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by Robert Davis

# A MAGNETIC FIELD MAPPING DEVICE EARTHQUAKE PREDICTOR?

This device may not work. Then again, it might. But until it is tested thoroughly, we will not know if it works or how well it works. My hope is that several of these can be built and installed in several cities across the country. Then, when an earthquake occurs in one of those cities, we will know if this device will work properly or not work at all. If it does work, then a history of various earthquakes will have to be collected in order to be able to accurately predict the time and severity of an upcoming earthquake. This method of predicting earthquakes is based on the following facts.

1. Contrary to what scientists teach, earthquakes ARE predictable. In every case, animals have behaved abnormally for hours to days before an earthquake. In Kobo, Japan, the zoo animals were acting so strange that the zoo keepers took it as an omen that something terrible was about to happen. In other cases, dogs have barked wildly, or pets have simply run away in mass.

Scientists attribute this behavior of animals to what they call "micro tremors." These are believed to be earthquake tremors so small no instrument can measure them, but somehow animals can still detect them.

2. Animals are sensitive to, and can even navigate by, magnetic fields. Stories of long lost animals finding their way home abound. Cats and dogs have found their way back home from thousands of miles away, sometimes from the other side of the country.

In an attempt to understand this ability of animals to find their way, scientists studied sea turtles. They can return to the same beach where they were born 30 years later. How do they find that beach? Scientists discovered that baby sea turtles, when placed in a pool, swam exactly East to West. When a magnet is placed near the pool, they will swim around the magnetic

field.

It is a little known fact that magnetic fields are strongest at the North and South poles and weakest at the equator. If you can sense the strength and direction of magnetic fields, you can navigate by them. (The information on animal navigation is from a PBS special.)

3. Magnetic abnormalities exist around fault lines and the edges of tectonic plates.

These are believed to be "fixed" and thought to not change. Scientists attribute them to iron ore that settled when the North to South magnetic field was pointed in a different direction, or before the tectonic plate rotated from its original axis.

My belief is that they are caused by rocks like quartz that produce electricity when put under pressure. This electricity, when it flows through minerals and water, produces a magnetic field. This field aligns iron ore, etc., to match the abnormal field. Quartz only produces brief currents when the pres-

sure on it changes so it might appear as pulses of abnormal magnetic fields. That would explain the confusion of animals if they navigate magnetically.

## OPERATION

To operate, the sensor is pointed North, then rotated from down to East to up to West.

A stepper motor performs the operation of rotating the sensor and stops several times along the way for the computer to record the field strength. The stepper motor is from an old 5-1/4 inch floppy drive.

The magnetic field sensor is glued on one end of a three-inch piece of plastic. The other end is screwed into the wheel on the stepper motor's shaft. The sensor is powered from positive and negative five volts so that if there is no magnetic field, the output will be close to zero volts. The regulators must be fairly accurate so the output will stay close to zero volts.

Magnetic field strength is measured using a 12-bit analog-to-digi-

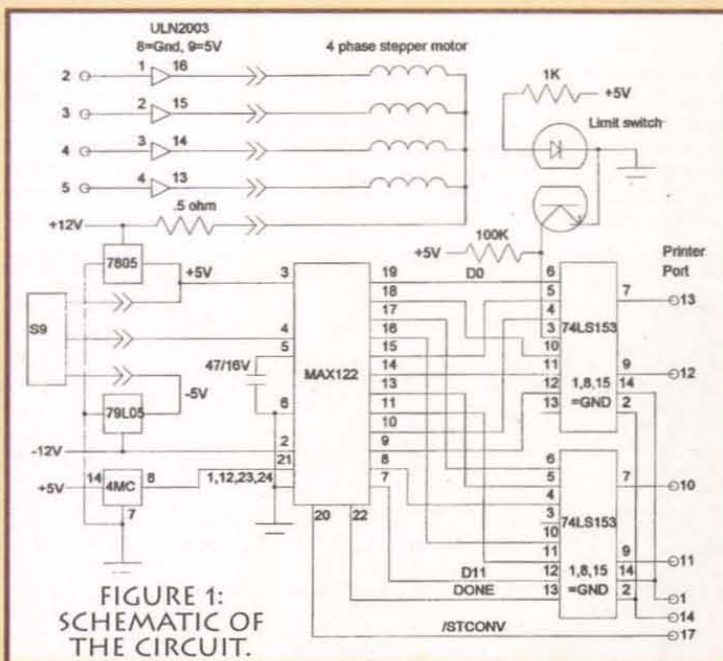


FIGURE 1:  
SCHEMATIC OF  
THE CIRCUIT.



# EARTHQUAKE PREDICTOR?

**Below is the latest update to the software.** It now can run automatically every hour and save the results to the hard drive. This program works well on an IBM 486 Thinkpad. The screen and hard drive shut off so only the CPU keeps running. Make sure the CPU does not go into "suspend" mode or the program will not run except for the very first time.

Another improvement is to add three 2.2K resistors from the printer port pins 1, 14, and 17 to the regulated five-volt power supply. This change will reduce noise when you are using a longer printer cable.

Also not mentioned in the schematic or text is the color code for the used Teac stepper motor. The Brown lead is the 12-volt power source. The color of the four wires for the phases are from top to bottom yellow, red, blue, and white.

I don't remember if I mentioned it in the text but the variable "waittime" must be set according to the processor speed. If it is too small, the motor won't move. If it is too large, the stepper doesn't move smoothly.

```
CLS : PRINT "Magnetic Field Mapper, Copyright 1999 By Robert J Davis"
PRINT "Output readings are in milligauss use maximum-minimum / 2"
INPUT "Use Printer Port Number: ", LPT
dout = &H378: cout = &H37A: cin = &H379
IF LPT = 1 THEN dout = &H3BC: cout = &H3BE: cin = &H3BD
IF LPT = 3 THEN dout = &H278: cout = &H27A: cin = &H279
mhour$ = MID$(TIMES$, 1, 2)
DIM mfield(99)
```

```
start:
hour$ = MID$(TIMES$, 1, 2)
IF hour$ = mhour$ AND cycle = 1 THEN GOTO start
cycle = cycle + 1
IF cycle > 2 THEN cycle = 0
mhour$ = hour$
```

```
max1 = -999: max2 = -999 'use for negative numbers
max3 = -999: max4 = -999 'use for negative numbers
min1 = 0: min2 = 0: min3 = 0: min4 = 0
waittime = 42 '486 - 25 speed
Findstop:
OUT cout, 0
FOR b = 0 TO 3
    OUT dout, 2 ^ b
    IF (INP(cin) \ 16) MOD 2 = 1 THEN GOTO getforward
    FOR A = 1 TO waittime: NEXT A
NEXT b
GOTO Findstop
```

```
getforward:
FOR c = 1 TO 16
```

```
getinput1:
OUT cout, 8
OUT cout, 3: value1 = (INP(cin) XOR &H80) \ 16
OUT cout, 2: value2 = (INP(cin) XOR &H80) \ 16
OUT cout, 1: value3 = (INP(cin) XOR &H80) \ 16
tvalue1 = value1 + (16 * value2) + (256 * value3)
IF tvalue1 > 2048 THEN tvalue1 = tvalue1 - 4096
LOCATE c + 3, 1: PRINT tvalue1
IF max1 < tvalue1 THEN max1 = tvalue1
IF min1 > tvalue1 THEN min1 = tvalue1
mfield(c) = tvalue1
```

```
getinput3:
OUT cout, 8
OUT cout, 3: value1 = (INP(cin) XOR &H80) \ 16
OUT cout, 2: value2 = (INP(cin) XOR &H80) \ 16
OUT cout, 1: value3 = (INP(cin) XOR &H80) \ 16
tvalue3 = value1 + (16 * value2) + (256 * value3)
IF tvalue3 > 2048 THEN tvalue3 = tvalue3 - 4096
LOCATE c + 3, 20: PRINT tvalue3
IF max3 < tvalue3 THEN max3 = tvalue3
IF min3 > tvalue3 THEN min3 = tvalue3
mfield(c + 40) = tvalue3
```

```
counterclockwise:
FOR d = 1 TO 3
    FOR b = 3 TO 0 STEP -1
        OUT dout, 2 ^ b
        FOR A = 1 TO waittime: NEXT A
    NEXT b
NEXT d
NEXT c
```

```
getreverse:
FOR c = 1 TO 16
```

```
clockwise:
FOR d = 1 TO 3
    FOR b = 0 TO 3
        OUT dout, 2 ^ b
        FOR A = 1 TO waittime: NEXT A
```

```
NEXT b
NEXT d
```

```
getinput2:
OUT cout, 8
OUT cout, 3: value1 = (INP(cin) XOR &H80) \ 16
OUT cout, 2: value2 = (INP(cin) XOR &H80) \ 16
OUT cout, 1: value3 = (INP(cin) XOR &H80) \ 16
tvalue2 = value1 + (16 * value2) + (256 * value3)
IF tvalue2 > 2048 THEN tvalue2 = tvalue2 - 4096
LOCATE 20 - c, 10: PRINT tvalue2
IF max2 < tvalue2 THEN max2 = tvalue2
IF min2 > tvalue2 THEN min2 = tvalue2
mfield(c + 20) = tvalue2
```

```
getinput4:
OUT cout, 8
OUT cout, 3: value1 = (INP(cin) XOR &H80) \ 16
OUT cout, 2: value2 = (INP(cin) XOR &H80) \ 16
OUT cout, 1: value3 = (INP(cin) XOR &H80) \ 16
tvalue4 = value1 + (16 * value2) + (256 * value3)
IF tvalue4 > 2048 THEN tvalue4 = tvalue4 - 4096
LOCATE 20 - c, 30: PRINT tvalue4
IF max4 < tvalue4 THEN max4 = tvalue4
IF min4 > tvalue4 THEN min4 = tvalue4
mfield(c + 60) = tvalue4
NEXT c
```

```
Park:
FOR d = 1 TO 27
    FOR b = 3 TO 0 STEP -1
        OUT dout, 2 ^ b
        FOR A = 1 TO waittime: NEXT A
    NEXT b
NEXT d
OUT cout, 0 'shut off stepper
```

```
display:
LOCATE 9, 40: PRINT "Scan1 Scan2 Scan3 Scan4 Average"
LOCATE 10, 40: PRINT max1 - min1
LOCATE 10, 46: PRINT max2 - min2
LOCATE 10, 52: PRINT max3 - min3
LOCATE 10, 58: PRINT max4 - min4
LOCATE 10, 64: PRINT (max1 - min1 + max2 - min2 + max3 - min3 +
    max4 - min4)
/ 4
Save:
mfile$ = "c:" + MID$(DATES$, 7, 4) + MID$(DATES$, 1, 2) + MID$(DATES$,
    4, 2)
OPEN mfile$ FOR APPEND AS #1
FOR c = 1 TO 16
    PRINT #1, mfield(c);
NEXT c
PRINT #1, " "
FOR c = 21 TO 36
    PRINT #1, mfield(c);
NEXT c
PRINT #1, " "
FOR c = 41 TO 56
    PRINT #1, mfield(c);
NEXT c
PRINT #1, " "
FOR c = 61 TO 76
    PRINT #1, mfield(c);
NEXT c
PRINT #1, " "
PRINT #1, "Range", max1 - min1, max2 - min2, max3 - min3, max4 -
    min4
PRINT #1, TIMES
CLOSE #1
```

```
GOTO start
END
```



# EARTHQUAKE PREDICTOR?

tal converter. The converter has a range of positive to negative five volts, so it can measure any field the sensor can detect. The sensor is 25 millivolt per Gauss or .025 volts per Gauss. If 2048 is 5 volts and -2048 is -5 volts, then the smallest measurable voltage is 5V/2048 or .0025 volts. If my math is correct, that would then correspond to a field of .1 Gauss.

An optical switch from the track zero stop of an old 5-1/4 inch floppy disk drive is used to sense when the sensor is pointed down. A nail is glued into the slot on the back side of the stepper pointed so that it interrupts the optical switch when the sensor is pointed down.

The program always starts by rotating the sensor and looking for a signal from the optical switch to say that the sensor is in the down position. It then takes a sample of the field strength. Since we are collecting 12 bits, four bits at a time, this will take three, four-bit inputs to get all 12 bits of data. The result is then checked to see if it is a new minimum or maximum field strength and, if it is, it is stored for future reference. After two samples at each position, the sensor is then

rotated back for two more samples at each position.

Once a pass is completed, the sensor is parked in the up position, and the final results are tallied and displayed. The difference between the minimum and maximum from each pass is displayed and the average of the four passes is computed. Even then, I run three or four cycles because the results vary with each cycle. Eventually, I hope to add software to automatically run the program every hour for 24 cycles a day.

The software is available for downloading at my web site located at [www.elim.edu/tech](http://www.elim.edu/tech). The magnetic field mapping device program listing is in Quick Basic.

## CONSTRUCTION

Everything is mounted on a piece of plastic about 12 inches by four inches in size. I used some surplus red plastic, but any insulating material would suffice. The stepper motor is mounted with the bracket that held it into the disk drive. Some one-inch metal spacers are used to mount it up higher. The circuit board is mounted with similar spac-

ers. The stop sensor on the back of the stepper motor is glued on.

The magnetic field sensor is a Hall-Effect sensor made by Micro Switch. It is available from Newark Electronics for about \$15.00 each. The part number is SS94A1F; it was chosen for its higher sensitivity of 25 mV/Gauss. The Hall-Effect sensor is glued onto the end of the plastic piece of wire mold with the components facing up. The pin connections are from left to right, positive power, output, and negative power. An extra long wire is used to allow room for it to rotate freely.

The power supply is an AC adapter with positive and negative 12 volts outputs. I cut off the connector that came with the adapter and used a binding post to connect it to the circuit board.

A 26-pin header connector is used to connect a ribbon cable about two foot long to a 25-pin male connector that plugs into the printer port of a laptop computer. A desktop computer may not work as well as it will generate magnetic fields that might interfere

with the operation of the detector. A solution there might be to use a five-foot, 25-pin extension cable.

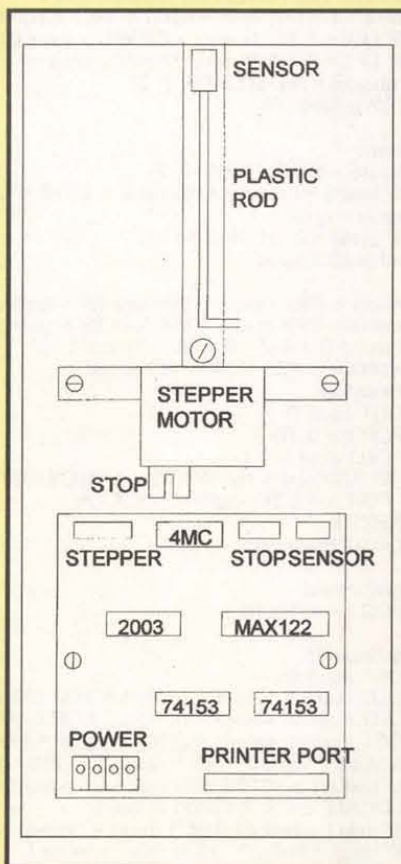
Not shown on the schematic, but very necessary for proper operation, are filter capacitors on the inputs and outputs of the voltage regulators. Also filter capacitors are needed on the ICs, especially on the MAX122 analog-to-digital converter's power and ground pins. **NV**

- 1 SS94A1F Analog position sensor
- 1 MAX122BCNG-ND 12-bit A-to-D converter
- 1 4-phase stepper motor
- 1 Optical switch
- 1 ULN2003 Darlington driver
- 2 74LS153 dual 4-to-1 multiplexer
- 1 7805 5-volt regulator
- 1 79L05 -5 volt regulator
- 1 26-pin header
- 1 4MC crystal oscillator
- 5 IC sockets
- 1 Positive and negative 12-volt AC adapter
- 1 26-pin header socket to 25-pin male cable
- 1 3-inch by 3-inch pad per hole circuit board
- 1 Various resistors and capacitors

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## PARTS LIST

FIGURE 2: PARTS LAYOUT DRAWING.



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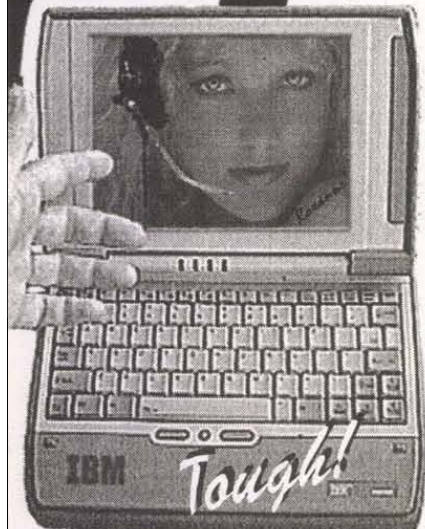
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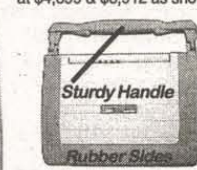
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### Dear Nuts & Volts:

Thanks for the complimentary Feb. 2000 issue. The first thing I read was the Tech Forum answers to #1007 on page 86.

Far be it from me to discourage anyone from learning DOS. DOS, UNIX, and LINUX are where it's at. Navigating the multi-layers of Windows for the Internet and such uses is one thing; working to understand computers is another.

Yes, Windows 95 has DOS 7 behind it as one can see by reading the COMMAND.COM file. About 1/3 of the way into that file, appears "MS-DOS Version 7." One who is proficient in DOS knows how to read that file.

The easiest way is to get Vernon Buerg's LIST utility. Write him at 139 White Oak Circle, Petaluma, CA 94952. (Tell him Homer Tilton and Nuts & Volts sent you!)

Another way is to use DEBUG with its (S)earch command. See the procedure on page 2.

Here's a little known but highly useful technique that works with MS-DOS versions 3.2 to 7.1, and maybe on future versions as well: You can use GWBASIC right at the DOS prompt just as if COMMAND.COM had a mathematical capability. If you have Microsoft GWBASIC.EXE archived from DOS 3.30 (not Tandy GWBASIC), dig it out and try this DOS command on a DOS or Windows 95 or 98 PC:

Echo ?2+2,3\*3,4^4|GWBASIC

(First, use the "Restart in MS-DOS" shutdown option.) That not

only returns the answers to "What is 2 plus 2, 3 times 3, and 4 raised to the 4th power?" It also brings back the DOS prompt in preparation for your next DOS command. This kind of command can also be used in batch files. (If you use batch replaceable parameters %1, %2, etc., DOS will make the substitutions you give it as command parameters before it sends the instructions on to BASIC. Wow!)

No other flavor of BASIC is "smart" in that way. The method, accidentally discovered by Dave Bushong just before QBASIC was introduced, has become overlooked and lost. It seems Microsoft is totally unaware of it; indeed in *The MS-DOS Encyclopedia* — a Microsoft publication — they claim on page 759 that "the pipe symbol (|) ... and any characters following it are ignored" in an Echo command!

The DOS "bible" is still Paul Somerson's 1988 1200-plus page tome, *DOS Power Tools* from Bantam Books, ISBN 0-553-34526-5.

Homer B. Tilton  
Tucson, AZ

### Dear Nuts & Volts:

Nuts & Volts readers seeing an item in the March Reader Feedback column, page 12, may be greatly misled by figures given there.

In the Reader Feedback column, Dave Bunting writes into Evert Fruitman about LEDs, claiming they're inefficient light sources.

Bunting states that LEDs are rated in microcandelas and using this assumption gives numbers showing LEDs are worse light sources than fluorescents or even

tungsten lamps.

Unfortunately, in interpreting component ratings, Mr. Bunting or his quoted engineering brother may have made a very large error, confusing MICROcandelas with MILLicandelas. This introduces a 1000x error, which is huge.

Many white light LEDs, such as HPs, are rated at 2000 mcd (millicandelas NOT microcandelas) or 2 candlepower, and this output is at 20 mA, or about 0.06 watt! It is thus quite possible to produce a lot of light with high energy efficiency: 33 candlepower per watt.

I suggest readers not be put off to LED usage because of this accidental misinterpretation. I've used these LEDs, and they are astoundingly bright, yet use very little power.

For sample information, see: <http://www.semiconductortor.agilent.com/news/pr/15mar99.html>

Bert Koehler  
via Internet

### Dear Nuts & Volts:

Regarding Fred Blechman's March '00 "Build A Telephone-Busy Lite," to extend battery life, replace the LED with a flashing LED.

Look in All Electronics catalog, part #LED-60 works well.

Roger Flaten  
via Internet

### Dear Nuts & Volts:

The "Telephone-Busy Lite" project in your March issue is seriously flawed. It does not meet the FCC Type 68 telephone interface requirements, and the circuit design

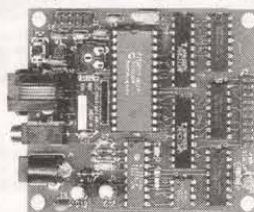
Continued on page 72

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# Digital dB Using the BASIC Stamp II: kup Table Approach

## All Signals Great and Small

A solution adopted in some instruments to this dynamic range problem is to change the scale or range according to the instantaneous magnitude of the signal. But this can be inconvenient and, even if automatic (i.e., "autoranging"), may not be fast enough. And the action at the low end of any scale is much less visible than the action at the high end.

Sound levels are conventionally expressed in terms of dB, because the dB scale is a better match to the human perception of sound intensity. Analog sound meters often display on multi-range non-linear dB scales. Audio "VU meter" (volume unit) scales are actually special dB scales. Radio-frequency signals are commonly converted to a dB scale. The logarithmic transformation can be usefully applied to DC values, as well as AC, even though the result may not usually be termed "dB."

perceived effect on the photograph than would exposure time. One "f-stop" amounts to a 2x change in exposure or 6 dB (at 20 dB/decade). An example from chemistry is the "pH" unit; a one-unit change in pH amounts to a 10x change in ion concentration or 20 dB.

This project's objective is to logarithmically transform an input DC voltage signal, with an input range of a few millivolts to a few volts. The input may come from any source, and may represent a physical variable such as those mentioned above, or may simply be a circuit voltage with a wide dynamic range.

The BASIC Stamp II (BS2) module, by Parallax, Inc., includes a microcontroller and EEPROM memory on a small circuit board. It is pro-

real-time gain control to deliver a high-level positive voltage signal. In the amplifier stage, one of four feedback gains is selected by the BS2 such that the amplifier output is at a reasonably high level, without saturating.

The amplifier output is input to A/D converter ADC0804, whose eight output pins are connected to the BS2. Then the PBASIC program digitally transforms the A/D output to a logarithmic or scaled dB form.

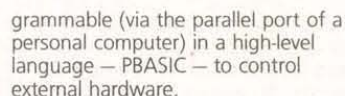
At this point, we have a scaled dB result (0-255) in digital form. It can be monitored on the host computer screen using the "debug" feature of the B52. To avoid tying up a computer, an LCD display could be interfaced to display the 0-255 result, or the rescaled 0-60 dB value. However, we have chosen to convert to analog form using the pulse-width modulation (PWM) instruction and

### Scaled dB Equation

Mathematically, the logarithmic dB transformation accomplished by the BS2 circuit is given by

$$V_{out} = 20 \cdot \log_{10}(1000 \cdot V_{in}/V_{max}) \cdot (V_{hi}/60)$$

The factor  $(V_{hi}/60)$  scales the 60 dB range to the "high" level on the BS2 output pin (a few millivolts below V<sub>DD</sub>). Otherwise, the equation above is the conventional way of transforming voltage levels to dB. The zero-dB reference point is  $V_{max}/1000$ . Note the relationship of 20 dB per decade (factor of 10), which is conventional for voltage dB



just a single I/O pin, along with a low-pass filter. The one-byte dB result sets the duty-cycle of the PWM signal on the output pin. The RC filter smoothes the PWM signal, yielding the final scaled analog dB output voltage. The output of the RC filter can be connected to an

conversion. Conversion of power level to dB uses 10 dB per decade of power. There is no inconsistency since power goes as the square of voltage, i.e., a 10x change in voltage corresponds to a 100x change in power — 20 dB either way.

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```

Title: Digital dB Converter
File Name: db60.bs2
Range: 60dB (3.0 decades)
Resolution: 255 counts/60 dB = 4.25 counts/dB
Hardware: Basic Stamp II + op amp + A/D + analog mux
Four selectable op amp gains in 5.623:1 ratio
Author: Allen Rushing, arushing@rochester.rr.com
        429 Tara Lane
        Webster, NY 14580
Copyright(c) Allen Rushing (This work is unpublished.)
LUT00 data @0,0,0,1,2,3,4,5,6,6,7,8,8,9,10,10,11,11,12,13
LUT01 data @20,13,14,14,15,15,16,16,17,17,18,18,19,19,20,20,21,21,22,22,23
LUT02 data @40,23,23,24,24,25,25,26,26,27,27,28,28,29,29,30,30,30
LUT03 data @60,31,31,32,32,33,33,33,34,34,34,35,35,35,36,36,36,37,37
LUT04 data @80,37,38,38,38,39,39,39,40,40,40,40,41,41,41,41,42,42,42,42
LUT05 data @100,43,43,43,44,44,44,44,45,45,45,46,46,46,46,47,47,47,47
LUT06 data @120,47,48,48,48,49,49,49,49,50,50,50,50,51,51,51,51,52
LUT07 data @140,52,52,52,53,53,53,53,54,54,54,54,55,55,55,55,56
LUT08 data @160,56,56,56,56,57,57,57,57,58,58,58,58,59,59,59,59,60
LUT09 data @180,59,59,59,60,60,60,60,61,61,61,61,61,62,62,62,62
LUT10 data @200,62,62,62,63,63,63,63,64
db var byte '0-255 scaled decibel conversion of the input
delt var byte 'the db increment according to gain
k var word 'counter
ADC var int 'A/D output byte, connected to BS2 P0(lsb) to P7(msb)
code var out 'code (0-3) to select the op amp gain
dir1=%00000000 'low byte I/O pins (P0-7) receive A/D count as input
dirh=%00000111 'P8-9 for gain code output to DG408; P10 for PWM output
'code outputs gain code to switch: 0,1,2,3 for
'nominal gains of 178, 31.6, 5.62, 1.00, respectively.
'Initialize gain code; start with smallest gain (code=3)
code=3
k=0
again:

```

