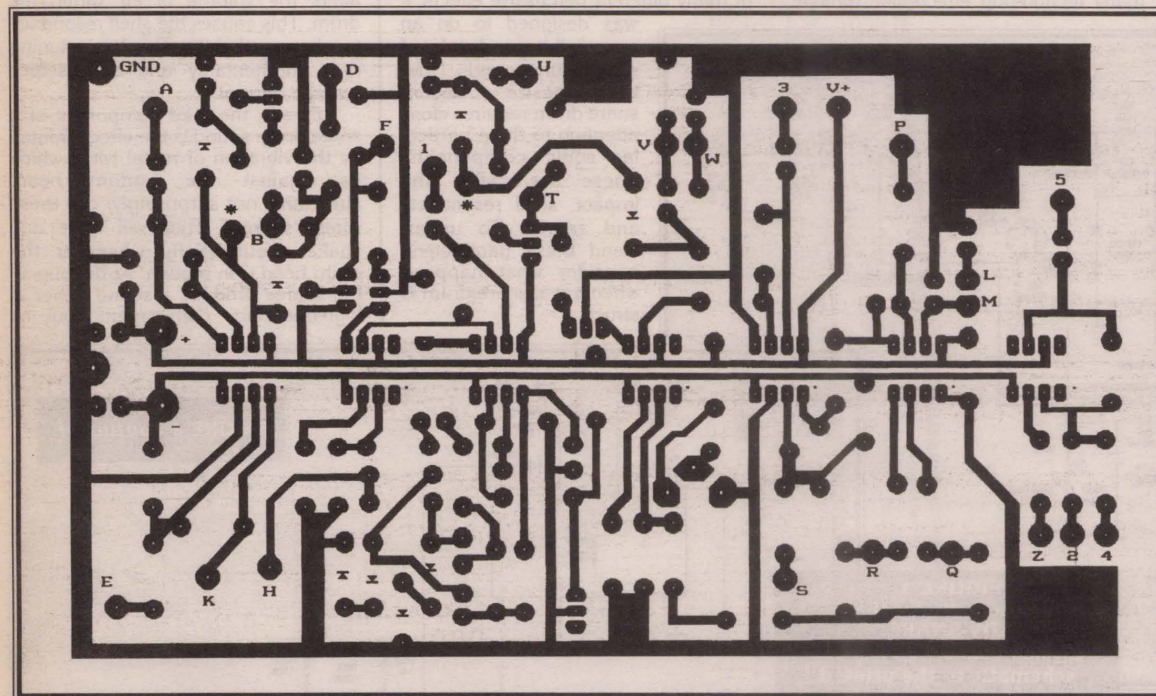


FIGURE 2.

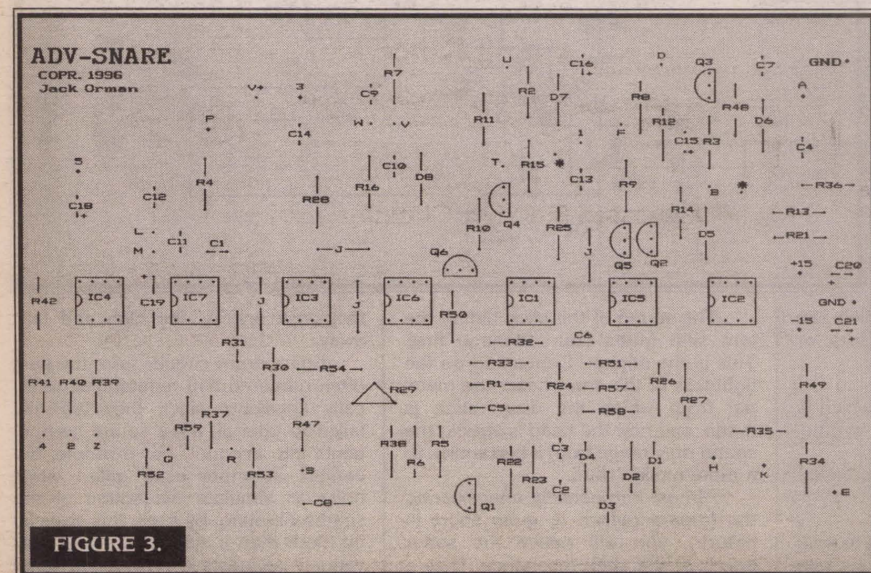


FIGURE 3.

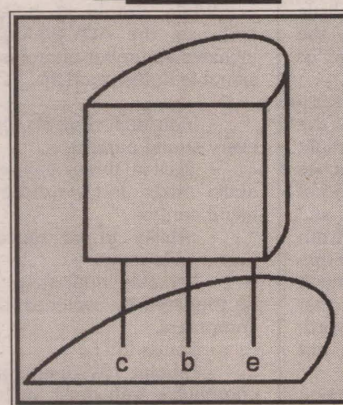


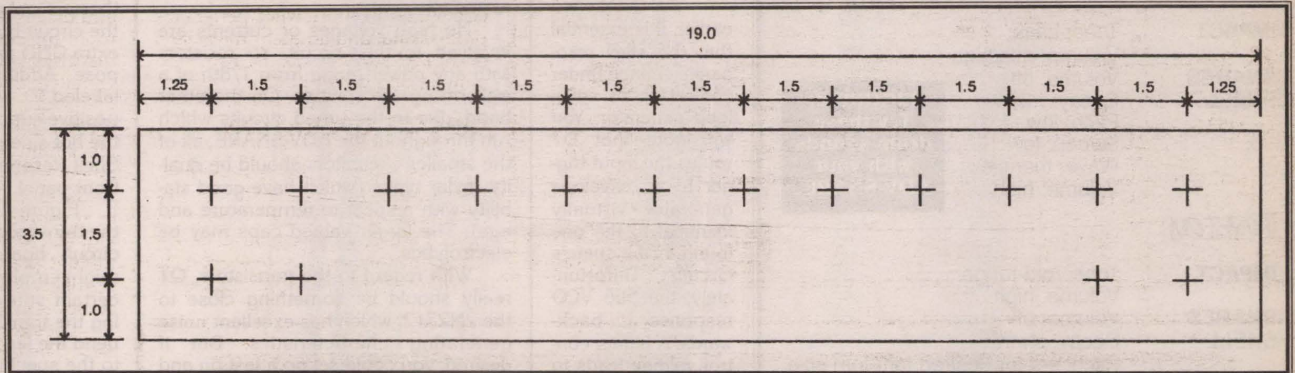
FIGURE 4.  
Transistor orientation  
assumed on the parts  
placement guide.





**FIGURE 5.**  
ADV-SNARE Front  
Panel.

**FIGURE 6.**  
Front Panel  
Drilling Guide.  
All measurements  
in inches.  
(Shown at 75% of  
actual size)



this VCF was abandoned by most music synthesizer designers is that it thumps if the control voltage changes too rapidly. But obviously, in a percussion unit, this is hardly a defect, and may even add to the overall effectiveness! Of course, the whole reason for using a VCF here is to replicate the sound of the snares losing energy as the vibrations die out. It will be shrill at the outset, then increasingly devoid of high-frequency components during the decay stage.

But something has to control the VCF, so let's look at the envelope generator now. The squared up trigger pulse at the output of A2 is directed by D5 to C15. The voltage on this capacitor rises to a value near the positive supply rail. D5 blocks the reverse path, so the only way the charge will be dissipated is through R12 and R60. Hence, the attack time is fixed to be virtually instantaneous, while the decay is continuously adjustable via R60.

This voltage is then buffered by Q2 and its associated components. The result is tapped off of the emitter and routed around to inverting amplifier A1. Recall that the VCF discussed above has a backwards response. That is, the higher the control voltage, the lower the cut-off frequency of the filter. So, A1 in conjunction with the nearby parts, inverts, attenuates, and level shifts the envelope generator signal appropriately. While the input applied to R34 swings from 0V to about +10V, the output at pin 1 of A1 goes from about +5V to 0V, exactly what the filter wants.

Notice that potentiometer R17 lets you dial in the desired amount of modulation to the VCF. Moreover, switch S1 lets you configure the filter to operate in Fixed or Envelope mode. In the former case, rotating R17 permits you to manually set the tone of the snares, while Envelope mode forces the VCF to follow the envelope generator as described previously.

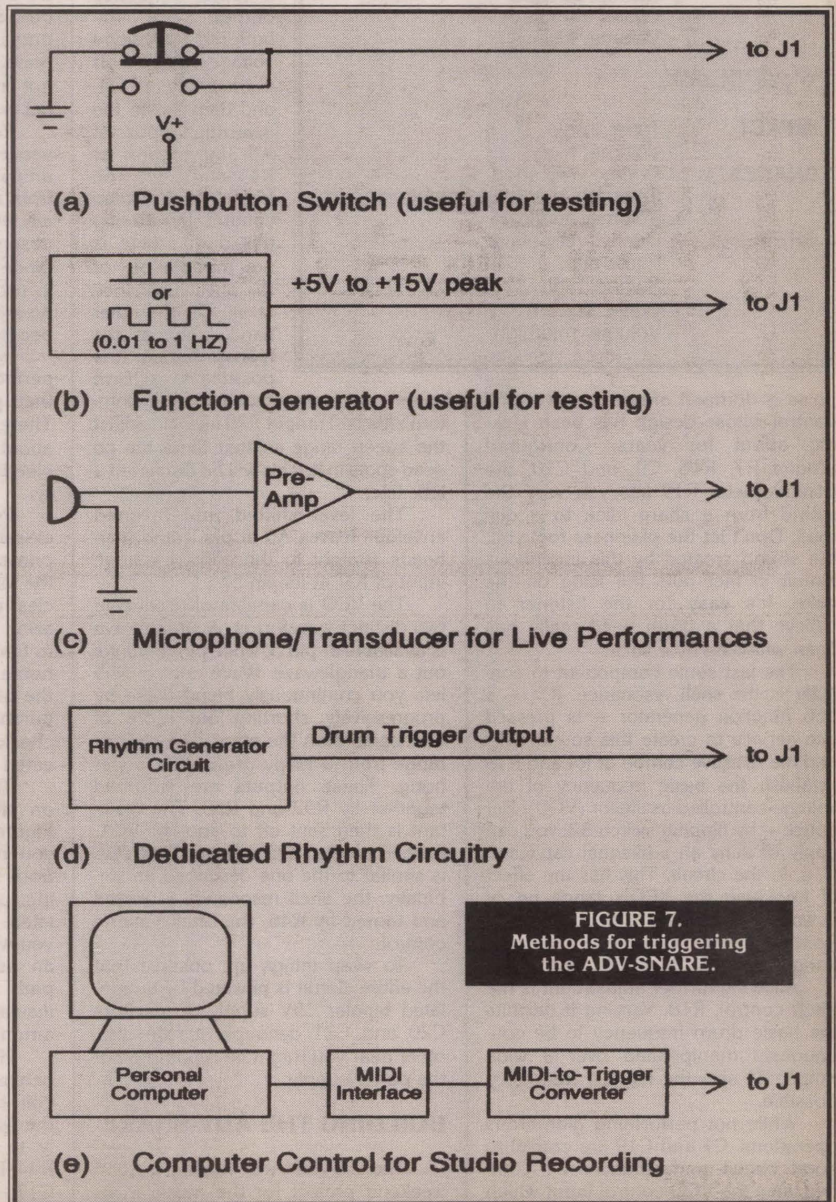
But back to the filter. The output of the VCF is capacitively coupled by

C6 to the VCA built around IC5. This is the ubiquitous 3080, an operational transconductance amplifier. To keep it operating in its linear range, the white noise signal is chopped down by R26 and R51. The gain (or more properly, the transconductance) of the amp is set by a control current applied to pin 5. Notice how the envelope generator output is tapped off of the emitter of Q2 and converted to a current by transistor Q5. R9 keeps this at a level safe for the proper operation of the 3080.

The output of IC5 is also a current. Resistor R25 and buffer A4 convert this to a voltage, while adding quite a bit of gain to boot. The signal appearing at the output (pin 7 of A4) can have a maximum amplitude of about 10V p-p, which is a common music synthesizer standard. In general, all audio paths within the ADV-SNARE run at this level to help maintain a good signal-to-noise ratio.

After the white noise has been processed by the VCF and VCA, it is sent to the output mixer configured around A7 and the associated components. R45 lets you adjust the relative volume of the snares, while R20 sets the level of the complete mix. Remember, these are strong signals; therefore, be sure to ease the Output Volume up slowly so that you don't inadvertently blow out either your loudspeakers or ears!

As long as we're looking at the mixer, we might as well see how the impact is handled. Nothing could be simpler, or more effective for that matter. Notice that, once again, the cleaned-up trigger from the input is delivered to the remaining circuitry by a diode, D8. The



**FIGURE 7.**  
Methods for triggering  
the ADV-SNARE.



## SNARE DRUM

IMPACT	Tone: treble
	Volume: high
SNARES	Decay: short
	Filter: envelope/full modulation
	Volume: low
SHELL	Decay: short
	Pitch: mid/high
	Sweep: mid/low
	Wave: triangle
	Volume: high

## BASS DRUM

IMPACT	Tone: bass
	Volume: mid/high
SNARES	Volume: off
SHELL	Decay: mid
	Pitch: low
	Sweep: low
	Wave: triangle
	Volume: high

## TOM-TOM

IMPACT	Tone: mid-range
	Volume: high
SNARES	Volume: off
SHELL	Decay: short
	Pitch: set for desired tom-tom size
	Sweep: mid/low
	Wave: triangle
	Volume: high

## WOODBLOCK

IMPACT	Tone: treble
	Volume: high
SNARES	Decay: very short
	Filter: envelope/full modulation
	Volume: mid/low
SHELL	Decay: very short
	Pitch: high
	Sweep: high
	Wave: square
	Volume: mid/high

**FIGURE 8.**  
Try these  
drum sounds  
with your  
ADV-SNARE.

keeps it from breaking into spurious oscillation. C19, which should be mounted close to the 566, simply decouples and isolates the chip and prevents it from imposing any nasty spikes onto the power supply lines. Do not ignore either of these capacitors.

As mentioned earlier, it is essential that the shell resonance change under control of an envelope generator. You will note that D7 routes the input trigger to an envelope generator virtually identical to the one found in the snare's circuitry. Unfortunately, the 566 VCO response is backwards. A higher control voltage leads to a lower frequency output. So, the buffered envelope voltage is tapped off of the emitter of Q4, and then fed to the inverting input of A5, by means of R43 and R47. The former is a Sweep control; by turning this down, there is no modulation of the shell resonance at all. On the other hand, when at the highest setting, it is possible to achieve

some neat ooh-ooh-ooh tunable tom-tom effects. Trimpot R29 lets you adjust the sweep range so that there are no dead spots in it. This will be discussed a little later.

The level shifted and inverted envelope leaves A5 at pin 1 and then heads straight to the control voltage input of IC7 at its pin 5.

The VCO is capable of producing two distinct waveforms. A squarewave is available at pin 3, while pin 4 cranks out a trianglewave. Wave control R55 lets you continuously blend these by progressively shorting out more of one signal than the other. The sounds range from a raspy growl, to a softer bong. These outputs are summed together by R52 and R53. The resultant is then sent off to another VCA, formed around IC6 and A6. This VCA is similar to the one described earlier. Finally, the shell resonance is mixed and tamed by R46, the Shell Volume control.

To wrap things up, observe that the entire circuit is powered by a regulated bipolar 15V supply. Capacitors C20 and C21 decouple it from any other gear you might be running off of the power supply.

## BUILDING THE ADV-SNARE

The ADV-SNARE makes a good weekend project for the musician or

hobbyist who is interested in quality audio circuits. Your first task will be to obtain all of the parts needed, but fortunately none of these are expensive or hard to find. Refer to the Parts List. As a convenience to readers, a kit available by mail order is also described there. However, if buying the parts individually, pay close attention to the potentiometers. For example, when an audio taper potentiometer is specified, be sure to stick to it (and similarly for the linear taper ones). This will guarantee that the front panel controls feel right and perform as expected.

No high voltages or currents are involved in this circuit, so resistors with any power rating from 1/8th of a watt on up are suitable. On the other hand, due to the tuned circuits which run throughout the ADV-SNARE, all of the smaller capacitors should be quality mylar types (which have good stability with respect to temperature and age). The larger valued caps may be electrolytics.

With regard to the transistors, Q1 really should be something close to the 2N2712, which has excellent noise generating characteristics. But if desired, you could set up a test rig and try some alternatives from your junk box. Simply pick the transistor which puts out the best sounding white noise. The remaining transistors are not critical, and virtually any good signal type may be substituted.

You can't get any more garden variety than the 1458 and 741 op-amps. These are easily obtainable from many different sources, and usually at bargain basement prices. Also observe that the 3080 transconductance operational amplifier is available in two housings: the older metal can type or the plastic eight-pin DIP. Most people prefer the latter, nowadays.

If building up this circuit using perfboard and wirewrap techniques, then pay close attention to neatness. There are some hot signals running about, and you won't want these to bleed into other portions of the circuitry.

Perhaps the simplest and most elegant approach, though, is to use a printed circuit board. Figure 2 shows the foil side artwork for this. Many articles have been published in this magazine and elsewhere, explaining how to fabricate your own circuit boards at home using fairly simple methods. On the other hand, should you desire to purchase one ready-made, be sure to check out the mail order source indicated in the Parts List.

There are five jumpers indicated on the parts placement guide in Figure 3. Four of them are labeled J; you may use leftover leads snipped from resistors for these. One remaining jumper, however, should be insulated. On the parts placement guide, you will notice two points labeled with an asterisk (\*). Connect these two pads with a short piece of 22 gauge insulated wire, and dress it neatly among the components.

Notice that C17 mounts directly behind the front panel, not on the circuit board. This capacitor connects the wiper of potentiometer R19 directly to the hot side of potentiometer R44. Be sure to observe the polarity of C17, and use insulating spaghetti to

cover its bare leads.

Observe that the circled characters (letters or numbers) on the schematic correlate the board to the front panel connections. For example, you will note that the wiper of R17 (the Filter control) is called out on the schematic by a circled H. Thus, the central solder lug of the pot should be connected to the pad labeled H on the printed circuit board. Other pads provide connections to V+, V-, and GND (ground). But heed the following: To avoid ground loops which can lead to insidious hum problems, be sure that there is only one path from GND on the circuit board to the front panel. An extra GND pad is provided for this purpose. Additionally, you'll find a pad labeled V+ which is used to route the positive supply voltage to LED D9 and the hot side of potentiometer R18 (the Shell Resonance Pitch control) on the front panel.

Figure 4 shows the orientation of the transistors assumed on the printed circuit board. Some manufacturers might employ a different pin-out, so be certain you check this before soldering the transistors in place. If need be, bend the leads as required to conform to the specified pattern.

Finally, you will want to give some thought to an enclosure for the unit. If you intend to build up an extensive studio-type drum system featuring many different circuits of which this is only one, then perhaps a modular rack panel approach is best. Figure 5 shows a suitable layout. The panel is made of 1/8 aluminum stock and has the industry standard dimensions of 3-1/2 by 19. Figure 6 shows the associated drilling guide. (Incidentally, since the ADV-SNARE is capable of so many different percussive effects, you will probably want to build two or more of them. For example, a set consisting of three of these units could play simultaneous snare, bass, and tom-tom arrangements). For a stand-alone instrument, any metal enclosure (which has good shielding characteristics) or wooden frame with metal panel would get the job done.

After fabricating the panel, consider using dry transfer letters to designate the various switch, jack, and potentiometer functions. Several layers of clear plastic spray will protect the panel from chips or scratches. Another possibility is creating custom decals using a home computer and a printer. Mailing label material can provide the sticky back to adhere the decal to the painted panel.

The circuit board or handwired perfboard can be mounted behind the front panel with standoffs or small angles; #4 hardware (nuts, machine bolts, and lock washers) can be used to secure everything in place. Make certain that the ADV-SNARE is not only wired neatly, but that all connections are mechanically sound as well.

The ADV-SNARE requires a regulated bipolar 15V power supply in order to operate. Plan on using about 20 milliamps on the positive side, and 10 milliamps on the negative side. You can build a separate circuit to meet this need, or may be able to tap the required voltages off of existing music synthesizer equipment. If you've applied power and no smoke or flames result, then you are ready to

pulse is dumped onto a passive tone control whose design has been kicking about for years. Configured around R7, R16, C9, and C10, the potentiometer R19 lets you vary the sound from a sharp click to a dull thud. Don't let the plainness fool you; the sound created by this ingenious circuit in fact puts the icing on the cake. It's easy for the listener to believe that a drum head really has been whacked by a stick.

The last sonic component to consider is the shell resonance. IC7 — a 566 function generator — is pressed into service to create this sound. C11 and the resistive combo of R4 and R18 establish the basic frequency of the voltage controlled oscillator (VCO). But notice — by flipping switch S2, you can apply or deny an additional capacitor, C12, to the circuit. This has the effect of knocking the VCO's range up or down by an octave. With it, anything from a gigantic timpani to a minuscule bongo is at your finger tips now.

Allowing further adjustment is the Pitch control, R18. Varying it permits the basic drum frequency to be continuously manipulated over a wide range. R4 sets the highest frequency possible.

While not performing glamorous operations, C1 and C19 are crucial to good circuit performance. C1 compensates the VCO control input which



begin using the ADV-SNARE! The next section will get you started.

## MAKING MUSIC WITH THE ADV-SNARE

As intimated earlier, there are many ways to play the ADV-SNARE. Figure 7 shows a few of the possibilities. When first getting accustomed to the instrument, you may wish to simply trigger the unit by hand with a pushbutton switch. This will permit you to you set the controls as desired, and try out the resulting sounds at once for comparison sake. As we proceed here, we'll assume that this is the arrangement you are using. Prepare a pushbutton switch and connect it to J1 as illustrated in Figure 7A.

Turn all of the front panel controls down to their minimum positions. Using a patch cord, connect the Line Out to a suitable amplifier, but keep the level low at first. Turn on the bipolar 15V supply, which powers-up the ADV-SNARE. Press the pushbutton switch a few times and confirm that the Status LED flashes.

Turn up the Output Volume a bit and set the Wave control to full trian-

glewave. Then, rotate the Shell Decay control to its full-on position and turn the Shell Volume up slightly. Press the pushbutton and you should hear a damped trianglewave (i.e., the wave-form starts out loud and dies away with time). Now turn the Sweep control to its maximum position. Press the pushbutton again and you will still hear the damped trianglewave, but now it should modulate in frequency somewhat.

While repeatedly pressing the pushbutton switch, adjust trimmer R29 until the pitch transition is smooth, continuous, and free of dead spots. The optimal position of the trimmer will be somewhere near the center of its rotation. Or if you prefer, simply adjust R29 to create the sound you like best. This completes the calibration procedure, and you are now ready to start making music with the ADV-SNARE.

There is quite a potpourri of sounds possible with this versatile percussive instrument, so the next few paragraphs are intended only to get you started. But in the long run, your best bet is simply to experiment! Think about the various drums you

have heard and try to analyze their acoustical components. Then see if you can build up the sound, step-by-step, by manipulating the various controls of the ADV-SNARE.

