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Nuts & Volts

The Preferred Magazine Of The Electronics Hobbyist/Industry
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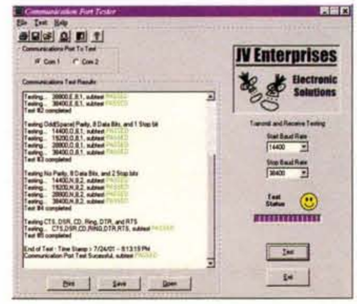

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A New and Simple Way to Measure Temperature With Your Computer

Building a Serial Port Digital Period Thermometer

By Ray Green

Here is a new and simple way to measure temperature and print it on your screen. It does this by using your computer's serial port. The best part is that you can build it for under $10.00.

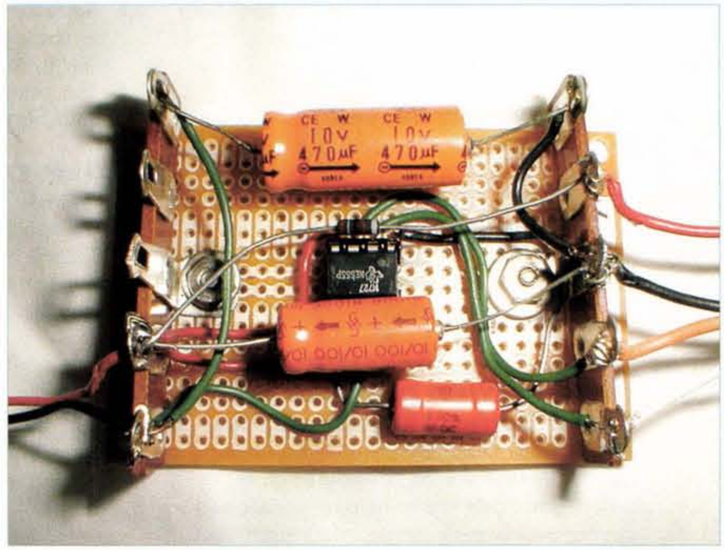
For years, I've experimented with various methods of using my computer to control various parts of my home. Many of these methods involved expensive and complex A/D and D/A converters, as well as "lookup" tables for converting a variable input to a digital interface. Throughout this time, I've been searching for a simple method to read temperature. One day while playing with a 555 timer circuit, it occurred to me that if I used a thermistor to control the duty cycle and measure it, I could convert that measurement to temperature. Sound like a dream? It was for me. Here are the results of my experiments.

You can use it to measure outside temperature, attic temperature, water heater, refrigerator, freezer or to control your heating system. It is amazingly stable and accurate, and operates over the temperature range of 0 degrees F to 120 degrees and beyond. All the parts are available at your local RadioShack and the part numbers are included in the parts list. For the sake of this article, I'll call it a "digital period thermometer" because temperature is read by measuring the period (length or duration) of a pulse.

Almost any PC-compatible computer can be used. It works fine with an old DOS-type PC or a newer one operating in DOS under any Windows program. Old computers have become so prolific that many people are giving them away. For my experiments, I used an old 486 computer.

In order to read temperature, we'll use the program SerTemp.bas as listed later in this article. It may either be typed in or downloaded from the *Nuts & Volts* web site at www.nutsvolts.com.

Now this is a most unusual way to use the serial port, since there is nothing serial about it at all and I'm simply using it as any other input/output port on your computer.



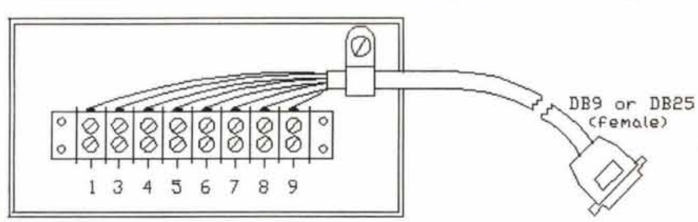


FIGURE 1

How It Works

The circuit uses a 555 timer IC connected as a one-shot multivibrator. It is operated from current stolen from the serial port so that no external power is required. A 10,000 ohm thermistor is connected to the IC in series with a 470 mH capacitor and the charge time is measured by the program. Typically, it takes nine seconds to charge the capacitor at 70 degrees Fahrenheit and about 21 seconds at 32 degrees. These long periods help achieve accurate results. The program uses a curve fitting formulae to convert the charge time to temperature and prints the value on your monitor. The wide temperature range possible is illustrated by the fact that the thermistor has a resistance of 10,000 ohms at 70 degrees, but increases to 27,280 ohms at 32 degrees Fahrenheit.

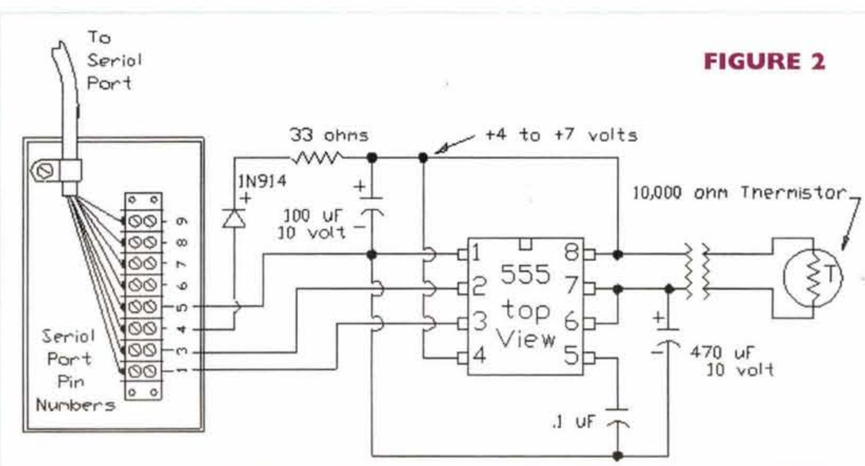


FIGURE 2

The Serial Port Connections

To use your serial port the easy way, mount an eight-position barrier strip — RadioShack part number 274-670 — on a block of wood as shown in Figure 1. Connect the eight-terminal strip through an eight-wire cable to a D-sub female connector. Use part number 276-1538 for a nine-position connector. Number the barrier strip as shown in Figure 1. These are the same pin numbers as those on the computer's nine-pin serial port. Omit pin 2 because it can't be used here. All external devices will connect to this barrier strip.

If you are using a 25-pin serial port connection, use a DB25 part number 276-1548. Use the pin connection numbers under 25 pins on the chart, but still label the barrier strip as if it were a nine-pin port as demonstrated.

Serial Port Connector

9 pin		25 pin
Pin #1	Input	Pin #8
#3	Output	Pin #2
#4	Output	Pin #20
#5	Ground	Pin #7
#6	Input	Pin #6
#7	Output	Pin #4
#8	Input	Pin #5
#9	Input	Pin #22

The Base Addresses (like a street address) for serial port COM1: is &H3F8 and is used for all program examples in this article. If you are using COM2: as your serial port, then simply use &H2F8 as your base address in the program's line 120.

Construction

My favorite method of building most small circuits is to use a multipurpose PC board with a five-lug tie point strip mounted at each end. This provides a platform to mount the parts on, as well as offering an easy way to connect to the circuit. I generally mount the parts on the PC board and run wires to the tie point eyelets. This leaves the actual tie point connections free for external wiring.

This is a very simple circuit using only an IC, a diode, a resistor, and two capacitors, so almost any layout will work. Figure 3 shows the board as I constructed it.

Making and Using the Temperature Probe

The temperature probe is simply a long two-conductor cable with the thermistor connected to the end, as shown in Figure 4. Any lightweight two-wire cable may be used. I found that 22- or 24-gauge stranded speaker or alarm wire works well. The thermistor, of course, measures the temperature. If used outdoors, it will be exposed to all kinds of weather so it must be covered to keep it dry. After years of trying to make thermistor probes waterproof, I finally hit on a method that works great as follows:

(1) Cut a piece of 1/8-inch diameter heat-shrink tubing about 3-1/2 inches long.

(2) Connect and solder the thermistor leads to one end of the two-conductor cable. Make your connections as small as possible and wrap each connection and the exposed wires with a small piece of plastic electrical tape. The thermistor and its connections must be small enough to slide inside the heat-shrink tubing.

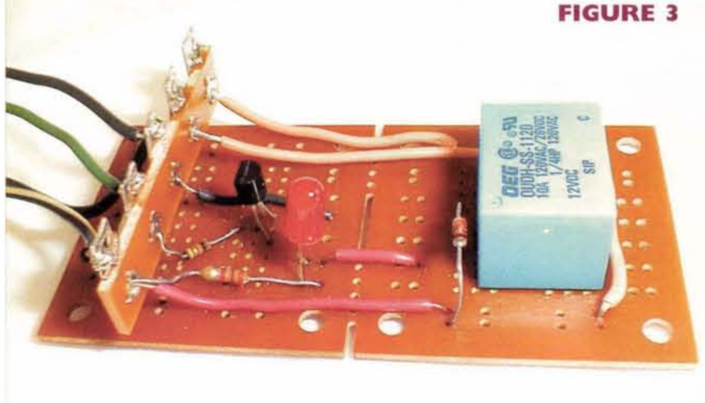
(3) Use a house caulking gun and fill the tubing from one end with Dow Corning™ 100% Clear Silicone Sealant. You can also use clear bathtub caulk.

(4) Now slide the thermistor and its connections into the tube. The end of the thermistor should be about 3/4" from the filled end. Poke as much caulk back in as you can easily do.

(5) Finally, use a heat gun or a stove burner and carefully shrink the tubing around the cable and the thermistor. Take your time so you do not overheat in one spot and burn the tube (maybe you should experiment first). As you heat the tubing and it shrinks, excess caulking will come out of both ends of the tube, but wipe it away and its no problem. Let the probe dry a day or two and you're done.

The best way to mount the thermistor probe outdoors is to strap it to a thermometer. I like to leave at least 10 feet of wire outdoors so room heat is not conducted to the thermistor. This gives you a good check on its accuracy over various temperature ranges. Of course, you will want to calibrate it initially before you put it outdoors.

FIGURE 3



Running SerTemp.bas

You will need a copy of either the programmer's file GWBASIC.EXE or QBASIC.EXE in your computer. Practically all 386 and 486 computers prior to Windows95 have one of these files in their DOS directory. If you are using Windows 95/98/ME, copy either the file GWBASIC.EXE or QBASIC.EXE from the old PC and put it into your C:\WINDOWS\COMMAND directory. You will also need a copy of my file SerTemp.bas. Either run one of the BASIC files above and type it from the listing in this article and SAVE it, or download it from www.nutsvolts.com.

For GWBASIC, put your computer into DOS and load and run the program by typing GWBASIC SERTEMP<Enter>. As the program runs, it will display the temperature about every 10 seconds. To stop the program, hold down the Control Key and press the Break Key. The program must be stopped before you can exit or print a listing. To list the program, press F1. To run the program again in GWBASIC, press F2 or type RUN <Enter>. Don't forget to SAVE any changes you've made. To do this, press F1 to get a listing, and move your cursor to the bottom of the page to a blank line on the screen. Then press the F4 key so the word SAVE" appears and type SERTEMP",a. (the total command will read SAVE"SERTEMP",a). To exit the program in GWBASIC and go back to DOS, type the word SYSTEM on a blank line.

To run in QBASIC, put your computer into DOS and type QBASIC/RUN SERTEMP <Enter>. To stop the program, hold down the Control Key and press the Break Key. To run the program again in QBASIC, click on RUN. To exit, click on file then Exit. Note you will get an error message when you run SerTemp, if you have not connected the circuit to your computer.

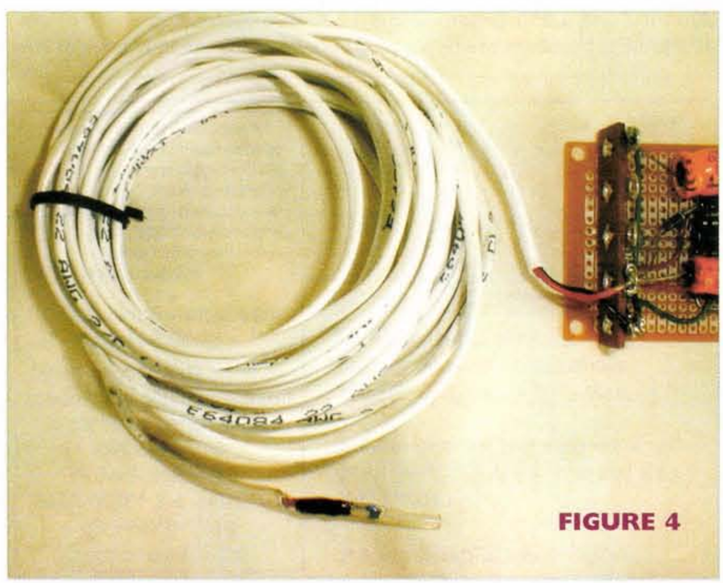
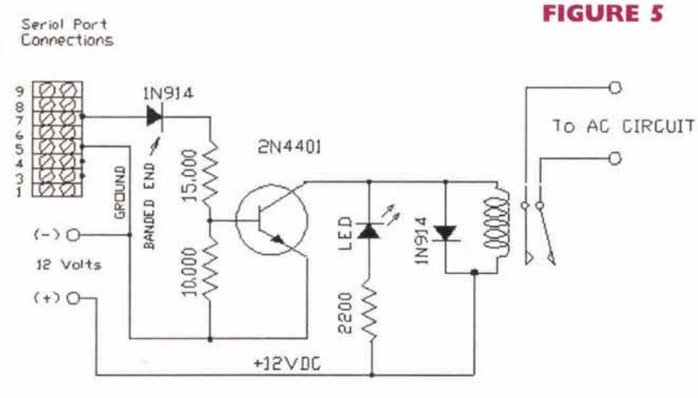


FIGURE 4

FIGURE 5



Calibrating the Temperature Readings

Due to the wide tolerance of the 470 mF charging capacitor, it is unlikely that your digital period thermometer will initially display the proper temperature. The easiest way to correct this is to simply increase or decrease the number 533 in line 240 (known as the constant) until it does so. Tie the probe to the thermometer so the probe and the thermometer bulb are touching. Let the program run for several minutes until you have a stable reading on your computer. If the temperature displayed is higher than the actual temperature, reduce the constant by about the same amount (or vice-versa).

Example: The thermometer reads 73 degrees and the computer prints 75 degrees. Changing the constant to 531 should cause the computer to print near the actual temperature of 73 degrees. The constant may also be a decimal number such as 548.3, etc. Because any unit built should exhibit a similar curve, your digital thermometer should also track over the whole temperature range. You may wish to check it at the cold end by putting the probe along with 10 feet of wire and a thermometer into your freezer.

The curve fitting equation in line 160 was calibrated by using a curve fitting program. I used 32 temperature vs. period readings over the range of 0 to 120 degrees Fahrenheit. I was able to achieve an accuracy of 1/4 degree over most of the range.

The temperature is a function of the logarithm of the period:

$$T = A + (B * \log(P)) + (C * \log(P)2)$$

The Program

```
10 CLS : KEY OFF: REM "SERTEMP.BAS" 8/14/01
20 PRINT "'SerTemp' measures temperature by measuring time to
   charge Capacitor"
30 PRINT " in a 555 Timer using a 10 K ohm thermistor."
40 REM Pin Numbers are (9 pin plug) connections are to the Serial Port.
50 REM Program starts by switching on +4 to +11 Volts from Ser Out
   pin 4
60 REM Wait 2 Sec for warm-up.
70 REM Next Switches pin 3 'Lo' by using Command: OUT BAS + 3, 0
80 REM Next Switches Pin 3 'Hi' again with Command: OUT BAS + 3,
   64
90 REM This forms a trigger input pulse for the 555's input.
100 REM The 555 raises pin 1 'Hi' until cap is charged, sending pin 1
   'Lo'
110 REM When pin 1 goes 'LO', charge time is converted to tempera-
   ture
120 BAS = &H3F8: REM COM1: Base Address, Change to &H2F8 for
   COM2:
130 X = 1: OUT BAS + 4, X + Y: REM Puts Vdc on pin #4 thru 1N914 for
   power
140 TI = TIMER: WHILE TIMER < TI + 2: WEND: REM 2 Sec Timer
150 LOCATE 4, 6: PRINT "Start time test"
160 OUT BAS + 3, 0: TIM = TIMER: OUT BAS + 3, 64: REM Pin 3
170 REM PRINT INP(BAS+6) AND 128
180 WAIT BAS + 6, 128, 128: REM Wait till Pin 1 goes 'LO'
190 REM PRINT INP(BAS+6) AND 128
200 P = (TIMER - TIM) * 100
210 LOCATE 4, 6: PRINT "Test Over   "
220 X = 0: OUT BAS + 4, X + Y: REM Turn Off pin 4
230 LOCATE 8, 5: PRINT USING "Period = ###.## Seconds"; P / 100
240 T = 533 - 88.6299 * LOG(P) + 3.0209 * LOG(P) ^ 2: REM 10 K
   Therm
250 LOCATE 10, 7: PRINT USING "Temp = ###.#"; T
260 REM IF T<70 THEN Y = 2 : LOCATE 12,6 : PRINT "Relay On "
270 REM IF T>72 THEN Y = 0 : LOCATE 12,6 : PRINT "Relay Off"
280 REM OUT BAS + 4, X+Y : REM turn pin 7 On or Off
290 TI = TIMER: WHILE TIMER < TI + 2: WEND: REM 2 Sec Timer
300 GOTO 120
```

Note that the address in line 280 also contains a value for X which controls the output on pin 3, in line 130 in case it is also calling for output. Thus the value for X+Y may be 0, 1, 2, or 3.

Control Something Using Temperature or Time

I used the relay circuit in Figure 5 in my Nov. 2001 article "Control Lights, a Burglar Alarm, and Other Circuits using the Computer's Serial Port." I've found it to be reliable and easy to build. It connects to the output bit on pin 7 which is not used for the temperature measurement. Use it to control anything such as an attic fan, your heating system, or to sound a temperature freeze alarm. It may be operated with a battery using the #275-005 nine-volt relay or with a 12-volt DC adapter using the #275-248 12-volt relay.

To use the relay with the program "SerTemp.bas," remove the first REM in lines 260, 270, and 280. This is an example of using the relay for heating control. Set your on and off temperature desired in lines 260

Parts List

All of the parts below are shown with their part numbers as listed in the RadioShack catalog.

1 - Multipurpose PC board #276-150
2 - Five lug wire tie points #274-688
1 - Eight-pin IC socket #276-1995
1 - 555 Timer IC #276-1723
1 - 10K ohm Thermistor #271-110
1 - 470 mF, 35V Capacitor #272-1018
1 - 100 mF, 35V Capacitor #272-1016
1 - .1 mF, 50V Capacitor #272-1069
1 - 33 ohm Resistor #271-1104
1 - Heat Shrink Tubing #278-1610
1 - Two-conductor speaker wire #278-1301 (24-gauge stranded)
1 - Nine-pin female connector #276-1538 (solder D-sub type)

Notes: The heat shrink tubing, speaker wire, and female connector are all optional if you already have something else to use. You will also need two 4-40 x 1/4" bolts, nuts, and washers to secure the tie points to PC board.

and 270. Connect the home thermostat contacts across the relay contacts and set the thermostat to turn off above the temperature in line 270 for fail safety.

Of course, you can modify the above lines to control anything you desire. Another example for night light switching:

```
260 Y = 0 : IF TIME$ > "19:30:00" AND TIME$ < "23:30:00" THEN
  Y = 2
270 IF Y = 2 THEN LOCATE 11,6 : PRINT "Relay On "
275 IF Y = 0 THEN LOCATE 11,6 : PRINT "Relay Off"
280 OUT BAS + 4, X + Y : REM turn pin 7 On or Off
```

Reading and Writing to the Serial Port

I'm presenting this section to help you understand how to read and write to the serial port. The serial port as we are using it has four available inputs and three available outputs.

Input Bit Connections

Here's how to read each of the four inputs using the BASIC command INP followed by the address as follows:

```
For pin #1 input: IN1 = -((INP(&H3FD) AND 128 = 128)
For pin #6 input: IN6 = -((INP(&H3FD) AND 32 = 32)
For pin #8 input: IN8 = -((INP(&H3FD) AND 16 = 16)
For pin #9 input: IN9 = -((INP(&H3FD) AND 64 = 64)
Pin #5 is circuit ground.
```

An input will read "0" when open and switch to "1" when an external voltage over +5 volts is applied. Example: The command to PRINT IN9 will return a "0" on your screen when pin 9 is open, and a "1" with a +6 volts battery connected to ground.

Output Bit Connections

In the "off" or "0" position, each output connection will measure about -11 volts between the output pin and ground. To switch any of the three output bits to "0," use the BASIC command OUT with the address followed by a zero:

```
Pin #3 Output: OUT &H3FA, 0   (Base address + 3)
Pin #4 Output: OUT &H3FB, 0   (Base address + 4)
Pin #7 Output: OUT &H3FB, 0   (Base address + 4)
Pin #5 is circuit ground.
```

In the "on" or "1" position, each output connection will measure about +11 volts between the output pin and ground. To switch any of the three output bits to "1," simply use BASIC command OUT as follows:

```
For pin #3 Output: OUT &H3FA,64   (Base address + 3)
For pin #4 Output: OUT &H3FB,1    (Base address + 4)
For pin #7 Output: OUT &H3FB,2    (Base address + 4)
To switch both pin #4 and pin #7 to "1," use: OUT &H3FB,3
```

Each output may be connected to a similar relay circuit as used on pin 7 in this article.

The real reward for any author is hearing from his or her readers. Please let me know how you liked the article and if you have any questions.

My email address is **raygreen@juno.com**. **NV**

by Jeff Eckert

TechKnowledgy 2002

Advanced Technologies

Invasion of the Robotic Tunas

Let's say you're on vacation at an oceanfront resort, and you scurry down to the beach and throw yourself into the surf. Suddenly an eight-foot, 300-pound yellow-fin tuna begins circling around you. The good news is that it is harmless. The bad news is that you won't be having it for dinner, because it is "Robotuna," a prototype from Draper Laboratory, Inc. **(www.draper.com)**.

The unit's proper name is Vortical Control Unmanned Underwater Vehicle (VCUUV). Named after the vorticity control flow control mechanisms employed by fish to propel and maneuver, the VCUUV mimics the form and kinematics of a real tuna. Several times more maneuverable than conventional unmanned devices, this type of propulsion is said to offer significant advantage in tight quarters, and Draper envisions entire schools of the fish for use in undersea exploration, recovering unexploded mines, laying cable, and other practical applications.

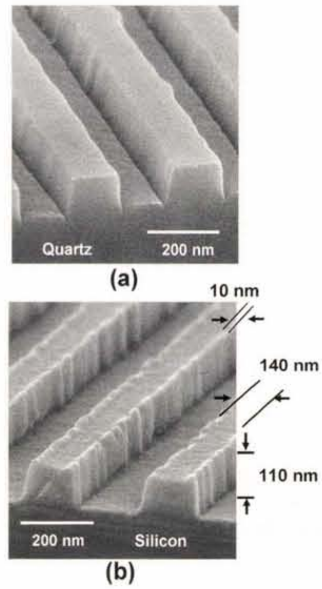
According to Draper, across the broad spectrum of fish form and movement, tuna are most desirable as a vehicle platform, as they are streamlined, relatively rigid in the forebody, and propelled with low-amplitude movements in conjunction with a high-performance hydrofoil (caudal fin). Most tuna swim continuously at one to two body lengths per second, but can burst to speeds in excess of 10 lengths per second. Additionally, tuna are highly maneuverable as compared to conventional underwater vehicle systems, due largely to the integrated nature of the main propulsor and maneuvering control surfaces.

Draper's "Robotuna" may have applications in undersea exploration, clearing mines, and laying cable. Source: The Charles Stark Draper Laboratory, Inc., Cambridge, MA, USA.

New Technique for Faster, Smaller, Cheaper Chips

In a discovery that could significantly reduce the size and cost of computer chips, researchers at **Princeton University (www.princeton.edu)** have found a fast method for printing ultrasmall patterns in silicon wafers. According to a recent press release, the method could allow electronics manufacturers to increase the density of transistors on silicon chips by 100-fold while streamlining the production process.

The method — called laser-assisted direct imprint (LADI) — involves pressing a mold against a piece of silicon and applying a laser pulse for just 20 billionths of a second. The surface of the silicon briefly melts and resolidifies around the mold. Researchers in electrical engineer Stephen Chou's lab have used the technique to create patterns with features measuring 10 nm only. The method avoids the step of etching (i.e., photolithography), which is typically used to make small patterns in silicon. While the etching process takes 10 or 20 minutes to produce a single chip, Chou's imprint method accomplishes it in a quarter millionth of a second.



The LADI Process: (a) quartz template used to press ultra-small patterns into silicon and (b) the pattern as it appears in silicon. The measurements are in nanometers (billionths of a meter).

The process is based on an excimer laser, which is commonly used in laser surgeries because it can heat just the thinnest surface layer of a material without causing damage underneath. Using conventional etching, Chou made a template of the pattern he wanted out of quartz, which is transparent to the laser beam, and pressed it against the silicon. A brief laser pulse melted the silicon surface around the mold. The silicon does not stick to the quartz.

In addition to its commercial applications, the discovery opens an interesting avenue of scientific research, according to Chou. Understanding the physics behind melting and solidifying on such small scales will require input from many fields, including materials science, mechanics, and microfluidics.