```

' pause 500
'slow down to view debug; remove pause for
'PWM
' if k=10000 then timeout
' k=k+1
if ADC=255 then gmin_test 'A/D saturated?
if ADC<45 then gmax_test 'A/D count too low?
'read scaled dB from the LUT; then add delt according to gain
read ADC-45, db
lookup code,[0,64,128,192],delt 'lookup the increment
db=db+delt 'db byte (0-255)
pwm 10,db,5 'DAC by pulse-width-modulated pin 10; 5 cycles
debug ? code, ? ADC, ? db, CR 'show the gain code & scaled db
'enable this debug slows down the update
'rate
goto again 'loop endlessly
gmin_test: 'is the gain minimum?
if code=3 then range_hi 'input is too big
code=code+1 'increment code to decrease gain
goto again 'loop endlessly
gmax_test: 'is the gain maximum?
if code=0 then range_lo 'input is too small
code=code-1 'decrement code to increase gain
goto again 'loop endlessly
range_hi: 'error message:
debug "input too big", CR 'input too big-saturated at min gain; db>255
goto again 'loop endlessly
range_lo: 'error message:
debug "input too small", CR 'input too small for the LUT; db < 0
goto again 'loop endlessly
timeout:
debug ? k
end

```

set by the minimum gain of the op-amp stage (1x in the circuit shown), times the span of the A/D converter (set to be V<sub>hi</sub> by the Vref/2 adjustment). The V<sub>max</sub> input yields an output of 60 dB, which we scaled to V<sub>out</sub> = 4.85V for a nominal five-volt BS2 supply voltage. For inputs equal to or less than V<sub>in</sub> = V<sub>max</sub>/1000 (4.85 mV), the output V<sub>out</sub> = 0.

The logarithmic slope is therefore ~81 mV/dB or 1.617 V/decade. Equal V<sub>out</sub> increments correspond to equal dB and equal percentage changes of V<sub>in</sub>. A 50% increase of a 10 mV input is just as visible as a 50% increase of a 1V input! Both are 3.5 dB increases, or 3.5\*(4.85/60) = 283 mV increases in V<sub>out</sub> for the circuit shown.

## Circuit and Program Details

Since the BS2 has plenty of I/O pins, an eight-bit parallel output A/D is used. This permits a simpler PBA-SIC program and faster execution speed, compared to using a serial output A/D. The span adjustment — Vref/2 — is adjusted to be V<sub>hi</sub>/2. This assures that the A/D output code = 255 when the A/D input = V<sub>hi</sub> (~4.85 V) of the BS2.

In the circuit shown, Vref/2 is left alone after this adjustment. In a variation from the circuit shown, Vref/2 could be adjusted automatically by the BS2 and a D/A converter. This adjustment would effectively control the gain, and would be an alternative to the op-amp with the four gain resistors. But that is another project. In any case, the eight-bit A/D output is fed in parallel to INL (the pre-defined byte name for BS2 input pins P0-P7).

The circuit's range is 60 dB (1000:1 dynamic range). With the eight-bit output, we get 60/255 = .235 dB resolution (~2.7% of V<sub>in</sub>). The range is determined by the four op-amp gains. The range could be extended to smaller inputs by using larger resistance for higher gain. But be careful that noise and offset error don't dominate the smallest inputs! And the resolution will worsen, since the eight-bit output is spread over the larger range.

For V<sub>in</sub> > 4.85V, add a voltage divider ahead of the op-amp to avoid saturation. Bear in mind that this increases the zero-dB reference voltage by the same factor as the voltage division.

In selecting the op-amp gain values to cover the 3.0 decade (60 dB) range, considerations of resolution and resistor count must be balanced. We want a design that avoids skipping any of the 256 codes of the eight-bit output scaled dB. For any given gain, the log or dB output resolution worsens as V<sub>in</sub>

decreases. A single count at the low end of the A/D range represents a larger percentage (or dB) increment than a single count at the high end. To preserve resolution for a decreasing V<sub>in</sub>, we must switch to the next-higher gain resistor before a dB output code value is skipped.

The next-higher gain resistor should be sized such that, at the switching point, the amplifier output is just below saturation. But don't switch too soon because that will require additional precision resistors to span the 3.0 decades. Four gain values in a 5.62:1 ratio, one-to-the-next, will do the job. In the non-inverting op-amp configuration shown, the gain is ideally related to the resistor values by

$$\text{Gain} = 1 + R_1/R_2$$

The DG408 analog switch selects R<sub>1</sub> to be 0, 22.6k, 154k, or 887k. Resistance R<sub>2</sub> is 4.75k in series with 68 ohms = 4.82k.

The op-amp is a precision single-power supply type (AD822) capable of driving the output close to the 0-5V power supply limits, i.e., "rail-to-rail." The resistors around the op-amp are standard 1% values.

The standard values shown are the ones that came closest — in testing one particular set of components — to giving the target 5.62:1 gain ratios, after accounting for R<sub>on</sub> in the analog switch (~100 ohms). The result is eight-bit resolution over the 3.0 decades (60 dB) of V<sub>in</sub>, with no skipped codes in the 0-255 scaled dB output.

Within the BS2, the A/D output byte forms the address for entering a table of scaled logarithms. The table is created and stored in EEPROM at compile-time by the DATA statements. The table values are derived assuming the nominal maximum gain is the actual maximum gain. This is the reason for the 1% tolerance on the input resistor and

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To form the scaled dB output byte (0 to 255), the log table output is augmented according to the op-amp gain (15 dB added for every step down in gain from the maximum gain, or 64 counts in the 0-255 scaled dB values). This operation assumes that all the actual gains equal the nominal gains, and is the reason for the 1% tolerance on the other feedback resistors.

When monitoring the dB analog output, use a high input-impedance ( $>10$  megohm) scope or meter to avoid loading the RC filter and introducing significant error. Or buffer the RC filter output with an op-amp follower.

## Performance Limitations and Extensions

The input voltage should be DC or low-frequency AC, since the BS2 program loops and updates the output roughly every 10 mS. This update time is greatly increased if the digital dB is sent to the computer using "debug" or to an LCD. The PWM instruction, set for five cycles, accounts for about 5 mS of the update time. The update time defines the response speed of the digital dB conversion to a changing Vin. A further limitation on the analog output is the RC filter time constant of 10 mS. After a step change in the digital dB byte, several five-cycle PWM instructions are required to drive the RC filter to steady-state.

Where response speed is not an issue, analog output stability can be improved by increasing the capacitance in the RC filter. A longer RC time-constant essentially averages a larger number of digital updates. A bigger capacitor can also reduce the PWM charge-discharge amplitude if the load resistance is  $<10$  megohm and there is a long update time during which the charge decays (e.g., because "debug" is in use).

The BS2 approach will be too slow for those applications requiring the speed of an analog logarithmic amplifier. But the BS2 circuit has reasonable accuracy as long as the input is not too small, and the flexibility for enhanced programmed features. For example, the program could be extended to compute the dB difference from a variable reference value, store a string of dB conversions for later output or review, check for alarm conditions, compute averages, max, min, etc. This flexibility opens the door to putting more "smarts" close to the signal source, rather than in the host instrument or computer.

Other possibilities involve multiplexed input channels handled by a single STAMP, with the STAMP computing channel differences, or other multivariable statistics.

BS1 Stampers who try adapting the digital dB application to the BS1 will face challenges: eight I/O pins rather than 16, and only 256 bytes of program memory rather than 2048. A serial A/D would reduce the

I/O pins needed for the A/D. But the extra EEPROM needed to store the 211-byte LUT would require two or three more I/O pins. Performance compromises seem certain — in range, or resolution, or speed. But we are always surprised at what clever Stampers can do with limited resources!

Let us conclude with a more general point. The digital dB application demonstrates the use of a lookup table in a microcontroller, a technique adaptable for any arbitrary conversion of scale. The LUT approach is particularly appealing for nonlinear conversions, such as the logarithmic, or trigonometric, or non-linear sensor outputs, because the corresponding mathematical equation may be difficult to program, or may even be non-existent.

NV

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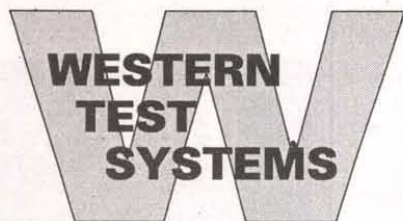
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2. Direct CAP code entry of the 7 digit numeric address, send any numeric or alphanumeric message, up to 16 characters.
3. The POCSAG baud rate: 512, 1200, 2400 can be selected.
4. Single or continuous transmit select, this will send the message out once, or continuous for testing and troubleshooting receivers and Pagers or PDRs. Also send out Preamble only, once or continuous.
5. Battery operation, or wall adapter for in-house operation.

## ZMI ENGINEERING

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## OSCILLOSCOPES & ACCESSORIES

### OSCILLOSCOPES

TEK 2445 150 MHz 4-channel Oscilloscope	\$950.00
TEK 2465 300 MHz 4-channel Oscilloscope	\$1,500.00
TEK 7104 1 GHz 2-Channel Oscilloscope, w/7A29,7A29-04,7B10,7B15	\$2,000.00
TEK 7844 400 MHz Dual Beam Oscilloscope with 7A24,7A26,7B80,7B85	\$750.00
TEK 7904 500 MHz Oscilloscope, with 7A24, 7A26, 7B80, 7B85	\$750.00

### PROBES

HP 1122A Probe Power Supply	\$150.00
TEK 1101 Accessory Power Supply, for FET probes	\$175.00
TEK A6901 Ground Isolation Monitor	\$150.00
TEK A6902B Voltage Isolator, DC-20 MHz, 20 mV-500 V/div	\$500.00
TEK P6046 100 MHz Differential Probe	\$400.00
TEK P6101A pair 1X 34 MHz Probe pair, 10 Megohm/32pF, new in plastic	\$50.00
TEK P6201 900 MHz 1X/10X/100X FET Probe	\$400.00
TEK P6202A 500 MHz 10X FET Probe	\$200.00
TEK P6205 750 MHz 10X FET Probe, for TDS series	\$325.00
TEK P6701-opt.02 O/E Converter, 450-1050 nm/0-1 mW: DC-700 MHz, ST conn.	\$175.00

### CALIBRATION

TEK 067-0587-02 Signal Standardizer Calibration Fixture	\$750.00
TEK SG503 Level Generator, 250 kHz-250 MHz, TM500 series	\$600.00

## WAVEFORM GENERATORS

### FUNCTION

HP 3312A 13 MHz Function Generator	\$500.00
HP 3314A-001 Function Generator, 0.001 Hz-19.99 MHz, 30 Vp-p, HP1B	\$1,200.00
HP 3325A 21 MHz Synthesized Function Generator, HP1B	\$900.00
HP 3325A-002 21 MHz Synthesized Function Generator, HV output option	\$1,200.00
HP 8165A-002 Prog. Signal Source, 1 mHz-50 MHz, log sweep option	\$650.00
TEK AWG5102 Arb. Waveform Gen., 20 MS/s, 12 bits, 50ppm synthesis <1MHz	\$800.00
TEK AWG5105-opt.02 Arbitrary Waveform Generator, dual channel option	\$200.00
TEK D0501 Digital Delay & Burst Gen., for function & pulse gen's	\$950.00
TEK FG5010 Programmable 20 MHz Function Generator, TM5000 series	\$275.00
TEK FG502 11 MHz Function Generator, TM500 series	\$250.00
TEK FG503 3 MHz Function Generator, TM500 series	\$175.00
TEK RG501 Ramp Generator, TM500 series	\$650.00
WAVETEK 288 20 MHz Synthesized Function Generator, GPIB	

### PULSE

BERKELEY NUCLEONICS 7085B Digital Delay Generator, 0-100 mS, 1 nS res., 5 Hz-5 MHz	\$550.00
HP 8007B 100 MHz Pulse Generator	\$450.00
HP 8012B 50 MHz Pulse Generator, variable transition time	\$500.00
HP 8013B Dual Output 50 MHz Pulse Generator, 3.5 nS Tr	\$500.00
HP 8080A/81A/83A/84A 300 MHz Word Generator	\$650.00
HP 8080A/81A/82A/83A 1 GHz Single Channel Pulse Generator	\$800.00
HP 8082A 250 MHz Pulse Generator	\$1,250.00
HP 8111A 20 MHz Pulse/Function Generator	\$1,100.00
TEK PG502 250 MHz Pulse Generator, Tr<1nS, TM500 series	\$600.00
TEK PG508 50 MHz Pulse Generator, TM500 series	\$350.00
WAVETEK 802 50 MHz Pulse Generator	\$250.00

## VOLTAGE & CURRENT

### VOLTMETERS

FLUKE 845AR High Impedance Voltmeter / Null Detector	\$400.00
HP 3456A 6-1/2 Digit Voltmeter, HP1B	\$450.00
HP 3457A 7-1/2 digit Voltmeter, HP1B	\$1,000.00
HP 3478A 5-1/2 digit Multimeter, HP1B	\$450.00
KEITHLEY 181 6-1/2 digit Nanovoltmeter, 10 nV sensitivity, GPIB	\$800.00
SOLARTRON 7081 8-1/2 digit Voltmeter	\$3,000.00
TEK DM5010 4-1/2 digit Multimeter, TM5000 series plug-in	\$300.00
TEK DM501A 4-1/2 digit Multimeter, TM500 series plug-in	\$225.00

### CALIBRATION

FLUKE 510A AC Reference Standard, 10 VRMS, 0-10 mA	\$450.00
FLUKE 515A Portable Calibrator, DC/AC/Ohms, line & battery power	\$900.00
FLUKE 5220A Transconductance Amplifier, DC-5 kHz, 0-20 A	\$2,500.00

### VOLTAGE SOURCES

HP 6115A Precision Dual Range Power Supply, 50V 0.8A / 100V 0.4A	\$750.00
KEITHLEY 228 Programmable Voltage/Current Source	\$1,900.00
TEK PS5004 Precision Programmable Power Supply, TM5000 series	\$1,000.00

### CURRENT METERS & SOURCES

HP 4140B Picoammeter / DC Voltage Source, without test fixture	\$1,500.00
HP 6181C DC Current Source, to 100 V, 250 mA	\$500.00

HP 6186C DC Current Source, to 300 V, 100 mA	\$750.00
KEITHLEY 225 Current Source, 0.1 uA-100 mA, 10-100 V compliance	\$450.00
KEITHLEY 227 Current Source, 1 uA-1 A, 0-50 V compliance	\$600.00
TEK CT-5 High Current Transformer for P6021/A6302, to 1000A	\$375.00
TEK P6022 AC Current Probe w/termination, 935 Hz-120 MHz, 6 A pk	\$275.00

## IMPEDANCE & COMPONENT TEST

### L.C.R.

BOONTON 62AD 1 MHz Inductance Meter, 2-2000 uH	\$550.00
BOONTON 72BD 1 MHz Capacitance Meter, 3-1/2 digit display	\$650.00
BOONTON 72C 1 MHz Capacitance Meter, 1-3000 pF full scale	\$800.00
GR 1658 RLC Digibridge, 120 Hz/1 kHz	\$1,000.00
GR 1659 RLC Digibridge, 120 Hz/1 kHz	\$1,100.00
HP 4192A LF Impedance Analyzer, 5 Hz-13 MHz	\$5,000.00
HP 4262A-101 3-1/2 digit LCR Meter, 120 Hz/1 kHz/10 kHz test, HP1B	\$1,000.00
HP 4342A Q-Meter, 22 kHz-70 MHz	\$950.00

### STANDARDS

E.S.I. SR-1 Standard Resistor, various values	\$125.00
E.S.I. SR1010 Resistance Transfer Standards, 1 Ohm-100 K/step	\$550.00
E.S.I. SR1050-1M Resistance Transfer Standard, 1 Megohm/step	\$2,000.00
GR 1404-A 1000 pF Reference Standard Capacitor	\$700.00
GR 1405 Standard Air Capacitors, GR900 connector, 0.1% acc.	\$275.00
GR 1432-U 4-Decade Resistor, 0-11,110 Ohms, 0.01 Ohm resolution	\$100.00
GR 1433-J 4-Decade Resistor, 0-11,110 Ohms, 1 Ohm resolution	\$150.00
GR 1433-K 4-Decade Resistor, 0-1,110 Ohms, 0.1 Ohm resolution	\$150.00
GR 1433-L 4-Decade Resistor, 0-111,100 Ohms, 10 Ohms resolution	\$200.00
GR 1433-N 5-Decade Resistor, 0-11,111 Ohms, 0.1 Ohm resolution	\$250.00
GR 1433-X 6-Decade Resistor, to 111,111.0 Ohms, 0.1 Ohm res.	\$750.00
HP 4440B 4-Decade Capacitor, 40 pF-1.2 uF	

### T.D.R.

TEK 1503B-03.04 T.D.R., 0-50,000 pF, chart recorder	\$3,000.00
TEK 1503-opt.04 Time Domain 0-50,000 pF, chart recorder & battery power	\$1,400.00

## POWER SUPPLIES

### SINGLE OUTPUT

HP 6110A 0-3000 V 0-6 mA CV/CL Power Supply	\$250.00
HP 6200B Dual Range Supply, 0-20 V 0-1.5 A / 0-40 V 0-750 mA CVCC	\$200.00
HP 6207B 0-160 V 0-200 mA CV/CC Power Supply	\$200.00
HP 6215A 0-25 V 0-400 mA CV/CL Power Supply	\$100.00
HP 6256B 0-10 V 0-20 A CV/CC Power Supply	\$200.00
HP 6263B 0-20 V 0-10 A CV/CC Power Supply	\$400.00
HP 6268B 0-40 V 0-5 A CV/CC Power Supply	\$400.00
HP 6267B 0-40 V 0-10 A CV/CC Power Supply	\$550.00
HP 6271B 0-60 V 0-3 A CV/CC Power Supply	\$375.00
HP 6274B 0-60 V 0-15 A CV/CC Power Supply	\$650.00
HP 6282A 0-10 V 0-10 A CV/CC Power Supply	\$200.00
HP 6289A 0-40 V 0-1.5 A CV/CC Power Supply	\$200.00
HP 6299A 0-100 V 0-750 mA CV/CC Power Supply	\$200.00
HP 6384A 0-40-5.5 V at 8 A CV/CL Power Supply	\$125.00
HP 6443B 0-120 V 0-2.5 A CV/CC Power Supply	\$450.00
HP 6632A System DC Power Supply, 0-20 V, 0-5 A, 100 Watts, HP1B	\$800.00
HP 6652A 0-20 V 0-25 A 500 Watt Programmable Power Supply, HP1B	\$1,875.00

KEPCO ATE 36-30M 0-36 V 0-30 A CV/CC Power Supply	\$900.00
KEPCO ATE 36-8M 0-36 V 0-8 A CV/CC Power Supply	\$375.00
LAMBDA LK-352-FM 0-60 V 0-15 A CV/CC Power Supply	\$600.00
SORENSEN DCR 150-3B 0-150 V 0-3 A CV/CC Power Supply	\$550.00

SORENSEN DCR 600-0.75B 0-600 V 0-750 mA CV/CC Power Supply	\$650.00
SORENSEN DCS 40-25 0-40 V 0-25 A CV/CC Power Supply	\$350.00
SORENSEN SRL 20-12 0-20 V 0-12 A CV/CC Power Supply	\$500.00
SORENSEN SRL 60-8 0-60 V 0-8 A CV/CC Power Supply	\$175.00
TEK PS501-1 Power Supply, 0-20 V, 2 mV res., 400 mA, TM500 series	

### MULTIPLE OUTPUT

HP 6205C Dual Power Supply, 0-40 V 300 mA & 0-20 V 600 mA, CV/CL	\$300.00
HP 6228B Dual 0-50 V 0-1 A CV/CC Power Supply	\$375.00
HP 6236B Triple Output Power Supply, +/- 0-20V 0.5A & 0-6V 2.5A	\$375.00
HP 6253A Dual 0-20 V 0-3 A CV/CC Power Supply	\$375.00
HP 6255A Dual 0-40 V 0-1.5 A CV/CC Power Supply	\$375.00
KEPCO MPS-620M Triple Output Power Supply, dual 0-20V 1A tracking & 0-6V 5A	\$200.00
LAMBDA LPF-7202-FM Triple Output Power Supply	\$450.00
TEK PS5010 Programmable Triple Power Supply, TM5000 series	\$500.00

TEK PS503A Dual Power Supply, TM500 series	\$200.00
<b>MISCELLANEOUS</b>	
ACME PS2L-500 Programmable Load, 0-75 V / 0-75 A / 500 Watts max.	\$350.00
BEHLMAN 25-C/D/OSCD-1 AC Power Source, 250 VA, 0-130 VAC, 45-2000 Hz	\$850.00
ELGAR 501C/400SD AC Power Source, 45 Hz-5 kHz, 500 VA, 0-135 VAC	\$1,150.00
HP 59501B HP1B Isolated DAC/Power Supply Programmer	\$175.00
HP 6060A 300 Watt Programmable Load, 0-50 A / 3-60 V, HP1B	\$950.00
KEPCO BOP 20-20M Bipolar A Op Amp/Power Supply, to 20 V 20	\$675.00
KEPCO BOP 50-2M Bipolar Op Amp/Power Supply, to 50 V 2 A	\$400.00
TRANSISTOR DEVICES DAL-50-15-100 Programmable Load, 0-50 V, 0-15 A, 100 Watts max.	\$200.00

## TIME & FREQUENCY

### UNIVERSAL COUNTERS

HP 5314A-001 100 MHz/100 nS Universal Counter; TCXO reference option	\$250.00
HP 5315A 100 MHz/100 nS Universal Counter	\$350.00
HP 5315A-002,003 100 MHz/100 nS Univ. Counter; batt. power & 1 GHz C-ch.	\$550.00
HP 5315A-003 100 MHz/100 nS Univ. Counter, 1 GHz C-channel option	\$450.00
HP 5315B 100 MHz/100 nS Universal Counter, HP1B	\$375.00
HP 5316A-001,003 100 MHz/100 nS Univ. Counter, HP1B, TCXO, 1 GHz C-ch.	\$450.00
HP 5316B 100 MHz/100 nS Universal Counter, HP1B	\$550.00
HP 5335A-10,30,40 200 MHz/2 nS Universal Counter, OCXO ref., 1.3 GHz C-ch	\$950.00
HP 5370A 100 MHz/20 pS 11 digit Universal Time Interval Counter	\$750.00
HP 5370B 100 MHz/20 pS Universal Counter, 11 digits	\$1,200.00
PHILIPS PM6672/411 120 MHz/100 nS Universal Counter, C-channel 70-1000 MHz	\$375.00
TEK DC5004 Programmable 100 MHz/100nS Counter/Timer, TM5000 series	\$200.00
TEK DC5009 Programmable 135 MHz Univ. Counter/Timer, TM5000 series	\$350.00
TEK DC5010 350 MHz / 3.125 nS Universal Counter, TM5000 series	\$750.00
TEK DC503A 125 MHz/100 nS Universal Counter, TM500 series	\$275.00
TEK DC509 135 MHz/10 nS Universal Counter, TM500 series	\$275.00

### FREQUENCY COUNTERS

EIP 545A 18 GHz Frequency Counter	\$750.00
FLUKE 7220A-010,131,351 1.3 GHz Counter; battery power, OCXO, and res. mult.	\$500.00
HP 5340A-002 18 GHz Frequency Counter, rear panel input	\$450.00
HP 5342A 18 GHz Frequency Counter	\$1,250.00
HP 5343A-001 26.5 GHz Frequency Counter, OCXO reference	\$3,000.00
HP 5343A-001,011 26.5 GHz Frequency Counter, OCXO reference, HP1B	\$3,500.00
HP 5345A/5355A/5356B 26.5 GHz CW/Pulse Frequency Counter	\$3,500.00
HP 5351B-001 26.5 GHz Frequency Counter, HP1B, OCXO reference	\$4,250.00
HP 5364A Microwave Mixer / Detector, for modulation domain an.	\$2,000.00

### STANDARDS

HP 105B Quartz Oscillator, 0.1 / 1.0 / 5.0 MHz, battery power	\$1,100.00
HP 5087A-opt.032 Distribution Amplifier, 12 outputs at 5 MHz	\$1,750.00

## AUDIO & BASEBAND

### SPECTRUM ANALYSIS

HP 3586C Selective Level Meter, 50 Hz-32.5 MHz, 50 & 75 ohms	\$1,200.00
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### DISTORTION ANALYZERS

HP 334A Distortion Analyzer, 5 Hz-600 kHz, 0.06% THD	\$375.00
HP 8903A Audio Analyzer, 20 Hz-100 kHz	\$1,200.00
HP 8903B-001 Audio Analyzer, 20 Hz-100 kHz; rear input option	\$1,650.00

### RMS VOLTMETERS

FLUKE 9322A True RMS Voltmeter, 180 uV-700 V, 2 Hz-11 MHz	\$450.00
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### OSCILLATORS

HP 3336C-004,005 21 MHz Synthesizer/Level Gen., OCXO & hi accuracy att.	\$1,400.00
TEK SG502 Sine/Square Osc., 5 Hz-500 kHz, 70 dB step attenu., TM500	\$200.00

### MISCELLANEOUS

HP 3575A-002 Phase-Gain Meter, 1 Hz-13 MHz, dual display	\$850.00
HP 461A Amplifier, 20 dB or 40 dB gain, 1 kHz-150 MHz	\$125.00
HP 467A Power Amplifier, X1/X2/X5/X10, DC-1 MHz, 10 W output	\$375.00
KROHN-HITE 3103 High/Low Pass Filter, 10 Hz-3 MHz, 24 dB/octave	\$350.00





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KROHN-HITE 3200 High Pass / Low Pass Filter, 20 Hz-2 MHz, 24 dB/octave	\$275.00
KROHN-HITE 3202 Dual HP/LP/BB Filter, 20 Hz-2 MHz, 24 dB/octave	\$450.00
KROHN-HITE 3342R Dual HP/LP Filter, 0.001 Hz-99.9 kHz, 48 dB/octave	\$900.00
ROCKLAND 852 Dual Highpass/ Lowpass Filter, 0.1 Hz-111 kHz	\$650.00
TEK AM502 Differential Amplifier, 0.1 Hz-1 MHz, TM500 series	\$475.00
WAVETEK 716 Brickwall Filter	\$1,500.00

## RF & MICROWAVE

### SPECTRUM ANALYZERS

HP 11517A/18A/19A/20A Mixer Set, 12.4-40.0 GHz, for HP 8555A/8569A	\$500.00
HP 11970A WR28 Harmonic Mixer, 26.5-40 GHz	\$1,100.00
HP 11970K WR42 Harmonic Mixer, 18.0-26.5 GHz	\$1,100.00
HP 11970Q WR22 Harmonic Mixer, 33-50 GHz	\$1,400.00
HP 11971A WR28 Harmonic Mixer, for HP 8569B	\$800.00
HP 11971K WR42 Harmonic Mixer, for HP 8569B	\$800.00
HP 70620B Preamp/Filter, 1.0-26.5 GHz, for 70000 series	\$3,900.00
HP 8559A/853A-001 Spectrum An., 0.01-21 GHz, 1 kHz res., rackmount frame	\$3,750.00
HP 85640A Tracking Generator, 300 kHz-2.9 GHz, for HP 8560 series	\$5,000.00
HP 8568B Spectrum Analyzer, 100 Hz-1.5 GHz, 10 Hz min. res.	\$8,500.00
HP 8569B Spectrum Analyzer, 100 Hz-2.2 GHz, 100 Hz min. res. bw.	\$5,500.00
TEK WM782V WR15 Harmonic Mixer, 50-75 GHz	\$1,500.00

### NETWORK ANALYZERS

HP 11550A Network Analyzer Accessory Kit, APC7	\$600.00
HP 11665B Modulator, 0.15-18 GHz, for HP 8755B/7	\$2,500.00
HP 36676A Reflection/Transmission Test Kit, 5 Hz-200 MHz	\$850.00
HP 85054A Type N Calibration Kit, for HP 8510 series	\$1,800.00
HP 8757A-001 Scalar Network Analyzer	\$3,750.00
HP 8757C-001 Scalar Network Analyzer, fourth detector input option	\$5,500.00
HP 850528A WR28 Detector, 26.5-40 GHz, for HP 8757 series	\$1,200.00

### SIGNAL GENERATORS

FLUKE 6060A Synthesized Signal Gen., 0.1-1050 MHz, 10 Hz res., GPIB	\$1,900.00
FLUKE 6060A/AN Synthesized Signal Generator, 10 kHz-520 MHz, 10 Hz res.	\$950.00
FLUKE 6060B/BAK Synthesized Signal Gen., 0.1-1050 MHz, 10 Hz res.	\$1,900.00
GIGATRONICS 6006-12 Synthesized Source, 6-12 GHz, 1 kHz res., GPIB	\$2,500.00
GIGATRONICS 8755/0 Levelled Multiplier, x4, 50.0-75.0 GHz output, -3 dBm	\$2,500.00
GIGATRONICS 9002-8 Synthesized Signal/Sweep Gen., 2-8 GHz, 1 MHz res., GPIB	\$2,500.00
GIGATRONICS GT9000-opt.26A Synthesized Signal Gen., 0.01-20 GHz, 1 kHz res.	\$6,000.00
HP 11707A Test Plug-in for HP 8660 series	\$500.00
HP 11720A Pulse Modulator, 2-18 GHz, 80 dB on/off ratio	\$450.00
HP 3335A Synthesizer/Level Gen., 200 Hz-81 MHz, -87 to +13 dBm	\$3,000.00
HP 85100V Frequency Mult., 10-15 GHz in / 50-75 GHz out >0 dBm	\$3,750.00
HP 8640B Signal Generator, 0.5-512 MHz, AM, FM, pulse modulation	\$950.00
HP 8656A-001 Signal Generator, 0.1-990 MHz, 100 Hz res., HP/IB, OCXO	\$1,600.00
HP 8657A-002 Signal Generator, 0.1-1040 MHz, 10 Hz res., HP/IB	\$2,750.00
HP 8660C/8660D/8663B Synth. Sig. Gen., 1-1300 MHz, AM / FM	\$2,500.00
HP 8660C/8660D/8663B Synth. Synthesizer, 1-2600 MHz, 1 Hz res., AM / FM	\$3,250.00
HP 8672A Synthesized Signal Generator, 2-18 GHz, +3 dBm output	\$5,000.00
HP 8673G-004,008 Synth. CW Signal Generator, 2-26 GHz, >+8 dBm output	\$12,500.00
HP 8684B Signal Generator, 5.4-12.5 GHz, AM / WBFM / Pulse	\$3,000.00

### SWEEP GENERATORS

HP 8340B Synthesized Sweep Generator, 10 MHz-26.5 GHz, AM, FM	\$20,000.00
HP 8350A/8354A-002,004 Sweep Oscillator, 2.0-8.4 GHz, 70 dB step attenuator	\$4,000.00
HP 8350A/8354A-002 Sweep Oscillator, 5.9-12.4 GHz, 70 dB step attenuator	\$4,000.00
HP 8350B/83522A Sweep Oscillator, 10-2400 MHz, +13 dBm levelled	\$4,000.00
HP 8601A Generator/Sweeper, 0.1-110 MHz, +20 dBm levelled	\$400.00
HP 8620C Sweep Oscillator Frame	\$550.00
HP 86222A RF Plug-in, 10-2400 MHz, +13 dBm levelled	\$1,200.00
HP 86230B RF Plug-in, 1.8-4.2 GHz, +10 dBm levelled	\$375.00
HP 86241A-001 RF Plug-in, 3.2-6.5 GHz, +8 dBm levelled	\$300.00
HP 86250D RF Plug-in, 8.0-12.4 GHz, +10 dBm levelled	\$500.00
HP 86260A-H04 RF Plug-in, 10.0-15.0 GHz, +10 dBm levelled	\$1,250.00
HP 86290A-004 RF Plug-in, 2.0-18.0 GHz, +7 dBm levelled, rear output	\$1,250.00
WAVETEK 962 Sweep Generator, 1.0-4.0 GHz, markers, +12 dBm unlvld.	\$4,500.00

### POWER METERS

ANRITSU MP-81B/ML-83A Power Meter, 75-110 GHz (WR10), -20 to +20 dBm	\$2,500.00
BOONTON 42B41-4E Analog Power Meter, with 1 MHz-18 GHz sensor	\$450.00
HP 432A/478A Power Meter, -30 to +10 dBm, 10 MHz-10 GHz	\$300.00

HP 435B/484A Power Meter, -30 to +20 dBm, 10 MHz-18 GHz	\$900.00
HP 435B/482B Power Meter, 0 to +43 dBm, 100 kHz-4.2 GHz	\$1,500.00
HP 435B/482H Power Meter, -10 to +34 dBm, 100 kHz-4.2 GHz	\$900.00
HP 436A-022/4841A Power Meter, -30 to +20 dBm, 10 MHz-18 GHz, HP/IB	\$1,400.00
HP 436A-022/4844A Power Meter, -70 to -20 dBm, 10 MHz-18 GHz, HP/IB	\$1,400.00
HP 8477A Power Meter Calibrator, for HP 432 series	\$500.00
HP Q8486A Power Sensor, 33.0-50.0 GHz, WR22, for 435/6/7/8	\$1,500.00
HP R8486A WR28 Power Sensor, 26.5-40 GHz, for HP 435/6/7/8	\$1,500.00
RACAL-DANA 9303 RF Millivoltmeter, 10 kHz-2 GHz, -70 to +20 dBm	\$750.00

### AMPLIFIERS, MISCELLANEOUS

AMPLIFIER RESEARCH 4W1000 Amplifier, 40 dB gain, 4 Watts, 1-1000 MHz	\$950.00
HP 11729B-003 Carrier Noise Test Set, 5 MHz-3.2 GHz	\$2,250.00
HP 415E SWR Meter	\$200.00
HP 8406A Comb Generator, 1/10/100 MHz increments, to 5 GHz	\$500.00
HP 8447A Amplifier, 20 dB, 0.1-400 MHz, 5 dB NF, +6 dBm output	\$375.00
HP 8447E Amplifier, 22 dB, 0.1-1300 MHz, +13 dBm output	\$750.00
HP 8901A Modulation Analyzer, 150 kHz-1300 MHz	\$1,750.00
HP 8901B-1,2,3 Modulation An., 0.15-1300 MHz, rear input, OCXO, ext. LO	\$2,250.00
HP 8970A Noise Figure Meter	\$4,000.00
HUGHES 1177H10F000 TWT Amplifier, >30 dB gain, 1.4-2.4 GHz, 20 Watts	\$2,500.00
HUGHES 8010H13F000 TWT Amplifier, >30 dB gain, 3-8 GHz, 10 Watts	\$2,500.00
HUGHES 8020H1F000 TWT Amplifier, >30 dB gain, 2-4 GHz, 20 Watts	\$4,250.00
RF POWER LABS ML50 Amplifier, 2-30 MHz, 47 dB gain, 50 Watts, metered, 28V	\$350.00
ROHDE & SCHWARTZ ESH2 Test Receiver, 9 kHz-30 MHz	\$3,750.00

## COAXIAL & WAVEGUIDE

AEROWAVE 28-3000/10 WR28 Directional Coupler, 10 dB, 26.5-40 GHz	\$300.00
AMERICAN NUCLEONICS AM-432 Cavity Backed Spiral Antenna, LHC, 2-18 GHz, TNC(I) "NEW"	\$95.00
AVANTEK AMT-400X2 WR28 Active Doubler, +10 dBm in / +10 dBm out 26-40 GHz	\$450.00
BIRD 6735-3001 1 kW Load, 25-1000 MHz, LC(I), with wattmeter	\$650.00
BIRD 8201 500 Watt Oil Dielectric Load, DC-2.5 GHz, N(I)	\$350.00
BIRD 8251 1 kW Oil Dielectric Load, DC-2.4 GHz, N(I)	\$500.00
BIRD 8325-30 30 dB Attenuator, 500 Watts, DC-500 MHz	\$400.00
FXR/MICROLAB S3-02N Triple Stub Tuner, 200-1000 MHz, 100 Watts max., N(mv)	\$125.00
FXR/MICROLAB SL-03N Stub Stretcher, 0.3-6.0 GHz, 100 Watts max., N(mv)	\$75.00
GR 874-LT Constant Impedance Trombone Line, 0-44 cm, DC-2 GHz	\$400.00
HP 11590A-001 Bias Network, 1.0-18.0 GHz, APC7	\$450.00
HP 11636A 2-Way Power Divider, DC-18 GHz, N(mv)	\$300.00
HP 11692D Dual Directional Coupler, 22 dB, 2-18 GHz	\$900.00
HP 33321K Programmable Step Atten., 0-70 dB, DC-26.5 GHz, 3.5mm	\$475.00
HP 33321L-006 Programmable Step Attenuator, 0-70 dB, DC-40 GHz, 2.9mm	\$1,000.00
HP 774D Dual Directional Coupler, 20 dB, 215-450 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 7780-011 Dual Dir. Coupler, 20 dB, 100-2000 MHz, APC7 test port	\$450.00
HP 83017A Amplifier, 25 dB gain, 0.5-26.5 GHz, >+15 dBm	\$3,250.00
HP 8431A 2-4 GHz Band Pass Filter, N(mv)	\$150.00
HP 8472B Crystal Detector, 10 MHz-18 GHz, negative polarity, SMA	\$225.00
HP 8494G-002 Programmable Step Attenuator, 0-11 dB, DC-4 GHz, SMA	\$350.00
HP 8495H-001 Programmable Step Attenuator, 0-70 dB, DC-18 GHz, N	\$400.00
HP 8496A-002 Step Attenuator, 0-110 dB, DC-4 GHz, SMA	\$375.00
HP 8497K-004 Programmable Step Attenuator, 0-90 dB, DC-26.5 GHz	\$750.00
HP K382A WR42 Direct Reading Attenuator, 0-50 dB, 18.0-26.5 GHz	\$2,750.00
HP K422A WR42 Flat Broadband Detector, 18.0-26.5 GHz	\$350.00
HP K532A WR42 Frequency Meter, 18.0-26.5 GHz	\$450.00
HP K752C WR42 Directional Coupler, 10 dB, 18.0-26.5 GHz	\$450.00
HP K752D WR42 Directional Coupler, 20 dB, 18.0-26.5 GHz	\$450.00
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HP K914B WR42 Moving Load, 18.0-26.5 GHz	\$300.00
HP K752D WR22 Directional Coupler, 20 dB, 33-50 GHz	\$650.00
HP R382A WR28 Direct Reading Attenuator, 0-50 dB, 26.5-40 GHz	\$2,250.00
HP R422A WR28 Crystal Detector, 26.5-40 GHz	\$400.00
HP R752D WR28 Directional Coupler, 20 dB, 26.5-40 GHz	\$450.00
HP R914B WR28 Moving Load, 26.5-40 GHz	\$250.00
HP V365A WR15 Isolator, 25 dB, 50-75 GHz	\$750.00
HP V752D WR15 Directional Coupler, 20 dB, 50-75 GHz	\$650.00
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HUGHES 45712H-1000 WR22 Frequency Meter, 33-50 GHz	\$900.00
HUGHES 45714H-1000 WR15 Frequency Meter, 50-75 GHz	\$900.00
HUGHES 45716H-1000 WR10 Frequency Meter, 75-110 GHz	\$900.00
HUGHES 45721H-2000 WR28 Direct Reading Attenuator, 0-50 dB, 26.5-40 GHz	\$1,000.00
HUGHES 45724H-1000 WR15 Direct Reading Attenuator, 0-50 dB, 50-75 GHz	\$1,000.00
HUGHES 45732H-1200 WR22 Level Set Attenuator, 0-25 dB, 33-50 GHz	\$250.00
HUGHES 45772H-1100 WR22 Thermistor Mount, -20 to +10 dBm, 33-50 GHz	\$400.00

HUGHES 45773H-1100 WR19 Thermistor Mount, -20 to +10 dBm, 40-60 GHz	\$650.00
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HUGHES 47316H-1111 WR10 Tuneable Detector, 75-110 GHz, positive polarity	\$600.00
HUGHES 47741H-2310 WR28 Phase Locked Gunn Osc., 32.000 GHz, +18 dBm	\$2,000.00
HUGHES 47742H-1210 WR22 Phase Locked Gunn Osc., 42.000 GHz, +18 dBm	\$2,750.00
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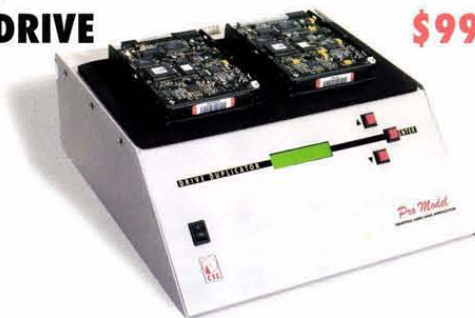
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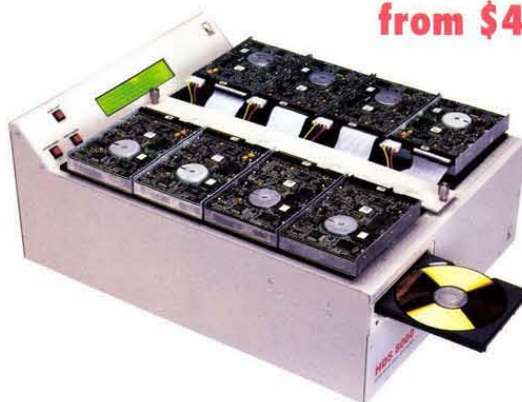
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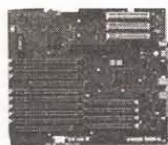
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# Newsbytes

## SURF THE WEB IN PRIVACY WITH SURFSECRET™

Avercast LLC has released version 2.9R of its popular privacy utility. Several new features have been added, as well as support for the Windows 2000 operating system.

SurfSecret is a complete privacy tool. Surf anywhere you want — and SurfSecret will clear your tracks so that nobody will know where you've browsed. As you surf the web, pictures and text get stored on your hard disk, creating a mirror image of your surfing experience. Browsers create cache files and store information on your hard disk, creating a trail that can be easily read. SurfSecret is designed to periodically destroy this trail.

Designed to work on Windows 95/98/NT/2000, SurfSecret integrates with popular browsers such as Netscape, MS Internet Explorer, and AOL. SurfSecret also cleans tracks in important windows locations such as the document menu, run menu, find menu, and Recycle Bin. It runs quietly from the system tray, eliminating tell-tale files at a regular interval of your choosing. Other features include Stealth Mode and Password Protection — to keep its operation secret.

Version 2.9R adds two new features to the SurfSecret arsenal of privacy tools. "Keystroke Wakeup" allows the user to remove all visual instances of SurfSecret from the desktop. SurfSecret then hides in memory running silently until a certain keystroke combination is typed. "Cookie Saver" allows the user to instruct SurfSecret to save certain cookies from trusted sites.

SurfSecret 2.9R for Windows costs \$29.95 for a single-user license. SurfSecret LITE for AOL, SurfSecret LITE for IE, and SurfSecret LITE for Netscape all cost \$19.95 for a single-user license. Site licenses are available for all products. For more information and to download the evaluation copy, visit the SurfSecret Web site at <http://www.surfsecret.com>.

## SUPERBOT DOWNLOADS ENTIRE WEBSITES WITH A SINGLE CLICK

EliteSys announces the release of SuperBot 2.1 — an automated download utility for Windows 95/98/NT4 that copies entire Internet sites with as little as one click. Thanks to SuperBot's HTML rewriting technology, copied sites look and act just

like their online counterparts.

Once SuperBot has downloaded a website, it can be viewed in any web browser, at high speed and without a Internet connection. Modem users are therefore able to surf the Net without missing calls. A copied site can be transferred directly to floppy disk or CD (or any other storage medium) for archival or distribution purposes.

SuperBot's intuitive interface is perfect for both new and experienced users. Although the default settings make perfect copies of most websites, SuperBot can be configured to filter downloads by location, date, file type, link type, depth, and file count. Once a copy operation has begun, it can be paused, stopped, and restarted easily. SuperBot utilizes HTTP/1.1 "Smart Restart" technology to resume any partially completed file transfers.

SuperBot coordinates seamlessly with your computer's web browser. With the "Monitor clipboard" feature, you can download a website by merely copying its address and pressing Enter. SuperBot can automatically launch a copied site in your browser, as well as recording its location in a log file. Because SuperBot preserves the downloaded files' format and directory structure, they can also be viewed or manipulated with Windows Explorer.

SuperBot costs \$24.95. An evaluation copy may be downloaded from the EliteSys website at <http://web.idirect.com/~elitesys/superbot>. Internet Explorer 4.0 or above is required.



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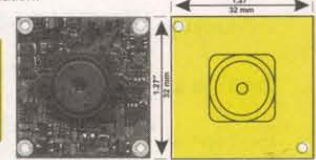
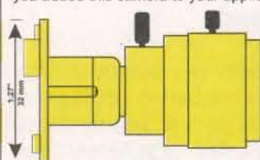
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Nuts & Volts Magazine/April 2000 21



by Joseph J. Carr

# Open Channel

## Dummy Loads and the USB Port

This month, **W**hen I was a kid, we used a light bulb on 60 to 90 watt transmitters for dummy loads. That is, until I worked a guy across town with an S-9 receiver S-meter reading, while "transmitting" into that dummy load! Ooops!

One reason to use a dummy load is to adjust the transmitter off-the-air while transmitting. Another is to measure the RF power level produced by the transmitter.

### Measuring RF Power Output

The RF power can be measured with the set-up shown in Figure 1. In this instance, an RF wattmeter is connected to a dummy load. When the transmitter is keyed, the RF power is indicated on the wattmeter. Unless the wattmeter is designed for modulated signals, the unmodulated RF output power is used.

RF power can also be measured by measuring the RF voltage across the load ( $P = E^2/R$ ) or the current flowing in the load ( $P = I^2R$ ).

### Dummy Loads

So, what exactly is a dummy load? A dummy load is a non-radiating substitute for an antenna. That is, perhaps, why the British have traditionally called these devices "artificial aeri-als."

So, why use a dummy load instead of radiating directly from the antenna? Several reasons. First, it is illegal in most countries to radiate a signal when testing transmitters if it interferes with other users on the channel. One is allowed to

radiate only RF energy needed for communications. Another reason is that it is just plain rude to cause interference on a radio channel just because you want to test your transmitter. Rather than pressing the push-to-talk and interfering with other stations, we can silently key the power into a dummy load.

And finally, there is a very good technical reason for using a dummy load to test a transmitter: Antennas cannot be relied upon to provide the constant and consistent test load that is necessary to make sense out of transmitter tests and adjustments. The measurements that you make may not match the specifications given in the transmitter's manual, even though there is nothing wrong.

Figure 2 shows the standard circuit for the dummy load. It consists of a non-inductive resistor mounted inside of a shielded enclosure, with either a coaxial connector or other transmission line connector to the outside world.

The resistor has to be non-inductive so that the impedance it represented is similar to what would be seen on a resonant antenna. For most applications, an impedance of 50 ohms is used as the system impedance, although examples of 75-ohm, 300-ohm, 450-ohm, and 600-ohm systems are also occasionally seen. Most modern transmitters are designed to work into a 50-ohm resistive load.

### Resistive Loads?

The impedance of any load can be

described by:

$$Z_L = \sqrt{R^2 + (X_L - X_C)^2}$$

where:

R is the resistive component

XL is the inductive reactance component

XC is the capacitive reactance component

If an antenna is resonant, then  $X_C = X_L$ , so the reactances cancel out leaving only the resistive component. But not all antennas work directly on resonance, especially if they are required to work over a band of frequencies. When the transmitter frequency is lower than the resonant frequency, the antenna appears too short and exhibits some capacitive reactance ( $X_C$ ).

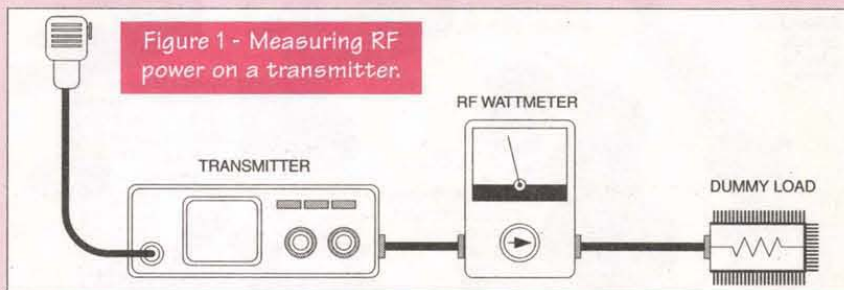
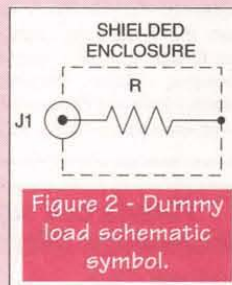
The usual solution is to add some inductive reactance ( $X_L$ ) to cancel it out. Similarly, when the exciting frequency is above the resonant frequency, the antenna appears too long and exhibits inductive reactance. In both cases, the impedance will not be resistive, but rather complex.

The assumption that we will see only resistive loads is reasonable for some transmitters, but for others it is a fallacy. Whether or not it is true depends on the nature of the antenna system connected to the transmitter, and whether or not the transmitter stays on one frequency.

For now, however, we will make the resistive assumption.

### Simple Dummy Loads

There are



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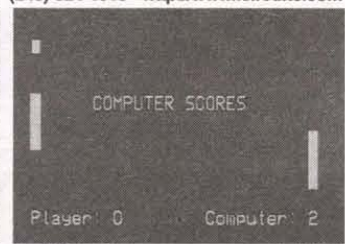
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## Open Channel Dummy Loads and the USB

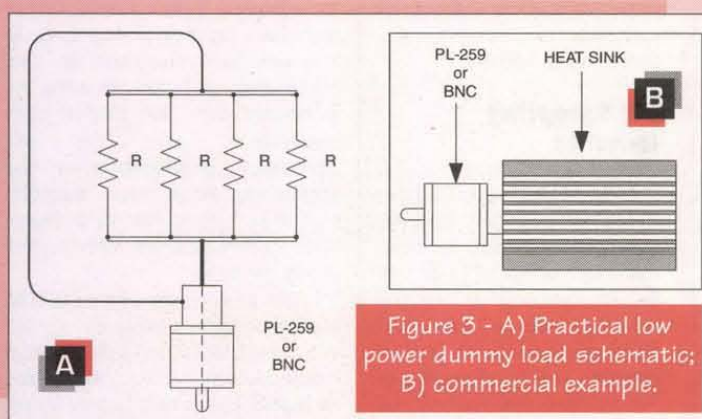


Figure 3 - A) Practical low power dummy load schematic; B) commercial example.

a number of dummy loads that you can buy from commercial sources, but for now let's take a look at some basic forms. Figure 3A shows a simple low-power dummy load that can be used on HF QRP rigs, or many VHF transmitters up to the VHF bands. It consists of two or more parallel resistors (R) connected across either a male BNC connector or a PL-259 "UHF" coaxial connector, depending on the particular transmitter it is used to test.

The values of the resistors depend on the power level and the particular impedance being created. Let's assume 50 ohms for the overall impedance. If you place four 200-ohm resistors in parallel, then you will have a 50-ohm impedance. The power rating will be the total power rating of the resistors. For example, if you use one-watt resistors, then it will be a four-watt dummy load. Similarly, if the dummy load is made from two-watt resistors, an eight-watt load is created. The resistors should be either carbon composition or metallic film. In no case should they be wire-wound resistors.

Higher power levels can be accommodated by using a larger number of resistors, with correspondingly higher value resistances in Figure 3A. Twenty 1,000-ohm, two-watt resistors can be used to

make a 40-watt load. However, keep in mind that the higher the number of resistors, the greater the distributed capacitances, which essentially limits the frequency response of the load.

Small dummy loads are built in this manner. Figure 3B shows a representation of a common 20- to 50-watt dummy load used in both commercial and amateur communications testing.

### Oil-Filled Paint Can Dummy Antenna

A popular approach to making high power ham radio (or impromptu commercial) dummy loads is the paint can dummy antenna. These loads were popularized by the old Heathkit Cantenna. It consists of a standard one-gallon paint can. A non-inductive 50-ohm power resistor is placed inside the can, and the can is then filled with either motor oil or mineral oil (at least one commercial variant used a silicone oil, I am told).

When searching for resistors, you must find a non-inductive resistor. Nearly all of the power resistors that you will find are wire wound, and not usable as a dummy load. You can recognize the non-inductive resistor because it will be a ceramic cylinder with a coating of carbon-like

material on the outer surface. In some cases, there will not be any connectors. The electrical connection is provided by hose clamps connected to the ends.

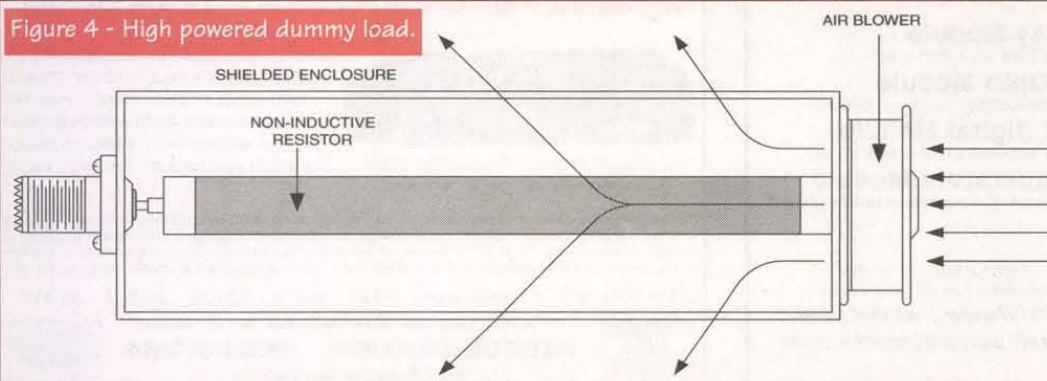
### Air-Cooled Dummy Loads

The air-cooled dummy load is probably a lot more practical than oil-filled loads. The down side is that the power rating of the resistor element must be higher. Oil-filled loads can be operated at higher than rated powers because the oil couples heat to the surface of the can where it can be radiated to the air around it. Commercial dummy loads at high powers (up to 50 kW are easily obtained) use either internal oil or an external water jacket to carry heat away from the resistor element.

Figure 4 shows a basic air-cooled dummy load. This figure represents a large number of 250-watt to 2,500-watt dummy loads. Most are built without the fan, although I've seen many commercially-available models that have the blower fan cut-outs on one end of the perforated aluminum cabinet. If you want to increase the power rating of the dummy load, then add the fan and get rid of the heat.

Another approach is shown in Figure 5. This type of dummy load uses a finned heatsink to radiate

Figure 4 - High powered dummy load.



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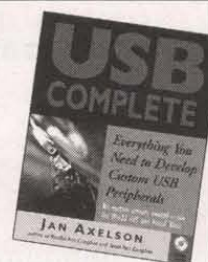
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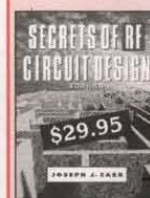


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away the heat dissipated by the dummy load resistor. The internal cavity of the dummy load might be filled with either oil or a silicone gel material that matches the thermal impedance of the resistor to that of

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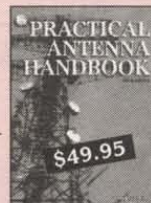


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## Open Channel Dummy Loads and the USB

Figure 5 - Higher powered dummy load used heat finned heatsink to radiate heat.

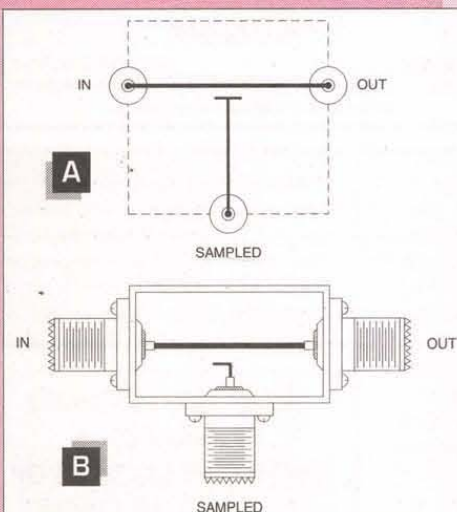
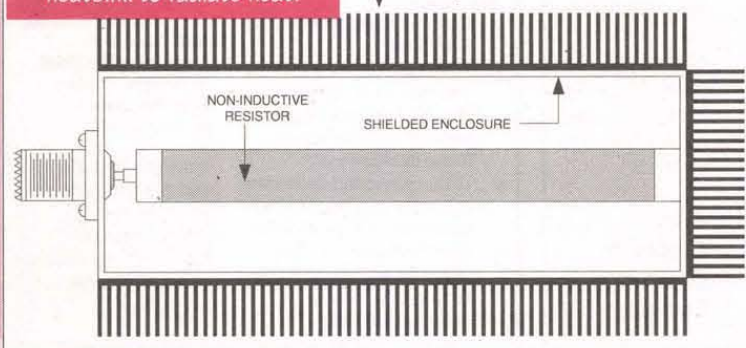


Figure 6 - A) RF sampler schematic; B) physical manifestation.

the shielded enclosure wall.

**Caution Note:** A lot of ham-rated dummy loads have a short duty cycle so might be less useful for commercial work. Look at the specifications of any load you obtain to find out how long you can keep the trans-

mitter keyed without damaging the resistor. Some of them have remarkably short duty cycles. One model I saw said "60-seconds off for 10-seconds on." That means a one-minute cooling off period is needed every time you key the transmitter for 10 seconds. If a particular model looks a bit too small for the wattage rating printed in big letters, then look at the fine print to see the duty cycle rating.

### Complex Impedance Dummy Loads?

Virtually every commercial dummy load is a resistive impedance. But not all antennas are resonant at all frequencies within their bands of operation. Some have reactive components, as well as resistive. In those

instances, suitable amounts of capacitive or inductive reactance will be needed.

### RF Sampling Devices

Some dummy loads have RF sampling circuits built in, while in other cases, an external device needs to be provided. Devices such as isolated hybrid combiners and directional couplers can be used to provide a sample of the RF signal. Another approach is the coupled tee connector shown in Figure 6. The IN/OUT path is a

straight transmission line, in which the SAMPLED port is connected to a wire or small single-turn loop in close proximity to the transmission line. It picks off a small sample of the signal and feeds it to other instruments used in the measurement process.

The RF sample can be used to view the modulation waveform on a Y-time oscilloscope, or display it on a spectrum analyzer. It can also be used to drive an RF power meter if the attenuation factor is known.

### New Book

*Nuts & Volts* writer Jan Axelson has done it again. She's added the book *USB Complete* (ISBN 0-9650819-3-1) to her line up of "...Complete" books (*Parallel Port Complete* and *Serial Port Complete*). The sub-title of this book is "Everything You Need to Develop Custom USB Peripherals," and the book lives up to its billing. If you want to add the Universal Serial Bus (USB) port to your repertoire, then this is the book for you.

For developers who are deciding whether the USB is the right choice

for a project, there's a discussion of the USB's abilities and limitations. You will find information on controller chips and how to write the embedded code that permits communications with the PC. Applications programmers will find step-by-step Visual Basic examples that show how to identify a device, open communications with it, and exchange data.

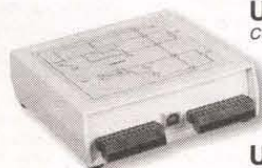
This book comes with a CD-ROM containing various programs for use with the USB. It is available from **Amazon.com** or **Lakeview Research** [2209 Winnebago Street, Madison, WI 53704; (608) 241-5824 (voice), (608) 241-5848 (FAX), E-Mail: [info@lvr.com](mailto:info@lvr.com), website <http://www.lvr.com>]. More information is available on the USB at the USB Implementers Forums web site (<http://www.usb.org>).

The USB interface is a joint effort of Compaq, Intel, Microsoft, NEC, and other manufacturers involved with PC hardware. Advantages to USB include hot pluggability, automatic detection of devices by the operating system, no user configuration required (!), built-in power conservation features, and the ability of many peripherals to use bus power (so they don't need "wall bug" transformers to power them). The bus transfers data at 12 megabits per second, and supports error correction and guaranteed delivery rates. Inexpensive ports allow users to expand the number of ports beyond the usual two provided on most PCs. **NV**

### Connections ...

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# 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'm designing a device to provide some data while I'm bike riding. I think I've figured out speed, acceleration, and distance.

I'm looking for a way to measure grade — how steep a hill I'm going up. Is anyone aware of a sensor, or other way to measure this?

**4001** Jeffrey Schwartz  
Orange, CT

How is the current held reasonably constant in MIG welders?

I've got everything I need to put one together, but I can't figure out what is needed to achieve the constant current requirement. Transistors, SCRs, or what? And with what circuitry?

**4002** Nick  
via Internet

I need a circuit that will interface with a PC-type keyboard and display on an LCD display the characters typed.

**4003** Jeffrey Thompson  
Lennox, CA

I would like to build a circuit to control a 300-400W water heating pad for a king-sized waterbed for maximum economy without causing the water temperature to fluctuate more than  $\pm 3^\circ\text{F}$ .

**4004** James P. Koch  
Memphis, TN

I need information on cable TV cable connectors. I am not sure how to tell the difference between various types of CATV cables and their connectors.

I have a 15 ft. cable (not sure what kind) running from a wall jack. I attempted to install a RadioShack CF-56 connector to one end so I could hook it up to my VCR. After crimping and screwing the cable to the back of my VCR, the signal was dirty.

**4005** Bryan Murphy

Several years ago, one of the projects in the RadioShack 101 projects kit was a radio-powered radio. It consisted of two receivers: One tuned to the strongest local AM station and then converts the signal into a useful current to power the second receiver. How did it work?

In back issues of *Nuts & Volts*, I

Send all material to **Nuts & Volts Magazine**, 430 Princeland Court, Corona, CA 92879. OR fax to (909) 371-3052, OR E-Mail to [forum@nutsvolts.com](mailto:forum@nutsvolts.com)

have seen readers making reference to this type of converting circuit for their low-power projects, but no how-to info was offered.

I have been looking for the RS schematic, plus other similar plans, books, etc., with no real success. Could be I don't know what to look for. I can sure use a good starting point.

**4006** Verl Wooters  
Centralia, IL

I am seeking some help on a Ultrasonic cleaner. The part I need the most help with is the oscillator to produce 40 to 60 KHz 1,000V sinewave to the piezoelectric transducers. I have a 1,000V transformer (1,500mA) with 110 VAC input.

**4007** P. W. Carnahan  
Marietta, GA

I want to build a simple RF power amp. The approximate specs would be 12 VDC, a few hundred micro watts in, 3-5 watts out.

For years, I have looked for a simple schematic for a simple single or maybe two transistor amps that will amplify up to about five watts in the 30 MHz to 100 MHz range.

Is there a schematic that's simple to build, using only a transistor or two, a few caps and coils, no baluns or transformers?

Please provide values and transistor number.

I currently have a Ramsey LPAL kit. It works but is too weak and it has to bread a frequency range.

**4008** J. B. Young  
Burgin, KY

I want to run the feed from my satellite dish about 150 feet under the lawn, but I have been unable to identify the types of coax that are suitable for burial. Is there some marking (like the UF for power cables)?

None of the references I have on coax mention burying the cable. Why?

**4009** Don Paul  
Clovis, CA

I have a Radio Plus FM sub-carrier tuner, manufactured by Fox Marketing or Fox Technology of Dayton, OH. It was manufactured in the "7th" year, so 67 or 77?

There is a potentiometer, and a 10-pin dip switch to tune in channels. I can tune in several different stations and sub-carrier channels, and I've made several comparisons from dip settings to the frequencies, but I can't make heads or tails of how the dip switch settings relate to the channel frequencies. Any suggestions?

**4010** Steve Crabb

I am wondering how to make a 555 timer circuit that has an adjustable speed, and can still maintain a 50/50 duty cycle on pin 3 (the output). Having a 50/50 duty cycle is the easy part, but I don't know how to make it adjustable by using a trimmer pot.

Can anyone draw me a diagram?  
**4011** Ray Samples  
Fayetteville, NC

## ANSWERS

### ANSWER TO #2001 - FEB. 2000

*Need to add an analog S-meter to my portable AM/FM radio for AM reception only?*

The simplest solution is to measure the automatic gain control (AGC) signal derived from the AM detector diode. This signal may be positive going or negative going depending on the design.

You will need an oscilloscope and a bit of Ohm's Law to study the change in the voltage from "no signal" to a very strong station and calculate a resistor divider string to operate whatever meter you plan to use (50uA, 200uA, 500uA). An LED bargraph driven by an LM3914 (or two) would be straight-forward and look very sharp.

If the bias at the detector diode is a problem, take a look at Mr. Russell Kincaid's isolation circuit in the Jan. 2000 issue of *Nuts & Volts* on page 27.

Robert Miller  
Trenton, NJ

### ANSWER TO #20015 - FEB. 2000

*I need to configure a roof-mounted antenna distribution system that piped both AM/FM signals over the same 100 ft. coax to be distributed to six outlets using a RadioShack*

## ANSWER INFO

- Include the question number that appears directly below the question you are responding to.
- Payment of \$25.00 will be sent if your answer is printed. Be sure to include your mailing address if responding by E-Mail.
- In most cases, only one answer per question will be printed.
- Your name, city, state, and E-Mail address, (if submitted by E-Mail), will be printed in the magazine, unless you notify us otherwise with your submission.
- The question number and a short summary of the original question will be printed above the answer.
- Unanswered questions from a past issue may still be responded to.
- Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

## 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.

*auto antenna preamp.*

*I am looking for a better way to combine amplified AM/FM signals so there is plenty of signal to work with at the other end.*

Your problem is similar to the ones in CATV systems. Unfortunately, the inexpensive CATV components do not work in the AM band, so you must look at other suppliers such as Minicircuits or make your own.

Many configurations are possi-



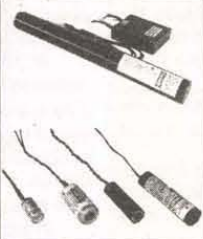
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# TECH FORUM

ble. The first problem is the antennas. An FM antenna covers a 20% bandwidth, so its output impedance can be reasonably constant.

An AM antenna must cover more than an octave, and the wavelengths are impractically long (about 300 meters).

## ANSWERS TO #3007 - MAR. 2000

I have a pretty good dissecting microscope and I would like to be able to project images of material on the microscope stage onto a TV B/W screen. Where does one get a "relay lens system" and a C-mount camera?

#1 If your microscope already has a C-mount video port, all you might need is a video head. Depending on your setup and resolution requirements, they could be B&W security-type to high-end scientific.

There are also mounts that have microscope eyepiece adapters such as the Videoflex <http://www.focuscorp.co.kr>

<http://geologyone.com/cameras.htm> looks to be a good source to find the proper adapter or <http://www.videolabs.com/>

If you don't have the C-mount and want to keep costs as low as possible, I would consider a lipstick or board camera and building a boot to go over the eyepiece.

The mere mention of a lens relay system seems to equate to places that don't list prices.

Will your B&W TV work with the setup?

Most cameras output via a RCA video connector ... if the TV is old it lacks a RCA video in, then you'll have to spend \$20-\$30 for an adapter available at sources such as RadioShack to make things work together.

**Ed Bell  
Colchester, VT**

#2 Edmund Scientific, 101 East Gloucester Pike, Barrington, NJ 08007-1380, sells relay lens systems. You can get their Optics and Optical Instruments catalog by calling 609-573-6250.

My catalog is two years old, so the prices and catalog numbers are stale.

The purpose of the relay lens system is to send the image from the microscope onto the camera's image sensor. There are two types

of systems.

The replacement-type relay lens replaces the microscope's eyepiece; it fits into the microscope barrel (23mm in a DIN microscope; most microscopes are DIN standard). In the replacement-type system, the relay lens has some optical gain (a typical eyepiece might have a 10X gain, and this gain is lost when the eyepiece is removed).

Edmund has a replacement-type microscope video relay lens, stock number F37820, for \$230.00 (1998 price).

The second type is the thru-type relay lens. The thru-type fits over the existing eyepiece. Edmund's thru-type microscope video relay lens, stock number F39925, is \$230.00 (1998).

Both relay lenses expect a video camera with a industry standard C-mount, which is a 1"-32TPI threaded mount.

Most video cameras with interchangeable lenses use a C-mount or a CS mount. CS stands for a "shortened" C mount. You convert a CS mount to a C mount by adding a 5mm spacer (thus lengthening the shortened mount). Many CS mount cameras come with the 5mm adapter.

There is nothing particularly special about the video camera. I'd pick one up on the surplus market, and there are several dealers in *Nuts and Volts*. A black and white camera should be less than \$100.00. Find a small camera to keep the bulkiness of the assembly down.

The output of the camera should be an NTSC signal, and it will drive a video monitor directly.

Most modern TV sets have a video in port (usually an RCA jack) that will accept the NTSC signal. If your TV doesn't have a video in port, then you need an RF modulator. You can find them, but it might be less trouble to buy a newer TV or use the RF modulator in a VCR.

**Gerald Roylance  
Mountain View, CA**

The AM antenna will offer a poor match to a transmission line. The saving grace is the band is very noisy, so a poorly matched antenna can work. Some companies, such as Rohde and Schwarz, sell active antennas that might solve the AM/FM reception problem in one step.

If the RadioShack preamplifier is designed correctly, it would have an output impedance of 75 ohms and could drive a coax cable of arbitrary length. Your comments about a 46 inch cable and coupling with two capacitors is discouraging. If the design can tolerate a 3dB loss, then AM and FM signals could be combined with a power splitter/combiner. If that loss is unacceptable, then the design should use a diplexer.

A diplexer is a combination of a lowpass filter and a highpass filter, the filters are connected together at the common port. The cutoff of both filters is set at the geometric mean

of the desired band edges (in your case, the geometric mean of 1.6 MHz and 88 MHz = 11.9 MHz). Both filters are designed to be reflective in their stop bands (i.e., they look like an open circuit).

The lowpass filter should connect to the common port with a series inductor, and the highpass filter should connect to the common port with a series capacitor. (The suspicious RS preamp used two capacitors, but they might be DC blocks.)

If the filters are 75-ohm single L sections, then  $L = 1.4\mu\text{H}$  and  $C = 126\text{pF}$ . Multiple section filters are used in satellite TV diplexers.

The amplifier can be a big problem because strong signals can mix together to form intermodulation products that interfere with weak stations.

The amplifier must be linear, and that requires good design and lots of power. The amplifier for an active

## ANSWER TO #20017 - FEB. 2000

Need a pulse train transmitter circuit that operates on a frequency of 230 MHz.