First, to make sure that you understand the nature of the impact tone, shell resonance, and snares, try each sound by itself. Turn all controls down again, and then ease up on the Output Volume. Now bring the Impact Volume up to a comfortable level, and begin triggering the unit. Rotate the Tone control back and forth until you really have a feel for the different sonic effects possible. Then, turn the Impact Volume down again.

Now bring up the Shell Volume. Fire the unit, and observe what happens as you increase its Decay setting. Leave the knob at its highest value (to make what follows more noticeable). Now play with the Pitch control and Hi/Low switch. Notice how you can easily cover virtually every sound from low bass to high treble.

To really jazz things up, dial in some Sweep now. You'll probably find this to be the most fun pot to twiddle! But don't forget the Wave blend. With it, you can put a synthesized edge on

the shell resonance, or melt it into a more mellow acoustical drum sound. If you've explored this category enough, then turn the Shell Volume down once more.

Finally, boost the Snare's Volume, and set the Decay on max. Trigger the unit and notice the explosive nature of this effect. Try adjusting the Filter and Envelope switch until you understand how they work. Of all the controls on the ADV-SNARE, these last two are the most subtle, so don't be disappointed if you can't immediately get the effect you're after.

Of course, making good sounds with the ADV-SNARE requires a fair amount of experimentation, but isn't that true of any instrument? So, spend some time rehearsing with the circuit not only in the lab, but in a real musical situation.

To get you started, refer to Figure 8 which presents general guidelines for re-creating several common drum effects. But remember, what counts in the long run is the feel. There's no illegal combination of controls with the ADV-SNARE; if you think the resulting effect sounds good, then use it. And happy drumming! **NV**

### All resistors are 1/8-watt, 10% values.

R1,R2 — 1K  
R3 — 1.5K  
R4-R7 — 2.2K  
R8-R11 — 4.7K  
R12-R13 — 5.6K  
R14-R16 — 10K  
R17-R19 — 10K linear potentiometer  
R20 — 10K audio potentiometer  
R21 — 39K  
R22-R28 — 47K  
R29 — 50K trimmer potentiometer  
R30 — 68K  
R31 — 82K  
R32-R42 — 100K  
R43 — 100K linear potentiometer  
R44-R46 — 100K audio potentiometer  
R47 — 180K  
R48 — 220K  
R49 — 270K  
R50-R54 — 470K  
R55, R56 — 500K linear potentiometer  
R57-R59 — 1M  
R60 — 1M linear potentiometer

### All capacitors are rated at 16V.

C1 — 0.001mF mylar  
C2,C3 — 0.0047mF mylar  
C4 — 0.01mF mylar  
C5,C6 — 0.047mF mylar  
C7-C10 — 0.1mF mylar

C11-C14 — 0.22mF mylar  
C15-C18 — 2.2mF electrolytic  
C19 — 4.7mF electrolytic  
C20,C21 — 10mF electrolytic

### Semiconductors

D1-D8 — 1N914 diode  
D9 — LED  
Q1 — 2N2712 NPN transistor (see text)  
Q2-Q4 — 2N3904 NPN transistor  
Q5,Q6 — 2N3906 PNP transistor  
IC1-IC3 — 1458 dual op-amp  
IC4 — 741 op-amp  
IC5,IC6 — 3080 transconductance op-amp  
IC7 — 566 function generator

### Other components

S1 — SPDT switch  
S2 — SPST switch  
J1,J2 — 1/4" phone jack

**Miscellaneous:** LED holder, circuit board or perf-board, wire, solder, front panel, knobs.

### ORDERING INFORMATION

As a convenience to readers, the 2N2712 is available in single unit quantities. Send a check for \$1.00 and a stamped self-addressed envelope to the following address: **PAIA Electronics, Inc.**, 3200 Teakwood Lane, Edmond, OK 73013. PAIA Electronics can be

found on the World Wide Web at:  
<http://www.qns.com/paia/>

The following items are available from: **Midwest Analog Products**, P.O. Box 2101, North Mankato, MN 56003.

### E-Mail:

map@prairie.lakes.com  
**World Wide Web Homepage:**  
<http://prairie.lakes.com/~map>

•Etched and drilled printed circuit board — \$18.00

• **Kit of parts** including etched and drilled circuit board, resistors, capacitors, semiconductors, sockets, LED holder, potentiometers, switches, and jacks (does not include front panel, knobs, wire, or solder) — \$62.00

US and Canadian orders add \$2.00 S/H for the printed circuit board alone or \$4.00 S/H for the printed circuit board and kit of parts. Write for shipping information to other countries.

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BOSS 3	\$210	\$195	\$185	CALL

### ZENITHS

ST-1600	\$210	\$195	\$185	CALL
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## REFURBISHED CONVERTERS

REGAL • SA • PANASONIC CALL FOR THIS MONTH'S SPECIALS

# 1-800-800-0766

# KIMTRONICS INC

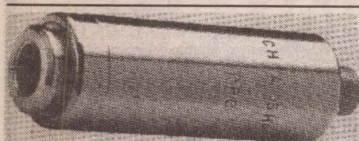
30 day money back guarantee. All shipping and handling at customers expense.  
Anyone implying theft of cable service will be denied sale. NO FLORIDA SALES.

WE WILL MEET OR BEAT ALL COMPETITOR'S PRICES IN THIS MAGAZINE



#### CABLE TV cont.

**DSS TEST CARDS.** Turns on all channels including PPV. Also programmers and other accessories. Lowest prices, quickest service (even overnight). No hassles. Call us and let us prove it. **SOLAR SYSTEMS 905-571-7967.** Open 11am-7pm EST.



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**CABLE DESCRAMBLER! ANYONE** can build in **SEVEN EASY STEPS** with **RADIO SHACK** parts costing **under \$12.** **PLANS \$5.** **1-800-818-9103.**

**HAMLIN PROGRAMMING EQUIPMENT.** Model NP-12. Hamlin MLE-64 encoder. Hamlin Model MLE-12 encoder. Perfect for testing. Make offer. Credit cards OK. Fax/message: 501-223-9406. Internet address: pager@aristotle.net **Surplus City,** Box 23016, Little Rock, AR 72221.

**WANTED TO BUY: CABLE BOXES.** **CALL FOR PRICING. 1-800-676-6342** Gene/Jim.

**FOR SALE:** DSE 1000 encoder, excellent condition, great for testing and repairing. Trimode and S/A converters and descramblers. Best offer. Call, 1-800-909-4333.

**\$15 BLOWOUT!** Multimode PIO NO E4. Scientific Atlanta Z-TAC. PIO Writers Filters Super-Q. PIO-AUTOMAP NO E2-E8. Converters. 7am-4pm PST M-S. Tech Support, 1-800-562-8442.

**PIONEER NO E-4 TEST MODULES!** \$15 ea, minimum 5. Test modules for SAtlanta, Zenith, Pioneer master files \$325. Other master files available: SA, TCM07 and SCM06. 1-800-MODULE-0

**ZENITH TEST kits (ZL3) wired.** 1-10 \$8.95 each, 11-25 \$7.50. 3-wire test bd. \$14.95 each. S/A 8580 \$15.95/\$24.95 each. 8600 bd. \$15.95, etc. CBE. 1-800-436-8630.

**MASTER COMPONENTS**  
**CABLE TV TEST MODULES**  
**EXPERT DESIGNS. 1-800-233-0570**  
**See our DISPLAY AD**  
**on Page 57.**



**MODULES ARE PRETESTED:** 3-wire modules 10 @ \$12 ea.; 2-wire test modules 10 @ \$10 ea.; 3055 and 7055 28-pin EPROMS 10 @ \$10 ea.; 2R/5V/TCF multimodes \$15-\$25 ea.; BA 5100-BA6199 PIC multimodes \$22 ea. BA6300 PIC E2 clear/test @ \$25 ea. Zenith 10 @ \$12 ea.; SA 8500, 8550, 8570, 8580, 8590, 8600 40-pin processor and quick modules \$24 ea. Other modules available. KCS, 1-800-879-8820.

**FTGs FOR** addressable series/w filter \$70 ea. 10 pack. Saw filters; ch. 3. 600 available \$2 ea. Full test PV7s \$175 ea. w/new remote. DAVE 602-380-0064.

**ZENITH 79 channel descrambler for sale.** Quantity pricing available. Call 718-297-9221, 718-297-4877, or FAX 718-657-4015. Ask for Fred.

**BBPD 7XXX** from \$239, PD 7XXX from \$149. Test modules available. Ask about special on MM kits. No CA sales. 818-352-8300.

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**CABLE DESCRAMBLERS,** Pioneer 6310s Scientific Atlanta 8580s, 8590s, and other major brands. We have low overhead so we can sell for less. 30-day money back guarantee. Call anytime. Houston, TX. 713-691-4610.

**CABLE DESCRAMBLER!** Built with 7 **RADIO SHACK** parts costing **UNDER \$12!** Instructions \$8: F.A.S.T., Box 369-VN9, Pt. Salerno, FL 34992-0369.

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**BUYING GENUINE,** unmodified Jerrold DPV and DPBB, SA 8550, 8580, 8600 and Zenith 1600s. Quantities 5-500, Fax surplus or request list to 201-728-2615 or call 201-728-3217 10am-6pm EST.

**PIONEER BOXES,** 6310s Scientific Atlanta 8580s + others. In full test mode. Low prices. Quantity discounts. Houston, TX. 713-691-4610.

**CATV CONVERTER TEST** modules. All types. **Multimode** works on all. Soon to be: Multimode tracking device. 7 and 6 units. Killer prices on software packages. Software that works. All use the same circuit. We can configure your software for your circuit board. 717-462-4657. After 7pm est.

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**\$15 BLOWOUT!** Multimode PIO NO E4. Scientific Atlanta Z-TAC. PIO Writers Filters Super-Q. PIO-AUTOMAP NO E2-E8. Converters. 7am-4pm PST M-S. Tech Support, 1-800-562-8442.

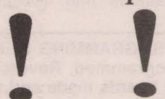
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## \$1,695

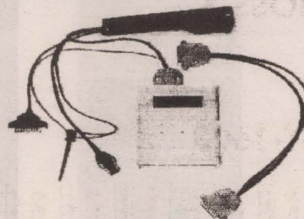
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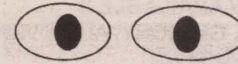


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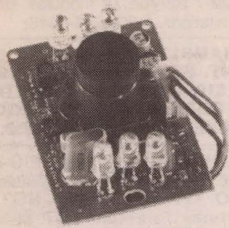
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**UNIVERSAL CABLE DESCRAMBLER.** Random reverse video and manual vertical sync driving you nuts? Fix it with our kit. Plans \$25, kit \$75. Call 1-800-540-3437.

**PIC MASTER PIC16C54, PIC16C56, PIC16C57.** Guaranteed lowest price, chip burning available, min. 100 pc. 908-726-1309.

**MASTER PROGRAMMING FILES.** Memory devices programmed. Reverse engineering. Circuit boards made and much more. 407-676-2530.

**OAK SIGMA** board \$125, multi-mode 2200, multi-mode, SA-8600, SA-8580, Pioneer T3/7 boards \$12 each. SA-8610X boards available. Minimum 10 pc. Call 718-349-6506.

**DEALERS NEEDED. FAST MOVING CABLE TV INDUSTRY NEW TECHNOLOGY AVAILABLE DOES ALL CABLE BOXES. FREE CATALOG, PRODUCTS & PRICING, 1-800-676-6342.**

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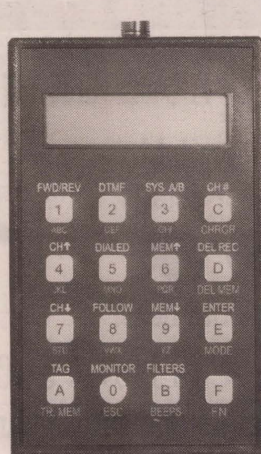
**ALL RAW** field pulls, 10 lot. Zenith 1600 \$85, ST100 \$50, Pioneer 5430 \$75, TM 03 \$40, 07 \$100, 7XXX BBPD \$160, TFC \$200, SA 8600 \$175, 8580 \$120, 321 \$35. Apex 1-800-500-9825.

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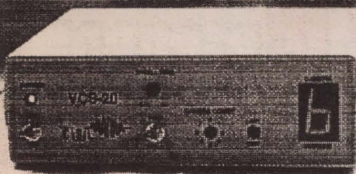
• COD ORDERS WELCOME

**CMI**

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FOR ORDERS CALL FROM 8AM-5PM PST: (818) 425-2243

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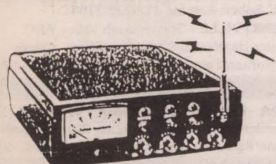
**ATTN. DEALERS:** All makes and models of Zenith CATV converters. Guaranteed working, field pulls, completely screened and cleaned. Any way you want them! Call 619-929-0585 ask for Amy V.

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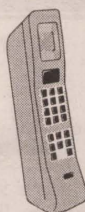
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Z-TAC ZF-1	\$15.95	11.95
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T-20 TORX	\$10.95	CALL!
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# Events

# CALENDAR

**JULY 1996**

**JULY 4**

**PA - ALLENTOWN** - Computer Show, Days Inn, Conference Center. Peter Trapp Shows 607-369-2796  
**PA - BRESSLER** - Harrisburg RAC Hamfest & Computer Show. Emerick Cibort Park. 717-232-6087

**JULY 5-6**

**MS - PASCAGOULA** - Jackson County ARC Hamfest. Jackson Co. Fairgrounds. 601-826-5811

**JULY 6**

**CANADA - ONTARIO - MILTON** - Hamfest. Milton Fairgrounds. Burlington ARC. Norm 905-335-8962  
**CA - ANTIOCH** - Computer Show. Contra Costa Fairgrounds. MarketPro Shows 415-456-6730  
**CA - SAN FRANCISCO** - Robert Austin Computer Show. Cow Palace. 800-346-0100  
**CA - SANTEE** - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052  
**IL - WHEATON** - Six Meter Club Hamfest. DuPage County Fairgrounds. InfoLine: 708-442-4961  
**MI - TAYLOR** - Computer Show. Democratic Club Hall. 313-283-1754  
**NC - SALISBURY** - NC Alligators Group's Fire-cracker Hamfest. Civic Center. Walter 704-279-3391

**JULY 7**

**CA - LIVERMORE** - Swapmeet. Las Positas College. Noel Anklam 510-447-3857  
**CA - MODESTO** - Computer Show. Centre Plaza. MarketPro Shows 415-456-6730  
**CA - SAN DIEGO** - Computer Show. Scottish Rite Center. MarketPro Shows 415-456-6730  
**CA - SAN JOSE** - Computer Show. Santa Clara Co. Fairgrounds. MarketPro Shows 415-456-6730  
**OH - LISBON** - Triangle ARC Hamfest. Columbiana County Fairgrounds. Dick Sisley 330-385-1245  
**OH - MENTOR** - Computer Show. Travelodge Hotel. National Expos Corp. 216-235-1350  
**MI - LANSING** - Computer Show. Holiday Inn South Convention Center. 313-283-1754  
**PA - LEHMAN** - Murgas ARC's Wilkes-Barre Hamfest & Computerfest. Luzerne County Fairgrounds. Bob 717-288-3532

**JULY 12-13-14**

**MI - LANSING** - Antique Radio Club 11th Extravaganza. Holiday Inn South Convention Center. 517-694-8123  
**ND - DUNSEITH** - Hamfest. Int'l Peace Gardens. John Engle, 616 8th St. SE, East Grand Forks, MN 56721.  
**PA - LANCASTER** - National Scanning's National Communications Convention. Lancaster Host Resort/Holiday Inn. 610-273-7823

**JULY 13**

**CA - FONTANA** - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves  
**CA - FRESNO** - Computer Show. Fresno Fairgrounds. MarketPro Shows 415-456-6730  
**CA - LOS ALTOS HILLS** - Perham Foundation Electronics Flea Market. Foothill College, Parking Lot A. 408-734-4453  
**CA - OAKLAND** - Robert Austin Computer Show. Convention Center. 800-346-0100  
**CT - GOSHEN** - Southern Berkshire ARC Hamfest. Robert Schoenfeld 413-229-8695  
**IN - INDIANAPOLIS** - MIST AtariFest. Best Western Waterfront Plaza. 317-535-4829  
**ME - CLINTON** - Maine Council of ARCs Hamfest. Robin Walls 207-442-9405  
**NY - POUGHKEEPSIE** - Computer Show. Mid-Hudson Civic Center. MarketPro 201-265-1075  
**OH - CLEVELAND** - Computer Show. Grays Armory. Peter Trapp Shows 607-369-2796  
**PA - PHILADELPHIA** - Computer Show. Holiday Inn. Micro-Mart 609-924-2344  
**TX - TEXAS CITY** - Tidelands ARS Hamfest. Carl Steele 409-948-0308  
**WI - OAK CREEK** - South Milwaukee ARC Swapfest. American Legion Post #434. 414-762-3235

**JULY 13-14**

**IN - INDIANAPOLIS** - Hamfest. Marion County Fairgrounds. Indianapolis Hamfest Association. 317-251-4407

**JULY 14**

**CA - LANCASTER** - Computer Show. Antelope Valley Fairgrounds. MarketPro Shows 415-456-6730  
**CA - STOCKTON** - Computer Show. Civic Auditorium. MarketPro Shows 415-456-6730  
**IL - SUGAR GROVE** - Fox River Radio League's Hamfest. Waubesa Community College. Diana 708-293-7485  
**NH - NASHUA** - Computer Show. Sheraton Tara Hotel. Northern Computer Shows 508-744-8440  
**NJ - AUGUSTA** - Sussex County ARC Summerfest.

80 July 1996/Nuts & Volts Magazine

The Events Calendar is a free service limited to electronic events such as computer shows, hamfests, flea markets, etc. If your organization is sponsoring an event and would like a free listing, contact us at least 60 days prior to the event. Include your flyer, estimated attendance, name of the person to contact, and phone number.

Complimentary issues are available upon request for distribution to your attendees. A street address for UPS is required.

While we strive for accuracy in our calendar, we can not be responsible for errors or cancellations. The information contained in this column is for the use of the readers of *Nuts & Volts* and may not be republished in any form without the written permission of T & L Publications, Inc.

All listing information should be sent to:

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Fax 909-371-3052

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**AUGUST 3**

**CA - HAYWARD** - San Francisco Scientific & Technical Antique and Collectible Show. Centennial Hall. Al Roberts, The Rational Past 310-476-6277  
**CA - OAKLAND** - Robert Austin Computer Show. Convention Center. 1-800-346-0100  
**CA - SANTEE** - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052  
**MA - MARLBOROUGH** - Computer Show. Royal Plaza Trade Center. KGP Productions 908-297-2526  
**MI - ESCANABA** - Delta County ARS Hamfest. John Anderson 906-789-9148  
**NC - HIGH POINT** - High Point ARC's Lomer L McMahan Memorial Hamfest. National Guard Armory. 910-887-3039  
**NY - CLAYTON** - Jefferson County RAC1000 Island Int'l Hamfest. Clayton Recreation Park Arena. Janet Long 315-788-8543  
**NY - WHITE PLAINS** - Computer Show. Westchester County Center. MarketPro Shows 201-265-1075

**AUGUST 3-4**

**FL - JACKSONVILLE** - Northern FL Section Convention and Greater Jacksonville Hamfest & Computer Show. Prime F Osborn III Convention Center. Karl Hassler 904-268-2302.  
**WA - SPOKANE** - Spokane Hamfest. University High School. KBARA, NW Tri-State ARO, Spokane Radio Amateurs, & Inland Empire Radio Amateurs. JoAnn 509-928-1808

**AUGUST 4**

**CA - LIVERMORE** - Swapmeet. Las Positas College. Noel Anklam 510-447-3857  
**IL - PEOTONE** - Hamfesters Radio Club 62nd Annual Hamfest. Will County Fairgrounds. John Dvorak 312-586-0128  
**MA - WELLESLEY** - Ham Radio Flea Market. Pepsico Pavilion, Babson College. Wellesley ARS & Babson Wireless Club. Barbara 617-329-2628  
**MI - FARMINGTON HILLS** - Computer Show. Farmington Hills Activity Center. 313-283-1754  
**MI - FOWLERVILLE** - Livingston County HamFair. Fowlerville Fairgrounds. Livingston Amateur Radio Club. Ray 517-546-9209  
**MI - PORT HURON** - Eastern MI ARC Swap '96. St. Clair Co. Community College, Student Center. Jim 810-367-3059  
**NY - STONY BROOK** - Computer Show. SUNY Stony Brook. MarketPro Shows 201-265-1075  
**OH - RANDOLPH** - Portage ARC Hamfair. Portage Co. Fairgrounds. Joanne 330-274-8240  
**PA - EASTON** - Hamfest. Career Institute of Tech. Delaware Lehigh ARC. Amy 717-386-3513  
**PA - MATAMORAS** - Tri-State ARC Hamfest. Ray Rothstein 914-856-0426  
**PA - NORTHAMPTON COUNTY** - Delaware Lehigh ARC Hamfest. Amy Zimmerman 717-386-3513  
**PA - WASHINGTON TWP.** - Skyview Radio Society Hamfest. Robert Reihms 412-727-2194  
**VA - BERRYVILLE** - Shenandoah Valley ARC Winchester Hamfest & Computer Show. Clarke County Ruritan Fairgrounds. Irv Barb 540-955-1745

**AUGUST 9-10-11**

**CANADA - BRITISH COLUMBIA - VERNON** - Sky High Hamfest. Silver Star Mountain Resort. North Okanagan Radio Amateur Club. Leigh 604-542-9362

**AUGUST 10**

**CA - FONTANA** - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves  
**CA - LOS ALTOS HILLS** - Perham Foundation Electronics Flea Market. Foothill College, Parking

**AUGUST 10-11**

**CANADA - BRITISH COLUMBIA - VERNON** - Sky High Hamfest. Silver Star Mountain Resort. North Okanagan Radio Amateur Club. Leigh 604-542-9362

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**CA - LOS ALTOS HILLS** - Perham Foundation Electronics Flea Market. Foothill College, Parking

continued on page 119

Computer & Ham Radio Fair. Red Barn Sportsman Club. Bill McMullen 412-397-2702  
**PA - MARION CENTER** - Summerfest. Indiana County ARC. 412-397-2702  
**VA - NEWPORT NEWS** - Computer Show. Knights of Columbus Hall. Pro Am Shows 804-463-1136

**JULY 26-27**

**OK - OKLAHOMA CITY** - Central OK Radio Amateurs Ham Holidays. OK State Fair Park. CORA, POB 95942, Oklahoma City, OK 73143.