Computers and Networking

Software Bugs Cost Big Bucks

There are very few product categories in which consumers actually believe that major defects are routine and inevitable, but computer software appears to be one of them. In 2000, total sales of software in the US reached the $180 billion level, backed by a workforce of 697,000 software engineers and 585,000 computer programmers. We know that many software products are sold without being adequately debugged, but until recently, it was impossible to quantify the problem. But now we know.

According to a newly released study commissioned by the Department of Commerce's **National Institute of Standards and Technology (NIST, www.nist.gov)**, software bugs are now so prevalent and detrimental that they cost the US economy an estimated $59.5 billion annually. This represents about 0.6 percent of the gross domestic product (and about twice the recent value of Bill Gates' Microsoft stock holdings). More than half of the costs are borne by software users, with the remainder absorbed by software developers and vendors. The study also found that more than a third of the related costs (approx. $22.2 billion) could be eliminated if developers would implement improved testing to identify and remove software defects earlier.

Currently, more than half of all bugs are not found until "downstream" in the development process or when users discover them.

NIST funded the study, which was conducted by the Research Triangle Institute (RTI) in North Carolina as part of a joint process to help identify and assess means of improving software-testing capabilities. You can download a free copy of the 309-page NIST Planning Report 02-3 — The Economic Impacts of Inadequate Infrastructure for Software Testing — from **www.nist.gov/director/prog-ofc/report02-3.pdf**. Hopefully, software developers will get a copy and clean up their test processes. In the meantime, it is up to users to reject defective products, demand a refund, and pressure the software industry to do a better job.

10 GB Ethernet Standard Approved

The recently released IEEE Standard 802.3ae®, a new standard from the Institute of Electrical and Electronics Engineers **(www.ieee.org)**, extends the speed of Ethernet operations to 10 Gbit/s and provides for linking Ethernet local area networks (LANs) to municipal and wide area networks (MANs and WANs). The new standard, which offers a direct upgrade path for Gigabit Ethernet backbones, is specified for fiber optic media and uses full duplex operation. Its optical interfaces provide options for single mode fibers at distances up to 40 km and for multimode fibers at distances to 300m. The new standard uses the same management architecture as appears in earlier Ethernet standards. In enterprise applications, this will allow most users to keep using their installed architecture, software, and cabling.

The standard reaches beyond Ethernet's traditional LAN space and enables connection to other networking technologies. An optional WAN physical layer allows 10 Gbit/s Ethernet links to be extended over MAN and WAN distances. The WAN PHY maps the Ethernet frames into a synchronous optical network/synchronous digital hierarchy (SONET/SDH) payload. As a result, service providers can create high-speed, longer-distance Ethernet links at a competitive cost by using existing infrastructure. For further information on IEEE 802 standards projects, visit **www.ieee802.org/**.

Circuits and Devices

Single-Chip Audio IC for Portable Devices

National Semiconductor's LM4854 audio chip offers click suppression circuitry in a dual-amplifier package. Courtesy of National Semiconductor Corp.

National Semiconductor Corp. **(www.national.com)** recently introduced the LM4854, an integrated Boomer® stereo headphone amplifier and monophonic speaker amplifier designed for use in small portable electronics such as cellular phones, PDAs, and notebook computers. The LM4854 integrates a 1.9W mono speaker amplifier and an 85 mW stereo headphone amplifier for use in 3V and 5V systems. This device has a 0.1 ms turn-on and turn-off time. Switching from mono BTL to an SE headphone configuration is accomplished using a headphone sense pin.

The device features pop and click suppression circuitry for quieter turn-on and turn-off, and the device eliminates output coupling capacitors, saving component count and board space. Other features include an active-low micropower shutdown mode, an "instant-on" low-power standby mode, and thermal shutdown protection circuitry. The LM4854 is available in 12-bump micro SMD, 14-pin LLP, and 14-pin TSSOP packaging, and the price is $1.10 in 1,000-unit quantities.

Miniature DC Motors Offer High Power-to-Volume Ratio

A new family of precision miniature in-line DC motors, encoders, and gearheads from **Micro-Motors Co. (www.micro-motors.co.uk/)** offers a diameter of only 12 mm. The new coreless DC-micromotor type 1224 —

Micro-Motors' Type 1224 miniature DC motor is available with 6, 12, and 15V ratings. Courtesy of Micro-Motors Co.

available with 6, 12, and 15V ratings — is designed to offer a high power-to-volume ratio. The ironless skew-wound rotor uses patented System Faulhaber® technology and features low inertia for fast acceleration and high efficiency. The motor delivers up to 1.3W, 13,900 rpm, and stall torque of 3.7 mNm.

A choice of two all-metal gearheads offers a variety of combination options. Type 12/4 provides true planetary gearing in a compact design with torque and load-carrying capacity of up to 450 mNm. The zero-backlash spur gearhead type 12/5, with preloaded gears, offers precision backlash-free output shaft movement with up to 100 mNm torque. Reduction ratios from 4:1 to 2,050:1 provide flexibility for applications that require a large speed range. The in-line magnetic encoder Type 30B uses solid-state Hall sensor technology for velocity and position control of the DC-micromotor. It features two-channel TTL-level output with 10 lines at a frequency range of up to 7.2 kHz. This miniature drive is intended for motion control applications in such fields as precision instrumentation, medical equipment, security devices, automation, robotics, and aerospace.

New Low-Power, Zero-Drift Op Amps

Texas Instruments **(www.ti.com)** recently introduced a line of low-power zero-drift operational amplifiers from the company's Burr-Brown product line. According to the company, they are particularly well suited for precision, power-sensitive applications such as handheld test equipment, medical instrumentation, temperature measurement, transducer signal amplification, electronic scales, automotive systems, and battery-powered instruments.

The OPA334 and OPA335 op-amps are available in micro-size SOT23 packages and feature low quiescent current (300 µA), single supply operation, and rail-to-rail output swing within 10 mV of the rails. The devices use auto-zeroing techniques to provide ultra- low offset voltage (1 µV typical) and near-zero drift over time and temperature (0.02 µV/C).

The OPA334 family includes

a shutdown mode that allows it to be switched from normal operation to a standby current that is less than 1 µA. The OPA334 and OPA335 operate on single or dual supplies as low as +2.7 V (±1.35V) and up to +5.5V (±2.75V). All versions are specified from -40°C to +125°C.

The OPA334 (single version with shutdown) comes in a SOT23-6. The OPA335 (single without shutdown) is packaged in a SOT23-5 and SO-8. The OPA2334 (dual with shutdown) comes in an MSOP-10. The OPA2335 (dual without shutdown) is available in an MSOP-8 and SO-8. The OPA334 and OPA335 are priced from $0.95 retail in 1,000 piece quantities. The OPA2334 and OPA2335 are priced from $1.50 in 1,000 piece quantities.

Industry and the Profession

Computer Industry Achieves Major Milestone

It has been said that the bravest man who ever lived was the one who was first to eat an oyster. Likewise, we can now look back and marvel at the courage of whoever bought the first personal computer. If we start by looking at machines that enjoyed moderate commercial success, we have to go back to 1975 and the 4.77 MHz Altair Altair 8800 machine, powered by an Intel 8080 chip, loaded with 256 bytes of memory, and selling for $439.00 (in kit form) or $621.00 (preassembled). It came standard with 256 bytes of memory, but for an additional $264.00, you could add a 4k memory board.

Not much more than a quarter of a century later, according to Gartner Dataquest **(www.dataquest.com)**, someone, somewhere, bought the world's billionth personal computer in April 2002. While there is no way of telling what brand or configuration it was, we can be relatively certain that it bears little resemblance to the primordial Altair. Gartner is predicting that the two-billionth computer will probably be sold in 2008, quite possibly in China, Latin America, or Eastern Europe, where the greatest growth is expected to occur. **NV**

BRAND NEW, VIDEO MOTION SENSOR. The model VM-10 connect to any standard video signal and you've got an electronic "watchman" diligently watching the entire scene. Or any adjustable sized area within the scene. Such as a doorway or even a drawer or cabinet. A state of the art security aid. The unit will close a contact when it senses a change. Auto or manual reset. Internal buzzer with volume control and adjustable on time. VCR record and VCR stop output. (use with time lapse VCR.) 110VAC powered. Adjustable sensitivity. Video loop through. **VM10....$179ea.**

SUPER, f1.8, 10x SURVEILLANCE LENS, Perfect for long range observation.

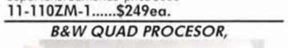
New, Fujinon, 11mm to 110mm ZOOM optics, standard C-Mount. Make any of our C-Mount cameras a long range stealth-cam! WOW! Provides 20X on a 1/3" CCD camera. A super lens. Edmunds' price $800 **11-110ZM-1......$249ea.**

A SECOND SERIOUSLY SIZED SERVOMOTOR SLIDE, By ANORAD, Provides 23.5" of Precise Travel. But Wait...There's a Z AXIS BONUS!

These SUPER HEAVY DUTY, motorized linear slides, do their sliding on crossed roller bearings. The X axis is motivated by a 2.25" diam. EG&G servomotor type: MT-2130-012BE or similar with encoder driving a flex coupled 0.75" diam. ball screw drive. The huge carriage is: 28" L x 5.5" Wx 1.1" Thick. The X axis is a massive precision machined (Mehanite) casting. Mounted to the carriage is a substantial Z axis unit sporting dual THK, YH2218, 0.6"H x 0.5"W rails or similar. Riding the rails are four recirculating ball carriages attached to a 1/4" thick aluminum plate. (Two carriages on each side) Running down the center is a 1/2" diam. ball screw driven by a size 23 stepper motor. This motor provides the drive for the 10.5" travel, Z axis. These units were originally designed to be used in a "gantry" configuration. ie. suspended over the workpiece with the workpiece moving in the Y axis. Overall size is 48"L x 17"W x 20"H. This is the perfect setup for heavy duty cutting or engraving. Slides of this quality don't come around very often. Don't miss out. We have a very limited quantity. These units must ship via truck. These are used in good condition removed from optical equipment. **ANORAD SLIDE.. $349 ea. or 2 for $649**

WE ARE LOOKING for UNIQUE ELECTRO-OPTICAL, MOTION CONTROL DEVICES and RELATED. PLEASE FAX US YOUR LIST of AVAILABLE MATERIAL.

B&W QUAD PROCESOR,

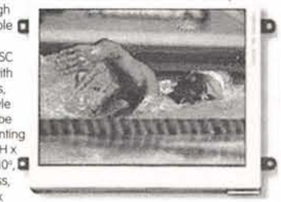


The GM4-BQ is an unbeatable value. Four camera inputs with loop through. Full screen image, REAL TIME display, high resolution: 960 x480, brightness adj. for each chan. Alarm time (1-20 sec.) 4 alarm inputs. Auto Sequencing mode with adj. dwell:1-4 sec. Quality video processing. Specs: •4 video inputs. •1 monitor out and VCR in/out, •4 alarm inputs •Buzzer •2 Alarm Out •Dim: 239 x166 x55 mm. **GM4-BQ QUAD..........$179**

SERIOUSLY SIZED SERVOMOTOR SLIDE, provides 21" of precise travel. But Wait...There's More!

These heavy duty, motorized linear slides, do their sliding on 3/4" diam. Thompson steel rail. The X axis is motivated by a substantial 3.4" diam. EG&G servomotor type: ME3515-191B with an EG&G 1000 count encoder driving a flex coupled 1/2" pulley which belt drives 2.2" diam. transfer pulley which direct drives the 1.5" final drive pulley which moves the 0.6" wide toothed belt which moves the carriage. The X axis carriage contains a motorized rotary unit with the same type EG&G servomotor driving a 5.5" diam. 1/4" thick aluminum platter mounted at about a 20 degrees angle to the base. Rotation is via an anti backlash gearing system directly driven by the motor. Supporting all these goodies is a welded, 3" wide steel channel frame. The system overall size is: 45"L x 14.25"W x 8.75"H. These units must ship via truck. Very limited quantity. These are used in good condition. **XSLIDE-ROTARY....... $229 ea. or 2 for $399**

NEW! 6.8" LCD COLOR, TFT, ACTIVE MATRIX DISPLAY, A huge 23sq. inch VIEWABLE AREA, Super Deal. 2.8X the VIEWING AREA of a 4" WOW! We wish you could see the color saturation and resolution of this superior LCD display. Excellent contrast ratio, high quality, full color images are comparable to a CRT. Perfect, portable, general purpose color monitor for standard NTSC color or B&W video. Fully compatible with all our cameras as well as Camcorders, VCR's, DVD's etc. OEM "component" style unit has no outer cabinet. Designed to be installed in YOUR housing via four mounting tabs as shown. Specs: Resolution, 1152H x 234V, 270K Pixels! Viewing angle, Top 10°, Down 30°, Left 45°, Right 45°. Brightness, 300 nit, Size: W x H x D (mm/in), 157.2 x 122.6 x 8.0, 6.2" x 4.83" x 1.1", Weight, 10oz. Supplied with 30" input cable. Video input via BNC jack., 12VDC input via a standard barrel connector.



BRAND NEW, FIRST QUALITY. GMTFT68.......$169ea.
Regulated 12 VDC/110VAC power supply.......$8.95ea.

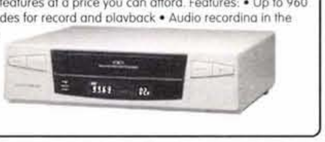
SPECIAL, CARL ZEISS, S-PLANAR LENS, GCA type 37, 1.4/75, M1:5nA=0.30,

A fantastic lens with a current replacement cost of $20K. Extremely flat field and extemely high quality.

Removed from wafer-lithography system, excellent condition. **ZEISS-PLANAR..$495..NOW$395**

NEW, GM960R TIME LAPSE VIDEO RECORDER

Finally a brand new, 4 head, T/L recorder with all the features at a price you can afford. Features: • Up to 960 hours on a standard T-120 VHS tape.• 12 different modes for record and playback • Audio recording in the 12H and 24H mode. • 30Day memory backup • Easy mode setting.• On- screen menus • Auto-Repeat recording mode • Serial or One-shot recording • Time, Date, speed, and Alarm indicators on screen. These deluxe units are front loading and are 14"W x 3.5"H x 12.2"D, 110VAC powered. **SPECIAL, GM960R-VCR ......$379ea.**



POWER to SPARE, 12 VOLTS at 17.2 Ah, NEW EXIDE SEALED RECHARGEABLE LEAD ACID BATTERY

Type NP-18-12, Now is your chance to perk up those power projects. Perfect for powering many portable devices such as GPS, laptop or telescope, fish finder or underwater camera. The list is endless. Don't be left out of this opportunity. The size is a manageable 7"W x 6.75"H x 3"D, weight is 14 lbs. Heavy duty post type connections. Use two in parallel for 34 Ah WOW! Ltd. qty. **EXIDE-NP1812.....$24ea.**
Case of 4, EXIDE-NP1812-4..$89 1amp Charger, EX-CHGR..$15ea.

SPECIAL, DAY/NIGHT TECHNOLOGY, OPTIMIZED COLOR / IR OPTICS DSP technology and 10 Automatic LED's. Weather Tight GM450K-IR Makes it Happen

Features include: Interactive infrared illuminator with 10 high power, wide angle LEDs @ 880nm . See objects 60 feet away during total darkness. A super quality 5 element, glass lens, specially coated with a 100 layer optical coating. For perfect focus with white light and a crisp image under infrared. Normally impossible due to the different focal point for IR and visible light. Solid state infrared optical switch provides day time IR cut filter for excellent color. At night infrared filter will turn off to allow infrared to pass. Also, night time IR LEDs will gradually turn on with proper amount of illumination. You can also see color images such as lights and signs at night. Fog free cover glass. Specs: 0.5 lux color sensitivity. 60dB S/n ratio typical. 12" I/O cable with BNC video and DC barrel jack. 120 dB smear rejection ratio. Adjustable mount and power adapter included. **GM450K-IR..$199ea. NOW $169**

SPECIAL, LINEAR SLIDES from DCI, Three models available: The large is 6"L x 2.6"W x 1"H with 4" of travel. The medium is 5"L x 2.6"W x 1"H with 3" of travel. The small is 1.75"W x 1.75"L x 0.75"H with 1" of travel with a removable spring return for use against a micrometer or similar. Features common to all include: Solid machined aluminum with anodized construction, hardened steel ways. Slides are usable in any position and can carry heavy loads. Over 100lbs for the large and medium and 25lbs for the small. Straight line accuracy of 0.00008"/inch of travel. All are new. Ltd. Qty. **DCI-LONG.......$69ea. NOW $59**
DCI-MEDIUM...$59ea. NOW $49
DCI-SHORT.......$39ea. NOW $29

NEW! WEATHERPROOF B&W mini TUBE CAMERA Industrial strength, solid machined housing.

Sleek black anodized, BRASS, housing is O-Ring sealed & WATERPROOF. Adjustabe mount included. Specs: 1/3" CCD, 400 Lines resolution, 0.05 Lux sensitivity, AGC, Auto Shutter. Operates on 12VDC @200mA, 4mm, 78° FOV lens, A real glass lens. NTSC video out. Superior construction. SENSITIVE to IR. Ultra small Size only: 1.25" diam. X 2" long. With 60 ft. cable. Great for outdoor use too. **NEW, GM300K-N........$99**

NEW! 0.01 Lux, COLOR NIGHT VISION CAMERA! FANTASTIC LOW LIGHT PERFORMANCE. Exclusive ON SCREEN, menu driven setup of all camera parameters. NEW, STATE of the ART, GMV-35KOSD,

Perfect for covert, military & scientific applications that must be color. Unbelievable 0.01Lux @ f1.2 performance is enhanced through low speed electronic shuttering, digital frame integration & advanced DSP. Auto sensitivity mode starts as it becomes dark. 24 hour surveillance is possible with the optional f1.2 lens shown below. Specs: Shutter speed auto or manual, 1/60 to 1/120,000, 60dB S/N ratio!, 154dB Smear rejection!, AGC gain 0 dB to 18 dB. Digital gain 0dB to 12dB. Digital zoom continuous from up to 2X in 0.1X steps. Masking mode allows hiding 4 programmable zones for privacy protection. Camera on screen name. Choose you own name for the camera and display it on monitor for easy identification.) White balance modes: Auto tracking, one push or selection from 3200k, 4800k, 5600k, 7800k, and "double white balance" independent white balance circuit for both bright and dark zone, maintains correct white balance even with combined indoor and outdoor lighting. Programmable 48 zone back light compensation mode for difficult lighting situation. Negative mode for negative film reading. Mirror image and up/down selection for rear view and camera mounted upside down. Seven Gain/Shutter modes are user selectable. Normal, X2, X4, X8, X16, X24, X32, X64. These provide frame rates of 60, 30, 15, 8, 4, 3, 2, and 1 per second. Alum. housing, dual 1/4x20 mtg. Specs: 1/3" CCD, 811(H) X 508(V), with 412K pixels, 470 Lines, 12VDC ±1V@250mA, Std. video out on BNC. Std S-Video out on 4Pin connector. Size: 2"H x 2"W x 4.5" long. Regulated power adapter included. C-mount lens not included.

GMV-35KOSD.............$399ea.
High performance lens, 4mm, f1.3....$ 49ea.

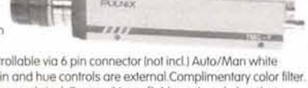
NEW, 470 LINE, DSP COLOR Micro CAM The HIGHEST PERFORMANCE available. MICRO SIZED PACKAGE too!

Yes 470 lines with a 60db S/N ratio to back it up! That's 16X better than a typical 46dB standard camera! The GM-4500, CCD camera with its' DSP technology provides high speed white balance with no color rolling. Auto shutter speed of 1/60 to 1/120,000 second. Truly state of the art. Sleek cast aluminum housing protects the 18mm x 26mm pc board inside.Mounting bracket & 18" cable with BNC video and DC pwr. jack for, no sweat hook up. requires only 12VDC@ 65mA. Optional mirror function available. Why fool around with an open P.C. board? This camera has it all. • 1/4" CCD • 1 Lux • AGC • Auto Shutter • 270k pixels • Std. 3.7 mm, 68° FOV lens • Focus:10mm to infinity • 3<ounce! • Size (mm): 33W x 29H x 30D **GM-4500-STD, SPECIAL...$99ea.**

NEW, lower cost, High quality, MINI BOARD CAM,

1/3" CCD, 420 Lines Res., 0.3 Lux sens., AGC, Pwr. from 9 to 12VDC @100mA, 266k PIXELS, 3.7mm, 92° FOV lens,A real glass lens. Auto shutter from 1/60 to 1/100,000 sec. Focus from 10mm to infinity. Std. NTSC video out. 1/2 ounce! SENSITIVE to IR. Size: 1.25"sq. x 1"d. Connections via a 3" pigtail with PC board connector. **GM-1000B-STD........$45ea.**

PULNIX, TMC7 INDUSTRIAL 1/2", COLOR CCD CAMERA, with Pentax Lens. For No Compromise Performance.

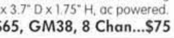


Specs: 1/2" CCD, 460 Lines resolution, 768H x 494V Pixels, 2 Lux sens. @f1.4, Auto/Man AGC, Auto/Man Shutter: 1/60 to 1/10,000 remotely controllable via 6 pin connector (not incl.) Auto/Man white balance, Manual gain and hue controls are external.Complimentary color filter. 12VDC @320mA, Pwr supply incl. Pentax, 16mm f1.4 lens, A real glass lens. Included. Std. NTSC video out on BNC. Y/C (S-Video) output available on 12 pin connector supplied. Superior construction. Compact size only: 1.6"W x 1.25"H x 5.5" long. Perfect for use in process monitoring, medical, surveillance and microscopy. Used, excellent condition, Regular price $600. Limited quantity. **PULNIX, TMC-7.............$149ea. or 2 for $249**

NEW! 0.005 Lux, COLOR NIGHT VISION CAMERA! UNBELIEVABLE LOW LIGHT PERFORMANCE. State of the Art Video, Exclusive ON SCREEN, menu driven setup of all camera parameters!

For covert, military & scientific applications that must be color, this is it. Unbelievable 0.005Lux @ f1.2 performance is enhanced through low speed electronic shuttering, digital frame integration and advanced DSP. Auto sensitivity mode starts as it becomes dark. 24 hour surveillance is possible with the optional f1.2 auto iris lens shown below. Seven Gain/Shutter modes are user selectable. Normal, X4, X8, X16, X24, X32, X64. These provide frame rates of 60, 15, 8, 4, 3, 2 and 1 per second. Auto/Man. white balance 3200° to 10000°K, auto/man BLC, S/N >52dB, Mirror on/off, Gain on/off, auto electronic shutter 1/60 to 1/120,000 sec., Alum. housing, dual 1/4x20 mtg. Specs: 1/2" CCD, 768(H) X 494(V), with 380K pixels, 470 Lines, 12VDC ±1V@200mA, Std. video out on BNC. Size: 51mm x 51mm x115mm long. Regulated power adapter included. All functions can be externally controlled. Use standard c-mount lens not included.
GMV-3K-OSD..........$449ea.
High performance auto iris lens, 12mm, f1.2...$199ea.

NEW! 4 or 8 CHANNEL, VIDEO AUTO SWITCHERS



Connect four or eight std. video signals and they will be sequentially output to the dual rear panel BNC outputs. Front panel user adjustable, variable dwell 1 to 15 sec per channel. Auto/manual switching with channel bypass. Compact only 8.6"W x 3.7" D x 1.75" H, ac powered. Video loop through. **GM-34, 4 Chan...$65, GM38, 8 Chan...$75**

NEW, SECURITY MONITOR. NOW YOU HAVE THREE CHOICES!

Commercial quality, Hi-resolution B&W and Color monitors. Brand new, 90 day warranty. BNC video in and loop through. Rugged black steel case. Three models are available: choose a 9" or 15" Black and White with 1000 lines of resolution or a 14" color with 450 lines of resolution. You will be amazed at how much better they will make your video look! There is no substitute for a real monitor. With UL, FCC and FDA approvals.

SPECIAL, BWMONITOR-9HR....$94 ea.
BWMONITOR-15HR........$159ea.
COLORMON-14HR.........$219ea.

by Robert Nansel

Amateur Robotics

As I write, I am packing to drive 2,000 miles to my parent's log home in Three Forks, MT. Brouhaha. Confusion. Consternation. And a column to finish, aargh!

Boy, do I need a vacation.

This month, I finish up the last details of building the cheap linear actuator, and I'll also present some ideas for future improvements. Next, I dive into color. It may look like I'm just dipping my toes in the water, but I'm practically drowning in the sea of information on this topic. I'll close with an announcement.

First to the actuator.

Actuator Loose Ends

The actuator design as it stands has a few problems. First, though I wanted a quick actuator, this design is a little too zippy for some uses. It would benefit from some gear reduction, if only 2:1 or 3:1.

Second, it has a tendency to overshoot under a light load when using the simple limit switch circuit, since there's no position feedback and nothing to brake the motor other than friction. This is more a problem for extension than retraction, because the rod-end pivot provides a mechanical stop on retraction. Even then, it's possible for the motor's inertia to draw the slide tube in tight enough to jam. Using a silicone lubricant alleviates the jamming problem, at the expense of increasing overshoot.

Third, my initial design is just plain harder to build than it needs to be. I mentioned a simpler thrust bearing set-up last month, and I've got lots of other ideas for ways to improve its performance and make it easier to build.

One easy improvement is using machine-cut threaded rod rather than rolled threads because machine-cut threads are more precise and have a smoother finish. Machine-cut threaded rod costs a little more, but the follower nut will last longer and there will be less friction.

Another improvement would be to use a pre-machined follower nut to avoid all the hassle of precisely drilling and tapping one yourself. Standard threaded standoffs are obvious candidates for premade follower nuts because they are cheap and readily available. Standoffs are available in round and hexagonal sections, in aluminum, brass, and nylon, and range from 2-56 to 10-32 threads. Metric threads are available, too.