This oscillator followed by a two-stage limiter should do the job. The 1K pot should give some control of pulse width, although a fixed 1K to a variable voltage source would be more effective.

The diodes prevent Q2 and Q3 from saturating which would allow charge storage and stretch the turn-off time.

The parts are all available from RadioShack.com

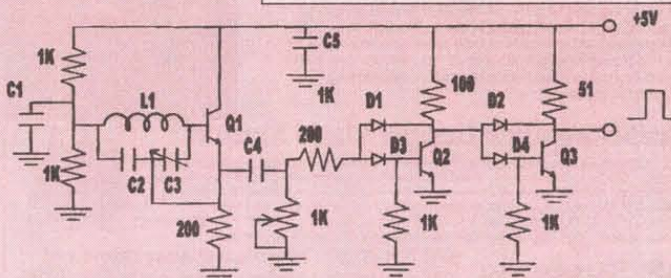
The resistors may be 1/4 watt except the 51 ohm should be 1/2 watt.

I have not built this, so some tweaking may be required.

**Russell Kincaid  
Milford, NH**

## Parts list:

C1, C5	1,000pF disc ceramic	900-2216
C2, C4	47pF disc ceramic	900-2197
C3	10pF trimmer	900-5849
Q1	2N5179	900-5450
Q2, Q3	2N5109	900-5451
D1, D2	1N5711	900-5686
D3, D4	1N4148	900-2908
L1	55nH eight turns #30 wire on 0.1 inch dia. resistor of 1 megohm or greater	





# TECH FORUM

antenna can take 10W. The amplifier should not have a lot of gain because that aggravates the intermodulation distortion. Too little gain loses the

weak stations in the noise.

Sometimes you cannot win. Some [older] CATV installations use filters and attenuators to equalize all

stations to the same power level.

The coax cable has little loss at these frequencies, so it should not be a problem. For foam cable, the loss

per hundred feet in the AM band is about 0.4dB, the FM band loss is about 3dB.

At the tail end, you can use a combination of power splitters and directional couplers to provide the signal taps. Power splitters are the simplest solution if a cable must branch in different directions. They also provide higher signal levels.

If you need to serve a string of offices, then directional couplers make sense. The main cable would run by each office and terminate in a resistor, each office would have a 10 to 20dB directional coupler and a drop cable. A 20dB resistive tap could also be used — that is just a 680-ohm series resistor.

All of the taps should be terminated, but the power splitters and directional couplers minimize the effects of reflections. I would use diplexers on the tail ends to control reflections and avoid overloading the receiver's front end, but that is probably overkill.

Gerald Roylance  
Mountain View, CA

## ANSWER TO #20018 - FEB. 2000

What is the best way to build a 15- or 20-watt tube amp for a guitar?

Tube amplifiers are highly over-rated, their only advantage is that they don't sound as bad as transistor amplifiers when overdriven.

Transistor amplifiers are more reliable, give as good or better fidelity, and are cheaper. So, instead of building a 20-watt tube amp and overdriving it, buy a 50-watt transistor amp and don't overdrive it.

The quality of the sound from any amplifier depends almost entirely on the quality of the speaker, so don't skimp there.

Russell Kincaid  
Milford, NH

## ANSWER TO #20019 - FEB. 2000

When I record on a chip and move the pentameter during play-

Continued on page 84

## ANSWERS TO #3004 - MAR. 2000

Can someone give me a simple circuit design that will track the sun for a solar panel and tracking sound?

**#1** The basic idea of a tracker is simple. You need two sensors (left and right) and a difference amplifier. If the left sensor is getting more light than the right sensor, then the difference amplifier says turn left. If the right sensor is getting more light, then the amplifier says turn right.

The tracker is a servo system, so the loop gains and the frequency response of the positioning system come into play.

The sensors require some thought, too. Typically, one lens focuses the image onto two side-by-side sensors, and the target image must be smaller than the sensor area, but larger than the gap between the sensors. Some pyro detectors are well-suited for this application.

Altitude-azimuth tracking uses a 2x2 sensor array. The azimuth drive compares the two left sensors against the two right sensors. The altitude drive compares the two top sensors against the two bottom sensors.

Getting initial lock can be a problem. If the sensors have a narrow field of view, then they must either scan for the target or wait until one happens by. If the target can turn off, then there are more problems.

Tracking sound can be done the same way, but the directional microphones can be challenging. In the long run, it is probably easier to cross-correlate the left and right channels and calculate the sounds angle of arrival.

Addressing the solar panel issue, you probably do not want to make a solar tracker. Yes, you can gather more energy with a solar tracker, but the question becomes is the added complexity worth the added gain? The tracker requires more parts and motors, and they add cost and maintenance headaches. If you need more power, it may be cheaper to increase the size of the array. Consult a book on solar energy and read about optimizing the [static] tilt angle of the array.

There are some interesting observations about the sun's angle and intensity. The sun is brighter (in the northern hemisphere) during winter, but the days are shorter. If the system works during the [cloudy and overcast] winter, then making it work during the summer is easy.

If you still want to position the solar arrays, don't bother building a tracker. Just calculate the position of the sun and point the arrays accordingly. A solar tracker would have a hard time tracking during overcast days, and something needs to return it to the east for a new day.

If you calculate the position of the sun, then none of those problems arise.

If your solar array is photovoltaic, then you might want to add a power tracker — a device that extracts the maximum amount of power from the array.

Gerald Roylance  
Mountain View, CA

**#2** This tracking circuit follows the sun. If you are more specific about what you are doing with sound, I can come up with a circuit.

There are two photo transistors. When both see the sun or it is dark, the drive motors do not move. When one photo transistor is shaded, the other one turns on a motor to drive the unit until both see the sun.

Here is how it works: The exclusive-or (7486) output will be high when either input is high, but not both. When both inputs to the 7486 are high or low, the output will be low. The 7402 is a quad NOR gate, but I used one as an inverter and two as inverted AND gates.

The 7402 output will be low when either or both inputs are high, and the output will be high only when both inputs are low. This truth table will show the logic:

A	B	C	D	E
H	H	L	H	L
L	L	L	H	L
H	L	H	L	L
L	H	H	L	L

The unused inputs should not be left floating, so I have shown one way to connect them.

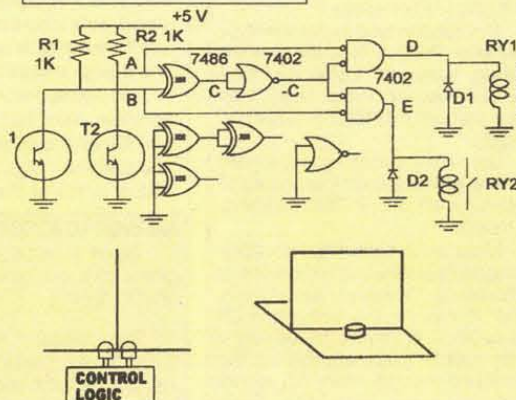
You can use 74, 74LS, 74ALS, 74HC, or 74HCT logic. The cheapest is best. RadioShack doesn't stock the '86, but you can order it.

The relays can handle up to 1 amp. If the motors are large, use these to drive larger relays.

The parts list is all RadioShack parts.

Russell Kincaid  
Milford, NH

Parts List	
74HC86	RSU 12168639
74HC02	RSU 10880045
T1, T2	276-145
RY1, RY2	275-232
D1, D2	276-1101
R1, R2	271-1321



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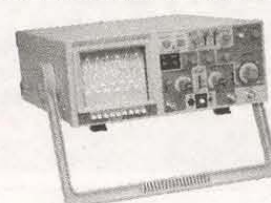


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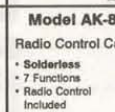
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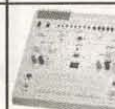
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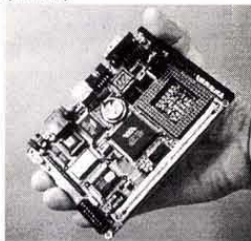
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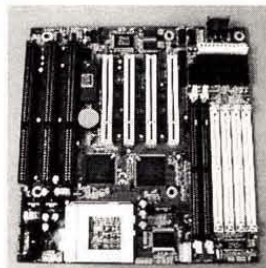
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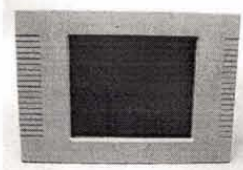
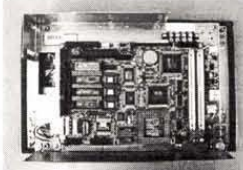
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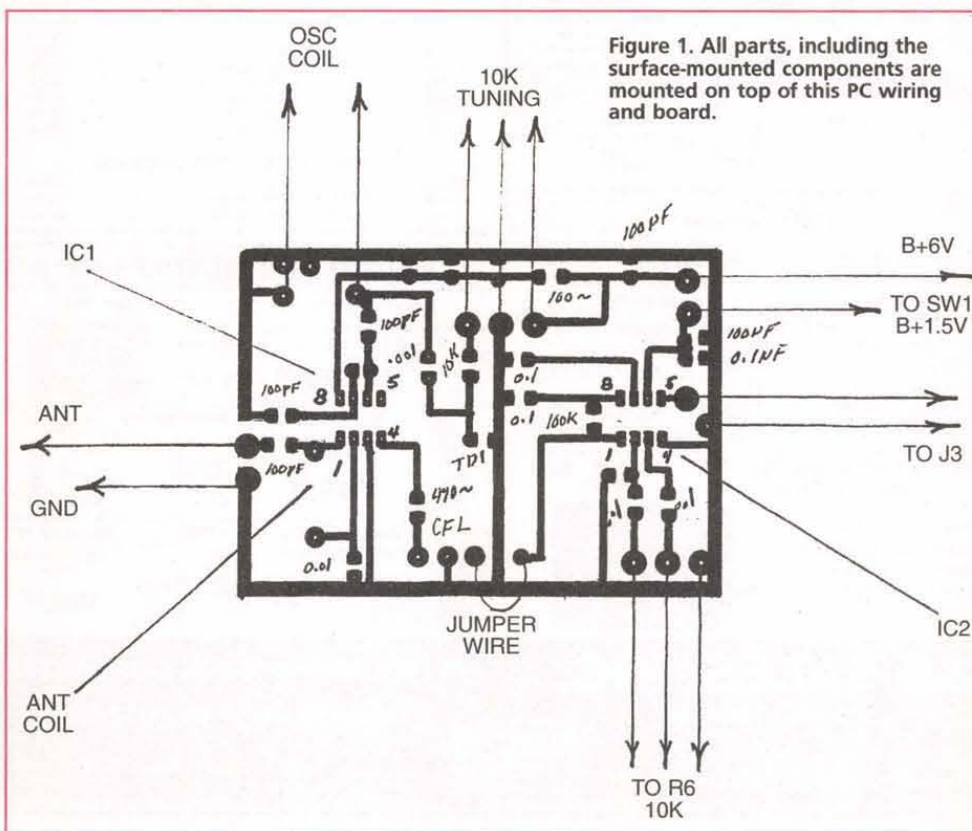
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The resulting IF frequency (455KHz) is coupled from pin 4 of IC1 to pin 1 of IC2. CF1 is a intermediate frequency (IF) ceramic filter, that requires no alignment. IC2 is a 10-transistor, tuned-radio frequency (TRF) detector IC (like the Z414Z), with added buffer and amplifier. Here the RF section is used in the IF amplifier circuit. The internal audio AF circuits of Z416E were designed to feed into a low-impedance headphone (64 ohms), like those found in a small cassette player.



The small SMD shortwave receiver can be tuned to the 41 or 31 meter band.





Although, Z416E IC was designed to work in a low audio amplification, without a volume control, R6 was tapped into the audio output (pin 2) and input of the pin 3 circuit. By adding another coupling capacitor (C10), R6 is isolated from pin 2 and 3 voltage terminals. The volume control must be lowered on the very strong foreign broadcast stations, for easy earphone listening.

## Coil Data

L1 and L2 are both commercial-built coils that can be ordered from electronic mail order firms. L1 can be purchased for less than \$1.00 and L2 for less than \$5.00. L1 is a fixed 8.3uH iron core molded RF coil, while L2 is an adjustable 4.60 to 8.50 uH inductance. L1 terminals are cut real short and soldered directly to the PC wiring. L2 stands upright. All three terminals of L2 are bent at right angles for the mounting pads. Both coils were purchased from Circuit Specialists, Inc., 220 S. Country Club Dr., Mesa, AZ 85210.

## PC Board Layout

Cut the 2x2-1/2 inch PC board from a larger piece. Layout the PC wiring with direct etching dry transfer patterns. Extend the IC eight-pin transfers by placing another set upon the end of each pin terminal. This method will hold the IC terminals when they are bent outward. The same IC pad transfers can be doubled-up (back-to-back) for the tiny SMD mounting pads. The distance of these IC patterns is ideal for mounting the tiny capacitors and resistors (Figure 3). Both IC pattern terminals are placed in the middle of each section.

Place a wider layer of PC pattern clear around the audio and RF sections. Both RF and AF sections are isolated with a strip down the middle. Leave a small space in the RF section for the antenna terminal connection. Only two jumper wires are needed: one at the six-volt source going to pin 8 of IC1 and another at the IF output of CF1 to the input terminal 1 of IC2. These small jumper wires can be ends cut from regular resistors or capacitors.

After etching the board, place solder upon the copper wiring and wipe off excess with a cloth. Check all wiring terminals and pads so they do not touch. Double-check each IC terminal so they do not connect to one another. Cut out the copper pattern with a razor blade, if they are too close together. Clean off all solder flux around the SMD and IC parts with the edge of a pocket knife

or small screwdriver blade.

## SMD Component Selection

All components for the SMD receiver can be purchased locally or from mail order firms. IC1 (NE-602N) can be ordered from mail order firms, while IC2 was purchased at Kevin Electronics, 10 Hub Drive, Melville, NY 11747. Try to obtain all SMD parts at one electronic mail order firm. The SMD bypass and coupling capacitors are purchased in 5-, 10-, or 20-lot packages. These fixed SMD resistors and capacitors are mounted upon a plastic strip. The electrolytic capacitors can be purchased separately. These capacitors are much cheaper when purchased in a 10-lot package and can be used for other electronic SMD projects.

Do not purchase any electrolytic SMD capacitors with a working voltage under 16 volts. Sometimes a six-volt supply may break down or heat up an electrolytic capacitor with a 10-volt working rating. All

bypass and coupling capacitors are of the 50-volt variety. Notice capacitors C2, C3, C4, and C5 are NPO 50-volt capacitors. The SMD resistors are

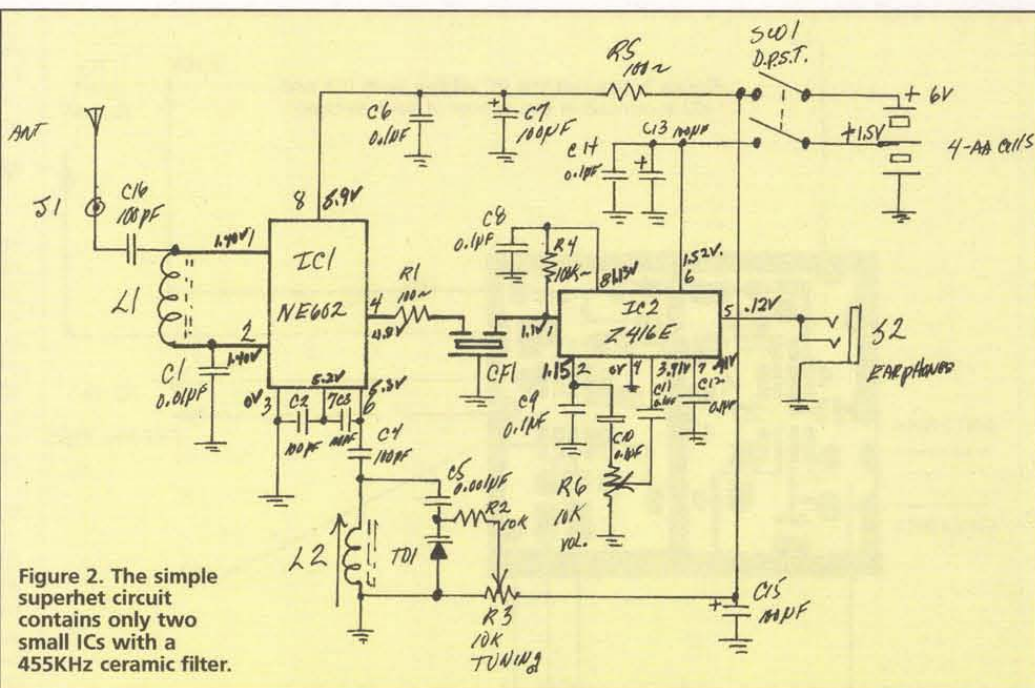
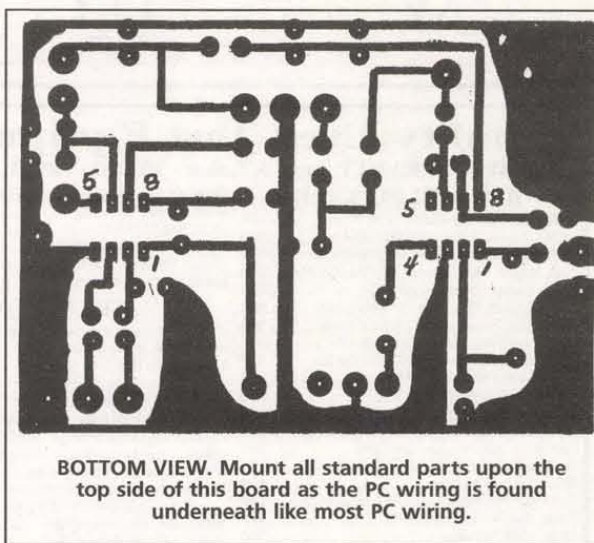


Figure 2. The simple superhet circuit contains only two small ICs with a 455KHz ceramic filter.



BOTTOM VIEW. Mount all standard parts upon the top side of this board as the PC wiring is found underneath like most PC wiring.

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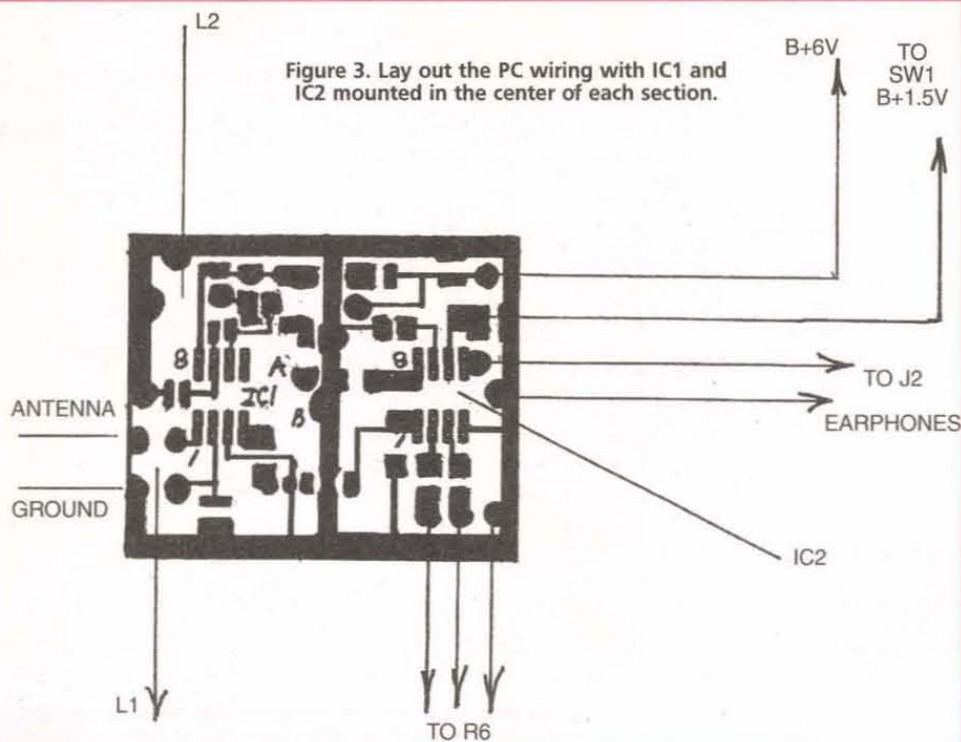
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Figure 3. Lay out the PC wiring with IC1 and IC2 mounted in the center of each section.



rated at 1/8 watt units. For instance, all SMD resistors, capacitors, and CF1 can be purchased from Digi-Key of Thief River Falls, MN. The necessary parts and where you can purchase SMD parts are found in the Parts List.

### Mounting the SMD Parts

Double-check the capacitance and resistance of each part within a plastic package. Mark the microfarads and resistance upon each package, if not found there. Remove only one part at a time to solder into position, as these small SMD capacitors and resistors are not marked upon the top side. Peel back the plastic cover, push out the SMD part with a pocket knife blade or miniature screwdriver. Do this over a white sheet of paper. Remember, these tiny parts can easily be lost or dropped (Figure 4).

Place a bead of solder upon each pad where the SMD part mounts. Use small 0.031 or 0.021 thin gauge solder for these small connections. Only a dab will do. Where the SMD part straddles across the PC wiring (like C4 and R1), build the pad up a little higher, then place the SMD part upon pads and solder up. Use a pair of small tweezers to handle the small SMD parts. After soldering each component into the circuit, check for shorts across it. Test for correct resistance of each mounted resistor. Make sure the right part is soldered into the right pad. Hold the part with tweezers on the pad and place the small iron tip

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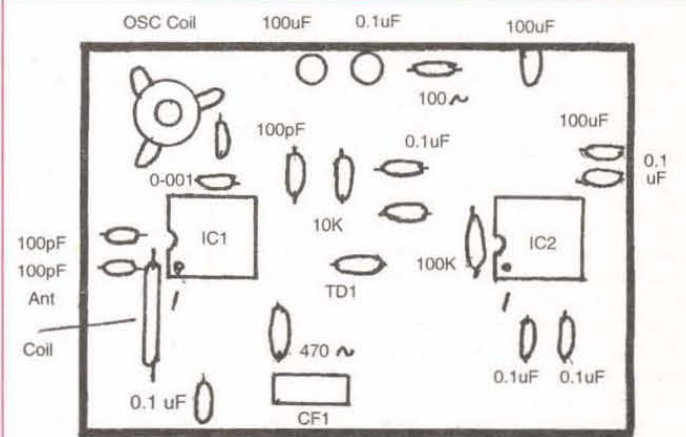
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TOP SIDE OF THE BOARD. All standard components are mounted on top of the board with holes drilled through the board to the PC wiring.

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at the end of the SMD part to make a good bond.

First, mount IC1 and IC2. Bend the terminals out at a right angle so the ICs will mount flat over each pin terminal (Figure 5). Check for a white line or "U" indentation of IC for pin 1 of NE-602. Likewise check for a white dot on Z416E for pin 1. Make sure pin 1 of IC is over pin 1 of PC wiring. Solder pin 1 and then go over to the other side and solder in pin 8. Place only enough solder upon PC wiring for a good connection. Do not leave the iron on the pin terminal too long. Check for leakage between each terminal with the low-ohm scale of DMM.

Check each bypass and coupling capacitor across the terminals with a 200-ohm scale of the digital multimeter. A normal 0.001 to 0.1 uF capacitor will have a quick ohm indication and then an infinite reading. Test the electrolytic capacitors on the 20,000-ohm scale and watch the capacitor charge up and down, indicating no shorts or leakage and good SMD part connections. Test each part as it is soldered into the circuit and the SMD receiver will correctly operate when you are finished.

### Testing Out

Double-check all SMD part connections with a magnifying glass. Make sure all ends of the SMD parts are covered with solder (Figure 6). Take a resistance measurement across the +6 and +1.5-volt source to common ground. If normal, only an infinite resistance measurement should be found on a 2K ohm resistance scale.

Temporarily, connect extension hookup wires to the volume control, antenna post, tuning control, and earphone jack. The correct length can be cut off after it is mounted in the cabinet. Make sure the common ground terminal of the stereo earphone jack is at ground potential. If not, when mounted in a metal cabinet, the audio will be grounded out with pin 5 of IC2 connection. Now solder wires to the +6 and 1.5 volt sources for testing. It is best to test the chassis out before placing in the cabinet.

Although, any small shortwave receiver operates best at night on a single long wire antenna, you can give it a test during the day. Plug in a pair of low impedance earphones. Connect the

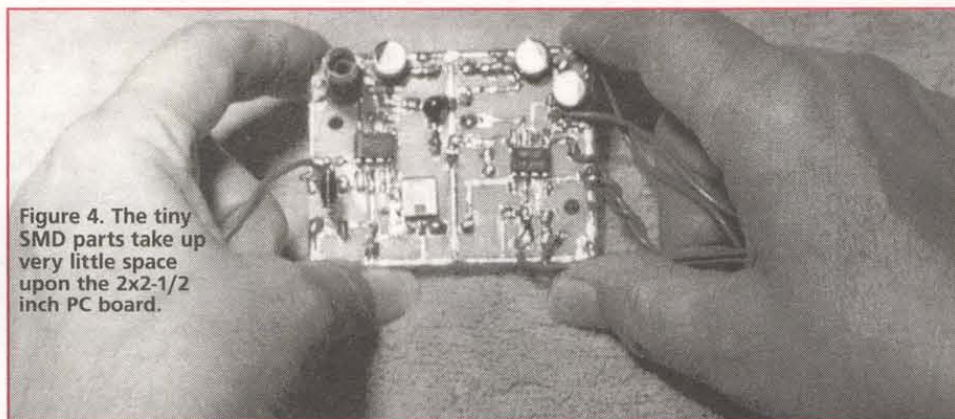


Figure 4. The tiny SMD parts take up very little space upon the 2x2-1/2 inch PC board.

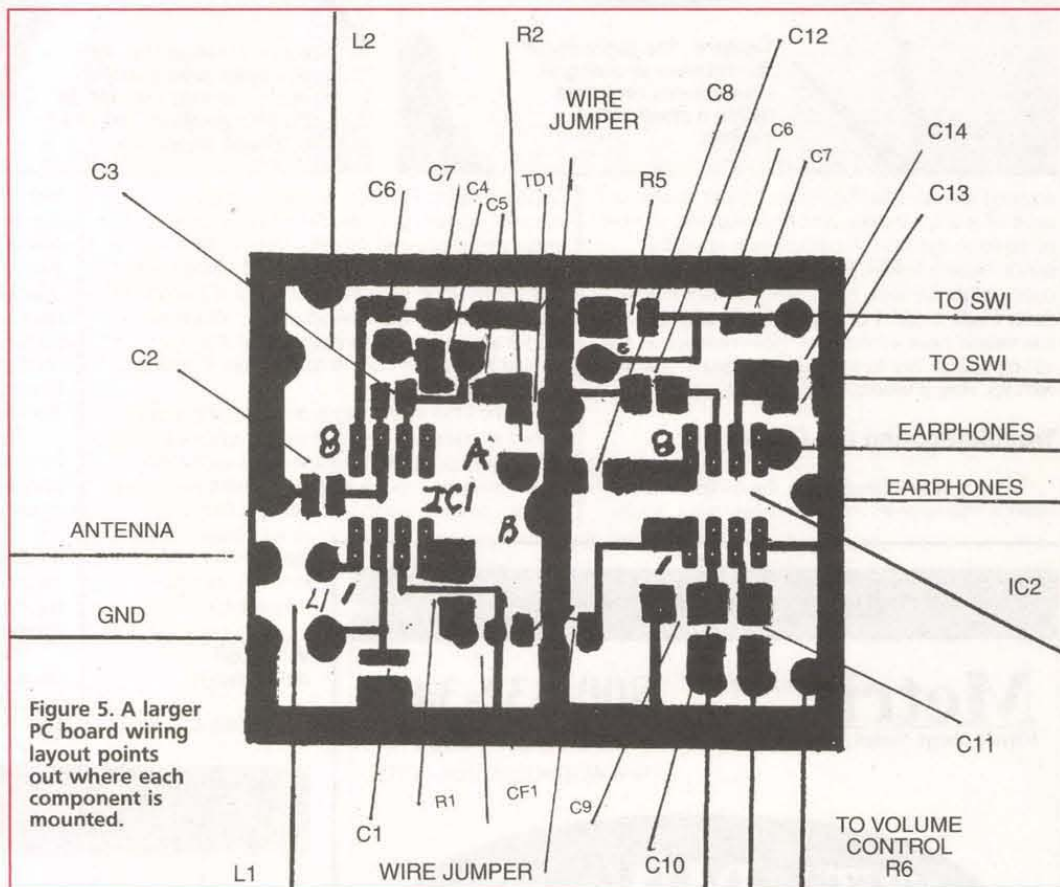


Figure 5. A larger PC board wiring layout points out where each component is mounted.

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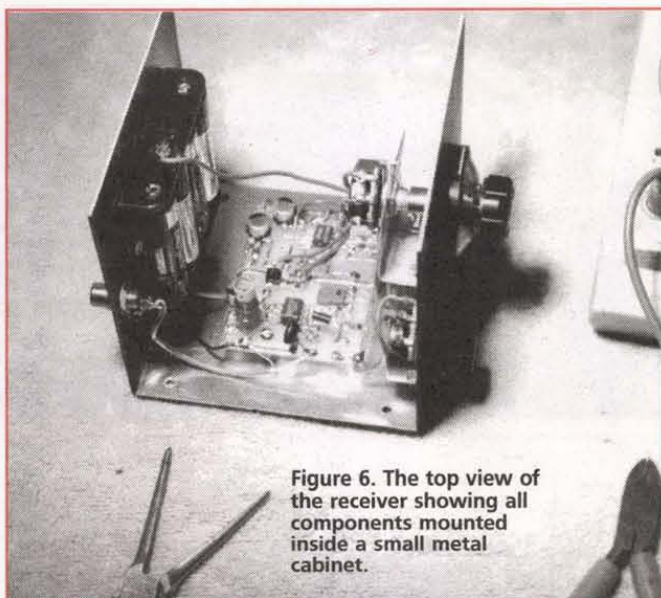


Figure 6. The top view of the receiver showing all components mounted inside a small metal cabinet.

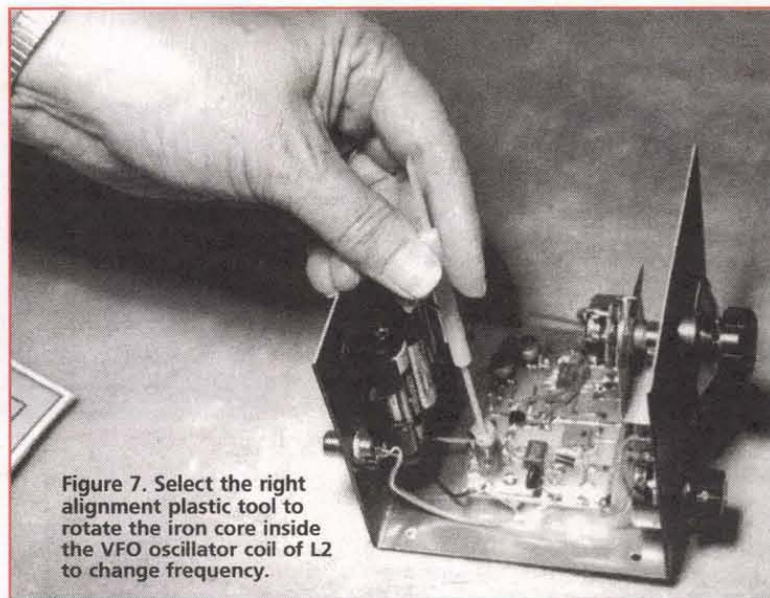


Figure 7. Select the right alignment plastic tool to rotate the iron core inside the VFO oscillator coil of L2 to change frequency.

antenna wire to C16. Tie in the 1.5-volt source to pin 6 of IC2 for testing. A connecting wire can be soldered to the 1.5-volt battery rivet upon the plastic battery holder. First, test out the audio circuits. Rotate R6 wide open. Place a small screwdriver blade to pin 1 of IC2 or the wire jumper. You should hear a loud hum. Now connect up the +6-volt source. Try to tune in a shortwave station with R3. Hey, it works!

### Troubleshooting the Chassis

If no sound is heard from the audio circuits, insert a milliamperes meter between the 1.5-volts

source and pin 6 of IC2. Suspect a leaky IC2, shorted PC wiring, or misplaced parts if the measurement is over 10 mills. Double-check all audio part connections. Take critical voltage measurements upon each terminal pin of IC2 and compare with those upon the schematic. When pins 2 and 3 are touched with the blade of IC2, you should hear a low hum. A louder hum should be heard on pin 1.

When the audio stages are operating and no tuned in stations, check the voltage upon each pin of IC1 with the DMM. Double-check each SMD part connection to the PC board. Check each pin of IC1 to common ground for leakage. Only pin 3 should show a shorted measurement. Make sure the antenna is connected.

meter band, adjust the iron core of L2 almost clear out of the coil winding (Figure 7). Tune in a strong shortwave station. Compare this frequency with those of another commercial built receiver, if one is available. You can now check the frequency of the station received. Also, check the frequency of the station as they provide it on the hour. Another method is to place the small shortwave receiver next to a commercial one and rotate the tuning dial until a beat whistle or squeal is heard.

Trace the oscillator whistle to the high and low end of the dial. The 41 meter frequency is in the 7 MHz band. You may be able to tune in the time signal station of Ottawa, Canada at 7.335 KHz.

To adjust the SMD receiver to the 30-31 meter band, set the tuning dial in the center of rotation. Adjust L2, until WWV at 10MHz (10,000KHz) is heard. This standard frequency and time station operates from Fort Collins, CO.

Now you can sit back and listen to the many shortwave stations and see what is going on all around the world, with this tiny SMD SW receiver.

NV

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## Parts List

IC1	NE-602N IC	Oak Hills Research
IC2	Z416E IC	Kelvin Electronics
L1	8.2uH molded RF coil #9230-42	Circuit Specialists, Inc.
L2	4.60 to 8.50 uH adjustable coil #23686RPC	Circuit Specialists, Inc.
CF1	455KHz ceramic filter #TK2330-ND	Digi-Key, Inc.
C1	0.01uF 50V SMD capacitor	
C2,C3,C4	100 pF NPO 50V SMD capacitors	
C5	0.001uF NPO 50V SMD capacitor	
C6,C8,C9,C10,	0.1uF 50v SMD capacitors	
C11,C12,C14	100uF 16-volt SMD electrolytic capacitors	
C7,C13,C15	100 pF NPO or Silver Mica 50V capacitor	
C16	100 ohm 1/8-watt SMD resistor	
R1	10K ohm SMD resistor	
R2	10K ohm linear taper variable control	
R3	100K ohm SMD resistor	
R4	1000 ohm SMD resistor	
R5	10K ohm audio taper volume control	
R6	DPST miniature toggle switch	
SW1	MV2109 33 or 36 pF tuning diode	
TD1	Miniature antenna jack	
J1	Miniature stereo headphone jack	
J2		
1	Four AA 1.5-volt plastic battery holder	
1	Cabinet — LMB #444 metal; 4" depth x 4" wide x 2-5/8" height or equivalent	
Misc.	PC board, hook-up wire, batteries, solder, etc.	



# Events

## APRIL 2000

### APRIL 1

**CA - HANFORD** - Swapmeet. Hanford Fraternal Hall, 10th Ave. @ Florida. Talk-in: 145.11, 147.33, 224.44, 441.900 PL100. The Kings ARC, Rick 559-945-2266 8am-5pm. Doug 559-582-0949 8am-5pm

**CO - LONGMONT** - Hamfest. Boulder County Fairgrounds. VE Testing. Talk-in: 147.270+ repeater, 146.52 simplex. Longmont ARC, Fred Pilz KB0JUD, 303-678-5830. E-Mail: larc@qsl.net Web: <http://www.qsl.net/larc/>

**CT - WATERFORD** - Ham Radio Auction. Senior Center, Rt. 85. Talk-in: 146.730. RASON, Tony Griggs AA1JN, 860-859-0162. Web: [www.rason.org](http://www.rason.org)

**MO - LEBANON** - Hamfest. Lebanon ARC, Micki Jensen KC0EEX, 417-588-2335. E-Mail: mjensen@ilion.org

**NJ - WEST ORANGE** - Hamfest. High School, 600 Pleasant Valley Way. 8:30am-1pm. IRAC, Jim Howe N2TDI, 973-402-6066

**TX - BRENNHAM** - Hamfest. Brenham ARC, Dan Lakenmacher N5JNU, 409-836-8739. E-Mail: lindan@phoenix.net

### APRIL 2

**CT - SOUTHTON** - Hamfest. High School, 9am-1pm. Southton ARC, Chet Bacon KA1ILH, 860-628-9346. E-Mail: chet@chetacon.com Web: <http://www.chetacon.com/sara.html>

**NC - KINSTON** - Hamfest. Lenoir County Fair Grounds. 8am-3pm. FCC Exams. Talk-in: 146.085/146.685. Down East Hamfest Assn., Doug Burt W4OFO, 252-524-5724

### APRIL 7-8

**WI - MILWAUKEE** - Hamfest. Amateur Electronic Supply, Ray Grenier K9KHW, 414-358-4088. E-Mail: rayk9khw@aol.com Web: <http://www.aes/fam.com>

### APRIL 8

**AR - FORT SMITH** - Hamfest. Columbus Hall, 10201 Columbus Acres Rd. VE Testing. Talk-in: 146.940. Fort Smith Area ARC, Kelsey Mikel KK5KU, 501-651-7003. E-Mail: kk5ku@amsat.org Web: <http://www.qsl.net/fsaar>

**CA - FONTANA** - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves

**MN - ROCHESTER** - Hamfest. Graham Arena E., Olmsted County Fairgrounds. VE Testing. Rochester ARC, John Scott N0HZN, 507-285-6522. E-Mail: n0hzn@aol.com

Web: <http://members.aol.com/rarchams>

**NH - TWIN MOUNTAIN** - Hamfest. Town Hall, 8am-2pm. VE Exams. Talk-in: 147.345 (114.8 Hz). North County ARC and LARK, Richard Force WB1ASL, 603-788-4428.

E-Mail: bhabooks@together.net

Web: <http://www.qsl.net/k1ncr>

**OK - LAWTON** - Hamfest. Lawton Ft. Sill ARC, Bob Morford KA5YED, 580-353-8074 or 580-355-6120

**TN - CLINTON** - Hamfest. Old Armory. 9am-4pm. Talk-in: 146.880 or 146.970. Oak Ridge ARC, David Bower K4PTZ, 865-690-8360. E-Mail: d.bower@ieee.org

Web: <http://www.kornet.org/orac>

**WA - SPOKANE** - Hamfest. Spokane Community College. 9am-5pm. VE Testing. Talk-in: 146.52 simplex and 147.38 repeater. Lilac City ARC, Warren Kelsey KJ7BB, 509-534-8443

### APRIL 8-9

**FL - SARASOTA** - Sarasota Municipal Auditorium, 801 N. Tamiami Trl. Frank Cox Productions, 941-954-0202

### APRIL 9

**NC - RALEIGH** - State Convention. Jim Graham Bldg., NCS Fairgrounds. 8am-4pm. Raleigh ARC, Chuck Littlewood K4HF, 919-992-5851. E-Mail: k4hf@arrl.net Web: <http://www.rars.org>

**NJ - HAMILTON TWP.** - Hamfest. Tall Cedars of Lebanon picnic grove, Sawmill Rd. Talk-in: 146.67. 609-882-2240.

Web: <http://www.slac.com/w2zq>

**PA - MONROEVILLE** - Hamfest. Palace Inn, Mossdale Blvd. 8:30am-3pm. Talk-in: 146.73, 147.12 repeaters and 146.52. Two Rivers ARC, Michael Kowalcheck K3VL, 412-751-9657. E-Mail: w3oc@nb.net Web: <http://www.qsl.net/w3oc>

**WI - STOUGHTON** - Hamfest. Mandt Community Center, 400 Mandt Pkwy., Junior Fairgrounds. 8am-1pm. Talk-in: 147.75/15. Madison Area Repeater Assn., Paul Toussaint N9VWH, 608-245-8890. E-Mail: n9vwh@arrl.net

Web: <http://www.qsl.net/mara/>

### APRIL 14-15

# CALENDAR

The Events Calendar is a free service for publicizing electronic events such as amateur radio hamfests, flea markets, etc. If your organization is sponsoring an event and would like a free listing, contact us at least 60 days in advance. 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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### Events Calendar

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706-838-4827.

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[www.gibraltartrade.com](http://www.gibraltartrade.com)

[ubs/msuarc/hamfest/ham-fest.htm](http://ubs/msuarc/hamfest/ham-fest.htm)

**NH - NASHUA** - Hamfest. Res Ctr Church. NE

Antique RC 617-923-2665

### APRIL 29

**AL - MOULTON** - Hamfest. H. A. Alexander Park, Court Street. 9am-4pm. VEC Testing. Talk-in: 53.17, 146.96 and 442.425. Bankhead ARC, Rex Free KN4CI, 256-905-0822.

Web: <http://www.hometead.com/n4idx>

**CA - SONOMA** - Hamfest. Sonoma Valley Veteran's Memorial Bldg., 126 1st St. W. 8am-12pm. VE Testing. Talk-in: 145.35, 600, PL 88.5. Valley of the Moon ARC, Darrel Jones WD6BOR, 707-996-4494

**IA - DES MOINES** - Hamfest. Des Moines RAA, Duane Bower WB0UCY, 515-287-6542. E-Mail: [duaneab@uswest.net](mailto:duaneab@uswest.net)

**IL - STICKNEY** - Hamfest. Hawthorne Race

Course, 3500 S. Cicero Ave. VE Testing. Talk-in: 145.25. DuPage ARC, 630-985-9256.

E-Mail: [DARChamfest@aol.com](mailto:DARChamfest@aol.com)

Web: <http://WWW.W9DUP.ORG>

**SC - SPARTANBURG** - Hamfest. County Fairgrounds, 275 W. Bishop St. 8am-3pm. Blue Ridge ARS, Inc., Robert G. Watson W4RGW, E-Mail: [w4rgw@arrl.net](mailto:w4rgw@arrl.net)

**TX - BELTON** - Hamfest. Bell County Expo Center. 7am-2pm. Talk-in: 146.820. MHz (PL 123.0). Temple ARC, Mike LeFan WA5EQQ, 254-773-3590. E-Mail: [hamexpo@tarc.org](mailto:hamexpo@tarc.org)

Web: <http://www.tarc.org>

### APRIL 30

**DE - NEW CASTLE** - State Convention. Nur Temple, Rt. 13. 8am-1pm. VE testing. Talk-in: 146.955 or 224.220/R. Penn-Del ARC, Hal Frantz KA3TWG, 302-793-1080.

E-Mail: [hfrantz@snip.net](mailto:hfrantz@snip.net)

Web: <http://www.maggpage.com/pennidel>

**IL - ARTHUR** - Hamfest. Moultrie/Douglas

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Web: [www.petertrapp.com](http://www.petertrapp.com)

County Fairgrounds. 8am-1pm. Talk-in: 146.055/146.655 & 449.275/444.275. Moultrie ARK, Ralph Zancha WC9V, 217-543-2178 days and 217-873-5287 eves.

E-Mail: [rzancha@one-eleven.net](mailto:rzancha@one-eleven.net)

**IL - GALVA** - Hamfest. Galva National Guard Armory. 8am-2pm. VE Testing. Area Amateur Radio Operators Club, Bill Anderson WA9BA, 309-932-3023. E-Mail: [bill@inw.net](mailto:bill@inw.net)

Web: <http://www.qsl.net/aaro/index.html>

**OH - ATHENS** - Hamfest. Athens Recreation Center. 8am-2pm. Talk-in: 145.15(-). Athens County ARA, John Cornwell NC8V, 740-593-6474. E-Mail: [jcornwell@eureknet.com](mailto:jcornwell@eureknet.com) Web: <http://www.seorh.ohio.edu/~xx017/hamfest.html>

**PA - WASHINGTON** - Hamfest. WACOM, Dave DeMotte N3IDH, 724-228-8178. E-Mail: [n3idh@bellatlantic.net](mailto:n3idh@bellatlantic.net)

## MAY 2000

### MAY 5-6

**LA - BATON ROUGE** - State Convention. Baker Civic Auditorium, 3325 Groom Rd. VE Testing. Baton Rouge ARC, Herb Ramey W5LSU, 225-654-6087. E-Mail: [W5GIX@AOL.COM](mailto:W5GIX@AOL.COM)

Web: <http://www.barc.org>

### MAY 6

**AR - SILOAM SPRINGS** - Hamfest. St. Mary's Catholic Church, 1996 Hwy. 412 E. 8am-3pm. Talk-in: 146.67. Siloam Springs ARC, Matt Hyde N5UYK, 501-524-4797

**AZ - SIERRA VISTA** - Hamfest. Cochise ARA, Raymond Berger WILYT, 520-378-4214

**CO - MONUMENT** - Hamfest. Lewis-Palmer High School, 1300 Higby Rd. 8am-2pm. Talk-in: 146.970 (100Hz) or 146.520 simplex. Pikes Peak

RAA, Robert Ryals K10GF, 719-265-9950.



# Events CALENDAR

E-Mail: rryals@pcisys.net  
Web: <http://www.qsl.net/ppraa/swapfest.htm>  
**KY - LOUISA** - Hamfest. Louisa Middle School.  
Talk-in: 147.390+ repeater. Big Sandy ARC, Fred Jones WA4SWF, 606-638-9049. E-Mail: wa4swf@arll.net Web: <http://qsl.net/wa4swf/>  
**MI - CADILLAC** - Hamfest. Wexauke ARC, Alton McConnell N08L, 231-862-3774.  
E-Mail: amcconnell3@hotmail.com  
**WI - CEDARBURG** - Hamfest. Ozaukee RC, Joe Holly AA9HR, 262-377-2137. E-Mail: aa9hr@execpc.com. Skip Douglas, 262-284-3271

**MAY 6-7**

**AL - BIRMINGHAM** - Hamfest. Glenn Glass KE4YZK, 205-681-5019.

E-Mail: ke4yzk@bellsouth.net Web: <http://www.bro.net/barc/slideshow/index.html>  
**NJ - EDISON** - Trenton Computer Festival. NJ Convention & Exposition Center, Raritan Center. KGP Productions, Inc., 1-800-631-0062.  
E-Mail: kgp@mail.com Web: <http://pcshow.com>  
**TX - ABILENE** - Hamfest. Abilene Civic Center. Sat: 8am-5pm, Sun: 9am-2pm. VE Testing. Talk-in: 146.160/760. The Key City ARC, Peg Richard KA4JPA, 915-672-8889. E-Mail: ka4upa@arll.net

**MAY 7**

**IL - SANDWICH** - Hamfest. Sandwich Fairgrounds, 8am-2pm. Talk-in: 146.730- or 146.52 simplex. Kishwaukee ARC, Bob Yurs W9ICU, 815-895-3219.

E-Mail: w9icu@tbcnet.com Web: <http://www.tbcnet.com/~jleonard/hamfest.htm>  
**MD - HAGERSTOWN** - Hamfest. Hagerstown Community College Recreation Center. VE Testing. Talk-in: 146.94 & 147.09. Antietam RA, Inc., Tina Jones KB8ZQM, 304-728-7769.  
E-Mail: kb8zqm@intrepid.net Web: <http://www.qsl.net/w3cwc>  
**NY - YONKERS** - Flea Market. Lincoln High School, Kneeland Ave. 9am-3pm. VE Exams. Talk-in: 440.425 PL 156.7, 223.760 PL 67.0, 146.910, 443.350 PL 156.7, Metro 70cm Network, Otto Supliski WB2SLQ, 914-969-1053.  
E-Mail: wb2slq@juno.com Web: <http://www.metro70cmnetwork.com>  
**PA - WRIGHTSTOWN** - Hamfest. Middletown

Grange Fairgrounds. Talk-in: 147.09 and 443.950. Warminster ARC, Roy Conners K3TEN, 215-974-9373. E-Mail: k3ten@arll.net Web: <http://www.voicenet.com/~k3dn>

**MAY 12-13**

**NH - ROCHESTER** - Hamfest. Fairgrounds. Hoss Traders, Joe, 207-469-3492

**MAY 13**

**CA - FONTANA** - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves

**MAY 13-14**

**CA - FERNDALE** - Hamfest. Humboldt ARC, Marcy Campbell KE6IAU, 707-442-3866.  
E-Mail: marcidon@quik.com

Web: <http://www.humboldt.com>  
**WA - YAKIMA** - State Convention. Masonic Center, 510 N. Naches Ave. Sat: 9am-4pm, Sun: 9am-1pm. VE Testing. Yakima ARC, Jack Wrenn N7KNO, 509-249-0897. E-Mail: n7kno@arll.net Web: <http://eagle.ykm.com/~w7aq/hamfest.html>

**MAY 19-20-21**

**OH - DAYTON** - ARRL National Convention. Dayton ARA, Dave Coons W7HW, 937-849-0604. E-Mail: wt8w@arll.org Web: <http://www.hamvention.org>

**MAY 20-21**

**IL - ELGIN** - CoCoFEST. Elgin Plaza Hotel, 345 W. River Rd. Tony Podraza 847-428-3576. E-Mail: tonypodraza@juno.com

**MAY 21**

**MA - CAMBRIDGE** - Flea at MIT. Albany and Main Sts. 9am-2pm. Talk-in: 146.52 & 449.725/444.725 W1XM/R PL 114.8 (2A). Nick Altenbernd KA1MQX, 617-253-3776 (9-5). Web: <http://web.mit.edu/w1mx/www/swapfest.html>

**MAY 26-27**

**MS - PASCAGOULA** - Hamfest. Civic Center, Jackson County Fairgrounds. Fri: 5-9pm, Sat: 8am-2pm. VE testing. Talk-in: W5WA 145.110. Jackson County ARC, Charles F. Kimmerly N5XGI, 228-826-5811.  
E-Mail: montehat@datasync.com

**MAY 27**

**KY - DAWSON SPRINGS** - Pennyroyal Area Tailgatefest 2000. Dawson Springs ARC, Princeton ARS, Hopkins County AREA, & Pennyroyal ARS, Curt Beshear KE4UZE, 270-797-9117. E-Mail: ke4uze@spis.net  
**NC - DURHAM** - Hamfest. South Square Mall. 8am-3pm. FCC Exams. Talk-in: 147.225+.  
Durham FM Assn., Joseph Fields KF4QYV, 919-596-3738. Web: <http://www.vramp.net/~dfma/>

**MAY 27-28**

**WY - CASPER** - State Convention. Radisson Inn. Casper ARC, Warren (Rev) Morton W57W, 307-235-2799 or 307-237-9301. E-Mail: mortonwg@aol.com Web: <http://w3.trib.com/~c-arc/hamfest.html>

**MAY 28**

**MD - WEST FRIENDSHIP** - Hamfest. Howard County Fairgrounds. 8am-2:30pm. Talk-in: 146.76, 224.76, 444.00. Maryland FM Assn., Mike WA3TID, 410-923-3829

## JUNE 2000

**JUNE 2-3-4**

**NY - ROCHESTER** - Convention. Monroe County Fairgrounds, Rt. 15A. Fri: 12pm-5:30pm, Sat: 8:30am-5:30pm, Sun: 8:30am-1:30pm. Harold Smith K2HC, 716-424-7184. E-Mail: rochfst@frontiernet.net Web: <http://www.rochesterhamfest.org>

**JUNE 3**

**IL - SPRINGFIELD** - Hamfest. State Fairgrounds, Gate 11. VE Testing. Talk-in: 146.685-. Sangamon Valley RC, Edmund Gaffney KA9ETP, 217-628-3697. E-Mail: egaffney@family-net.net Web: <http://www.w9dua.net>

**ME - HERMON** - Hamfest. Pine State ARC, Edward Richardson K1DTW, 207-825-4417. E-Mail: edandglo@earthlink.net

**MI - GRAND RAPIDS** - Hamfest. Hudsonville Fairgrounds. VE Testing. Talk-in: 147.16. Independent Repeater Assn., Kathy KB8KZH, 616-698-6627 between 4-7pm Eastern. Web: <http://www.iserv.net/~w8hvg>

**NJ - TEANECK** - Hamfest. Fairleigh Dickinson University. 8am-2pm. Talk-in: 146.19/79. Bergen ARA, James Joyce K2ZO, 201-664-6725. E-Mail: hamfest@bara.org Web: <http://www.bara.org>

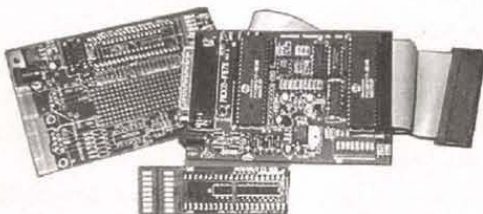
**JUNE 3-4**

**OR - SEASIDE** - Northwestern Division ARRL Convention. Convention Center. VE testing. Talk-in: 146.660 (-600). SEAPAC, Randy Stimson KZ7T, 503-297-1175. Web: [www.seapac.org](http://www.seapac.org)

**JUNE 4**

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# Events CALENDAR

**IL - PRINCETON** - Hamfest. Bureau County Fairgrounds. Talk-in: 146.955-600 PL 103.5. Starved Rock Radio Club, Alan Erberderis N9PIB, 815-498-9675. E-Mail: erb.n9pi@junol.com Web: <http://www.qsl.net/w9mks/hamfest/htm>

**PA - BUTLER** - Hamfest. Butler Farm Show Grounds, 8am-4pm. Talk-in: 147.96/36. Breezeshooters ARC, H. Rey Whanger W3BIS, 412-826-8006. E-Mail: w3bis@breezeshooters.net Web: <http://www.breezeshooters.net>

**VA - MANASSAS** - Hamfest. Prince William County Fairgrounds. Talk-in: 146.97-, 224.660-, 442.200+. Ole Virginia Hams ARC, Jack McDermott N4YIC, 703-335-9139. E-Mail: N4YIC@arrl.net or patnjack@erols.com Web: <http://www.qsl.net/olevahams/>

## JUNE 9-10

**TX - ARLINGTON** - State Convention. HAM-COM, Maury Guzik W5BGP, 214-804-0680. E-Mail: chairman@hamcom.org Web: <http://www.hamcom.org>

## JUNE 10

**CA - FONTANA** - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves

**MO - MACON** - Hamfest. Macon Vo-Tech School. 8am-12pm. FCC Exams. Talk-in: 146.805(-). Macon County ARC, Dale Bagley K0KY, 660-385-3629. E-Mail: n0pr@arrl.net Web: <http://www.cyberusa.com/~kfoster/hamfest.htm>

**NC - WINSTON-SALEM** - Hamfest. Forsyth ARC, John Kippe N0KTY, 336-723-7388. Web: <http://members.xoom.com/w4nc/hamfest.htm>

**PA - BLOOMSBURG** - Eastern PA Section Convention. Bloomsburg Fairgrounds, 8am-3pm. VEC Testing. Talk-in: 147.225 (+600) and 146.52 simplex. Columbia-Montour ARC, George Law N3KYZ, 570-784-2299. E-Mail: n3kyz@epix.net Web: <http://www.bafn.org/~cmarc>

## JUNE 11

**IL - WHEATON** - Hamfest. Six Meter Club of Chicago, Joseph Gutwein WA9RIJ, 630-963-4922 or 708-442-4961. E-Mail: wa9rij@mc.net Web: <http://cyberconnect.com/orion/smcc.html>

**NY - BETHPAGE** - Hamfest. Long Island Mobile ARC, Ed Muro KC2AYC, 516-520-9311. E-Mail: hamfest@limarc.org Web: <http://www.limarc.org>

**OH - CANFIELD** - Hamfest. Twenty Over Nine ARC, Don Stoddard N8LNE. E-Mail: n8lne@junol.com

**OH - SUFFIELD** - Hamfest. Goodyear ARC, Fred Mealy KC8BQX, 330-665-4563. E-Mail: fmealy@earthlink.net

**TN - KNOXVILLE** - Convention. National Guard Armory, 3330 Sutherland Ave. 9am-4pm. VE Exams. Talk-in: 147.30+, 224.50-, 444.575-. RAC of Knoxville, David Bower K4PZT, 423-670-1503. E-Mail: rack@kornet.org Web: <http://www.kornet.org/rack>

## JUNE 17

**MO - HOUSTON** - Hamfest. Ozark Mountain Repeater Group, Blanche White NOFLR, 417-967-3000

**NJ - DUNELLEN** - Hamfest. Raritan Valley Radio Association, Fred Werner KB2HZO, 732-968-7789. E-Mail: wb2njh@aol.com Web: <http://www.w2qw.org>

## JUNE 18

**IN - CROWN POINT** - Hamfest. Lake County ARC, Rick Terpstra WN9Z, 219-696-8324. E-Mail: terpstra@netnetico.net

**MA - CAMBRIDGE** - Flea at MIT. Albany and Main Sts. 9am-2pm. Talk-in: 146.52 G 449.725/444.725 W1XMR/PL 114.8 (2A). Nick Altenbernd KA1MQX, 617-253-3776 (9-5). Web: <http://web.mit.edu/w1mx/www/swapfest.html>

**MI - MONROE** - Hamfest. Monroe County Radio Communications Assn., Fred VanDaele KA8EBI, 734-587-2250 or 734-242-9487. E-Mail: ka8ebi@arrl.net Web: <http://www.mcrca.org>

**OH - MACEDONIA** - Hamfest. Nordonina High School. 8am-1pm. Talk-in: 146.82(-) repeater. Cuyahoga ARC, Rich James N8FIL, 1-800-404-2282. E-Mail: n8fil@aol.com Web: <http://www.cars.org>

## JUNE 24-25

**CA - FERNDALE** - Hamfest. Humboldt ARC, Marcy Campbell KE6IAU, 707-442-3866. E-Mail: marcidon@quik.com Web: <http://www.humboldt.com>

## JULY 2000

### JULY 2

**PA - WILKES-BARRE** - Hamfest. Murgas ARC, Stanley Perry KE3TC, 570-735-2385. E-Mail: slperry@epix.net

### JULY 7-8-9

**UT - BRYCE CANYON** - State Convention. UT Hamfest Committee, Kathy Rudnicki N7JSH, 801-

547-9218. Web: <http://www.utahhamfest.org>

### JULY 8

**CA - FONTANA** - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves

**GA - GAINESVILLE** - State Convention. Georgia Mountains Center. 8:30am-3pm. VE Testing. Talk-in: 146.67(-). Lanierland ARC, Ken Johnson N24Q, 706-335-9658. E-Mail: nz4q@aol.com Web: <http://www.mindspring.com/~w4tl/hamfest.htm>

**IN - INDIANAPOLIS** - Central Division Convention. Indianapolis Hamfest Assn., Rick Ogan N9LRR, 317-257-4050. E-Mail: oganr@in.net Web: <http://www.indyhamfest.com>

**MO - KANSAS CITY** - Hamfest. PHD ARA, Bob Roske WA0CLR, 816-436-0069. E-Mail: wa0clr@worldnet.att.net Web: <http://members.tripod.com/~PHDARA/>

**NC - SALISBURY** - Hamfest. Salisbury Civic Center. VE Testing. Talk-in: 146.73 tone 94.8 and 146.52 simplex. Rowan ARC, Jim Morris KA4MPP, 704-278-4960 or Carol Maher W4CLM, 704-633-6603. E-Mail: rbrown@salisbury.net

**WI - OAK CREEK** - Hamfest. The American Legion Post 434, 9327 S. Shepard Ave. 6:30am-4pm. Talk-in: 146.52 simplex. South Milwaukee ARC, Bob Kastelic WB9TIK, 414-762-3235 days & early eves.

### JULY 9

**IL - PEOTONE** - Hamfest. Will County Fairgrounds. Talk-in: 146.94 (-600). Kankakee Area Radio Society, Don Kerouac K9NR, 815-939-7548. E-Mail: k9nr@junol.com Web: <http://www.w9az.com>

**PA - PITTSBURGH** - Hamfest. North Hills ARC, Keith Ostrom KB3ANK, 412-821-4135. Web: <http://www.nharc.pgh.pa.us>

### JULY 14-15-16

**MT - EAST GLACIER** - State Convention. Glacier/Waterton Int'l Hamfest Committee, Frank Phillips AC7AY, 406-273-2894. E-Mail: ac7ay@bigsky.net Web: <http://www.latech.com/hamfest/>

Continued on page 83

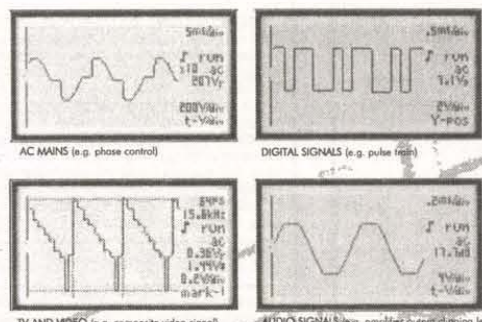
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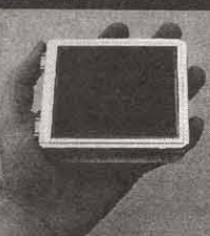
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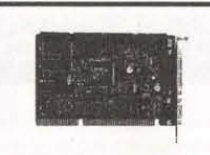
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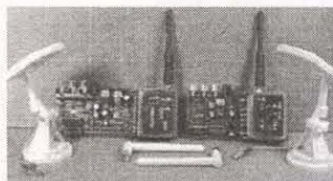
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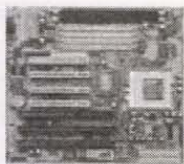
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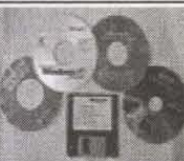




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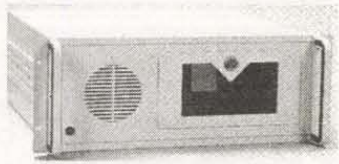


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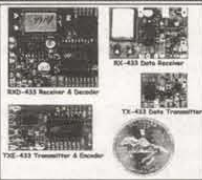
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We call them the 'Cubes'... Perfect video transmission from a transmitter you can hide under a quarter and only as thick as a stack of four pennies - that's a nickel in the picture! Transmits color or B&W with fantastic quality - almost like a direct wired connection to any TV tuned to cable channel 59. Crystal controlled for no frequency drift with performance that equals models that cost hundreds more! Basic 20 mW model transmits up to 300' while the high power 100 mW unit goes up to 1/4 mile. Their very light weight and size make them ideal for balloon and rocket launches, R/C models, robots - you name it! Units run on 9 volts and hook-up to most any CCD camera or standard video source. In fact, all of our cameras have been tested to mate perfectly with our Cubes and work great. Fully assembled - just hook-up power and you're on the air! One customer even put one on his dog!

C-2000, Basic Video Transmitter..... \$9.95 C-2001, High Power Video Transmitter..... \$17.95

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IR-1, IR Illuminator Kit for B&W cameras ..... \$24.95  
IB-1, Interface Board Kit ..... \$14.95

## AM Radio Transmitter

Operates in standard AM broadcast band. Pro version, AM-25, is synthesized for stable, no-drift frequency and is settable for high power output where regulations allow, typical range of 1-2 miles. Entry-level AM-1 is tunable, runs FCC maximum 100 mW, range 1/4 mile. Both accept line-level inputs from tape decks, CD players or mike inputs, run on 12 volts DC. Pro AM-25 includes AC power adapter, matching case and bottom loaded wire antenna. Entry-level AM-1 has an available matching case and knob set that dresses up the unit. Great sound, easy to build - you can be on the air in an evening!

AM-25, Professional AM Transmitter Kit..... \$129.95  
AM-1, Entry level AM Radio Transmitter Kit..... \$29.95  
CAM, Matching Case Set for AM-1..... \$14.95

## Mini Radio Receivers

Imagine the fun of tuning into aircraft a hundred miles away, the local police/fire department, ham operators, or how about Radio Moscow or the BBC in London? Now imagine doing this on a little radio you built yourself - in just an evening! These popular little receivers are the nuts for catching all the action on the local ham, aircraft, standard FM broadcast radio, shortwave or WWV National Time Standard radio bands. Pick the receiver of your choice, each easy to build, sensitive receiver has plenty of crystal clear audio to drive any speaker or earphone. Easy one evening assembly, run on 9 volt battery, all have squelch except for shortwave and FM broadcast receiver which has subcarrier output for hook-up to our SCA adapter. The SCA-1 will tune in commercial-free music and other 'hidden' special services when connected to FM receiver. Add our snazzy matching case and knob set for that smart finished look!

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FR-6, 6 Meter FM Ham Band Kit ..... \$34.95  
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Matching Case Set (specify for which kit) ..... \$14.95

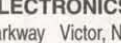
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Easy to use programmer for the PIC16C84, 16F84, 16F83 microcontrollers by Microchip. All software - editor, assembler, run and program - as well as free updates available on Ramsey download site! This is the popular unit designed by Michael Covington and featured in Electronics Now, September 1998. Connects to your parallel port and includes the great looking matching case, knob set and AC power supply. Start programming those really neat microcontrollers now...order your PICPRO today!

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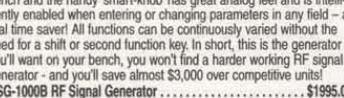


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RS-1000B RF Signal Generator ..... \$1995.00



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FM-100, Pro FM Stereo Transmitter Kit ..... \$249.95

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LPA-1WT, Fully Wired LPA-1 with Case ..... \$99.95  
FMBA-1, Outdoor Mast Mount Version of LPA-1 ..... \$59.95

## FM Station Antennas

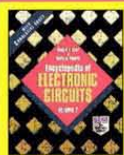
For maximum performance, a good antenna is needed. Choose our very popular dipole kit or the Comet, a factory made 5/8 wave, coilinear model with 3.4 dB gain. Both work great with any FM receiver or transmitter.

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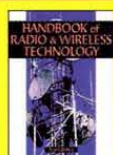




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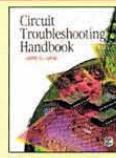
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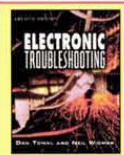
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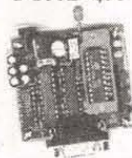
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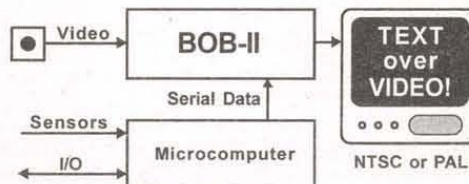
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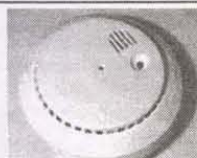
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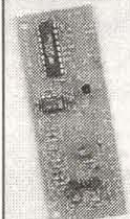
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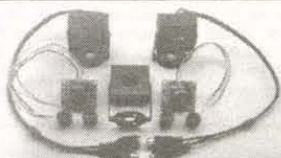
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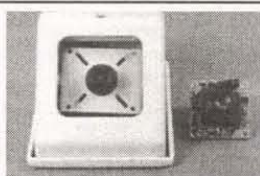
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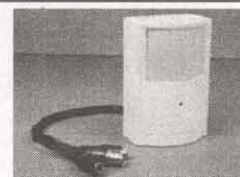
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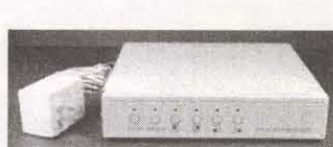
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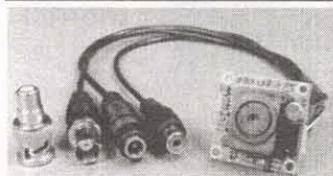


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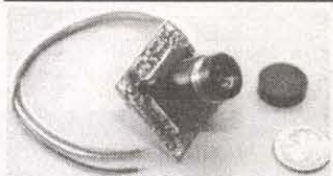
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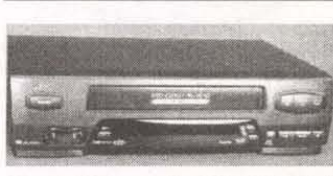
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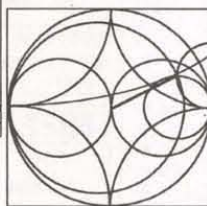
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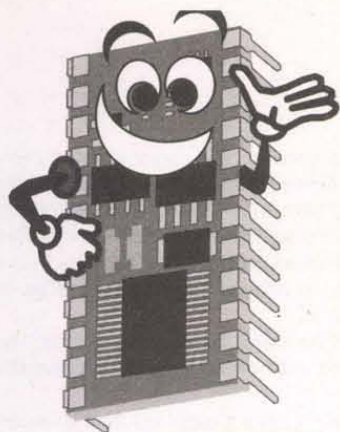
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Plug end-to-end.

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by Jon Williams

# Stamp Applications

## Calling All Stamps

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

**I remember my first modem ... What a beauty: a 300-baud brick of a device that plugged right into the back of my trusty Commodore 64. On its first day of operation, I used that modem to chat with my friend, Bruce, who lived about 20 miles away. We stayed up almost all night typing messages back and forth to each other. It was horribly inefficient — as far as communication goes — but it was just so darned cool; our computers could talk to each other. Not long thereafter, we discovered uploading and downloading. The world had suddenly become a much brighter place.**

Today, modems are ubiquitous and we take them for granted. Our access to the Internet is enabled with modems and yet, we hardly give it a thought. I write these articles in Texas and, using my modem, send them off to California for publication. The point is, our big blue world has been made quite a bit smaller by connecting devices with modems. So ... how might we use one with a Stamp?

The BASIC Stamp is a great tool for data collection and control. Its ease of programming, I/O, and built-in serial capabilities make it a great lab tool that can be connected to a host PC. But what if the Stamp data-collector and the PC are not located in the same room or, better yet, you want to talk to several remote devices?

As we've seen, it's really not a problem; all we need is a modem. There are applications all over the Internet that demonstrate connecting a modem to the Stamp. The problem, thus far, has been packaging. How does one neatly package a salvaged modem with the Stamp? It can be a bit tricky, especially if you want one nice, neat, small box in your remote location.

A California-based company called Cermetek ([www.cermetek.com](http://www.cermetek.com)) has solved the packaging problem with their line of embedded modems. These modems are very small — not much bigger than a BS2. And, like the BS2, they're configured as DIP (albeit 0.8") packages. The modem that we'll use in our application is the Cermetek CH1786, which is available in an App Kit directly from Parallax.

### CH1786 Basics

For review, the purpose of a modem is to allow two computers to "talk" to each other over some form of remote connection; usually, but certainly not limited to, telephone lines. In its most basic form, this is accomplished by converting the serial stream of ones

and zeros to tones that are compatible with telephone line standards. This is called modulation. The receiving modem converts these tones back to ones and zeros. This is called demodulation. Hence, the term, modem. It's a contraction for modulation/demodulation.

Phone modems also provide an important electrical interface to the telephone line. This is called a Data Access Arrangement (DAA). Keep in mind that the telephone companies are justifiably fussy about devices that are connected to their lines. The CH1786 includes an FCC approved DAA. Even with the approved DAA, it is recommended that protective devices be installed between the modem and the telephone jack. That will reduce the chance of a surge coming in from the telephone lines (pretty common occurrence in high-lightning areas) from damaging the CH1786. The nice thing about using the Cermetek modem is that you can put it into a commercial device without going through the rigors and considerable expense of an FCC evaluation.

Like the Stamp, modems are "smart" devices and will respond to commands. The CH1786 is no exception. The list of commands is referred to as the "AT" (for attention) command set and was originally developed by Hayes for its modems. All modem manufacturers have adopted the AT command set (with modifications). With the sophistication of current modems, the AT command set is very broad and, unfortunately, not always universal. Thankfully, we only need a few of the basic commands for our project.

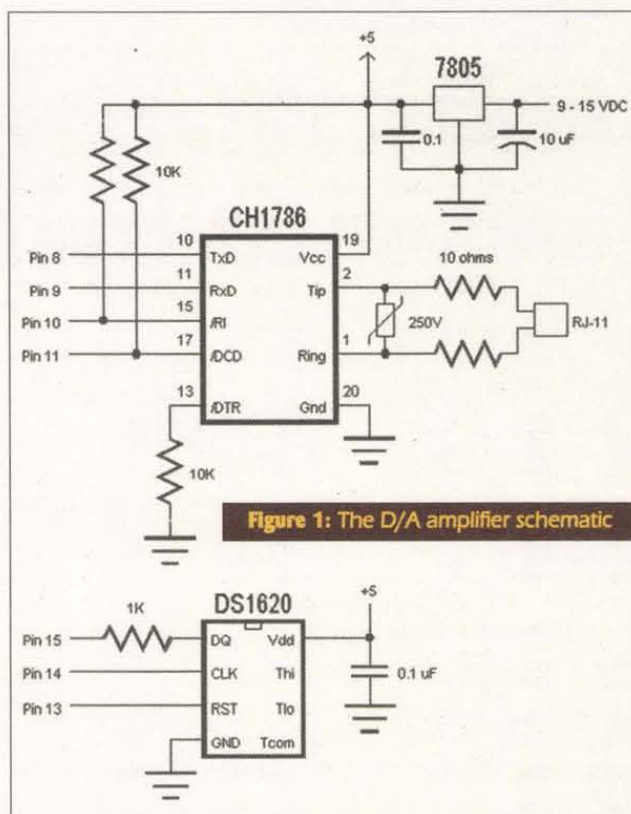


Figure 1: The D/A amplifier schematic



# STAMP APPLICATIONS

## Calling All Stamps

### Our Project: A Remote Temperature Monitor

Our demonstration project is a simple recording thermometer — a remote recording thermometer. It constantly scans a Dallas Semiconductor DS1620 digital thermometer and records the current, high, and low values. We'll get the data from the Stamp by calling it with a terminal program.

When a call is detected by the modem, the line is answered and the temperature information is sent to the user's remote terminal. From the remote location, the user is able to refresh the temperature display and even reset the stored high and low temperature values.

To keep things simple, we'll use a general-purpose terminal program (such as Windows® Terminal) as our remote access. But keep in mind that your terminal program does not have to run on Windows®. That's one of the neat things about the remote contact part of this project: the user can be running any operating system. The only requirements of the terminal program are that it runs ANSI emulation and can dial into your Stamp project through the remote computer's phone modem.

### About the Circuit

With my typical adherence to the "KISS" theory (Keep It Simple, Silly), the circuit is very straightforward. Four lines are used to connect the Stamp to the CH1786: TX (transmit), RX (receive), RI (ring indication), and DCD (data carrier detect).

A quick scan through the code will show that we're not even using the Ring Indicator — it's there for possible future use.

The reason is because the RI line does not go low and stay low during the ring, it actually pulses (low-high transitions) at a 20 to 30 Hz rate (corresponds with the ringing sound and is probably there to allow your processor to detect distinctive ringing where available). The code includes a short sub-routine for dealing with the pulsing RI line should you want to use this input in your projects (more later).

So how will we know when the user is calling? The DCD line will tell us. This input goes low when the remote user has called in and the two

modems are "hooked up." It's very convenient. You might wonder then, why bother with the Ring Indicator? One possible reason is to use it as a sort of warning. By detecting the ring, critical processes could be finished before the modem answers and has to deal with the remote connection. You might also decide to ignore a call based on current conditions. In our case, we're going to tell the modem to answer the phone and let us know when everything is connected.

The DS1620 is connected with a standard three-wire interface. The clock and data signals can be shared with other devices that use the same three-wire bus.

Also notice that an external power supply is required. This is important. In operation, the modem draws more current than the Stamp can provide. A simple three-terminal regulator gives us the necessary five volts from a junk-box DC power supply.

### The Software

The general structure of the software is a task switcher. In operation, a task switcher works like this:

- Do maintenance
- Do a task
- Do maintenance
- Do another task ...

This design allows the program to be broken up into small, manageable tasks that don't take a long time to run. This is important in our design since we want to keep tabs on the DCD indication. We'll put that in the maintenance section.

When using the task switcher design, there are two choices for updating the task control variable: in the maintenance section (before the **BRANCH** command) or individually within each task. The method used here is the latter; the task variable is updated by the current task. This allows the system to be more dynamic. For example, a task might use the state of an input pin to determine which task will run next.

To new programmers, designing a program in this manner may

' Nuts & Volts - Stamp Applications				FF	CON	12	' form feed (clear remote screen)
' April 2000				' DS1620 commands			
' -----[ Title ]-----				RTmp	CON	\$AA	' read temperature
' File..... CERMETEK.BS2				WTHi	CON	\$01	' write TH (high temp register)
' Purpose... Cermetek CH1786 demo program				WTLo	CON	\$02	' write TL (low temp register)
' Author.... Jon Williams				RTHi	CON	\$A1	' read TH
' E-mail.... jonwms@aol.com				RTLo	CON	\$A2	' read TL
' -----[ Program Description ]-----				Strt	CON	\$EE	' start conversion
' This program monitors a Dallas Semiconductor DS1620 digital thermometer				StpC	CON	\$22	' stop conversion
' while waiting for an incoming call. When a call is received, the Stamp				WCfg	CON	\$0C	' write configuration register
' causes the modem to answer the call then displays temperature data on				RCfg	CON	\$AC	' read configuration register
' the remote terminal.				NtTasks	CON	3	' total number of tasks
' -----[ I/O Definitions ]-----				' -----[ Variables ]-----			
' modem pins				tmpIn	VAR	Word	' 9-bit temp input from DS1620
TX1	CON	8	' transmit to modem	nFlag	VAR	tmpIn.Bit8	' negative flag
RX1	CON	9	' receive from modem	hlfBit	VAR	tmpIn.Bit0	' half degree C bit
RI_	VAR	In10	' ring indicator	tempF	VAR	Word	' converted fahrenheit value
DCD_	VAR	In11	' carrier detect	tempC	VAR	Byte	' converted celcius value
' DS1620 pins				tmpNow	VAR	Word	' current temperature
Rst	CON	13	' DS1620.3	tmpLo	VAR	Word	' low temp
Clk	CON	14	' DS1620.2	tmpHi	VAR	Word	' high temp
DQ	CON	15	' DS1620.1	sign	VAR	Byte	' - for negative temps
' -----[ Constants ]-----				sLo	VAR	Byte	
True	CON	1		sHi	VAR	Byte	
False	CON	0		inByte	VAR	Byte	' input from user terminal
No	CON	1		cmd	VAR	Byte	' command pointer
Yes	CON	0		answer	VAR	Byte	' user response to prompt
T2400	CON	396	' 2400 baud for modem	task	VAR	Byte	' task control variable
LF	CON	10	' line feed character	riFltr	VAR	Byte	' for ring indicator filter
' -----[ EEPROM Data ]-----							



# STAMP APPLICATIONS

## Calling All Stamps

seem like a lot of work. It really isn't, once you've tried it and — I promise — it will make your programs easier to deal with as they become more sophisticated, and much more flexible when you need to make a design change.

All right, let's look at our code. We start by setting our **Dirs** (I/O direction) which, in this program, are not actually necessary because the various Stamp commands will set the pins appropriately. It's still a good idea though, if only a reminder to you as to what each pin is doing.

The saved high and low temperatures are set to their opposite extremes. We do this so that these values will be reset to the current temperature on the first scan of the DS1620.

Initializing the modem is handled in two sections. First, we train the modem for speed by sending "AT" and a carriage return at the baud rate we want to use (up to 2400 baud for the Cermetek CH1786). Since we're connecting directly to the modem, we use a "true" (non-inverted) connection. In the Constants section, you'll find we've defined T2400 to make the program easier to read.

Our **SEROUT** command to the modem includes the pacing parameter. This is important on command strings, especially when they get long (the CH1786 will allow up to 40 characters in a command string). If everything works, the modem should respond by sending back "OK." You'll see a **SERIN** line after our commands. This is to ensure the modem is working. If the modem does not respond with "OK" within two and a half seconds, the program will jump to a routine called **Error** (once we get past the initialization section, we'll assume the modem is fine and stop "listening" for "OK").

The error handler doesn't actually do anything except wait for one second, then jump back to the initialization section to try again. You could enhance this code by illuminating an error indicator. Just be sure to turn off your error indicator when the modem does initialize.

Most of a modem's behavior is controlled by values stored in what are called "S registers." There are dozens of S registers. Thankfully, we only need to worry about two. The first, S0, allows the modem to answer the phone line if set to a value greater than zero. We'll use two.

The second register that we're concerned with is S7. This register determines how long the modem will wait for a carrier from the remote

device once it's answered the phone. Thirty seconds should be long enough for the two devices to connect. Don't ignore this setting. I did while experimenting and found that when this register wasn't set, my project would never let go of the phone line when a call had been answered.

Once the modem is working, we'll fire-up the DS1620. Interestingly, it also communicates serially with the Stamp but, in this case, it's synchronous serial communications. What this means is that the Stamp must provide a clock signal with the data. The BS2 commands **SHIFTOUT** and **SHIFIN** take care of this very nicely.

The first thing we do with the DS1620 is tell it that we're writing to it. Once we've done that, we send the configuration byte. Our set-up is for use with a CPU (that is, we're going to retrieve data from it) and to use free-run mode (continuously scan temperature). With our configuration byte sent, we have to release the DS1620 momentarily so that it can be stored in the DS1620's EEPROM. This takes about 10 milliseconds. With that done, we send it the command to start running. Pretty easy stuff.

Okay, now we're into the heart of the code. The first part (maintenance section) gets the current temperature and updates the stored values. Calling **ScanT** does this. This routine connects with the DS1620 and retrieves the current temperature. The temperature comes back as a nine-bit value that is actually expressed in 0.5 degrees (Celsius) increments. In our program, a call to **GetF** will take care of the conversion to Fahrenheit. If you want to stick with Celsius, change the call to **GetC**. Both of these routines deal with converting the DS1620 data to whole number values and setting the sign appropriately. Once we've got our current temperature, we update stored high and low values, if necessary.