**JULY 27**

**CA - BAKERSFIELD** - Computer Show. Kern Co. Fairgrounds. MarketPro Shows 415-456-6730  
**CA - SAN FRANCISCO** - Robert Austin Computer Show. Cow Palace. 800-346-0100  
**FL - TAMPA** - Univ of So FL, Radio & Electronics Club Last Minute Hamfest. USF Campus, Indoors. 813-979-0033  
**IL - ROCKFORD** - Rockford ARA Hamfest. Marsha Plasters 815-399-9233  
**IN - INDIANAPOLIS** - AGI Computer Fair. Indianapolis Events Center. 317-299-8827  
**MI - LIVONIA** - Computer Show. Livonia Elks Lodge Hall. 313-283-1754  
**MI - MIDLAND** - Midland ARC Hamfest. Midland Armory. Bill 517-832-3053  
**NC - HAYWOOD COUNTY** - Western Carolina ARS Hamfest. Haywood County Fairgrounds. Ron Carmack 704-254-5637  
**NJ - PENNSAUKEN** - Computer Show. KGP Productions 908-297-2526  
**NJ - SOMERSET** - Computer Show. Garden State Exhibit Center. MarketPro Shows 201-265-1075  
**NY - SYRACUSE** - Computer Show. NY State Fairgrounds, Horticulture Bldg. Peter Trapp Shows 607-369-2796  
**PA - BERWICK** - Columbia-Monitor ARC Hamfest. Dave Schack 717-752-6851  
**WI - EAU CLAIRE** - Swapfest. Eau Claire County Fairgrounds. Eau Claire ARC. Carol 715-723-9205

**JULY 27-28**

**CA - SANTA ANA** - Swapmeet. ACP Parking Lot. Mary Russo 714-558-8813  
**FL - ORLANDO** - Bahia Shrine AR Unit Hamcon. Bahia Shrine Temple. Cecil Morehouse 407-281-9169

**JULY 28**

**CA - SANTA ANA** - Swapmeet. ACP Parking Lot. Mary Russo 714-558-8813  
**CA - VALLEJO** - Computer Show. Solano Co. Fairgrounds. MarketPro Shows 415-456-6730  
**IL - GLEN ELLYN** - Computer Central. College of DuPage, Phys Ed Bldg. 708-940-7547  
**MA - SWANSEA** - Computer Show. Venus De Milo. Northern Computer Shows. 508-744-8440  
**MD - BRUNSWICK** - Mid-Atlantic DX & Repeater Assn Sweatfest. MARC Train Station. Voice BBS 301-416-8447, Box #109  
**MD - TIMONUM** - Baltimore Amateur Television Society Hamfest & Computerfest. Timonium Fairgrounds. 410-467-4673  
**MI - MADISON HEIGHTS** - Computer Show. UF & CW Hall. 313-283-1754  
**NJ - PARSIPPANY** - Computer Show. Parsippary Hilton. MarketPro Shows 201-265-1075  
**NY - BATAVIA** - Genesee Radio Amateurs Hamfest. Alexander Fireman's Grounds. Barb 716-343-5580  
**OH - ASHTABULA** - Ashtabula County ARC Hamfest & Computer Show. Nappi's Party Center. Ken Stenback 216-964-7316 eves  
**OH - XENIA** - Hamfest & Computer Expo. Heartland Flea Market & Bingo Hall. 513-429-5403 eves.

**AUGUST 1996**

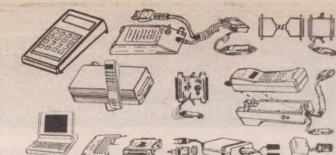




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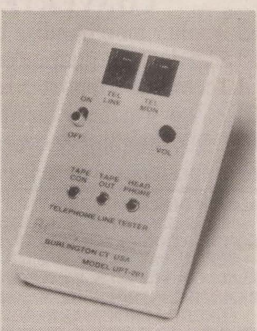
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screen. It loads all of the text from the 80-column by 25-line DOS screen into an array, then searches that array for the keyword "ERROR." This is a sufficiently useful trick for QBASIC that I wrote it as a function that can search the screen for any string and return an integer representing that string's position on the screen. If the string isn't there, the function returns zero. See the function screenSays in Listing 1. Once this function is defined, checking for the word "ERROR" in BSLOAD's screen output goes like this:

```
IF screenSays%("ERROR") THEN...
```

with the consequences of the error following THEN.

## Wrap-up

Now you know how to manipulate the BS1 EEPROM contents. The program I've presented almost certainly doesn't do the particular job that you need done, but it illustrates every important, Stamp-specific function. Please don't bombard me with requests for custom features, or translations to Visual BASIC or C — writing your program is your job!

A couple of final notes: I asked Parallax about some of the drawbacks of the existing BSLOAD utility, such as the lack of error reporting, and the verbose screen message that displays the BASIC Stamp name and Parallax' phone number. They said that they're willing to spruce up BSLOAD to meet the requirements of manufacturers or others who need to make heavy-duty use of this capability.

I also asked about a BSAVE/BSLOAD capability for the Stamp II (BS2). There isn't one right now, but it may be incorporated into the upcoming BS2+ design.

Where's BASIC for Beginners? That department is taking a break this month. Its allotted time was snarfed up by negotiations to publish a beginners' PBASIC book. Details and schedule are currently as vague as election-year platforms, but it looks like a good bet. **NV**

```
updateCell (cursPos)
cursPos = (cursPos + 16) AND 255
  attribs(cursPos) = attribs(cursPos) + 1
updateCell (cursPos)
END SUB
```

```
SUB goEnd
' Respond to the END key by going to the last location
' in data memory.
attribs(cursPos) = attribs(cursPos) - 1
updateCell (cursPos)
cursPos = (code(255) - 1) AND 255
  attribs(cursPos) = attribs(cursPos) + 1
updateCell (cursPos)
END SUB
```

```
SUB goHome
' Respond to the HOME key by going to the 0th location.
attribs(cursPos) = attribs(cursPos) - 1
updateCell (cursPos)
cursPos = 0
  attribs(cursPos) = attribs(cursPos) + 1
updateCell (cursPos)
END SUB
```

```
FUNCTION HEXX$(NUM AS INTEGER)
' Convert 8-bit integer to 2-digit hex values with leading 0s.
IF NUM > 15 THEN
  HEXX$ = HEX$(NUM)
ELSE
  HEXX$ = "0" + HEX$(NUM)
END IF
END FUNCTION
```

```
DEFINT A-Z
SUB leftKey
' Respond to left arrow by moving back one cell.
attribs(cursPos) = attribs(cursPos) - 1
updateCell (cursPos)
cursPos = (cursPos - 1) AND 255
  attribs(cursPos) = attribs(cursPos) + 1
updateCell (cursPos)
END SUB
```

```
SUB makeBkgd
' Print instructions. Draw a color rectangle on the screen and add
' program title to it.
LOCATE 21, 22: PRINT "Address: Decimal: ASCII: "
LOCATE 23, 7
PRINT "ENTER to edit | ALT-S to save | ALT-R to download | ESC to quit";
FOR i = 2 TO 19
  COLOR foreground, background
  LOCATE i, 15
  PRINT SPC(49);
NEXT
LOCATE 2, 29: PRINT "BS1 Code Viewer/Editor"
END SUB
```

```
SUB readFile
' Read in the 256-byte BS1 object code file and store
' it in the code(n) array.
OPEN filename FOR INPUT AS #1
FOR i = 255 TO 0 STEP -1
  code(i) = ASC(INPUT$(1, 1))
NEXT i
CLOSE #1
```

```
END SUB
SUB rightKey
' Respond to right arrow key by moving forward one data cell.
attribs(cursPos) = attribs(cursPos) - 1
updateCell (cursPos)
cursPos = (cursPos + 1) AND 255
  attribs(cursPos) = attribs(cursPos) + 1
updateCell (cursPos)
END SUB
```

```
SUB saveFile
' Save the code array to current filename.
LOCATE 22, 22: PRINT "saving: "; filename;
OPEN filename FOR OUTPUT AS #1
FOR i = 255 TO 0 STEP -1
  PRINT #1, CHR$(code(i));
NEXT i
CLOSE #1
LOCATE 22, 22: PRINT SPC(58);
END SUB
```

```
FUNCTION screenSays% (searchString AS STRING)
' Load the current contents of the 25x80 DOS screen into a
' string and search that string for "searchString." Return
' an integer representing the position of the string on the
' screen, or 0 if the string isn't found.
screenText$ = ""
FOR i% = 1 TO 25
  FOR j% = 1 TO 80
    screenText$ = screenText$ + CHR$(SCREEN(i%, j%))
  NEXT
NEXT
screenSays% = INSTR(screenText$, searchString)
END FUNCTION
```

```
SUB updateCell (cell AS INTEGER)
' Print the specified data cell to the screen.
' Use its attributes to determine color.
cellRow = 4 + (cell \ 16)
cellCol = 16 + (3 * (cell MOD 16))
LOCATE cellRow, cellCol
SELECT CASE attribs(cell)
CASE 0
  COLOR foreground, background
CASE 1
  COLOR background, foreground
CASE 2
  COLOR foreground, lockout
CASE 3
  COLOR lockout, foreground
END SELECT
PRINT HEXX$(code(cell));
LOCATE 21, 30: COLOR white, black: PRINT USING "###"; cell;
LOCATE 21, 43: PRINT USING "###"; code(cell);
LOCATE 21, 54: PRINT " ";
LOCATE 21, 54: PRINT CHR$(code(cell));
END SUB
```

```
SUB upKey
' Respond to the up arrow by moving up a row.
attribs(cursPos) = attribs(cursPos) - 1
updateCell (cursPos)
cursPos = (cursPos - 16) AND 255
  attribs(cursPos) = attribs(cursPos) + 1
updateCell (cursPos)
END SUB
```



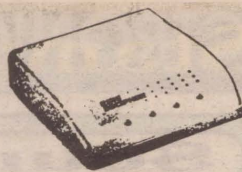
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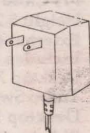
Everything you need to make your PC into a Multimedia PC. 16-bit sound card, double speed CD-ROM drive, pair of non-powered speakers. With Suite of 12 multimedia and business audio software applications and utilities. Bonus Game: Doom version 1.2. System req. 486SX-25 or higher. 8 meg RAM. VGA graphics. 1.44 drive, mouse. Sound Galaxy Stellar (MM 103) .....\$74.95 Ea.

## NEW MICROSOFT TWO-BUTTON PS/2 MOUSE

The old-style type, but old reliable. Note: No software included with mouse. MS PS/2 Mouse .....\$19.95 Ea.

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Input: 117 Vac 50/60 Hz. Outputs Available.



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## NEW CYRIX FASMATH COPROCESSOR CX-83D87-33-GP

New Cyrix FastMath coprocessors for 80386DX16-33 systems. This FPU unit is used in place of Intel's 80387DX16-33 part. Originally priced at \$100.00, a steal \$10.95. Case: 68 pin grid array. Cyrix CX-83D87-33-GP .....\$10.95 Ea.

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New Toshiba 2X CD-ROM drive model #XM-3401BMQ. This CD-ROM drive comes in an add-on kit (IBM EduQuest Add-On). Kit consists of 1) CD-ROM drive, CD-ROM caddy, 14" SCSI cable, 11" audio cable for sound card. Face plate color: Beige. Data Transfer 330KB (2X)/180KB (1X). Access times 200ms average. TOS 2X CD-ROM (XM-3401BMQ) .....\$74.95 Ea.

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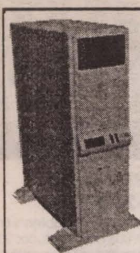
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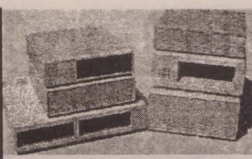
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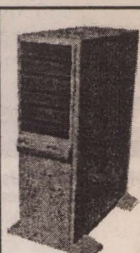
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**F**or years, science fiction movies have frequently portrayed the future home or space station as one being centrally controlled by an intelligent master computer. This so-called "central brain" analyzed various input stimuli (time of day, movement, sound, user input, etc.) and, in turn, maintained/influenced the humanoid environment.

With the eruption of the personal computer era, and a little help from a not-so-new remote transmission scheme, this concept has not only shifted from science fiction to reality, but has become affordable to even the most modest budgets. You can now create your own program on your PC to control all your household current devices!

Beginning in 1978, home automation products began hitting the market which used common household AC power lines as a medium for the transmission of data needed for the remote operation of lamps, appliances, or any other device

plugged into an AC outlet — called Power Line Carrier transmission (PLC).

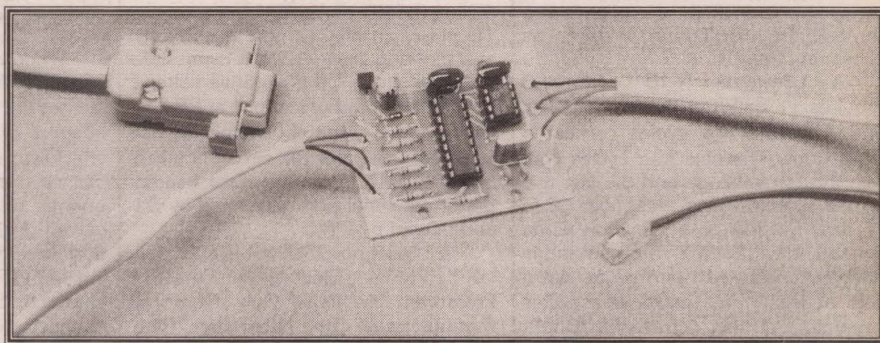
The PLC technology was developed by a group of engineers working for Pico Electronics Ltd., a subsidiary of X-10 Ltd., and was later known as just X-10.

The X-10 code format was originally introduced with the line of home automation products sold by Sears and Radio Shack. Today, it is the most widely used protocol and can also be seen in home automation products offered by many private labels such as Stanley, Heath/Zenith, Nutone, Leviton, A.C.T., etc.

The X-10 product line consists of various modules which plug into or replace an AC wall outlet. The device shown in Photo 1 is a typical lamp dimmer module which can be used to turn on/off/dim an incandescent lamp

by Terry Weeder

# Home Automation Controller



plugged into its two-prong receptacle located at the bottom of the device. A wireless transmitter/receiver pair is shown in Photo 2. The receiver (right) plugs into an electrical outlet, and sends X-10 signals in response to commands received from the battery-powered RF transmitter (left).

## Home Automation Controller

The Home Automation Controller as described in this text is your PC's link to this X-10 world. It connects a TW523 Power Line

Interface module (Photo 3) to an RS-232 serial port on your computer. Any X-10 signals transmitted over the AC power line are decoded, converted to ASCII character pairs, then sent to the PC. Your computer can, in turn, transmit X-10 signals simply by dumping a string of ASCII character pairs representing the X-10 commands to the HAC (Home Automation Controller). The HAC handles all the timing-critical aspects of the transmission including the sensing of noise or a collision with another X-10 signal at the time of transmission; automatically re-transmitting the last command if one of the former is detected.

With the HAC, you are able to create your own custom program to interact with your home automation system. Have your computer turn on/off your sprinklers at certain times of the day. Dim lamps in the evening and turn on the porch light. Verify that all indoor lights are turned off at a specific hour of the night, and in the morning, turn off the porch light, start the coffee maker, and wake you up with the sound of music from your stereo. Your PC could also set back the thermostat during the day when you're at work, then reset it an

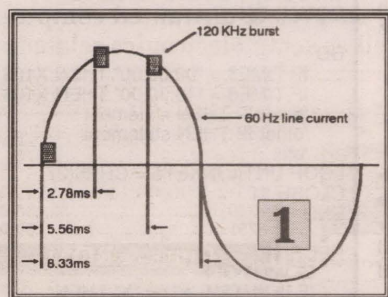
hour before you get home. When on vacation, your computer can be programmed to turn on and off various lights throughout the house at different time intervals simulating actual living conditions.

Because your PC can also hear X-10 signals, your program can be set up to react to commands sent to it from any X-10 transmitter. Hence, pressing one button on a transmitter can cause a series of events to be initiated by the PC. For example: In the morning, pressing button #1 on the transmitter beside your bed will turn on the bedroom, bathroom, and kitchen lights, turn off the porch lights, start the coffee maker, and turn on the radio. Hit button #2 as you walk out the door to turn off all lights and set the thermostat back.

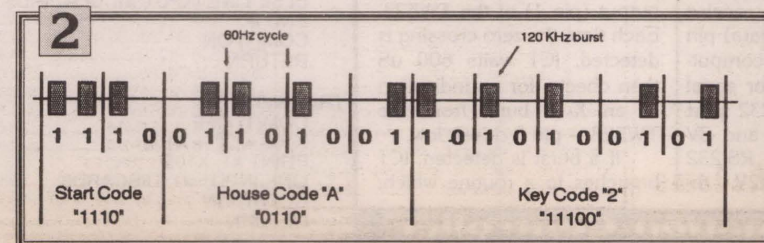
An additional button could be set up to tell your computer to run the sprinklers for an hour that day. When returning home after work, pressing button #3 on your remote transmitter in your car will turn on the garage and porch lights, and any other lights in your home you wish to be on when you walk in the door. In the evening, pressing button #4 will turn off the kitchen and dining room lights, turn on the living room lights, dim to 50%, and turn on the TV.

## The X-10 Protocol

X-10 signals are transmitted over the AC power line by superimposing a series of one millisecond bursts of a 120 KHz carrier onto the 60 Hz power line in sync with its zero cross-



**Figure 1 - The X-10 bursts are transmitted three times during a half cycle of the AC power line to coincide with the zero crossing points of all three phases in a three-phase distribution system.**



**Figure 2 - Each X-10 bit is transmitted in both true and complement form on alternate half cycles, with the exception of the Start Code.**

House Codes			Key Codes		
Title	ASCII	Code	Title	ASCII	Code
A	A	0110	1	1	01100
B	B	1110	2	2	11100
C	C	0010	3	3	00100
D	D	1010	4	4	10100
E	E	0001	5	5	00010
F	F	1001	6	6	10010
G	G	0101	7	7	01010
H	H	1101	8	8	11010
I	I	0111	9	9	01110
J	J	1111	10	A	11110
K	K	0011	11	B	00110
L	L	1011	12	C	10110
M	M	0000	13	D	00000
N	N	1000	14	E	10000
O	O	0100	15	F	01000
P	P	1100	16	G	11000
All Units Off			H	00001	
All Lights On			I	00011	
On			J	00101	
Off			K	00111	
Dim			L	01001	
Bright			M	01011	
All Lights Off			N	01101	
Extended Code			O	01111	
Hail Request			P	10001	
Hail Acknowledge			Q	10011	
Pre-Set Dim			R	10101	
Pre-Set Dim			S	10111	
Extended Data			T	11001	
Status=on			U	11011	
Status=off			V	11101	
Status Request			W	11111	

**Figure 3 - List of X-10 codes and the ASCII character used by the PC and HAC to represent them.**



ing. A presence of a burst represents a logic 1 and an absence of a burst represents a logic 0. To reduce the possibility of interference caused by noise generated by large loads on the AC line, the 120 KHz bursts are transmitted as close as possible to the zero crossing point of the 60 Hz AC, where line current (thus noise) is at its minimum. Though each X-10 receiver listens for a burst only at this zero crossing point, in actuality, the burst is transmitted three times during each AC half cycle to coincide with the zero crossing points of all three phases in a three-phase distribution system, as shown in Figure 1.

A complete X-10 command requires 11 cycles of the 60 Hz power line. The first two cycles contain a Start Code. The next four cycles contain the House Code and the last five cycles contain either a Number Code (1 through 16) or a Function Code (on, off, etc.). Each X-10 command is always transmitted twice sequentially, with at least three power line cycles separating distinct commands. Bright and Dim functions consist of a continuous string of commands transmitted with no gaps. With exception to the Start Code, each bit is transmitted in both true and complement form on alternate half cycles of the power line, as shown in Figure 2, and is used for error checking.

## Circuit Theory

The Home Automation Controller connects directly to a TW523 Power Line Interface module which is manufactured by X-10 Ltd. This module plugs directly into an AC outlet and provides the source for generating and sensing the 120 KHz bursts on the power line. The TW523 incorporates opto-isolated inputs and outputs for the zero crossing detect, X-10 received data and X-10 transmit data, which completely isolates the HAC from the AC power line.

Refer to the schematic diagram shown in Figure 7. The heart of the circuit is IC1 (part no. PIC16C54), an eight-bit CMOS microcontroller manufactured by Microchip. IC1's firmware — explained in detail later — is programmed to handle all the timing critical operations of transmitting the X-10 commands as explained earlier. Bit 4 of port-B is used to monitor the zero crossing detect output of the TW523 and lets the microcontroller determine the exact times to transmit and listen for the X-10 bursts which are represented by logic levels sent and received on bits 2 and 3 of port-B.

Bit 1 of port-B is used to receive data from the TD (Transmit Data) pin on the RS-232 serial port of a computer. The voltage levels used for serial communications on an RS-232 port are +3V to +25V for a logic 0, and -3V to -25V for a logic 1. Most RS-232 devices use +12V and -12V, re-

spectively.

The current limiting resistor (R3) and the internal protection diode associated with each I/O pin on the microcontroller convert this voltage to TTL levels at the input of port-B, pin 1. Bit 0 of port-B is used to send data to the serial port.

A logic 1 is generated by placing bit 0 at a high level which turns off Q1, thus allowing the -12V from the TD pin to be applied to the RD (Receive Data) pin through R2. Bit 0 is sent low to produce a logic 0 which turns on Q1, pulling the RD pin to +5V. Because the TD pin of an RS-232 port is normally at a marking level (-12V), it is possible to "steal" from it the negative voltage needed for communications at RS-232 levels and a separate supply is not required. Power for the circuit is taken from the DTR (Data Terminal Ready) pin of the serial port, regulated by D1 and filtered by C1.

IC2 (part no. 93LC46) is a 1K serial EEPROM (Electrically Erasable Programmable Read Only Memory) manufactured by Microchip. The 93LC46 uses a four-wire interface which is connected to port-A of IC1. Of the four wires, there is a CHIP SELECT, CLOCK, DATA IN, and DATA OUT. The microcontroller (IC1) communicates with the 93LC46 by placing a high on the CHIP SELECT pin. Data is then transferred serially to and from the 93LC46 on the positive transition of the clock pin. Each READ or WRITE function is preceded by a start bit, an opcode — identifying the function to be performed (read, write, etc.) — then a seven-bit address, followed by the eight bits of data which is being written to, or read from, that address.

Because the speed at which data is received from the PC (1200 baud) is much faster than that which can be sent to the TW523, IC2 is used as a 128-character buffer to hold data received from the serial port until it has a chance to be transmitted as an X-10 code.

## The PIC Firmware

A PIC16C54 microcontroller which has been pre-programmed with the Home Automation Controller firmware can be purchased from the supplier mentioned in the parts list.

After power-up, the microcontroller (IC1) constantly monitors both the TD pin on the serial port looking for a start bit, and the zero crossing output (pin 1) of the TW523. Each time the zero crossing is detected, IC1 waits 600  $\mu$ s then checks for an indication of an X-10 burst from the TW523 — pin 3 driven low.

If a burst is detected, IC1 branches to a routine which,

after verifying a valid Start Code, receives the four-digit House Code and five-digit Key Code (number/function) from the TW523 in the X-10 code format shown in Figure 3. IC1 converts the House and Key Codes to a pair of ASCII characters as depicted in Figure 3, then sends it to the RS-232 serial port preceded by an "X" — used to identify the string as an X-10 command, and followed by a carriage return. This four-character string is stored in the PC's internal RS-232 buffer ready for input into a program such as QuickBASIC with a "LINE INPUT #" command.