None of the standard sizes are a direct fit inside any of the telescoping tubes that Small Parts carries, either square or round, so a bit of shimming before soldering or gluing would be in order.

Another alternative is threaded brackets such as those made by Keystone Electronics, Inc., and available from Mouser Electronics (www.mouser.com) — in particular Mouser part #534-631 and #534-708. You might also look into E-Z LOK threaded inserts, also available from Small Parts, though these require a tapped hole themselves to be installed.

Different Strokes

As I noted above, lack of position feedback is a major shortcoming of the present design. You know the actuator's position only when fully extended or retracted; it's an open-loop control system, and positions between the extremes are anyone's guess.

You could time how long the actuator takes to extend or retract, then run the motor some fraction of that time in the hope of getting close to the desired position. The problem is the final position will depend on lots of factors beyond timing (wear, lubrication, and changing load come to mind). A better way is to incorporate positional feedback and close the control loop.

Optical encoders are often the first choice among robot builders because they interface easily to digital controllers. Absolute position encoders, either linear or rotary, will do the job, but they can be expensive, and there's really no need. A simple incremental encoder combined with a home-position switch allows determination of the absolute position of the slide tube.

This method will work with either rotary or linear incremental encoders. The main requirement for the encoder is that it be one with two quadrature channels so the direction of movement can be determined. Simply count the number and direction of pulses since the last time the slide was homed. With any luck, the position will be dead on (but home the slider early and often to be sure).

The retract limit switch can make a convenient home-position sensor, but if you do this, you won't be able to use the simple limit switch circuit described last month. Instead, you would need to use the retract limit switch as a sensor. Rather than directly interrupting current to the motor when the limit is reached, the switch would be wired to a free input pin of a microcontroller or other digital controller. The controller detects when the switch closes or opens and outputs the appropriate PWM levels to the motor driver to start or stop the motor. A pull-up resistor to logic V+ is necessary for an input line that lacks an internal pull-up.

Linear Slide

On the analog side of things,

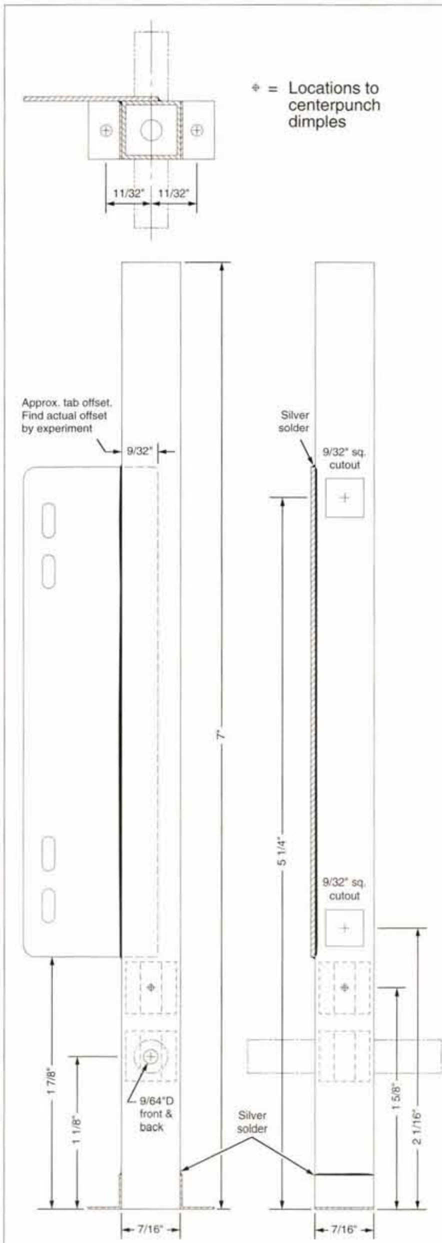


Figure 1: (a) TSLx257 spectral responsivities with no external filter; (b) spectral responsivities with external IR cutoff filter. (Graphs from TAOS, Inc. TAOS027A datasheet, p5.).

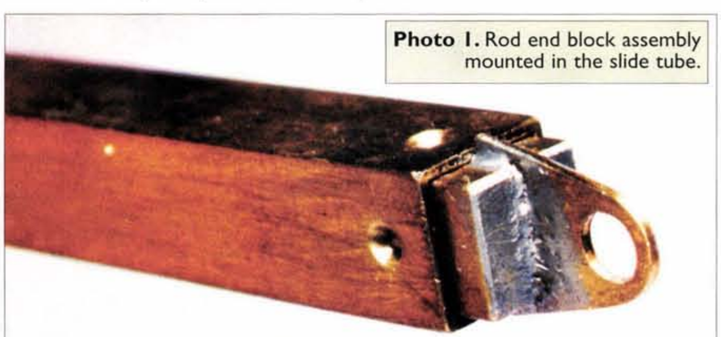


Photo 1. Rod end block assembly mounted in the slide tube.

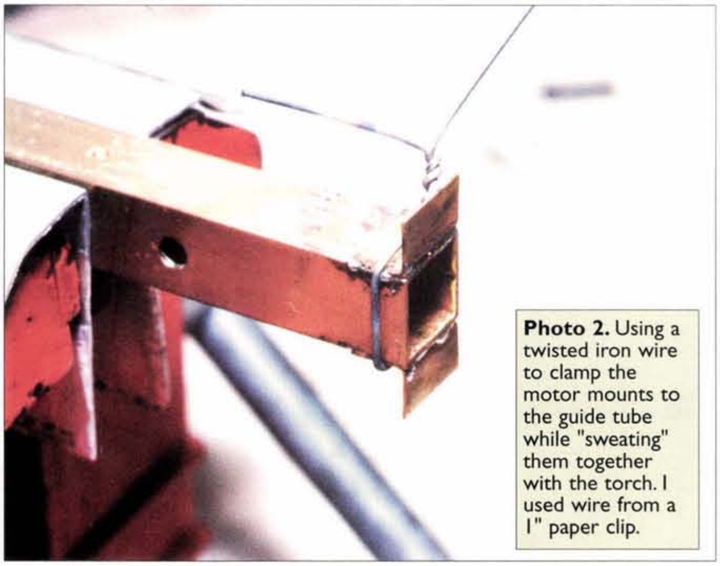


Photo 2. Using a twisted iron wire to clamp the motor mounts to the guide tube while "sweating" them together with the torch. I used wire from a 1" paper clip.

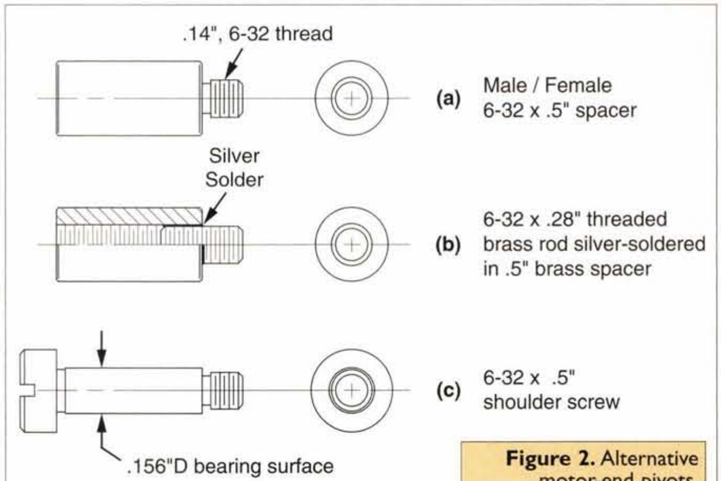


Figure 2. Alternative motor-end pivots.

a linear slide potentiometer makes a fine position sensor, and it just so happens I designed this actuator with a travel compatible with commonly available slide pots. You may need to cut a slot in the guide tube for the pot lever, depending on how you mount the slide pot. The slot allows a more compact assembly, but it's more complex to build and it opens the assembly to environmental crud.

I have toyed with the idea of building a homebrew slide pot into the actuator slide. I envision broaching an internal groove in the guide tube and a matching external groove on the slide tube. The grooves would accept a strip of insulated resistance element and a sliding contact. If I can figure out a simple way to perform the broaching operations with simple hand tools, I might give this one a whirl.

Whatever potentiometer is used, it could be very interesting to use a hobby servo motor and electronics board to drive the linear actuator, either directly or through one stage of gear reduction. The slide pot would then directly replace the stock servo's rotary feedback pot. This way, the actuator would use a standard servo three-wire interface. What could be simpler?

I've had a lot of fun with this linear actuator project, and I'd love to hear from any of you who build your own versions of it. I've spent half this month talking about its flaws and fixes, and I have faith others will come up with better ideas than I have. For instance, I'd love to combine the function of shock absorber and linear actuator in one design, but I haven't come up with a clean design yet.

Now to shift gears to the world of color sensing and perception.

Color!

As mentioned in past columns, I'm working on a two-pronged attack on low-cost color sensing for robots. I've got one of the CMUcam color vision systems on my shelf (available from from Seattle Robotics, www.seattlerobotics.com) just waiting for a robot in which to install it. It has 80 x 143 resolution and can track user-defined color blobs at 17 frames per second. It can also output a pulse train compatible with hobby servos such that the camera will tend to track the lateral movement of a defined color blob. All this for under $100.00.

I have been about ready to bust, so eager have I been to try this vision system out. However, I've had other important projects in the queue ahead of it. One of those projects is a simple RGB color sensor.

Rather than a video camera with thousands of pixels, I just want a single pixel. I want a color sensor more like a phototransistor than a video camera, applicable in the same situations as a phototransistor. It should consume little power and be easy to use with simple robots (BEAM-style robots, for instance).

BEAM robots produce interesting emergent behavior using simple monochrome optosensors (phototransistors and CdS photocells and the like), and I've wondered what new kinds of behaviors might be possible with color sensors.

In the past year, the job of designing a color sensor has become much simpler with the TSLx257 series of color light-to-voltage sensors from TAOS, Inc. (www.taosinc.com).

These parts include a photodiode, transimpedance amplifier, and integral color filter in a three-pin package, the same sort of package as phototransistors. You connect ground and +5V to pins 1 and 2 and read the sensed light intensity as a rail-to-rail analog voltage on pin 3. The TSLR257 senses red, the TSLG257 green, and the TSLB257 blue.

Despite the integral color filters, all three parts still respond to IR; you must add an external optical filter to block near IR wavelengths to get true measurements. Figure 1 shows the relative spectral responsivities for the TSLx257 sensors with and without an external IR cut-off filter.

Expensive Glass

I couldn't find the Hoya CM500 the datasheet calls for, and the cheapest alternative I could find was an unmounted 15mm square glass IR cut-off filter from Edmund Industrial Optics (part #L53-709). This piece of glass costs nearly $30.00. There's got to be a cheaper filter out there since every color camera using a silicon imaging chip has the same problem with IR. Junked camcorders or digital still cameras might be a source, but I've never taken any of these apart. (If any of you know of a good source for IR cut-off filters, I'd like to hear about it.)

In order to use my expensive little filter, I needed some sort of mounting cell for it and a diffuser, and I further needed an opaque tube to shield the sensors from stray light. The diffuser smears out the light so the sensors all see the same patch of color. Figure 2 shows my basic design.

The filter cell is made from a sandwich of three cardboard disks painted flat black. The cardboard is the kind used to back large pads of paper, and it needs to be about 1.1mm (.043") thick, the same as the filter. As for the opaque tube, I used two film cannisters, the black plastic kind that Kodak 35mm film comes in. I made square cutouts in the bottom of both cannisters, as well as holes for mounting screws, then attached them to both sides of my home-made filter cell. One end is left open for light to enter, and the sensor array mounts in a plastic film cannister cap snapped on to the other end. This arrangement gives roughly a 45-degree field of

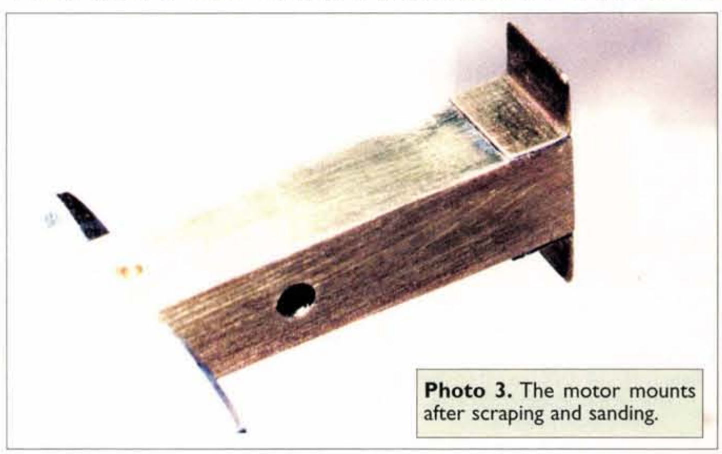


Photo 3. The motor mounts after scraping and sanding.

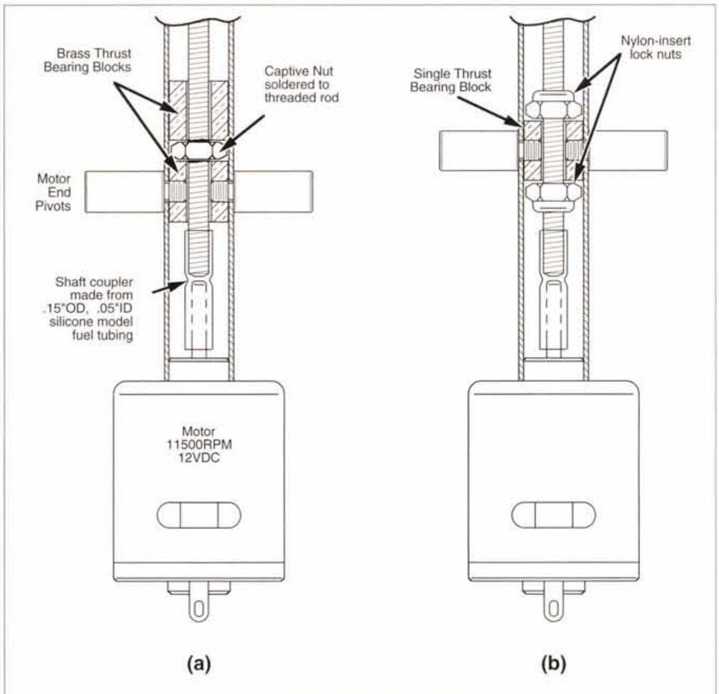


Figure 3. Two thrust bearing styles.

view. Though I have not tried it, you could mount a lense on another plastic cap to make the color sensor more directional.

The design is a bit bulky, but it's easy and (except for the filter) cheap to build. Figure 3 shows how I propose to use this sensor.

Color Perception

If the robot resembles a classic Braitenberg vehicle, that is no coincidence. If it appears I've been a bit vague on what happens inside the Color Comparator function block, that's no coincidence, either. The RGB sensor does a good job of measuring energy in the red, green, and blue wavelengths of visible light, but color is a complex perceptual phenomenon only indirectly tied to RGB measurements. In terms of RGB values, it doesn't really make sense to talk about object colors such as "fire engine red" or "pastel green" or even "white." Those are purely human perceptions, and there are no unique values of R, G, and B that produce these colors.

For instance, you were probably taught in grammar school that white is just all three colors mixed together. However, if you had only just enough of each color to be visible in a dark room, you would most likely perceive it as gray. Another example is the rainbow. Physics tells us that a rainbow should spread the colors evenly across the spectrum, but we perceive rainbows as wide bands of green and red with much narrower bands of yellow, orange, and blue interspersed.

Object color is complicated enough, but there's also the color

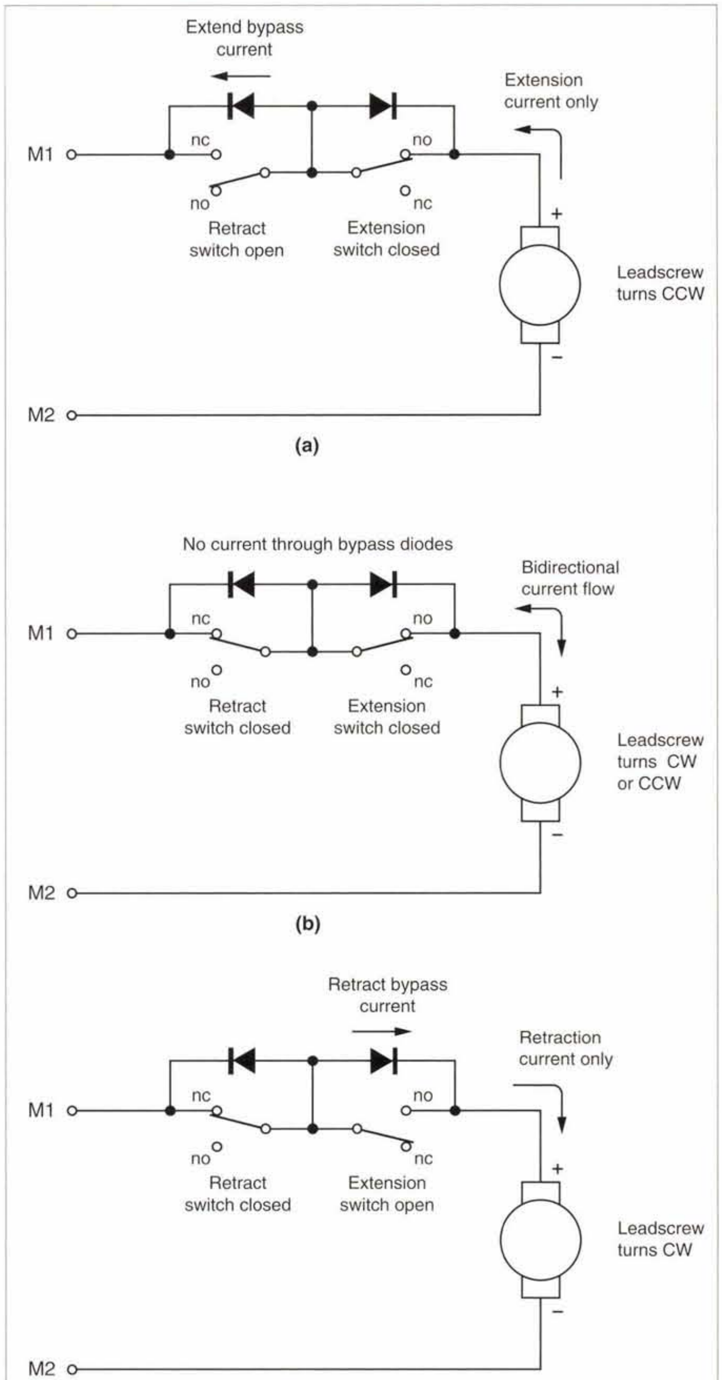


Figure 4. Limit switch states.

of illumination to reckon with. In 1977, Edwin Land (inventor of Polaroid photography) showed that you can illuminate a color painting with just two basis colors (say green and blue), yet still be able to perceive the colors correctly — even colors not present in the two illuminating wavelengths.

To understand how this can be, you need to understand the idea of color space. Figure 4 shows the basic idea.

Color Space

The most basic is RGB color space, a unit cube containing all possible values of each basis color, and thus all possible colors. But as the above examples have shown, it doesn't explain color perception. Other color spaces are more useful when thinking about that, most notably the HSI color space, or Hue, Saturation, and Intensity.

Intensity is the same as the brightness control on a TV. Saturation is the amount a color is "diluted" by white; "fire engine red" is fully saturated, but if you mix enough white in, it will turn pastel pink. Hue is roughly pro-

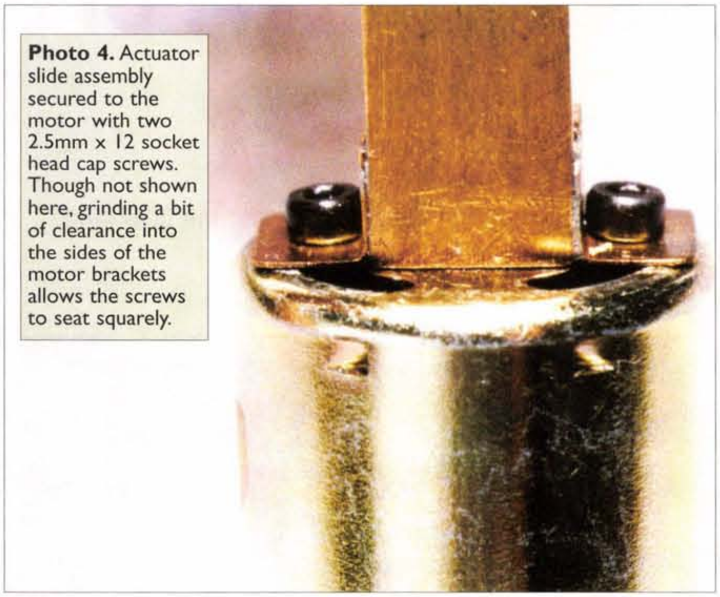


Photo 4. Actuator slide assembly secured to the motor with two 2.5mm x 12 socket head cap screws. Though not shown here, grinding a bit of clearance into the sides of the motor brackets allows the screws to seat squarely.

portional to the average wavelength of the color, and hence is what I want to use as the starting point for the color tracker. The color comparator will compare left and right values of hue to an internal reference; saturation and intensity will be used as threshold values. A color must be bright enough and saturated enough to be considered. I haven't tried this, but I think it is a good start.

Color space transforms can be mind-bogglingly complex, and HSI is one of the more complex. I don't have the space here to go into the details, but HSI color space can be transformed from RGB by the equations in the sidebar. Figure 4 gives a visualization to the ideas embodied in those equations.

If you don't understand it at first, you're in lots of good company. I can recommend two textbooks to take you further in your understanding. The first is the college text from which I very nearly learned the material 20 years ago: *Computer Vision* by Dana Ballard and Christopher Brown (Prentice Hall, New Jersey, 1982, ISBN 0-13-165316-4). (n.b. They refer to HSI as IHS.)

A more recent text, a portion of which is available online for download, is Gonzalez and Woods' *Digital Image Processing* (Addison-Wesley, 1992). You can download the HSI conversion chapter at the following URL (no spaces or breaks): www.imageprocessingbook.com/downloads/material_from_last_edition/rgb-to-hsi-conversion.pdf

I'll have more to say about color sensing in future articles — and I welcome tips from anyone who works every day with this stuff — but I am flat out of room this month. And I still have to get to my announcement.

Equations

RGB to HSI color space conversion

Intensity:

$$I = \frac{1}{3}(R + G + B)$$

Saturation:

$$S = 1 - \frac{3\,[\min(R, G, B)]}{(R + G + B)}$$

Hue:

$$H = \cos^{-1}\left\{\frac{(R-G)+(R-B)}{2[(R-G)^2+(R-B)(G-B)]^{1/2}}\right\}$$

If $(B/I) > (G/I)$ then $H \leftarrow 360^\circ - H$

To normalize H to the range [0,1]:

$$H \leftarrow H/360^\circ$$

Things to watch out for:

- Hue undefined when Saturation is zero (when R=B=G)
- Saturation undefined when Intensity is zero (when R=B=G=0)
- When calculating the difference between two hues, remember H is cyclic, and H=0 and H=1 are the same hue (red):

$\text{Diff} \leftarrow H_1 - H_2$
If $\text{Diff} > .5$ then $\text{Diff} \leftarrow \text{Diff} - 1$
Else If $\text{Diff} \leq -.5$ then $\text{Diff} \leftarrow \text{Diff} + 1$

The End?

After much soul searching, I have very reluctantly come to the conclusion that I must end my role as the monthly robotics columnist for *Nuts & Volts*. Shoshana and I have spent many hours discussing this over the past year, and I have come to believe that I cannot be the father I want to be for my two boys if I must sequester myself for the 30 or 40 hours each month it takes to research and write my column.

This was brought home to me this Spring when Yonatan, my three-year-old, told me he couldn't come play Silly Loud Dinosaurs with his brother Nadav and me because, he said, "I'm busy working on my computer" (in the same pleading tone of voice I apparently use when I'm on deadline). And Nadav is going through a phase where he needs to have either Shoshana or me in sight most of the day.

It's been a wild, fun, hilariously nerve-wracking four years, made all the better by letters and emails from you, the readers. To those who wrote to tell me you always read my column first, there were several months where such notes tipped the balance and kept me going. Thank you for the kindness.

It has been a privilege to write the Amateur Robotics column; the folks at *Nuts & Volts* are simply the best there is, and to them — Natalie, Larry, and, most of all, Robin — I thank you for your seemingly endless patience and faith in me.

Do not fear, folks, I am not retiring. I still intend to write robotics and other tech hobbyist articles, and you'll see them in these pages (and others) from time to time. I just can't do it on a monthly schedule anymore.

Although I will no longer be doing this column, I'm still interested in hearing from you. If you have suggestions, questions, or comments about amateur robotics topics, as always you can reach me at:

Robert Nansel
Box 228
Ambridge, PA 15003
Email: bnansel@nauticom.net

By the time you read this, I also will have a website to point folks toward information on my past columns and my current projects: **www.countryrobot.com.** It'll be pretty bare bones in the beginning, but you'll see lots more after I recover from vacation. Don't expect much fancy Java, animation, or sound — I'm on 56k dialup, and those things just cheese me off. I won't inflict them on you. Do expect lots of good information on robotics and general gadgeteering, much available nowhere else. Amateur Robotics is not dead. Long live Amateur Robotics! **NV**

Product Review: Line6 GuitarPort

By Edward B. Driscoll, Jr.