```

Terminal - STAMP.TRM
File Edit Settings Phone Transfers Help

=====
Remote Stamp - Station 001
=====

Temp (Now).... 73
Temp (Low).... 62
Temp (High)... 82

[T] Re-display current readings
[R] Reset high and low temps
[D] Disconnect

--> █
    
```

```

' -----[ Initialization ]-----
Init:  Dirs = %0110000100000000
      tmpLo = $FFFF ' start with opposite extremes
      tmpHi = 0

I_Modm: PAUSE 250 ' allow modem to power up

      ' train modem for speed
      SEROUT TX1, T2400, 10, ["AT", CR]
      SERIN  RX1, T2400, 2500, Error, [WAIT ("OK")]
      PAUSE 250

      ' auto answer on second ring (S0=2)
      ' set max time for carrier detect to 30 secs (S7=30)
      SEROUT TX1, T2400, 10, ["ATS0=2 S7=30", CR]
      SERIN  RX1, T2400, 2500, Error, [WAIT ("OK")]

I_1620: HIGH Rst ' alert the DS1620
      SHIFTOUT DQ, Clk, LSBFIRST, [Wcfg] ' write configuration
      ' use with CPU; free run mode
      SHIFTOUT DQ, Clk, LSBFIRST, [%00000010]
      LOW Rst
      PAUSE 10 ' pause for DS1620 EE write cycle
      HIGH Rst
      SHIFTOUT DQ, Clk, LSBFIRST, [Strt] ' start temp conversions
      LOW Rst

NoDCD: IF DCD_ = Yes THEN NoDCD ' make sure DCD is clear

' -----[ Main Code ]-----

Main:  GOSUB ScanT ' get current temperature
      IF DCD_ = Yes THEN GetMdm ' call received

      BRANCH task, [Task0, Task1, Task2]
      GOTO Main

Task0: ' task code here

      task = 1 ' select a specific task
      GOTO NextT ' go do it

Task1: ' task code here

      task = 2
      GOTO NextT

Task2: ' task code here

      task = 0
      GOTO NextT

NextT: ' task = task + 1 // NTasks ' round-robin to next task
      GOTO Main

      END

' -----[ Subroutines ]-----

' =====
' Modem Routines
' =====

' error with modem
' - structured as separate routine to allow user indications/enhancements

Error: ' additional code here
      PAUSE 1000
      GOTO I_Modm ' try to initialize again

GetMdm: PAUSE 5000 ' let other end get ready
Modm1:  GOSUB DoMenu ' show readings and menu
Get1:   SERIN RX1, T2400, [inByte] ' wait for input

      ' process user input
      cmd = 99
      ' convert letter to digit (0..5)
      LOOKDOWN inByte, ["tTrRdD"], cmd
      cmd = cmd / 2 ' fix for BRANCH
      ' branch to handler
      BRANCH cmd, [Cmd0, Cmd1, Cmd2]
      GOTO Modm1

Cmd0:  GOSUB ScanT ' get current temp
      GOTO Modm1

Cmd1:  GOSUB RstT ' reset high and low
    
```



# STAMP APPLICATIONS

## Calling All Stamps

Next, we check the DCD line. If it's low, the modem has answered and we can talk to the remote device. On detecting DCD, the program jumps to **GetMdm**. The first thing this does is pause a bit so that the other end can be ready. I found that some combinations of modems/terminal programs did not respond to the carrier detection as fast as the Stamp/CH1786. You may need to experiment with the **PAUSE** value.

With everything hooked up and ready, the Stamp sends a menu to the remote computer. The menu displays our current and stored temperature readings. With the menu displayed, the program waits for the remote user to press a key.

The key is decoded with a **LOOKDOWN** command. This code is simple and very effective. The first thing we do is set the variable **cmd** to a known bad value. **LOOKDOWN** will convert a valid key (upper or lower case) to a value from zero to five. If the key is not valid, **cmd** will not be changed. Since we only have three things to do, but have six possible **cmd** values, we divide the command by two. This fixes it for the **BRANCH** command. If the key was bad, **cmd** will not work in the **BRANCH** command (its value exceeds the range of options) and the program will loop back to get another key.

If the remote user presses "t" or "T," the program will go get the current temperature and redisplay the menu.

If the user presses "r" or "R," the program will prompt the user for a confirmation before resetting the stored high and low temperatures. The confirmation is handled by a routine called **YesNo**. This routine will display the prompt, "Are you sure? (Y/N) : " and then wait for up to five seconds for the user to respond. If the user does not respond or presses a key other than "y" or "Y," the answer variable is set to No and the program resumes.

The menu choice of "d" or "D" (for disconnect from session) is handled in the same manner.

### Extending the Project

There are several logical extensions to this simple project. The first would be the addition of a real-time clock (i.e., DS1302) to record the time and date of the high and low temperature values. The Stamp might

also collect the state of other inputs at the time of the temperature recordings. Finally, you might take advantage of the modem's ability to dial out by sending an emergency message to the user's pager (see below).

For advanced applications, a specialized terminal program could be developed. This would be simply for sending and receiving large amounts of data. Such a program could, for example, be set up to automatically poll the remote Stamps and record the readings to a hard disk. The RTCs in the remote units could be checked and automatically synchronized with the PC. The possibilities for custom applications are endless.

### Sending Data to a Pager

Access to most numeric pagers is incredibly easy: dial the pager service, wait for the service to be ready, then punch in a set of numbers on the telephone keypad. This can be accomplished with a modem. The trick is to keep the modem in "command" (dialing) state so that DTMF digits can be sent to the pager service. You can do this by adding a semi-colon to the end of the telephone number.

This bit of code will send "911" to a digital pager:

```
Pager: SEROUT TX1, T2400, 10, ["ATDT123-456-7890;", CR]
        PAUSE 10000 ' let service answer and get ready
        ' send the numbers
        SEROUT TX1, T2400, 10, ["ATDT911", CR]
        PAUSE 5000 ' let number be dialed
```

```
Cmd2: GOTO Modm1
      GOSUB Discon ' disconnect from user
      IF answer = No THEN Modm1 ' stay with user
      GOTO NoDCD ' back to the beginning

' clear remote terminal and display menu
DoMenu: SEROUT TX1, T2400, [FF]
        SEROUT TX1, T2400, ["=====", CR, LF]
        SEROUT TX1, T2400, ["Remote Stamp - Station 001", CR, LF]
        SEROUT TX1, T2400, ["=====", CR, LF]
        SEROUT TX1, T2400, [LF]
        SEROUT TX1, T2400, ["Temp (Now).... ", sign, DEC tmpNow, CR, LF]
        SEROUT TX1, T2400, ["Temp (Low).... ", sLo, DEC tmpLo, CR, LF]
        SEROUT TX1, T2400, ["Temp (High).... ", sHi, DEC tmpHi, CR, LF]
        SEROUT TX1, T2400, [LF]
        SEROUT TX1, T2400, ["[T] Re-display current readings", CR, LF]
        SEROUT TX1, T2400, ["[R] Reset high and low temps", CR, LF]
        SEROUT TX1, T2400, ["[D] Disconnect", CR, LF]
        SEROUT TX1, T2400, [LF, "--> "]
        RETURN

' reset high and low temperatures
RstT: SEROUT TX1, T2400, [CR, LF, LF, "Reset? "]
      GOSUB YesNo
      IF answer = No THEN RstX
      GOSUB ScanT
      tmpLo = tmpNow
      sLo = sign
      tmpHi = tmpNow
      sHi = sign
RstX: RETURN

' disconnect
Discon: SEROUT TX1, T2400, [CR, LF, LF, "Disconnect? "]
        GOSUB YesNo
        IF answer = No THEN DiscX
        SEROUT TX1, T2400, [CR, LF, LF, "Disconnecting.", CR, LF]

        ' return modem to command state
        ' and hang up
```

```
PAUSE 2000
SEROUT TX1, T2400, ["+++" ]
PAUSE 2000
SEROUT TX1, T2400, 10, ["ATH0", CR]
DiscX: RETURN

' confirm for [Y]es or [N]o
' and get user input (default = No)
YesNo: SEROUT TX1, T2400, ["Are you sure? (Y/N) : "]
        answer = No
        ' get answer
        ' - but only wait for 5 seconds
        SERIN RX1, T2400, 5000, YesNoX, [inByte]
        IF inByte = "y" THEN IsYes
        IF inByte = "Y" THEN IsYes
        GOTO YesNoX
IsYes: answer = Yes
YesNoX: RETURN

' process ring indicator
' - filters pulsing ring indicator
' - waits for about 0.25 second of no RI pulsing before returning
DoRing: ' your code here
        ' (i.e., count number of rings)
        RIWait: riFiltr = 0
        RIchk: IF RI_ = Yes THEN RIWait
                riFiltr = riFiltr + 1
                IF riFiltr > 50 THEN RIX
                PAUSE 5
                GOTO RIchk
        RIX: RETURN

        ' clear the "no pulses" counter
        ' still pulsing
        ' not pulsing, increment count
        ' RI clear now
        ' 5 ms between RI scans
        ' check again
        ' done - outta here

' =====
' DS1620 Routines
' =====

' get current temperature
' -- update high and low readings
```

### Resources:

**Jon Williams**  
3718 Valley View Lane, #3040  
Irving, TX 75062  
(972) 659-9090  
jonwms@aol.com

**Parallax**  
599 Menlo Drive, Suite 100  
Rocklin, CA 95756  
(888) 512-1024  
www.parallaxinc.com

**Cermetek**  
406 Tasman Drive  
Sunnyvale, CA 94089  
(408) 752-5000  
www.cermetek.com

For more information on the Cermetek modem, download files **ch1786.pdf** and **atcmd1.pdf** from the [www.nutsvolts.com](http://www.nutsvolts.com) ftp library.



## STAMP APPLICATIONS

### Calling All Stamps

```
SEROUT TX1, T2400, ["+++"]
PAUSE 2000
SEROUT TX1, T2400, 10, ["ATH0", CR] ' hang up
RETURN
```

Some pager services expect a terminating character (usually '#'). If this is the case with your service, simply add it to the message string:

```
SEROUT TX1, T2400, 10, ["ATDT911,#", CR]
```

The comma inserts a small delay (which is programmable in the modem through the S8 register) between the message numbers and the terminating character.

The code listing above is for example only; I don't suggest that you embed operational data this way. A better way to go would be to store your pager service number(s) and possible message in DATA statements. Then call a subroutine that points to the stored pager service number and message.

A final note on sending messages to pagers: Some paging services are finicky about DTMF dialing speed, that is, the duration of each digit in the dial string. The CH1786 has a default dialing speed of 95 milliseconds for each digit. This should work for most systems. If you find, however, that your system is not being dialed correctly or digits are missing from the transmission string, you can adjust the dialing speed with the S11 register. To change the dialing speed to 125 milliseconds, you can add this line to the modem initialization section:

```
SEROUT TX1, T2400, 10, ["ATS11=125", CR]
```

Sending text messages to an alphanumeric pager is a substantially

more involved procedure, so much so that it may not be possible to do with the current line of Stamps (I haven't tried myself). If you're interested, download the Telelocator Alphanumeric Protocol (TAP) from [www.motorola.com](http://www.motorola.com).

### Wrap Up

Just when you thought SERIN and SEROUT across wires on your bench was cool, we've demonstrated that connecting to a remote Stamp across a telephone network is pretty easy too. And, with Cermetek's line of embedded modems, professionally packaging our project is not an issue. As an example of what can be done with a Stamp 2 and a Cermetek modem, take a look at [www.hotwireftx.com](http://www.hotwireftx.com) ...

So what's next? Well, I've got some ideas but I'd really rather hear from you. Feel free to put your computer's modem to work and send your suggestions via E-Mail. **NV**

### Suggested Reading:

I consider these "must have" books for any Stamp programmer:

#### Programming And Customizing The Basic Stamp Computer

by Scott Edwards  
[www.seetron.com](http://www.seetron.com)  
ISBN 0-07-913684  
(paperback)

Also available from Parallax

Scott's book has a great project that allows you to control X-10 devices remotely using a modem and simple terminal program.

#### Serial Port Complete

by Jan Axelsson  
[www.lvr.com](http://www.lvr.com)  
ISBN 0-9650819-2-3

If you want to learn the nitty-gritty details of serial communications, this is the book for you. Everything you need to know to roll your own communications programs. It even has a large section devoted to Stamps.

```
ScanT: HIGH Rst ' alert the DS1620
SHIFTOUT DQ, Clk, LSBFIRST, [Rtmp] ' read temperature
SHIFTIN DQ, Clk, LSBPRE, [tmpIn/9] ' get the temperature
LOW Rst
GOSUB GetF ' convert to Fahrenheit
tmpNow = tmpF
IF (tmpLo < tmpNow) THEN THigh ' set new low
tmpLo = tmpNow
sLo = sign
THigh: IF (tmpHi > tmpNow) THEN TDone ' set new high
tmpHi = tmpNow
sHi = sign
TDone: RETURN

' convert reading from 1/2 degrees input (rounds up)
GetC: IF nFlag = 0 THEN CPos ' check negative bit (8)
sign = "-" ' set sign
tempC = -tmpIn / 2 + hlfBit ' if neg, take 2's compliment
GOTO CDone
CPos: sign = ""
```

```
tempC = tmpIn / 2 + hlfBit
CDone: RETURN

' convert (1/2 degrees C) to Fahrenheit with rounding
-- general equation (for whole degrees): F = C * 9 / 5 + 32