When a start bit is detected on the RS-232's TD pin, the microcontroller fetches the first character from the serial port of the PC and checks to see if it is an "X." If not, all subsequent characters received from the serial port are ignored, allowing the PC to communicate with other projects connected to the same serial port. If the X-10 header character (X) is detected, IC1 branches to a routine which fetches each character, converts it to its X-10 code, then stores it in the EEPROM (IC2), repeating until receiving a carriage return.

After the reception

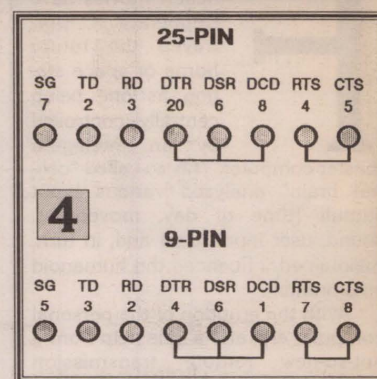
**Figure 5 - Simple QuickBASIC program which will display any X-10 command which is transmitted over the AC power line. Press "X" on the keyboard to transmit an X-10 command, or "Esc" to exit program.**

```
CLS
OPEN "COM1:1200,N,8,1" FOR RANDOM AS #1
ON COM(1) GOSUB RECEIVE
COM(1) ON
```

```
DO
  IF TIME$ = "09:00:00" THEN X10$ = "A1AK": GOSUB TRANSMIT
  IF TIME$ = "10:30:00" THEN X10$ = "A1AJ": GOSUB TRANSMIT
  'other IF THEN statement
  'other IF THEN statement
  'etc.
LOOP UNTIL INKEY$ = CHR$(27)
CLOSE #1
END
```

```
RECEIVE:
COM(1) OFF
IF INPUT$(1, #1) = "X" THEN
  LINE INPUT #1, X10$
  IF X10$ = "B1" THEN X10$ = "A1AJA2AJALALALALALALAL": GOTO TRANSMIT
  IF X10$ = "B2" THEN X10$ = "A1AKA2AK": GOTO TRANSMIT
  'other IF THEN statement
  'other IF THEN statement
  'etc.
ELSE LINE INPUT #1, DISCARD$
END IF
COM(1) ON
RETURN
```

```
TRANSMIT:
COM(1) OFF
X10$ = "X" + X10$
PRINT #1, X10$
LINE INPUT #1, DISCARD$
COM(1) ON
RETURN
```



**Figure 4 - Hook-up diagram for both a 9-pin and 25-pin RS-232 serial connector. Include the jumpers as shown.**

```
CLS
OPEN "COM1:1200,N,8,1" FOR RANDOM AS #1
ON COM(1) GOSUB RECEIVE
COM(1) ON
```

```
DO
  KEY$ = INKEY$
  IF UCASE$(KEY$) = "X" THEN
    INPUT "Enter X10 code ", X10$
    GOSUB TRANSMIT
  END IF
LOOP UNTIL KEY$ = CHR$(27)
CLOSE #1
END
```

```
RECEIVE:
COM(1) OFF
IF INPUT$(1, #1) = "X" THEN
  LINE INPUT #1, X10$
  PRINT X10$
ELSE LINE INPUT #1, DISCARD$
END IF
COM(1) ON
RETURN
```

```
TRANSMIT:
COM(1) OFF
X10$ = "X" + X10$
PRINT #1, X10$
LINE INPUT #1, DISCARD$
COM(1) ON
RETURN
```

```
CLS
OPEN "COM1:1200,N,8,1" FOR RANDOM AS #1
ON COM(1) GOSUB RECEIVE
COM(1) ON

DO
  IF TIME$ = "09:00:00" THEN X10$ = "A1AK": GOSUB TRANSMIT
  IF TIME$ = "10:30:00" THEN X10$ = "A1AJ": GOSUB TRANSMIT
  'other IF THEN statement
  'other IF THEN statement
  'etc.
LOOP UNTIL INKEY$ = CHR$(27)
CLOSE #1
END

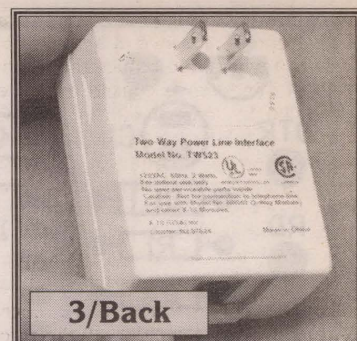
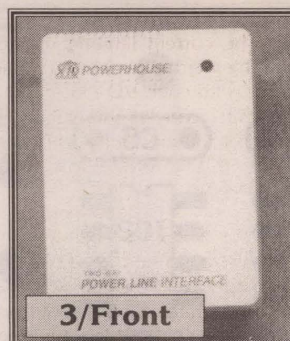
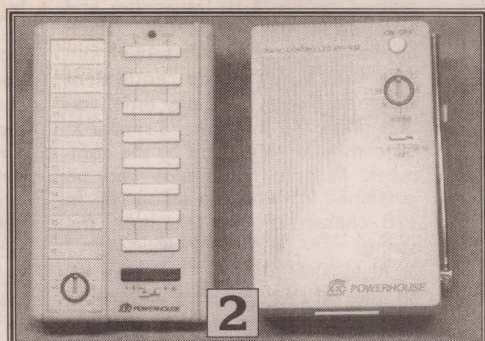
RECEIVE:
COM(1) OFF
IF INPUT$(1, #1) = "X" THEN
  LINE INPUT #1, X10$
  IF X10$ = "B1" THEN X10$ = "A1AJA2AJALALALALALALAL": GOTO TRANSMIT
  IF X10$ = "B2" THEN X10$ = "A1AKA2AK": GOTO TRANSMIT
  'other IF THEN statement
  'other IF THEN statement
  'etc.
ELSE LINE INPUT #1, DISCARD$
END IF
COM(1) ON
RETURN

TRANSMIT:
COM(1) OFF
X10$ = "X" + X10$
PRINT #1, X10$
LINE INPUT #1, DISCARD$
COM(1) ON
RETURN
```

**Figure 6 - Example of a QuickBASIC program which will transmit X-10 commands in response to date/time or upon reception of an X-10 command from another transmitter.**



## Home Automation Controller



of a carriage return from the PC's serial port, each X-10 code which was stored in IC2 is sent to the TW523 for transmission as an X-10 command in the same order as received. Because each X-10 bit is sent in both true and complement form on alternate half cycles, each full cycle of the AC

power line will always contain an X-10 burst and an absence of a burst — the order depicting the actual logic.

During the X-10 transmission procedure, at each half cycle, IC1 either sends a burst by placing a high on the X-10 transmit input (pin 4) of the TW523, or listens to verify an

absence of a burst on the X-10 receive output (pin 3). If an unexpected X-10 burst is detected, it can be assumed that there is either noise on the line, or another X-10 transmitter is currently sending a command. A flag is set in IC1's status register if this occurs — indicating a collision

the two IC sockets. Next, solder in all resistors and capacitors paying attention to the orientation of the polarized capacitor C1. The zener diode (D1) should be mounted with its band positioned as shown in the diagram. Finish by soldering in the transistor (Q1) and the crystal (XTAL1). Note, leave a small gap between the bottom of the crystal and the PC board to avoid the chance of its metal case shorting the two pads together.

Obtain a piece of four-conductor telephone modular cord (available from Radio Shack), cut off one of the connectors, and strip and tin the wire ends. Align the modular plug with the socket of the TW523 as if plugging in, and determine the color order with respect to the numbers 1 through 4 shown on the case of the TW523.

Match this order with the corresponding numbers shown on the parts placement diagram and solder the wires to the PC board. Use another piece of four-conductor telephone cord to run between the PC board and the RS-232 connector.

Figure 4 shows the hook-up diagram for both a 9-pin and 25-pin connector. Match the "DTR," "RD," "TD," and "SG" connections on the board with their corresponding pins on the connector, as shown in the diagram. Solder a jumper wire on the RS-232 connector between pins "RTS" and "CTS," and between "DTR," "DSR," and "DCD" as shown.

After all components and wires have been soldered, closely examine both sides of the PC board for solder bridges and/or cold solder joints, and re-solder if necessary. Carefully plug IC1 and IC2 into their sockets using the orientation as shown in the parts placement diagram. Mount the board in a plastic enclosure and cut two notches in the seam of box for the cords to exit. Tie a knot in each cord for strain relief, then assemble the two halves of the box.

### Operation

Use the simple program written in QuickBASIC and shown in Figure 5 to test out the circuit. Plug the Home Automation Controller into the TW523 and the RS-232 serial port, and plug the TW523 into an AC wall outlet. Start the program, then hit "X"

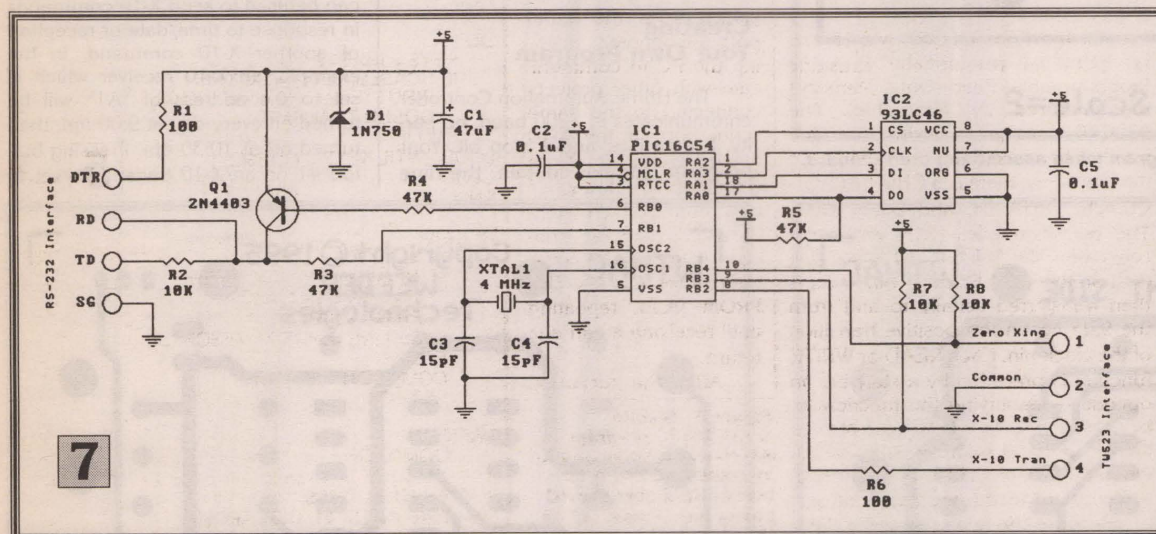


Figure 7 - Schematic diagram of the Home Automation Controller. The microcontroller (IC1) handles all the timing critical aspects of X-10 transmissions and RS-232 communications.

## Parts List

### Resistors

(All are 1/4-watt, 10% units)

- R1, R6 - 100 ohm
- R2, R7, R8 - 10,000 ohm
- R3, R4, R5 - 47,000 ohm

### Capacitors

- C1 - 47 uF, 35-WVDC, electrolytic
- C2, C5 - 0.1 uF, Mylar
- C3, C4 - 15 pF, ceramic disc

### Semiconductors

- IC1 - PIC16C54-XT/P (Pre-programmed) 8-bit microcontroller (Microchip)
- IC2 - 93LC46 serial EEPROM (Microchip)
- Q1 - 2N4403, general-purpose PNP silicon transistor
- D1 - 1N750A, 4.7-volt zener diode

### Other components

- XTAL1 - 4 MHz crystal

### Miscellaneous: TW523 Power Line

Interface module, X-10 Receiver/Transmitter modules, enclosure, PC board, IC sockets, telephone cord with modular plug, RS-232 connector & cable, solder, hardware, etc.

The following items are available from **Weeder Technologies**, P.O. Box 421, Batavia, OH 45103. **513-752-0279**.

- Double-sided etched and drilled PC board (WTHAC-B), \$9.50
- All board mounting components including pre-programmed PIC16C54 (WTHAC-C), \$29.00
- A pre-programmed PIC16C54 only (PIC-HAC), \$21.50
- Power Line Interface module (TW523), \$29.50

All orders must include an additional \$4.00 for shipping and handling. Ohio residents add 6% sales tax.

detection, and IC1 re-transmits the X-10 command upon completion of the current transmission.

### Construction

Thanks to the simplicity of the circuit due to the use of a microcontroller, all components fit easily on a double-sided PC board measuring under 2.5" square. The artwork is provided here for those who wish to etch and drill their own PC boards, or a pre-fabricated one can be purchased from the supplier mentioned in the parts list.

Refer to the parts placement diagram shown in Figure 8, identify the component side of the PC board which is marked, and begin by soldering in



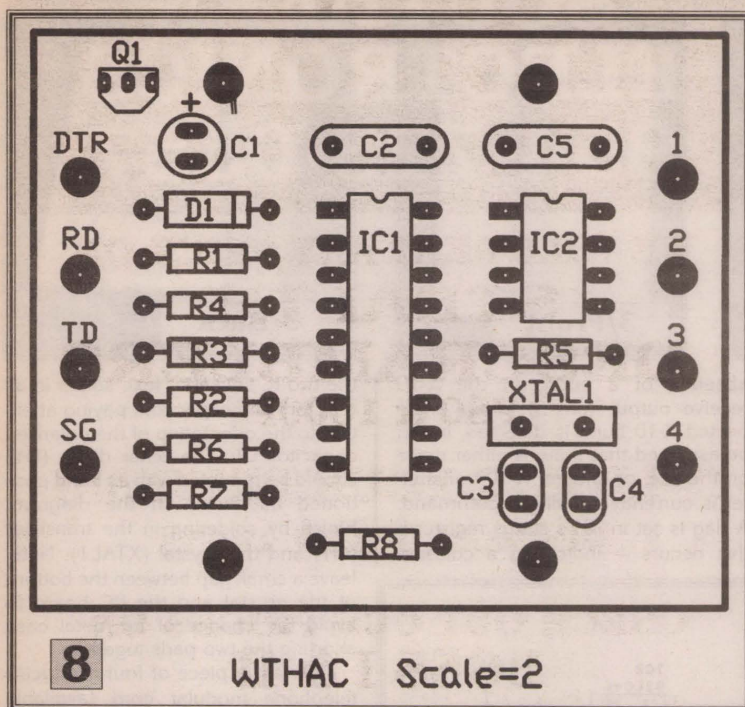
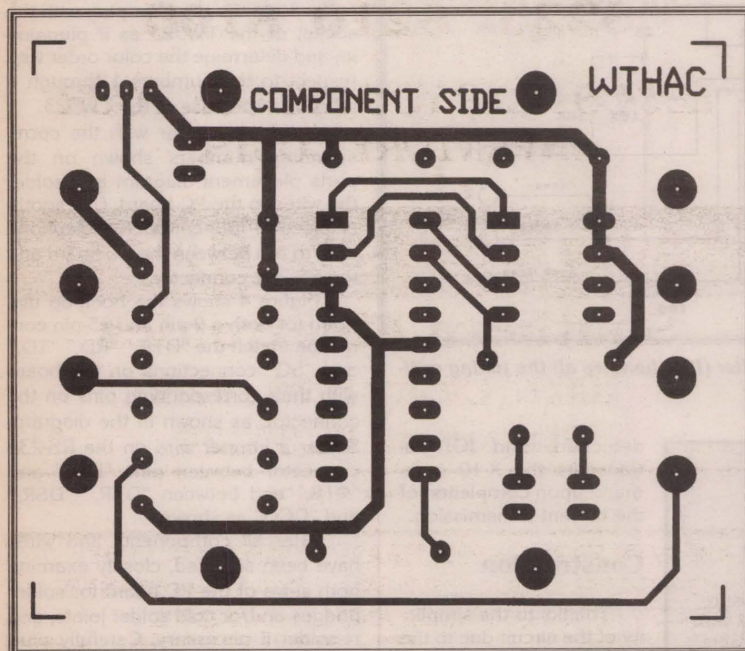


Figure 8 - Use this parts placement diagram when assembling the PC board.



HOME AUTOMATION CONTROLLER  
TOP SIDE  
SCALE = 2:1

on the computer keyboard. A prompt will appear on the screen asking for an X-10 command. Type in "A1" or another valid House Code (Key Code pair as shown in Figure 3), hit enter, and verify that the LED on the TW523 flashes. If not, closely examine the two cables and their connections for errors.

Use an X-10 transmitter with the House Code set to "A" and hit the "on" button for #1. The LED on the TW523 will flash twice and the char-

acters "A1" then "AJ" will appear on the computer screen. Now hit the "off" button for #1. The characters "A1" then "AK" will appear.

An X-10 function usually consists of two distinct commands. The command "A1" is the House Code "A," followed by the Number Code "1" which addresses the receiver, while the command "AJ" is the House Code "A" followed by the Function Code "J," which causes that receiver to turn on.

Experiment by pressing different

buttons on the X-10 transmitter and comparing the characters which appear on the computer screen with the House/Key Code equivalent shown in Figure 3. At any time, you may press "X", then enter a similar X-10 command to be sent by the computer. Multiple commands can be contained in the same string (up to 128 characters). For example, the string: "A1AJ A2AK A3AJ ALALALALALALAL" will turn on #1, turn off #2, turn on #3, and dim to 50%. Note the spaces and quotation marks are inserted for clarity only, and should be omitted in the actual string. If you try to enter an invalid X-10 command, or if there is one or more invalid characters in your string — such as a non-capital letter — the HAC will automatically ignore the whole string. To exit the program, simply hit the "ESC" key.

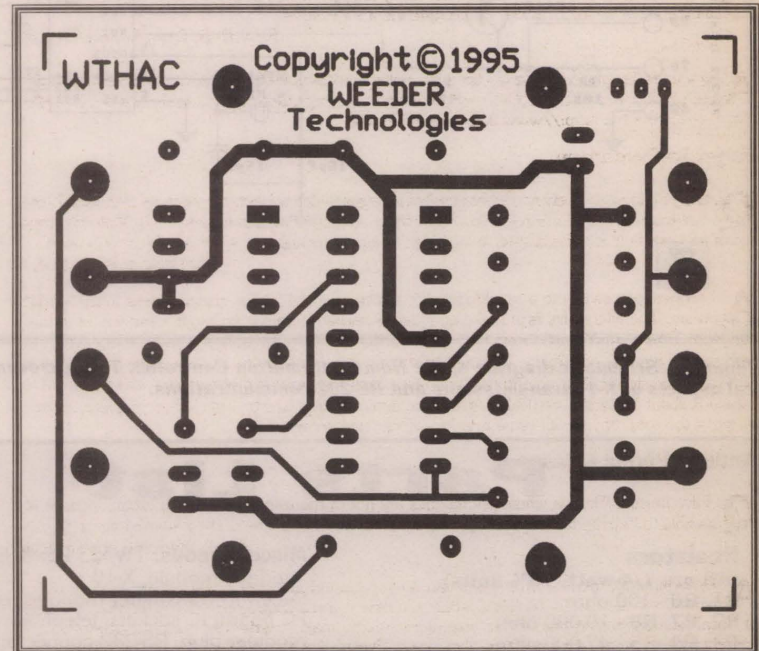
## Creating Your Own Program

The Home Automation Controller communicates at 1200 baud, no parity, 8 data bits, and 1 stop bit. Your program should contain the line

by a carriage return.

Two important notes here: Because of the structure of the RS-232 interface used by the HAC, all characters that are sent to the HAC are also echoed back to the PC. Therefore, your program must use the COM(1) OFF statement prior to using the PRINT #1, and then a LINE INPUT #1 statement to dump all echoed characters in the com buffer before issuing a COM(1) ON statement. Also, always use the COM(1) OFF statement at the beginning of your subroutine branched to by the ON COM GOSUB statement, then a COM(1) ON statement at the end after all characters have been received. Failure to turn off event trapping as mentioned above will cause communication errors between the PC and HAC.

Figure 6 shows a program which can be used to send X-10 commands in response to time/date or reception of another X-10 command. In the example, an X-10 receiver which is set to the address of "A1" will be turned on every day at 9:00 am, then turned off at 10:30 am. Pressing button #1 on an X-10 transmitter set to



HOME AUTOMATION CONTROLLER  
BOTTOM SIDE  
SCALE = 2:1

OPEN "COM1:1200,N,8,1" FOR RANDOM AS #1, or similar. Also, the ON COM GOSUB statement should be used as shown in the sample programs to handle branching to a subroutine when an X-10 command is received. All X-10 commands sent by the HAC to the serial port are preceded by an "X" — identifying the string as an X-10 command, and ending with a carriage return. All X-10 strings sent by the PC to the HAC must also be preceded by an "X" and followed

House Code "B" will turn on A1 and A2, then dim A2 to 50%. Pressing #2 on the transmitter will turn off both A1 and A2. You can add as many IF THEN statements in this format as you want.

With the dropping prices of used computers, it is not unheard of to be able to pick up an old XT for under \$100.00, and with the Home Automation Controller, it can serve as the perfect "brain" for your home automation system. NV



can run Netscape. There are three requirements for Netscape Navigator:

1. A direct connection to the Internet either via Ethernet, or a dial-up SLIP or PPP account.
2. TCP/IP stack.
3. WINSOCK.DLL driver.

You can get a direct connection to the Internet through a service provider in your area. Just make sure that you can get a SLIP or a PPP account from the provider (on a dial-up account), too, because not all Internet providers offer this service. Once you have full Internet connectivity, Netscape loads the TCP/IP stack, dialer, and WINSOCK.DLL file. These items are provided by the Internet server. The problem with America Online is that it doesn't ship with a WINSOCK.DLL driver. Fortunately, you can download the driver from America Online, or from our WEB site (<http://www.nutsvolts.com>) under the name WINSOCK.DLL. Download this file to your Windows System directory (typically C:\WINDOWS\SYSTEM), then quit and restart Windows. You're now ready to go. To use Netscape, simply start AOL and establish an Internet connection. You can now load and run Netscape Navigator by clicking on its icon.

#### Monitor Maintenance

**Q.** I have a Goldstar VGA monitor, model 1425 Plus, which looks fine in the text mode. When switched into graphics mode, though, the colors "smear" horizontally across the full length of the screen. Any help and/or schematics would be greatly appreciated.

David Hanes, Loveland, CO

**A.** I had an NEC 3D monitor with a similar problem. It was caused by a cable with a faulty sync wire. After hours of troubleshooting, I threw up my hands, bought a new video cable, and everything started working fine. However, as my 3D monitor aged, so did its mode switches and controls. A persistent problem was the horizontal size switch which sometimes sent the screen into a tailspin. I had to spray the controls and switches frequently with a tuner cleaner, like Radio Shack part number 64-3320, to keep it running. Color smearing problems are always caused by signal ringing which, in turn, is generally caused by dirty contacts. Whatever you do, DON'T be tempted to "polish" your contacts with a nail file or other abrasive. It will only remove the plating and aggravate the problem. Use the tuner cleaner or alcohol and a Q-Tip, instead.

#### Seeking Capacitors

**Q.** I am designing a circuit which can identify resistors, diodes, and capacitors mounted on an PC board edgcard with a cable. I can easily find the values of diodes and resistors, but for capacitance, I see no information. Please give me a suggestion.