If you're a "weekend warrior" musician looking for a practice or recording tool that you can plug into the USB port of your PC, then GuitarPort might just be right up your alley.

The instructions seem to say "plug your electric guitar into the USB port of your personal computer," which sounds like a pretty good deal. Back in the 1950s, when guitarists like Muddy Waters and Chuck Berry wanted a great guitar sound, they had to take a gigantic Eniac mainframe computer that took up the entire floor of an office building on the road with them.

Okay, so plugging a guitar into a personal computer is in reality a much newer phenomenon. (Which is too bad, because "Chuck Berry Eniac Tour 1956" would have made a great Micro Memories column. That was the tour where Chuck sang Johnniac B. Goode, I think.)

Line6, which has manufactured a line of amps and effects boxes for guitarists that recreate the vintage sounds of the 1950s and 60s vacuum tube-powered amps (beloved by electric guitarists for their warm tone and, when overdriven, their "musical" distortion), is betting that guitarists will want to plug into their computers, and they've invented a product that allows them to do just that.

A Variety of Uses

The GuitarPort — which retails for $229.99, but can often be found on sale for well under $200.00, and vaguely resembles some alien prop from "Star Trek: The Next Generation" — plugs into a PC's USB outlet, as well as its multimedia speakers and, in turn, has a quarter-inch jack into which you plug your guitar. Once connected, it features an amazing variety of pre-set sounds (most geared towards rock and blues), as well as an online capability (with a $7.99 monthly fee that allows for not only additional tones to be downloaded, but also notational tablature, lessons, and several whole songs which have guitar parts that can be switched on or off to practice to (including several by Jimi Hendrix, thanks to a deal that Line6 cut with his estate). The downloads feel seamless for anyone with a broadband connection.

For guitarists looking to improve their "chops," the GuitarPort will transfer tracks from audio CDs into MP3s, and play them at an optional half-speed (while keeping the sound in the same key). So, for example, if a guitarist wanted to practice the George Harrison's solo from Something by the Beatles, the Abbey Road CD could be inserted into a PC, copied as an MP3, then Harrison's guitar tone on that song could be downloaded from the GuitarPort's accompanying web site, and finally Something could be played at both half and normal speeds until the solo is memorized.

What Does It Sound Like?

Even if it doesn't make sense to bother with the online component of the GuitarPort, there's a lot here to play with. Professional electric guitarists and serious amateurs spend years crafting the tone of the instrument, and most would probably say that a vintage amplifier sounds better or more authentic than Line6's computer-driven recreations. However, to my ears, the sounds of the GuitarPort are pretty darn good, and amazingly diverse. Plug a Gibson Les Paul in and dial-up the "British High Gain" pre-set, and you're instantly transported to a small London club where a hungry young Jimmy Page or Jeff Beck is jamming. Or for something completely different, switch to "Snow Dome," with a hypnotic and mystical combination of echo and reverb that almost seems to play the guitar itself.

The 78 or so other presets run the gamut from 1950s-style small amps perfect for B.B. King and Muddy Waters style blues leads, to shredding heavy metal buzz saw sounds and all points in between. And, of course, all of the unit's simulated amps, speaker cabinets, and effects can be tinkered with, assembled, and dissembled for even more tones.

Bucking the Hum

The GuitarPort also has a guitar tuner, a noise gate, and a hum-reduc-

ing feature, which is especially helpful for anyone recording guitars with single-coil pickups (such as most Fender instruments). "The hum reducer is an interesting thing, because one of the early challenges that we identified is that if people are going to be sitting in front of a CRT, you're going to get hum through pickups, especially on a single-coil guitar," according to Mark McCrite, product manager for Line6. "So if you click on the hum reducer, it gives you graphic instructions, and what you basically do is try to isolate the hum."

This involves putting your guitar's noisiest pickup on and moving around the monitor until the pickup is humming at its worst, and "then you click on the Analyze button, and it will record a little bit of that hum, and then figure a way to 'suck it out,' McCrite says. "We call it a hum reducer, and not a hum canceller, because if you took all of that out, it would be pretty invasive to the guitar's tone." And it definitely will leave some hum, but in many cases, this will be masked by other instruments when recording. Which leads us to ...

Home Recording

For recording programs, such as Cakewalk's Sonar XL 2.0 (see "Abbey Road in a Box" in the Nov. 2001 issue of *Nuts & Volts*), the unit works seamlessly, making it a natural for home recording (although it may be incompatible with version 1.3 of Sonar. Check with Cakewalk and/or Line6 to see if there's a workaround available if this version is your primary recording software).

While many guitarists will still prefer to mic a real amplifier rather than use an input device, others will appreciate the ability to get good sounds instantly, without having to wake the neighbors (or parents) in the process.

The software is designed to work with Windows 98, Me, and 2000. As of May, XP drivers were in the works to be released by the time this article appears in print. And Apples are not yet supported by GuitarPort.

Because of the driver issues, possible incompatibility with some home recording products, and the need for a reasonably fast PC with a USB port, GuitarPort isn't for everyone. But if you're a "weekend warrior" musician looking for a practice or recording tool, GuitarPort might just be right up your alley. **NV**

A Universal FET Tester

By Peter Lehmann

It's a good idea to test FETs prior to building circuitry with them.

When you are working with surplus FETs or FETs removed from the circuit boards of any of your previous projects or of scrapped equipment, it's a good idea to test them prior to building circuitry with them. Enter the Universal FET Tester ...

Field effect transistors or FETs that can be tested are junction gate FETs or JFETs, both N-channel and P-channel, and insulated gate FETs or IGFETs (MOSFETs being the most common type of IGFET), both N-channel and P-channel, both enhancement- and depletion-mode and three lead or four lead. The tester can also accommodate any package and particular pin sequence of a FET, that is, the arrangement of leads to the gate, drain, source, and substrate of the FET. Adding this tester to your collection of testing equipment will also prove advantageous for determining the type of unknown FETs and troubleshooting.

To make it work, the tester is connected between your existing function generator or oscillator capable of producing squarewaves and your general-purpose oscilloscope. The frequency and amplitude of the squarewave at input to the tester need to be, respectively, 1 KHz and 10V peak-to-peak into a 10KW load. The output signal from the tester should be DC-coupled to the vertical amplifier of the scope.

Uses for FETs and an explanation as to where FETs can be used to advantage in place of bipolar transistors can be found in the excellent series of articles by Ray Marston, "FET Principles and Circuits" in the May 2000 through August 2000 issues of *Nuts & Volts* magazine.

TESTING PURPOSES

IGFETs have a very thin dielectric or insulator between the gate and substrate of the FET forming a small and fragile capacitor. This capacitor can be easily damaged by a discharge of static electricity during handling. Also, IGFETs are most commonly manufactured in plastic TO-202 or TO-220 packages that must be soldered into working circuits. So being able to test the FET before soldering it into place is advantageous. Sockets for FETs in the TO-3 package are available, but FETs so packaged are a great deal more expensive than the ones in plastic packages. IGFETs are also available in the dual in-line pin or DIP package, but these are limited in terms of power dissipation.

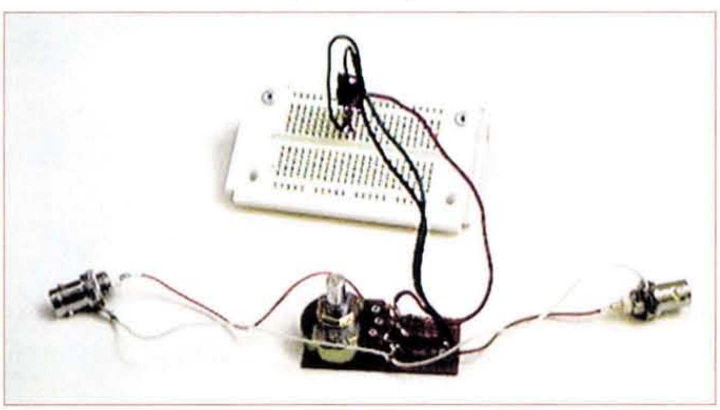


PHOTO 1: Interconnection of components of tester.

FUNCTIONAL METHOD

Figure 1 is a schematic diagram of the very simple circuit of the dynamic tester with FET Q1 being the transistor tested and showing the waveforms of the squarewave applied at the input and taken at the output of the tester. Resistor R1 provides a path of current leakage from the gate to the source of the FET being tested preventing an excessive accumulation of charge at the gate of the FET if the wiper of potentiometer R2 inadvertently lifts off its track. By voltage division, the setting of potentiometer R2 controls the peak voltage taken between the gate and source terminations of FET Q1. If FET Q1 were a JFET, then resistor R3 provides loading for the generator of the squarewave at input where the gate to source junction of the JFET is forward-biased. Resistor R4 is the load resistance for FET Q1 and connected from the drain of FET Q1 to 0V or ground.

The FET shown in Figure 1 is an N-channel enhancement-mode MOSFET with three leads and the substrate and source of the FET internally connected. An IGFET with four leads requires externally connecting the substrate and source leads for testing. The substrate is P-type material and the drain and source are N-type material implanted in the substrate. During the peak positive half-wave of the input signal, the voltage taken at the substrate with respect to that at the drain is positive, producing a forward bias across the substrate to drain PN junction. Potentiometer R2 varies the voltage of the gate relative to that of the substrate from 0V to -5V. The surface of the substrate directly under the gate insulator correspondingly changes from P-type material identical to that of the remainder of the substrate to material that locally has a net positive charge. A conductive channel from the source to the drain does not form regardless of the voltage of the gate relative to that of the substrate. Under these conditions, the FET can be modeled as a forward-biased diode and the positive half-wave viewed on the display of the scope essentially follows that of the input signal and has a peak voltage of nearly 5V.

During the peak negative half-wave of the input signal, the voltage taken at the substrate with respect to that at the drain is negative producing a reverse bias across the substrate to drain PN junction. Adjusting the gate to source voltage, VGS, equal to 0V by rotating the shaft of potentiometer R2 causes the material of the surface of the sub-

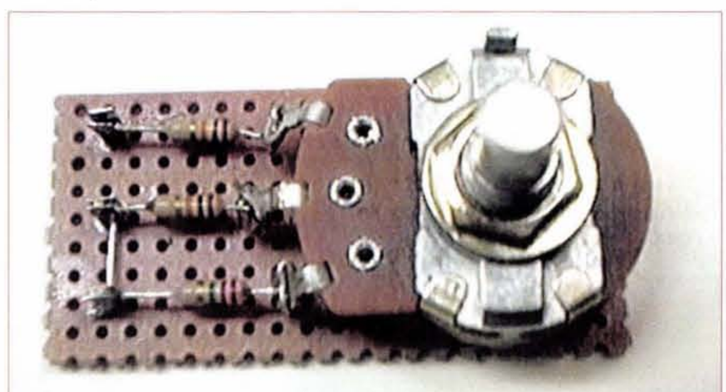


PHOTO 2: Resistive network.

strate directly under the gate insulator to be P-type material identical to that of the remainder of the substrate, and a conductive channel from source to drain does not form. Therefore, no current can flow through the FET and the negative half-wave of the input signal does not appear on the scope.

If during the negative half-wave of the input signal the shaft of potentiometer R2 is rotated causing VGS to be greater than +1V, then the surface of the substrate directly under the gate insulator becomes locally negatively charged and a conductive channel from source to drain is formed. The resistance of this conductive channel is very much less than that of load resistor R4. The waveform appearing on the scope corresponds to the voltage drop across resistor R4, so this adjustment to the setting of potentiometer R4 results in the appearance of a negative square half-wave on the scope with a peak amplitude of -5V.

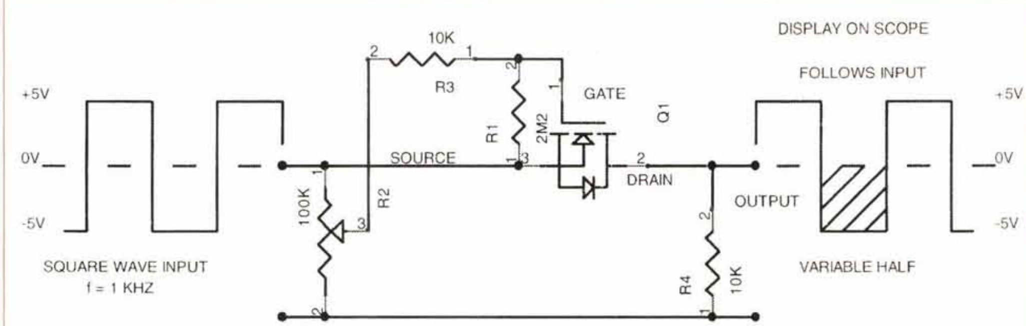


FIGURE 1: Schematic diagram of tester.

In the case of the FET Q1 shown in Figure 1, if the FET is good, then the peak amplitude of the positive and negative half-waves on the scope are respectively equal to nearly +5V for any setting, and variable between 0V and -5V with the setting of potentiometer R2.

Alternatively, FET Q1 in Figure 1 might be a good N-channel JFET. For this type of JFET, the substrate is N-type material, the source and drain are ohmic contacts to the substrate, and the gate is P-type material implanted at the middle of the substrate. Note that all JFETs are depletion-mode devices, that is, with zero volts taken across the gate-to-source junction, maximum current flows from source to drain.

During the negative half-wave of the input signal, the position of the wiper of potentiometer R2 varies the gate with respect to source voltage from zero volts to +5V. For Q1 in Figure 1 alternatively being a good N-channel JFET, then the gate-to-source junction varies from zero bias to being forward-biased. Therefore, the JFET is ON for any setting of potentiometer R2 and the negative half-wave on the scope follows the input negative half-wave. During the positive half-wave of the input signal, the gate-to-source voltage is varied from zero volts to -5V by the setting of potentiometer R2. The PN junction between the gate and source of the JFET can thus be increasingly negatively biased by the position of the wiper of potentiometer R2 being moved closer to a position of no resistance between ground and the wiper. Current from source to drain is increasingly cut off in proportion to the negative bias of the gate-to-source junction, which means that the setting of potentiometer R2 varies the peak amplitude of the positive half-wave taken across load resistor R4 viewed on the scope.

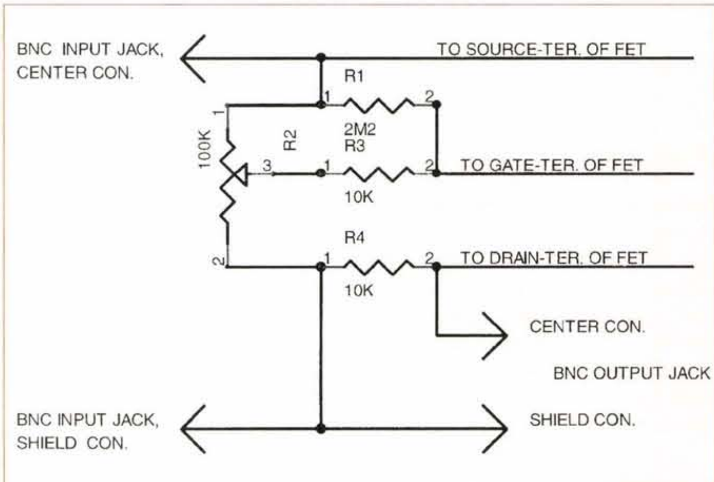


FIGURE 2: Layout and interconnection of resistive network of tester.

For JFETs and depletion-mode IGFETs, the maximum absolute value of VGS produced by this tester equal to 5V is generally less than the turning OFF threshold voltage for these FETs. Therefore, the variable half of the output squarewave of a good FET of these types will be variable over a range of less than 5V.

PARTS LIST

(Fig. 2)

Part #	Stock #	Value/Description	Vendor
R1	291-2.2M	2.2 Megohm 1/4W 5% carbon film resistor	Mouser Electronics
R2	31VA501	100K ohm linear taper 24mm potentiometer	Mouser Electronics
R3	291-10K	10K ohm 1/4W 5% carbon film resistor	Mouser Electronics
R4	291-10K	10K ohm 1/4W 5% carbon film resistor	Mouser Electronics
—	276-1394	4-1/2" x 6" IC-spacing perfboard	RadioShack
—	278-1224	22 AWG stranded & insulated hook-up wire	RadioShack
—	574-T42-1/C	Vector push-in terminals for .042" holes	Mouser Electronics
—	161-9323	BNC female jacks (2)	Mouser Electronics
—	276-175	Socket board 2-1/8" x 3-5/8" x 1/16"	RadioShack
—	270-1803	5" x 2-1/2" x 2" project enclosure	RadioShack
—	274-403	1/2" dia. plastic knob	RadioShack
—	—	Two of 1/8" dia. 1/2" Grip Al pop rivets, two of #6-1/2" sheet metal screws, Goop® or an epoxy adhesive	Local hardware store

Mouser Electronics — www.mouser.com — **1-800-346-6873**

CONSTRUCTING IT

Photo 1 shows how the components of the tester are connected omitting the enclosure. At the bottom of the photo is the resistive network which consists of a potentiometer connected to three 1/4W fixed resistors mounted on a small section of perfboard glued to the back of the potentiometer. The network is connected to a pair of input/output female BNC jacks and three color-coded 22 AWG stranded and insulated wires. The tinned opposite ends of the color-coded wires are inserted into the socket board at the top of the photo to connect to the pins of a FET to be tested which is also inserted into the socket board. Accompanying this article is a parts and materials list including stock numbers and the corresponding vendor name.

Photo 2 shows the resistive network. To construct it, first cut a 1" x 2" section of perfboard and glue it to the back of the 100KW pot, R2. After the glue has set, three push-in terminals are inserted into the perfboard in line with the terminals of the potentiometer R2. Solder the three fixed 1/4W resistors R1,

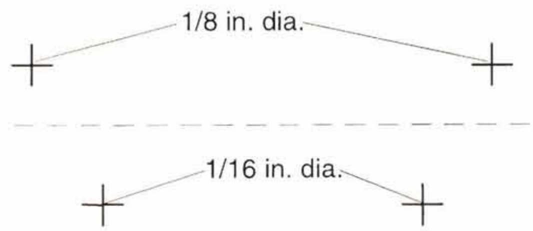


FIGURE 3: Full-size template for bracket supporting socket board.

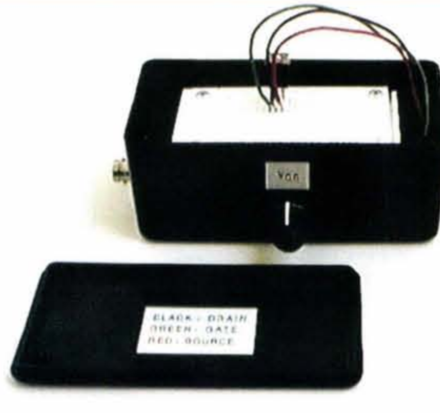


PHOTO 3: The completed tester.

R3, and R4 to potentiometer R2 and the push-in terminals as shown in Figure 2. At this time, also connect lengths of hook-up wire to the network to be connected to the pair of BNC jacks and for insertion into the socket board.

While waiting for the glue holding the small section of perfboard to the back of the potentiometer to set, you can construct the bracket for mounting the socket board in the enclosure. See Figure 3, which is a full-size template for cutting, drilling, and bending the aluminum lid supplied with the enclosure to form the right angle mounting bracket. The template is attached to the lid with paper-sticking glue between the existing mounting holes drilled in the lid. Reduce the size of the lid to the perimeter of the template. Drill the indicated holes of the template and then form a right angle bend along the dashed line of the template with a bending brake or a bench vise.

Attach the socket board to the mounting bracket with pop rivets through the 1/8" diameter holes in the bracket. With the plastic lid unattached to the enclosure, position the socket board and attached mounting bracket along a first side of the enclosure with the top surface of the socket board about 3/8" below the edge of the opening of the enclosure and centered horizontally. Using the two 1/16" diameter holes in the mounting bracket as a guide, mark the positions on the first side of the enclosure where 1/8" diameter holes are to be drilled for attaching the bracket to the enclosure.

Drill 5/16" diameter and 1/8" diameter holes, respectively, 1-3/8" and 1-13/16" distance from the (top) edge of the opening of the enclosure along a vertical line equidistant from the ends of the second side of the enclosure for mounting the potentiometer. Drill 3/8" diameter holes at both ends of the enclosure 1-3/8" distance from the top edge of the opening of the enclosure and centered left to right for mounting the BNC jacks.

Mount the resistive network and BNC jacks in the enclosure and solder the connections from the resistive network to the jacks. Mount the socket board in the enclosure by attaching the mounting bracket to the first side of the enclosure with sheet metal screws. A note can be attached to the interior of the plastic lid of the enclosure indicating the colors of the wires to be connected to the gate, drain, and source leads of the FET to be tested. When the tester is not in use, the lid can be attached to the enclosure to protect the breadboard and contain the wires for making connections to a FET. See Photo 3. **NV**

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MISCELLANEOUS

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Circle #48 on the Reader Service Card.

Reader Feedback

Dear Nuts & Volts:

I am disappointed to see more time and energy wasted on the misguided building of regenerative receivers. They stink. Because they don't require alignment, there is little useful experience to be gained in building them and their performance is lousy compared to superheterodyne receivers. With the possible exception of the passive TRF receiver for use in very specialized applications building anything besides superhets is a waste of effort.

Anonymous

Dear Nuts & Volts:

The most important observation in Louis Frenzel's article on current flow is that it really doesn't matter. For example, Kirchoff's Laws — as universally applied by engineers, physicists, and technicians — are formulated in terms of "algebraic sums," with the sign of each quantity determined by convention. If it really irks you that someone has defined positive current flow at a junction to be conventional current flowing in, you can redefine it as electrons flowing out. The key is self-consistency.

But the convention of current flowing from the negative terminal of a battery to the positive is not self-consistent — at least not with the bigger picture. Positive current flow from point A to point B is defined as a movement of positive charges from point A to point B — or equivalently, negative charge from point B to point A. A positive potential difference between point B and point A means the electric field vector points from A to B, and the force vector on a positive charge points in the same direction. In the model, Frenzel advocates current appears to flow uphill.

Had Benjamin Franklin — the true culprit in this misunderstanding — guessed right about the direction of the charge carriers he was observing, everything would be exactly the same as it is now, except what is now labelled the positive terminal of a battery would be marked negative and vice versa. To compare changing over from conventional to electron flow and changing from English to metric units is a bit of an oversimplification. Either we could legislate some illogical sign changes into Maxwell's equations, akin to drawing a mustache on the Mona Lisa, or we could fix the "real world" by shipping power supplies and batteries with their terminals marked opposite to present practice. The second choice would create disasters far greater than mere confusion. The current flow convention would then reflect "the truth" for most metals, but not for p-wafers or metals with complicated Fermi surfaces like tungsten. (Freznel's sanctimonious description of his way reminds me of a certain right-wing radio talk show host. No wonder he sees such emotional responses to the subject.)

Franklin's true brilliance in this field — not to mention several hundred others — lay in the realization that a signed number is appropriate for describing any electric charge, and that which sign describes which charge is arbitrary. At the risk of adding fuel to the fire, I think engineers, physicists, and college professors resist standardizing on electron flow not because they are old, stodgy, and resist change (most professors are engaged in state-of-the-art research as a condition of their continued employment), but because they see a bigger picture than technicians.

David Liguori
Albany, NY

Dear Nuts & Volts:

I know of Louis E. Frenzel. I've known of Lou since I began writing about electronics in 1960 after reading many of his articles. I'm no Louis E. Fenzel — although I've written almost 100 articles for *Nuts & Volts*.

And now that Joe Carr, Anthony Charlton, Herb Friedman, and so many of the other prolific electronics writers of the last century have gone to the big master grid in the sky, Louis E. Frenzel is one of the few remaining deans of electronics scribes, together with Forrest M. Mims III, Don Lancaster and, of course, TJ Byers.

However, I must disagree with Lou's favoritism of electron flow (EF) versus conventional current flow (CCF). (July 2002, Page 40.) While EF makes physicists comfortable, as an electronics hobbyist, I prefer to "go with the flow" — positive to negative — for one basic reason: the arrows in semiconductor devices point that way! And, at 75, I'm old fashioned.

Whenever I look at a circuit to try to figure out what is happening, I follow the arrows. If I try to use EF reasoning, I get hopelessly confused — or more hopelessly confused!

In all my hundreds of articles in many electronics magazines in the last over-40 years, admittedly written mostly for beginners and intermediate electronics hobbyists, I've strived for practical explanations over theory, always using positive-to-negative current flow for explanations of circuit action. I leave the atoms, holes, valences, doping, and such to those who dabble in theory, while I crank up the iron and build something ... or I did until recently going partially blind.

In one of my recent books (*Simple Low-Cost Electronics Projects* — Butterworth-Heinemann), the circuit descriptions for all 22 projects are explained in detail using current flow rather than electron flow. I've had no complaints.

I'm a KISSer (Keep It Simple, Stupid), not a KICKer (Keep It Complicated, Knucklehead — or they'll figure it out for themselves, and won't need you!).

Fred "Sparks" Blechman

Dear Nuts & Volts:

The direction current "really" flows is the direction that positive charge flows while moving from greater potential to lesser potential. That is the only direction it can possibly flow in order for the math to work out. If we redefine current flow to be the direction that electrons happen to move, then we must also define protons to have negative charge and electrons to have positive charge. Is it really necessary to change the model of the atom simply to appease ornery individuals who are annoyed that the most common charge carrier happens to be negative?

Christopher J. Burian
Waltham, MA

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Circle #35 on the Reader Service Card.

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*** *or by snail mail at Nuts & Volts Magazine, 430 Princeland Ct., Corona, CA 92879.*

What's Up:

Two IR remote control receivers, a simple KVM switch, and the definitive chart of TTL output driver circuits. Looking for hard-to-find parts? Sources for custom panel meters, USB-to-serial port converters, and used Tektronix scopes. How to earn a CET or A+ Certification, and some very techie cool web sites.