GetF: sign = ""
IF nFlag = 0 THEN FPos1
tmpIn = -tmpIn & $FF ' convert from negative
IF tmpIn < 36 THEN FPos0
FNeg: sign = "-"
tempF = tmpIn * 9 / 10 + hlfBit - 32
GOTO FDone
FPos0: tempF = 32 - (tmpIn * 9 / 10 + hlfBit)
GOTO FDone
FPos1: tempF = tmpIn * 9 / 10 + 32 + hlfBit
FDone: RETURN
```



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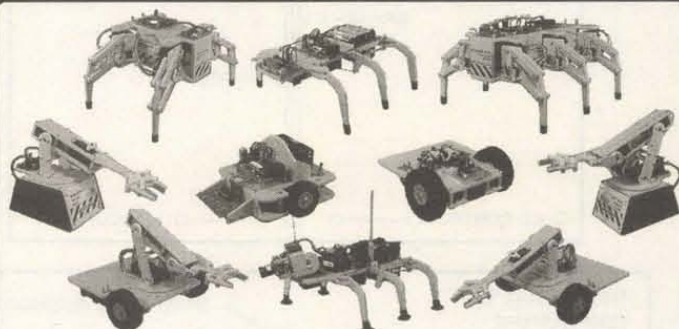
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For most people, the comfort zone is a fairly narrow temperature range centered more-or-less around 75 degrees F (23.9° C), which we often call "room temperature." Some of our electronic instruments are even more demanding. Crystal oscillators need a closely controlled temperature for best frequency stability. Standard cells and Zener diode voltage references also perform best in a temperature stable environment.

In this article, we'll take a cruise through this interesting realm and look at some of the devices we use to measure and control temperature. I have summarized the most pertinent information in a Comparison Table for easy reference.

# TEMPERATURE MEASUREMENT AND CONTROL

by Ron Tipton

## THE MECHANICAL THERMOSTAT

With the advent of electric utility companies, central heating and cooling started to appear in our living and work spaces. And we needed some means for automatically turning the heat or cooling on and off at our choice of temperature. The bimetallic strip thermostat was invented to do this job.

You can make a bimetallic strip by attaching to each other two strips of material with different expansion coefficients, such as brass and iron as shown in Figure 1. When the strip is heated, the brass lengthens more than the iron. This curls the strip away from the "cold" contact, breaking the circuit and turning off the heater. This simple mechanical device is so reliable that it's still a widely used temperature controller in homes and offices.

But this thermostat needs hysteresis (as do all on-off controllers). That is, when used for heating, the temperature at which

the contacts open must be higher than the temperature at which they close. This provides a "coarser" degree of control, but keeps the contacts from rapidly opening and closing at the set-point temperature. In fact, some early thermostats (1930s) didn't have any mechanical hysteresis and had to be used with a time delay to keep the heat on long enough to get a several degree control range. Hysteresis in a typical heat cycle is shown in Figure 2.

For cooling, the temperature at which the contacts open has to be lower than the temperature at which they close. This is done by using the common and "hot" contact as shown in Figure 1.

## MERCURY THERMOSTAT

Mercury has a pretty linear thermal expansion coefficient over the temperature range we're usually interested in, so mercury makes a good thermometer. Because of cost and environmental concerns, mercury has mostly been replaced by other fluids in "room" thermometers. But laboratory thermometers still use mercury although electronic units with comparable accuracy are available. Digital thermometers are easier to read, too.

Back in the 1960s, mercury column thermostats were sometimes used in lab applications. For example, they were used to control the temperature of the outer "box" in a two-stage constant temperature enclosure. Platinum wires were sealed into the glass capillary tube to make

electrical contact with the mercury column. They were very reliable as long as the current was kept small, generally less than five milliamperes, so arcing never occurs.

## THERMOCOUPLES

You can make a thermocouple by joining wires of different metals as illustrated in Figure 3. When the joints (or junctions) are at different temperatures, a voltage is produced which is proportional to the temperature difference.

Many kinds of wire can be used, but certain combinations have been standardized and there are tables of their output voltage vs. temperature (ANSI-MC96.1-1982). Two of the more common combinations are copper-Constantan (type T) and Chromel-Alumel (type K). Copper-Constantan has the advantage that the wires to the voltmeter can be low-resistance copper without introducing another junction between different metals.

Traditionally, the cold junction is held at 0° C in a melting ice bath and voltage-temperature tables are usually based on this assumption. But this is inconvenient (or impossible) in many applications, so the usual practice is to let the cold junction follow "room temperature" and compensate electronically for the difference above 0° C.

Thermocouples have a low output voltage (about 40 microvolts per degree C for type K) so they must be used with a stable, high input-resistance voltmeter or data acquisition system. But they are very rugged and are the only temperature sensor usable at very high temperatures — almost to the melting point of the wires. And, except for the types using an exotic metal (platinum), they are fairly inexpensive so their use continues.

## THERMISTORS

Thermistors are bulk-type passive semiconductors. That is, they are made of a homogenous material, usually metal oxides.

Figure 1 — Bimetallic strip thermostat. Brass and iron are shown in this sketch, but other combinations of metals can be used.

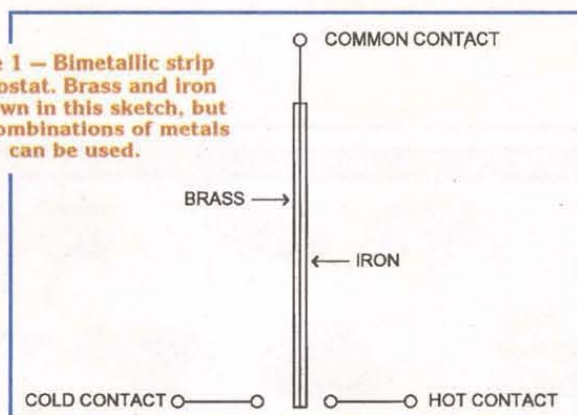
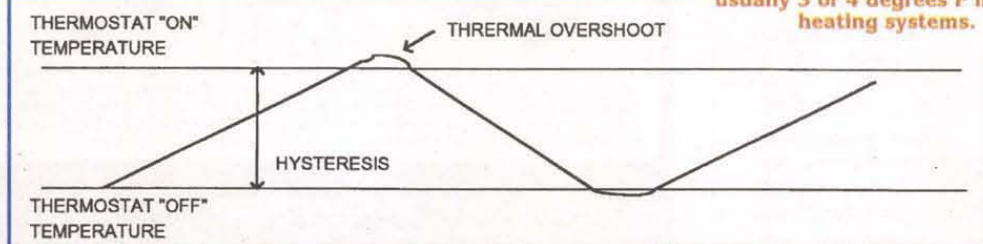
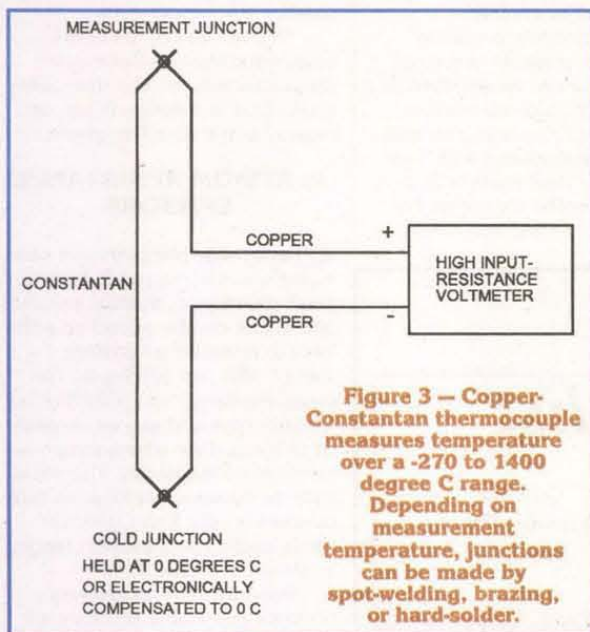


Figure 2 — Typical heat cycle showing thermostat's hysteresis, usually 3 or 4 degrees F in home heating systems.







They exhibit a large change in resistance for a relatively small change in body temperature. Negative temperature coefficient (NTC) thermistors are usually used for temperature measurement and control because of their larger thermal coefficient as compared to their positive temperature coefficient cousins.

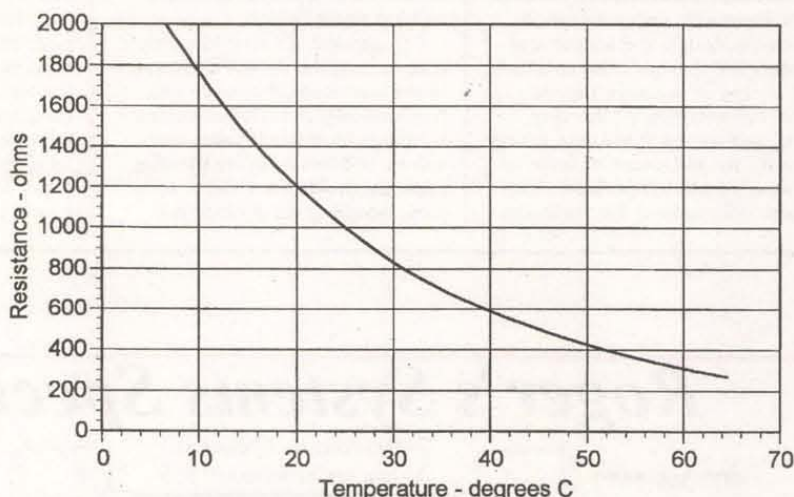
Because they are bulk devices, they can be fabricated in many shapes and sizes: from 0805 surface mount to large rods. Small beads and glass encapsulated probes are common in electronic applications. A typical resistance vs. temperature curve is included in Figure 4.

Thermistors have been the temperature measurement and control "work horse" for many years. They are rugged and inexpensive and about the only precaution in their use is to keep the current flow small enough to avoid self-heating. A thermometer can be as simple as an ohmmeter measuring the thermistor's resis-

tance. Instead of ohms, the meter can be calibrated in degrees Fahrenheit or Celsius.

Thermistors are also common as the sensing component in temperature control circuits for oscillators, etc. There are as many different controller circuits as there are designers with the circuits generally falling into one of two basic types. Type 1 is direct, proportional DC control; an example circuit is shown in Figure 5. Let's look at how it works.

When the circuit is turned on, the thermistor, R6, is "cold" and the differential input voltage applied to A1 is more than three volts. A1 has a gain of 100 so its output is driven into saturation, about 6.75 volts. The voltage at pin 5 of A2 is now about 0.39 volt due to the voltage divider R8, R9. The high open-loop gain of A2 forces the inverting input voltage (pin 6) to follow the pin 5 voltage. So A2 sends enough base current into Q1 to make the voltage drop across R10 (1.2 ohms) equal



**Figure 4 — Resistance-temperature curve for a typical NTC probe thermistor (Fenwal 121-102EAJ).**

about 0.39 volt. This is a Q1 collector current of about 325 milliamperes which heats Q1 and the enclosure it's attached to.

As the thermistor heats, its resistance goes down so there is less voltage drop across it. The A1 output voltage goes lower, so the A2 non-inverting (pin 5) input voltage goes lower. A2 supplies less base current to Q1 so its collector current goes down. Theoretically, the set-point is the temperature at which the voltages at pins 2 and 3 of amplifier A1 are equal. In practice, this is affected by the heat loss as set-point is approached. Good insulation is important.

R1 is a 5% resistor, but both R2 and R3 are one percenters. Also, I could see that R2 and R3 were hand-soldered to the foil side of the board. Commercial thermistors often have a 10% resistance tolerance so either you have to use a trimmer pot or hand-pick a resistor or two to get the desired set-point temperature.

In the second circuit type, the thermistor's resistance change varies an oscillator's pulse width.

This duty-cycle change produces a corresponding change in the average heater power. You may argue that this approach is less sensitive to DC drift than direct DC control. This is probably true, but well-designed circuits of both types perform well in commercial use.

In either type, the heating element can be one or more power transistors thermally connected to the enclosure to be controlled. The sensing thermistor can be epoxied or otherwise attached (mechanically and thermally) to the enclosure near the heater. An example of this construction is shown in the Figure 6 photo.

Sometimes the thermistor is merely placed on the controller PC board along with the other components. Then the board is placed inside the controlled enclosure. In this case, the thermistor is sensing the air temperature instead of the enclosure temperature. Although there may be a thermal gradient in the enclosure's air space, a stable temperature at the thermistor should indicate a stable temperature at the crystal or other critical

ANSI-MC96.1-1982, Thermocouple temperature/EMF tables  
**American National Standards Institute**  
 1430 Broadway, New York, NY 10018  
*(Portions of the tables are also reprinted in temperature sensor catalogs.)*

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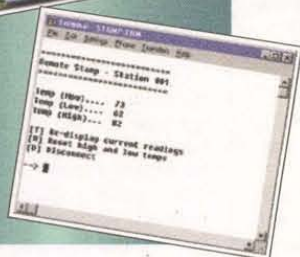
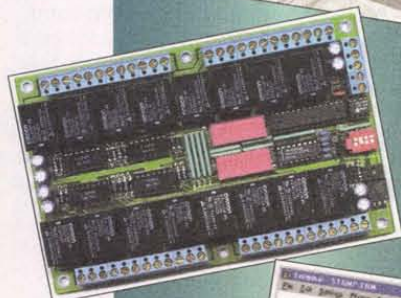
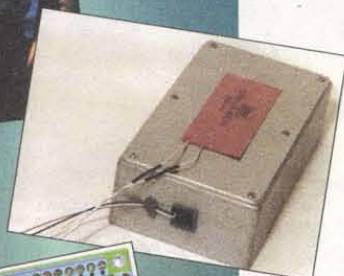
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component. However, there can be a problem with using still air to thermally couple the sensor and heater. The thermal time constant will be 10s of seconds, perhaps even 100 seconds. At the very least, this means it will take a long time for the enclosure to settle to its steady-state temperature. The heater will overheat the enclosure

because the sensor response is lagging so far behind.

In general, it's best to tightly couple both the sensor and heater to the enclosure, thermally and mechanically. A metal enclosure conducts heat much faster than still air and has a higher thermal capacity (holds more heat) so close coupling will provide the

best temperature control.

Flexible resistance heating pads are also available in a range of sizes. These can be attached to the inside or outside surfaces of the enclosure. Of course, the heated region is surrounded with insulation, usually rigid foam or fiberglass. This lessens the amount of heater power needed and helps

stabilize the temperature.

As you can see, there are many variations on thermistor-sensed enclosures. But this clearly shows that one design is not necessarily better than the others.

## PLATINUM RESISTANCE SENSORS

Small gauge platinum wire can be wound on a rod to form a small diameter cylindrical sensor or the wire can be wound on a flat form to resemble a "postage stamp" with two wire leads. The Minco Products, Inc., S32PB11 is the later type and can be cemented to the surface whose temperature is to be measured. The sensitivity or resistance change vs. temperature is very linear over the whole useful measurement range, as shown in Figure 7.

Platinum sensors are very accurate and stable and they are also rather expensive. But when you need precise measurement or control, this sensor is by far the best choice. Thin-film platinum sensors are available for applications with relaxed requirements at much lower cost. For example, the Minco Products S245PD12 has a resistance tolerance of  $\pm 0.12\%$  at zero degrees C at a small quantity price of only \$4.00. The thin-film repeatability and long-term stability are almost as good as those of their higher-priced relatives.

The National Institute of Science and Technology (NIST) used a platinum sensor to control the temperature of the inner enclosure for their standard cell groups. The temperature instability over periods of several days is less than  $0.00002^\circ\text{C}$  (20 microdegrees). Figure 8 shows a block diagram of this controller. So how does this circuit work?

The 400 Hz oscillator is a Wein bridge circuit with an amplitude drift of less than 0.005% so as to have negligible effect on the controlled temperature. The oscillator output drives a two-stage transformer with an electrostatic shield between the stages. A tapped auxiliary transformer provides the temperature adjustment by effectively varying the turns ratio between the two transformer stages. The transformer output is coupled to a 400 Hz bandpass filter through a platinum sensor, which is the temperature controller.

The bandpass filter reduces 60 Hz noise. The 400 Hz amplifier "block" is actually two opamps in cascade which provide 90 dB gain. This output goes to a phase-sensitive detector used as a rectifier. The DC amplifier provides the current gain to drive the heater.

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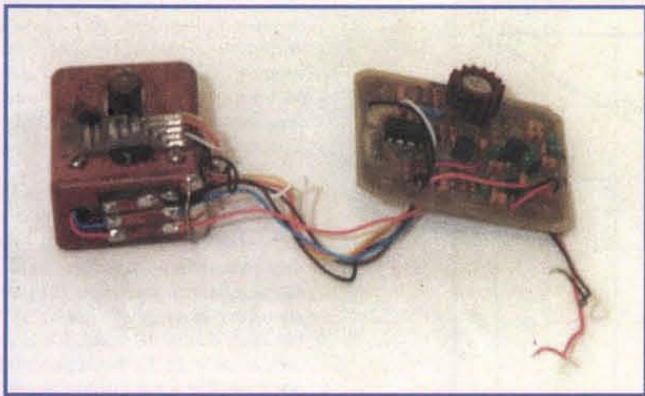


Figure 6 — Frequency control crystal oven showing the power transistor used as the heater and the temperature sensing thermistor.

Having most of the system gain at 400 Hz gives better overall stability than is possible with DC control.

### ACTIVE SOLID-STATE SENSORS

Over the last several years, many active solid-state temperature sensors have been introduced. Some have digital outputs while others are analog. The Dallas Semiconductor DS1620 is an example of the digital type and lends itself to building a digital-display thermometer (for an example, see the article in *Circuit Cellar* INK for June '95, page 72).

### ANALOG DEVICES TMP01

This sensor has a temperature-proportional output voltage and two user programmable temperature trip points. You can easily set an over and under-temperature logic output with three external resistors. These outputs will provide the hysteresis for an electronic thermostat, or sound an alarm, or open a relay. Of course, you also have the analog output for measurement or control.

This IC operates from a single supply voltage, 4.5 to 13 volts, and comes in an eight-pin DIP, SOIC surface mount, or TO-99 metal can. The metal can is especially easy to use because the chip die is thermally attached to the can. The DIP and SOIC aren't as convenient because the epoxy package is a rather good thermal insulator. Heat is primarily conducted to the die by the metal leads. So, if you are wanting to use this sensor to control an enclosure's temperature, how do you attach it?

You need good thermal contact to the usually metal enclosure, but you also need electrical insulation. One approach is to solder the

wire leads to the needed pins (three pins for temperature control) and then embed the sensor in a "glob" of thermally-conductive epoxy (such as Omega Bond OB-101) on the enclosure. This holds true for other eight-pin epoxy packages that need to be in good thermal contact with a surface.

The TMP01 can be used between -55 and +125°C with a typical accuracy of  $\pm 0.5^\circ\text{C}$  over this range. Its analog output voltage (VPTAT) is five millivolts per (degree) Kelvin which equals  $5\text{ mV} \times (\text{degrees C} + 273)$ , or about 1.49 volts at +25°C. Five millivolts per degree is a good signal level for short distances to the measurement or control circuit, but as the distance increases, resistance loss in the wire and noise pickup can degrade accuracy. Figure 9 shows a simple way to preserve low-error performance with a voltage-to-frequency converter. At the other end, the original analog voltage can be recovered with a frequency-to-voltage converter.

Analog Devices has a data sheet and design program for Microsoft Windows which will give you the details on choosing the external programming resistors. Free on request.

### ANALOG DEVICES TMP03

This three-terminal sensor has a serial digital output which consists of a squarewave with a variable duty cycle. This is illustrated in Figure 10. You can use a counter or microprocessor to measure the T2 time interval which is proportional to the temperature. A single-wire interface is about as

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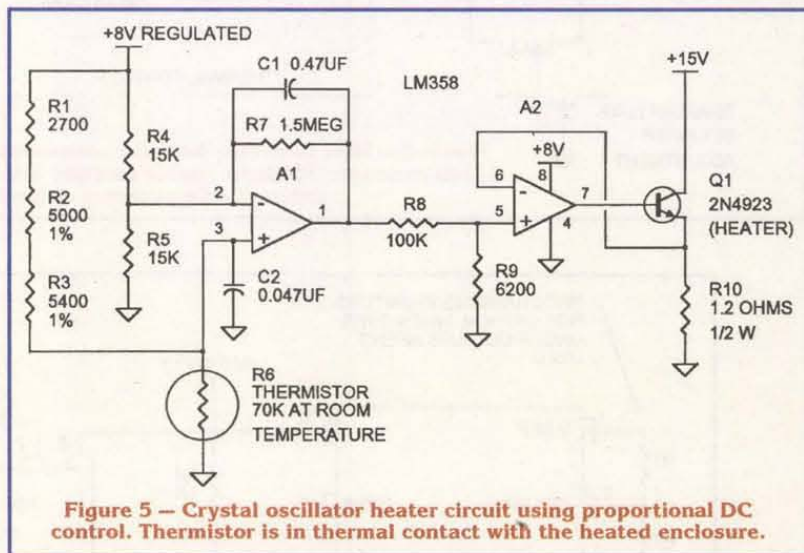


Figure 5 — Crystal oscillator heater circuit using proportional DC control. Thermistor is in thermal contact with the heated enclosure.

simple as it gets!

This sensor will operate from 4.5 to 7 volts and supply current is just 1.3 milliamperes maximum at five volts. The TMP03 comes in three epoxy packages: a TO-92, an eight-pin SOIC, and TSSOP surface mount. In the eight-pin units, five pins are unused.

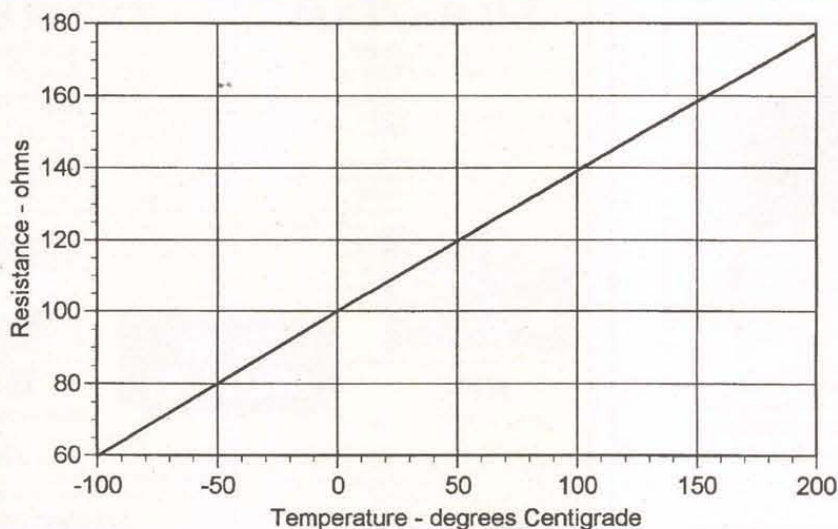
The TMP03 has an accuracy of  $\pm 4^\circ\text{C}$  maximum over its -25 to +100°C operating range so it's basically less accurate than the TMP01. However, its simple digital interface may compensate for its

lower accuracy. This article isn't meant to be a comprehensive survey of ALL active temperature sensors. For any measurement or control problem, get data sheets on every one you can find and compare the specs.

### NATIONAL SEMICONDUCTOR LM34, LM35, and LM45

These are all three-terminal sensors with an analog output voltage proportional to tempera-





**Figure 7 — Typical platinum resistance thermometer resistance-temperature curve (Minco Products type S32PB11). These sensors have excellent accuracy and stability.**

ture. The LM34 is calibrated in degrees Fahrenheit, and the LM35 in degrees Celsius. Both of these come in TO-46, TO-92, and surface mount SO-8 packages and they can be ordered from Digi-Key Corporation (see Resources list).

The LM45 is calibrated in degrees Celsius, has an output of 10 millivolts per degree over a temperature range of -20 to +100, and comes in a teeny-tiny SOT-23 surface mount package. It operates from a supply voltage between 4 and 10 volts. Its accuracy is only  $\pm 3^\circ\text{C}$ , but it seemed a good choice for a control application since stability is often more important than the actual temperature. The 10 mV per degree is a good, hefty signal to work with. Besides, I had a couple of free samples.

Earlier I mentioned that another type of controller used a variable pulse duty cycle to control the average heater power. I needed this type controller in a particular application because the circuit

becomes battery operated during power outages. On-off control of the amplifier that supplies the heater current is very efficient. This circuit is diagrammed in Figure 11. Let's take a look at how it works.

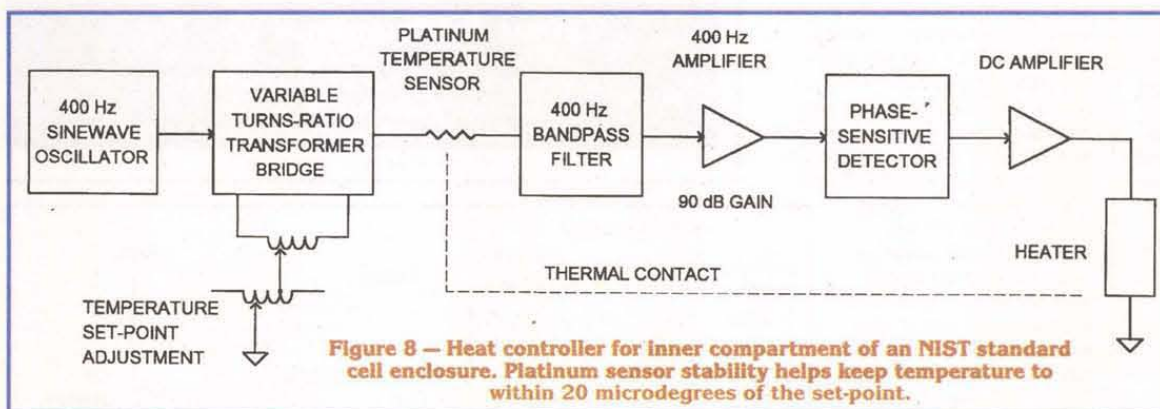
IC1 is connected as a low frequency oscillator (about 3 Hz) with a sawtooth output taken from pin 2. Q1 and its associated resistors (R1, R2, and R3) supply a constant current which makes the sawtooth ramp-up more linear than just using a single resistor.

The sawtooth is applied to the non-inverting IC3 input.

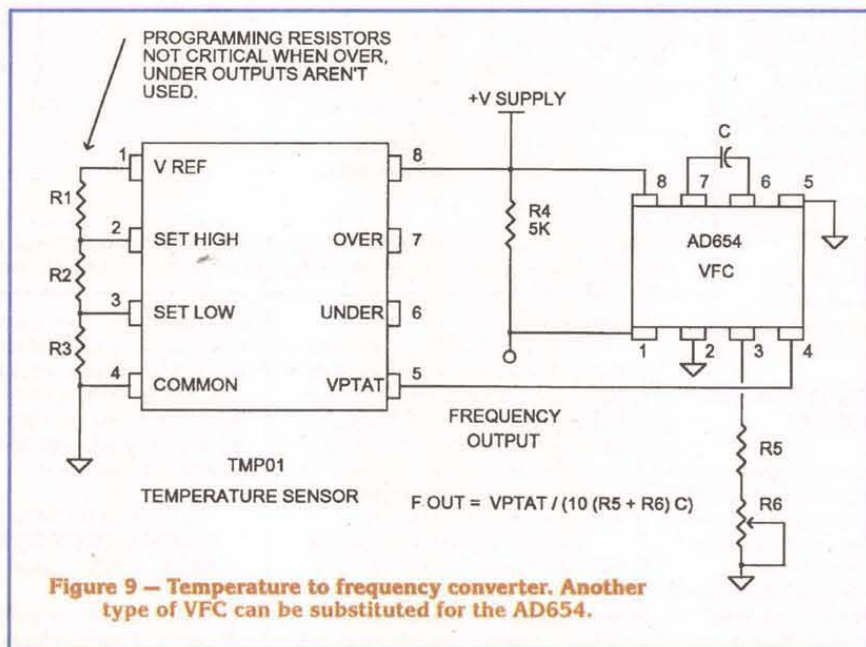
The amplified sensor voltage goes to the inverting input. IC3's output goes high whenever the sawtooth voltage equals or exceeds the sensor voltage at the inverting input. The result is a pulse whose width is proportional to the sensor temperature.

When the circuit is first turned on, the sensor is at room temperature and the sawtooth voltage is always higher than the sensor voltage. IC3's output stays high and maximum heater current flows through Q2. As the sensor heats, its output voltage goes up and the circuit goes into pulse mode. The dissipation in Q2 is very low because it is either on or off, and the power MOSFET has a very low on resistance.

The heater, shown as the flat rectangle in the Figure 12 photo, is a flexible stick-on unit with a resistance of about 55 ohms so maximum heater power is a low four watts. Heat up time is a very

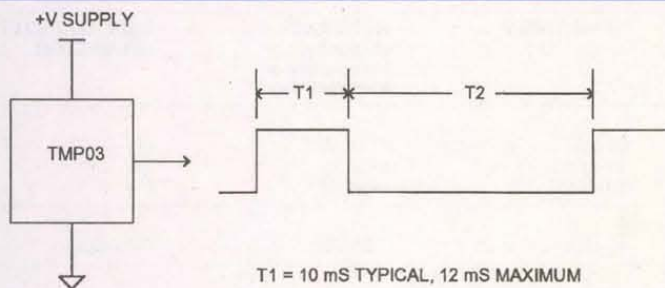


**Figure 8 — Heat controller for inner compartment of an NIST standard cell enclosure. Platinum sensor stability helps keep temperature to within 20 microdegrees of the set-point.**



**Figure 9 — Temperature to frequency converter. Another type of VFC can be substituted for the AD654.**





**Figure 10 — Analog Devices TMP03 temperature sensor serial output timing.**

$T1 = 10 \text{ mS TYPICAL, } 12 \text{ mS MAXIMUM}$   
 $\text{TEMPERATURE (DEGREES C)} = 235 - ((400 \times T1) / T2)$   
 IF  $T1$  AND  $T2$  ARE MEASURED WITH THE SAME CLOCK,  
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long several hours, but this circuit is intended to be on all the time so low power consumption seemed more important. The power decreases to about 1.2 watts at the set-point temperature in a box with three inches of rigid foam insulation on all sides.

Temperature stability after warm up is a "straight line" at my measurement resolution of  $0.05^\circ\text{C}$ .

The LM45C is soldered to a small PC board along with its three wire leads. Then I stuck it to one end of the aluminum enclosure, sensor towards the enclosure, with a bit of Bondo Plastic Metal (see photo). This stuff seems to work, as well as thermally conductive epoxy and it's available at your corner hardware store.

Set-point temperature is determined by the gain of amplifier IC2 and it's set by varying the resistance of  $R4$ , as shown in Figure 13.

Constant temperature control systems that are left on all the time should have an over temperature monitor. This can be as complex as using an LM75, which we'll be looking at next, or as simple as a mechanical thermostat which opens at a temperature 5 to 10 degrees higher than the set-point. A variety of thermostats can be found in the Elmwood Sensors catalog. Ask for a copy.

#### NATIONAL SEMICONDUCTOR LM75

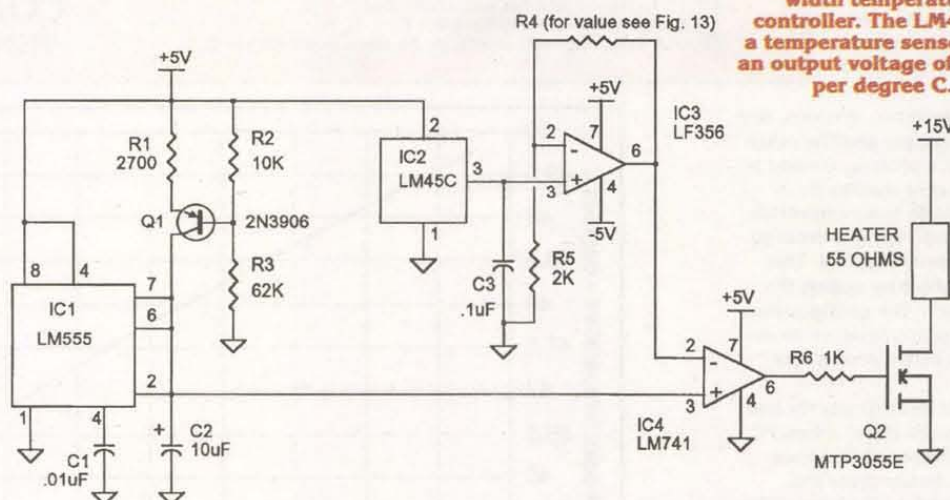
The LM75 is a temperature monitor, analog-to-digital converter, and digital over-temperature detector with a serial interface, all in a tiny eight-pin SO-8 surface mount package.

This sensor has a three line address input, so up to eight units can share an address bus. The host computer or microprocessor can program the over-temperature set-point and read out the temperature at any time over the serial interface. The temperature data

**Figure 12 — Flexible, stick-on heater and LM45C temperature sensor shown attached to a 7.5 x 4.3 x 2.4 inch aluminum enclosure. The LM45C is between the circuit board and the enclosure.**



**Figure 11 — Variable pulse width temperature controller. The LM45C is a temperature sensor with an output voltage of 10 mV per degree C.**



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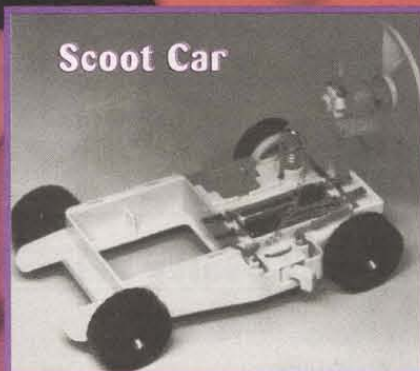
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 (page 82)



format is a nine-bit, two's complement word with the least significant bit equal to 0.5°C.

The LM75 can be used as an over-temperature protector by programming a host microprocessor to monitor the temperature and then sound an alarm — play "Dixie," light a lamp, or just open a relay to disconnect heater power if the limit is exceeded. Default over-temperature is set to 80°C on power-up, so this sensor can be used as a stand-alone thermostat at this setting. An independent over-temperature output is provided at pin 3.

Available in two versions, one for five-volt supply and the other for 3.3 volts, operating current is one milliamper maximum. A shutdown mode is also available which reduces supply current to one microampere typical. This mode is enabled by setting the shutdown bit in the configuration register. Over-temperature monitoring stays active during shutdown.

National Semiconductor had (and maybe still does) a free PC board with Microsoft Windows software to demonstrate the LM75's operation. A photo of the LM75 demo board and smaller LM60 demo board is shown in Figure 14.

Many active, solid-state sensors aren't even touched on here, but this is a representative sample. Collect all the data sheets and catalogs you can find and compare specs. Then the next time you have a temperature measurement or control problem, the information in this article will help get you pointed in the right direction. NV

SENSOR TYPE	USEFUL TEMPERATURE RANGE	SENSITIVITY	ACCURACY (Actually, inaccuracy or uncertainty)	REPEATABILITY (STABILITY)
Thermocouples				
Chromel-Constantan (type E)	-270 to 400°C	60 $\mu$ V/°C	$\pm 1$ to $\pm 5^\circ$ C	[1]
Chromel-Alumel (type K)	-270 to 1400°C	40 $\mu$ V/°C	$\pm 1$ to $\pm 5^\circ$ C	[1]
Copper-Constantan (type T)	-270 to 1400°C	40 $\mu$ V/°C	$\pm 1$ to $\pm 5^\circ$ C	[1]
Thermistors				
Fenwal 121-102EAJ (glass bead)	-100 to 300°C	40 ohms/°C at 25°C	0.25°C[2]	0.25°C[3]
Platinum Resistors				
Minco S245PD (thin film)	-70 to 400°C	0.4 ohm/°C	0.3°C	0.1°C
Minco S32PB	-62 to 220°C	0.4 ohm/°C	0.1°C	0.1°C
Reference thermometer	-180 to 500°C	0.4 ohm/°C	$\pm 0.025^\circ$ C	0.0025°C/year
Active Solid-State Sensors				
AD TMP01	-55 to 125°C	5 mV/°C	$\pm 1.5^\circ$ C max	0.25°C typical
AD TMP03	-25 to 100°C	0.12 mS/°C	$\pm 4^\circ$ C max	0.5°C typical
NS LM45C	-20 to 100°C	10 mV/°C	$\pm 3^\circ$ C max	0.12°C typical
NS LM75	-25 to 100°C	0.5°C[4]	$\pm 2^\circ$ C max	0.5°C typical

Notes: [1] depends on environment  
[2] 1% tolerance probe or with calibration  
[3] if used at less than 100 degrees C  
[4] 9-bit word with least significant bit equal to 0.5 degree C

## COMPARISON TABLE TEMPERATURE SENSORS

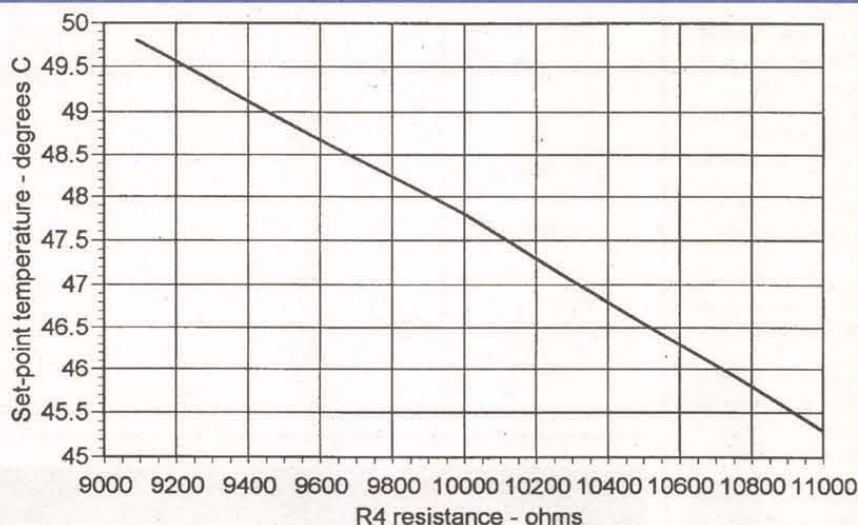


Figure 13 — Set-point temperature control in the variable duty-cycle controller using an LM45C temperature sensor.

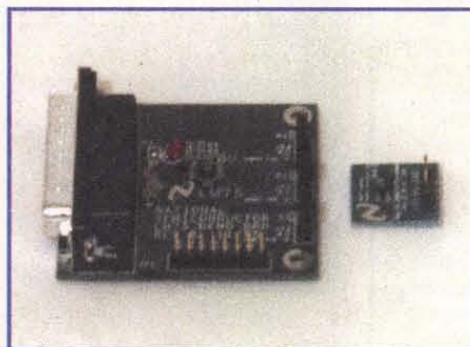


Figure 14 — National Semiconductor LM75 and LM60 (smaller) temperature sensor demo PC boards. The LM75 board has an RS-232 port for connection to a Microsoft Windows computer. Demo software is supplied with the board.

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Oak Sigma 99 Channel	\$45	\$40	\$35
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Continued from page 42

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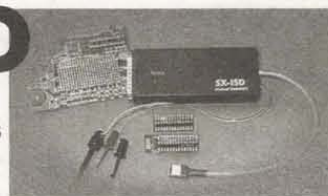
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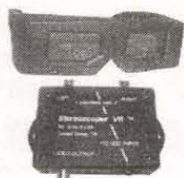
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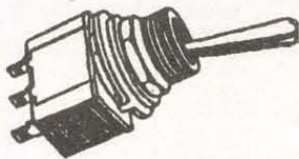
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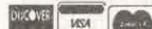
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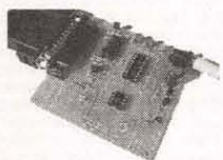
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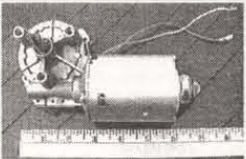
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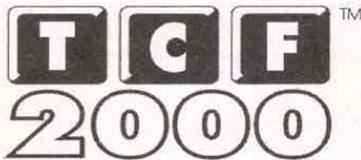
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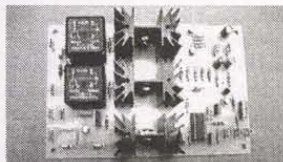
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Continued on page 80

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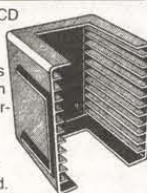
Digital timer from Mr. Coffee™. Small modular design, no brand name or logo. Ideal for use in any product that needs to be turned on automatically at a specific time. Operates on 120 Vac. Switch loads up to 10 amps. Can be switched manually. White plastic face. 2.48" X 1.77", with four digit LED clock. Overall size: 2.48" X 2.17" X 1.88" deep behind face. 02.5" qc terminals. Easy to connect and operate. Includes instruction sheet.



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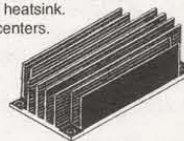
Daewoo # 16216L-5-VSO 5 x 7 dot format. 2.56" x 0.54" viewing area. 3.15" x 1.41" module size. LED backlight. Includes hook-up/spec sheet.



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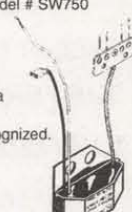
4.53" X 2.3" X 1.44". High-capacity black anodized aluminum heatsink. 4.2" x 2" mounting centers. Weight: 0.54 lbs.



CAT# HS-65 \$3.75 each

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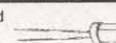
Seawise Industrial Ltd. Model # SW750 Input: 120 Vac Output: 7.5 KV 60 Hz. The main component in a household ionization unit. 2.2" x 1" x 0.86" thick with a mounting tab that extends 0.75" from the unit. UL recognized.



CAT# SW-750 \$4.50 each

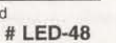
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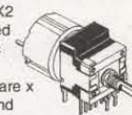
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# BUILD AN ELECTRONIC COMPASS

**SOLID-STATE CIRCUIT • CONTAINS NO MOVING PARTS**

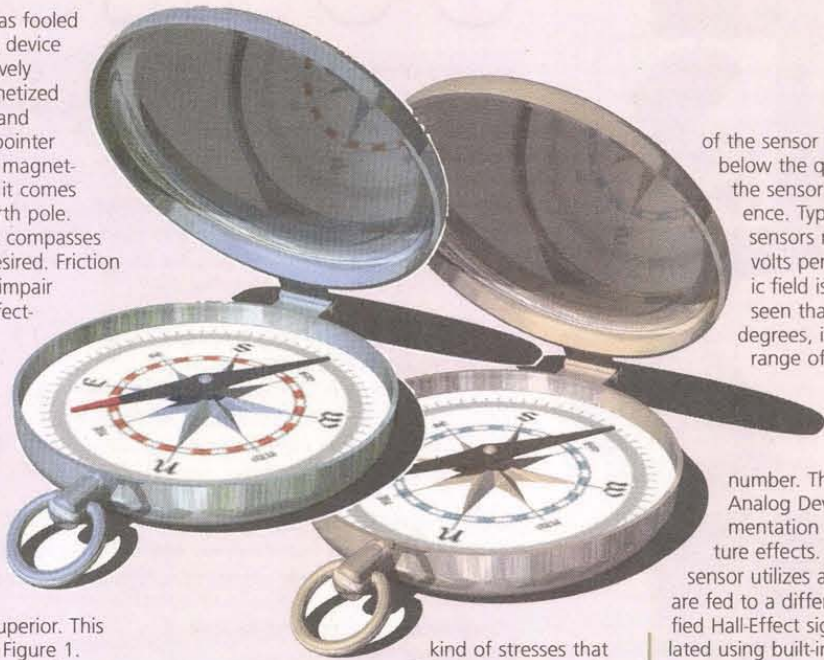
Just about every one of us has fooled around with that ubiquitous device we call a compass. It's relatively simple, consisting of a magnetized pointer or needle balanced and suspended on a pivot. The pointer — influenced by the earth's magnetic field — is free to rotate and when it comes to rest, it points to the magnetic north pole. Although even the most inexpensive compasses really work, they leave a lot to be desired. Friction between the pointer and pivot may impair operation, they need to be held perfectly horizontal for reliable operation, and it takes some time for the pointer to come to rest at a point that we hope is true magnetic north.

The magnetic north pole of the earth is actually located in the Northwest Territories of Canada. Because of this, a magnetic compass will not point to true geographical north unless it is located near an imaginary line that stretches from the Alabama Gulf to Lake Superior. This line is identified as "zero degrees" in Figure 1.

For all other locations, one must take into account the offset — called magnetic declination — which can be as much as  $\pm 20$  degrees in the United States. The map in Figure 1 can be used to determine the amount of magnetic declination for all parts of the continental United States.

Modern electronics technology has provided the means to construct a solid-state compass containing no moving parts, thus avoiding mechanical problems. The electronic compass described here is extremely easy to build, and will easily outperform the old fashioned magnetic types. It utilizes a device called a linear Hall-Effect generator which produces an electrical output that is proportional to the intensity of the magnetic field passing through the semiconductor material.

Since this compass contains no moving parts, it is extremely rugged and can tolerate virtually any



kind of stresses that might be encountered when traveling in rough or mountainous terrain. It is easy to use, and will provide a quick and reliable reading. Power to operate the circuit is provided by a common nine-volt transistor radio battery that will allow many hours of intermittent operation.

## HOW IT WORKS

Refer to Figure 2. A Hall-Effect sensor consists of a small sheet of semiconductor material through which a bias current flows. Its output voltage — measured perpendicularly to the flow of current — is a function of the intensity of magnetic lines of force that pass through the chip in the direction depicted in the illustration.

Depending upon the actual direction of the magnetic field and its intensity, the output voltage

by Anthony J. Caristi

of the sensor will be somewhat above or below the quiescent value that exists when the sensor is not subject to magnetic influence. Typical sensitivity of many Hall-Effect sensors may be in the order of two millivolts per Gauss. Since the earth's magnetic field is about one-half Gauss, it can be seen that as the sensor is rotated 360 degrees, its output voltage may vary over a range of  $\pm$  one millivolt.

Unfortunately, Hall-Effect sensors are not very temperature stable, and the output voltage will not be an absolute number. This problem has been solved by Analog Devices Corporation using instrumentation technology to reduce temperature effects. Their AD22151 magnetic field sensor utilizes a pair of Hall-Effect devices that are fed to a differential amplifier. The two amplified Hall-Effect signals are synchronously demodulated using built-in circuitry, and the result is a temperature compensated, low offset output voltage that is proportional to the intensity and direction of the external magnetic field.

## ABOUT THE CIRCUIT

Refer to the schematic diagram. Nine-volt battery power is applied to U1, a fixed five-volt linear regulator. The use of a regulator is required to maintain circuit stability as the terminal voltage of the battery decreases with use. A spring loaded switch applies voltage to the circuit so that once a reading is taken, the power will automatically disconnect when the user releases the switch.

U2 is a surface mount linear output magnetic field sensor that produces an output voltage which is proportional to a magnetic field that is applied perpendicularly to the top surface of the package.

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# ELECTRONICS

# Q & A

With TJ Byers

*In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist.*

*Feel free to participate with your questions, as well as comments and suggestions.*

*You can reach me at:*

**TJBYERS@aol.com**

**TJBYERS@juno.com**

*or by snail mail at*

*Nuts & Volts Magazine,*

*430 Princeland Ct.,*

*Corona, CA 92879.*

## What's Up:

PCB chemical waste,

Headphone impedance

matching, Audio arti-

cles, Strobe power,

Mouse adapters, Solar

tracker, Modem prob-

lems, Useful websites,

IC prefixes.

## Safe Disposal of Waste PCB Chemicals

**Q** - I'm concerned about the disposal of waste printed circuit board chemicals. I've never built any projects that need an etched copper-clad board because I can't figure out where to rid myself of the expended etching chemicals. I've never seen mention of this important subject anywhere. Does the average hobbyist dump them down the toilet, bury them in the yard, or use a convenient storm drain? Most official disposal sites deal with waste oil, not hazardous chemicals.

**A** - The etching agent used for printed circuit boards is ferric chloride, which is not classified as a hazardous material. In fact, it's often used in water treatment plants to reduce sludge. Moreover, copper is a trace element needed by the human body and, therefore, isn't a toxic metal. And if ferric chloride weren't recognized for its etching qualities, it would probably qualify as an excellent sun-tanning ointment. In other words, contact with it turns your skin a yellow brown — something like the artificial skin-tanning creams do, and it's darn near impossible to wash off.

As to its disposal, please don't store it in a paint can or other metal container because the ferric chloride will eventually eat through the can and run amok — and worse yet, contact with an aluminum container can generate explosive hydrogen gas. Should you have a ferric chloride spill, neutralize the acid with lime (calcium hydroxide), limestone (calcium carbonate), or soda ash (sodium carbonate) — basically anything caustic. CAUTION: Limestone and soda ash will produce CO<sub>2</sub> gas, which, while non-explosive, can accumulate in enclosed areas. Ventilation should be provided; use an absorbent material (like a paper towel) to pick up the spill. What I do is bury it in the backyard around the hydrangeas, but flushing it down the toilet is totally acceptable in the small amounts you'll generate. For more information on ferric chloride safety, check out the chart at [www.injectorall.com/MSDS%20199.htm](http://www.injectorall.com/MSDS%20199.htm) (this table is also available on our Web site at [www.nutsvolts.com](http://www.nutsvolts.com) under the name [safeFeCl.html](http://www.safeFeCl.html)).

## Modem Madness

**Q** - This is a two part question. First, what is the best modem to use, PCI or ISA bus? A friend tells me ISA is better because of On/Off hardware flow. Second, what causes a modem to not reset? Sometimes I have to turn off the PC and restart the computer for the modem to initialize.

**Joe Spinola**  
via Internet

**A** - The two parts aside, it's a tough question because it generates more questions than it does answers. First, there is no such thing as a perfect modem — just like there's no such thing as the perfect car. Each is tailored to do a specific job the best it can. For example, would you buy an 18-wheeler to take the kids to school and run errands? On the other hand, how many refrigerators can you fit in the back of a mini-van? It's the same with modems. For some users, a 33.6 kbps modem that's used for E-Mail only is more than adequate. But it won't work for a Wall Street investor, who very often has several modems connected to dedicated T1 lines. In between are the 56 kbps, ISDN, and TV cable modem links — each with its own

niche in the scheme of things. So it's not a matter of which slot to plug into, but what you need in the way of communications.

The second request is a trick question, isn't it? Suppose your car won't start one morning and you call up a mechanic and simply say, "Hello, my car won't start. How come?" He'll say, "Dunno." Same answer here. What make, model, speed, provider connection, and so forth? Without this information, I can only speculate — which I'll try to do now, but don't hold me to it. If the modem won't reset, first check to see if it's let loose of the phone line — hangs up. If not, the problem is probably with the server, be it AOL software or somebody else's. If there is a dial tone and the modem won't reset, then the problem is local inside your PC. Turning off the PC simply erases all evidence of what caused the problem, allowing it to happen again. Now you know as much as I do about your situation. Good luck!

## Audiophiles, Lend Me Your Ear

**Q** - Articles that deal with audio topics seem to be few and far between in hobby magazines, so I was wondering if you know of a magazine that deals mostly with audio? BTW, I tried the fix you gave me for my Variac and it works great!

**Garry Iman**  
via Internet

**A** - There was a time when audio was a hot DIY (do it yourself) topic found in every electronics magazine and several audio/hi-fi publications. But the current state-of-the-art puts quality audio projects beyond the reach of most hobbyists, so virtually all of the articles you'll find on the subject today deal with news, equipment reviews, interviews, and company profiles. Thanks to the explosion of the Internet, though, finding good audio material has become easier and more plentiful. Here is but a handful of publications and ezines (electronic magazines) I found useful for our readers.

## Bound for Sound Report

(<http://www.boundforsound.com>)

Publishing since 1989, Bound for Sound Report is 14 to 16 pages of concise, in-home reviews of hi-end equipment and software in all price ranges, includes mainstream and underground components. Technical articles include such topics as interconnects, line conditioning/power cables demystified; set-up advice, tweaks, and component matching.

Browse the 10-year index to read back articles; published monthly on both the Internet (free) or via first class mail (\$24.00/yr.).

## Hi-Fi+ (<http://www.hifiplus.com>)

British, bi-monthly magazine with articles, news, reviews, and previews.

## Planet HiFi (<http://planet.hifi.com>)

Planet Hi-Fi, The Magazine of High Fidelity, is a free bi-monthly audio/video resource on the web. Equipment and music reviews, monthly columns, free classifieds, and the web's first Audio Doctor.

## Stereophile (<http://www.stereophile.com>)

Inside this rather plain looking ezine (your typical assortment of reviews, industry news, and tips), you'll find access to an amazing selection of audio and video links (<http://www.stereophile.com/cgi-bin/lm.cgi/ep>) that had its start as Ron Rathe's "The Enthusiast's Page" a couple of years back. These links are combed and updated on a weekly basis.

## UHF Magazine: Ultra High Fidelity

(450-651-5720; <http://www.uhfmag.com>)

Despite its lofty name, UHF Magazine is anything but pie-in-the-sky journalism. In addition to the regular news updates, reviews, tips and interviews is a great audio doctor who is ready to answer your every audio



need. UHF Magazine has been redefining true high-fidelity since 1982.

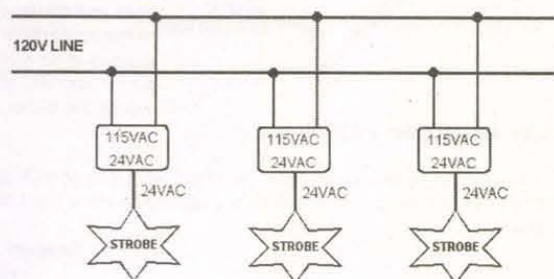
## Strobe Alley Needs Power

**Q** - I'm looking for a 24-volt transformer to power 18 strobe lights drawing 0.85 amps each.

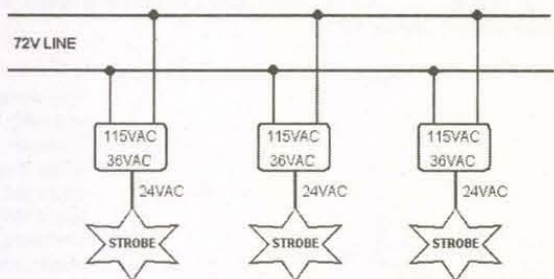
The lights will be wired in two circuits, with nine lights on each leg. The distance to the first light is 500 feet, after which each light will be 330 feet apart. I plan on running #4 AWG copper wire for 1,490 feet then switch to #6 AWG copper wire for the remainder of the run. Any help you can give me to find a supplier of this transformer would be appreciated.

Robert Mitten  
via Internet

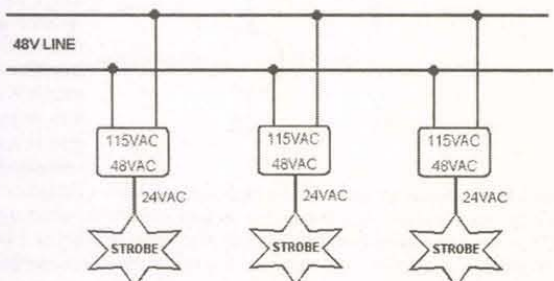
**A** - First of all, I wouldn't use a 24-volt distribution line for this application. Instead, I'd go with a 120 VAC line and tap the line at each strobe location using a small 24-volt, 1-amp transformer, like the Alltronics (408-943-9773; [www.alltronics.com](http://www.alltronics.com)) 97N002 (\$4.95) or Mouser (800-346-6873; [www.mouser.com](http://www.mouser.com)) 553-F46X (\$9.26).



120V SYSTEM



72V SYSTEM



48V SYSTEM