Fazil Rafi, Long Island City, NY

**A.** It sounds like you're probing with a DC voltage when you should be using AC testing. Set your probe frequency to 1 KHz and you'll find your capacitors. For more details on the technique, check out the <http://www.fluke.com> WEB site.

#### Pager In Purgatory

**Q.** Do you know of a company that makes a pager which accepts an external antenna? I have a basement office in a fringe area, and I frequently miss important pages. My Motorola pager seems to work fine at ground level, but garbles or ignores messages when I'm in the basement.

Kim White, Highland, IL

**A.** I suggest you switch to a satellite service, which can find you no matter where in the world you are. The alternative is to make an antenna basket to hold your pager when you're in the dungeon. Take a small plastic soap tray, the kind that sticks to the wall of a shower, and wrap it with several turns of #16 gauge insulated solid wire (the stuff you find in the electrical department of a hardware store). After you do the wrapping, bend the loose end of the wire straight up and extend it about 18 inches vertically. Attach the assembly to a nearby wall. When you place your pager in the soap tray, it will serve as a loosely-coupled antenna.

#### Antique Phone Lines

**Q.** I live in rural Virginia where phone lines are not of the same quality as in urban areas. Is it possible to build a device to balance or equalize the phone line to improve modem usage?

Frank Pisciotta, via Internet

**A.** Unfortunately, there's nothing you can do at your end to improve your phone service. If memory serves me, the problem is that you have a three-wire system that goes through a lot of "local" stations before two of the three wires reach a major carrier (the daughter of Ma Bell, under whatever name she goes by in your area). Therein lies the problem, because the lines are very noisy and the bandwidth is barely the 3 KHz required for voice quality, much less modem requirements. If you're as far out as your query implies, you probably have cable TV or a satellite connection, right? If so, ask them about a modem hook-up. It's the new "in thing" for cable servers.

#### Power FETs Drive Motor

**Q.** Do you have any experience using MOSFETs in a H drive motor circuit? I am having difficulty turning on the high-side FETs completely. I am using 4000 series CMOS at 15 VDC as the drive voltage and 24 VDC as the switched voltage. Any suggestions?

Steve Jacob, via Internet

**A.** Been there, done that. The problem is the upper FETs see the circuit as an emitter follower. Try referencing the upper FETs to VCC rather than ground, and the problem should disappear.

*Why is this space blank? Because it's your space! Submit a reader's tip on any circuit design or computer topic, and I'll consider it for publication. If I select your submission, you'll receive \$25.00 and be credited for the idea. Time to get those beanie's glowing. Have fun. — TJ*

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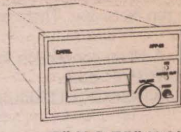
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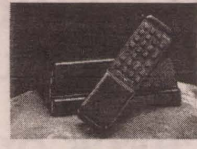
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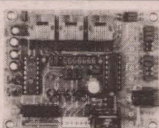
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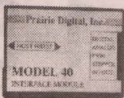
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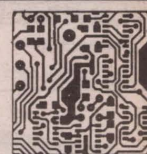
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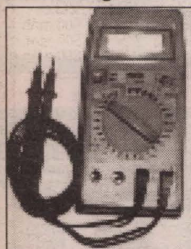
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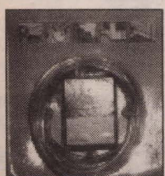
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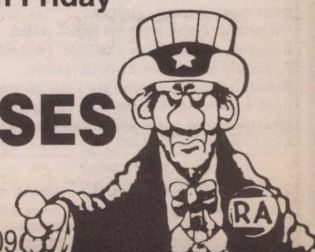
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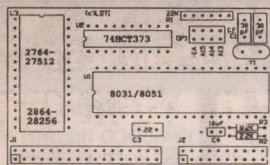
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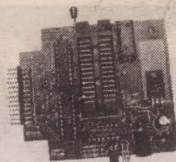


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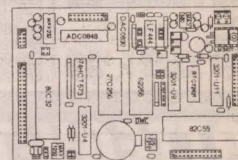


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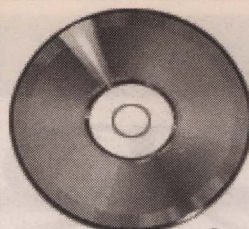
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• Up to 1/2 mile range.  
• Miniature photo battery mounts right on circuit board. (Included with kit)  
• Amazing audio sensitivity, picks up sounds at the level of a whisper.

**CRYSTAL CONTROLLED TRANSMITTER**  
This is the Worlds smallest crystal controlled FM transmitter. Transmits to any scanner type receiver. Easy to assemble, uses pre-assembled circuit board.

**XTL1000 E-Z KIT ..... \$69.95**

• Smallest Phone transmitter anywhere!  
• Up to 1/4 mile range.  
• Tunes 88-108 MHz.  
• No batteries required, powered by phone line.  
• Attach to phone line anywhere in house, even inside phone.

**SUPER-MINIATURE PHONE TRANSMITTER**  
Worlds smallest FM phone transmitter. Use with any FM broadcast receiver. Easy to assemble, all chip components are pre-assembled to the circuit board.

**XSP250 (E-Z) Kit ..... \$28.95**

• Digital voice changing: male to female, female to male, adult to child, child to adult.  
• Use with any modular phone.  
• 16 levels of voice masking.  
• Connects between handset and phone.  
• Not a kit, fully assembled.

**VOICE CHANGING ACCESSORY**  
STOP THOSE ANNOYING TELEPHONE CALLS! Sound older and tougher when you want to. Not a kit. Fully assembled. Use with single or multi-line phones.

**TRANSITION 2001 ..... \$59.95**

• Transmit high quality stereo to any FM stereo receiver.  
• Built in output level monitor for quick and easy tuning.  
• Ideal for use with personal CD player.

**FM STEREO TRANSMITTER**  
Transmit full bodied Hi Fi stereo to any FM stereo receiver. Separate left and right inputs and gain controls. Includes an output booster stage for greater range.

**XFS108 KIT ..... \$39.95**

**XFS-MATCHING CASE SET .... \$13.95**

• Uses sensitive microwave transistor amplifier.  
• Compact hand held unit.  
• Covers 1 to 2,000 MHz.  
• Includes miniature loud speaker for audio indication of detected signals.

**SUPER SENSITIVE BUG DETECTOR**  
When the XBD200 intercepts a signal in the 1 to 2,000 MHz range, it emits a growl that increases to a high pitched squeal as the signal strength increases.

**XBD200 (C) Kit ..... \$39.95**

• Powerful 2 stage audio amplifier.  
• Up to 1 mile range.  
• Use with any FM broadcast receiver.  
• Hear every sound in an entire house!

**MINIATURE FM TRANSMITTER**  
The XFM100 has a super sensitive microphone and is capable of picking up sounds at the level of a whisper and transmitting them to any FM broadcast receiver.

**XFM100 (C) Kit ..... \$21.95**

• Transmits a continuous beeping tone.  
• Adjustable from 88 to 108 MHz.  
• Up to 1 mile range.  
• Works with any FM broadcast receiver.  
• Operates from battery voltages of 3 to 18 Volts.

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Measuring 0.7 by 2.4 inches, the XTR100 is ideal for use in locating lost model rockets, bicycles, automobiles, games of hide and seek, and contests.

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• Dial your phone from anywhere and listen to the sounds inside your home.  
• Two digit Touch Tone code for secure operation.

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The latest in home or office security. Dial home from any other telephone, enter a two digit security code, and listen to all the sounds in your home. Automatically turns on without ringing the bell, waits for code, then remains activated for one and a half minutes.

**XPS1000 KIT ..... \$55.95**

**XPS-MATCHING CASE SET .... \$13.95**

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Nuts & Volts Magazine/July 1996 97



# Questions & Answers

# TECH FORUM

This is a READER TO READER Column. All questions AND answers will be provided by *Nuts & Volts* readers and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. All questions submitted are subject to editing and will be published on a space available basis if deemed suitable to the publisher. All answers are submitted by readers and *NO GUARANTEES WHATSOEVER* are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

## QUESTIONS

I am looking for the pinout and technical information for the accessory connector on the back of a cellular Motorola flip phone. I would like to build a cable that combines an external antenna and power/charging.

**7961** **Kim White**  
**Highland, IL**

Pertaining to the Laser 128 computer, I need a source for finding a power supply, PIN arrangement at power input port, and information about the use of an LCD screen with the Laser 128.

**7962** **Verl Wooters**  
**Centralia, IL**

Is there any way to modify a VCR so the timer record function does not require power off? Ideally, one could program a full week of TV viewing, also specifying which are to be recorded. The next-best would simply allow the timer to override the selector and switch to the channel to be recorded, even if there were a program in progress.

**7963** **Anonymous**

Is there such a thing as a over-the-airwaves Internet, bypassing the phone lines, sort of like a TV broadcast system? How would it work?

**7964** **Tom Earns**  
**Mt. Pleasant, MI**

From a box lot, I got an electrical contraption that I need help in identifying. The electronics are contained inside a thick-walled aluminum case measuring 8.5" x 3.5" x 2". On one end is a socket exactly like the plug end of a printer cable (computer end). It also has a socket similar to that used for cable TV. It was made by Motorola w/model #S1895A and serial #194DPYN357Y and also says "Tx Power Output -3 W, Pri. Pwr. 12 VDC Neg. Gnd. FCC ID: ABZ89FT5725." Except for capacitors and resistors, I can't identify any transistors inside.

**7965** **Michael E. Keller**  
**Lancaster, PA**

For those of us who live on remote Mexico beaches part of the year, inverters are a fact of life. Our answer to SCE is a combination of solar panels, a battery pack, and an inverter to convert the stored power to a more usable form (120 volts 60 Hz). Most of us have traditionally used a Trace Engineering or Hart Interface unit.

Solid, reliable, but not of particularly cost-effective construction in comparison to recent offerings from newer vendors. We use a gas or diesel generator to supplement the solar power for larger power usages, such as a washing machine, air conditioner, or an air compressor. This generator charges our batteries while providing power for these devices.

Basically, the older inverters convert the low-voltage DC at 60 Hz and require a very large transformer to move large currents up to 120 volts. The newer units convert the low voltage to a high frequency (20 KHz) and thus require a much smaller transformer. This voltage is raised to approximately 140 volts, rectified, and this DC voltage is then changed to a 60 Hz modified sine wave for end use. These inverters are cheap despite their greater complexity. A 1,500 watt (continuous) is presently available from Damark for \$370.00, less than half the price of a comparable unit from Trace Engineering.

MY QUESTION: Why can't I simply store my power at the higher voltage (140 VDC) and avoid all the waste of converting the voltages back and forth? Many of us have changed to 24 VDC over the years due to the greater efficiencies and smaller wire sizes available, but this is the highest voltage inverter available at a reasonable price. Storing the voltage is no problem. If you can series-parallel connect batteries for 24 VDC, you can do the same to obtain 132 VDC (fully charged). Same for solar panels (mine are presently series-parallel connected for 24 VDC).

The efficiencies seem obvious: You'd rectify the current from your generator and use it to charge your battery bank directly (with an appropriate controller). You'd drive your inverter directly from your battery bank. Many items (anything with universal motors such as vacuums, power tools, and purely resistive devices such as incandescent lights and toasters) would run directly from the 132 VDC (nominal) without any further modification. Wire sizes would go from 0000 to #10. No more 600-amp fuses.

Can anyone help me with a circuit, or a referral to a source book, to start working in this direction? I would like to use a 2N6770 N-channel MOSFET available from C & H Sales for \$5.00 as my building block. I would like to use a small, commercially available unit to provide my frequency source, wave form, and driver. (Damark has a 140 watt continuous unit from Power TO GO available for \$39.00. I took the unit

apart in an attempt to reverse engineer it. The raw components would cost me more than twice that.) This would be the most complex part of the inverter; if it failed you'd replace the entire box for another \$39.00. I would like to use 10 #27 deep-cycle batteries, available at the Price Club for about \$55.00 each, wired in series. I would like to wind up with 3,000 to 5,000 watts final output continuous, that would vary no more than 110-127, with a 60 Hz modified sine wave.

I believe this concept has serious commercial potential; many of my neighbors have stand-alone installations that run into thousands of dollars and every house has its own setup.

**7966** **John Shepard**  
**Corona, CA**

## ANSWERS

### ANSWER TO #49634 - APRIL 1996

Have you tried entering your device driver in the DOS 6+ setup file list? Check your DOS manual for the procedure. Some device drivers check for DOS version and setup will lie to the driver when it checks.

**John H. Smith**  
**Collison, IL**

### ANSWER TO #59610 - MAY 1996

A Closed Caption Decoder used to be available from Sears for about \$200.00. A construction article was published in *Radio Electronics* a number of years ago, but they are pretty complicated. By far the best, cheapest, and most satisfactory way to obtain Closed Captions is to buy a new TV. By federal law, they all must include one, and a 19 inch costs \$175.00 to \$190.00.

**Travis Brackeen**  
**St. Louis, MO**

### ANSWER TO #49612 - APRIL 1996

Most Motorola pagers are programmed via a special program run on an IBM compatible personal computer. The program called "RSS" or Radio Service Software, is specific to each model or family of pager. Connected to the PC is an interface box. The interface box connects to a head that is molded to hold the particular pager to be programmed. The RSS software packages, interface box, and pager fixtures are available only from Motorola. Be warned that a set-up for a single pager can cost several hundreds of dollars. Motorola's parts division can be reached at 1-800-422-4210.

**John Gilbert**  
**Lake Zurich, IL**

## ANSWER INFO

- Include the question number that appears directly below the question you are responding to.
- Payment of \$25.00 will be paid within four weeks of publication if your answer is printed.
- Only one answer per question will be printed.
- If you do not want your name, address, or phone number available to the reader please so indicate or it will be assumed that you have no objection.
- In the event that more than one person submits the same solution, the choice will be made at the discretion of the publisher.
- Due to space limitations, we can not reprint the original questions with the answer. The question number and the issue it appeared in are printed above the answer.

## QUESTION INFO TO BE CONSIDERED FOR PUBLICATION

All questions should relate to one or more of the following:

- 1) Circuit Design
- 2) Electronic Theory
- 3) Problem Solving
- 4) Other Similar Topics

## INFORMATION/RESTRICTIONS

- No questions will be accepted that offer equipment for sale or equipment wanted to buy.
- Selected questions will be printed one time on a space available basis.
- Questions may be subject to editing.

## HELPFUL HINTS

- Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
- Write legibly (or type). If we can't read it, we'll throw it away.
- Include your Name, Address and Phone Number. Only your name will be published with the question, but we may need to contact you.

## ANSWER TO #5967 - MAY 1996

First of all, both single coil and two coil five-volt latching relays are available in the price range of 90¢ to \$1.50 from the advertisers in *Nuts & Volts*. Check with M. P. Jones, Brigar, or All Electronics.

If you want to latch a non-latch relay, use a second set of contacts on this relay to hold power on the coil. To unlatch it, interrupt the power to the holding contact. This can be accomplished by a normally closed pushbut-



ton (opens on pressing) or by a second relay. Power to latch several relays can be routed through the normally closed contact of this second relay and they will all be reset (or opened) when this relay is energized.

If the load being switched is of the same voltage as the relay, the coil can be wired in parallel to the load using diodes to isolate the control line from the relay output line. The power to the relay and load could then be interrupted as described above.

**James J. Schmidt**  
Deer Lodge, MT

## ANSWER TO #6962 - JUNE 1996

Building an FM transmitter is a fairly complex task, but you can find sample designs in the *ARRL Handbook*, which is probably available at your local library. If you want to look at an "off-the-shelf" solution you might call **Agrelo Engineering** at **1-800-588-4300** or **518-381-1057**. They make a selection of miniature transmitters used for ham "fox hunts." A typical model is about 1.5 inches by 0.5 inches with a power output of 200 to 400 milliwatts. The unit is crystal controlled. They also have a companion digital voice recorder board to broadcast pre-recorded messages.

Another approach would be to find a used miniature 2 M handi-talkie such as the Standard CS-108. This radio is smaller than a cigarette pack and can be programmed for any 2 M channel you like. It is powered by 2 AA cells and puts out about 250 mW. It weighs under 5 ounces.

You will have to lift more than a nine-volt battery in any case. To develop the 250 mW of power you want, a typical transmitter will need nearly 600 mW of input, or about 100 mA at six volts. I'd use lithium batteries for whatever transmitter you select. They have a very high amp-hour rating and weigh practically nothing.

The antenna solution is pretty straightforward. You don't need to cover the kite in foil to make a ground plane; a couple of 1/4 wavelength wires run down the "wings" will do. Another option is to use a wire J-pole and stretch it along the kite string. This halfwave antenna needs no groundplane. They are available pre-built from several suppliers (like MFJ 1-

800 647-1800) for under \$20.00 or can be built from plans in the *ARRL Antenna Handbook* or ham magazines.

**George Scott**  
Alexandria, VA

## ANSWER TO #6965 - JUNE 1996

According to the FCC Public Access link an ID # of JNQ is for Age Technology Co., Ltd. 3F, No 248, Sec 4, Hsin-Yi Road; Taipei, Taiwan.

The **FCC BBS (301) 725-1072** and choice #1 Access Equipment Authorization Database is a great resource to determine who really made that board inside your computer. I couldn't find a Web address for the equivalent information, but I can get in and out of the database in about a minute so long distance charges don't add up too much. My modem connects using fairly standard N-8-1.

**Ed Bell**  
Colchester, VT

## ANSWER TO #6969 - JUNE 1996

Here are some easy and inexpensive answers for building your remote weather station.

You said your wind speed generator produces an output of 600 mV at 90 mph. The easiest way to display this is with a ready-made digital panel meter. I found one for \$9.95 at **B.G. Micro, Inc.** (phone **1-800-276-2206**). This is a 3-1/2 digit meter; so it will easily display speeds from 0 to 90 mph.

If you're sure that 600 mV really equals exactly 90 mph, you can also use a fixed resistor voltage divider. The top leg should be 11.3 K ohms, the bottom leg should be 2.00 K ohms, both 1%; your meter should read 90.2 [mV] for a generator output of 600 mV. If you can only get 5% resistors, use a top leg of 11 K ohms and a bottom leg of 2 K ohms; this will read roughly 92 [mV] for a generator output of 600 mV.

If you prefer adjustable calibration, connect the DC output from your generator across a 10 K ohm potentiometer. Connect the negative lead from the meter to the negative lead from the generator. Connect the positive lead from the meter to the wiper of the potentiometer. The potentiometer can now be used to calibrate the meter to read accurate wind speed.

Note that 600 mV is a pretty low voltage, so this circuit will be susceptible to noise from various sources. I suggest using two-conductor shielded wire from the generator to the read-out. You may also want to place a small bypass capacitor in parallel with the meter input and/or the generator output terminals, to reduce any high-frequency noise (such as RF from nearby transmitters).

To indicate wind direction, use four magnetic reed switches at the transmitter (see the Alltronics ad on page 46 of the Jun. '96 *Nuts & Volts*). Just mount a small magnet on the shaft of the direction sensor; and as the magnet moves around, it will close the reed switches. If you adjust the mounting geometry of the switches, you can have two switches closed simultaneously when the magnet is half way between them (when wind direction is between the cardinal compass points). The simplest display would be to connect one LED to each reed switch, using an appropriate series resistor (390 ohms is good if you use a nine-VDC power supply). Then either one or two LEDs will be on at any given time, showing wind direction. You'll need a five-conductor cable for this, one common from your power supply out to the switches, and four return lines (one from each switch).

With a little effort, you could come up with a simple logic circuit to drive an eight-LED display. Use AND gates to drive the intermediate LEDs (NE, SE, SW, NW). Invert the output of the AND gates, to gate OFF the cardinal LEDs. For example, if NE is on, then force N and E to be off.

If you want to use only three-conductor wire, you could do the following. Use an AC power supply, connected to all four reed switches (wire #1). Connect the NORTH switch to the anode of a diode; connect the SOUTH switch to the cathode of a diode; connect the remaining leads of those diodes together to a N/S wire (wire #2). Do the same thing with the EAST and WEST switches, feeding wire #3. At the display, connect wire #2 to the NORTH and SOUTH LEDs, and connect the polarity so NORTH lights with a positive voltage, and SOUTH lights with a negative voltage. Connect the EAST and WEST LEDs to wire #3, in the

same fashion. Again, don't forget those series resistors, or you'll fry the LEDs!

I have seen humidity sensors advertised in various surplus catalogs recently; however, I don't have any information about calibration, so these might be a bit more complex to implement.

I found some other surplus parts that might interest you, sold by **Electronic Goldmine (602-451-7454)**. They sell a humidity sensor, part no. G5069, for \$1.89. They also sell a Radiosonde electronics assembly, part no. G5578, for \$4.95, which includes an atmospheric pressure sensor and temperature sensor. Since these are surplus, there's probably not much documentation, so you'll have to experiment a bit to get the information you want out of these parts. It's possible that you might just hook up each sensor to a DMM, and get either a voltage or resistance reading. Then you could create your own "calibration table" that relates the DMM reading to actual temperature, humidity, etc.

**Greg Miller**  
State College, PA

## ANSWER TO #59617 - MAY 1996

The Macintosh serial port is RS-422 rather than RS-232, so there is not a direct pin correlation. The Mac serial port can be wired for RS-232 so you might be able to adapt the Mac DFI hand scanner to work depending on what connections it used on the MAC. Something like this would be a good starting point:

Mac mini-DIN8	DB-25	DB-9
1 HskD	20 DTR	4 DTR
	4 RTS	7 RTS
2 HskK	5 CTS	8 CTS
3 TxD-	2 TxD	3 TxD
4 Grd	7 SG	5 SG
8 RxD+		
5 RxD-	3 RxD	2 RxD
6 TxD+		
7 NC		

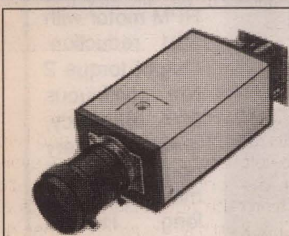
The Mac mini Din-B has the pins numbered like this:

8 7 6  
5 4 3  
2 1

The largest hurdle will be driver software. DFI has drivers for DOS and

*Continued on page 118*

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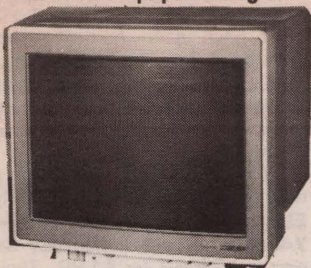
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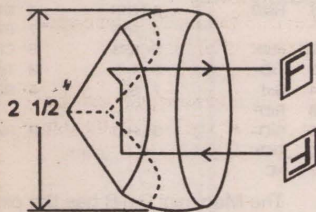
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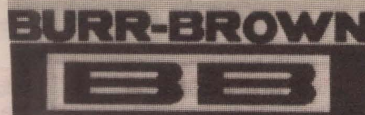


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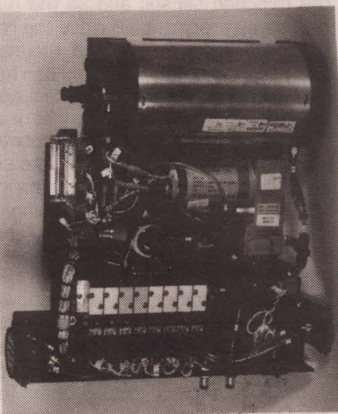


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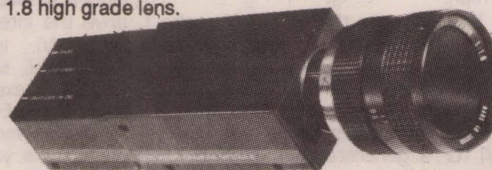
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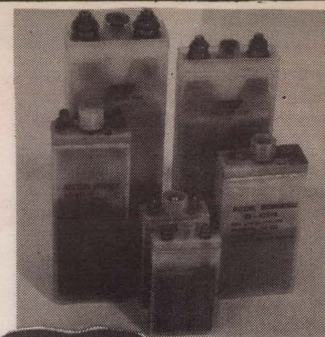
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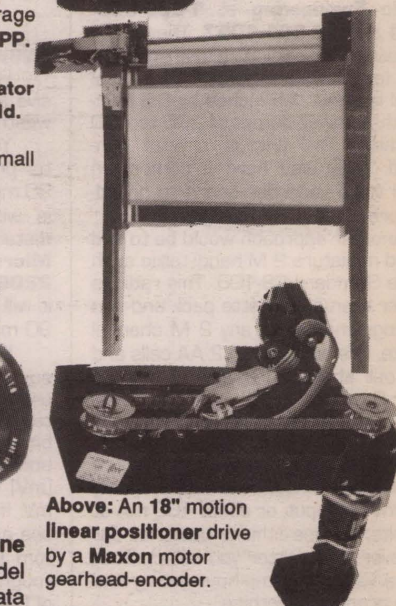
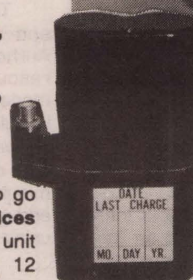
Best regards from the surplus mines. For those of you who like to follow government (cold) war surplus offerings, the address for Defense Reutilization and Marketing Service (DRMS) is now box 6276 2163 Airways Blvd, Memphis TN 38114-5210. Or Internet <http://www.drms.dla.mil>.