Remote Control Tester

Q. I am looking for a circuit to check TV/VCR remote controls. The circuit should consist of an IR detector and a corresponding circuit that would light an LED to show that the remote is working. It would be nice if I could fit the tester in a RadioShack 270-283 project box.

Bernie Petrasek
via Internet

A. If all you want to do is check to see if the remote is emitting light, RadioShack sells a card (276-1099) that fluoresces when IR light strikes it. But I suspect you have other plans for the signal, otherwise you wouldn't have asked for an LED indicator. Figure 1 is a simple circuit built around a GP1U52X IR receiver module that will fit in your desired project box.

By the way, you don't need to drill a hole in the case to let in the IR light. It will penetrate the plastic, albeit the range will be reduced by about half.

Remote Control Relay

Q. I wish to drive a small five-volt relay from the output of a TV remote IR receiver. The receiver is housed in a metal can and has three pins: +5 volts, ground, and output.

Ken Schultis
via Internet

A. From your description of the receiver, it sounds identical to the GP1U52X module I used in the Figure 1 circuit. This time, though, I'm adding an optoisolator. If you wish, the TLP624 can be replaced with a Darlington transistor, like an MPSA14. The 10uF cap filters the output pulse and prevents the relay from chattering.

Roll Your Own Drivers

Q. In the June 2001 issue, you made a circuit for a sequential timer that controlled 110 VAC lights. Recently, I restored an old railroad color position light — the B & O R.R. type. It's about 3.5 feet in diameter and has two red, two yellow, and two green lights. The bulbs are 12 volt (1156) and each color-pair are wired in parallel. Could you alter your circuit for my 12-volt application? My application would call for each color to be turned on for the same amount of time in the sequence.

Herb Henry
via Internet

A. Either of the circuits I published in the March and June 2001 issues will work for your project. I recommend the 4017 sequencer in Figure 3 because it gives the evenly-spaced intervals you desire

Now to your question: how to interface the output to your specific lights. I'm sure a lot of readers have the same question because I often publish schematics that almost fill their needs if only the output could be changed to match their specific device. So I'm going to serve up a medley of solutions that should let you interface any popular device to any TTL-compatible output. Refer to the drawings in Figure 4 on the next page.

In drawing **(a)**, the output drives an LED when it's low; in drawing **(b)**, the LED lights when the output goes high. R1 limits the drive current to about 10 mA. For heavier loads, a transistor is used: **(c)** turns on the transistor (and powers the load) when the output is high, **(d)** turns on the transistor when the output is low. The maximum load current for the transistors shown is about 600 mA. Figures **(e)** and **(f)** are isolated drivers for DC and AC loads, respectively; output current is determined by the device itself. Circuit **(g)**

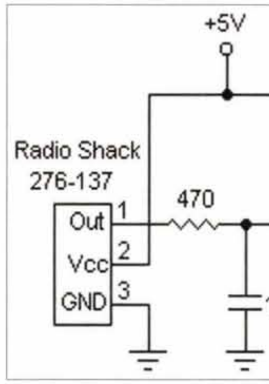


Figure 1

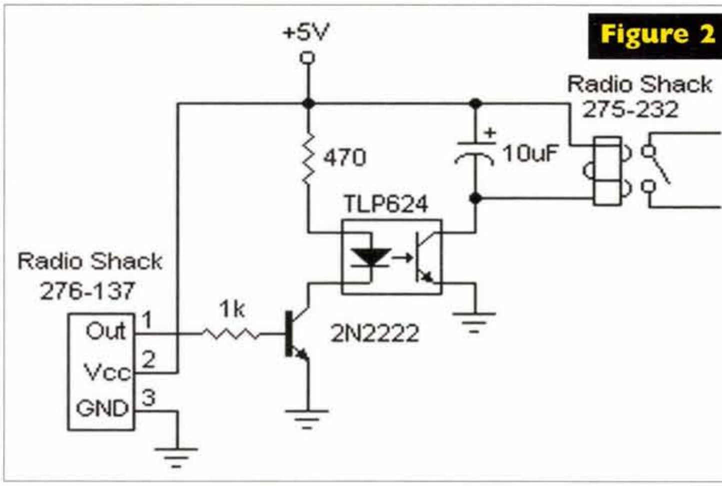


Figure 2

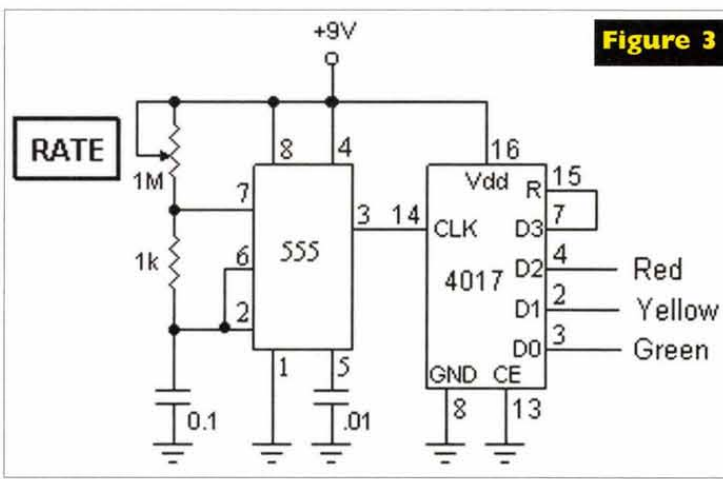
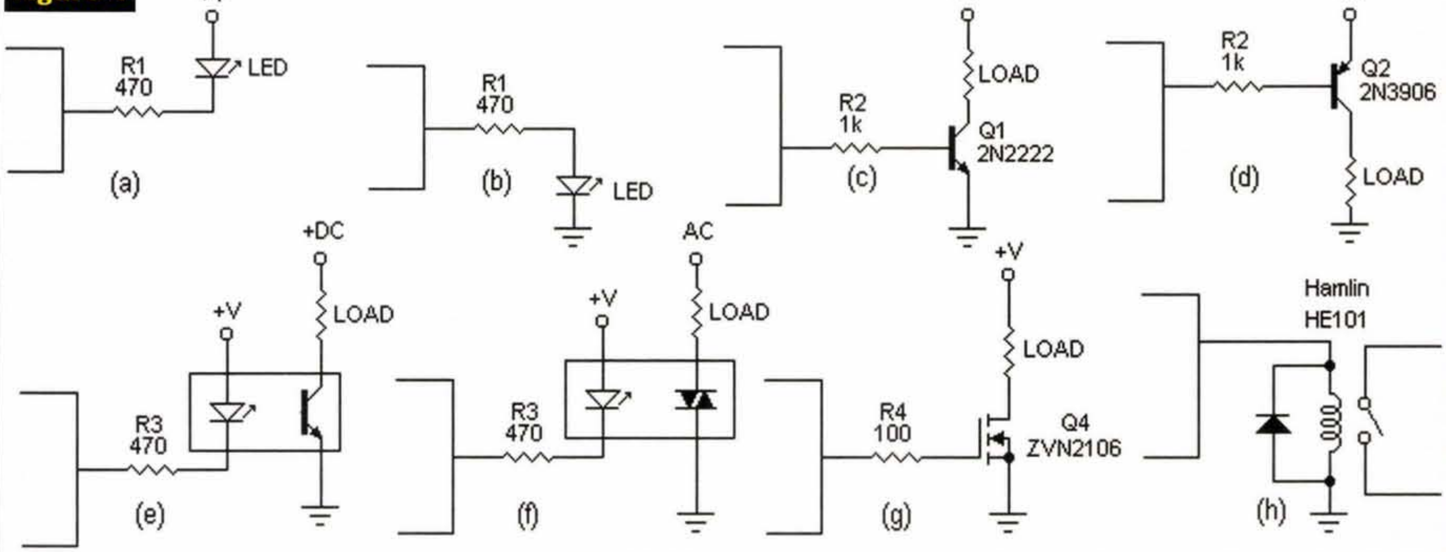


Figure 3

Figure 4



is an FET driver capable of delivering 450 mA when the output is high, and **(h)** drives a Hamlin reed relay capable of switching 0.5 amps at 200 volts.

Your project needs solution **(d)**. Let's do a little math here to determine the type of transistor you need. Two 1156 lamps in parallel draw about four amps, which means you need to be looking at a power transistor and not a small 2N2222 often found in my designs. The drive current of a TTL gate is between 10 mA and 25 mA, where 10 mA is typical for chips like the 4017. That means we need a gain (Hfe) of 800 (4A/5mA = 800) using a value of 1k for R2.

To obtain that much gain and current in a single package, we have to turn to a Darlington transistor; I lean toward the popular TIP series, which includes the TIP125. It's rated 5A at 60 volts, and is available from a number of sources. Of course, you'll need three TIP125 transistors, one for each color.

Customized Panel Meters

Q. I need to locate a source for analog panel meters with a scale of 250 degrees, a 50 uA or 100 uA full scale that's not affected by the panel material, and fast pointer response. I want to use these as instruments for auto/ATV vehicles, so they have to be rugged, and would prefer new units over surplus. The major distributors seem to have dropped this line, and I'm definitely not interested in digital meter replacements. I would greatly appreciate any pointers that you can provide.

Joseph F. Richmond
Joppa, MD

A. Yes, these once-popular movements have given way to digital displays. However, they still make them, but get your pocketbook ready, because they ain't cheap. Here are your best bets.

Simpson Electric
www.simpsonelectric.com/pdf/webpdfe/250%20ADC.pdf

Her Rong Electrical Works
www.herrong.com

Beede Electrical Instrument Co.
— build your own, USA built
www.beede.com/panel_meters.htm

However, there is an alternative to this expensive solution: LED gauges.

Become A Professional

Q. Please recommend suggested reading material that would help me get up to speed for the National Occupational Competency Test for Electronics (NOCTI). Although I have 35 years in electronics and vocational teaching, with a diploma from Devry of Chicago, I need this permit to teach electronics at the grade and high-school level. Much to my surprise, NOCTI did not offer much help.

Bob Eichman
via Internet

A. Technology is advancing so fast that it takes a kid on a skateboard just to keep up with it. And you're not the only reader, young or old, who feels like you're being left in the dust. Fortunately, there are several sources available that can keep you up to speed or advance your education, no matter what your level of expertise.

The NOCTI test consists of two parts: written and performance. The written test consists of approximately 200 multiple-choice items and requires three hours to complete. It covers factual knowledge, technical information, understanding of principles, and problem-solving abilities related to the occupation. The second part is a performance test that's administered in a laboratory or industrial setting and consists of work assignments that require four to five hours to complete. It is designed to sample the manipulative skills required by an occupation and, in your case, is most likely optional.

I know, so far I haven't told you anything you don't already know. Yes, I can give you a long list of reading material that is much too boring and time consuming to make any sense. But I'll tell you a secret. If you can pass the CET (Certified Electronic Technician) test, you can pass the NOCTI test. Better news yet is that the people at CET encourage you to look at sample questions that are representative of the questions on the test (**www.iscet.org/certification/associate.html**), and they score your results. The results will point out your weak and strong points. I strongly recommend this free offer for all serious hobbyists and professionals.

Interested in other certifications that can improve your life and increase your income? Here is a short list.

A+ Certification for Information Technology (IT) professionals.
www.comptia.org

Microsoft certifications: MCP, MCSA, MCSD, and more.
www.microsoft.com/traincert/mcp/default.asp

Novell certifications: CNA, CNE, CDE, and more.
www.novell.com/education/certinfo/

Certified Internet Webmaster
www.ciwcertified.com/

List and links of certifications around the web.
www.certcities.com/certs/other/

Serial To USB

Q. I'm looking for a circuit to interface serial devices to a USB port. My old computer (with four serial ports) in my ham shack died, and I replaced it with a laptop/docking station with one serial port and one USB port. I'd like to build an adapter to convert a serial port to a USB port or, ideally, four serial ports into one USB port.

Don
via Internet

A. Yes, I suppose you could make a converter built around TI's 8052-based TUSB3410VF serial-to-USB chip, but it's not an overnight project by any stretch of the imagination. Even if you could piece together all the hardware needed, there's still a small detail of programming the chip.

What I'd do is buy a serial-to-USB cable sold by many retailers. A single port interface cable costs between $25.00 and $50.00 (Figure 5), and a four-port interface box will set you back $109.00 to $229.00. My suggestion is to shop around. Here are a few places to start.

Figure 5

B&B Electronics
www.bb-elec.com/convert_serial_port/usb_chart_nonisolated.asp

Jameco
www.jameco.com/cgi-bin/ncommerce3/ProductDisplay?prmenbr=91&prrfnbr=4849&cgrfnbr=501&ctgys=

USBHardware
www.sellusb.com/usb-serial-adapter.html

Simple KVM Switch

Q. I am trying to make a cheap KVM switch. I have two computers and one monitor, and want to switch between the two with one button. It seems like the monitor switching can easily be done with the analog multiplexers, but I'm not sure how to deal with the data lines for USB. Also, do I just connect all of the grounds for both computers and the monitor together, or should I switch them too?

Shawn Jordan
via Internet

A. As the computer industry grew in the early 1980s, many server rooms and data centers were faced with the problem of having dozens and even hundreds of monitors, keyboards, and mice, taking up valuable rack space, and adding unnecessary heat issues. The KVM (Keyboard Video Mouse) switch was developed to solve the problem. These KVM switching products allow a single user to access multiple CPUs from a single monitor, keyboard, and mouse.

Both graphical environments and mice were not common in the early 1980s, so the first switches only supported keyboard and video switching, and were very basic A/B type push-button switches. In addition to improving server manageability, heat disbursement issues, and the space savings, there was a huge cost savings from not having to purchase a separate monitor, keyboard, and mouse for each CPU.

These type of KVM switches are still available, and sell for as little as $49.00. However, for monitor switching alone, it's possible to build your own KVM using a handful of relays, as shown in Figure 6. Notice that only two relays are shown (it simplifies the wiring on the drawing). When building the switcher, the coils of all relays in the related bank are wired in parallel and switched together. RF relays are preferred for optimum performance, and the coil voltage can be changed to any voltage that's convenient for you. Be sure to take care in dressing the wires to prevent crosstalk between the colors.

Shopping For A Tektronix

Q. TJ, didn't you once highly recommend some retired guy who refurbishes and sells Tektronix oscilloscopes? I've looked through all my back issues, and I cannot find it! Would you please tell me where to find him? It's about time I bought a decent scope, and the Model 454 looks pretty good: 150 MHz, dual trace, delayed sweep and, of course, Tektronix!

E. Nicholas Cupery
Senior Consultant
Farba Research

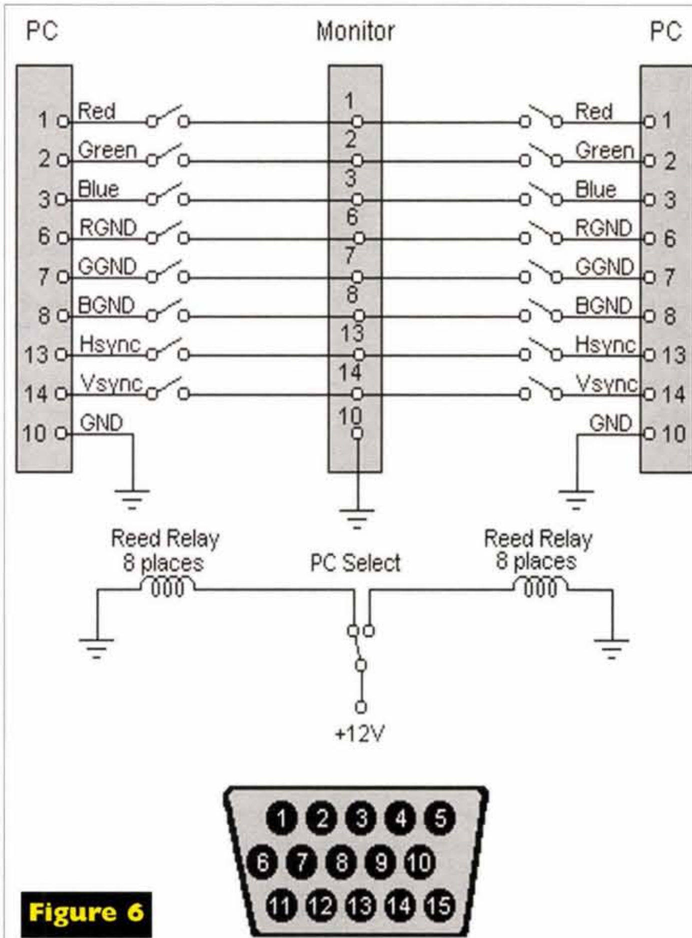


Figure 6

Cool Web Sites

Wonder what Supreme Court Justices do with their time? **True tongue-in-cheek rulings.**

http://forbes.com/fyi/2002/0513/088.html

Nodal Analysis of Op Amp Circuits — very serious stuff; not for the faint of heart.

http://a330.g.akamai.net/7/330/2540/5d687a213018af/www.e-insite.net/contents/pdf/A320orga.pdf

How do ADCs work? — slightly lighter than above nodal analysis.

www.e-insite.net/index.asp?layout=article&articleId=CA224083&title=Search+Results&publication=e%2Dinsite&webzine=e%2Dinsite&verticalID=156

Stealing USB-Port Power. How to power your next project from the USB port. The file is also posted on our web site under USB_Power.pdf.

http://a330.g.akamai.net/7/330/2540/41b8e6582fdc9a/www.e-insite.net/ednmag/contents/images/220400.pdf

A. I haven't heard from this guy in a while, so I don't know what the story is. However, I was able to track down a handful of sources that sell this gem of a scope for a reasonable price. This list will be added to the PartFind file located on our web site (**ftp://nutsvolts.com/partfind.txt**).

Tech-Systems Electronics, Inc.
http://shop.store.yahoo.com/techsystems

Valley Computer Technologies
http://home.earthlink.net/~vct/vctsale.htm

Tektronix Oscilloscopes & Other Stuff!
http://www.aactrinity.com/tektroni.htm — fixer-uppers, too

Gootee
www.fullnet.com/u/tomg/tek.htm

Toronto Surplus & Scientific Inc.
www.torontosurplus.com/test/scope.htm

MAILBAG

Dear TJ:

In the July issue, you responded to a reader named Hank (WD5JFR) who was looking for a 32.768 kHz ultrasonic microphone. You might want to inform him that a pair of transmitting and receiving transducers for 32.8 kHz can be purchased from **Marlin P. Jones & Assoc., Inc. (www.mpja.com),** for $5.49 per pair. The part number is 12940-UT, described on page 66 of their newest catalog #02-06.

Jerry L. Wilson, AC5ZJ
via Internet

Dear TJ:

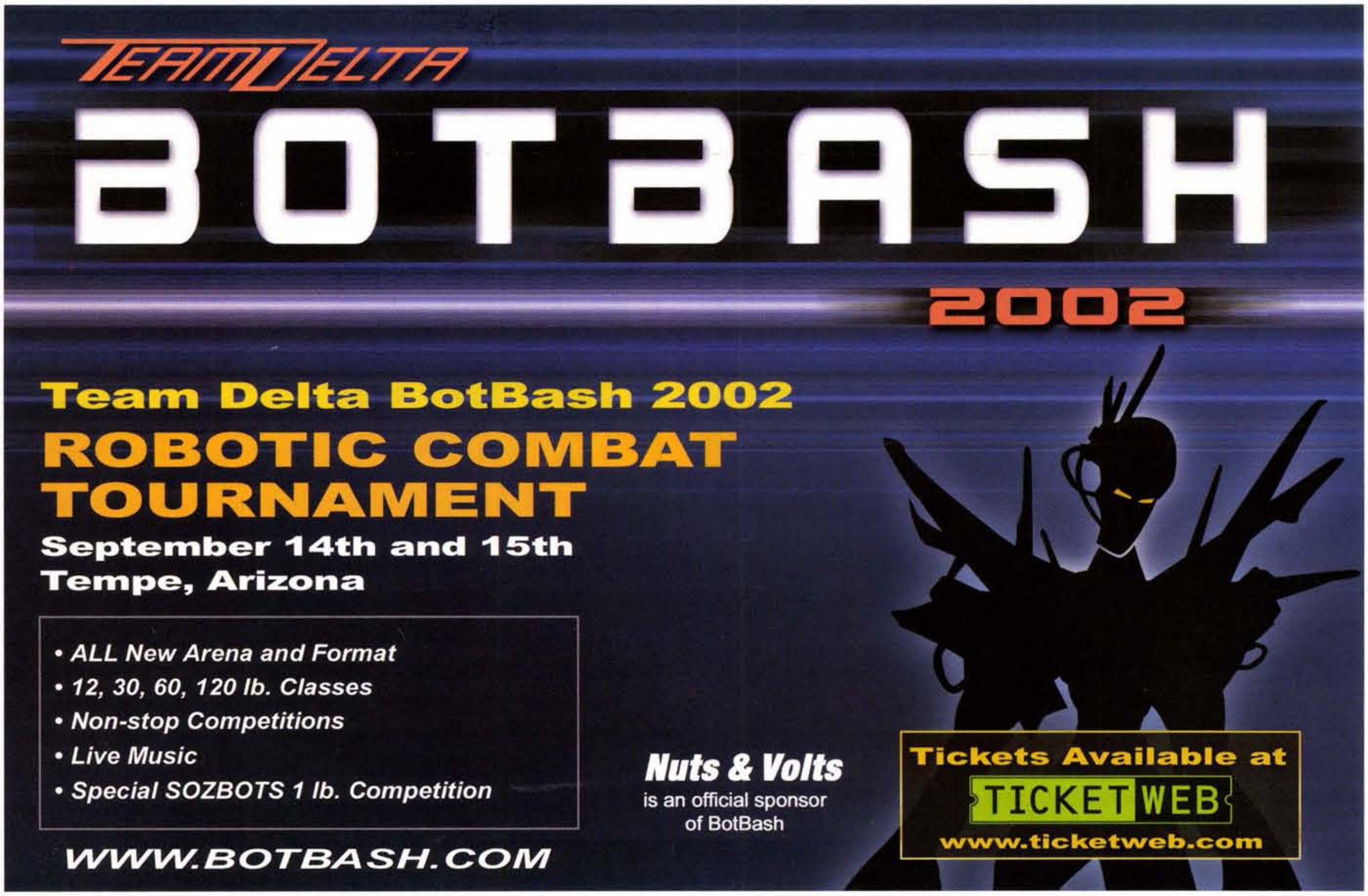
I have spent many an hour perusing the sources that you find and publish. However, the July column could use some clarification. In Figure 4, there is a symbol for an electret microphone that seems to be unique. I thought that a microphone would be symbolized differently. The schematic includes the necessary polarity and source load resistor. Then, in Figure 6, the same symbol is used to represent a raw piezo disc, also with polarity markings. Does this part indeed have polarity markings?

Phillip Milks
via Internet

Yes, all electret and most piezo devices are polarized.

TJ Byers
Q & A Editor

Check out the *NV Bookstore* on page 88. Our new expanded listing has something for just about everyone. If you don't find what you need here, check our website at **www.nutsvolts.com**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$5
RAM
1 MB 30 Pin 4 For $1
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1200 Marshall st
Shreveport, La 71101
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by Jon Williams

Stamp Applications

Digital Data Recording

Our project this month is a simple event recorder that will monitor up to eight inputs and record changes in the state of these inputs to an external EEPROM. We'll use a real-time clock for accurate timing and our design will scan the inputs every second.

My first job after military service was working for a large turf irrigation company. With a background in electronics, my focus was, of course, directed at irrigation controllers [sprinkler timers]. I got pretty good at fixing them and was quickly promoted to the testing group where I got to work with new designs. Working with new ones was much more fun that fixing the broken ones.

Keep in mind that a sprinkler controller is a real-time device designed to sequentially activate selected stations [outputs] at some predetermined time. In our lab, the standard piece of equipment used to verify this behavior was a paper strip chart recorder (this was 18 years ago). We'd program the controller to run a test sequence and start the strip-chart recorder, noting the time that the test was started. In the morning, we would verify the controller activity by reading the strip-chart markings.

Why am I dredging up what is — electronically —ancient history? Well, a recent posting on the BASIC Stamp mailing list caused me to remember my time in the test lab. A Stamp user was looking to build an event recorder using the BASIC Stamp. The post made me think about the good old days of paper strip-charts and the PC system we ultimately designed to replace them. I wondered what I could [simply] do with a stock BS2. As it turned out, the project is pretty neat.

Just Save The Changes

A big problem with the old strip chart-recorders is that they used paper to record activity and would happily spit out loads of paper — even if nothing was happening. If we equate paper to memory, this is really just a waste. A more efficient plan is simply to note the time when something changes.

And that's what we'll do here. Our project this month is a simple event recorder that will monitor up to eight inputs and record changes in the state of these inputs to an external EEPROM. We'll use a real-time clock for accurate timing and our design will scan the inputs every second.

Inside The "Box"

I envisioned this project as something that would be used remotely — a smart "black box." This being the case, the interface to the user is provided via the PC through the Stamp programming port. The heart of the circuit (Figure 1) is simply the Stamp and a couple of eight-pin dip components (the EEPROM and RTC). The circuit and battery can be easily packaged in a very small plastic or metal box.