This accomplishes three desirable goals. First and foremost, it reduces the size of the wire from 4 gauge to 14 gauge — typical house wire. Observe: The current requirement for the 24-volt system is about 8 amps per leg, and the resistance of 4-gauge wire is 0.267 ohms per 1,000 feet, which gives a voltage drop of 1.1 volts in the 500-foot section. ( $E = IR = 8 \times 0.134 = 1.1$  volts.) That's nearly 5 percent of the power lost in the wiring alone. The current of the 120-volt system, on the other hand, is just 2 amps per leg. With a resistance of 2.73 ohms per 1,000 feet, the voltage drop across 500 feet of 14-gauge wire is just 2.73 volts, or about 2 percent of the total power. Furthermore, you can use 14-gauge wire throughout the system, eliminating the need to mix two heavy-gauge wires. Last, but not least, 4-gauge wire costs 43 cents per foot, (\$4,428.00 total with 1650 feet of #6 @ 28 cents per foot), whereas 14-gauge wire costs 5 cents per foot, (\$630.00 total), for a savings of about \$3,800.00. If a 120-volt system isn't practical because of building codes, the line voltage can be reduced to 72 or 48 volts, as shown in the wiring diagram above. Here are two charts showing wire resistance versus wire size, and recommended wire

sizes for the three above systems.

Gauge (AWG)	Diameter (mm)	Area (cir mils)	Resistance (1000 ft.)
0	8.252	53.49	0.105
2	6.543	33.62	0.168
4	5.189	21.15	0.267
6	4.115	13.30	0.425
8	3.264	8.367	0.687
10	2.588	5.261	1.08
12	2.05	3.310	1.71
14	1.63	2.081	2.73
16	1.29	1.3088	4.35
18	1.02	0.8231	6.92
20	0.81	0.5176	10.9
22	0.64	0.3255	17.5
24	0.51	0.2047	27.7
26	0.40	0.1287	44.4
28	0.32	0.0810	70.7
30	0.25	0.0509	112
32	0.20	0.0320	176
34	0.16	0.0201	280
36	0.13	0.0127	445
38	0.10	0.0080	708
40	0.08	0.0050	1093

### Recommended Wire Sizes

System Voltage	Total Amps	Amps per Leg	Voltage Drop (first 500 ft.)	Wire Size
120	3.06	1.53	2.09/2%	14
72	4.09	2.05	1.75/2.4%	12
48	7.15	3.58	1.23/2.6%	8
24	15.3	7.15	0.96/4%	4

If you insist on using the 24-volt system you describe, the transformer you want is called a furnace or power control transformer. They are available from Allied Electronics and Newark Electronics, but are very costly. You can save money by cruising the surplus electronic outlets, like All Electronics (<http://www.allelectronics.com>) — subject to availability, of course. (Note: Any 24-volt transformer with a 16-amp secondary or greater will work.) A better bet is to use two 8-amp, 24-volt transformers, one for each line, rather than a 16-amp behemoth. They're easier to find and cheaper.

## More Mouse Adapters

**Q** - I read with interest your recent PS/2 to nine-pin serial adapter answer in the Dec. '99 issue, and would like to add my two cents worth. I have two mice that are both PS/2 and nine-pin serial port compatible using adapters like you described. However, neither adapter is wired like your example and, interestingly enough, neither mouse will operate with the other's adapter.

The first is a \$5.00 Tandy generic (Precision Instruments) special that I use for testing. The second is a real nice Logitech Marble Ball trackball. Their wired:

### Tandy Generic Adapter

PS/2	9-pin
1	2
2	3
3	5
4	4
5	7
6	N/C

### Logitech Marble Ball Adapter

PS/2	9-pin
1	4
2	2
3	5
4	8
5	7
6	3

From the above, it would appear that both of these devices use additional signals to indicate to the mouse which port is being used. In one instance, Vcc is derived from DTR and in the other it's CTS. The only common denominator seems to be the ground pin. Maybe this will help someone. I suppose with proper software either adapter could be used.

Don Pomeroy  
via Internet

**A** - Congratulations! You've just hit on the number one reason it was so hard to make early computers work properly: the lack of standards. Back in the early days there were a lot of players in the PC game, each wanting a slice of the pie. They used many ploys to get you to buy their products, but none more devious than setting their own standards. They figured that if you bought into their company and used their products, you would be forced to buy their upgrade products because it was the only part that would match



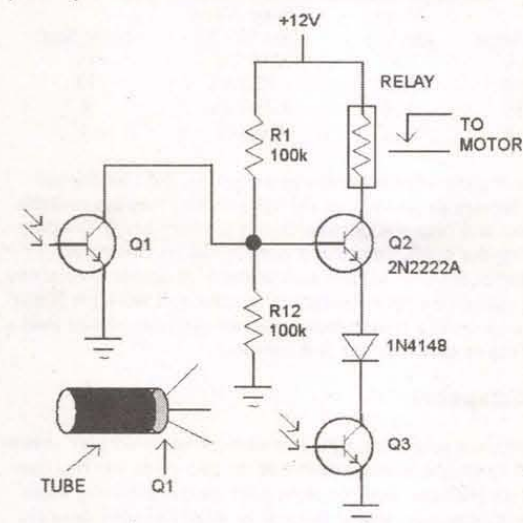
your system. The mouse is but one example. As you noticed, the adapters aren't interchangeable between the mice. Let's suppose you're using your Logitech Marble Ball and want to switch over to a mouse for one project. Well, you'd need to buy a mouse from Logitech or go through a lot of adapter swapping — with no guarantee the kluge would work properly. This is how they hoped to keep your business. Fortunately, the scheme backfired and most companies that tried it have switched to a more common standard or now RIP.

### I'll Just Follow The Sun

**Q** - I am trying to build a small solar furnace and I thought it would be fun to make it track the sun. I'd like something that would move the oven toward the sun's position by driving two motors (servos, stepper, etc.): one for the base rotation and the other for elevation. I've surfed the web, but can only find high-end commercial products. Do you know of a simple design that won't take a rocket scientist or NASA-like budget to build?

Craig Kessler  
via Internet

**A** - Over the years, I've built and/or tested many different kinds of sun trackers, each with its own merits — and price. Here's one I designed myself that's very reliable and inexpensive. It uses but a handful of electronic components and a single, garden-variety motor. The brains of the design is a pair of phototransistors, like the RadioShack 276-145.

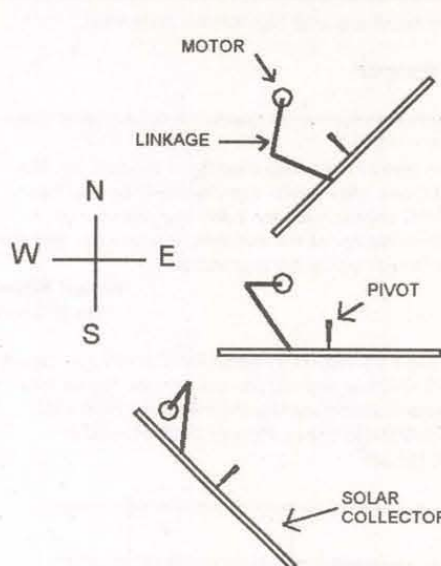


The heart of the circuit is Q2, a 2N2222A transistor, which is basically a relay driver. When the transistor is conducting, the relay, a normally-open reed relay, pulls in, which starts the motor. The two phototransistors give the relay driver some brains. Disregard Q1 for the moment. Q3 is in series with the emitter of Q2 and behaves like a variable resistor. When the photoresistor is dark, its resistance is high and very little current flows through Q2; so little, in fact, that the relay can't pull in. As light begins to fall on Q3, the transistor starts to conduct. At some point the current flow is enough to engage the relay. This photo sensor is used to determine if there is enough sunlight to warrant tracking the sun, and prevents the motor from running at night.

Q1 is the actual positioning sensor. When Q1 is dark and Q3 is bright, the relay is engaged. When light falls on Q1, it begins to conduct, which shorts out the base of Q2 causing it to turn off along with the relay. Q1 is housed in a short cylinder so that only light that hits the photo sensor straight on will trigger this process. Light off to the side of the perpendicular axis can't enter the cylinder.

Let's put this into a real-life scenario. First we have to assume that Q3 is unshaded and has full access to ambient light — which it does. As the sun comes up in the morning, the current through Q3 will begin to flow; the amount of current is proportional to the amount of light. After the sunlight is intense enough to do useful work, the relay engages and starts the motor. This point is determined by the value of R1, which has a nominal value of 100k. A potentiometer can replace R1 to adjust the trigger point. The motor will continue to run until light falls on Q1, causing Q2 to turn off. If Q1 is mounted on the rotor mechanism, this will occur when the solar tracker is pointed directly at the sun. As the sun moves across the sky, it will cast a shadow on Q1, which turns the motor back on to rotate the tracker. And so it goes until the sun sets at night and the tracker goes to sleep. The next morning Q3 awakens everybody and it starts all over again.

Most solar trackers use limit switches that reverse the direction of the motor when it reaches the ends of its sweep. Unfortunately, bi-directional motors are not easy to come by and are costly. My solution is a cam assembly that lets you use any low-speed motor. Be it AC, DC, or a hamster in a cage, it doesn't matter. All you have to do is start and stop the motor when the controller says so as the sun chariots across the sky.



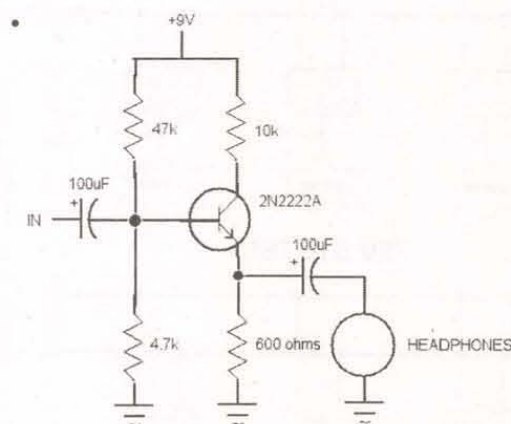
The amount of sweep is adjusted by the size of the cam and the position of the link rod. This will vary from project to project depending on the physical size and weight of the solar collector. No provisions have been made for azimuth adjustment (up/down) tilt, only the horizontal sweep. That's because the azimuth angle changes very little from day to day, and it's easily adjusted manually to compensate for the seasons. Yes, this design does require some customizing in both the ambient light level and the east-west swing, something the expensive commercial units do for you. But it's well worth the bucks saved.

### Emitter Follower Fable

**Q** - I have a pair of 8-ohm headphones that I want to use with a Drake 2C shortwave radio with a 600-ohm output jack. How can I make the connection?

Gregory Lehmann  
via Internet

**A** - It's usually done using a matching transformer, like the RadioShack 273-1380. However, you can also do it using a transistor amplifier stage called an emitter follower; shown below



This design was originally labeled a "cathode follower" when it was first observed in vacuum tubes. When vacuum tubes ruled the planet, somewhere around the time of T. Rex and his buddies, a cathode resistor was very often included in an amplifier circuit to establish a negative bias voltage for the grid. It was actually serendipity when

one day a ham offered to share his headphone jack with a neighbor and discovered (to his surprise) that there was no loss of volume when the low-impedance headsets were paralleled across the cathode resistor. How much truth there is to that story, I don't know, but the same effect can be created by inserting a resistor in the emitter of a transistor. While this circuit can never achieve more than unity gain, it has very good impedance matching and current driving characteristics.

### Useful Websites

Great experimenter's project and information site  
[www.us-epanorama.net/index.html](http://www.us-epanorama.net/index.html)

Have a couple of teenage hackers at home?  
Here's a way to fool them into thinking Ping doesn't work.  
[www.pibmug.org/SEPT/ping.exe](http://www.pibmug.org/SEPT/ping.exe)

Locate persons by birthdate  
[www.switchboard.com/bin/cgiqa.dll?SR=&MEM=I&F=Robert&L=Michaels&T=&S=CO&Submit=Search](http://www.switchboard.com/bin/cgiqa.dll?SR=&MEM=I&F=Robert&L=Michaels&T=&S=CO&Submit=Search)

Continued on page 82



## AMPLIFIED MULTIMEDIA SPEAKERS

**Advent AV370.** Built-in amplifier gives the left and right speakers 20 Watts of audio power while the companion subwoofer puts out 30 Watts. Speakers measure 7" x 5" x 6" and subwoofer is 7" x 14" x 13". These are Advent speakers so quality is no doubt superb. List price was \$234.95. Refurbished.

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**93W009 \$3.95 each**

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## DELUXE 101-KEY KEYBOARD

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**94L010 \$14.95 each**

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Works with TVs, VCRs, cable boxes, etc. With docs and list of devices it may control.  
**99V020 \$9.95**

## DIGITAL MULTIMETER

This meter is a professional measuring instrument, capable of performing the following functions: DC and AC voltage and current measurements; Resistance measurement; Diode and Transistor tests; Audible continuity test; DC 200µA, 2A, and AC 200µA, 2A current ranges; 200MW resistance range; Capacitance, Frequency and Temperature measurements. Maximum display: 1999. LCD display size: 43mm x 68mm. Uses 9V battery.  
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## DUAL FULL-BRIDGE DRIVER IC

Up to 46V operating supply voltage. Total DC current up to 4A. Low saturation voltage. Overtemperature protection. Logical "0" input voltage up to 1.5V (high noise immunity). Multiwatt-15 package. Docs are available at our website.  
**L298 \$9.95 each**

## ULTRABRIGHT WHITE LED

T1 1/4 ultrabright white, 5.6cd. It will stun your eyes!  
**SE5084J \$4.95 each**

## SQUARE MAGNIFYING LENS

Double convex. Approx 1.75" x 2", 4X magnification. A pair of these would make a nifty set of magnifying goggles.  
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## TV AUDIO DEMODULATOR BOARD

Originally used in cable TV application, this subassembly takes channel 3, 4 or 5 signal and demodulates the audio. Comes with documentation and schematics, plus additional schematics to build add-on video demodulator board.  
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## RG-174U COAX CABLE

50-Ohms. Ten-foot minimum order.  
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**MW7507 \$5.69 each**

## PRECISION RESISTOR ASSORTMENT

Many individually packaged.  
**94P030 5 Lbs. for \$9.95**

## ATARI 1020 COLOR PRINTER

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**94C037 \$14.95 each**

## MINIATURE C-BAND LNB

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**94G001 \$29.95 each**

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 • Fits 0.5" x 1.75" cutout.  
**98B007 - Red \$1.25**  
**98B008 - Green \$1.25**  
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**98B009 - Yellow \$1.25**

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**95L007 \$7.95 each**

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DTC P/N 5160. New.  
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This kit contains a UCN5804 unipolar stepper motor driver IC; a 42mm dia. by 22mm thick stepper motor, with shaft 3mm dia. x 12mm long and 13-tooth gear approx 16.6mm dia. x 5mm thick. 7.5°/step, 48s/rev., 12VDC, 50 Ohms, 6-wire; and all necessary documentation to make the stepper motor circuit.  
**93I003 \$7.95 kit**

## UCN5804 IC Only

With docs.  
**93I002 \$4.50 each**

## Pulse Motor Only

With docs.  
**92M010 \$3.95 each**



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## BLUE LED

T1 1/4 blue water clear.  
**SE5064N \$4.95 each**

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T1 1/4 ultrabright white, 5.6cd. This will stun your eyes!  
**SE5084J \$4.95 each**

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**00E004 \$4.95 each**

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**94Z026 \$1.50 each**

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For #30 wire.  
**92Z025 \$1.95 each**

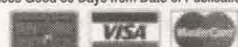
## 10.7 MHz FILTER

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The so-called chaser or sequencer is one of the most popular types of LED-driving circuit and is widely used in advertising displays and in running-light 'rope' displays in small discos, etc.

It consists — in essence — of a clocked IC or other electronic unit that drives an array of LEDs in such a way that individual LEDs (or small groups of LEDs) turn on

grams of the IC, which incorporates a five-stage Johnson counter and has CLOCK, RESET, and CLOCK INHIBIT input terminals. The internal counters are advanced one count at each positive transition of the input clock signal when the CLOCK INHIBIT and RESET terminals are low. Nine of the 10 decoded outputs are low, with the remaining output high, at any given time. The outputs go high sequentially, in step with the clock signal, with the selected output remaining high for one full clock cycle. An additional CARRY OUT signal completes one cycle for every 10 clock input cycles, and can be used to ripple-clock additional 4017B ICs in

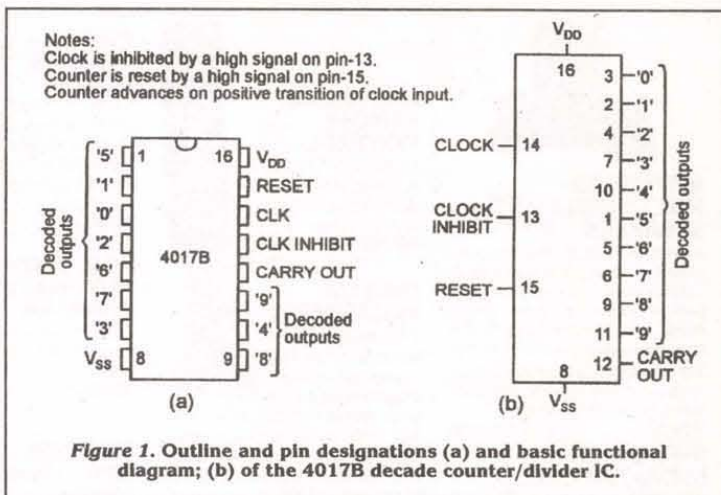


Figure 1. Outline and pin designations (a) and basic functional diagram; (b) of the 4017B decade counter/divider IC.

# LED CHASER/SEQUENCER CIRCUITS

by Ray Marston

and off in a predetermined and repeating sequence, thus producing a visually attractive display in which one or more ripples of light seem to repeatedly run through a chain or around a ring of LEDs.

The 4017B CMOS IC is probably the best known and most widely used LED-driving IC used in chaser/sequencer applications. This article looks at a variety of practical circuits based on this particular IC.

## 4017B BASICS

The 4017B is a member of the popular '4000B' family of CMOS digital ICs and can use any DC supply voltage in the 3V to 15V range. It is actually a clocked decade counter/divider IC with 10 fully decoded short-circuit-proof outputs that can each be used to directly drive a simple LED display. If desired, various outputs can be coupled back to the IC control terminals to make the device count to (or divide by) any number from two to nine and then either stop or re-start another counting cycle.

Numbers of 4017B ICs can be cascaded to give either multi-decade division or to make counters with any desired number of decoded outputs. The 4017B is thus an exceptionally versatile device that can easily be used to chase or sequence a basic LED display of virtually any desired length.

Figure 1 shows the outline, pin notations, and basic functional diagram of the 4017B, and Figure 2 shows the waveform timing dia-

multi-decade counting applications.

Note that the 4017B counting cycle can be inhibited by setting the CLOCK INHIBIT terminal (pin 13) high, and that a high signal on the RESET terminal (pin 15) clears the counter to zero and sets the decoded '0' output terminal (pin 3) high.

## A 4017B LED-DRIVING TEST CIRCUIT

The 4017B is a versatile and easy-to-use IC and (like most 4000B-series ICs) has short-circuit-proof outputs that exhibit slightly surprising characteristics when driving LED-type loads. Figure 3 shows a practical 4017B test circuit that can be used to demonstrate the IC's basic actions and output-driving characteristics. The circuit is best built on a 'plugblock' type of breadboard unit, in which components and wires are simply pushed into the unit's sprung-contact blocks.

In Figure 3, the 555 timer IC (IC1) is used as a variable-frequency asymmetrical squarewave generator that feeds clocking signals to the CLK input terminal of the 4017B IC (IC2). This output waveform is normally high, but briefly flips low once per cycle and drives LED5 on. The 4017B's internal switching actions are initiated as this signal flips high again and LED5 switches off. Note that the clocking signal is fed to the 4017B IC via removable Link A, and can thus be physically

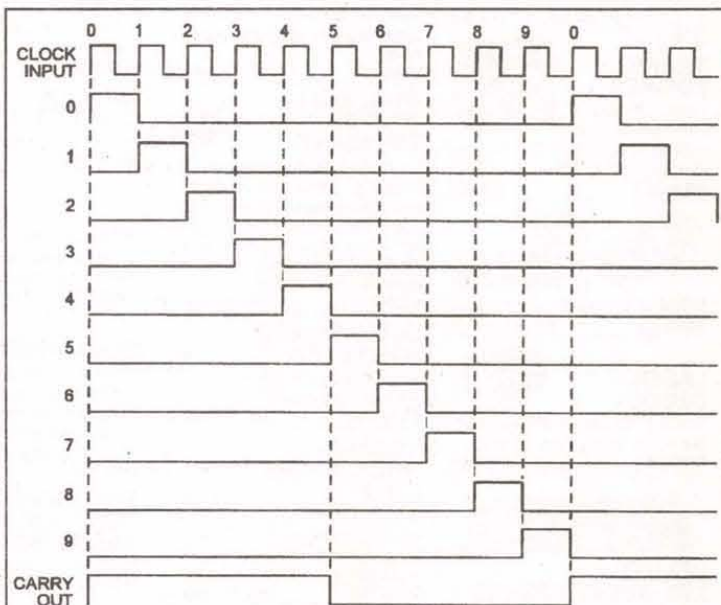


Figure 2. Waveform timing diagram of the 4017B with its RESET and CLOCK INHIBIT terminals grounded.

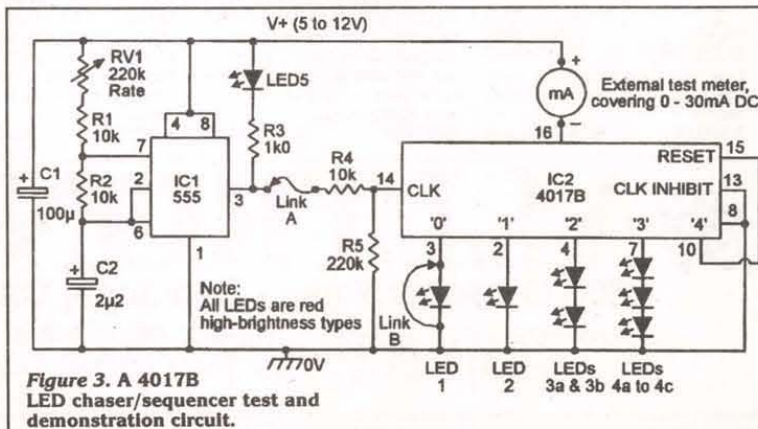


Figure 3. A 4017B LED chaser/sequencer test and demonstration circuit.



interrupted whenever required; R4 and R5 protect the 4017B's input against damage when Link A is open or IC2's positive supply connection is broken.

In Figure 3, the positive DC supply line is connected to pin 16 of the 4017B IC via an external multi-range DC current meter that (since IC2's quiescent current is negligible) gives a direct readout of the current drawn by the IC's currently-active output load. The 4017B is wired (via pins 10 and 15) in the 'divide-by-four' mode and sequentially drives four sets of output loads, which are notated '0' to '3.'

Output '0' takes the form of a single LED when Link B is open, or a short-circuit when Link B is closed. Output '1' takes the form of a single LED. Output '2' takes the form of two series-connected LEDs. Output '3' takes the form of three series-connected LEDs. All LEDs are red high-brightness types.

When construction of the Figure 3 circuit is complete, close

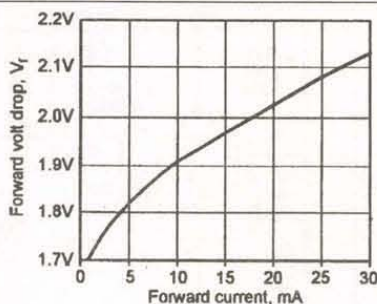


Figure 4. Typical forward current/voltage graph of a high-brightness red LED.

all of the display LEDs (LEDs 1 to 4) operate at almost equal brightness, and that all output loads produce fairly similar current readings on the test meter.

When testing the Figure 3 circuit, you can check the individual load currents by waiting until the load activates and then 'freezing' the display by opening Link A. When load '0' is active, the load current is typically 17.5mA with Link B open or 19mA with Link B closed; the load '2' and load '3'

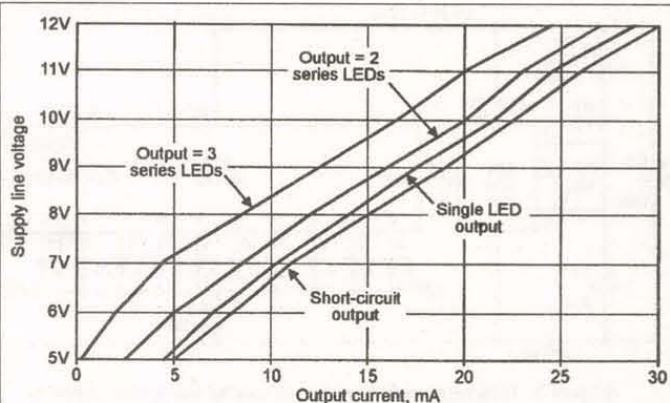


Figure 5. Typical supply voltage versus output current graph of the Figure 3 circuit when driving different types of loads.

Figure 4 shows the typical forward current/voltage graph of a high-brightness red LED. Note that large variations in forward current produce relatively small variations in forward voltage. Thus, when the current is increased from 10mA to 30mA, the forward voltage increases by only 0.22V and, in this case, the LED thus acts like a pure voltage (zero impedance) load in series with an 11-ohm impedance. In practice, this impedance varied between 10 and 15 ohms over most of the LED's working cur-

rent range.

Figure 5 shows the typical supply voltage versus output current graph that applies to each output of the Figure 3 circuit when driving different types of loads.

Note that each CMOS output stage acts like a loosely-controlled constant-current generator that has its short-circuit output current determined by the supply voltage value, but has its LED-driving current value influenced by the actual  $V_{out}$  value of the stage.

In the Figure 3 circuit — when

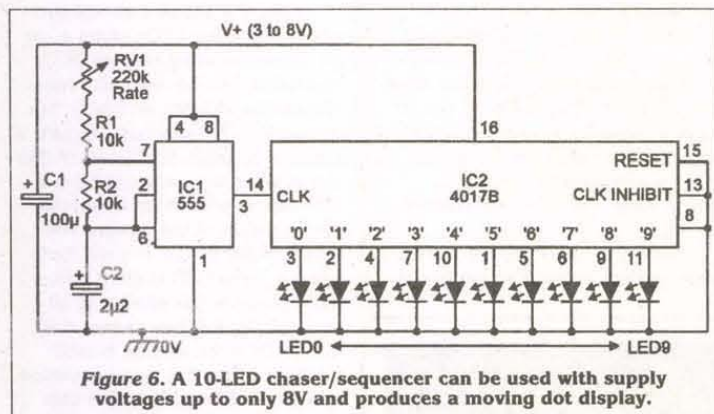


Figure 6. A 10-LED chaser/sequencer can be used with supply voltages up to only 8V and produces a moving dot display.

Link A, open Link B, connect the meter in place, and connect the unit to a 9V DC supply. Adjust RV1 to give a slow clocking rate, noting that LED5 gives a brief flash during each cycle, and that all other LEDs or groups of LEDs activate sequentially. You will probably be surprised to note that

currents are typically 16mA and 12.5mA, respectively. Thus, when using a 9V supply, the load current is typically 19mA when driving a short-circuit, or 12.5mA when driving three series-connected red LEDs. The graphs of Figures 4 and 5 help explain this circuit action.

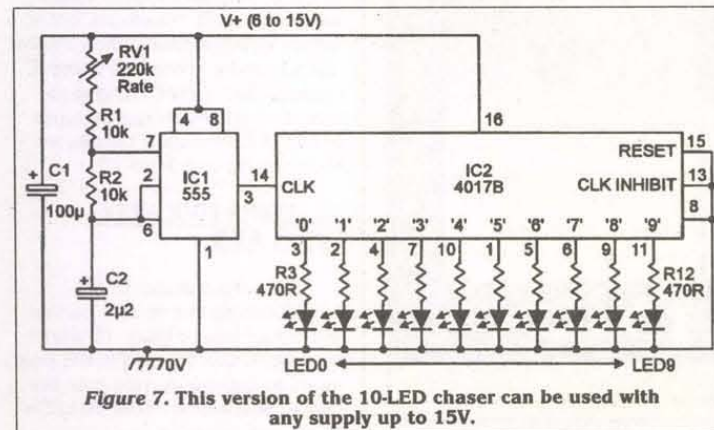


Figure 7. This version of the 10-LED chaser can be used with any supply up to 15V.

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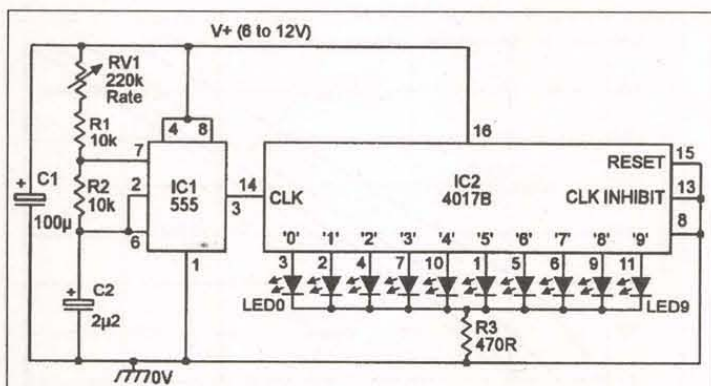


Figure 8. This version of the chaser can be used with supplies up to 12V maximum.

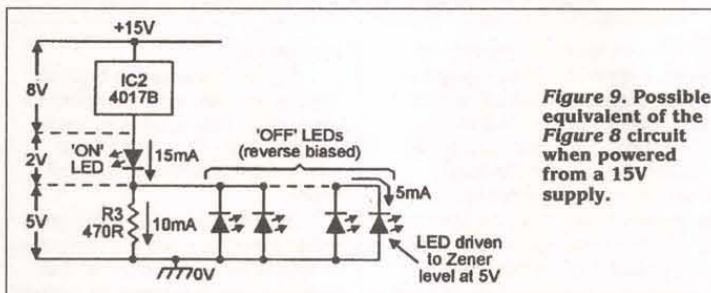


Figure 9. Possible equivalent of the Figure 8 circuit when powered from a 15V supply.

using a 9V supply —  $V_{out}$  is zero when driving a shorted output and, under this condition, 9V is developed across the output stage,  $I_{out}$  is 19mA, and 171mW is thus dissipated in the output stage. When, on the other hand, the 9V circuit is driving three series-connected LEDs,  $I_{out}$  is 12.5mA,  $V_{out}$  is 5.85V (see Figure 4), 3.15V is developed across the output stage, and less

than 40mW is thus dissipated in the output stage.

Note that most 4000B-series CMOS data sheets list the maximum permitted DC power dissipation values of the 4017B IC as 100mW per-output-stage and 500mW per-package, and these figures should be kept in mind when experimenting with the Figure 3 test/demonstration circuit.

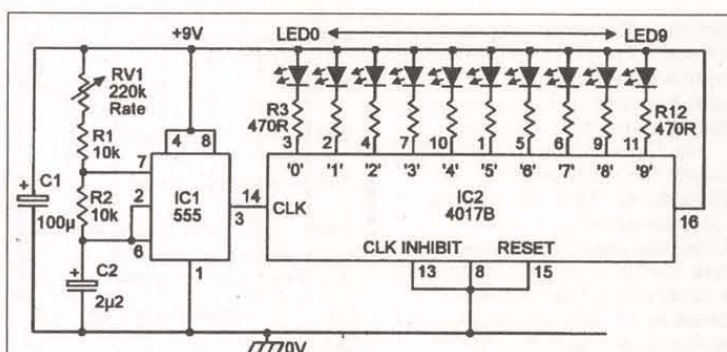


Figure 10. A 10-LED moving hole display.

## PRACTICAL 4017B CHASER/SEQUENCER CIRCUITS

Figure 6 shows the practical circuit of a 4017B 10-LED chaser in which IC1 acts as a variable-rate clocking generator and the 4017B IC is wired into the decade counter mode by grounding its CLOCK INHIBIT (pin 13) and RESET (pin 15) control terminals. The circuit action is such that the visual display appears as a moving dot that repeatedly sweeps from the left (LED0) to the right (LED9) in 10 discrete steps as the 4017B outputs sequentially go high and drive the LEDs on. The LEDs do not, of course, have to be connected in a straight line; they can, for example, be arranged in a circle, in which case, the circle will seem to rotate.

Note that the Figure 6 circuit relies on the internal action of the

4017B to limit the LED currents to safe values, and this circuit can thus be safely used with supply voltages up to a maximum of only 8V without risk of exceeding the IC's 100mW per-output-stage power dissipation limits.

Figure 7 shows a modified version of the above circuit, in which a current-limiting 470-ohm resistor is wired in series with each LED to help reduce the IC's power dissipation to a safe level. This circuit can use any DC supply in the 6V to 15V range.

Figure 8 shows a circuit variant in which the LEDs share a single current-limiting resistor (R3) and which can be used with reasonable confidence at supply values up to 12V maximum. Figure 9 shows a possible equivalent of this circuit when it is powered from a 15V supply and which illustrates the limitation of the design. The action of the 4017B is such that, when a given LED is on, it effectively grounds the anodes of all other LEDs; R3 thus causes the 'off' LEDs to be reverse biased. Because of the low reverse-voltage ratings of LEDs, this action can cause one or more of the 'off' LEDs to zener at about 5V, thus giving the results shown in the diagram and possibly causing a power overload in the IC's active output stage.

Thus, when the 4017B is used to drive simple 'one-LED-per-output' displays in the moving dot mode, the LEDs can be connected directly to the IC outputs if supply values are limited to 8V maximum, but at supply voltages greater than 8V, the LEDs must be connected to the IC outputs via current-limiting resistors. A variety of alternative types of 4017B LED display circuits are shown in Figures 10 to 15.

## ALTERNATIVE LED DISPLAYS

The output stages of the 4017B can source or sink current with equal ease. Figure 10 shows how the IC can be used in the sink mode to make a moving hole display in which nine of the 10 LEDs

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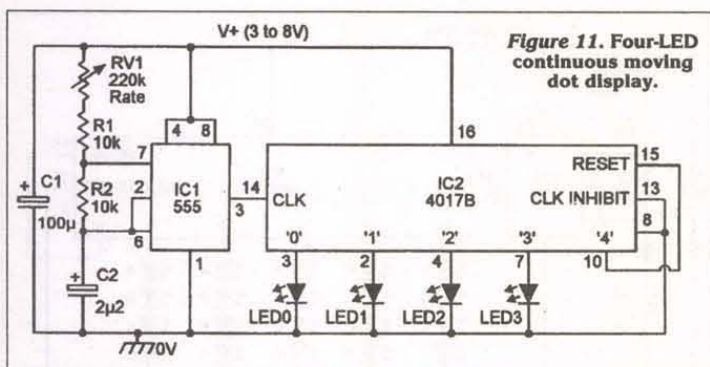
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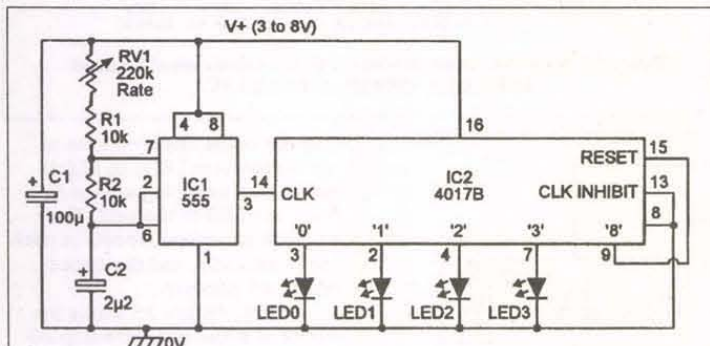
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**Figure 11. Four-LED continuous moving dot display.**



**Figure 12. Four-LED intermittent moving dot display with 50% blank period.**

are on at any given time, with single LEDs turning off sequentially. If the LEDs are wired in the form of a circle, the circle will seem to rotate. Note that, since all LEDs except one are on at the same time, each LED must be provided with a current-limiting resistor, to keep the IC power dissipation within safe limits.

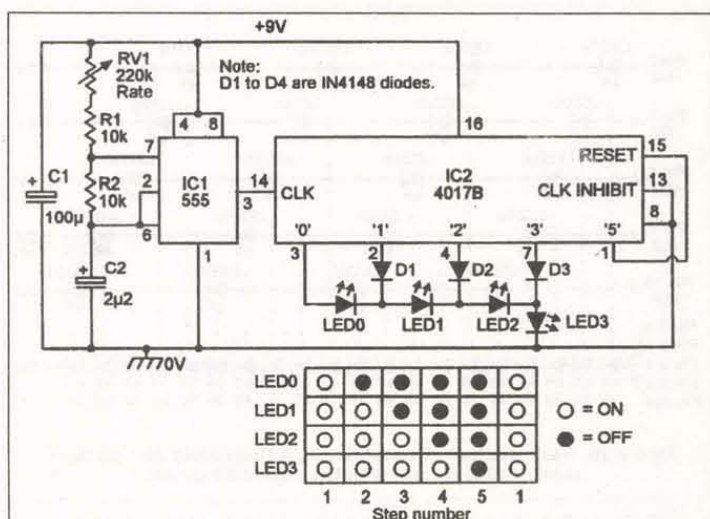
In practice, moving dot displays are far more popular than moving hole types. If desired, moving dot displays of the Figure 6 type can be used with fewer than 10 LEDs by simply omitting the unwanted LEDs but, in this case, the dot will seem to move intermittently, or to scan, since the IC takes 10 clock steps to completely sequence and all LEDs will thus be off during the unwanted steps.

If a continuously-moving less-than-10-LED display is wanted, it can be obtained by wiring the first unused output terminal of the 4017B to its pin 15 RESET terminal, as shown, for example, in the four-LED circuit of Figure 11. Alternatively, the circuit can be made to give an intermittent display with a controlled number of OFF steps by simply taking the appropriate one of the unwanted outputs to the pin 15 RESET terminal. In Figure 12, for example, the LEDs display for four steps and then blank for four steps, after which the sequence repeats, thus giving a moving dot display with a 50 percent blank period.

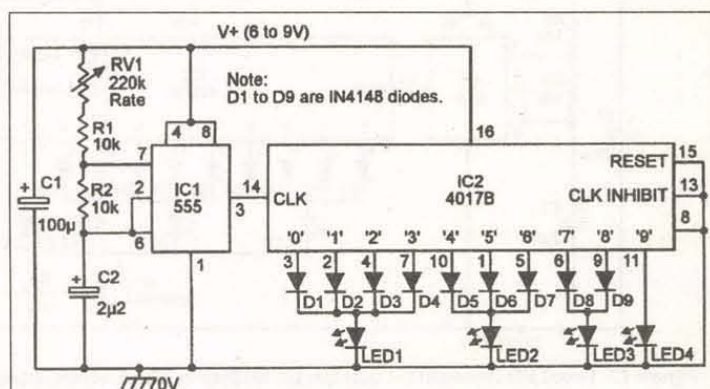
Figure 13 shows a rather unusual and very attractive four-LED five-step sequencer in which all four LEDs are initially on but

then turn off one at a time until eventually (in the fifth step) all four LEDs are off; the sequencing details are given in the table in Figure 13. Note in this circuit that the LEDs are effectively wired in series and that the basic circuit cannot be used to drive more than four LEDs.

Figure 14 shows another unusual and attractive LED display.



**Figure 13. Circuit and performance table of a four-LED five-step sequential turn-off display.**



**Figure 14. Four-LED continuous accelerator display in which the pattern seems to accelerate from left to right.**

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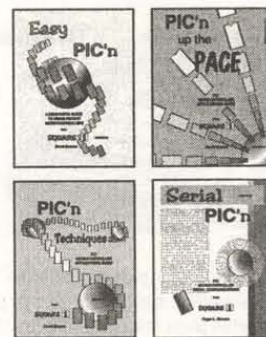
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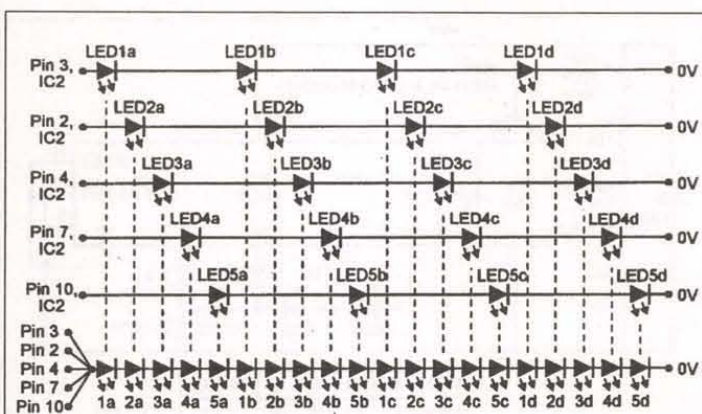


Figure 16. Basic method of constructing a five-strand 20-LED light-rope display for use with the Figure 15 circuit.

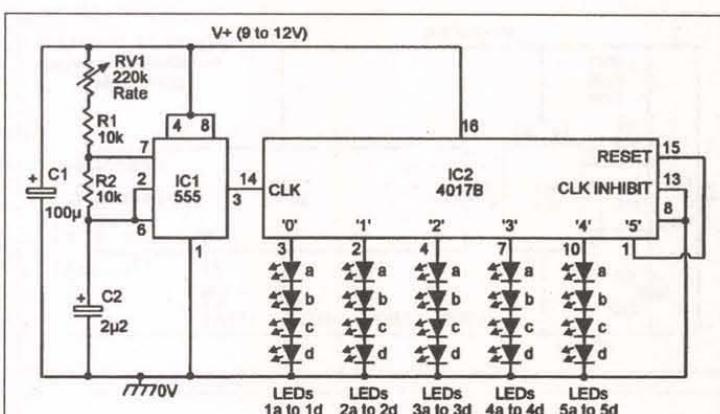


Figure 15. This four-bank five-step 20-LED chaser must be used with supply voltages of at least 9V.

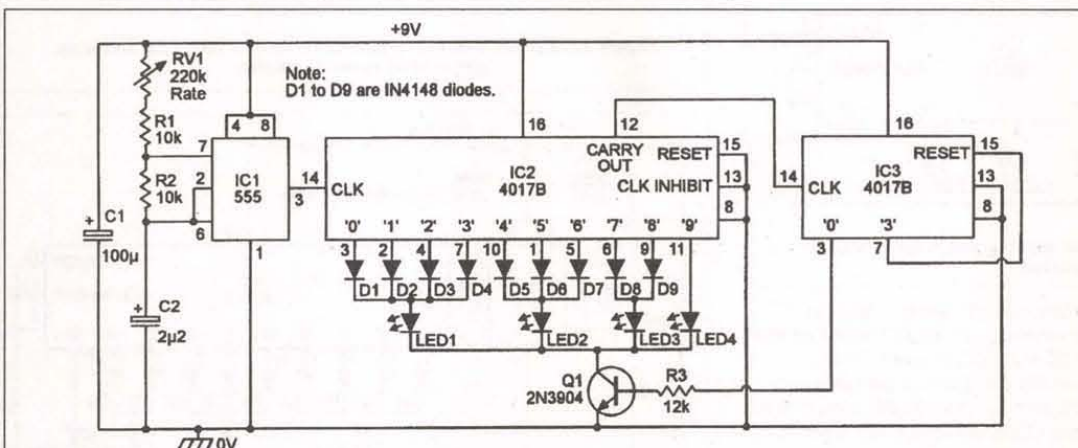


Figure 17. Four-LED intermittent accelerator display in which acceleration occurs for 10 clock steps in every 30.

In this case, the 4017B runs through a 10-step sequence, with

LED1 on for steps 0 to 3, LED2 on for steps 4 to 6, LED3 on for steps

7 and 8, and LED4 on for step 9. The consequence of this action is

that the visual display seems to accelerate from LED1 to LED4, rather than sweeping smoothly from one LED to the next. The acceleration action repeats in each switching cycle, and the cycles repeat ad infinitum.

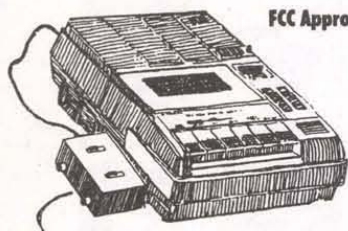
Finally, Figure 15 shows the circuit of a four-bank five-step 20-LED chaser that can be used as the basis of a variety of attractive LED displays. Note that a bank of four LEDs are wired in series in each of the five used outputs of the IC, so four LEDs are illuminated at any given time. Roughly 2V are dropped across each ON LED, giving a total drop of 8V across each ON bank, and the circuit's supply voltage must thus be greater than this value for the circuit to operate. A greater number of LEDs can be used in each bank if the supply voltage value is suitably increased.

One of the most attractive and popular LED sequencer displays is the 'light-rope' type, and Figure 16 shows the basic method of constructing a five-strand 20-LED light-rope display that can be driven by the Figure 15 chaser circuit. Here, each group of four series-connected 'step' output LEDs of the Figure 15 chaser circuit forms one 'strand' of the light rope. There are five strands, and each one must be color-coded to enable it to be connected to the correct output pin of the 4017B IC. In each strand, the four LEDs are evenly spaced apart, but are offset relative to the other four strands, so that there is an equal spacing between all 20 LEDs when the five strands are wrapped together (as shown at the bottom of Figure 16) to form the complete light-rope, which is usually threaded through a length of protective clear plastic tubing.

If a light-rope of this type uses a fixed spacing of (say) five inches between its LEDs, it will have a total length (allowing for a few unused inches at each end) of about eight feet. When the display

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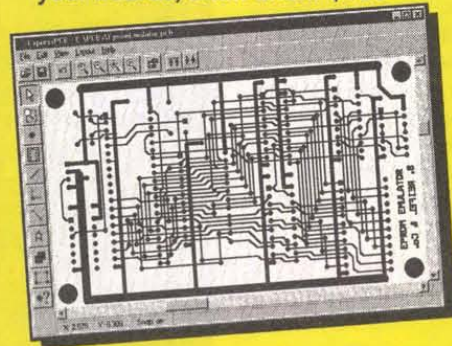
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is active, four evenly spaced ripples of light seem to run, continuously along the length of the light-rope, which is driven directly from the output of the Figure 15 chaser circuit.

## DISPLAY MULTIPLEXING

The basic action of the Figure 14 four-LED 'accelerator' circuit is such that the light display seems to repeatedly accelerate from left to right, taking a total of 10 clock cycles to complete each sequence. Figure 17 shows how the circuit can be modified to give an intermittent display in which the visual acceleration action occurs for 10 clock cycles, but all LEDs then blank for the next 20 cycles, after which the action repeats. The circuit action is as follows.

The 4017B has a CARRY OUT terminal on pin 2. When the IC is used in the normal divide-by-10 mode, this CARRY OUT terminal produces one output cycle each time the IC completes a decade count. In Figure 17, this signal is used to clock a second 4017B (IC3), which is wired in the divide-by-3 mode with its '0' output fed to the base of gating transistor Q1. Consequently, during the first 10

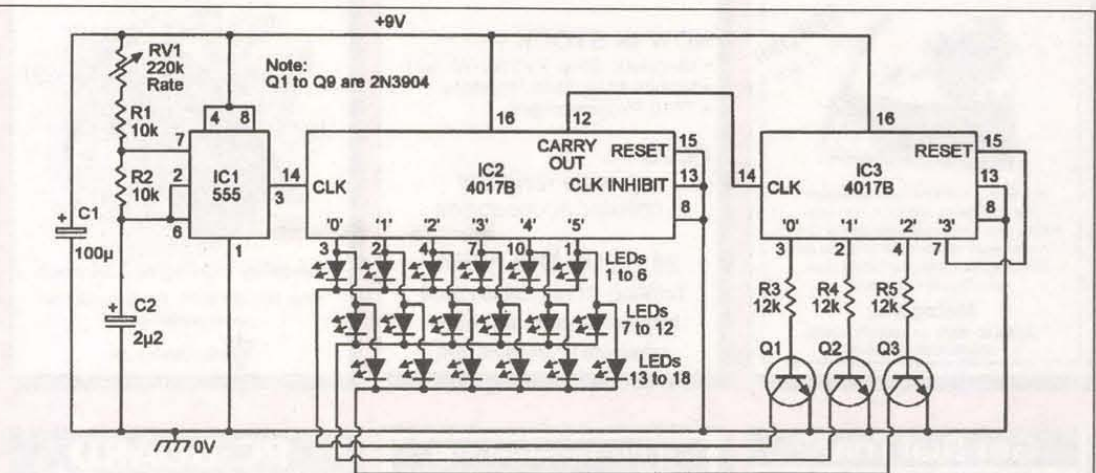


Figure 18. Multiplexed six-LED x three-line moving-dot display. The dot moves intermittently along the lines.

clock cycles of a sequence, the '0' output of IC3 is high and Q1 is biased on, so IC2 acts in the basic manner already described for Figure 14, with its LEDs turning on sequentially and passing current to ground via Q1. After the 10th clock pulse, however, the '0' output of IC3 goes low and turns Q1 off, so the LEDs no longer illuminate even though IC2 continues to sequence. Eventually, after the 30th clock pulse, the '0' output of

IC3 again goes high and turns Q1 on, enabling the display action to repeat again, and so on.

The Figure 17 circuit is a simple example of display multiplexing, in which IC3 and Q1 are used to selectively enable or disable a bank of LEDs.

To conclude this article, Figure 18 shows another example of a display multiplexing circuit. In this case, the display consists of three lines of six intermittently-

sequenced LEDs, and these lines are sequentially enabled via IC3 and individual gating transistors, with only one line enabled at any one time.

Note that the basic Figure 18 circuit can easily be expanded to control up to 10 sequentially-activated lines, which can each have up to 10 LED-driving outputs. The expanded circuit can thus be used as a chaser/sequencer with up to 100 LED-driving outputs. NV

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The chip contains a built-in op-amp that utilizes external resistors (R2 and R3) to set the gain of the device. Using the values shown in the schematic, the sensitivity of U2 is about 1.3 millivolts per Gauss. U3 is a combination op-amp and comparator chip that is used to amplify the output voltage of the magnetic sensor, and detect when it exceeds a certain value as set by potentiometer R7.

U3A is the op-amp section of the chip and has a gain of 470 as determined by R4 and R5. It has a large value of capacitance across the feedback resistor to filter out any AC signals generated by the demodulator in the magnetic sensor. The op-amp output voltage at pin 1 is fed to the positive input of comparator U3B, pin 5. Potentiometer R7 is set during calibration so that the voltage at the wiper is somewhere between the maximum and minimum output voltage at pin 1 of U3A as the compass is rotated a full 360 degrees.

Thus, it can be seen that the output voltage of the comparator at pin 7 will be high when the compass is facing magnetic north, and low when it is facing 180 degrees away from magnetic north. When R7 is properly set, the high level output of U3B will represent a smaller rotational arc (such as 90 degrees or less) than that for U3B low level output.

When the comparator output is high, Q1 is forward biased, illuminating LED1. In use, the compass is rotated to identify the arc at which the LED

is illuminated. Then, the North Pole indicator is positioned at the center of the arc. The scale of the compass will then indicate all compass directions.

## CONSTRUCTION

The compass is constructed on a small single-sided printed circuit board measuring about 3/4 by 2-1/4 inches. This allows it to be installed vertically in a small, square enclosure less than one inch high. The circuit is not critical, and may be wired on a perfboard, if desired. If you do not wish to etch and drill your own board, one may be purchased from the source listed in the parts list. Figure 3 illustrates the printed layout, shown in full size as seen from the copper side of the board.

The enclosure will also contain the nine-volt battery and the on/off push-button switch. At final assembly, LED1 will be mounted to the top surface of the enclosure, at the north indicator of the scale (Figure 7).

Figure 4 illustrates the parts placement. The first components that should be assembled to the board are U2 and U3. These are surface mount components that must be properly soldered in place, with a low wattage soldering iron, that has a pointed tip. As indicated in the printed layout of Figure 3, pin 1 of each IC pattern is represented by a dot. Figure 5 shows how to identify the corresponding pin #1 of each of these two parts. Use the following procedure to solder the chips to the board:

1. Gently clean the board with a scouring pad to remove oxidation and any other contaminants.

inants. Rinse well in cold water and dry thoroughly.

2. An assistant will be helpful with this and the next step. Place the IC directly over the copper pattern, observing where pin 1 of the chip is. Some ICs have a small dot that indicates pin 1. Others indicate pin 1 by the legend that identifies the part number. See Figure 5.

3. While holding the chip in place, solder only one corner pin to the board being careful not to use excessive heat or solder. Too much heat will cause the copper pad to lift off the board. Excessive solder may result in a short circuit between two adjacent pins.

4. Examine the location of all pins of the chip with respect to the copper pattern. All pins must lie directly over the pads. If not, adjust the chip's position or remove the IC and repeat steps 2 and 3.

5. If you are satisfied that all pins are properly positioned, solder the remaining seven in place. When finished, examine the connections to be sure they are solid with no solder bridges between pins.

Insert the remaining components into the board as illustrated in Figure 4, using Figure 6 to identify the connections of the terminal connections of Q1 and U1. Pay strict attention to the orientation of these parts and the electrolytic capacitor, which are polarized. Double check before soldering — any polarized component placed backwards in the circuit will cause an inoperative compass and possible damage to one or more of the parts.

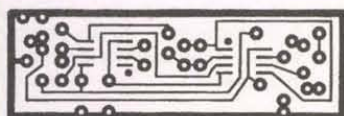


FIGURE 3.

Printed layout shown full size as seen from the copper side of the board.

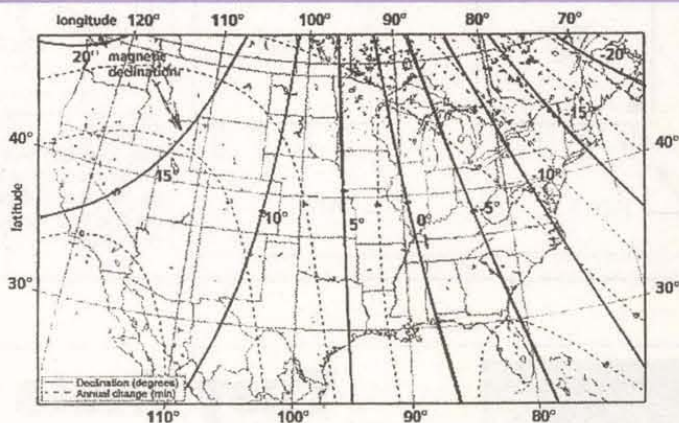
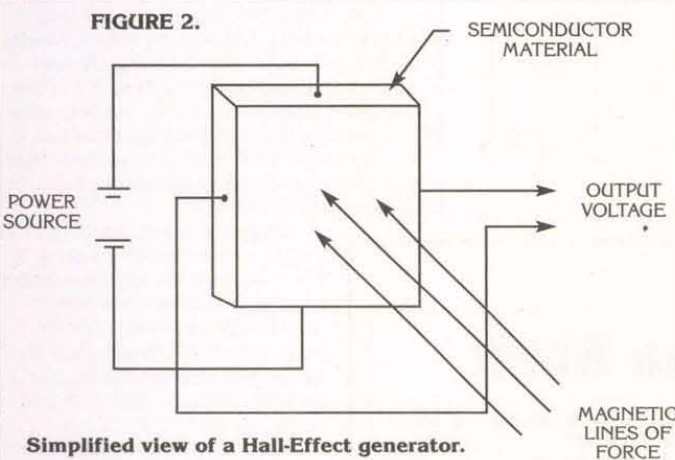


FIGURE 1. Positive value of magnetic declination indicate that True North lies west of the magnetic North Pole. Negative values indicate that True North lies east of magnetic north.

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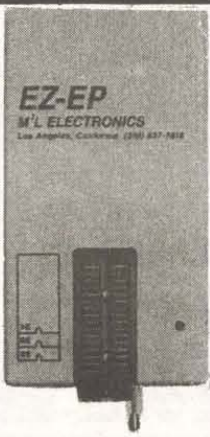
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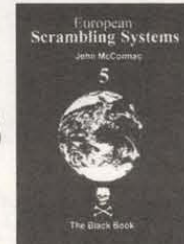
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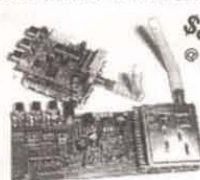
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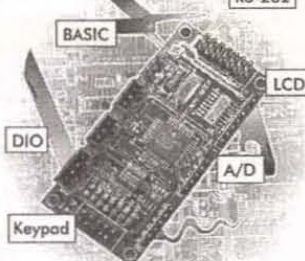
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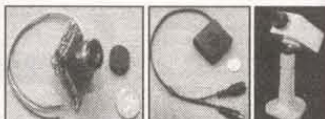
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## reader Feedback

Continued from page 14

is poor. I am surprised Electronic Rainbow can offer the kit for sale.

The DC resistance of a telephone must be greater than 10 megohms. The load a telephone places on a line is condensed into a ringer equivalence number (REN); you will find this number stated on every phone. A telephone's REN must be less than 5; my desk phone's REN is 0.2.

The Busy Lite's REN is about 500. The telephone company periodically (and automatically) tests for trouble on its telephone lines, and it will notice the high REN. Attach 10 Busy-Lites to your telephone line, and some central offices may think you went off hook.

Type 68 interfaces have other requirements to protect the user and the telephone company, such as no exposed metal, 1,500-volt isolation, and transient tolerance. Tip and ring have stringent balance requirements, and hooking the Busy-Lite to a grounded supply will upset that balance and possibly disable your telephone service.

Even if we ignore regulatory requirements, the circuit design is poor.

When a phone goes off hook, Q1 turns off. Q2 turns on. If Q2 turns on hard, then D1, D2, and Q2 are a direct short across the battery. The battery internal resistance will limit the current, and the battery life will be poor.

If the current limits at 100mA, the 9V battery will last about two and one-half hours off-hook. Talk to your ISP too long, and the battery is gone.

A better design replaces D2 with a 1K resistor, so the battery current will always be less than 9mA, and the battery will last for 25 off-hook hours. To get longer life, reduce the LED current and/or flash the LED at a low duty cycle. The battery savings will pay for additional complexity. Flashing 1.8mA at 10% duty cycle will give you more than 1,000 hours off hook. Use an inductor and get even more time.

The on-hook performance isn't great either. There will be about 3V across R3, so the current drain on the battery is 60uA. If the battery capacity is 200mA-hr, then the life-time is about 140 days. My watch uses a much smaller battery and runs for three years. A good circuit design would set the quiescent current drain below 10uA.

The project has many serious flaws and should not be used.

Gerald Roylance  
via Internet

## Fred's response ...

Regarding Gerald Roylance's comments about my Telephone Busy Lite construction project, I have no argument with any of his comments.

Mr. Roylance is a very capable and well-recognized author, and it is apparent from his previous articles and letters in *Nuts & Volts* — and his specific analysis and suggestions concerning the Telephone Busy Lite — that his technical knowledge is well beyond most experimenters and hobbyists.