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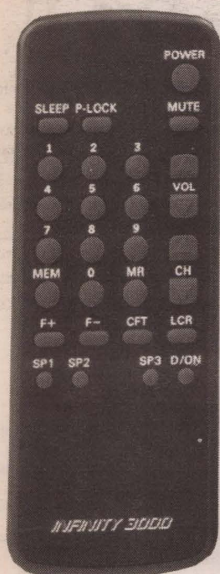
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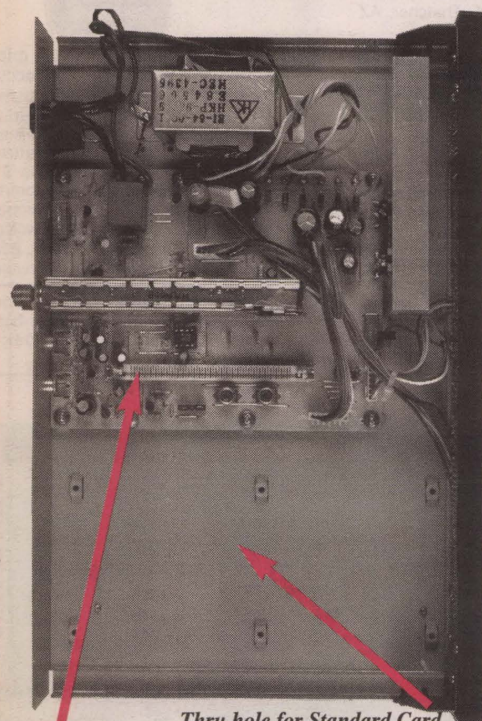
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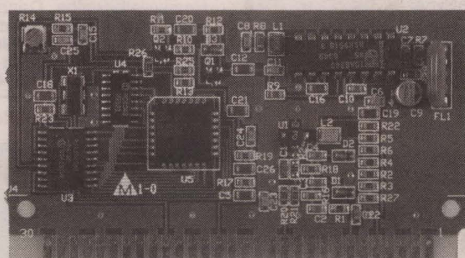
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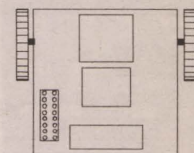
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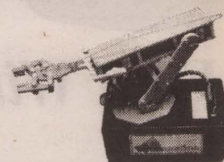
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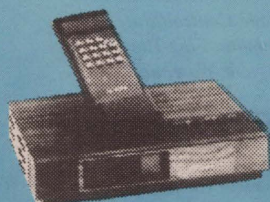


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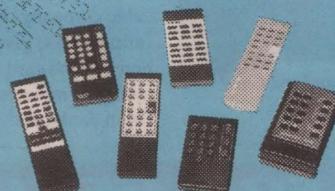
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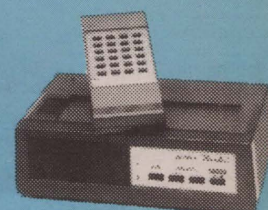
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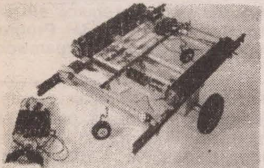


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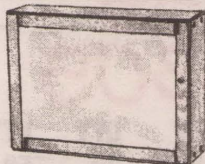
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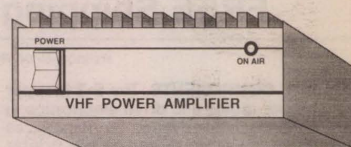
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Don Lancaster's

# RESOURCE BIN

number fifty four

## Picking a potent peck of pliant PICs.

**O**ur usual reminder here that the *Resource Bin* is now a two-way column. You can get tech help, consultant referrals, and off-the-wall networking on nearly any electronic, *tinaja* questing, personal publishing, money machine, or computer topic by calling me at (520) 428-4073 weekdays 8-5 Mountain Standard Time.

I'm now in the process of setting up my new *Guru's Lair* web site you will find at (where else?) [www.tinaja.com](http://www.tinaja.com) — This is the place you go for instant tech answers. Among the many files in our library, you will find complete reprint sets for all of the *Resource Bin* columns. Along with some new "rich text" global search features.

The site is still under construction, but I fully intend to move thousands of my files here. So, definitely come visit. But bear with me for a while till things really get into gear.

You will get the best results if you have both *Netscape Gold* and *Acrobat Amber*. These are downloadable from [www.netscape.com](http://www.netscape.com) or [www.adobe.com](http://www.adobe.com)

### Meet the PIC

This month, I thought we'd see just what the excitement is all about. The PIC microcontroller appears to have become *the* chip of the decade. To the point where there's no point *ever again* designing any bits-and-pieces classic hardware solution.

Especially one which involves 555 timers or other jellybean chips.

A PIC is basically a tiny black box that has lots of digital (and sometimes analog) inputs and outputs. You teach the box what relationship you want to have between your input and outputs. This gets done by writing a program or a command series on a PC host.

Those commands then get sent to a programmer which blasts instructions into one or more PIC chips. Your PIC then remembers what it is supposed to do. It can then be used anywhere.

There's several big time advantages to PICs that utterly and totally blow their competition away. It is not

even remotely close.

First and foremost, PICs are readily available in smaller quantities. And totally hassle free. To individuals, to students, to small scale tech start-ups, anybody. While typical onesie-twosie costs are \$4.00 to \$7.00, the prices on some chips drop under a dollar.

Second, a PIC uses a non-traditional *Princeton* RISC architecture in which your program and data memories are (usually) held strictly separate. These longer self-addressing instructions let you do most computer commands as *one byte* instructions which execute in *one single clock cycle!* This one-on-one feature gives you as much as a 3X speed advantage and up to a 3X code length advantage over classic 68XX or 80XX micros.

Third, the PIC is elegantly simple. There are scant few commands in the PIC instruction set. But they are super powerful and very easy to use.

Fourth, your PIC can be quite

### NEXT TIME: Don shows us a few insider secrets on net webmastering.

fast because of one byte commands, and because of 20 MHz clocks.

Fifth, the PIC is a very low-power device that is easily battery operated. With careful clock design, it can even become the core of your micropower system run off coin cells.

Finally, the PIC is extremely easy to learn and is lots of fun to use.

Additional specific technical details on what a PIC does and how it does it are in MUSE88.PDF and MUSE99.PDF on my new [www.tinaja.com](http://www.tinaja.com)

Let's try to interleave the PIC basics with today's major resources ...

### How Fast is Fast?

When you write custom crafted and hand-coded machine language,

a PIC chip might end up astonishingly fast. Sadly, most designers go out of their way to *slow their PICs down*.

Assume you want to quickly shove a squarewave out a port. Start with a 20 MHz PIC. By using internal machine language only, we toggle the port and then continuously repeat.

There are four PIC clock cycles per machine cycle. Thus, a 20 MHz clocked PIC executes each instruction in a blazing 200 nanoseconds.

Allow one machine cycle for your toggling, and two for the goback. Our squarewave has a half period of three cycles or a full period of six. The port output frequency is 833 KHz.

More realistically, you'll want to do a decrement or test of some sort that gobbles up at least one extra cycle and lowers you to 625 KHz.

That is *if* your code gets internally stored. Your normal way to expand a PIC's memory storage is with serial EEPROM. This route is cheap, simple, and needs few interconnects.

But dozens of clock cycles may be involved. Hundreds when you've got to write to memory as well.

If you are using external EEPROM memory, your squarewave's output frequency will drop on down into the 50 KHz range.

Most any computer program can be *interpreted* or *compiled*.

With any interpreted program, each program step gets read in order and then converted into a useful action *at run time*. This interpreted program is often first written in a chosen higher level language as *Basic* or *PostScript*. These are easy to write and interact with humans well.

With a compiled program, an initial *compiling* run is done to sort out only your essentials of exactly what has to be done. Only the precise instructions needed at run time get

used.

The rule is that machine compiled code is usually faster than interpreted code. And that hand-crafted machine language is way faster than either.

Continuing the speed examples, the *BASIC Stamp* from *Parallax* is still by far the most popular PIC interpreter. An original Stamp could output a squarewave at 500 Hz or so.

The key point is that interpreted vs. hand-generated speeds are not even remotely close. They differ by a factor of 10 to 100 or even more.

*Always hand code for speed!*

A PIC running at the usual 8 MHz slurps around 10 mils of its supply current when active. This may be far too much if you are trying to run off a tiny coin cell.

The PIC current is proportional

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# RESOURCE BIN

## SOME PIC RESOURCES

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to clock frequency. Typical micro-power apps often substitute a 32 KHz clock, thus trading speed for power.

Your usual route towards a fast PIC design is to do a slow design first. Using your BASIC Stamp.

This step makes sure your system does what it is intended. When only a modest further speed-up is required, you substitute Scott Edwards' (or other compiled) routines for each step in the program. For dramatic speed-ups, you rewrite the whole thing from the ground up in custom crafted machine language. Like you really should have done in the first place.

### Microchip Technology

These people are the prime supplier for PIC chips and tools.

They have got dozens of data books and app notes available. Start off with their free *PIC Data Book* and the fine *Microcontroller Applications Manual*.

Originally, there were three main PIC families. The 16C54 (and the other 16C5X chips) were their cheapest and simplest. They typically offer 12 to 20 port lines, 512 to 2048 bytes of fixed program memory, and 25 to 73 bytes of user RAM. With 12-bit opcodes.

Don't let all these seemingly small values fool you. PIC code takes up far less memory than is needed for classic micros and you can always easily tack on great heaping megabytes of external serial EEPROM.

Their 16CXX series has additional memory. Program memory to 4096 bytes and up to 192 bytes of RAM. The instruction words are 14 bytes wide. They also do include a full time serial port to simplify programming.

The high end 17CXX series offers a full 64K of memory space, interrupts, hardware multipliers, and all the rest of the bells and whistles.

And a brand new series of ultra low-cost PICs has just been announced in *eight-pin* packages for seriously low end apps. Priced well under a dollar in humongous quantities.

Microchip Technology also has

tech support, plenty of software, in-circuit emulators, and design seminars.

### Parallax

Lance Wally and his *Parallax* folks are the home of the *BASIC Stamps* — tiny modules that make PICs friendly and ultra easy to personally use.

Their original *BASIC Stamp I* was an *entire* microcontroller in a \$29.00 14-pin SIP package. Measuring half an inch high by an inch and a half wide.

This BS1 gave you eight I/O lines, 256 bytes of program memory, and ran 2,000 instructions per second.

Their newer BS2 is in the shape of a 24-pin integrated circuit. It has 16 I/O lines, executes 4,000 instructions per second, and handles serial data to 50 kilobaud. It also has new commands that produce DTMF tones and the X10 remote control instructions.

Parallax has also got lots of support products. From hardware interfaces to *Stamp Experimenter Boards* and full programmers. For serious designers, they also offer a series of *ClearView* in-circuit emulators.

The Parallax web site can be found at [www.parallaxinc.com](http://www.parallaxinc.com) — Do note that *inc* in the middle of their url address! [parallax.com](http://parallax.com) is somebody else. At any rate, they've got the full *BASIC Stamp* app notes, programming software, and bunches of other goodies available for your immediate downloading.

There's also a hot link to here from my [www.tinaja.com](http://www.tinaja.com)

### Scott Edwards Electronics

Scott Edwards is another *Nuts & Volts* writer. You will find his BASIC Stamp column and PIC Applications info right here on a monthly basis.

Scott is heavy into *PIC Development Tools*, his series of machine language software modules which do BS things much faster and far more compactly. They also extend the Stamp's memory and I/O capabilities

Scott also carries various *back-pack* add-on hardware goodies as

liquid crystal displays, thermometers, and applications that involve the low-cost radio control servos.

Scott also does custom consulting and application development.

### Advanced TransData

Any PIC device is a programmable microcontroller. You have to teach it what it is going to do. You have four main choices here: You can use a OTP or *one time programmable* chip. These are the cheapest for working and testing code in small to medium quantities. The earliest PICs required a fairly specialized programmer driven from a host's parallel port. Later versions use their serial I/O to greatly simplify programming and host interface.

When you are certain you will sell a minimum of 25,000 identical copies of your chip, factory programmed ROM versions are available.

What if you intend to develop or improve your code? There are more expensive EEPROM versions of PICs available. You could reprogram these over and over again. But when you are really serious about doing major PIC development work, you'll want to go to an ICE or *in-circuit emulator*.

An emulator fakes PIC behavior to the best of its ability. The simplest of emulators is more properly called a *simulator*. Simulators execute only a software model on a host computer, usually on a PC, very slowly.

Instead, true *emulators* hide a real PIC somewhere in their innards. A mid-priced emulator might run quite slow. Perhaps at only 1/100th of its normal speed while including such niceties as single stepping, tracing, debugging, and monitoring of key variables and data locations.

A *real-time emulator* does all this and does it at your normal and expected PIC speeds. Finally, an ICE has a physical plug on it you drop into your PIC socket.

The real-time emulators are usually based upon the special fancy PIC chip known as a *bond out version* in which additional access points are brought out to multiple pins. The real beauty of emulators and simulators is instant and continuous reprogramming.

The fancier in-circuit emulators are not cheap. Pricing in the \$600.00 to \$1,000.00 range is typical. Put another way, an in-circuit emulator can easily pay for itself in a few dozen hours of avoided design time.

While Microchip and Parallax both sell great in-circuit emulators,

lately I've been using the *RICE16-5X* from *Advanced TransData*.

Advanced TransData carries a nice collection of higher end development tools. Mostly centering on emulators and programmers. Plus their RICE16 development software.

Along with several other suppliers, they also offer C compilers. But note that *any* code you compile from the C language is *guaranteed* to end up as an *absolute atrocity* when it is run on any PIC system! Every time.

The reason is simple: Unless you know, fully grok, and genuinely love both PIC machine language code and its architecture, you're *certain* to get lousy results. That C language goes out of its way to lock you out of this essential understanding process.

### microEngineering Labs

This is Jeff Schmoeyer's operation up in Colorado Springs. Jeff is a superb source for the PICs themselves and for low-cost PIC prototyping boards. A 16C54 PIC sells for \$4.50 in singles, while their PIC Proto-18 breadboard goes for \$9.95.

Jeff is also big on *PBasic Compilers*. Host software which precompiles the PIC commands so they will run much faster than interpreted Basic. \$99.00.

Among dozens of other products, Jeff also has a \$29.00 *PIC Proto Demo Kit* which includes a PIC, a breadboard, LEDs, a speaker, and a collection of related goodies.

### Circuit Cellar

The Steve Ciarcia *Circuit Cellar* has long been a quality source of low-cost microcontroller systems. Especially those suited for home automation.

Steve's latest product is called the *Pic Stic1*. This combines their own hardware with software and tools by microEngineering Labs.

There are three devices offered. The first one is BS1 pin-for-pin compatible. Being interpreted code, this beats the BS1 by up to 15 times on speed. The second one adds a real-time clock, while the third adds some fancy A/D conversion capabilities.

These are not yet BS2 compatible. They are working on newer versions that shortly will be.

### Science First

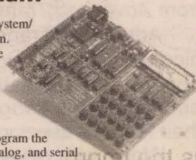
These folks are newcomers to the PIC arena. Their main gig is selling low-cost Van DeGraff generators and educational science demo projects to students and teachers.

They've just introduced a very easy-to-use PIC trainer and some simple real-world interface stuff. Intended mainly for non-program-



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# RESOURCE BIN

mers. Typical are relay drivers, displays, burglar alarms, EPROM emulators, and a few others. Prices from \$20.00 to \$60.00.

Contact Nancy Bell at *Science First* for free catalogs and newsletters.

## Synergetics

Uh, that's me, I guess. I'm strongly attracted to the PIC chip because of it being the heir apparent to the 6502, its elegant simplicity, and its ultra clean code. I've been mainly developing in two areas: Flutterwumpers and magic sinewaves.

As we've seen in previous columns, a flutterwumper can be anything that moves and either chomps or spits under intelligent control. X-Y tables, circuit drilling, engraving machines, signmakers, Santa Claus machines, or CAD/CAM mills.

The fine PostScript general purpose computer language is absolutely ideal for a flutterwumper's high-level side. Among zillions of other reasons, there is PostScript's incredible font variety and its graceful curves.

To me, it makes the most sense to split the problem. Use PostScript on a suitable host to initially generate your flutterwumper paths. Convert those paths to some simple meta language. Then let a PIC or two down on the flutterwumper do all of the low-level scut work for you.

While you can use HPGL or Gerber format, to keep costs really down, all you'd really need is a simple code of single ASCII characters. 0 for north, 1 for northeast, and so on; U for up and D for down; Q for quit.

By splitting PostScript on host and PIC on flutterwumper, a \$100.00 printed circuit drill and a \$200.00 Santa Claus machine should be possible.

Magic sinewaves are some newly discovered and ultra-long repeating sequences of ones and zeros. They have precisely controlled amplitudes and amazingly low distortions.

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Additional files on flutter-

wumpers, Santa Claus machines, and my magic sinewaves on [www.tinaja.com](http://www.tinaja.com)

## Also Rans

The PIC is absolutely ideal for small scale tech start-up ventures. Let's look at a few random samples ...

*Axiom Manufacturing* offers a *PIC Microprocessor Development Kit*. CCS has a group of PIC-related products, both programming and development oriented. Fred Eady's *E. D. Technical Publications* specializes in low-cost PIC development tools.

*ITU Technologies* sells the *PIC-1 Programmer*. The kit is \$29.00 while the assembled and tested version goes for \$49.00. They also do retail individual PIC chips and are heavy into Caller ID and similar PIC applications.

*Matrix Labs* is the home for the *QuicPic Language* and their new *16C57 Proto Boards*. Ken Pergola is the source for his *Micro-BRISC* programmers, software, and useful firmware. *Picard Industries* sells a number of interesting and low-cost PIC development aides.

As does *Zeta Electronic Design*.

## This Month's Contest

As our contest for this month, just tell me about any PIC resource I don't already know about. Or suggest some new, unique, or totally off-the-wall application for a PIC design.

There will be a largish pile of my new *Incredible Secret Money Machine II* books going to the dozen or so better entries, plus an all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for two that will go to the very best of all.

Send all your written entries to me here at *Synergetics*, rather than to *Nuts & Volts* editorial. **NV**

**Microcomputer pioneer and guru Don Lancaster** is the author of 33 books and countless tech articles. Don maintains his no-charge US tech helpline found at (520) 428-4073, besides offering all of his own books, reprints, and consulting services. Don also has two free catalogs full of his resource secrets waiting for you. Your best calling times are 8-5 on weekdays, Mountain Standard Time.

Don is in the process of setting up his *Guru's Lair* at <http://www.tinaja.com>

Full reprints and preprints of all Don's columns and ongoing tech support appear here. You can reach Don at *Synergetics*, Box 809, Thatcher, AZ 85552. Or send any messages to his US Internet address of [don@tinaja.com](mailto:don@tinaja.com)



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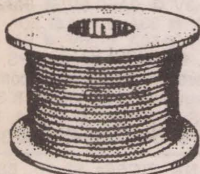
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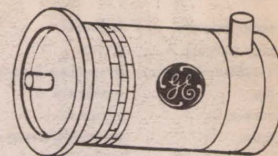
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by  
Gordon  
West

# EXTERNAL FILTERS CAN QUIET THE SQUAWK

The modern VHF and UHF commercial and amateur radio transceiver is regularly troubled with intermodulation. Yet bigger, 10-year-old transceivers with multiple stages of cavities and helical resonators work well in heavy RF environments.

"They don't make them like they used to," comments Bill Alber, a communications technician for his sheriff's aero squadron in the San Francisco Bay area. "The new small mobile and micro-handheld transceivers blow squelch all the time in the city," adds Alber, explaining that public safety personnel would constantly try to crank the squelch all the way to the right to decrease sensitivity to intermodulation, and ultimately turn the volume all the way down to cut the clutter. "The older radios did just fine, but newer radios have miniaturized themselves so small that their front-end circuitry just can't handle the overload," adds Alber.

Intermod distortion, nicknamed "intermod," arises from non-linear mixing of two or more signals in the front end of a receiver on the modern VHF and UHF transceiver with extra "hot" front-end GaAsFET circuitry. Non-linear mixing yields frequency products other than the signals applied to the mixer. Here is an example of non-linear mixing that can occur in a VHF handheld or mobile unit on two-meter ham band frequencies.

Two local repeaters are many times heard simultaneously as intermodulation on a new two-meter transceiver. One repeater outputs on 146.670 MHz, and the other repeater outputs on 146.880 MHz repeater. A perfectly linear front-end amplifier will contain just these two frequencies, and will amplify them by the amplifier gain figure. However, if the receiver amplifier is non-linear — many times a problem with the modern VHF or UHF receiver — the amplifier will contain the two repeater frequencies PLUS the sum and differences — 210 MHz difference and 293.55 MHz sum. Ham operators near military bases would find an intermod trigger if there was any major radio activity near 290 MHz.