I will leave input conditioning up to you. For my test, I used a simple N.O. switch circuit as shown in Figure 2. If you want to monitor high-voltage devices or AC, the switch could be replaced by the contacts of a relay. Or,

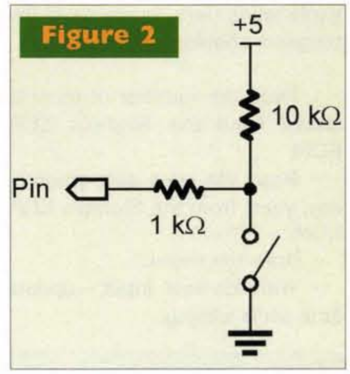


Figure 2

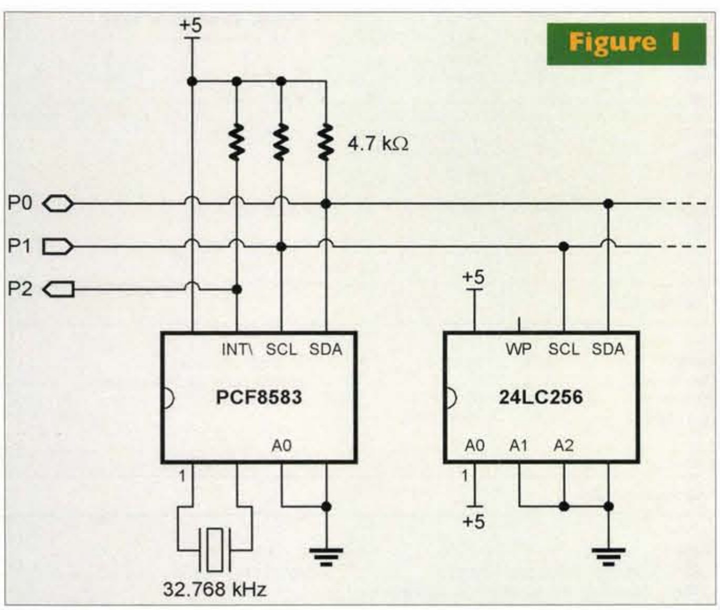


Figure 1

Figure 3

even better, you could use an optical isolator.

The hardware's pretty simple, isn't it? Well, the code really is too, albeit fairly long. As presented, the program uses up almost all of the Stamp's code space. Most of the program is fairly modular and we'll be taking advantage of some of the I2C code developed a couple of months ago — this time we'll put it to real use.

Before we get into the detailed explanation, let's review what the program should do:

- Read the number of records stored from the Stamp's EEPROM.
- Read the start date (month, day, year) from the Stamp's EEPROM.
- Draw the menu.
- Wait for user input —update time while waiting.
- Respond to the user input.

Response from the user can be:

- "T" : Enter new time (hours, minutes, seconds)
- "D" : Enter new start date (month, day, year)
- "R" : Start recording
- "V" : View stored records
- "C" : Clear records

The last part of our planning is the storage of an event. As discussed earlier, we will only store changes that are detected. Here's how the bytes in an event record are structured:

- 0 : Day (offset from start date)
- 1 : Hour
- 2 : Minutes
- 3 : Seconds
- 4 : Inputs

Let me just explain byte 0 a bit further. Instead of storing the event date in a record (which would take four bytes), we simply store an offset (number of days) from the start date of recording. This trims three bytes from the record, allowing more records to be stored. It also means that we don't have to send the date to or retrieve it from the PCF8583; the start date is simply recorded in the Stamp's memory for future reference. Let's get on with the code.

In the variables section, you'll notice a comment about not changing the order of a group of variables. In this program, we will take advantage of the Stamp's implicit array structure of variable memory. A group of variables of the same size can be accessed as an array by using the first of the group as the array name and applying an index. Here's the group I'm referring to:

dayOfs
hours
minutes
seconds
scan

In the code, we can access to the same group using these names:

dayOfs(0)
dayOfs(1) — same as hours
dayOfs(2) — same as minutes
dayOfs(3) — same as seconds
dayOfs(4) — same as scan

As you've certainly deduced by now, we'll use a loop counter to iterate through these variables.

Let's move on to the EEPROM section; another place with some-

Listing 1

```
'
' =========================================================================
'
'   File...... EventRecord.BS2
'   Purpose... Simple Event Recorder
'   Author.... Jon Williams
'   E-mail.... jwilliams@parallaxinc.com
'   Started... 26 JUN 2002
'   Updated... 28 JUN 2002
'
'   {$STAMP BS2}
'
'
' =========================================================================


' -------------------------------------------------------------------------
' Program Description
' -------------------------------------------------------------------------
'
' This program scans the upper eight inputs for changes and, when detected,
' records the new inputs with the day [offset] and time to an EEPROM
'
' Event Record Structure:
'  0 : days offset from start date
'  1 : hours
'  2 : minutes
'  3 : seconds
'  4 : input scan


' -------------------------------------------------------------------------
' Revision History
' -------------------------------------------------------------------------


' -------------------------------------------------------------------------
' I/O Definitions
' -------------------------------------------------------------------------

SDA             CON     0                       ' I2C serial data line
SCL             CON     1                       ' I2C serial clock line
IntPin          VAR     In2                     ' interrupt input pin from RTC
NewInputs       VAR     InH                     ' inputs on pins 8 - 15
TermIO          CON     16                      ' Terminal IO


' -------------------------------------------------------------------------
' Constants
' -------------------------------------------------------------------------

PCF8583         CON     %10100000               ' device code for RTC
EE24LC256       CON     %10100010               ' device code for EEPROM

ACK             CON     0                       ' acknowledge bit
NAK             CON     1                       ' no ack bit

RecSize         CON     5                       ' five bytes per event record
MemSize         CON     32768                   ' assuming 1 24LC256
MaxRecs         CON     MemSize / RecSize
ByteSize        CON     0                       ' byte-sized address (RTC)
WordSize        CON     1                       ' word-sized address (EEPROM)

Yes             CON     0
No              CON     1

TermBaud        CON     84                      ' 9600-8-N-1 (matches DEBUG)
CrsrXY          CON     2                       ' DEBUG Position Control
ClrRt           CON     11                      ' clear line to right


' -------------------------------------------------------------------------
' Variables
' -------------------------------------------------------------------------

device          VAR     Byte                    ' device to write/read
devAddr         VAR     Word                    ' address in device
addrSize        VAR     Bit                     ' (bytes in address) - 1
i2cReg          VAR     Byte                    ' register address
i2cData         VAR     Byte                    ' data to/from device
i2cWork         VAR     Byte                    ' work byte for TX routine
i2cAck          VAR     Bit                     ' ACK bit from device

records         VAR     Word                    ' events stored
recNum          VAR     Word                    ' counter for view display
oldInputs       VAR     Byte                    ' last event input data

' do not change order of next five variables
' -- program uses implicit array structure of user memory

daysOfs         VAR     Byte                    ' offset from start date
hours           VAR     Byte                    ' time of event
mins            VAR     Byte
secs            VAR     Byte
scan            VAR     Byte                    ' event data

month           VAR     recNum.LowByte          ' start date
day             VAR     recNum.HighByte
year            VAR     Word

response        VAR     Word                    ' user response
idx             VAR     Nib


' -------------------------------------------------------------------------
' EEPROM Data
' -------------------------------------------------------------------------

NumRecs         DATA    Word 0                  ' stored records
StartMonth      DATA    6                       ' start date of recording
StartDay        DATA    28
StartYear       DATA    Word 2002


' -------------------------------------------------------------------------
' Initialization
' -------------------------------------------------------------------------

Init:
  READ NumRecs, records.LowByte                 ' retrieve record count
  READ (NumREcs + 1), records.HighByte
```

thing a little different. Storing data in the Stamp's EEPROM is easy and we do it quite frequently. I want to point out a little-used modifier of the **DATA** statement: Word. This lets us store a word-sized variable as easily as putting it into a variable. The compiler will store the variable as two bytes, using the "Little Endian" approach (low byte first). Keep in mind that this modifier only works with **DATA** and not with **WRITE** or **READ**. For **WRITE** and **READ**, we still must deal with bytes.

The initialization section is straightforward, simply reading the number of records stored and the start date from the Stamp's EEPROM. A short **PAUSE** is inserted to allow the **DEBUG** window to open before we get to draw the menu.

Drawing the menu is easy and since we're using the **DEBUG** window, we'll take advantage of the cursor positioning command and later, the ability to clear a line from the cursor position to the right. These commands only work with the **DEBUG** window, so if you decide to change the program to work with a standard terminal, you'll need to write your own positioning and "clean up" code.

After the menu is displayed, we grab the current time from the PCF8583 — so let's go there. Jump down the routine called Get_Clock. This routine uses the low-level I2C code to access the seconds, minutes, and hours data from the PCF8583. When retrieving consecutive bytes from the PCF8583 (and other memory-type devices), we must first set the starting address with a write command. Once the address is set, we can perform sequential reads from that address. The PCF8583 will automatically increment its address pointer so we can do subsequent reads without having to send the next address.

Since the PCF8583 uses BCD for the time registers, we will convert to decimal with a bit of code that takes advantage of the HighNib and LowNib variable modifiers. This really isn't necessary for the program, but as most of us are more comfortable dealing with decimal numbers, it make sense to do it.

With the time in hand, we'll put it in the display along with the current start date and wait for the user to press a key. If no key is pressed within 900 milliseconds, the **SERIN** line times out and goes back to the Show_Time_Date code. What this does is create a "live" display, showing us the current time in the PCF8583.

When a key is pressed, it is decoded with a **LOOKDOWN** table. This will convert the response from a character to a value between zero and nine — if the key is valid. If the key isn't valid, the **LOOKDOWN** table will have no effect. Next, we divide by two, giving us a possible [legal] value between zero and four that will be used by **BRANCH** for our menu routines. If the key was legal, **BRANCH** will work. If not, the **BRANCH** statement will fall through and the code will restart at Main.

Resources:

Jon Williams
jwilliams@parallaxinc.com
Parallax
www.parallaxinc.com

```
  READ StartMonth, month                    ' retrieve start date
  READ StartDay, day
  READ StartYear, year.LowByte
  READ (StartYear + 1), year.HighByte

  PAUSE 250                                 ' let DEBUG window open


' ---------------------------------------------------------------------------
' Program Code
' ---------------------------------------------------------------------------

Main:
  DEBUG CLS                                 ' display menu
  DEBUG "==============================", CR
  DEBUG " BASIC Stamp Event Recorder ", CR
  DEBUG "==============================", CR

  DEBUG CrsrXY, 0, 6

  DEBUG "[T] Set Current Time", CR
  DEBUG "[D] Set Start Date", CR
  DEBUG "[R] Start Recording", CR
  DEBUG "[V] View (", DEC records, ") Records", CR
  DEBUG "[C] Clear Records", CR

  DEBUG CrsrXY, 0, 12, "--> ", ClrRt

Show_Time_Date:                             ' show current time & date
  GOSUB Get_Clock
  DEBUG CrsrXY, 4, 4
  GOSUB Display_Time
  DEBUG "  "
  GOSUB Display_Date

Get_User_Input:                             ' wait for response
  DEBUG CrsrXY, 4, 12
  SERIN TermIO, TermBaud, 900, Show_Time_Date, [response]
  LOOKDOWN response, ["tTdDrRvVcC"], response
  response = response / 2
  BRANCH response, [Set_Time, Set_Date, Go_Record, View_Recs, Clear_Recs]
  GOTO Main


' ---------------------------------------------------------------------------
' Menu Routines
' ---------------------------------------------------------------------------

' --- Time ---

Set_Time:
  DEBUG CLS, "Set Current Time"

Enter_Hours:
  DEBUG CrsrXY, 0, 2, "Enter Hours (0..23)..... ", ClrRt
  SERIN TermIO, TermBaud, [DEC2 hours]
  IF (hours > 23) THEN Enter_Hours

Enter_Minutes:
  DEBUG CrsrXY, 0, 3, "Enter Minutes (0..59)... ", ClrRt
  SERIN TermIO, TermBaud, [DEC2 mins]
  IF (mins > 59) THEN Enter_Minutes

Enter_Seconds:
  DEBUG CrsrXY, 0, 4, "Enter Seconds (0..59)... ", ClrRt
  SERIN TermIO, TermBaud, [DEC2 secs]
  IF (secs > 59) THEN Enter_Seconds

  GOSUB Put_Clock                           ' send new time to PCF8583
  GOTO Main


' --- Date ---

Set_Date:
  DEBUG CLS, "Set Start Date"

Enter_Month:
  DEBUG CrsrXY, 0, 2, "Enter Month (1..12)... ", ClrRt
  SERIN TermIO, TermBaud, [DEC2 month]
  IF (month < 1) OR (month > 12) THEN Enter_Month

Enter_Day:
  DEBUG CrsrXY, 0, 3, "Enter Day (1..31)..... ", ClrRt
  SERIN TermIO, TermBaud, [DEC2 day]
  IF (day < 1) OR (day > 31) THEN Enter_Day

Enter_Year:
  DEBUG CrsrXY, 0, 4, "Enter Year (2002+).... ", ClrRt
  SERIN TermIO, TermBaud, [DEC4 year]
  IF (year < 2002) THEN Enter_Year

  WRITE StartMonth, month                   ' save start date in EEPROM
  WRITE StartDay, day
  WRITE StartYear, year.LowByte
  WRITE (StartYear + 1), year.HighByte
  GOTO Main


' --- Record ---

Go_Record:
  DEBUG CLS, "Recording... ", CR, CR

  daysOfs = 0                               ' start today
  oldInputs = ~NewInputs                    ' force record on start

Wait_For_Int:
  IF (IntPin = No) THEN Wait_For_Int        ' wait for new second
  GOSUB Get_Clock                           ' get current time
  IF (hours <> 0) OR (secs <> 0) THEN Check_Inputs
  daysOfs = daysOfs + 1                     ' increment day counter
  IF (daysOfs = 0) THEN Stop_Recording      ' if > 255 stop

Check_Inputs:
  scan = %11111111
  FOR idx = 1 TO 5                          ' debounce inputs
    scan = scan & NewInputs
    PAUSE 5
  NEXT
```

The next section deals with code to handle each of the menu commands. The first two routines are identical, so we'll just discuss the first: Set_Time.

When we want to enter a new time, the screen is cleared and we're asked to enter the hours. To keep things simple (for the Stamp), we'll use the 24-hour format. The DEC2 modifier is used with **SERIN** to limit the number of characters accepted. If the value entered is out of range, we clear the entry and try again. The same technique is used to get the minutes and seconds.

Once a valid time has been entered, it is sent to the PCF8583 with the Put_Clock subroutine. This routine works very much like Get_Clock; just going the other direction (data to PCF8583).

The heart of the program is, of course, recording data. When this option is selected, we'll clear the days offset counter, then collect the current inputs and invert them. The reason for this is that we want to force the recording code to create an entry at the beginning. This way we have stored the starting time and initial state of the inputs.

Let me get away from code for a bit and tell you about the Interrupt\ output of the PCF8583. This output is used to indicate alarms from the device (by being pulled low). By default, it outputs a 1-Hz squarewave. This is perfect for us to trigger our new scan cycle. Each time this output goes low, we know it's a new second. Monitoring the Interrupt\ line is more efficient than continously reading the time and looking for a change.

The code will loop at Wait_For_Int until Stamp pin 2 is pulled low. When this happens, we grab the current time from the PCF8583. At first, this may not seem necessary if there was no new event. We have to do it though since we're keeping track of the days ourselves. So, if the current hours is zero (midnight) and the current seconds value is also zero, we've just hit a new day and we increment the daysOfs variable. If not, we simply skip ahead and look at the inputs.

Since inputs can be "noisy," the code at Check_Inputs will debounce them. We've used this code before; it simply loops a few times and makes sure that an input doesn't change (bounce) during the loop. Any non-changing input is passed through the loop as a good input.

If there has been a change in the inputs, we'll save the change and record the event to our 24LC256 with the Put_Record subroutine. Let's go there.

The Put_Record subroutine updates the record count and checks to make sure we still have room in the 24LC256 for data. If not, the program stops, otherwise we'll save the current scan time and inputs. The current record number is stored in the Stamp's EEPROM so we can retrieve it after a power loss or reset. The next step is to set up for the Put_Byte subroutine by selecting our device type and the address size.

The Put_Byte routine is a general-purpose update from older code that lets us use it for either the 24LC256 or the PCF8583 (if we want to set something other than the time). The update includes passing the device as a variable and a flag for the number of bytes in the internal address.

Listing 2

```
  IF (scan = oldInputs) THEN Wait_For_No_Int          ' if same, skip
  oldInputs = scan                                    ' save current scan
  GOSUB Put_Record                                    ' save record in 24LC256

  DEBUG DEC3 daysOfs, " "                             ' display record
  GOSUB Display_Time
  DEBUG " -> ", BIN8 scan, CR

Wait_For_No_Int:
  IF (IntPin = Yes) THEN Wait_For_No_Int              ' wait for high on int pin
  GOTO Wait_For_Int


' --- View ---

View_Recs:
  IF (records = 0) THEN Main                          ' oops...
  DEBUG CLS
  DEBUG "Records", CR                                 ' print header
  DEBUG "Start Date: "
  GOSUB Display_Date
  DEBUG CR, CR

  DEBUG "Day  Time       Inputs  ", CR
  DEBUG "---  --------   --------", CR

  FOR recNum = 0 TO (records - 1)                     ' print records
    GOSUB Get_Record
    DEBUG DEC3 daysOfs, "  "
    GOSUB Display_Time
    DEBUG "  ", BIN8 scan, CR
  NEXT

  DEBUG CR, "Press a key..."                          ' user escape
  SERIN TermIO, TermBaud, [response]
  GOTO Main


' --- Clear ---

Clear_Recs:
  records = 0                                         ' clear variable
  WRITE NumRecs, 0                                    ' clear EEPROM
  WRITE (NumRecs + 1), 0
  GOTO Main


' ----------------------------------------------------------------------------
' Subroutines
' ----------------------------------------------------------------------------

Display_Time:
  DEBUG DEC2 hours, ":", DEC2 mins, ":", DEC2 secs
  RETURN


Display_Date:
  DEBUG DEC2 month, "/", DEC2 day, "/", DEC4 year
  RETURN

Put_Record:
  records = records + 1                               ' update record count
  IF (records > MaxRecs) THEN Stop_Recording          ' check limit
  WRITE NumRecs, records.LowByte                      ' store count in local
EEPROM
  WRITE (NumRecs + 1), records.HighByte

  device = EE24LC256                                  ' setup for Write_Byte
  addrSize = WordSize

  FOR idx = 0 TO (RecSize - 1)
    i2cData = daysOfs(idx)                            ' byte to store
    devAddr = ((records - 1) * RecSize) + idx         ' caculate address in EE
    GOSUB Write_Byte                                  ' write it
  NEXT
  RETURN


Get_Record:
  device = EE24LC256                                  ' setup for Read_Byte
  addrSize = WordSize

  FOR idx = 0 TO (RecSize - 1)
    devAddr = (recNum * RecSize) + idx                ' calculate address in EE
    GOSUB Read_Byte                                   ' go get it
    daysOfs(idx) = i2cData                            ' place in user variable
  NEXT
  RETURN


Stop_Recording:
  END


' ----------------------------------------------------------------------------
' High Level I2C Subroutines
' ----------------------------------------------------------------------------

' Byte to be written is passed in i2cData
' -- address passed in devAddr

Write_Byte:
  GOSUB I2C_Start                                     ' send Start
  i2cWork = (device & %11111110)                      ' send write command
  GOSUB I2C_TX_Byte
  IF (i2cAck = NAK) THEN Write_Byte                   ' wait until [ee] not busy
  IF (addrSize = ByteSize) THEN Wr_Low_Addr
  i2cWork = devAddr / 256                             ' send address high byte
  GOSUB I2C_TX_Byte

Wr_Low_Addr:
  i2cWork = devAddr // 256                            ' send address low byte
  GOSUB I2C_TX_Byte
  i2cWork = i2cData                                   ' send data
  GOSUB I2C_TX_Byte
  GOSUB I2C_Stop
  RETURN


' Byte read is returned in i2cData
' -- address passed in devAddr
```

```
Read_Byte:
  GOSUB I2C_Start                                ' send Start
  i2cWork = (device & %11111110)                 ' send write command
  GOSUB I2C_TX_Byte
  IF (i2cAck = NAK) THEN Read_Byte               ' wait until [ee] not busy
  IF (addrSize = ByteSize) THEN Rd_Low_Addr
  i2cWork = devAddr / 256                        ' send address high byte
  GOSUB I2C_TX_Byte

Rd_Low_Addr:
  i2cWork = devAddr // 256                       ' send address low byte
  GOSUB I2C_TX_Byte
  GOSUB I2C_Start
  i2cWork = (device | 1)                         ' send read command
  GOSUB I2C_TX_Byte
  GOSUB I2C_RX_Byte_Nak
  GOSUB I2C_Stop
  i2cData = i2cWork
  RETURN


' Write seconds, minutes and hours .. sequntial mode
' -- variables are converted to BCD before sending to PCF8583

Put_Clock:
  GOSUB I2C_Start
  i2cWork = PCF8583                              ' send device address
  GOSUB I2C_TX_Byte
  i2cWork = 2                                    ' start with seconds reg
  GOSUB I2C_TX_Byte
  i2cWork = ((secs / 10) << 4) | (secs // 10)
  GOSUB I2C_TX_Byte
  i2cWork = ((mins / 10) << 4) | (mins // 10)
  GOSUB I2C_TX_Byte
  i2cWork = ((hours / 10) << 4) | (hours // 10)
  GOSUB I2C_TX_Byte
  GOSUB I2C_Stop
  RETURN


' Read seconds, minutes and hours .. sequntial mode
' -- variables are converted from BCD storage format

Get_Clock:
  GOSUB I2C_Start
  i2cWork = PCF8583                              ' send device address
  GOSUB I2C_TX_Byte
  i2cWork = 2                                    ' send seconds reg #
  GOSUB I2C_TX_Byte
  GOSUB I2C_Start                                ' restart
  i2cWork = (PCF8583 | 1)                        ' send read command
  GOSUB I2C_TX_Byte
  GOSUB I2C_RX_Byte                              ' read back seconds
  secs = i2cWork.HighNib * 10 + i2cWork.LowNib
  GOSUB I2C_RX_Byte
  mins = i2cWork.HighNib * 10 + i2cWork.LowNib
  GOSUB I2C_RX_Byte_Nak                          ' final byte - send NAK
  hours = i2cWork.HighNib * 10 + i2cWork.LowNib
  GOSUB I2C_Stop
  RETURN


' ---------------------------------------------------------------------------
-
' Low Level I2C Subroutines
' ---------------------------------------------------------------------------
-

' --- Start ---

I2C_Start:                                       ' I2C start bit sequence
  INPUT SDA
  INPUT SCL
  LOW SDA                                        ' SDA -> low while SCL high

Clock_Hold:
  IF (Ins.LowBit(SCL) = 0) THEN Clock_Hold       ' device ready?
  RETURN


' --- Transmit ---

I2C_TX_Byte:
  SHIFTOUT SDA,SCL,MSBFIRST,[i2cWork\8]          ' send byte to device
  SHIFTIN SDA,SCL,MSBPRE,[i2cAck\1]              ' get acknowledge bit
  RETURN


' --- Receive ---

I2C_RX_Byte_Nak:
  i2cAck = NAK                                   ' no ACK = high
  GOTO I2C_RX

I2C_RX_Byte:
  i2cAck = ACK                                   ' ACK = low

I2C_RX:
  SHIFTIN SDA,SCL,MSBPRE,[i2cWork\8]             ' get byte from device
  SHIFTOUT SDA,SCL,LSBFIRST,[i2cAck\1]           ' send ack or nak
  RETURN


' --- Stop ---

I2C_Stop:                                        ' I2C stop bit sequence
  LOW SDA
  INPUT SCL
  INPUT SDA                                      ' SDA --> high while SCL
high
  RETURN
```

The device code is actually supposed to be the write code for the device, but the program masks out the lower bit (read bit), just in case of an error.

After getting an ACK from the device (it's ready), we'll check the address size. For the 24LC256, we'll send two bytes (high byte first); for the PCF8583, we would only send one byte. After that, it's a simple matter of sending the data byte and generating a stop.

This code, as well as Get_Byte, are good copy-and-paste code chunks for programs that use I2C devices.

Back to Put_Record. A loop is used to iterate through the bytes in our event record. Now we can fully understand the earlier discussion of keeping the event variables in specific order in our definition section. It's not enough that they're defined, they have to be defined consecutively so that this loop code will send the correct information to the 24LC256. The 24LC256 address for a given byte in the record is calculated and finally stored with Put_Byte.

With the record stored, we'll display the change on screen and then check to the state of "interrupt" pin. As I told you earlier, what we'll see on the input of pin 2 is a 1-Hz squarewave generated by the PCF8583. If the storage and display of our record takes less than 500 milliseconds (I measured it at about 290 milliseconds with a BS2), then pin 2 will still be low when we're done. What we don't want to do, then, is go back to Wait_For_Interrupt — because we'll just do things again unnecessarily. So, we'll just wait for this pin to go back high, then we'll jump to Wait_For_Interrupt.

To stop recording, we'll reset the Stamp or cycle the power. Back to the menu, we should see the correct number of stored records indicated. Pressing "V" will display them on screen. The code at View_Recs is responsible for the display. It uses a loop and Get_Record to retrieve the data from the 24LC256.

Finally, we will want to clear our records for a new cycle. This is a simple matter of clearing the variable and writing zeros to the EEPROM locations that hold our record count. There's no need to actually erase the 24LC256 — this would simply be a waste of its available write cycles.