This article was my attempt to clarify operation and offer modifications to a useful device that Electronic Rainbow has been offering in kit form for years, and for which no similar commercial device was available. It was intended for experimenters and hobbyists, with several suggested changes.

I assumed the Electronic Rainbow design satisfied telephone interface requirements ... which were greatly relaxed since the CarterPhone decision many years ago involving the use of telephone answering machines.

Previous to that decision, any device being connected to the

phone lines had to use a special interface installed by the telephone company.

Mr. Roylance's suggested circuit changes seem valid, especially with respect to battery drain. You'll note that my article made several suggestions about using external power rather than battery power.

As a final note, I have personally been using three of these Telephone Busy Lite's, built from unmodified Rainbow kits, but using external power rather than batteries, since August of 1999, with no observed telephone problems.

Fred "Spark" Blechman

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# AMATEUR ROBOTICS

by Robert Nansel

As I write, we are still up to our hips in boxes here at the new Robot Ranch. I have had zero time for robotics the past four weeks, so I won't be talking about IC H-bridges this time as I promised. Nor will I be announcing a winner yet for the Second Lonely Gearhead Contest.

For one thing, I haven't had time to tabulate all the entries received to date and, for another, I haven't yet gotten a bound copy of the prize I promised (Karl Lunt's new book). AK Peters, the publisher of Karl's book, graciously provided me with a pre-press copy to review, but that will have to wait till next month because I haven't had time to read it either.

Therefore, by fiat I'm extending the time to send in your contact information if you are looking for a local robotics club, or your robotics club contact information if I haven't already included you in my club listing. Send your information in by May 1, 2000 and you'll be eligible for the drawing.

In my packing I did, however, come across a bunch of interesting motor driver and controller boards I built in the early 90's. They all use an interface scheme called ROBBi.

First some background.

Throughout the 25-year history of the modern amateur robotics movement, the goal for many in amateur robotics has been the development of plug-compatible robot modules, and we were no exception eight years ago in the Seattle Robotics Society. The topic comes up periodically in any robotics club, usually when someone says, "Say, we ought to have a standard robot for the club ..."

The discussion degenerates into religious arguments on the relative merits of various microcontrollers, about legs vs. wheels, or even (so help me) batteries vs. fuel cells, until somebody in exasperation points out that what is *really* needed is a way to interface commonly-used function blocks (which is the best we can expect to do because Gearheads are such a contentious lot). What goes on inside the blocks is then up to the individual cantankerous designer/builder.

The concept is simple: First, we decide what function blocks are necessary for building robots (this alone can take days of arguing), then we define interfaces between those function blocks.

## ROBBi To The Rescue

ROBBi (ROBBot Builder Interface) is a proposed standard I worked with in the early 90's that defined these blocks and the interfaces. Though a bit unwieldy for small robots (like Breadbot) because it uses 16- or 32-

pin connectors, ROBBi still makes sense for medium and large robots, especially if you want an exceptionally easy-to-understand interface.

What function blocks are needed? A simple mobile robot might only need to run a couple of motors, as well as monitor some bumper contact switches, while a more complex robot could have devices as complicated as hydraulic operated legs, gyroscopes, and laser range finders. To be useful, a standard interface must allow for this wide range of device types, but still be simple enough to understand and apply.

To distinguish devices from robot subsystems, I'll call robot subsystems gadgets. Gadgets come in four flavors that correspond roughly to the first four device types: motor, sensor, communicator, and computer. Devices are always single class; a DC motor is an actuator, a video camera is a transducer, and a speech synthesizer is an annunciator, but gadgets can be composed of devices of several classes.

The class of a gadget is determined by a common-sense analysis of the primary function of the gadget. For example, a mobility base with two motors (actuators), optical encoder feedback (transducers), and a motor controller (driver, controller) would be considered to be a *motor gadget*; a vision subsystem consisting of a video camera (transducer) mounted on a motor-driven pan-tilt head (actuator) would be a *sensor gadget*.

A combination of gadgets of several classes to form a single subsystem is called a complex gadget. A subordinate robot is an example of a complex gadget. For this three-tier hierarchy (Robots, Gadgets, and Devices), there are three corresponding interface levels: Robot Level, Gadget Level, and Device Level.

## Robot Level

Robot Level interfacing would involve things as sophisticated as speech recognition or perhaps running entire fleets of robots from a central computer. The information flowing through a Robot Level interface would have the character of task descriptions. These task descriptions specify goals, high-level commands such as "Go to the bedroom, find laundry basket, take basket to laundry room, wash clothes from laundry basket." These commands might be in a natural language, such as English, or may have some other more compact representation.

## Gadget Level

Gadget Level interfacing involves moving command, control, and sta-

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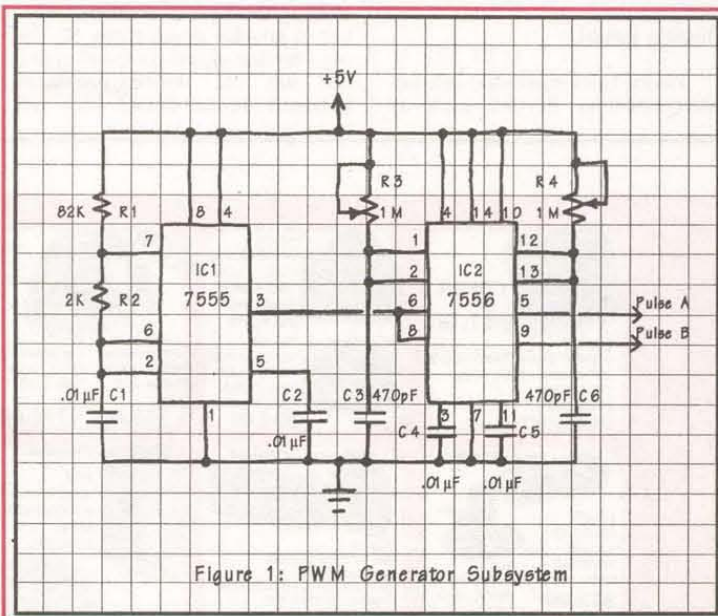


Figure 1: PWM Generator Subsystem

tus information between robot subsystems. Gadget level communication would take place on a high-speed

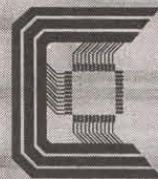
network; with all gadgets preferably sharing the same interface type. The information flowing through a

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Gadget Level interface would have the character of action descriptions such as "Go forward two feet, take sonar readings, turn 45 degrees left, report bumper status, run scanner motor CCW at 50 RPM."

## Device Level

Device Level interfacing involves interconnecting devices such as

motors, relays, sonars, power drivers, bumper contacts, motor controllers, etc. Device Level interfaces are byte-oriented. While there are only five device classes (actuators, transducers, annunciators, drivers, and controllers), there are an enormous number of possible device types. No single interface would do for all types, but we can define interfaces between device classes that will

cover most situations. This time, I'll define the classes of devices.

## Actuators

Actuators are the muscles of a robot. Devices such as DC motors, solenoids, hydraulic cylinders, stepper motors, ducted-fan thrusters, and rocket engines are all actuators. Actuators typically require high cur-

rent, high voltages, or both for operation; actuators are usually open loop control devices, so feedback is often used to close the loop to improve performance.

## Annunciators

Annunciators are the expressive personality of a robot. Devices such as speech synthesizers, "talking head" displays, strobe lights, and status readouts are examples of annunciators. Annunciators are typically used by a robot to communicate with people. The nature of the communication ranges from entertainment to danger warnings.

## Transducers

Transducers are the eyes, ears, and nose of a robot. Devices such as photocells, thermistors, force sensitive resistors, strain gauges, pressure transducers, battery voltage monitors, ultrasonic range finders, CCD video cameras, optical encoders, limit switches, and tachometers are all transducers. Transducers monitor physical quantities in the environment, as well as on board the robot. Transducer signals are often analog in nature.

## Drivers

Hardware drivers are the heart of a robot (not to be confused with software drivers). They form the bridge between devices that interact with the environment (actuators, sensors, and annunciators) and devices that interact with other devices (controllers). Drivers perform the mostly analog functions of power supply, power switching, signal conditioning, and signal conversion. Power supply functions can include voltage/current regulation, over/under current/voltage protection, battery charging, DC/DC conversion, and power distribution. Power switching functions can include switching high current/voltage loads and PWM motor drive. Conditioning functions can include amplification, level shifting, debouncing, and filtering. Conversion functions can include Analog to Digital (A/D), Digital to Analog (D/A), Voltage to Freq. (V/F), Freq. to Voltage (F/V), Resolver to Digital (R/D), etc.

## Controllers

Controllers are the brains of a robot, or at least the autonomous nervous system. Controllers bridge between higher and lower levels in the gadget hierarchy, decomposing complex actions into simpler actuator/sensor/annunciator command sequences. Controllers are generally high speed, general-purpose microprocessors or microcontrollers, but could also be logic state machines, digital signal processors (DSP), or user remote controls. Controller sig-



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## Putting It All Together

Actuators and transducers interface with drivers, and drivers interface with controllers. Interfaces between controller devices and driver devices are called *channels*. Raw device interfaces may carry any combination of digital or analog signals, high or low level, but channels carry only properly conditioned digital TTL or HCT-level signals.

## Motor Channels

The ROBBI Motor Channel allows simple interfacing to DC motors with device independence. One Motor Driver might use relays to control direction and a power transistor for PWM speed control of a 20 amp motor; another might use sophisticated MOSFET H-bridges for a 20 mA motor. With the ROBBI SMC, the same Motor Controller (MC) can be used for both. It is the division of the functions of control and drive that allows this to happen.

ROBBI Motor Channel interfaces come in Single Motor Channel (SMC) and Dual Motor Channel (DMC) varieties. The SMC uses a 16-pin ribbon connector (the "ROBBI-16" connector), while the DMC uses a 34-pin ribbon connector ("ROBBI-34"). The ROBBI SMC is comprised of eight signals: four outputs to give bidirectional control of a DC motor and optional brake, and four inputs to monitor

speed, direction, and limit status.

Table 1 gives the pin assignments for a ROBBI-34 DMC interface. The DMC is just two SMCs sharing the same connector with the addition of two new signals, T0 and T1, used to identify driver interface type.

## Generic Motor Channel Signals

**PWM.** A pulse width modulation signal is used to control speed.

**DIR.** 1 for positive motion, 0 for negative.

**EN.** Enable = 0 selects default pin functions, Enable = 1 selects alternate pin functions. The alternate pin functions allow future enhancements, such as the ability to control stepper motors with a ROBBI Motor

Channel interface. To ensure compatibility with future versions of ROBBI, when EN is brought high, the MD tristates TACH, SDIR, LP, and LN with the MC optionally pulling those corresponding lines high. Also, PWM, DIR, and BRK are isolated on MD from their corresponding MC pins and are pulled low on the Motor Driver.

**BRK.** This signal supports two different styles of braking: shunt and clutch. Shunt braking involves shorting the motor terminals together which slows the motor. Shunt braking occurs when the PWM and BRK signals are both low or both high. Clutch braking is active only when BRK is high, regardless of the state of PWM. This function is optional and can be used in addition to shunt

braking. If no clutch brake is implemented on the motor controller (MC), this line should be tied to ground.

**TACH.** This signal is used to monitor motor shaft output speed. The speed is determined from TACH by dividing its pulse frequency by the number of pulses the tachometer generates per revolution. Optical, magneto, and Hall-Effect type tachometers naturally generate pulse outputs which can be used directly for TACH; tachometers that create analog outputs, say a voltage proportional to speed of rotation, may be used with suitable signal conditioning (i.e., voltage-to-frequency conversion). If a tachometer is not used, this line should be pulled high by MD.

**SDIR.** The Sensed Direction signal can be derived from quadrature decoding in a discrete encoder or from the voltage polarity of an analog tachometer. For quadrature decoding, this signal may lag a few pulse times behind the TACH signal.

**LP, LN.** These signals act as limit condition sense lines where one or the other — but not both — lines dropping low informs the controller that a limit of travel has been reached in the corresponding direction. If both signals are low simultaneously, the interpretation changes to that of an index or home position pulse. LP and LN will normally be held high by the motor driver. If MD doesn't implement limit and index functions, these lines shall be tied to +5V.

**T0, T1.** These signals allow a driver module with a ROBBI-34 interface to identify what type of driver it

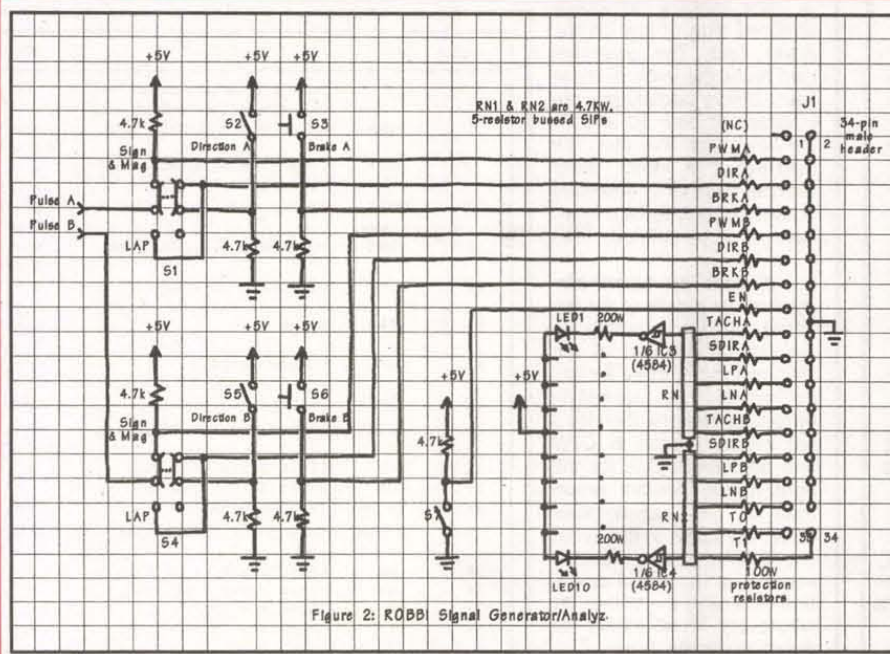
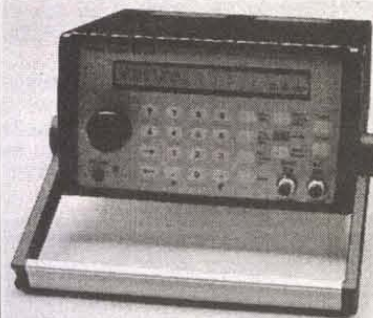


Figure 2: ROBBI Signal Generator/Analyzer.



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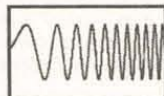
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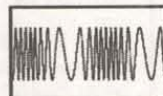
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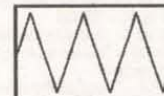
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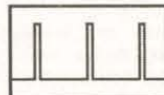
Int/Ext AM, SSB, Dualtone Gen.



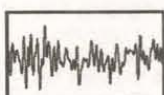
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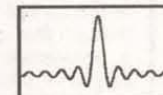
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is. These lines are individually strapped high or low on the driver card. The controller card reads the levels of these lines before initializing the interface. If both T0 and T1 are low, this indicates the interface is a motor driver channel (type 0) as described above. Other interface types have yet to be defined.

**A note on terminology:** Positive is defined for the above signals according to the natural function of the limit involved. If these are limits applied to tank-style propulsion motors, then for a left motor, positive is CCW and negative is CW; for the right motor, positive would then be CW and negative CCW. The rule is to pick what direction is positive for the actuator in its normal operation, reversing the wiring (or whatever) if necessary to maintain positive sense.

## Why So Many Grounds?

With the first eight signals, most DC motors can be controlled. The rest of the lines available in the channel (except for the driver type bits) are ground lines. This may seem a waste, but the ground lines are important.

Robots are electrically noisy creatures. Arcing commutator brushes, high current circuits, poor shielding, and layout make the difference between robots that work flawlessly and robots that don't work at all. Fortunately, we can do a great deal about shielding and layout.

There are two main types of electrical interference. One is capacitively coupled, the other is inductively coupled. For inductive coupling, reduction of loop area is the name of the game. A ground between every signal in a ROBBi channel ensures that each signal has the minimum possible loop area to pick up inductively coupled noise.

The ground lines also provide a modest amount of electrostatic shielding between signals. Whenever two wires run close to each other, they form a capacitance through which signals can be capacitively coupled. With a ground between two signal lines, the capacitors formed are between each signal and ground, rather than from signal to signal. This substantially reduces crosstalk.

Finally, having a dedicated ground for each signal allows the return current for each signal to flow through that ground. In a way, this is a restatement of the reduction-in-loop-area principle, but this also has the effect of reducing differences in ground potential between the two ends of the cable.

Ground potential differences are more commonly known as the dreaded Ground Loop. Note that a loop in

Pin #	Func	Description	Interpretation	Source
2-32	GND	Even # pins grounded		
1	--	(reserved for future exp.)		
3	PWMA	Pulse Width Modulation	0 = Motor OFF 1 = Motor ON	MC
5	DIRA	Direction of Motion	0 = Positive 1 = Negative	MC
7	BRKA	Brake	0 = Brake OFF 1 = Brake ON	MC
9	PWMB	Pulse Width Modulation	0 = Motor OFF 1 = Motor ON	MC
11	DIRB	Direction of Motion	0 = Positive 1 = Negative	MC
13	BRKB	Brake	0 = Brake OFF 1 = Brake ON	MC
15	EN=0	Enable default	0 = Def. funct. 1 = Alt. funct.	MC
17	TACHA	Tachometer Pulse A	PFM, freq. $f_0$ *	MD
19	SDIRA	Sensed dir. of Motion	0 = Positive 1 = Negative	MD
21	LPA	Limit Sense, Pos DIR		MD
23	LNA	Limit Sense, Neg DIR		MD
25	TACHB	Tachometer Pulse B	PFM, freq. $f_0$ *	MD
27	SDIRB	Sensed dir. of Motion	0 = Positive 1 = Negative	MD
29	LPB	Limit Sense, Pos DIR		MD
31	LNB	Limit Sense, Neg DIR		MD
33	T0	Interface Type bit 0		MD
34	T1	Interface Type bit 1		MD

MC = Motor Controller MD = Motor Driver  
\* Rev/sec =  $f_0 / (\text{counts/rev})$

Table 1: ROBBi DMC Signal Definitions

a ground does not a ground loop make; a ground loop is specifically a current loop created by differences in ground potential existing in the circuit. The goal is to reduce ground potential differences as much as possible. One way to do that is to provide dedicated grounds for every signal.

An excellent introduction to the causes and cures of electromagnetic interference can be found in Intel Applications Note AP-125 "Designing Microcontroller Systems for Electrically Noisy Environments," and Article Reprint AR-102, "PC Layout Techniques for Minimizing Noise." I recommend both articles.

## A ROBBi-34 Exerciser

The ROBBi-34 Exerciser presented here is useful both as a piece of test equipment and as a tool for exploring the mechanical behavior of your robot. The Exerciser allows you to manually control all of the signals needed to make two motors run under varying speed, direction and brake settings, as well as observe all tachometer, sensed direction, and limit conditions the DMD board provides.

You can do this before writing any motor control software for your Dual Motor Controller, indeed before you've even built the controller. Thus, you can check for correct drive motor wiring polarity before your controller errantly sends your robot careening in an unexpected direction.

## How The Circuit Works

The Pulse Width Modulation

(PWM) generator (Figure 1) is the heart of the Exerciser. With the values given for R1, R2, and C1, IC1 provides a time base of two kHz to trigger both timers of IC2. The timers of IC2 are wired in the monostable or one-shot mode so that each trigger pulse from IC1 initiates a single output pulse from each timer. The durations of these pulse outputs — Pulse A and Pulse B — are controlled by R3 & C3, and R4 & C6, respectively.

You can use most any one megohm linear taper potentiometers for R3 and R4, but I like to use linear slide pots for this purpose rather than ordinary rotary pots because the linear pots give immediate visual and tactile feedback on the duty cycles of the Pulse A and Pulse B outputs.

The rest of the Exerciser circuit can be broken down into two sections, the switch control section (left half of Figure 2) and the feedback display section (lower right of Figure 2).

Please note that my contact information is now different. If you have suggestions, questions, or comments about amateur robotics topics, you can now reach me at:

**Robert Nansel**  
Box 228  
Ambridge, PA 15003

The E-Mail address is the same:  
E-Mail: [bnansel@nauticom.net](mailto:bnansel@nauticom.net)



In the switch control section, when S1 is set to the "Sign & Magnitude" position, it routes the Pulse A and Direction A signals to the PWMA and DIRA output pins on J1; here S2 determines what the level of the DIRA output pin will be. However, when S1 is set to the "LAP" (Locked Anti-Phase) position, S2 is disconnected, PWMA is held high, and Pulse A is routed to DIRA instead of PWMA. S4 and S5 work the same way for PWMB and DIRB.

## S&M vs. LAP

As mentioned in previous columns, LAP is an alternate way to control motor speed and direction. With PWM held high continuously, DIR causes motor current to attempt to change direction at the two kHz time base. Motors cannot mechanically respond to such rapid current reversals, reacting instead to the average direction of the current.

When DIR outputs a 50% duty cycle waveform, the motor is motionless; higher than 50% the motor turns forward, lower than 50% the motor turns backward. The speed will be proportional to how far from 50% duty cycle DIRA goes.

Why do this? For many applications, Sign & Magnitude control of motors works fine, but from a control perspective, LAP offers the advantage that you can smoothly control a motor through zero speed.

With Sign & Magnitude control, motors behave non-linearly for low speeds. Some gearmotors I've experimented with refuse to turn, even with no load applied, at PWM duty cycles less than 40%; with LAP you do not have this problem.

LAP can use more power than Sign & Magnitude control if the PWM frequency isn't matched to the armature inductance of the motor, but this usually isn't a real problem. (The relay-type H-bridges shown earlier in this series can not use LAP control.)

The rest of the switch control section consists of S3 and S6, which provide logic levels for BRKA and BRKB, respectively, and S7, the interface enable switch. Both BRKA and BRKB override their respective PWM and DIR signals. If the DMD board is capable of it, the motor leads are shorted together to dynamically brake the motor; electromagnet-type clutch brakes are also activated by these signals.

The feedback display section allows simple line level monitoring of TACH, SDIR, LP, and LN signals for A and B motor channels. IC3 and IC4 are Hex Schmitt-Trigger inverter/buffers driving low current LEDs.

RN1 and RN2 provide pulldowns so the inputs of IC3 and IC4 won't float and thus be damaged if no DMD is plugged into J1. The 100 ohm series resistors provide protection against overvoltages and short circuits on the DMD side.

The TACH signals are active low

pulse trains, so the brightness of their indicators is inversely proportional to pulse frequencies. I prefer this approach because each LED then shows the true input level.

You could, however, use the two spare inverters to add another inversion to each of these signals so brightness would then be proportional to the TACH pulse frequencies. Some other improvements for

the circuit might be to add LED indicators for the output signals, digital frequency counter displays for the TACH signals, line floating indicators, etc.

If you try any of these variations, I'd be interested to see how they work. The circuit as it stands is simple and inexpensive and should provide a valuable tool for your robotics workbench.

## Now, Where Is That Box ...

By the time you read this, I should have my workshop unpacked and functioning smoothly again, so I can get back to the motor H-bridge series (and maybe even get back on track with the I2C code ...). Until then, don't forget to enter the Second Lonely Gearhead Contest. May 1st is the deadline. **NV**

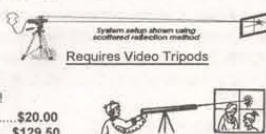
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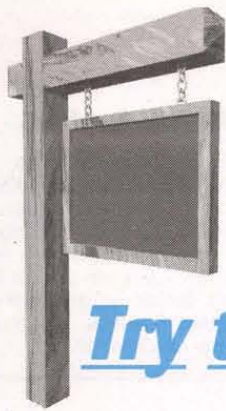
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The board requires one jumper wire, identified as J1 in Figure 4, to complete the circuit. This wire connects U2 and U3 pin 4 to circuit common. The LED may be temporarily soldered to the board, as indicated in the schematic diagram, for the preliminary test. Be sure to observe polarity of this component, which can be determined by using an ohmmeter that is set to one of the higher Ohms scales.

When finished stuffing the board, check for inadvertent short circuits and bad solder connections. Any connection which is not shiny and

smooth is suspect and should be redone by removing the old solder with braid, cleaning the joint, and applying new solder. Correct any problems now before proceeding.

### BATTERY CONNECTOR

Nine-volt battery clips are readily available from electronics parts suppliers, but one is easily fabricated by taking apart an old battery and removing the connector. It is best to solder a red and black flexible wire to the rear side of the connector, observing proper polarity which will be opposite to that of a battery. Be sure to check connector wiring by clipping on a fresh battery and

verifying with a DC voltmeter that the red wire is positive and the black wire is negative.

Once the polarity of the connector wiring has been verified, remove the battery and temporarily solder the two wires to the board at the +9 volt and common circuit connections as indicated in Figure 4 and the schematic diagram. When finished, set the board aside while preparing the enclosure.

### ENCLOSURE

Select a suitable enclosure — plastic and not metal — that is about 2-1/2 inches square so that it will accommodate the scale illustrated in Figure 7. Make a photocopy, lay it on the top side of the enclosure, and mark the location of the LED which should be on the north pointer of the scale. Drill a suitably-sized hole in the enclosure for the LED.

Place the PC board in a vertical position inside the enclosure, against the side that will correspond with the location of the LED and north pole indicator of the scale. U2 and U3 should be facing the outside, and potentiometer R7 should be on the right as seen from the top. Note the location of potentiometer R7, and drill a hole in the side of the enclosure that will permit a small screwdriver to be used for calibration. Determine a suitable location for the on/off switch, and drill a hole for that component.

Proceed to the preliminary checkout before permanently mounting the board and other parts to the enclosure.

### PRELIMINARY CHECKOUT

Take a fresh nine-volt battery and snap it on the connector. Measure the output voltage of the regulator (across C2) with a DC voltmeter. Normal indication is 4.75 to 5.25 volts. If you do not obtain the correct reading, measure the battery terminal voltage to be sure it is at least eight volts. If so, remove the battery from the circuit and troubleshoot the board to locate and repair the fault.

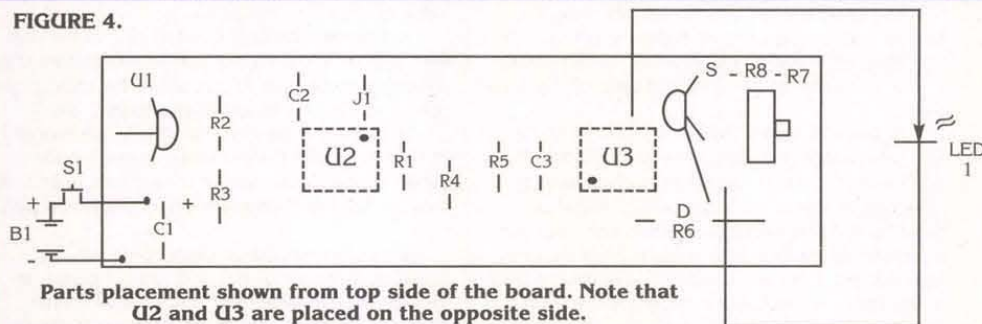
Check the orientation of U1, U2, and U3 as illustrated in Figures 4, 5, and 6. Measure the resistance across C2 to be sure there is no short circuit. Normal indication is 2.5K or more. Try a new regulator chip. Do not proceed with the checkout until the fault has been repaired and U1 delivers five volts to the circuit.

Continuing with the test, measure the voltage at pin 1 of U2. Normal indication is 2.5 to 4.5 volts. Rotate R7 over its range and verify that the LED will be lit at one part of the rotation, and extinguished for the remainder.

Hold the board in the vertical plane so that the long dimension is horizontal with the surface mounted components facing away from you, just as it would be when mounted in the enclosure. Turn your body so that the surface mounted components face north, and carefully adjust R7 so that the LED just comes on. Allow time for the long time constant of the amplifier to stabilize.

Now turn yourself and the board around slowly and note that the LED will be off when the chips on the board face south, and on when they face north. This completes the preliminary checkout.

FIGURE 4.



Parts placement shown from top side of the board. Note that U2 and U3 are placed on the opposite side.

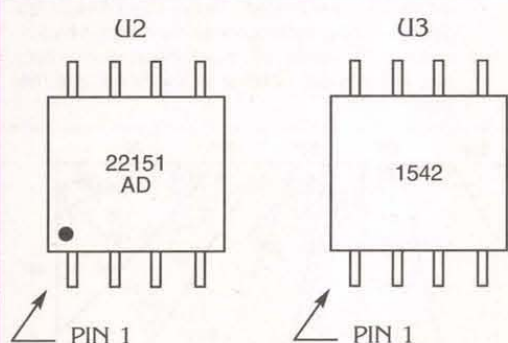


FIGURE 6.

Terminal identification of U1 and Q1.

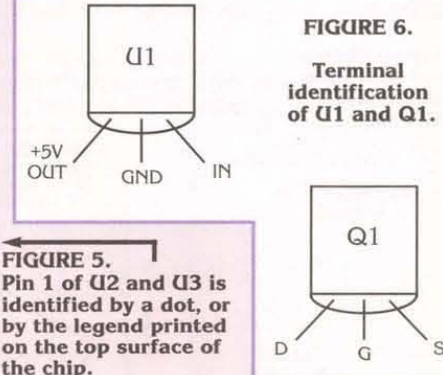


FIGURE 5.  
Pin 1 of U2 and U3 is identified by a dot, or by the legend printed on the top surface of the chip.

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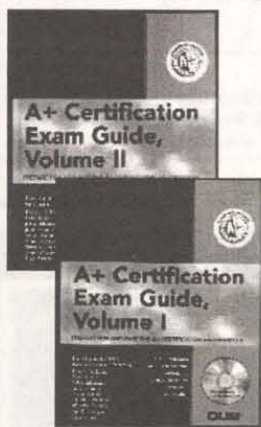
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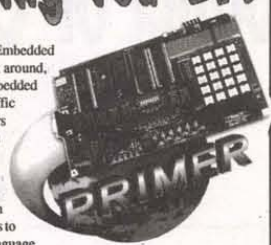
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Continued from page 59

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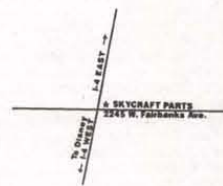
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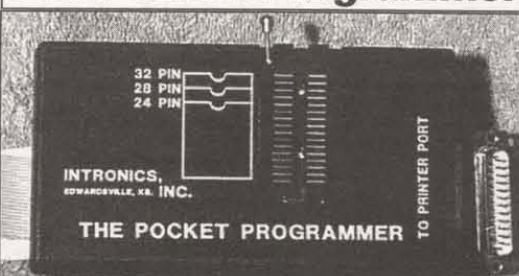
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Continued from page 62

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## MAILBAG

Hello TJ:

At first, I thought I'd add to your list of IC numbering prefixes using my handy-dandy Newark Electronics catalog. In the back, they have 34 pages titled "Manufacturer Series/Part Number Index" that's a more-thorough version of what you posted. Newark's listing covers all types of electronic components — including integrated circuits. Unfortunately, the list isn't exhaustive, for it does not contain the elusive "NJM" — the prefix of the device in question. Nonetheless, it's very handy; readers can get a printed or CD-ROM version of

the Newark catalog through their website (<http://www.newark.com>) or by calling 800-463-9275.

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Response:

Thanks for the great input. I thought Newark dropped that section, but it appears to be alive and well. Also, on the front cover of the Jameco catalog, you'll find logos of the various manufacturers; if you kept your old issues (which I didn't), you'll find logos for long-gone vendors. As to the mysterious NJM prefix, I found who sponsors it:

**NJR Corporation**  
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How'd I find it? Using Prefix Finder [www.hitex.com/chipdir/prefix/index.htm](http://www.hitex.com/chipdir/prefix/index.htm). Haven't had time to verify that, I'm at Carnival as I write this, so I leave that up to you. Thanks again for the input!

**TJ Byers**  
Q & A Editor

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2764-25	4.49	4.27	3.84
2764A-20	3.49	3.32	2.99
2764A-25	2.99	2.84	2.56
27C64-15	2.99	2.84	2.56
27256-15	4.79	4.55	4.10
27C256-15	2.99	2.84	2.56
27S12-25	3.09	2.94	2.65
27C512-25	2.99	2.84	2.56
27C010-15	2.79	2.65	2.39
27C020-15	3.49	3.32	2.99
27C040-12	5.49	5.22	4.70
27C080-12	10.99	10.44	9.40

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# Events CALENDAR

Continued from page 37

## JULY 15

**TX - SHERMAN/DENISON** - Hamfest, Wilmer O. Kinsey WB5DCU, 903-893-5872. E-Mail: wb5dcu@gte.net  
**TX - TEXAS CITY** - Hamfest. Tideland ARS, Joe Wileman AA5OP, 409-945-6794. E-Mail: aa5op@aol.com

## JULY 16

**MA - CAMBRIDGE** - Flea at MIT. Albany and Main Sts. 9am-2pm. Talk-in: 146.52 & 449.725/444.725 W1XM/R PL 114.8 (2A). Nick Altenbernd KA1MQX, 617-253-3776 (9-5). Web: <http://web.mit.edu/w1xm/www/swapfest.html>  
**MO - WASHINGTON** - Hamfest. Zero Beaters ARC, Keith Wilson K0ZH, 636-629-2264. E-Mail: jwpubl@fidnet.com Web: <http://zbarc.usmo.com/>  
**NJ - AUGUSTA** - Hamfest. Sussex County Fairgrounds, Plains Rd. Talk-in: 147.90/30. Sussex County ARC, Dan Carter N2ERH, 973-948-6999. E-Mail: n2erh@email.com Web: <http://www.scarcnj.org>  
**PA - KIMBERTON** - Hamfest. Mid-Atlantic ARC, Bill Owen W3KRB, 610-325-3995. E-Mail: gem@op.net Web: <http://www.marco.org/hamfest.html>

## JULY 21-22

**FL - MILTON** - Hamfest. Santa Rosa County Auditorium. Fri: 5pm-9pm, Sat: 8am-2pm. FCC Exams. Talk-in: 146.70. Milton ARC, Bill Couch W4VY, 850-623-0592. E-Mail: billcouch@sprintmail.com Web: <http://home.att.net/~k4cd/marc.htm>

## JULY 22

**NH - NASHUA** - Hamfest. Res Ctr Church. NE Antique RC 617-923-2665  
**OH - CINCINNATI** - Hamfest. Diamond Oaks Development Campus, 6375 Harrison Ave. 7am-2pm. VE Exams. Talk-in: 146.67 and 146.925. OH-KY-IN ARS, Gene McCoy N8KQJ, 513-541-6935. E-Mail: n8kqj@arri.net Web: <http://www.qsl.net/k8sch>

## JULY 23

**IL - SUGAR GROVE** - Hamfest. Waubensee Community College, Rt. 47 Harter Rd. VEC Exams. Talk-in: 147.210 (+600) PL 103.5/107.2. Fox River Radio League, Maurice Schietecat W9CEO, 815-786-2860. E-Mail: w9ceo@arri.net Web: <http://www.frrl.org/hamfest.html>

## JULY 28-29

**OK - OKLAHOMA CITY** - State Convention. OK State Fair Park (Hobbies, Arts & Craft Bldg.). Fri: 5-8pm, Sat: 8am-5pm. Talk-in: 146.82. Central OK Radio Amateurs, Harold Miller KB1ZQ, 405-672-7735 or 405-650-9963. E-Mail: n1lpn@swbell.net Web: <http://www.geocities.com/heartland/7332>  
**TX - AUSTIN** - Convention. Austin ARC, Austin Repeater Group, Texas VHF-FM Society, Joe Makeever W5HS, 512-345-0800

## JULY 28-29-30

**AZ - FLAGSTAFF** - State Convention. Ft. Tuthill. Fri: 12pm-5pm, Sat: 9am-5pm, Sun: 9am-2pm. VE Testing. Talk-in: 146.980 MHz with 100.0 Hz PL Tone. ARCA, Norm Martin K7OLD, 520-297-9562. E-Mail: norm@hamsrus.com Web: <http://www.hamsrus.com/tuthill.html>  
**CANADA - BC - VANCOUVER** - Pacific Northwest DX Convention. BC DX Club & Fraser DX Club, Dave Johnson VE7VR, 604-438-8715. E-Mail: ve7vr@rac.ca Web: <http://www.bcdx.org>

## JULY 30

**MD - TIMONIKUM** - Hamfest. Timonikum Fairgrounds. Talk-in: 147.03+ and 224.96. BRATS, Mayer Zimmerman W3GXX, 410-461-0086. E-Mail: w3gxx@arri.net Web: <http://www.smart.net/~brats>  
**OH - RANDOLPH** - Hamfest. Portage ARC, Joanne Solak KJ3O, 330-274-8240. E-Mail: ljsolak@aprk.net Web: <http://parc.portage.oh.us>

## AUGUST 2000

## AUGUST 5

**NM - ROSWELL** - Hamfest. Pecos Valley ARC, Vernetta Verasso KC5WKA, 505-627-7777. E-Mail: kc5wka@din.com Web: <http://www.pvarc.com>  
**OH - COLUMBUS** - Hamfest. Voice of Aladdin ARC, James Morton KB8KPJ, 614-846-7790. E-Mail: kb8kpj@cs.com

## AUGUST 6

**IN - ANGOLA** - Hamfest. Land of Lakes, Bill Brown WD9DSN, 219-475-5897. E-Mail: sharon.l.brown@gte.net  
**VA - BERRYVILLE** - Hamfest. Clarke County Ruritan Fairgrounds, VE Exams. Talk-in: 146.82-. Shenandoah Valley ARC, Irvin Barb W4DHU, 540-955-1745. E-Mail: ibarb@visualink.com Web: <http://www.valley.com/svarc/hamfest>

## AUGUST 12

**CA - FONTANA** - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves  
**IL - QUINCY** - Hamfest. Eagles Alps Grounds, 3737 N. 5th St. 8am-2pm. VEC Testing. Talk-in: 147.63/147.03. Western IL ARC, Jim Funk N9JF, 217-336-4191. E-Mail: jfunk@adams.net Web: <http://www.qsl.net/w9awe>  
**WV - HUNTINGTON** - Hamfest. Tri-State ARA, Dwight D. Smith, Sr. WB8JPJ, 304-522-7865. E-Mail: wb8jpj@home.com

## AUGUST 13

**IA - AMANA** - Hamfest. Amana Outdoor Convention Center. VE Exams. Talk-in: 146.745/145 and 146.520. Cedar Valley ARC, Chuck Bassett N0UTS, 319-378-0448. E-Mail: n0uts@rf.org Web: <http://cvarc.rf.org>  
**IN - GREENTOWN** - Hamfest. Greentown Lions Club Fairgrounds. Kokomo & Grant County ARCs, L.B. (Nick) Nickerson KA6NQW, 765-668-4814. E-Mail: ka6nqwnick@netusa1.net Web: <http://www.netusa1.net/~ka6nqwnick/hamfest.html>  
**MI - JACKSON** - Hamfest. Cascade ARS, Dennis Byrne KC8IJZ, 517-522-4058 or 517-796-6966. E-Mail: byrned@voyager.net  
**MN - ST. JOSEPH** - Hamfest. St. Cloud ARC, Linden Scott KA0DAQ, 320-252-4498. E-Mail: lscoth@aol.com Web: <http://www.w0sv.org/hamfest.html>  
**NJ - BAYVILLE** - Hamfest. Bayville Fire House, Rt. 9. VE Testing. Talk-in: 146.910 out, 146.310 in, PL 127.3. Jersey Shore ARS, Bob Murdock WX2NJ, 732-269-6379. E-Mail: jsarsfest@aol.com Web: <http://members.aol.com/jsarsfest/jsarsfest.html>

**NY - DEPEW** - Hamfest. Hearstone Manor, 333 Dick Rd. VE Testing. Lancaster ARC, Luke Calliano N2QDU, 716-634-4667 or 716-683-8880. E-Mail: lcalliano@freeweb.com Web: <http://hamgate1.sunyerie.edu/~larc>  
**CANADA - BC - PRINCE GEORGE** - Hamfest. Prince George ARC, Keith Powell VE7GDH, E-Mail: ve7gdh@rac.ca Web: <http://www.pghamfest.dhs.org/>

## AUGUST 18-19-20

**WA - LONGVIEW** - Hamfest. Cowlitz County Expo Center. 9am-1pm. Talk-in: 147.26+. Lower Columbia ARA, Bob Morehouse KB7ADO, 360-425-6076. E-Mail: kb7ado@aol.com Web: <http://www.qsl.net/nc7p/swapmeet.htm>

## AUGUST 20

**IN - LAFAYETTE** - Hamfest. Tippecanoe ARA, Bob Martin W9YE, 765-423-1035  
**KY - LEXINGTON** - Hamfest. National Guard Armory, adjacent to Lexington airport. 8am-4pm. VE sessions. Talk-in 146.760. Bluegrass ARC, John Barnes KS4GL, 606-253-1178. E-Mail: KS4GL@juno.com Web: <http://www.qsl.net/k4kjg>  
**MA - CAMBRIDGE** - Flea at MIT. Albany and Main Sts. 9am-2pm. Talk-in: 146.52 & 449.725/444.725 W1XM/R PL 114.8 (2A). Nick Altenbernd KA1MQX, 617-253-3776 (9-5). Web: <http://web.mit.edu/w1xm/www/swapfest.html>

## AUGUST 25-26-27

**MA - BOXBOROUGH** - Convention. Holiday Inn Conference Center. Ponto Tenta W1ABC, 617-248-6996 or 978-887-8887. E-Mail: w1abc@arri.net Web: <http://www.boxboro.org>  
**IL - DANVILLE** - Hamfest. Vermilion County ARA, Gary Denison KA9SKS, 217-759-7389. E-Mail: gdenison@danville.net  
**KS - SALINA** - State Convention. Central KS ARC, Ron Tremblay WA0PSF, 785-827-8149. E-Mail: tremblay@midusa.net Web: <http://www.qsl.net/w0cy>  
**NY - YONKERS** - Hamfest. Yonkers ARC, John Costa WB2AUL, 914-969-6548. E-Mail: wb2aul@aol.com  
**PA - NEW KENSINGTON** - Hamfest. Skyview Radio Society, Robert Livrone N3WAV, 724-339-9607. E-Mail: n3wav@arri.net

## AUGUST 27

**FL - MELBOURNE** - Hamfest. Melbourne Auditorium. Platinum Coast ARS, Tim Madden KI4TG, 407-724-9339. E-Mail: ki4tg@hotmail.com  
**SEPTEMBER 2000**

## SEPTEMBER 8-9-10

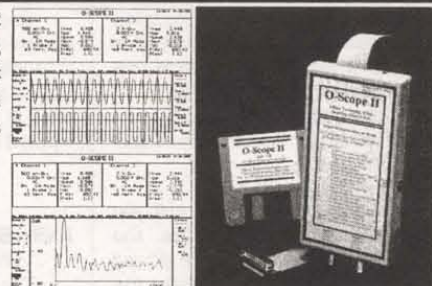
**FL - MELBOURNE** - Hamfest. Melbourne Auditorium. Platinum Coast ARS, Tim Madden KI4TG, 407-724-9339. E-Mail: ki4tg@hotmail.com

## SEPTEMBER 9

**CA - FONTANA** - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves  
**IN - SPENCER** - Hamfest. Owen County ARA, Kathryn Smith K9INJ, 812-829-2140  
**KY - LOUISVILLE** - State Convention. Greater Louisville Hamfest Assn., Herbert Rowe W4WQD, 812-294-4905. E-Mail: wd4ixl@juno.com Web: <http://www.thepoint.net/~gha/>

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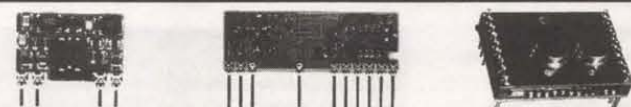
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- Wide supply range, 2-14Vdc
- SAW controlled - stability
- Also available in DIL package

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- 19200 baud with ASCII
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- Auto TX/RX changeover

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- 0.25mW & 10mW versions
- Reset switch and status LED's
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- Up to 19,200 bps half duplex
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back, the audio speeds up and slows down when I move the pentameter in the other direction.

Is this normal for all digital-to-audio chips? Is there audio output at the chip when I'm way beyond that clock frequency I recorded at?

What is the osc. frequency limits of the clock for voice communication?

You didn't specify which chip you were using, but chips like the ISD25120 can be sped up or slowed down by adjusting the oscillator frequency.

You can't count on varying the oscillator more than the allowance on the data sheet but, in reality, you will get away with a 10% to 20% variation easily.

Remember once you are operating an IC outside of the manufacturer's specification, all bets are off. Depending on how the digital-to-analog converter on the IC is designed and buffered, there might, in fact, be output down to very low oscillator frequencies. But once again, you can't count on it to work from chip to chip because you are so far outside the specifications.

If you want a circuit designed to adjust voices from James Earl Jones to Minnie Mouse then how about a small firmware/microcontroller/

hardware project with an A/D, a PIC controller, some memory, a DAC and an audio amp IC?

Record the sound with the A/D and let the PIC controller play it back through the DAC all the way down to 1Hz if you so desire. I've seen this done in a small voice recorder and it worked great.

Robert Miller  
Trenton, NJ

#### ANSWER TO #3006 - MAR. 2000

What are \*.gid files.

The file extension \*.gid is used by Windows as part of the HELP section of various programs. (Not every program uses a \*.gid file, though.) The information contained in the \*.gid file is what you would see if you clicked on HELP, then HELP TOPICS and then clicked on the CONTENTS tab.

The "links" you see under the CONTENTS tab are contained in this \*.gid file. The \*.gid files also contain information for the locations of actual help files. For instance, when you click HELP > HELP TOPICS > CONTENTS you now have links displayed to the actual help file contents.

When you double click one of these links and it opens a second window, you are actually opening another file. The \*.gid is just an index of the help information. The file name and location of the \*.gid usually can

tip you off to which program it is associated with.