But when you get MORE than two strong signals, out of band, coming into a non-linear RF amplifier in your receiver, the intermod mix and trigger gets closer to home. Take, for example, one reason why 152 MHz kilowatt paging transmitters regularly show up on two-meter receivers. Paging transmitters are assigned

between 152 MHz-153 MHz, and 157 MHz-158 MHz. Suppose paging transmitter "A" is on 152.240 MHz, paging transmitter "B" on 152.150 MHz, and paging transmitter "C" on 157.720 MHz. The sum of the first two frequencies minus the third sea channel ends up at 146.670 MHz — the output of a popular repeater channel found everywhere in the United States. Besides the third order intermodulation, there also commonly exists fifth order IM, too. The combinations of the frequencies become almost endless. The front end of the transceiver must somehow deal with all of these extraneous signals.

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The big band-pass filter is off-the-shelf for amateurs wishing to pass the two-meter band, either 144 MHz to 148 MHz, or for weak signal amateur radio use, 144 MHz to 146 MHz. Both companies will also tune to any specific commercial channel on VHF or UHF that you desire.

The band-pass filter goes in series with the antenna lead-in. In the case of a dual-band handheld operated from a single antenna port off of a dual-band base antenna, you will need to use a duplexer to single out the VHF and UHF circuits, and switch to two individual antennas or another duplexer. In other words, the band-pass filter for two meters would look like a stop-band filter for the 70 cm circuit. Keep this in mind when considering band-pass, dual-band filters for handheld operation with a single output jack.

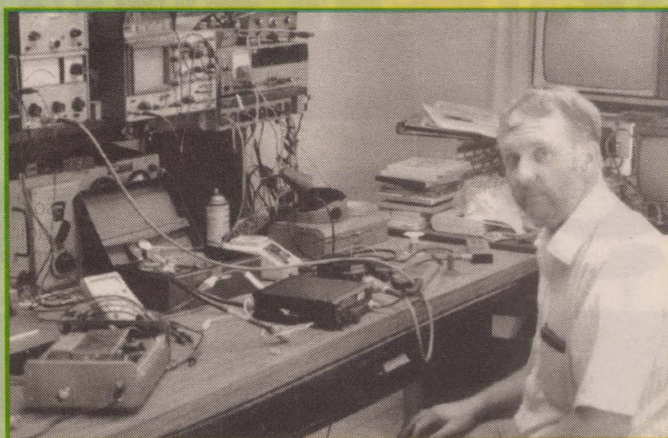
The insertion loss for the band-pass filter is less than 1/2 dB. Filter response is relatively steep, just what you want to offer up to 40 dB attenuation at 10 MHz away on either side of your operating frequency.

The band-pass filter is a "must" for any major two-meter base station installation where a mobile unit or a handheld is your operating transceiver. Even some two-meter base stations have little front-end cavity filtering on the inside, and the band-pass filter will do wonders to cancel intermod.

But for the two-meter ham band, 152-153 MHz pagers are still relatively close and within a portion of the band-pass filter response curve and can still give you reception headaches. The band-pass filter does a nice job of rolling off the 157 MHz signals that sometimes

create the mix, but nonetheless, 152 MHz pagers still creep through.

After you try the band-pass filter, chances are you're going to find a lot less out-of-band racket



**Jim Ford  
N6JF testing  
the band-  
pass filter.**

**Technician  
tuning a  
new band-  
pass filter  
system.**



of mobile and handheld transceivers is accomplished by reducing the out-of-band spectrum that the radio receives. One solution is the band-pass filter. These are shoebox-sized affairs, usually



creeping in on your desired channel. But you may still need more intermod suppression, and you'll need to do a little detective work to see where the signals are located on the radio spectrum that are creating the unwanted mix. Most likely, paging tones are still creating the unwanted mix, coming from kilowatt ERP transmitters in the 152 MHz-153 MHz band. Your solution is to specifically notch these frequencies out, relieving your receiver of having to deal with these overpowering signals. Paging transmitters traditionally run 200 watts or more into 10 dB gain linear antennas, yielding better than 2,000 watts effective radiated power. No wonder they are a nuisance to ham radio and commercial radio operators on nearby VHF channels.

The most popular notch filter is from Par Electronics (Lantana, FL; 407-586-8278). The Par filter comes in several different sizes — one for handhelds slightly larger than a Zippo lighter, and a slightly larger one about the size of a double-deck of cards for mobile units. Either filter offers negligible loss on ham frequencies two meters and 440 MHz. Instead of having to switch out the filter for UHF ham, the filter can remain in line with almost no loss or any significant VSWR. The Par filter has been patented with a 40 dB-50 dB notch in the lower of the two spectra occupied by pagers in the 152 MHz band.

The amateur handheld version has minimal attenuation, rising to near zero on the low side of the notch, while trailing off more slowly on the high

side while providing notches in excess of 50 dB only two-three MHz away. Ham radio contesters and weak-signal operators are also beginning to pick them up — they're especially useful for the new ICOM IC-706 VHF multi-mode transceiver.

Another interesting use of the Par notch filter is their natural 50-ohm impedance with an antenna that may not look like a perfect 50-ohm match. The unique dual-band German "Duo Quad" window antenna for hotel rooms and condos is a perfect example of where the Par filter really does its job well.

The German antenna, hung by suction cups around a metal-framed window, brings in so much signal that a handheld is usually swamped by out-of-band intermod interference.

The

filter notches out the offending 152 MHz paging intermod signals.

At the same time, it also reduces the relatively high VSWR encountered when a loop antenna is hung by suction cups near a metal window frame. This results in a perfect match to the handheld that will transmit cooler without significant VSWR problems.

The filter also minimizes the small coax cable on the handheld as being part of the

## Intermod Filters

### Par Electronics VHFDN152HT

(Notch Filter, with female input BNC and male output BNC connectors)

Frequency	Insertion Loss	SWR
144 MHz	.2 dB	1.35
148 MHz	.25 dB	1.1
152.4 MHz	35 dB	>5

152.4 MHz is the deepest null frequency and is in the middle of the paging band.

### Digital Communications DCI-146-4H

(Band-pass filter with female/female UHF connectors)

Frequency	Insertion Loss	SWR
140 MHz	34 dB	>5
144 MHz	.8 dB	1.4
146 MHz	.55 dB	1.3
148 MHz	1.65 dB	2.7
152 MHz	31 dB	>5

The loss at 148 MHz was a little high, but was understandable considering the custom tuning for the lower portion (sideband) of the two-meter band.

Tests conducted 3/24/96 by N6JF Jim Ford



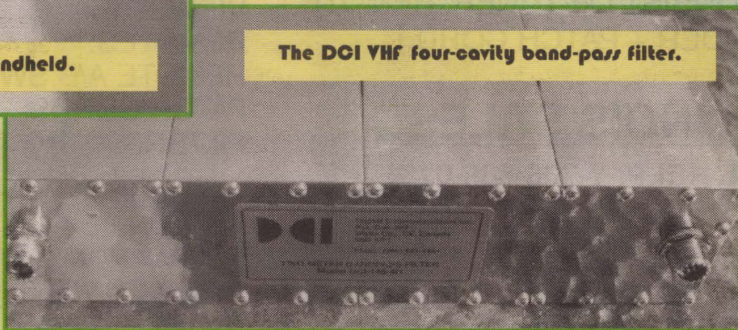
The Par filter is great for a dual-band handheld.

side. Although there is slight attenuation in the 154 MHz-175 MHz spectrum for ham sets that tune out-of-band signals, the filter still permits the reception of VHF high band.

There is a scanner version of this filter which has a steep slope on the high side of the notch to allow uninterrupted reception from 154 MHz to 900 MHz. The filters are designed by Dale Parfitt WA2YPY, an avid amateur operator who saw the need for these filters as more ham sets come on the market without internal helical resonators.

"I installed the Par Electronics VHF DN-153 HT scanner intermod filter on my Uniden Bearcat 890XLT, and it cut my intermod interference by 99 percent when using an outside antenna. After trying many different filters and cavities, the Par filter worked best," comments David Chandler KA1ZZJ. "Since installing the filter, I am now able to monitor stations never heard because of intermod problems," adds Chandler.

The Par filters also work well for satellite and packet ham radio users. The filter is used to reduce desensitization caused by the two-meter transmitter getting into the 70 MHz front end. This is where the asymmetrical notch technology within the Par filter shines as the loss is well below 1



The DCI VHF four-cavity band-pass filter.

antenna system. The filter mounts right at the antenna feedpoint on the unique German Duo Quad antenna. (Information: 714-549-5000, Monday thru Friday, 10:00 am to 4:00 pm, California time; \$65.00 as pictured.)

Both the notch filter, as well as the band-pass filter, simply connects to the antenna output of your transceiver or VHF/UHF receiver or scanner. It is not wired up on the inside. The Par filter works fine for dual-band handhelds and dual-band mobile units with only one antenna output. The band-pass filter only works on single-band outputs because it passes only 2 or 4 MHz of VHF OR UHF frequencies — not both.

For the notch filter to work at its best, you need to scan the frequencies outside of your normal operating band and see where the interfer-

ence is coming from. For pagers, try 152 MHz to 153 MHz, or 157 MHz to 158 MHz. For business radio calls, scan between 151 MHz to 152 MHz.

Once you know where the offending frequency is on the spectrum, look for other strong signals creating the unwanted mix, and then decide which one you are going to go after with the notch filter. If you can't identify the frequencies, you may wish to try the band-pass filter first. Each filter runs \$100.00.

You must also determine that the mix is occurring within your radio, as opposed to the less common transmitter mix which is actually occurring at a distant transmitter site. When this type of intermodulation occurs, a real signal appears on the input of your desired frequency, and no filter should have any effect on your desired channel of reception.

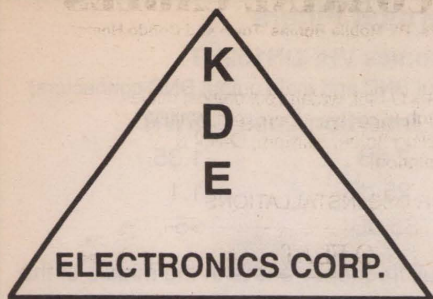
One way to identify whether or not the signal is inside your unit, or a problem outside of your unit, is to switch between several different radio sets and see whether or not they all pick up the same offending signal. If they do, chances are the offending signal may be square on frequency, and you'll need to figure out another way to suppress the problem at THEIR end of the circuit.

But chances are most of the mixing is occurring within your own handheld or mobile unit run off of a base station antenna, and here is where the band-pass filters and the Par notch filter will do their best in suppressing the problem. Par Electronics goes one step further and will handle your technical questions by calling them at their regular 407-586-8278 number during the day. Be prepared with information on what frequencies the offending intermod is coming from, and they will line up a filter that will probably notch out the signals that are causing you the problems.

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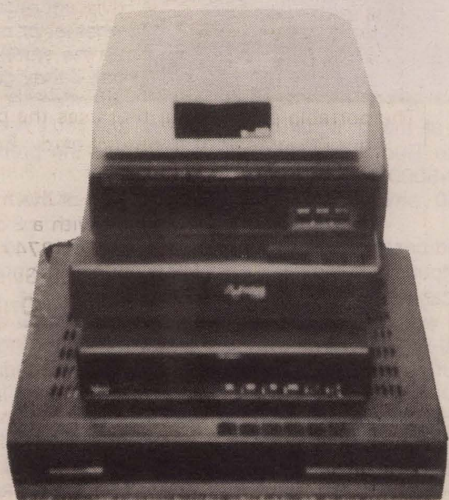
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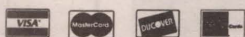


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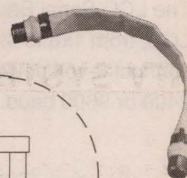
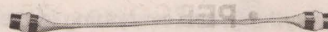
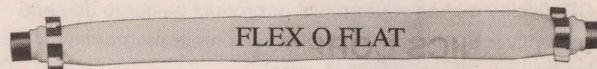
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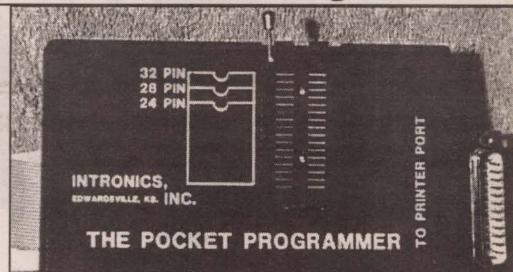
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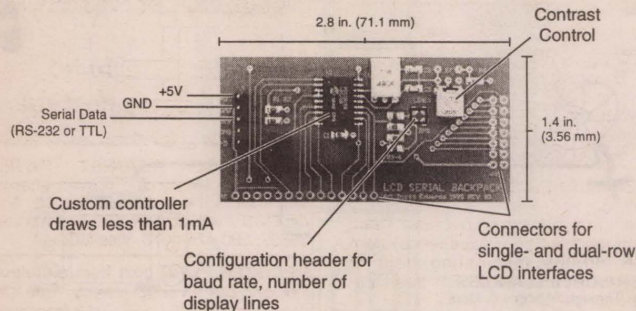


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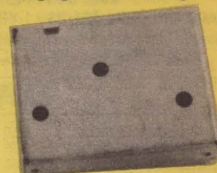
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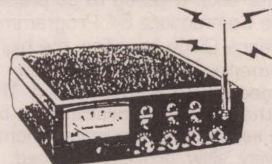
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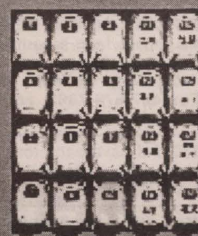


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Continued from page 99

## TECH FORUM

Windows 3.1, but they seem to only work with their scanner adapter card and not with a serial port.

If you have Internet access, you can get more information from the DFI Web site at <http://www.dfiusa.com/> or E-Mail technical support at [support@dfiusa.com](mailto:support@dfiusa.com)

**Doug Smith**  
[dougs@mcs.com](mailto:dougs@mcs.com)

### ANSWER TO #5961 - MAY 1996

I'm sure that there are several terminal operating programs available that would allow you to access the Internet or other BBSs using the Commodore 64 and a modem, but operating speed would be much too slow for such a set-up to be practical. As the Commodore 64 Programmer's Reference Guide specifies, the highest implemented baud rate on the Commodore 64 is 1200 Baud. There are other significant problems to overcome as well, such as limited memory, relatively slow processor speed, and the use of some non-standard ASCII control codes. File compression would be another problem, as most files available on BBSs today are in a compressed format to save time while downloading. You would need to have appropriate software to decompress or restore these files before you could view them. I realize that the Commodore computers have quite a loyal following and are still useful for many tasks, but they just don't have the required resources available for fast and efficient internet cruising.

**Anonymous**

### ANSWER TO #59615 - MAY 1996

Pen plotters are not designed to print color graphics as described in your letter. To print photo-like files you should investigate the different ink-jet printers on the market. Some are specifically designed for this type of printing need.

**Mark Hanz**  
**Houston, TX**

### ANSWER TO #59618 - MAY 1996

It is clear that what you need to do is a low-level format of the hard drive. This is different than the high level format you did on the drives. There are several ways you can accomplish a low-level format. One way is to access a low-level formatting program that is in the BIOS contained on the drive controller card. Assuming your controllers have this onboard BIOS, you can activate this program using the DOS debug command. First boot the computer with a bootable DOS disk (best to use DOS 5 or higher) containing the debug program. Then run debug and at the debug prompt type `g=c800:5`. If this does not start the low-level program, try the following addresses, `c800:6`, `c800:ccc`, `d800:5`, `d800:6`, or `cc00:5`. If none of these work, it probably means that the controller card does not have low-level format routines. An alternative method to do a low-level format is by using certain software programs intended for this purpose. Some of these programs are Microscope by Micro 2000, Ontrack Disk Manager, and Drivepro. There are

also numerous others available for downloading on bulletin board systems. Since most of the Zenith 286s I have seen have Seagate hard drives, I would recommend you call their BBS and download a copy of their low-level format program. You will find other information on Seagate drives there also. Their BBS number is 408-438-8771. Of course, after you do the low-level format, you must then partition the drive using fdisk and then do a normal high-level format.

**Michael Young**  
**Newville, AL**

### ANSWER TO #6961 - JUNE 1996

The TMS 2516 is Texas Instrument's version of the industry standard Intel 2716 EPROM (Electrically Erasable Read-Only Memory). They both hold up to 2048 bytes of information and are electrically and pin compatible. Thus, any manufacturers 2716 EPROM (Intel, Fujitsu, Hitachi, etc.) will work for you provided the speed is less than or equal to 350ns (the speed of your part). Ironically, the only part which you should NOT USE is Texas Instrument's own version of the 2716, the TMS 2716 which requires multiple supply voltages. This should not prove a problem since both of the TMS parts are essentially obsolete whereas the industry standard 2716s are still available.

If you have access to a PROM programmer, the procedure is easy. Simply copy the contents of your original EPROM into the programmer, replace the chip with an erased new EPROM and then copy (burn) the EPROM with the data in the programmer. Note that these parts have no read protection so anyone can read their data. They are only write protected in the sense that a 25 volt level must be supplied to one of its pins in order to program the part. This detail is taken care of by the programmer.

Although this part was a hot item in the mid to late 70s (I built a programmer for them once as a class project!), by today's standards it is physically large for its small memory content, slow to read and program, power hungry, and in the older 6/10-inch wide package. It is not as readily available as it used to be, but can still be found. Some sources are: **B.G. Micro, Inc.**, P.O. Box 280298, Dallas, TX 75228 Phone: **1-800-276-2206**. Also, **Jameco**, 1355 Shoreway Rd., Belmont, CA 94002; Phone: **1-800-831-4242**. You should also check the back of electronics magazines for other sources. The cost should only be at most a few dollars. If you absolutely cannot locate the part, an alternative would be to buy a 2732 EPROM which has twice the memory capacity (i.e., 4 K x 8) and simply transfer your program into both the lower and upper half this part. You will be able to directly plug it into the existing socket. The reason this will work is that pin 21 of the 2716 (which is used for programming) is held at +5 volts during normal operation. On the 2732, pin 21 is the most significant address line. When plugged into your socket, only the upper half of the 2732 EPROM will

ever be addressed thus, executing your program since it has been copied into both halves of the device.

**Jay Rabkin**  
**Pasadena, CA**

### ANSWER TO #6963 - JUNE 1996

The piezoelectric effect is manifest in certain types of ceramic crystals by the following two converse effects. First, when such a crystal is strained or deformed, an electric potential (a voltage) is produced across one or more of the crystal faces. Second, if an electric potential is externally applied across the same crystal, it will change its dimensions. In both cases, the magnitude of the voltage is proportional to the strain and changes sign with it. Not all crystals possess this property. In order for a crystal to be piezoelectric (pressure-electric), there has to be a lack of symmetry such that the centers of positive and negative charge within the crystal do not coincide. Such materials act like permanent electric dipoles with a positive and negative end (analogous to permanent magnets) and are sometimes referred to as electrets. When placed in an electric field, the mutual repulsion/attraction between the field and the dipole polarities accounts for the change in dimension.

A similar dimensional change known as electrostriction occurs in all materials placed in an electric field due to the temporary polarization of the material. However, this deformation is independent of the direction of the applied field and does not change sign with it. In addition, the electrostrictive effect is usually much smaller than the piezoelectric effect. There is also the pyroelectric effect and thermoelectric effect (by which thermocouples operate). Here, voltage potentials are developed by the heating of certain materials or the junctions between dissimilar materials. There are also analogous magnetic and electric interactions possible (the Joule effect, Wiedemann effect, etc.).

Applications include high stability quartz crystal oscillators, crystal microphones, phonograph cartridges, ultrasonic transducers, underwater hydrophones, audio transducers (such as those used in wrist watches), acousto-optical modulators and many others.

Some commonly used piezoelectric materials are quartz, tourmaline, and Rochelle-salt crystals, bariumtitanate and lead-zirconate-titanate ceramics, and ammonium dihydrogen phosphate, and lithium sulfate compounds among others.

Additional information can be obtained from the physics and engineering (materials/ultrasonics/acoustics) sections of university and public libraries and technical book stores. You might also read up on the lives of the Curie brothers who discovered the piezoelectric effect in 1880 and other contemporary researchers such as Lord Kelvin and Coulomb.

**Jay Rabkin**  
**Pasadena, CA**



# Events CALENDAR

continued from page 80

Lot A. 408-734-4453  
**FL - PALM BEACH GARDENS** - Computer Show & Sale. Palm Beach Gardens Marriott. Narisam 1-800-436-6707  
**IL - QUINCY** - Western Illinois ARC Hamfest. Jim Funk 217-336-4191  
**IN - VALPARAISO** - Porter County ARC Hamfest. Rich Ard 219-762-0484  
**KS - CHANUTE** - Hamfest. CAARC. Central Park Pavilion. Jerry 316-431-3268  
**NH - NASHUA** - Computer Show. Rivier College. MarketPro Shows 201-265-1075  
**NJ - HACKENSACK** - Computer Show. FDU/Rothman Center. KGP Productions 908-297-2526  
**NY - DRYDEN** - Tompkins County ARC Finger Lakes Hamfest. Dryden High School. Ross 607-844-4302  
**NY - TROY** - Computer Show. Troy Armory. MarketPro Shows 201-265-1075  
**PA - LEWISTOWN** - Hamfest. Decatur FC Grounds. Juniata Valley ARC & Decatur Township Fire Company. 814-237-1591  
**TN - CROSSVILLE** - Plateau ARC Hamfest. Nicholas Smith 615-484-8220  
**WA - TACOMA** - Tacoma Electronics Fleamarket. Charles Wright Academy. Radio Club of Tacoma. Alan 206-840-4947

## AUGUST 10-11

**LA - BOSSIER CITY** - Shreveport ARA Hamfest. Alice Prudhomme 318-872-9232  
**OH - PAULDING** - Paulding County ARG Hamfest. Paulding Co. Fairgrounds. Jon 419-399-4507

## AUGUST 11

**IA - CEDAR RAPIDS** - Cedar Valley ARC Hamfest. Wayne Kolosik 319-393-4224  
**FL - BOCA RATON** - Computer Show & Sale. Embassy Suites Hotel. Narisam 1-800-436-6707  
**KY - FRANKFORT** - Bluegrass ARS Hamfest. Western Hills High School. Bill DeVore 606-273-8345  
**MA - WEST SPRINGFIELD** - Computer Show. Eastern States Exposition. MarketPro 201-265-1075  
**ME - PORTLAND** - Computer Show. Verrillo's Conv. Center. Northern Computer Shows. 508-744-8440  
**MI - JACKSON** - Jackson Hamfest & Computer Show. Jackson Community College. 517-784-2398  
**NC - CHARLOTTE** - Charlotte ARC Hamfest & Computer Fair. Roll-A-Round Skate Center. Buck 704-522-4971 ext. 3330

## AUGUST 17

**CA - SAN FRANCISCO** - Robert Austin Computer Show. Cow Palace. 1-800-346-0100  
**CA - SANTEE** - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052  
**IN - INDIANAPOLIS** - AGI Computer Fair. Indianapolis Events Center. 317-299-8827  
**IN - WARSAW** - Tailgate Hamfest. Market Place of Warsaw parking lot. Hoosier Lakes Radio Club. Jim 219-839-5203  
**MN - WARROAD** - Hamfest. Warroad Area Community Center. Lake of the Woods Repeater Association. David Landby 218-386-1092  
**NH - SEABROOK** - Computer Show. Seabrook Greyhound Park. Northern Computer Shows. 508-744-8440  
**NJ - OAKLAND** - Ramapo Mountain ARC Ham Radio & Computer Flea Market. American Legion Hall. Steve Oliphant 201-962-4584  
**PA - WASHINGTON** - Computer Show. Ft. Washington Expo Center. KGP Productions 908-297-2526  
**RI - WEST WARWICK** - Computer Show. West Warwick Civic Center. MarketPro Shows 201-265-1075  
**VA - VIRGINIA BEACH** - Computer Show. Independence Hall. Pro Am Shows 804-463-1136  
**WA - LONGVIEW** - Ham Radio, Computer, & Electronic Equipment Swap Meet. Cowlitz County Fairgrounds. Lower Columbia ARA. 360-425-6076  
**WI - SUGAR CAMP** - Rhinelander Repeater Assn. & Northwoods ARES Hamfest. Sugar Camp Town Hall. Mary Berger 715-362-9296

## AUGUST 17-18

**GA - MARIETTA** - ComputerShow. Cobb County Civic Center. Computer Show 770-907-6225  
**NM - ALBUQUERQUE** - Albuquerque ARC Hamfest. Judy Kirby 505-891-9132  
**PA - YORK** - York Hamfest & Computer Show. York Interstate Fairgrounds. 717-751-9675

## AUGUST 18

**CA - GOLETA** - Santa Barbara ARC Hamfest. Marvin Johnston 805-682-1405  
**CO - GOLDEN** - Ham Radio and Computer Hobbyist Swapfest & ARRL State Convention. Jefferson Co. Fairgrounds. Denver Radio Club. 303-674-5389  
**CT - WATERBURY** - Computer Show. Waterbury Sheraton. MarketPro Shows 201-265-1075  
**DE - GEORGETOWN** - Sussex ARA & Delmarva Hamfest Assn. Hamfest. Tom 302-856-2938  
**KS - SALINA** - Central Kansas ARC Hamfest. Bicentennial Center Heritage Hall. Dan 913-263-8540  
**IL - ORLAND PARK** - Orland Park Computer Show.