Improvements

What you'll notice is that there isn't a whole lot of code space left for improvements — mostly because of all the **DEBUG** statements used to create our interactive display. We're going to solve that next time by using an external control program with Visual Basic. Until then, Happy Stamping! **NV**

New Product News

DIGITAL CLAMP METER MODEL ST1010

Elenco Electronics announces the introduction of a new Digital Clamp Meter that is rugged and ready to take on the tough jobs.

The new Model ST1010 has many new features and meets the rigid CE and CS standards, for safe use of current clamp meters.

The ST1010 is a 3-1/2 digit (2,000 count) LCD clamp instrument with the following features: AC current to 1,000 amp; AC voltage to 600 VAC; DC voltage to 1,000 DC; Resistance to 2M ohm; Frequency to 2KHz; Diode check; Continuity check (audible); and Data hold.

It comes in a soft zippered carrying case with a drop proof waist strap. Insulation testing is available (optional).

The ST1010 is an economical meter with a broad range of features and capabilities. The price is the lowest it has ever been and is affordable to every technician or student at $49.95 each. It is available for immediate delivery.

For additional information, contact:

ELENCO ELECTRONICS, INC.,
150 W. Carpenter Ave., Dept. NV
Wheeling, IL 60090
847-541-3800 Fax: **847-520-0085**
Web: **www.elenco.com/press/st1010.pdf**

NEW TECHNICAL VIDEO TEACHES THE FUNDAMENTALS OF OSCILLOSCOPE OPERATION

SYSPEC announces a new technical video training tape designed to acquaint hobbyists and technicians with the fundamentals of using an oscilloscope.

The VHS videotape is designed to take the mystery out of using the instrument to make basic signal measurements. It assumes no prior oscilloscope knowledge and begins with a detailed presentation about scope controls, as well as interpreting displayed waveforms.

The training video provides details on how to set up the various controls for making voltage and period measurements for a wide range of signals including sine, square, and sawtooth waveforms. Duty-cycle and pulse-width measurements are also discussed. Practical examples of common measurements are provided, including how to measure the pulse width of a fuel injector.

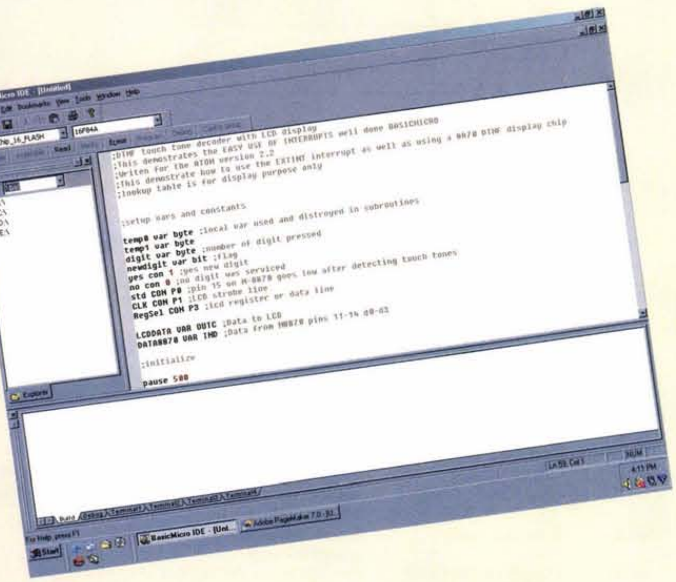
The training video also includes a free oscilloscope technical training manual. The manual offers many examples of waveforms measurements and includes a number of exercises designed to increase the proficiency of the reader. A section on oscilloscope setup helps the user choose the proper time base, vertical sensitivity, and trigger mode based upon the type of signal being measured.

The videotape is introductory-priced at $24.95 + $5.00 shipping and handling (continental US).

For more information, contact:

SYSPEC, INC.
P.O. Box 2546, Dept. NV
Syracuse, NY 13220
1-877-SYSPEC1
Web: **www.syspec.com**

MBASIC VERSION 5.2



Basic Micro introduces the newest version of the MBasic Compiler. MBasic Version 5.2 offers: 32-Bit math; 32-Bit Floating Point; Dallas One Wire Support; If..Then..Else..Elseif..Endif; Hardware PWM; Expanded LCD command; Read and Write Memory with Basic command; Basic Interrupts; Hardware Timers; Hardware Serial UART Hserin/Hserout; In Circuit Debugger now has more features; New Oscilloscope Software built in; Free Boot Loader Builder Included; and Free Boot Loader Interface Included.

The ability to debug code in Basic without knowledge of Assembly makes this compiler one of the most versatile programming software packages available. With the added ability of being able to customize menu options, built-in task reporting, and multiple document support.

MBasic Pro Version has more commands such as LCD, I2C, POT, PEEK, POKE, SPI, DO, WHILE, SWAP, SERVO, SPMOTOR.

The compiler is ideal for the hobbyist, students, and professionals. With many applications you can control robotics, CNC, LCD, keypads, and more!

Starting at just $99.95 for the MBasic Standard Compiler, with the ability to upgrade to MBasic Pro at any time.

For more information, contact:

BASIC MICRO, INC.
2882 Orchard Lake Road, Dept. NV
Farmington Hills, MI 48336
248-427-0040 Fax: **248-427-0051**
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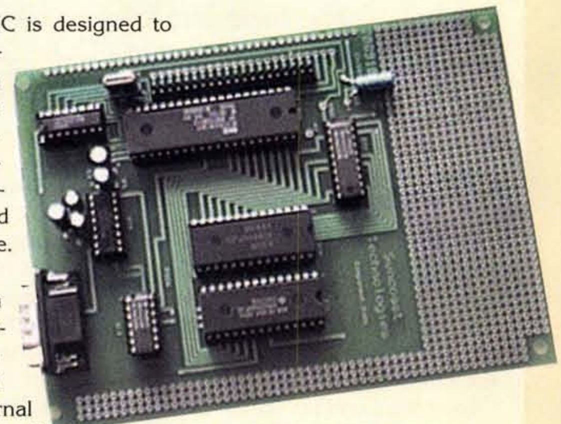
INEXPENSIVE 8052BASIC DEVELOPMENT SBC FOR HOBBYIST AND INDUSTRY



The 70691BASIC is designed to allow hobbyists and engineers alike to create highly sophisticated computer programs using easy-to-understand BASIC-52 language.

Created by Intel, BASIC-52 is a high-level programming language that is stored as part of the internal Read Only Memory of the 80C52 microcontroller. By incorporating this "smart chip," the programming of the 70691BASIC is an easy matter.

BASIC-52 programs can be saved in either of two ways. Download programs in ASCII format from 70691BASIC memory for subsequent saving on a hard drive or floppy disk. Or you can save the program on the supplied 2864 EEPROM (using accompanying BASIC-52 Utility Program).

Interfacing and circuit expansion is also an easy matter for the 70691BASIC. Just like all of our SBCs; the '91BASIC contains a 40-pin header connector that picks up all major 80C52 terminals (ex. Port 1, Port 3, Hi-Order Address Line, etc.), thus allowing these points to be brought to your prototype board using an inexpensive ribbon cable (available from Digi-Key Corporation).

The best feature of the 70691BASIC is to allow fast, easy program development.

With your program working just the way you want, BASIC-52 can now be transformed into SUPER FAST .ASM code by converting it with the Binary Technologies BCX-51 Compiler. When converted, this new program can then be placed into the EPROM chip of our 70691RAM board. Both 70691RAM and the 70691BASIC are 100% compatible with compiled BASIC-52 programs.

For more information, contact:

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The ComPort Tester

By Jon J. Varteresian

You have just finished building that new Gizmo of yours, plugged it into the ComPort on your PC, and POOF! Smoke starts billowing from the Gizmo! If only there was a way to test that ComPort to make sure it was still fully operational ...

Introduction

Consider this ... You have just finished building that new Gizmo of yours, plugged it into the ComPort on your PC, and POOF! Smoke starts billowing from the Gizmo! You frantically unplug everything in a 20-foot radius, but then what? How do you know the ComPort on your PC has survived the 'incident?' If only there was a way to test that ComPort to make sure it was still fully operational ... But wait! There is!

Enter the ComPort Tester. The PC ComPort Tester will fully test all of your external PC ComPorts giving you detailed feedback and port status. Attach the loopback connector described here, and with just one mouse click, you can exercise your ComPort through all its supported baud rates, as well as all the flow control signals. You can also attach the loopback connector to the end of a cable and test the cable, as well! Test results are reported in a status window for immediate feedback. You can also print and save the test results. The loopback connector is easily built from spare parts hanging around your lab and the software is free! Before we get into the details of testing a ComPort, a brief review of the PC ComPort is in order.

The ComPort

Just what exactly is a communications port, or ComPort? Ever since the dawn of the personal computer, people have wanted their PC to interact with their surrounding environment. They wanted to control equipment, monitor various things, or even just play a game with somebody on another computer. Enter the ComPort, or serial communications port. The term serial communications is just a fancy way of describing how the data is actually transferred across the wires. All information inside a computer is made up of 'words' that contain 8, 16, or 32, or more bits. A bit is just a single piece of information. When these words are transferred across a serial port, they must be transferred one bit at a time since there is only one transmit wire. That is where the term serial comes from. Data transferred across the PC ComPort takes the form of eight-bit words.

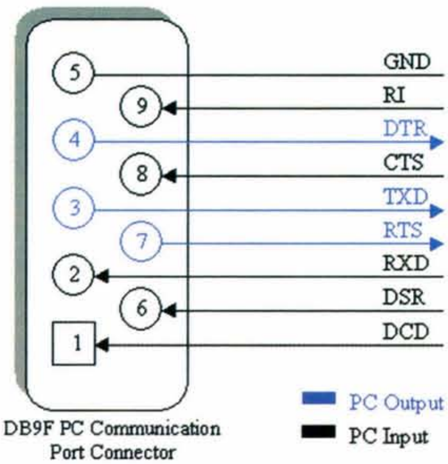

Figure 1

DB9F PC Communication Port Connector

Symbol	Name	Description
TXD	Transmit Data	Serial Data Output from PC, or terminal.
RXD	Receive Data	Serial Data Input to PC, or terminal.
CTS	Clear to Send	Asserts when the DCE is ready for (more) data.
DCD	Data Carrier Detect	Asserts when the DCE detects a "Carrier," or connect signal.
DSR	Data Set Ready	Asserts when the DCE is ready to begin a communication.
DTR	Data Terminal Ready	Asserts when the DTE is ready to begin a communication.
RTS	Request To Send	Asserts when the DTE is ready for (more) data from the DCE.
RI	Ring Indicator	Asserts when the DCE detects a ring.

Hardware Properties

Devices that use ComPorts for their communications are split into two categories. They are DCE (Data Communications Equipment) and DTE (Data Terminal Equipment). Data Communications Equipment are devices such as your modem, plotter, etc., while Data Terminal Equipment are your computer or terminal. The job of the data terminal is to create and/or process all serial communications, and the job of the data communications equipment is to pass that data to and from the data terminal.

The electrical specifications of the ComPort are contained in the EIA (Electronics Industry Association) RS232-C standard. It states many parameters such as:

- A "Space" (logic 0) will be between +3 and +25 volts.
- A "Mark" (logic 1) will be between -3 and -25 volts.
- The region between +3 and -3 volts is undefined.
- An open circuit voltage should never exceed 25 volts. (In reference to GND.)
- A short circuit current should not exceed 500mA. The driver should be able to handle this without damage. (Take note of this one!)
- Maximum baud rate (bit transfer rate) of 20,000 bits per second.

The items listed above are just some of the more important specifications found in the EIA RS232-C standard. Most users never need to

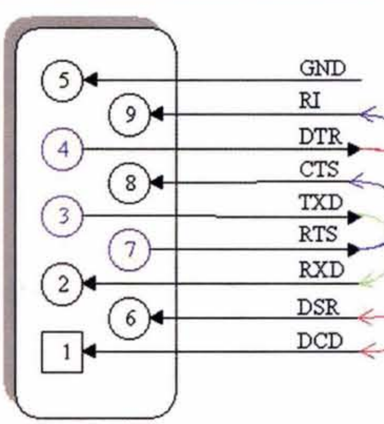

Figure 3

DB9F PC Communication LoopBack Connector know more than this, but if you do, you have to go look it up.

ComPorts come in two "sizes:" The D-Type 25-pin connector and the D-Type nine-pin connector, both of which are male on the back of the PC (they have pins instead of sockets), thus you will require a female connector on your device. The D-type 25-pin connector is hard to find and slowly disappearing from today's PC. Mostly, you will see the D-type nine-pin connector. The pinout for this connector is shown in Figure 1. This is what you will see when you look directly at the ComPort connector on your PC. Most D-type nine-pin connectors have the pin numbers molded into the plastic of the connector itself. If you look closely, you should see them.

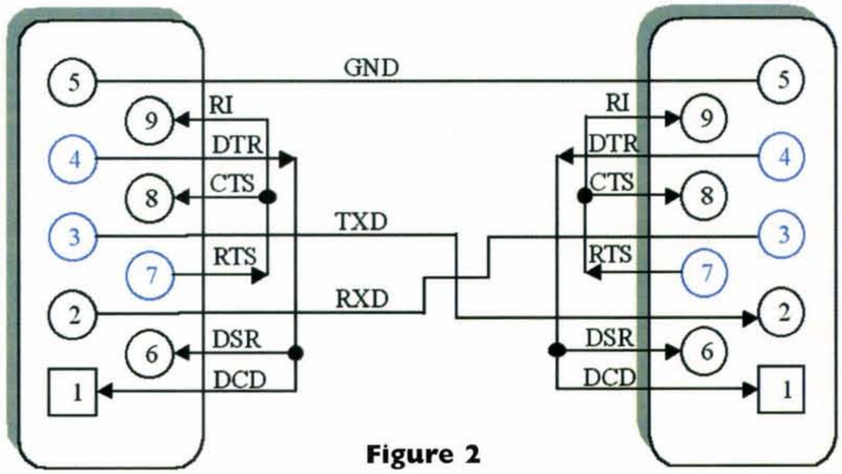

Figure 2

DB9F PC Communication Port Connector - DTE

DB9F PC Communication Port Connector - DTE

The Null Modem

A null modem (see Figure 2) is used to connect two DTEs or PCs together. This is commonly used as a cheap way to network games or to transfer files between computers using some protocol such as Zmodem or Xmodem.

The idea behind a null modem connection is to make a DTE or PC think it is talking to a modem or DCE, rather than another DTE, or PC. Any data transmitted from the first computer must be received by the second, thus TXD is connected to RXD. The second computer must have the same set-up, thus RXD is connected to TXD. Signal Ground (SG) must also be connected so both grounds are common to each computer.

The Data Terminal Ready is looped back to Data Set Ready and Carrier Detect on both computers. When the Data Terminal Ready is asserted active, then the Data Set Ready and Carrier Detect immediately become active. At this point, the computer thinks the virtual modem to which it is connected is ready and has detected the carrier signal.

All that is left to worry about now is the Request To Send and Clear To Send. As both PCs communicate at the same speed, flow control is not needed, thus these two lines are connected together on each computer. When the computer wishes to send data, it asserts the Request to Send high and as it's hooked together with the Clear to Send, it immediately gets a reply that it is okay to send and does so.

DTE/DCE Speeds

As stated before, a typical DTE is a computer and a typical DCE is a modem. Often people will talk about DTE-to-DCE and DCE-to-DCE speeds. DTE-to-DCE is the speed between your modem and computer, sometimes referred to as your terminal speed. This should run at the same or faster speed than the DCE-to-DCE speed. DCE-to-DCE is the link between modems, sometimes called the line speed. A DTE-to-DCE speed faster than DCE-to-DCE insures that all data that arrives at the DCE is processed by the DTE so no data is lost.

For a 28.8K or 33.6K modem, we should expect the DCE-to-DCE speed to be either 28.8K or 33.6K. Considering the high speed of the modem, we should expect the DTE-to-DCE speed to be about 115,200 BPS. (Maximum Speed of the 16550a UART.)

Modern modems should have data compression built into them. When set up correctly, you can expect compression ratios of 1:4 or even higher; 1:4 compression would be typical of a text file. If we were transferring that text file at 28.8K (DCE-DCE), then when the modem compresses it, you are actually transferring 115.2 KBPS between computers and thus have an effective DCE-DTE speed of 115.2 KBPS.

Some modem manufacturers quote a maximum compression ratio as 1:8. For example, a 33.6 KBPS modem may get a maximum of 268,800 BPS transfer between modem and PC.

Flow Control

Eventually the data transfer rate between our DTE-to-DCE is going to be faster than our DCE-to-DCE transfer rate. When this happens, data will probably get lost. You can't put jellybeans into a container faster than you are eating them. Sooner or later the jar will overflow making quite the mess, and probably getting you in trouble. In order to prevent this from happening, you have to have a way for the DCE to tell the DTE that it has too much data and it should stop sending it, and vice versa. Enter flow control.

Flow control comes in two flavors: hardware and software.

Software flow control, sometimes expressed as Xon/Xoff, uses two characters Xon and Xoff. The ASCII 17 character normally represents Xon, and the ASCII 19 character normally represents Xoff. In reality, a DCE will only have a small buffer (16 to 64 bytes is common), so when the DTE fills it up, the DCE sends an Xoff character to tell the DTE to stop sending data. Once the DCE has room for more data, it then sends an Xon character and the DTE sends more data. This type of flow control has the advantage that it doesn't require any more wires as the characters are sent via the TXD/RXD lines. However, it can substantially slow down communications on low baud rate links due to the extra traffic of the Xon/Xoff bytes. Flow control here is not automatic. The PC must monitor the incoming serial data from the DCE and adjust the output flow as needed. If the PC is momentarily busy and doesn't have time to mon-

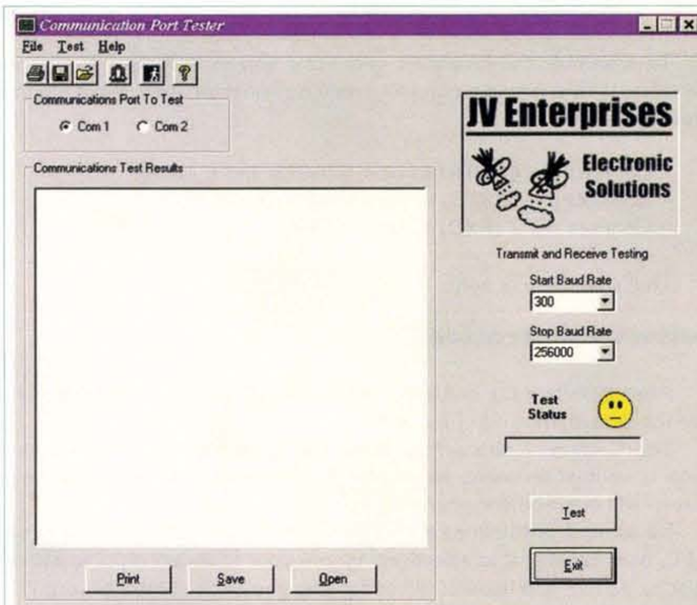

Figure 4

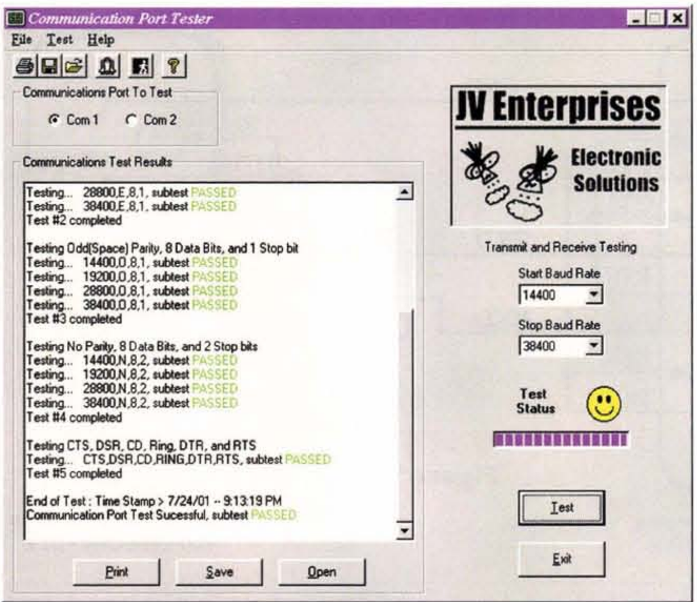

Figure 5

itor the incoming serial data from the DCE, it may send more data than the DCE can handle before shutting off the flow.

Hardware flow control is also known as RTS/CTS flow control. It uses two wires in your serial cable rather than extra characters transmitted in your data lines. Thus, hardware flow control will not slow down transfer times like Xon-Xoff does. Flow control here is usually performed directly at the hardware level, thus its effect is immediate. When the DTE wishes to send data, it asserts DTR and checks the state of CTS. If CTS is active, the DTE will send data, if it is not active, no data will be sent. When the DCE wishes to send data, it asserts DSR and checks the state of RTS. If RTS is active, the DTE is ready for data, if it is not active ,no data will be sent. In this way, the DCE and DTE can control the flow of data thus insuring that their data queues do not overflow.

That's a pretty good overview of the ComPort and serial communications. There are many good books on this subject. Pick one up if you want more.

The Loopback Connector

To assemble the loopback connector shown in Figure 3, all you need is a D-type nine-pin connector and a connector shell. Make the following connections:

- Connect pin 4 (DTR) to pins 1 (DCD) and 6 (DSR)
- Connect pin 7 (RTS) to pins 8 (CTS) and 9 (RI)
- Connect pin 2 (RXD) to pin 3 (TXD)

That's all there is to it!

Software Operation

After installing the software and starting the program, you should see the screen shown in Figure 4.

The Communications Port tester has a full-featured help system. Help is context-sensitive, so just hit F1 wherever you are and a help screen will open before your very eyes.

Be warned, sometimes a corrupt ComPort can effectively hang up a PC, thus causing it to effectively ignore your futile attempts to abort. Just be patient and the test will end giving you back control of your PC.

The Main program screen consists of a Menu tree, a toolbar for commonly-accessed functions, a test results window, and some various controls and buttons. Each section is described next.

Menu Tree

File->Open. Select this menu pick when you want to retrieve previously tested ComPort data. Information is stored in .RTF or Rich Text Format. Windows and most word processors easily display this format. Picking this menu item will present you with a Windows standard open screen allowing you to select the results file you want to open.

File->Save. Select this menu pick whenever you want to save the information shown in the test results window. Information is stored in .RTF. Windows and most word processors easily display this format. Picking this menu item will present you with a Windows standard save screen allowing you to change the preset file name and other great options.

File->Print. Select this menu pick whenever you want to print the information in the test results window. Note that after a test has completed, you can edit the information in the test results window in order to annotate them for other people's viewing pleasure. Picking this menu item will present you with a Windows standard print screen allowing you to choose the system printer and other great options. You can also select the print icon from the toolbar, or the print button in the test results window.

File->Exit. Select this menu pick whenever you want to exit this program.

Test->Test. Select this menu pick to begin testing the selected ComPort. When the test has begun, this menu item will automatically change to an Abort menu item. Selecting the abort will stop the current test. You can also select the test button on the main screen.

Test->Abort. Select this menu pick to abort the current test. When the test has been aborted, this menu pick will automatically change back to a test menu pick. You can also select the abort button on the main screen.

Test->Com1. Select this menu pick to choose Com1. A checkmark will appear next to the active ComPort in the menu list. The ComPort indicators on the main screen will also update, displaying the currently selected ComPort. You can also select the ComPort by clicking the menu buttons on the main screen.

Test->Com2. Select this menu pick to choose Com2. A checkmark will appear next to the active ComPort in the menu list. The ComPort indicators on the main screen will also update, displaying the currently selected ComPort. You can also select the ComPort by clicking the menu buttons on the main screen.

Help->About. Select this menu pick to get more information about this program such as build dates, versions, contact information, etc. You can also review all of your system resources from this screen.

Help->Help. Select this menu pick to get the help system.

The ComPort tester automatically tests the selected ComPort throughout its complete baud range. You can adjust the starting and stopping baud rates with the supplied pull downs. Just click the drop down arrow next to each box and choose the baud rate of your choice. If a baud rate is not supported, the ComPort tester will skip that particular baud. A sample test result is shown in Figure 5.

I have tested this software on every PC I could get my hands on including Windows 95, Windows 98, Windows NT, and Windows ME. I found that the flow control signals behaved slightly different on each system and the tests were adjusted accordingly.

Should you suspect any problems with the software, please contact me at jventerprises@att.net. **NV**

A CD with the program and an assembled loopback connector is available from **JV Enterprises**, P.O. Box 370, Hubbardston, MA 01452; or **www.jventerprises.com** for $14.95 which includes the shipping. This covers the cost of the CD and loopback connector only. The software is free. You can download the software directly from **www.jven terprises.com**, just click on the 'downloads' section.

Electronics Showcase

Special products and services for the electronics enthusiast.

Kenwood's FreeTalk Radios Make It Easy To Stay In Touch

It's all about communication these days. Who's got what best plan for where and can you connect to the Internet anywhere, anytime. How many minutes across how many states and how many family members can you get to sign up on a plan. Too complicated.

There is an alternative, however, that will accommodate most "communication" situations ...

One of the most overlooked methods available today for keeping in touch with loved ones — or whoever — is with FRS (Family Radio Service). You don't have to take a test and the air time is always free. Take, for example, Kenwood Communications new FreeTalk radio (Model UBZ-LH14). Designed for outdoor recreation activities, the UBZ-LH14 is easy to use and small enough to take anywhere. It is equipped with premium features like voice scrambling and automatic channel selection, and operates over a two-mile radius. FreeTalk radios operate on free airwaves designated as FRS by the Federal Communications Commission. In addition, two, three, four, or more people can take part in the same conversation.