If you want to play with one of these files COPY it (DO NOT move or edit the original file) to some location such as the desktop or some other folder. Rename the file and change the file extension from \*.gid to

#### ANSWER TO #3002 - MAR. 2000

I need a circuit that when 150 volts AC is applied, the output would be +5 volts DC, and when the voltage goes down to 100 volts AC, the output would be 0 volts DC, and at 125 volts AC, it would be 2.5 volts DC.

The solution to your problem involves a transformer to bring the DC voltage down to 15V DC after rectification with 150-volts AC RMS input and a 10-volt zener diode to drop the voltage to five volts.

Since the transformer provides a linear relationship of output to input, you should get 10V DC at 100V AC input which after dropping 10 volts through the zener diode, will

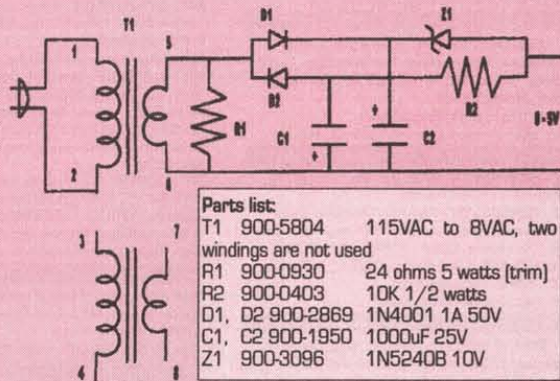
\*.TXT. (If you have the file extensions hidden or are hiding hidden and extensions for known file types, double click MY COMPUTER, then click VIEW > OPTIONS > VIEW. Remove the check marks for hiding known extensions and select SHOW ALL FILES. If you did not see the \*.gid files

give zero volts at the recorder.

Since the zener doesn't work well at low current, a negative voltage to maintain current through the zener is provided. If the output is too high, make R1 smaller and vice versa.

The parts are all from RadioShack.com.

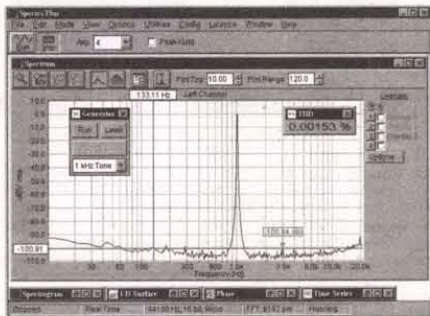
Russell Kincaid  
Milford, NH



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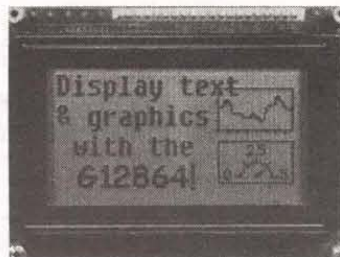
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# TECH FORUM

before, you will now be able to see them.)

Using NOTEPAD, or similar text editor, open the file and look at its contents. Some of what you see will not make sense (ASCII control characters, etc.), other things, such as topic headings, will be quite obvious. You might have to select Word Wrap in your editor in order to see the contents properly. Scroll down toward the end of the file and you can see path information to various files.

**Tim Naami**  
Poplar Grove, IL

## ANSWER TO #3009 - MAR. 2000

I am a ham operator and have a receiver and transmitter.

My 600 ohm 1MW audio output is too low to drive my Collins phone patch. It needs at least 1 watt or 1.5 watts and requires 500 ohms.

I would like also to control the level out.

You can build a really nice booster with two ICs from Analog Devices. Use the SSM-2017 audio preamplifier to boost the output voltage. This part is especially nice since it is an instrumentation amp. Therefore, it requires only one resistor to set the gain which can be a pot.

Use this to drive the SSM-2141 balanced line driver. This device is designed to drive 600-ohm transmission lines at 10-volts RMS with  $\pm 18$  volt supply rails so, it should have more than enough soup to drive your load.

Both parts are available through RadioShack.com Detailed information is available at analog.com including application schematics. You can also substitute parts from Burr-Brown which are available from Digi-Key.

**Al Sekeet**  
Grand Rapids, MI

## ANSWERS TO #3003 - MAR. 2000

How can I use the serial and parallel port to turn any load on?

Having several years experience on this particular topic, I can recommend two books:

For a general but practical understanding of how to use the ports, try *Build Your Own Low-Cost Data Acquisition And Display Devices*, by Jeffrey Hirst Johnson. (Tab Books, \$22.00.)

For a very applications-oriented guide to (mainly) the parallel port, you could settle for *Controlling The World With Your PC*, by Paul Bergsman. (High Text Publications, \$30.00.)

The first book teaches you more about how to use the ports, but the second book is easier to read.

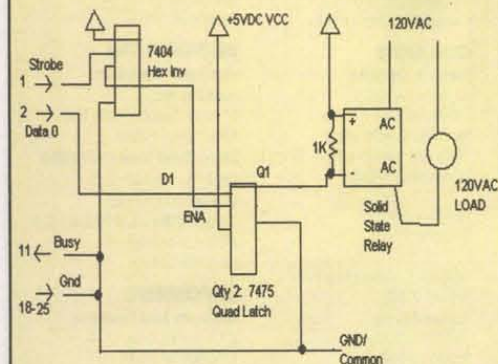
**Thomas Ng**  
San Jose, CA

## ANSWERS TO #3003 - MAR. 2000

I would spend the \$50.00 for a pre-made interface, such as Weeder www.weedtech.com digital I/O module, or *Nuts & Volts* March issue "More Bug Bytes" article on page 89.

If you are so inclined to build one yourself, use the parallel printer port. Search on Internet for "parallel port pinout" for a complete pinout of the connector.

Below is a simplified circuit



turned on bit 1 using `lprint chr$(1);` and then you also want bit 2 turned on, if you `lprint chr$(2);` bit 1 will turn off and bit 2 will turn on. If you `lprint chr$(3);` bit 1 would stay on and bit 2 would also come on ...

You will need to do a little bit of binary logic stuff here.

**Max Seim**  
Cottage Grove, MN

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# RESCUE BEACON SYSTEM TO THE TEST

by Gordon West

**T**he satellite emergency rescue beacons are known by a couple of different names, but their signals bring the same type of help. Pilots call them emergency locator transponders, "ELTs" for short.

Hikers and on-foot explorers may call them personal locator beacons, or "PLBs" for short. Mariners call them emergency position indicating radio beacons, or "EPIRBs" for short.

The basic signal for these emergency beacons is 121.5 MHz, an aviation frequency for use as a civilian search and rescue channel. The 121.5 MHz distress system has been around for years, and well predates the use of satellites to detect an activated rescue beacon. For many decades, search and rescue aircraft have been outfitted with radio direction-finding equipment designed to home in on 121.5 MHz. In fact, the vast majority — if not all of the world's non-military search and rescue aircraft and vessels — are equipped with radio direction-finding equipment for homing in on 121.5 MHz.

**"Sad to say, over 96 percent of 121.5 EPIRB activations from pilots, hikers, and boaters are accidental false activations," comments a search and rescue official at a local on-the-water beacon demonstration.**

In the early 70's, a worldwide combined rescue organization called COSPAS-SARSAT launched satellite-aided tracking that worked relatively well for detecting 121.5 signals and, through Doppler shift analysis, land stations could approximate the location of an activated 121.5 MHz beacon. Doppler shift came from low-earth-orbit satellites in near polar orbit, traveling north to south and converging at the poles.

These satellites orbit the earth at relatively high rates of speed — essential for Doppler shift processing. The polar orbit, and the perpendicular rotation of the earth relative to their track, allows these satellites that routinely do weather observation duty to determine a 406 MHz emer-

gency rescue beacon latitude and longitude by measuring the Doppler shift in frequency, and additional relative position checks by the signal strength.

But due to low-orbit altitude, their view of earth is limited, creating a potential delay in detection at just the 121.5 frequency. It would sometimes take up to six hours before rescue agencies had a sure-enough position to begin their search, and the location accuracy could be as much as 20 kilometers in diameter over a search of 1,260 kilometers squared.

A search mission in an airplane or helicopter, flying at 500 feet in good weather, can only observe approximately one-half mile on both sides of the flight path. With lower visibility and rougher terrain, the search width is even further reduced.

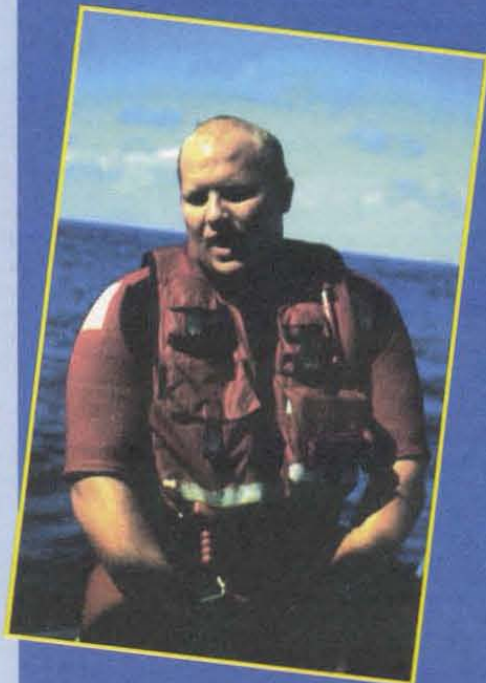
"Sad to say, over 96 percent of 121.5 EPIRB activations from pilots, hikers, and boaters are accidental false activations," comments a search and rescue official at a local on-the-water beacon demonstration. "So, it's no wonder that with such a high accidental activation, it sometimes takes many hours for officials to work out who is going to conduct the search effort, thinking in the back of their mind that here's another 'budget buster' in manpower, aircraft, and other equipment to locate what could be just one more false alarm," adds the SAR representative.

By international agreement, a new signal is now added to modern emergency locator beacons — that signal at 406.025 MHz containing the emergency radio beacon's name, address, and other pertinent data that uploads to a geostationary set of satellites every 50 seconds. The data burst is at five watts output, as opposed to a half-watt for the 121.5 MHz signal. The data burst lasts approximately one second, and gives rescue personnel on land at a Mission Control Center (MCC) an immediate readout of the station doing the transmitting. The beacon with 406 MHz capabilities is pre-registered with the National Oceanic &

Atmospheric Agency, and this information is right at the computer screen at Mission Control Center whose job it is to notify the appropriate rescue coordination centers based on the information they have.

The first job of the MCC when detecting an activated 406 MHz data burst is to look up the EPIRB information, and place a phone call to that listed phone number.

"We are picking up an activated EPIRB registered to you — do you have any idea where that EPIRB is?" is one question they'll ask. "Are they in an area that could necessitate an emergency call?" "Do you think







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- Cruising Speed: 120 knots
- Max Range: 300 nautical miles

this might be an accidental activation, or a real activation?" is another question they probably ask.

If the called party indicates that indeed their loved one is far out at sea, or way up in the Alps, or trudging across the tundra, the Mission Control Center will then go into action within minutes to notify the nearest rescue coordination center of the details.

The 406.025 MHz signal is detected by the new GEOSAR system. The beacon with a USA country code will be routed to the United States Mission Control Center, or NOAA. NOAA and USMCC then stand by for the low-earth-orbit satellites to locate the beacon on 121.5 MHz before forwarding the emergency to the closest appropriate rescue coordination center. The 121.5 MHz is still the frequency of choice for local radio direction-finding and homing, as well as low-earth-orbit position finding. The 121.5 MHz frequency works extremely well as a homing frequency, whereas the 406 MHz frequency is an extremely poor homing signal due to its

less than half-second broadcast duration and 60-second broadcast interval.

With this in mind, the obvious answer to improve the overall rescue response was to embed a GPS-derived position into the 406.025 MHz uplink signal. And this is what is being done by new state-of-the-art 406 MHz EPIRBs with GPS upload capabilities. The 121.5 MHz half-watt locating signal is still continuously on, but more important is the new information showing GPS-derived latitude and longitude every 50 seconds.

Northern Airborne Technology (Marlborough, MA) incorporated the GPS receiver within the GPS equipment itself. They aptly named their equipment a "GPIRB" — a land or sea self-locating emergency beacon that may upload a GPS position accurate to 100 meters to the GEOSAR satellite that has a footprint that provides coverage from 70 degrees north to 70 degrees south latitudes, and east/west 75 degrees from their respective location. Currently, there are four satellites in the GEOSAR network, stationed at 75 degrees west, 135 degrees west, 74 degrees east, and 93.5 degrees east, producing better than 95 percent constant coverage of the temperate waters of the world.

When activated, the GPIRB from NAT locates itself and, after verifying acceptable parameters of position accuracy, loads its current position digitally into the transmission sentence for broadcast to the satellites on 406 MHz. It does hit every 20 minutes.

The GPIRB from NAT may improve rescue efforts in several other ways, along with the initial activation location. The rescue coordination center (RCC) can calculate drift, and can save considerable search time by dispatching rescuers toward a computed recovery point based on how long it may take them to get to the scene.

Another EPIRB with GPS interface for mariners is from well-respected EPIRB manufacturer ACR Electronics (Fort Lauderdale, FL). The automatic or manual deployable 406 MHz EPIRB is connected to a ship or land GPS with an infrared interface. The EPIRB is dramatically

smaller in size than a similar EPIRB with the satellite receiver built in. The ACR EPIRB works with position information that is continuously updated and stored in the EPIRB every 20 minutes from the external GPS source.

When the EPIRB is taken out of its cradle, or automatically activates if a Category 1, it separates from the GPS datastream and begins sending the signal every 50 seconds on 406.025 MHz, and continuously sending a homing signal on 121.5 MHz. "We feel that this type of GPS connection is far superior to trying to receive a GPS signal within itself floating in the water," comments John Jones, Manager, ACR Product Line Government Contracts. "In heavy seas, it might be tough to receive a GPS position from a built-in receiver with water constantly flowing over the top of the unit," adds another ACR representative.

But George Lariviere at Northern Airborne Technology disagrees — "Our unit is far superior because it allows rescue agencies to determine drift and set every 20 minutes, and this will lead to a much faster position find."

Actually, both systems work extremely well because most rescue agencies will first fly to the location embedded in the 406 MHz EPIRB stream, and then switch on direction-finding equipment within their aircraft to home in on the floating or land-based signal. During recent sea trials in Miami, in cooperation with the United States Coast Guard and NOAA, it took only five minutes for the Mission Control Center to make that first phone call to find out what was going on with an activated beacon, and only 53 minutes for the United States Coast Guard's "Dolphin" — a short-range recovery helicopter — to fly overhead and deploy its rescue swimmer to our "victim" in the untethered life raft.

The 406 MHz signal with GPS information is far superior to anything else in the past, and to learn more about the new GPS EPIRBs for land, air, and sea, contact the following organizations: **Northern Airborne Technology**, 1-800-225-4767, and ask for George; and **ACR Electronics**, 954-981-3333, and ask for Paul Hardin, Vice-President, Marketing & Sales. **NV**

## NEW GORDON WEST LICENSE MANUALS

Gordon West WB6NOA, announces the completion of his three new and updated-for-restructuring license manuals for Element 2 Technician class, Element 3 General class, and Element 4 Extra class. West also announces his six-tape, learning-Morse-Code cassette course, too, specifically recorded for the 5 wpm Element 1 examination.

"Our new Technician class book covers all 394 questions and answers, plus my description of the correct answer," comments West. "The Technician book is fully illustrated and will provide the new ham operator with plenty of VHF/UHF references including the all important band plans," adds West. The Element 2 Technician class book is valid April 15, 2000, through June 30, 2003, and contains approximately 192 pages. There are several chapters specifically for the new ham to learn all about the restructured amateur radio service, plus a chapter specifically on how to learn the Morse Code Farnsworth method.

West's General class Element 3 book is 160 pages, including a special 16-page, pull-out section that focuses the reader to recent changes in General class licensing requirements. The new restructured General class written examination is 385 total questions. The book is well-illustrated and places emphasis on high-frequency operation, band plan courtesies, and illustrated figures on propagation. The General book is valid April 15, 2000, through June 30, 2004.

"My new Extra book covering Element 4 will be a whopping 240 pages with all technical formulas worked out in great detail," adds West. "My students reading the book won't need to be experts in trigonometry to get through the technical problems — I work them out in our pages with such detail anyone can follow the math, and I even give some shortcuts on how to immediately recognize the correct answer without all of the lengthy calculations," adds West.

There is also detailed pages on frequency privileges for all classes of license including grandfathered Advanced operators, plus discussions about RF safety. The new Element 4 Extra class book is valid April 15, 2000, through June 30, 2002, and contains all of the 676 Element 4 question pool.

Gordon West is well-known for his audio code-learning, long-play cassettes,

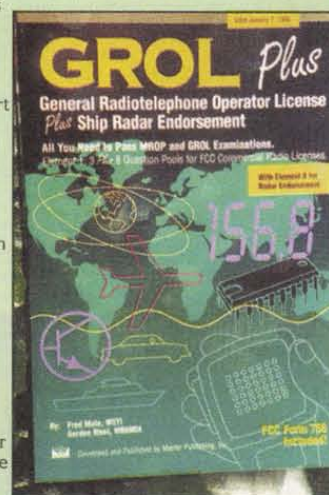
and his new six-tape code course prepares students to learn the code Farnsworth method and easily pass an Element 1, 5 wpm code test for Technician with code, General, and Extra class exams administered after April 15, 2000. Long-time expert Morse Code operators all agree that Gordon West code tapes are the most effective way to learn about on-air operating techniques, plus preparation for the Federal Communications Commission authorized code test. West also produces commercial radiotelegraph test preparation courses for 16 and 20 wpm code groups, and 20 wpm commercial radiotelegraph plain language.

For present Extra class operators, Gordon West also authors the 492-page *General Radiotelephone Operator License plus Ship Radar Endorsement* fully illustrated, test preparation book, updated January, 2000.

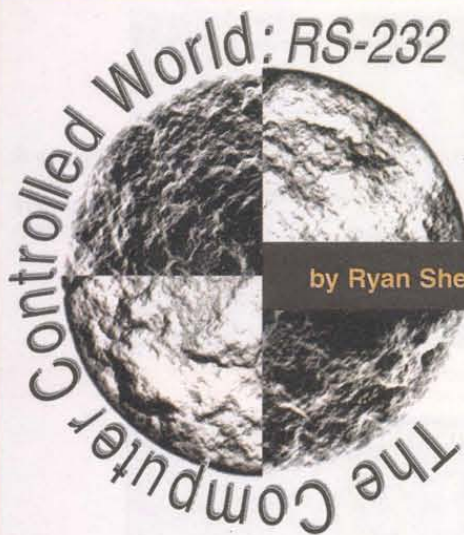
All books are copyrighted from Master Publishing, Inc., in Lincolnwood, IL, and are sold by all RadioShack stores, ham radio dealers, at ham flea markets, plus the W5YI distributor in Dallas, TX (1-800-669-9594). West is a contributor to the NVEC Question Pool Committee, and some of the amateur radio test questions were originally submitted by West himself.

"All of these amateur radio and commercial radio books reflect my enthusiasm for successful upgrades, as well as a better understanding on amateur radio operation over the bands," says West. "These study guides do a lot more than get you through the test — I relate many of the test questions to the real world of good ham radio operating techniques over the airwaves," finalizes West.

All books are immediately available and in stock throughout the country.







# RS-232 Network Control Methods and Applications

## Big Byte Bugs

by Ryan Sheldon, National Control Devices • (417) 646-5644 • [www.controlanything.com](http://www.controlanything.com)

**Discover seven new devices that offer even more capabilities.**

*If you have been following my articles in **Nuts & Volts**, then you have seen a number of new microprocessor-based devices that simplify your computer-controlled world. This month, I will introduce you to seven new devices that offer even more capabilities.*

### E3C

What you may or may not have picked up on is that some of our new devices are E3C-compliant. E3C is a standard that I developed that allows different types of devices to peacefully coexist on a single serial port. E3C stands for "Enabled 3-Wire Communication." Up to 256 different E3C-compliant devices may be connected to the same serial port, and individually or simultaneously controlled. Using E3C, it is possible to chain servo controllers, A/D converters, vacuum fluorescent displays, relay controllers, and digital I/O chips all on a single serial port.

When using an E3C-compliant device, the first thing you will need to do is give the device an E3C device number. On some devices, the device number must be burned into the processor prior to shipment. In other devices, a set of eight dip switches are used to set the device number. In some of our newer circuit board devices, the device number can be programmed into nonvolatile memory. A device number is simply a name in the form of a number from 0 to 255.

### Controlling E3C Devices

Here's how it works. When you first power up your computer and all your devices, you can send commands out your serial port and all 256 devices will respond. Using the E3C command set, you can control which devices are active and inactive. You can tell several devices to listen to your commands, or you can send commands to one device at a time. The E3C command set consists of six commands, shown in Figure 1.

E3C command 252 is the one most commonly used. This command allows you to speak to a specific device. All other devices will ignore your commands. E3C-compliant devices have the slider shown in Figure 2 as part of the Visual Basic 6 programming examples.

Command	Parameter	Description
248	None	E3C: Enable All Devices
249	None	E3C: Disable All Devices
250	0-255	E3C: Enable Selected Device
251	0-255	E3C: Disable Selected Device
252	0-255	E3C: Enable Selected Device, Disable All Other Devices
253	0-255	E3C: Disable Selected Device, Enable All Other Devices

Figure 1: The E3C Command Set.

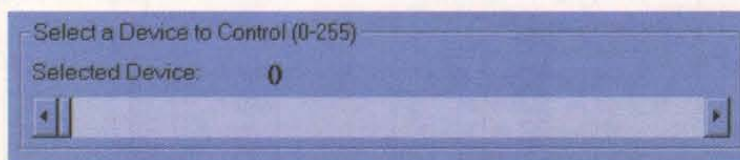


Figure 2: The E3C Device Selector Slider.

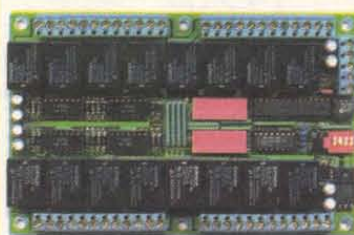


Figure 3: The R16 E3C-Compliant 16-Relay Controller.

Baud Rate	Clock Speed	DigiKey Part <a href="http://www.digikey.com">www.digikey.com</a>
1200	500 KHz	X922-ND
2400	1000 KHz	X926-ND
4800	2 MHz	PX200-ND
9600	4 MHz	X902-ND
14.4K	6 MHz	X904-ND
19.2K	8 MHz	X905-ND
24K	10 MHz	X906-ND
28.8K	12 MHz	X907-ND
38.4K	16 MHz	X908-ND
48K	20 MHz	X909-ND

Figure 4: The baud rate is selected by the use of different ceramic resonators.





**Use a photocopy of this artwork for the scale. Glue it in place on the top of the enclosure.**

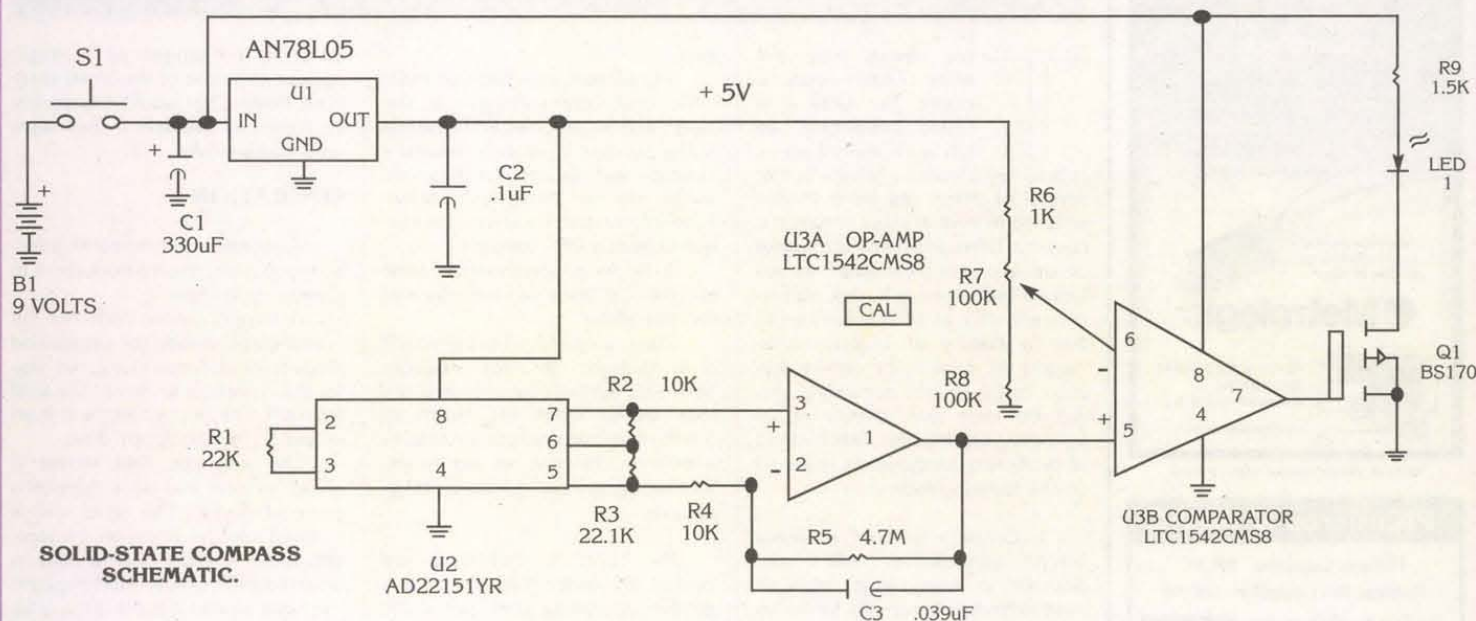
## FINAL ASSEMBLY

The easiest way to mount the PC board to the side of the enclosure is to use a small amount of RTV silicone rubber, but the builder has the option of using any other method that he or she finds suitable. The board must be mounted in the vertical plane against the side of the enclosure that corresponds to the LED and north indicator of the scale, with the surface mounted components facing to the outside. Mount the on/off switch, and



Note the position of the compass as the LED comes on from the left and from the right. True magnetic north will be that position of the compass when the LED is placed at the center of its lighted arc. Use the information in Figure 1 to offset the compass for the number of degrees that correspond with your location.

Once the compass is oriented to that position, all directions will be indicated by the scale. **NV**



Note: The values of R6 and R8 may optionally be tailored to center the adjustment range of R7 for the particular U2 chip used in the circuit.

## TROUBLESHOOTING

## FINAL ADJUSTMENT

## PARTS LIST

**U2:** Magnetic sensor, Analog Devices AD22151YR (Future Electronics)  
**U3:** Op-amp/comparator, Linear Technology LTC1542CS8-ND (Digi-Key)  
**S1:** Push-button switch, Digi-Key 150C-ND or similar  
**Misc:** Enclosure, battery clip, hook-up wire

## SOURCES OF SUPPLY

**Future Electronics (AD22151YR): 1-800-333-9943**

**Note:** The following parts are available from A. Caristi, 69 White Pond Road, Waldwick, NJ 07463: Etched and drilled PC board @ \$9.95, U1 @ \$2.00, U2 @ \$9.75, U3 @ \$6.75, set of four metal film resistors @ \$2.00, Q1 @ \$3.00. Please add \$5.00 postage/handling.

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NTN 5447 5521 5545 \$37.95	BP180 / CM79 \$34.95	Any brand 12.0V \$32.95
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<b>M I D L A N D</b>	FNB 3 4 12 14 16 \$32.95	Any Brand 18.0V \$45.95
B20-B10 B16 B19 B21 \$39.95	FNB19 21 26 27 38 \$32.95	<b>COMPUTER PACKS</b>
B25 B26 B32 B36 B60 \$39.95	FNB 10 1117 25 35 \$23.95	Send battery for quote.

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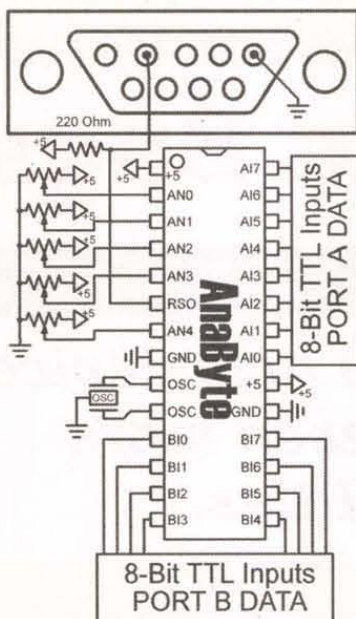
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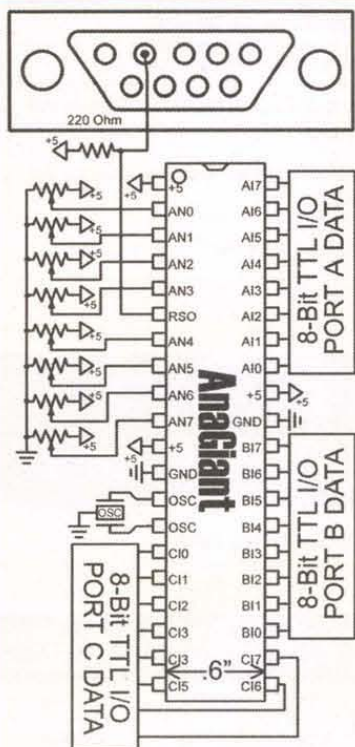
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**Figure 5: The AnaByte Parallel-to-Serial Encoder with Five A/D Inputs.**



**Figure 7: The AnaGiant Parallel-to-Serial Encoder with Eight A/D Inputs.**

Figure 3 shows our new E3C-compliant 16-relay controller. Up to 256 of these boards can be attached to a single serial port, and controlled individually. But more importantly, this device can be mixed on a single serial port with other types of devices such as some chips in this article.

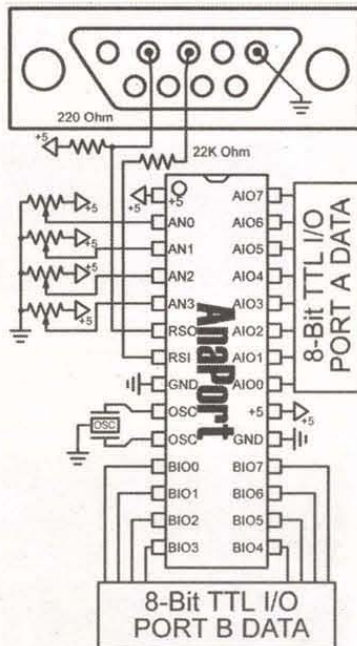
Each can be individually controlled in any combination. So, if you need hundreds of analog and digital inputs, as well as the ability to con-



**Figure 6: The AnaByte Monitor.**



**Figure 8: The AnaGiant Visual Basic Program.**



**Figure 9: AnaPort E3C-Compliant Four-Channel A/D with 16 Programmable I/O Lines.**

trol hundreds of relays, E3C-based devices will meet your needs for a long time to come.

### Baud Rates

The chips outlined in this and previous articles can be controlled at several different baud rates. Baud rates are determined by the speed of the oscillator, denoted as OSC or CR1 in the diagrams. Some devices are limited to eight MHz (such as the eight-pin chips in this article). Figure 4 shows a table of resonators that can be used. All resonators are available from Digi-Key ([www.digikey.com](http://www.digikey.com)). The first two resonators listed require capacitors. Please read the Microchip ([www.microchip.com](http://www.microchip.com)) data sheets on PIC devices for selecting the appropriate capacitors for your design.

### Non-E3C Devices

Some devices in this article are NOT E3C-compliant. They serve a small niche of people who need a quick and cheap solution to a problem, but may never need to expand. Non E3C-compliant devices are a little easier to work with, since they do not require any commands from a computer to tell them what to do.

### AnaByte

Figure 5 shows the AnaByte — a 16-bit parallel-to-serial encoder with five analog-to-digital converters. The AnaByte constantly transmits packets of data consisting of eight bytes. The baud rate is determined by the oscillator used on the OSC lines (see Figure 4 for details).

Figure 6 shows a simple Visual Basic 6 pro-



gram that reads packets of data generated by the AnaByte chip. These data are then used to adjust the five level meters and set the status of the 16 check boxes. The AnaByte is not an E3C-compliant device, so only one chip may be connected to a single RS-232 serial port. While easy to use, it is not expandable.

### AnaGiant

Figure 7 shows the AnaGiant — a 24-bit parallel-to-serial encoder with eight analog-to-digital converters. The AnaGiant constantly transmits packets of data consisting of 13 bytes. The baud rate is determined by the oscillator used on the OSC lines (see Figure 4 for details).

Figure 8 shows a simple Visual Basic 6 program that reads packets of data generated by the AnaGiant chip. These data are then used to adjust the eight level meters and set the status of 24 check boxes. The AnaGiant is not an E3C-compliant device, so only one chip may be connected to a single RS-232 serial port.

### AnaPort

AnaPort (shown in Figure 9) supports two-way communication between the host computer and allows you to read the A/D value on any (or all) analog inputs. In addition, the AnaPort has 16 programmable I/O lines. Under software control, you can read or write bytes to each of the two ports. The AnaPort is E3C-compliant, allowing 256 different devices to share a single serial port. The device number is programmed into the chip at the time of purchase.

Figure 10 illustrates a simple Visual Basic 6 program used to control the AnaPort chip. A slider is provided, allowing you to select which device to control. Other buttons allow you to read analog inputs (individually or simultaneously) and control the reading and writing of data to the two data ports.

### PortGiant

PortGiant is shown in Figure 11. PortGiant is nearly identical to the AnaPort, except that it offers more analog inputs and more programmable I/O data lines. Figure 12 illustrates a simple Visual Basic 6 program used to control the PortGiant chip. Again, the device number is programmed into the chip at the time of purchase.

### Bitabug3

The Bitabug3 provides three programmable TTL outputs from an RS-232 data input. The Bitabug3 supports the E3C command set, allowing up to 256 different devices to share a single serial port. The Bitabug3 also supports commands for controlling each output individually, as well as all outputs simultaneously. The Bitabug3 includes a four-MHz ceramic resonator for communication at 9600 baud.

Figure 14 illustrates a simple Visual Basic program used to control each of the three out-

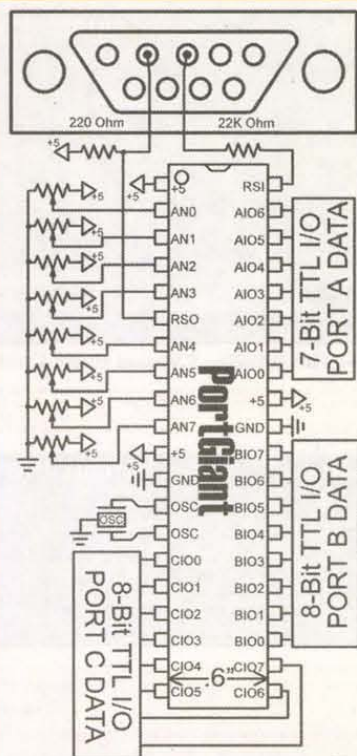


Figure 11: PortGiant E3C-Compliant Eight-Channel A/D with 23 Programmable I/O Lines.

puts. The E3C slider is used to select a device to control.

### Key3

If you ever needed the ability to monitor a few buttons from a serial port, the Key3 chip may be exactly what you are looking for. When a button is pressed, an ASCII character code from 0 to 7 is transmitted to your computer. The Key3 chip is combinational, allowing you to simultaneously press buttons for different output codes. Figure 16 shows a list of key-press combinations.

The Key3 Button Monitor program decodes the data generated by the Key3 chip, displaying which buttons have been pressed.

### JoyScam

Several readers have wanted to control servos using a joystick. The JoyScam chip was designed to accomplish this task by generating data packets that can be interpreted by the SCAM chip. The JoyScam connects to two potentiometers: one for vertical and one for horizontal. As the joystick is moved, SCAM-compatible data packets are generated for positioning two servos.

The JoyScam chip can share a serial port with the computer as shown in Figure 17. The computer can be used to select which SCAM

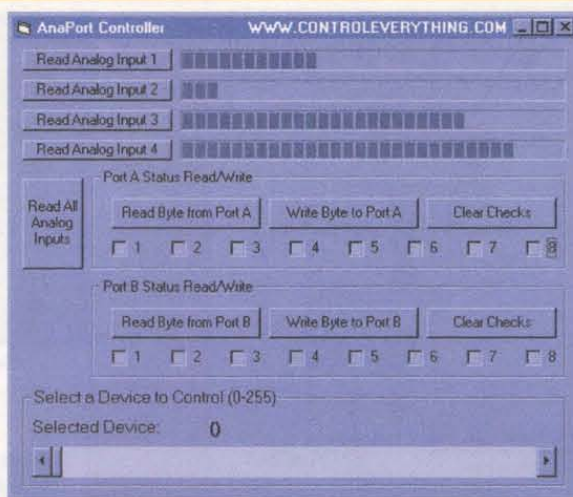


Figure 10: The AnaPort Visual Basic Controller Program.

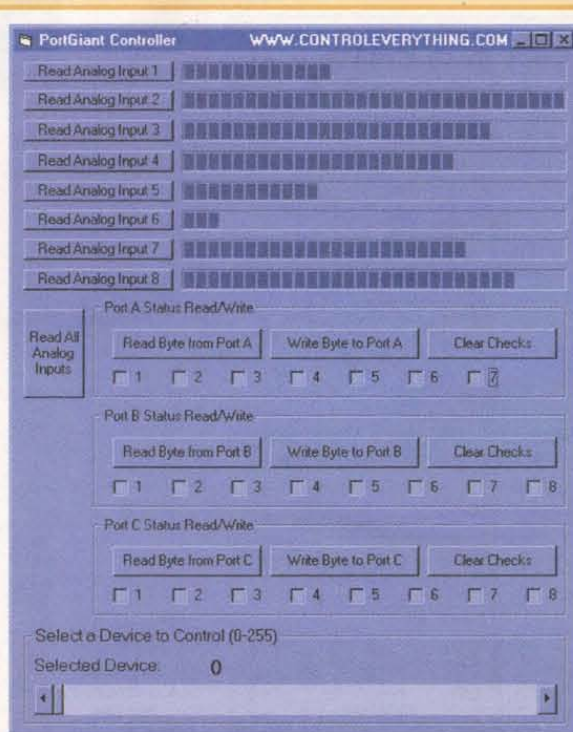
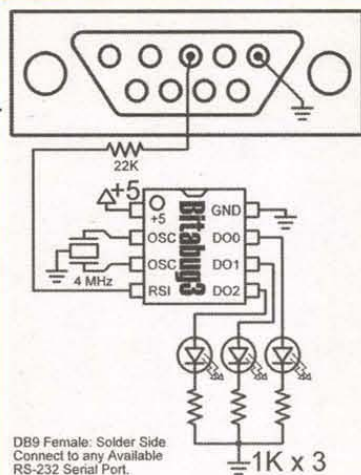


Figure 12: The PortGiant Visual Basic Controller Program.

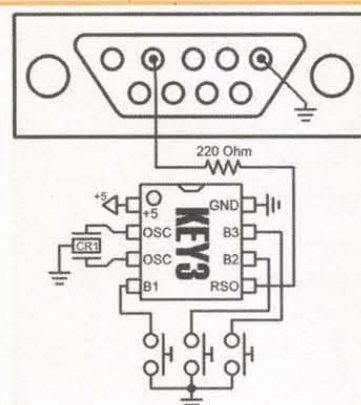
chip to control. The user interface shown in Figure 18 is also capable of positioning the servo motors.

The JoyScam chip also has a logic level input that is mirrored by the logic level output on the SCAM chip. The JoyScam chip is NOT compatible with the SCAM2 chip and should only be used with the original SCAM chip. Figure 18 shows a simple Visual Basic 6 program for controlling the SCAM chip, as well as the E3C device slider for controlling which device receives the data packets from the JoyScam chip. Either the Visual Basic 6 application or the JoyScam chip can be used to position the servos.

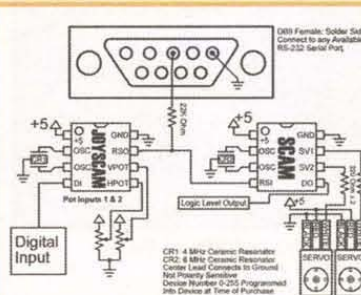




**Figure 13: Bitabug3 E3C-Compliant Three-Bit Serial-to-Parallel Converter.**



**Figure 15: The Key3 Three-Button Encoder with RS-232 Output.**



**Figure 17: JoyScam Joystick Controller for the SCAM Chip.**

### Software and Data Sheets

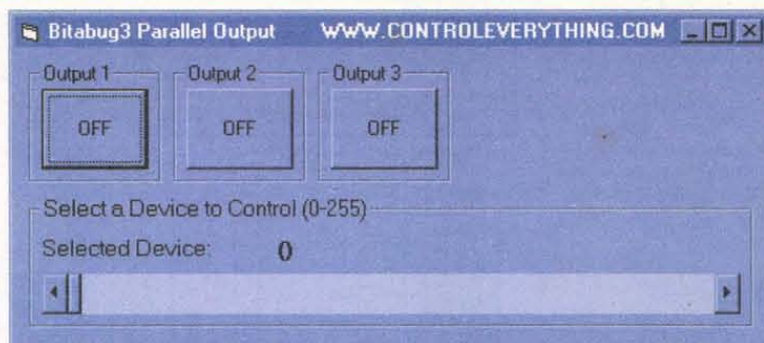
A few people have reported that they cannot find the software or data sheets for these chips. Both data sheets and software can be found at [www.controleverything.com](http://www.controleverything.com). Select the "Products" link, then select the "Microcontrollers" link. Download the Visual Basic 6 source code "Bugs.ZIP." The programs found in this archive are easily translated to other programming languages. The data sheets can also be found on this page. Select "Download Data Sheets" in red, linked several times on this page. More detailed information on

all available CPUs can be found in the data sheets.

### Availability

The microprocessors in this article were in development at the time of writing and should be available by the time you read this. The latest pricing and availability information can be found at [www.controleverything.com](http://www.controleverything.com). Select "Products," then "Microcontrollers." Pricing is located in the data sheets. These devices can be ordered by following the "Ordering" link from the main page.

I hope you enjoyed this month's "Computer-Controlled World." As usual, feel free to E-Mail or call with any questions you may have. **NV**



**Figure 14: The Bitabug3 Visual Basic Controller Program.**



**Figure 16: The Key3 Button Monitor Program for Visual Basic 6.**

Button 1	Button 2	Button 3	ASCII Output
Pressed			0
Pressed	Pressed		1
	Pressed		2
Pressed		Pressed	3
Pressed		Pressed	4
Pressed	Pressed	Pressed	5
Pressed	Pressed	Pressed	6



**Figure 18: The SCAM Controller Program for Visual Basic 6.**

### CONTACT INFO:

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**National Control Devices**  
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**Phone: (417) 646-5644**  
**FAX: (417) 646-8302**  
**[ncdryan@aol.com](mailto:ncdryan@aol.com)**  
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# New Product News



## WR-700 WEATHER RESISTANT CAMERAS

Matco releases the WR-700 Weather Resistant Cameras.

The WR-700 Weather Resistant Cameras provide protection from rain, snow, and sleet. They are ideal for outdoor applications.

The camera has a 1/3" interline CCD image sensor with no audio. It has a high resolution of 430 TV lines, 0.1 Lux for the B/W model, and 400 TV lines, 2 Lux for the color model. With the special moveable shroud, the camera can reduce glare in direct sunlight.

The camera requires 12 VDC power supply. The camera is 3-1/2" x 2-1/3" x 2-1/3" in dimensions. Mounting hardware is included in the packet.

For introductory sales, dealer pricing for the B/W WR-700 Weather Resistant Cameras is \$89.00 each and for the color WR-700-C Weather Resistant Cameras is \$179.00 each.

For more information, contact:

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## NHRC- INTELLIGENT REMOTE CONTROLLER

NHRC LLC announces the introduction and availability of the NHRC-Intelligent Remote Controller.

The NHRC remote is a low-cost DTMF remote controller that allows the remote control of six loads by sending DTMF commands over any audio circuit. The remote is based on the Microchip 16f84 microcontroller and the Telone M8870 DTMF decoder IC. The remote can be connected to almost any audio source, receiver, or transceiver without the need to go inside the radio for any signals. Since the remote works from any audio source, it does not require any modifications or exploration into a radio.

The NHRC remote has the ability to send command confirmation messages via Morse code that can be sent over any audio circuit. This makes the device useful for radio or wireline applications. For radio applications, the NHRC remote can send a Morse code ID message a predefined amount of time after first transmitting.

The compact, 3 x 3" size allows it to be embedded inside a repeater or other project.

The NHRC remote is available for \$89.00. NHRC has several other lines of repeater controllers starting from \$169.00 — including the brand new NHRC-10 Advanced Repeater Controller — which utilizes the newest technology available to provide maximum functionality with the fewest parts.

For more information, contact:

**NHRC LLC**  
444 MICOL RD., DEPT. NV  
PEMBROKE, NH 03275  
603-485-2248  
E-MAIL: [info@nhrc.net](mailto:info@nhrc.net)  
WEB: [www.nhrc.net](http://www.nhrc.net)

## INDUSTRY-STANDARD I2C PC CARD NOW IN PCI FORMAT

Saelig Company announces PCI90 — the only available PCI-format I2C-bus communications adapter.

Made in Europe, this new board complements Calibre UK's existing industry-standard range of ISA format I2C bus adapters (ICA90/93).

I2C is a two-wire bus that is widely used in Calibre's new PCI-to-I2C adapter television and audio systems, power supplies, and other systems to keep cable connections to a minimum.

I2C is now also being used for PC and server networking in Intel's IPMI implementation. PCI90 allows PC users to easily gain control of I2C systems in test, development, and manufacturing situations using self-configuring PCI slots.



PCI90 supports single and multi-master I2C operations and can also be programmed as a slave device.

32-bit Windows DLLs are included, giving users an easy software development path without requiring specialist PCI or Windows I/O knowledge.

For new I2C users wanting a quick start with the bus, ready-to-run WINI2CPCI Windows 95/98/NT software provides all the common I2C functions and also includes a unique real-time I2C bus monitor/datalogger for investigating bus activity.

PCI90 provides an easily-installed, cost-effective solution to I2C bus communications for software or hardware developers or test engineers.

PCI90 is available from stock at \$399.00.

For further information, contact:

**SAELIG COMPANY LLC**  
1193 MOSELEY RD., DEPT. NV  
VICTOR, NY 14564  
716-425-3753 FAX: 716-425-3835  
E-MAIL: [saelig@aol.com](mailto:saelig@aol.com)  
WEB: [www.saelig.com](http://www.saelig.com)



## EN-808 OUTDOOR HOUSING FOR BOARD CAMERAS

Matco releases the EN-808 outdoor housing for board cameras.

The EN-808 is one of the industry's smallest, most stylish, lowest profile cameras. It has aluminum construction with a lexan window. Dimensions are 3" x 3-3/4" footprints by

2-1/2" H.

The EN-808 camera can mount anywhere, ceiling or wall. With the unique design of weather resistant outdoor housing, the EN-808 provides protection from rain, snow, and sleet. It's ideally suited for outdoor surveillance applications.

The EN-808 camera includes an indoor camera housing which fits a B/W or color camera. Both B/W and color cameras are available from Matco.

As a special introductory offer, dealer pricing of the EN-808 is \$15.00 each for a limited time.

For more information, contact:

**MATCO, INC.**  
830 E. HIGGINS RD., #111-G, DEPT. NV  
SCHAUMBURG, IL 60173  
847-605-1020 FAX: 847-619-0852  
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**High Performance Auto Ranging DMM**

New to our DMM line-up and possibly (probably) the best DMM value anywhere! Includes: Analog Bar Graph! Auto-Ranging! Data Hold! Temperature Probe! Frequency Test! Continuity Test! AND MORE!

**Features:**  
Data Hold: Freezes reading for easy checking.  
Auto Ranging: For easy precise range settings.  
Range Hold Control: allows for manual selection of your test range.  
3-1/4 Digit LCD Display: Reads up to 3260.  
Easy to read display.  
Function Dial: Easy to use to select measurement type or turn unit off.  
4 Jack Plugs: Safety design with different capacities for different functions.  
Diode, Continuity Check Push-Button: For toggling between diode check and continuity check.  
Low Battery Indicator: Advises you when it's time to change battery.  
Extra Long 44" Test Leads: Helps get to hard to reach places.  
Screw-On Alligator Clips: Convert one or both probe tips to alligator clips.  
Fuse-Protected Circuitry.  
Built-In Stand: Makes one hand operation easier.  
Shock Absorbing Rubber Carrying Case: with convenient probe storage clips and hanging tab. Helps protect the DMM from damage if accidentally dropped.

**Measures:**  
DC Volts: up to 1000V  
AC Volts: up to 750V  
AMPS: up to 20 Amps (AC & DC)  
Resistance: up to 30M ohm  
Continuity Check: with audible signal (signal sounds if resistance is less than 20 ohms. Display reads actual resistance).  
Frequency: (1KHz to 300KHz) displays both digital and bar graph reading.  
Transistor hFE Test: Display shows approximate hFE value based on test condition of 10uA base current and Vce of approx. 3V.  
Temperature Test: Measures from 0° to 1832° F (probe supplied).  
Diode Test: Tests if diodes are shorted or open.

**Specifications:**  
Accuracy:  
Vdc: ±1.0% reading +5 digits  
Vac: ±1.5% reading +8 digits  
Adc: ±1.5% reading +5 digits  
Aac: ±1.5% reading +5 digits  
Resistance: ±1.5% reading +5 digits  
Frequency: ±0.0% reading +5 digits  
Temperature: ±1.0% reading +6 digits

#CS19903

Input Impedance: 10Mohm (Vdc/Vac); over 100Mohm on 300 mVdc range  
Requires two AAA batteries sold separately.

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**Other Models are Available. See www.web-tronics.com under "hard drive and accessories" for more details and pictures.**

RH-10C-IDE

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VM1035A 42mmx42mmx25mm, Standard lens, 12V with back light compensation \$49.00 any qty.

VMCB21 44mmx38.5mmx28mm, with 6 infra-red LEDs, 12V \$49.00 any qty.

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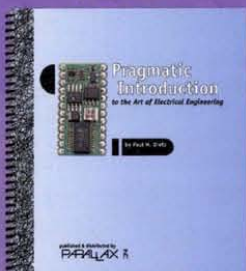
## Theory

Paul H. Dietz Ph.D.'s *Pragmatic Introduction to the Art of Electrical Engineering* teaches the theory and electrical concepts used with the BASIC Stamp through a full-semester college text. Electrical concepts are demonstrated with practical circuits and a microcontroller. There's nothing stuffy about this text, either - it's written in plain English with real-world examples. Schematics and simple calculations demonstrate the concepts of each project.

The 126-page text begins with an introduction to the BASIC Stamp, and explanation of how to wire it up on the breadboard and run your first program. "Clap On..." chapter shows how to create a system which toggles the state of a relay in response to clapping your hands, while filtering out unwanted noises. "Lights and Switches" shows simple control concepts including counting cycles and displaying on a seven-segment LED. Measuring temperature with A/D converters, making noise, and pump control is introduced in "Taking Control".

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