Civic Center. 24-Hour Hotline 708-974-3123  
**IL - STICKNEY** - DuPage ARC Hamfest & Computer Show. Hawthorne Race Course. 708-985-9256  
**MA - CAMBRIDGE** - Flea Market. MIT. Nick 617-253-3776  
**OH - BROADWAY** - Union County ARC Hamfest. Community Building. Gene Moore 513-246-5943  
**OH - CINCINNATI** - Hamfest. Kolping Center. Greater Cinti ARA. 513-563-7373  
**OH - CLEVELAND** - Computer Show. Holiday Inn. Strongsville. Peter Trapp Shows 607-369-2796  
**OH - WARREN** - Hamfest. Warren ARA. Al VanSlyke 330-889-3378  
**VA - NEWPORT NEWS** - Computer Show. Knights of Columbus Hall. Pro Am Shows 804-463-1136

## AUGUST 19-20-21

**VA - MCLEAN** - Surveillance Expo '96. McLean Hilton. Michael Sheehan 718-437-0160

## AUGUST 23-24-25

**CT - VERNON** - Eastern VHF/UHF Conference. Quality Inn & Conference Center. Mark 413-566-2445

## AUGUST 24

**MA - DEDHAM** - Computer Show. Holiday Inn Dedham. MarketPro Shows 201-265-1075  
**MI - WESTLAND** - Great Lakes Computer Expo. Wayne-Ford Civic Center. 313-416-1015  
**NJ - BRIDGEWATER** - Somerset County ARS Hamfest. 4H Center. Pete 908-429-9093  
**NY - CHAFFEE** - Hamfest. Manion Park. Pioneer Radio Operators Society. Michael 716-496-8241  
**WI - ONALASKA** - Hamfest & Computer Expo. Omni Center. Riverland ARC & Western Wisconsin Radio Collectors Club. Dick Low 608-784-9176  
**WV - JACKSON'S MILL** - Hamfest & ARRL Convention. West Virginia State Amateur Radio Council. Dave 304-462-7560

## AUGUST 24-25

**CO - WOODLAND PARK** - Mountain ARC 15th Annual Campfest. Colorado Lions Campgrounds. Don 719-687-3692.  
**CT - VERNON** - VHF/UHF Conference. Quality Inn & Conference Center. Ron Klimas 860-768-4758  
**NJ - EDISON** - Computer Show. New Jersey Convention & Expo Center. KGP Productions 908-297-2526

## AUGUST 25

**CO - GOLDEN** - Computer Show & Swap Meet. Jefferson County Fairgrounds. Greg 303-444-2664  
**IL - DANVILLE** - Vermillion County ARA Hamfest. Gary Denison 217-759-7389  
**IL - WOODSTOCK** - Tri-County Radio Group Hamfest. McHenry Co. Fairgrounds. 708-658-1678  
**MA - BOXBOROUGH** - Computer Show. Holiday Inn. MarketPro Shows 201-265-1075  
**MI - CORUNNA** - Five County Amateur Radio & Computer Swap & Shop. Shiawassee County Fairgrounds. Bay Area ARC. 517-893-3475  
**NY - YONKERS** - Hamfest/Computerfest. Yonkers Municipal Parking Garage. Yonkers ARC. John Costa 914-963-1021

## AUGUST 31

**NM - ALAMOGORDO** - Alamogordo ARC Hamfest. Larry Moore 505-437-0145  
**WI - HAYWARD** - Namekagon Valley Wireless Assn. Hamfest. Mary Lindberg 715-378-2368

# SEPTEMBER 1996

## SEPTEMBER 1

**CA - LIVERMORE** - Swapmeet. Las Positas College. Noel Anklam 510-447-3857

## SEPTEMBER 7

**FL - POMPANO BEACH** - Computer Show & Sale. Palm-Aire Hotel. Narisam 1-800-436-6707  
**IL - ROLLING MEADOWS** - W9DXCC DX Convention & Banquet. Holiday Inn. 708-343-1696  
**MA - WILMINGTON** - Computer Show. Shriner's. KGP Productions 908-297-2526

## SEPTEMBER 7-8

**KY - LOUISVILLE** - Hamfest, Computer Show, & State Convention. Kentucky Fair & Exposition Center. 812-294-4905

## SEPTEMBER 8

**IA - DUBUQUE** - Hamfest/Radiofest/Computer Expo. Dubuque Co. Fairgrounds. Loren Heber 319-556-5755  
**FL - WEST PALM BEACH** - Computer Show & Sale. Palm Beach Airport Hilton. Narisam 1-800-436-6707  
**OH - FINDLAY** - Hamfest & Computerfest. Hancock County Fairgrounds. 419-423-3402

## SEPTEMBER 13-14-15

**IL - PEORIA** - Superfest 1996, ARRL National Convention. Downtown Peoria Civic Center. Peoria Area Amateur Radio Club. 309-692-3378

# reader FeedBack

Continued from page 5

disks if you gave them to me for free. The best choice, I believe, is a high-capacity tape drive such as Iomega's new Jaz unit. It's one-gigabyte cartridge is a perfect match for my system.

As explained in the article, I use the Zip drive principally for frequent back-ups of selected directories that I am doing development work on. Even these portions of my overall drive will run from 20 to 50 megabyte chunks of program files. I also use the Zip drive, as mentioned, to transfer files larger than one megabyte between my PC and Macintosh, something the Zip drive is ideally suited for.

My best wishes to the writer and my fondest hope that when (not if, but when) his hard drive crashes, his 736 used 25 cent, generic brand floppies do the job of reliably restoring his valuable files before the read head on his disk drive gives out.

**Marvin C. Mallon**  
**West Hills, CA**

Dear Nuts & Volts:

As a longtime computer user, and also a longtime *Nuts & Volts* reader, I'm always looking forward to your computer related columns. I enjoy these columns (in particular, their discussion of the history of machines and software which is always mentioned to some degree).

I'm surprised, however, that with a magazine so oriented to the hobbyist, you've missed perhaps one of the best things to come along in computing in the last several years, and it's even FREE! Like other copylefted GNU software, LINUX is distributed, in part, to better computer users in a somewhat altruistic fashion.

Linux is a full UNIX type operating system with a complete implementation of X-windows, TCP-IP, any language you can call to mind, true pre-emptive multi-tasking, etc. It runs on a 386SX or better, Power PC, DEC Alpha, and other machines. (Uses as little as four megs (try Windows 95 on a four-meg 386SX!!), and now can be installed easily without much real knowledge of UNIX.

Distributions are available for free on the Net (including source code!), or on CD-ROM for under \$20.00!

Let's see Apple, Microsoft, IBM, Be, DEC, or anyone else benefit computing like this, and *Nuts & Volts* hasn't even mentioned LINUX! For shame.

I hope you can squeeze in a LINUX column at some point soon (though I realize that LINUX doesn't buy ads anywhere).

For more information:  
<http://www.linux.org>

**Alan D. Stein**

Dear Nuts & Volts:

Great job on an interesting column ("Electronics Q & A" with TJ Byers). I hope it runs a long time!

I have two comments about the circuit published for the automotive delay action circuit:

1. There is only one connection to the coil of the 12-volt relay. I assume it connects to the +12-volt line, but you know what happens when you assume?  
 2. The zener diode, D2 may be backward, based on your circuit description (okay — I know it is backward, but we all have feelings.) Probably caused by midnight oil dripping on your schematic!

It looks like you will have a lot of fun doing this, if the pesky readers don't pick too many nits! My concern for the accuracy is that some *Nuts & Volts* fans might build some of these circuits and be frustrated when they misbehave.

**Bob Kelly**

Dear TJ Byers:

I saw your nice little Basic program in the Electronics Q & A column of the June '96 issue, and immediately tried it on my IBM Clóne PC. However, it crashes when I enter the port value — undoubtedly because I don't have a game card in my computer. Can you please tell me if I can adapt the program to work with one of the serial ports in my PC, and if so, how do I go about doing it (including the pinout configuration of the serial cable)? P.S. If you are a HAM radio operator, please give me your call-sign. Thanks!

**Tullio/NT2P**

Response:

Was an aspiring HAM at one time, but hated having to work up to the 15 wpm of Morse code required to pass the FCC test when the technology had keyboard encoders and receiver decoders that did all the work for you. However, I extensively pursued the hobby by constructing antennae, building final amps, and designing SSB filters for my neighbor's rig (who had a General license) in exchange for some air time — with him at the helm, of course. I scored more than a few QSLs for him as I scanned the air waves.

As for your serial port project, it can't be done by software alone. You need additional hardware, which the game port provides. But if you look in the same *Nuts & Volts* Magazine June '96 issue, you'll discover an article by me "Understanding and Using A/D Converters" and the "Open Channel" column by Joseph J. Carr (K4IPV) that tells you everything you need to know about interfacing the outside world with your serial port.

**TJ Byers**  
**Q & A Editor**

Dear TJ Byers,

I just read your Electronics Q & A column, and like it. However, you should have put in a little biography of yourself. I have a question about the RF preamp circuit. Is that your design? I am curious only because I am an EE and found it to be somewhat complex for an answer in a column. I know that you would have to spend a good part of a day to calculate the values in the circuit, so I guess that what I want to know is if you did spend the day working on the design or did you recycle a circuit that's near and dear to your heart?

Your other answers are pretty good; you are a practical kind of guy. Keep up the good work, but get rid of the dot matrix printer.

**Steve Jacob**

Response:

Well, I, too, are an engineer (it's an old joke; don't shoot me!). I was among the many engineers who placed Buzz Aldrin on the moon. As for the RF preamp, this particular circuit comes from the pages of an old *Electronic Design* magazine. At first I thought about using one of the Mini-Circuits (718-934-4500) ERA amplifier chips, but their voltages are too restrictive given the application. Hence, the transistor design. Thanks for the kind words. I'll do my best to keep everything at an application level. BTW, it's not a dot matrix printer. It's a screen capture of a CircuitMaker schematic. This is a schematic capture and circuit simulation program that lets me "build" and test circuits without lifting a soldering iron. Maybe if I up the screen resolution another notch, the jaggies will disappear. We'll see.

**TJ Byers**  
**Q & A Editor**



# HOW TO PLACE A CLASSIFIED AD

TYPE or PRINT your **ELECTRONICALLY RELATED** ad copy **CLEARLY** (not all caps) on a separate piece of paper. Spell out words when submitting handwritten copy. Calculate the number of words and multiply it by the appropriate rate (see RATE PER WORD section). Include any charges for bold and/or CAPPED words, any artwork costs that would be applicable, and/or costs for boxing your ad (explained below). Choose the appropriate classification for your ad(s) to appear in (see below). If no classification is indicated, it will be placed in Misc. Electronics or wherever we deem most suitable. **Enclose your name, address, phone number, and Nuts & Volts account number from your mailing label** (if available) for identification purposes. Include full payment — **CLASSIFIEDS RUN ON A PRE-PAID BASIS ONLY** — and mail your completed order to:

**NUTS & VOLTS MAGAZINE**, 430 Princeland Ct., Corona, CA 91719.

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The ad rate for **current PAID subscribers** is **60¢** per word. All others pay **\$1.20** per word. There is a **\$9.00 minimum** charge per ad per insertion.

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You may fax in ad copy or changes before the closing date (5:00pm on the 10th) at 909-371-3052 using MasterCard or Visa. Include credit card expiration date, the name that appears on the card, a daytime phone number, and your *Nuts & Volts* account number. Ads without credit card information will not be listed as received until payment is received in full. **WE DO NOT CALL OR FAX BACK VERIFICATION OR QUOTES OF FAXED-IN ADS.** For verification of faxed-in ads, please call 909-371-8497.

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Prepaid ads received by 5:00pm on the closing date (10th of the month) will appear in the following month's issue. Ads postmarked through the 10th, but received after the closing date, will be placed in the next available issue. No cancellations or changes after the 10th. Cancellations and changes must be submitted in writing.

## IMPORTANT INFORMATION

All classified ads are running copy only. No special positioning, centering, dot leaders, extra space, etc. is allowed. All advertising in *Nuts & Volts* is limited to **electronically related items ONLY**. All ads are subject to approval by the publisher. We reserve the right to reject or edit any ad submitted. We do not take ad copy or changes over the phone. We do not bill for classified ads. Repeat ads or ads run in multiple classifications within the same issue are allowed. Paid subscribers may run ads at the 60¢ rate only through their subscription expiration date. **NO REFUNDS.** Credit only. No credit for typesetting errors will be issued unless you *clearly* print or type your ad copy.

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# Roger's Systems Specialist

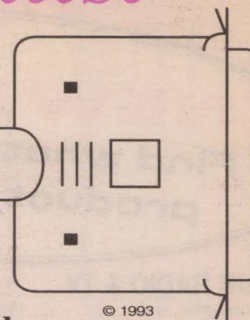
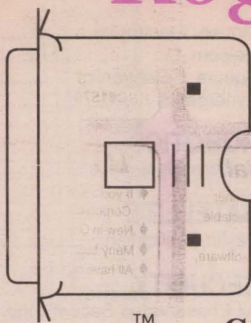
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24 Hour Tech-Support



#TM-291 \$10<sup>00</sup> each  
5pc/\$40  
Refurbished

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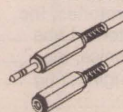
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Stand with double face tape  
Mfg. by Media Vision  
Works on all sound cards!



#TM-MIC-2 \$3<sup>00</sup> 5/\$10

### Mini Stereo Extension

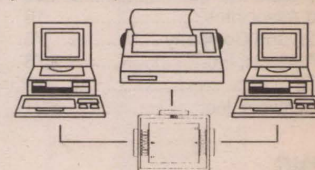
6ft. 3.5 mm male-female



\$1<sup>00</sup> each  
50 & up .75¢  
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### 2 Computers to 1 Parallel Printer

Auto Switch • No external power required  
Easy to install and operate • All DB25 female connections



\$10<sup>00</sup> each 5/\$40.00  
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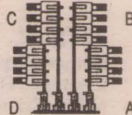
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30 Pin memory can be used in 72 Pin mother Board  
Ideal for all service, repair and upgrade business  
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\$10<sup>00</sup> each

#CA-MEM-A  
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#CA-MEM-C  
#CA-MEM-D



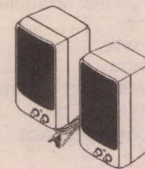
30-30 Pin and 72-72 Pin now available!

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9vdc power required  
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Great with any sound card • Refurbished

Black Case  
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Flexible Microphone  
Fully Adjustable  
Leather Pads  
Quality Built  
8 ft. Cable



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### Stereo Headphones

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10 FT cord super-dynamic  
Mfg. by Recoton

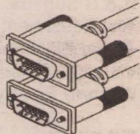


\$4<sup>00</sup> 3/\$10 #TM-170

### H.Q. VGA Cable

10 foot HD15, male to male  
Internal 3-coax type  
Molded-black PVC

#CC-VGA-9C \$5<sup>00</sup>  
Special! Limited Supply!



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Cable for HP Laser and others meets  
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#CC-PRI-1284 \$13<sup>00</sup>

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3' SCSI 1 to SCSI 2

#CC-679 \$18<sup>00</sup>

6' SCSI 1 to SCSI 2

#CC-686 \$24<sup>00</sup>

3' SCSI 2 to SCSI 2

#CC-678 \$24<sup>00</sup>

6' SCSI 2 to SCSI 2

#CC-678-6 \$30<sup>00</sup>

3' DB25 to SCSI 2

#CC-671 \$20<sup>00</sup>

6' DB25 to SCSI 2

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SCSI 3 also available

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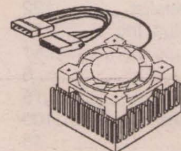
486 CPU #TM-FAN-2 \$6<sup>00</sup>

Pentium CPU #TM-FAN-66 \$7<sup>00</sup>

for 60-60 CPU

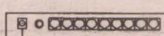
#TM-FAN-90 \$7<sup>00</sup>

for 75-150 CPU



### 10 Base-T Hub

6 RJ-45 Ports BNC Input  
IEEE 802.3 Specification  
MFG. By National Semiconductor



\$79<sup>00</sup> #TM-TBT-HUB6

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386/486/586 102 Key  
Alleviates Carpal Tunnel, two angle height  
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\$4<sup>00</sup> 7ft #TE-068-L5

\$6<sup>00</sup> 14ft #TE-128-L5

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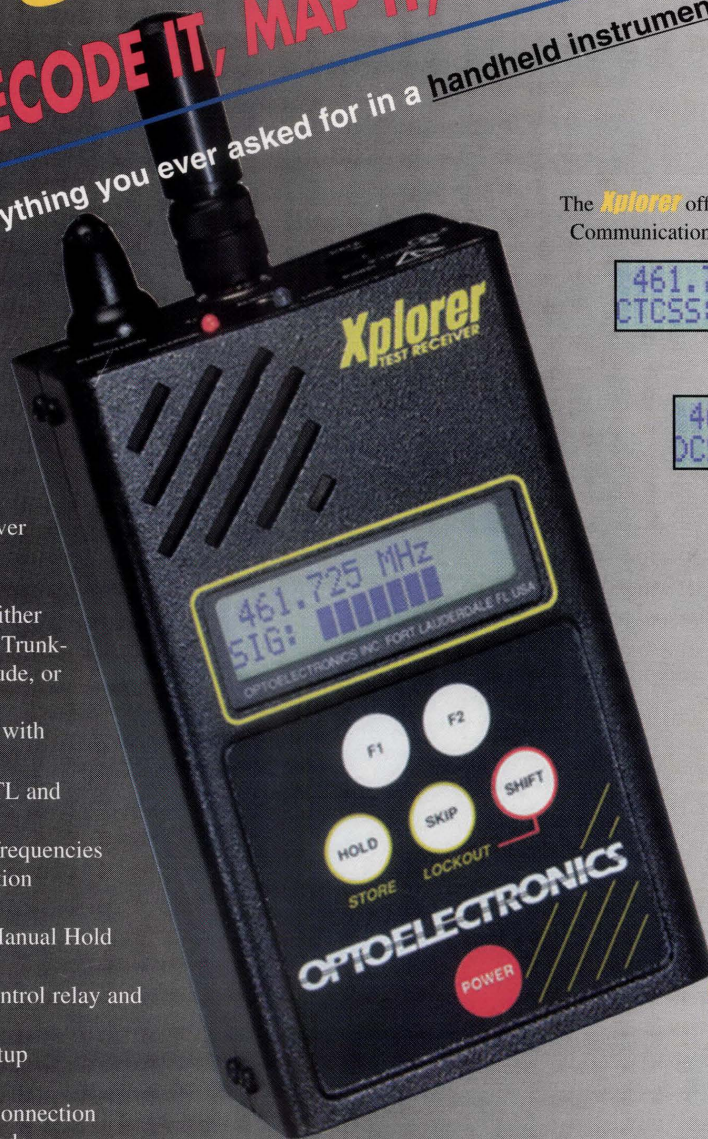
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  - NMEA-0183 GPS Interface provides tagging data with location for mapping applications\*
  - CI-V compliant Serial Data Interface with both TTL and RS232C levels
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  - Real-Time Clock/Calendar with battery back-up
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- \*Software for mapping applications is planned by third party Software Design Companies. Inquire about the availability and specific Companies to contact.



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CTCSS Mode

461.725 MHz  
DCS: 047

DCS Mode

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DTMF Mode

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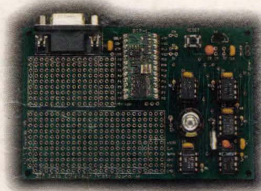
We've been making BASIC Stamps for several years, and we've gathered various photos along the way. In this ad, we thought it might be fun to show some of these photos.



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16 I/O lines  
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50k baud serial I/O  
24-pin DIP module

Same I/O instructions as BS1, plus touch-tones, frequency generation, pulse counting, serial shift registers, X-10 powerline control, etc. I/O functions common to both modules have a higher resolution on the BS2-IC, due to its faster clock speed.



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2000 instructions/sec.  
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Contains items needed to program BASIC Stamp modules; includes cables, PC software, manuals, and free technical support.

**Carrier Boards** **\$15-\$20**  
Provide small prototyping area, 9-volt battery clips, and programming connector. Not absolutely necessary, but recommended to make programming and experimentation easy.

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Charles Walsh and his students in Great Falls, Montana, use BASIC Stamps in robotics projects.



Marvin Green and his students in Hillsboro, Oregon, use BASIC Stamps to make small robots.



John McLean uses BASIC Stamps to gather data in Lechuguilla Cave (America's deepest cave, located in Carlsbad Caverns National Park).




Barry Jones of Tech-Warrior, Inc. (Lanham, Maryland) uses BASIC Stamps to add auto-repeat, LCD readouts, and other features to his paintball rifles.

### BASIC Stamp discussion list on the Net!

The list works like this: lots of people (currently 900) subscribe to the list, and then all questions and answers to the list are distributed to all members. It's a fun, fast, and free way to discuss BASIC Stamp issues.

To subscribe to the list, send email to [majordomo@parallaxinc.com](mailto:majordomo@parallaxinc.com) and write *subscribe stamps* in the body of the message.

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