There are virtually limitless scenarios to use these radios in. Say you're going to an amusement park and the kids want to go to a different area or ride. Or, if you're at a campground and part of your group wants to go for a walk or bike ride. FRS makes it easy to stay in touch with each other.

With the convenient headset, the "hands-free" capability is perfect for situations where you need use of both hands, but still need to talk. For example, if you're into boating, one of the hardest things about anchoring is having to either shout directions back and forth from one end of the boat to the other or else trying to use hand signals.

What about when you're manueuvering a trailer or motorhome into a tight spot and have to try to stay within view of the driver's mirrors? Or, maybe you're traveling in a group and need to change the off-ramp you're going to or have to pull over.

"Since their introduction, FRS two-way radios have become very popular," said Tom Wineland, Kenwood Communications president. "Our latest generation of FreeTalks are designed with exclusive features to offer more convenience and reliability than those from any other manufacturer."

New to this year's model is a "range in/out" detector and "channel scan." The range in/out detector lets users know if they are within transmission range or not. An icon shows up on the radio's LCD if the user is in range, or disappears if the user is out of range..

Channel scan finds available channels for transmitting and receiving messages. If there's too much interference while you're having a conversation, the FreeTalk radio will automatically scan channels in ascending order until a clear channel is located.

An extra large liquid crystal display (LCD) allows users to quickly note channel settings and the status of all radio indicators. The display is illuminated for easy viewing at night or in darkened rooms.

FreeTalk radio provides users with 532 channel combinations (14 channels, each with 38 talk groups) to make it easy to find one for uninterrupted conversations. A scramble mode maintains privacy and keeps unintended listeners from eavesdropping. Easily recognizable call tones can be sent between radios to let others in a group know who is trying to contact them.

The new FreeTalk, offered in black, yellow and platinum, has a suggested a retail price of $114.95 each. Kenwood Communications also offers three optional accessories, including a remote control speaker microphone (SMC-34), a hands-free voice-activated headset (HMC-3), and a clip microphone with earphone (EMC-3). For more details go to www.kenwood.net.

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Understanding and Using 'Norton' Op-Amp ICs — Part 2

By Ray Marston

Ray Marston concludes his look at Norton Current-Differencing Amplifier op-amp principles and circuits in this final part of this mini-series.

Last month's opening episode of this two-part mini-series explained the basic operating principles of the Norton current-differencing amplifier (CDA) op-amp and presented a variety of practical applications of the popular LM3900 quad Norton op-amp IC. This month's concluding episode presents a few more practical LM3900 applications, and then explains the operating theory and practical applications of the LM359 high-performance dual Norton op-amp.

LM3900 CURRENT-REGULATOR CIRCUITS

Figures 1 to *4* show various ways of using individual op-amps from the LM3900 quad Norton op-amp IC to make simple current-regulator circuits; note when using the LM3900 ICs that unwanted op-amps can be disabled by wiring their two input terminals to the IC's GND or low-voltage line.

The *Figure 1* circuit acts as a fixed (1mA) current source, which feeds a fixed current into a load connected between Q1 collector and ground almost irrespective of the load impedance (in the range zero to 14k). The circuit is powered from a regulated 15V supply. Potential divider R1-R2 applies a 14V reference (15V-1V0) to R3, so the op-amp output automatically adusts to give an identical voltage at the R4-R5 junction. This produces 1V0 across R5, resulting in an R5 current of 1mA. Since this current is derived from Q1 emitter, and the emitter and collector currents of a transistor are almost identical, the circuit's collector acts as a fixed current source. The source current can be doubled (to 2mA), if desired, by halving the R5 value, etc.

Figure 2 shows a simple variation of the above circuit, in which the source current is independent of variations in supply rail voltage. In this case, the input is set at 2V7 below the supply rail value via Zener diode ZD1, so 2V7 is automatically set across R4, which has a value of 2k7 and thus produces a fixed 1mA source current from the collector of transistor Q1.

Figure 3 shows a simple 1mA current sink, in which a fixed current flows in any load connected between the positive supply rail and Q1 collector, almost irrespective of the load impedance. Here, the non-inverting terminal of the op-amp is disabled, and 100% negative feedback is used between the output of the circuit (Q1 emitter) and the inverting input terminal. The voltage across R1 thus equals the V_{be} of the inverting terminal and, since this is roughly 0.55V, a fixed current of about 1mA flows through Q1 emitter and R1, and thus into Q1 collector from any

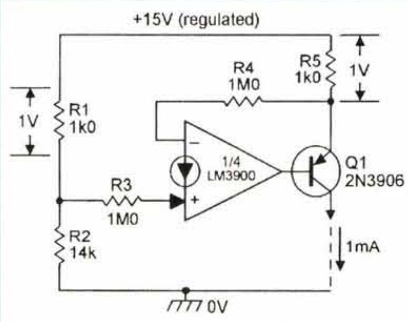


Figure 1. Fixed-current source (1mA).

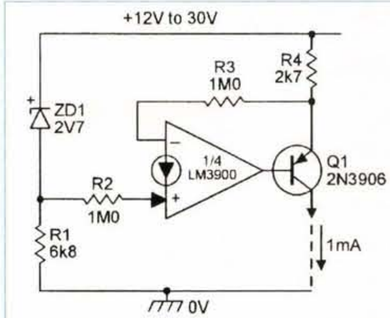


Figure 2. Alternative current source (1mA).

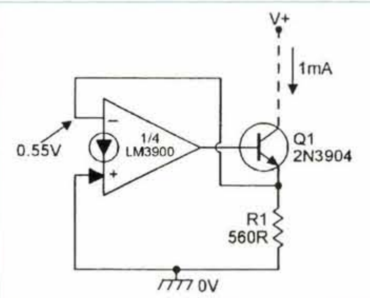


Figure 3. Simple 1mA current sink.

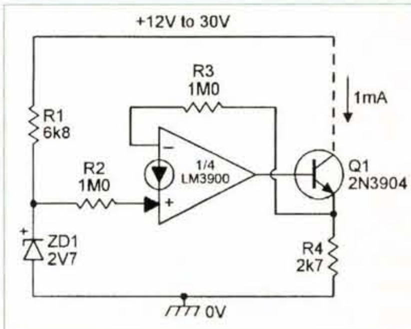


Figure 4. Improved current sink (1mA).

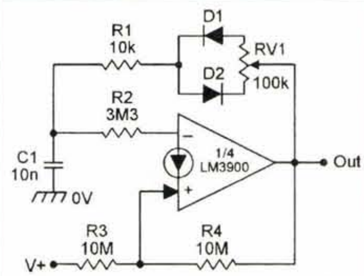


Figure 6. Variable mark/space ratio generator.

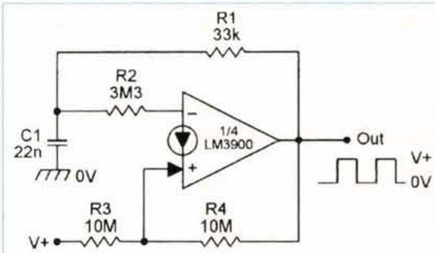


Figure 5. 1kHz squarewave generator.

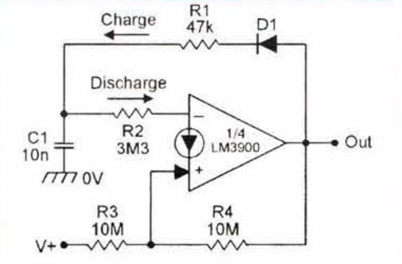


Figure 7. Pulse generator.

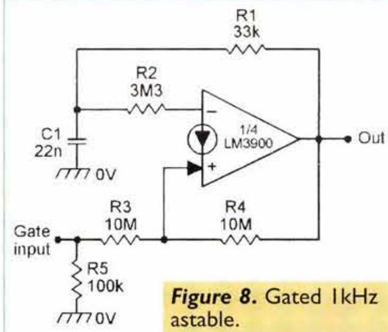


Figure 8. Gated 1kHz astable.

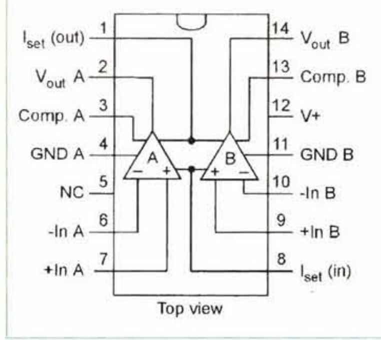


Figure 10. Outline and pin notations of the LM359 dual high-speed programmable Norton amplifier.

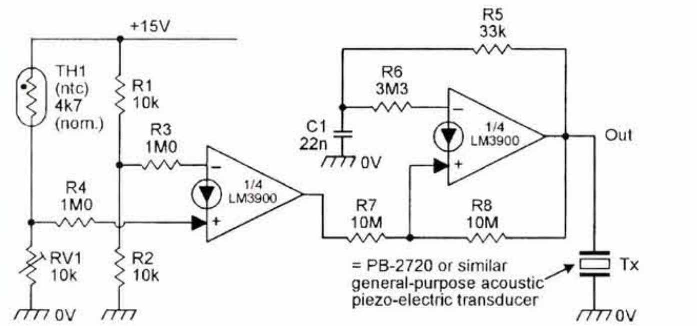
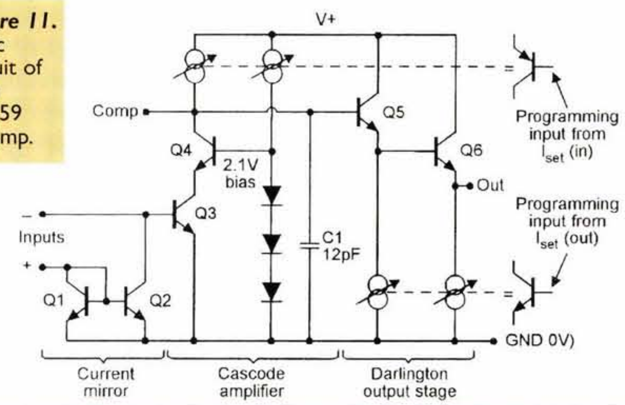


Figure 9. Audible-output over-temperature alarm.

Figure 11. Basic circuit of each LM359 op-amp.



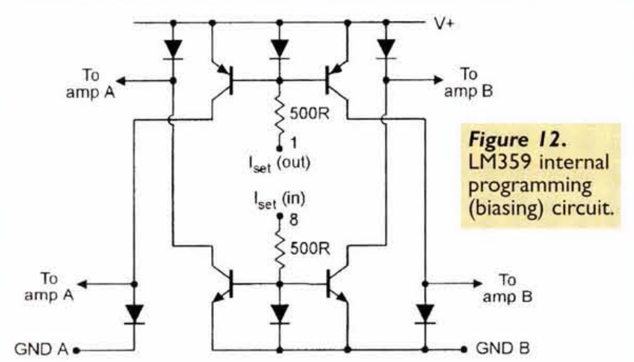


Figure 12. LM359 internal programming (biasing) circuit.

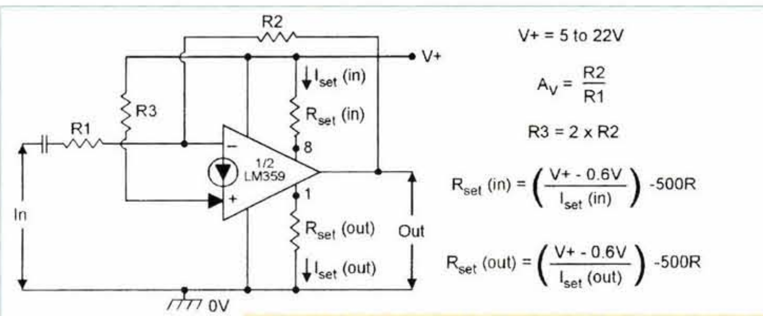


Figure 13. Inverting AC amplifier with supply-line biasing and individual IN and OUT programming resistors.

load that is connected. Note that the sink current of this circuit is not temperature compensated.

Finally, *Figure 4* shows an alternative type of current sink. In this case, the op-amp is fully enabled, and has a fixed reference of 2V7 applied to its non-inverting terminal via R2. Consequently, the circuit automatically adjusts to generate 2V7 across R4 which, since it has a value of 2k7, generates a current of 1mA in the emitter and collector of Q1. This current can be varied, if required, either by varying the value of R4 or by varying the input voltage fed to R2.

LM3900 WAVEFORM-GENERATOR CIRCUITS

To conclude this look at the LM3900 quad Norton op-amp IC, *Figures 5* to *9* show some useful ways of using its op-amps to make simple waveform-generator circuits. *Figure 5* shows a 1kHz squarewave generator, in which C1 alternately charges and discharges via R1. When the output is high, R3-R4 are effectively connected in parallel, and C1 charges until the current flow into R2 equals that flowing into the non-inverting terminal of the op-amp; this point occurs when the voltage across C1 rises to roughly two-thirds of +V. At this point, the circuit switches regeneratively, the output switches low, and C1 starts to discharge via R1. Under this condition, R4 is effectively disabled and the input current to the non-inverting terminal is determined only by R3, so C1 discharges until the R2 current falls slightly below that of R3. This point occurs when the C1 voltage falls to about one-third of +V. At this point the circuit again switches regeneratively, and the output goes high again. The action then repeats *ad infinitum*.

The *Figure 5* circuit is useful for generating squarewaves with frequencies up to a maximum of only a few kHz; because of the poor slew rate performances of the LM3900 (0.5V/μS), the output waveform has fairly poor rise and fall times. The circuit generates a symmetrical squarewave output. *Figure 6* shows how the circuit can be modified to give a variable mark-space (M/S) ratio output. In this case, C1 alternately charges via R1-D1 and the upper half of RV1, and discharges via R1-D2 and the lower half of RV1. The M/S ratio can be varied over the approximate range 1:10 to 10:1 via RV1.

Figure 7 shows a simple modification of the above circuit, which causes it to act as a free-running pulse generator. In this case, C1 alternately charges via R1-D1 and discharges via R2, producing an M/S ratio of about 1:60. *Figure 8* shows how the basic *Figure 5* circuit can be modified to act as a gated 1kHz astable or squarewave generator by taking R3 to ground via R5, rather than directly to the positive supply rail. The circuit becomes active only when the gate terminal is pulled high (to the positive supply rail).

Finally, to complete this look at LM3900 applications, *Figure 9* shows how this month's *Figure 8* and last month's *Figure 16* circuits can be combined to make an audible-output over-temperature alarm, which generates a 1kHz tone in a general-purpose acoustic piezo-elec-

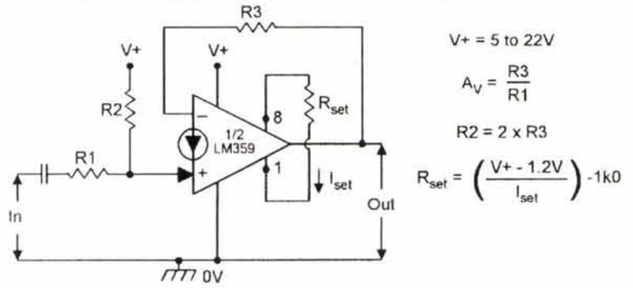


Figure 15. Non-inverting AC amplifier with supply-line biasing and single resistor IN/OUT programming.

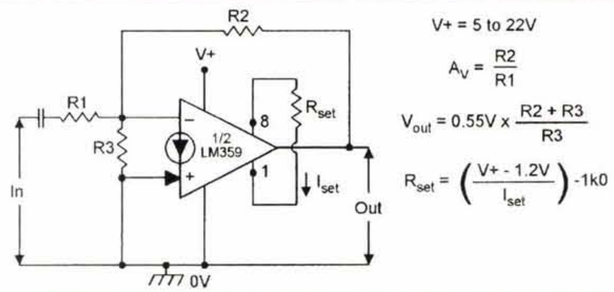


Figure 14. Inverting AC amplifier with N x V_{be} biasing and single resistor IN/OUT programming.

tric transducer when the TH1 temperature exceeds a value pre-set via RV1.

THE LM359 DUAL NORTON OP-AMP IC

The LM359 is not as well known as the LM3900, but is an outstandingly useful Norton type of IC. The LM359 is, in fact, a high-performance IC that houses two identical Norton op-amps, plus a common biasing network, in a 14-pin DIL package (see *Figure 10*) and can operate from a single-ended 5V to 22V power supply. Each of its op-amps offers a 30MHz unity-gain bandwidth, a 60V/µS slew rate, and a 72dB open-loop gain, and has many of its parameters fully programmable via one or two external resistors.

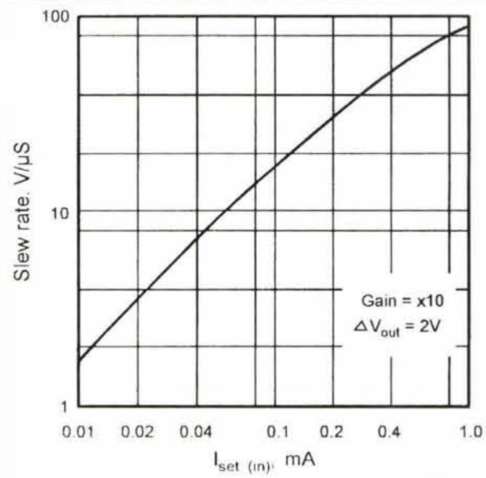


Figure 17. LM359 slew rate.

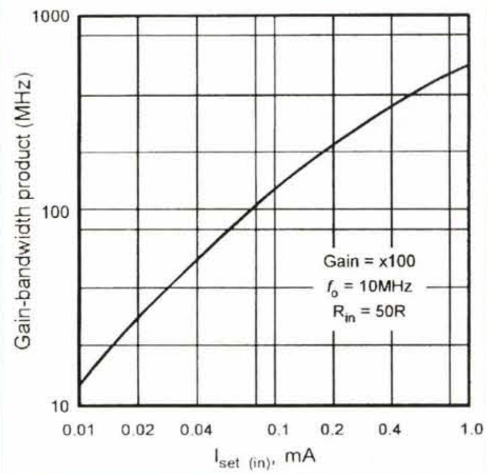


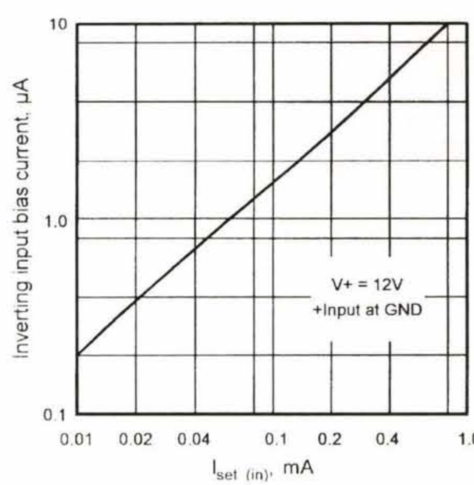
Figure 16. LM359 gain-bandwidth product.

The LM359's op-amps differ considerably from those used in the LM3900. *Figure 11* shows the basic LM359 op-amp circuit in slightly simplified form. This consists, in essence, of a mirror-driven (via Q1-Q2) wide-band cascade amplifier (Q3 and Q4), which does not suffer from output-to-input Miller or parasitic feedback effects and thus gives an excellent high-speed performance, plus a Darlington emitter follower output stage (Q5 and Q6).

Note that a 12pF capacitor is internally wired between Q4 collector (accessible at the COMP terminal) and ground, and that the Q3-Q4 operating current can be programmed via the $I_{set(in)}$ current of the IC's internal biasing network, thus enabling the circuit's input bias current, slew rate, bandwidth, and supply current to be pre-set. Similarly, the operating currents of the Darlington output stage can be programmed via the Iset(out) currents of the internal biasing network, enabling the output sink current and supply current to be pre-set.

Figure 12 shows the basic circuit of the IC's internal biasing network, which controls both op-amps. Thus, the $I_{set(in)}$ current can be set via suitable resistors wired between pin 8 and the positive supply rail, and the $I_{set(out)}$ current can be set via a suitable resistor wired between pin 1 and ground B. Alternatively, if $I_{set(in)}$ and $I_{set(out)}$ are to have equal values, the current can be set via a single resistor wired between pins 1 and 8.

Figure 18. LM359 inverting input bias current.



USING THE LM359

The LM359 is usually used in linear amplifier applications and, in such cases, the design procedure involves two simple stages: the first being the design of the input biasing network, and the second the selection of the programming resistor value(s).

The LM359 is biased in exactly the same way as the LM3900, using either voltage-reference biasing, supply-line biasing, or N x V_{be} biasing, as shown in last month's *Figure* 6 and fully described last month. Programming involves the wiring of either a single resistor between pins 1 and 8 of the IC, or of individual resistors between pin 1 and ground and between pin 8 and supply positive, as mentioned above. *Figures 13* to *15* show three typical circuits that can result from the above options, together with their relevant design formulas. Thus, the *Figure 13* circuit gives inverting AC amplifier action and uses supply-line biasing, and uses individual $R_{set(in)}$ and $R_{set(out)}$ programming resistors. The *Figure 14* circuit also acts as an inverting AC amplifier, but uses N x V_{be} biasing and uses a single resistor for $_{in}$ and $_{out}$ programming. Finally, the *Figure 15* circuit acts as a non-inverting AC amplifier and uses supply-line biasing and a single programming resistor.

I_{set} PROGRAMMING

The major operating parameters of the two LM359 op-amps can be

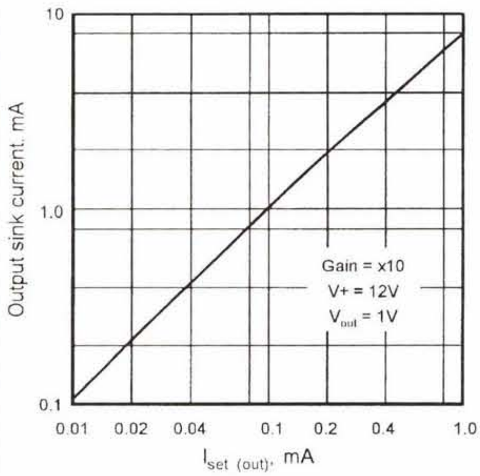


Figure 19. LM359 output sink current.

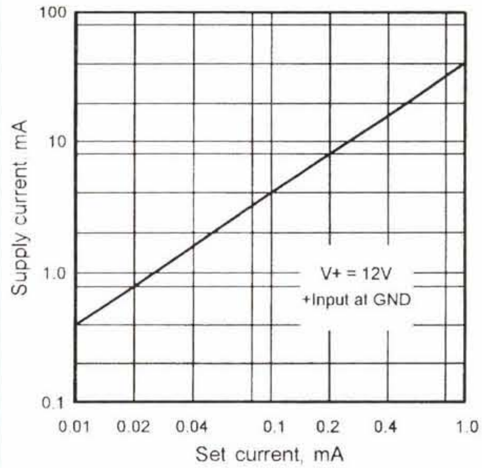


Figure 20. LM359 total supply current ($I_{set(in)} = I_{set(out)}$).

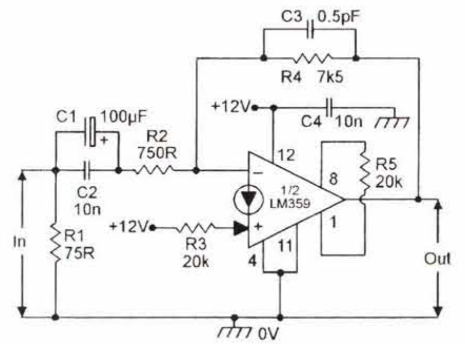


Figure 21. Wideband (>20MHz) x10 inverting amplifier.

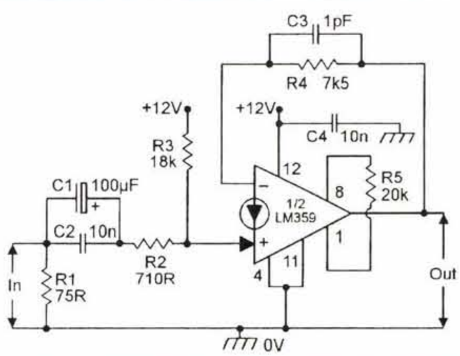


Figure 22. Wideband (>20MHz) x10 non-inverting amplifier.

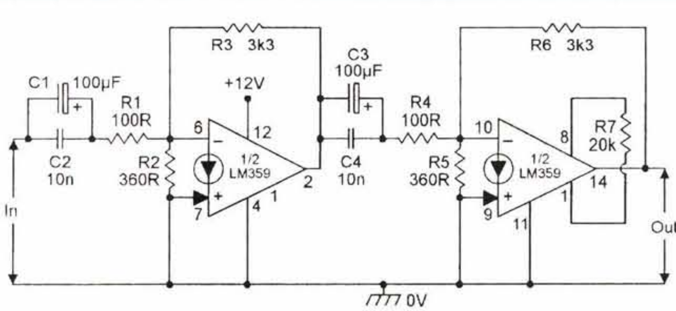


Figure 23. High-gain (x1000) general-purpose wideband (8MHz) amplifier.

programmed via the pin 1 and pin 8 I_{set} currents of the IC. The gain-bandwidth products, the slew rate, and the inverting input bias current can be programmed via the pin 8 $I_{set(in)}$ current, and *Figures 16* to *18* show the effects of this current on the individual parameters.

The gain-bandwidth product graph of *Figure 16* is based on a x100 inverting amplifier fed with a 10MHz input signal, but is valid for all types of amplifier. Thus, with a 10MHz input, it gives a gain of x60 and a gain-bandwidth value of 600MHz at an $I_{set(in)}$ current of 1mA, and a gain of x1.1 and a gain-bandwidth product of 11MHz at 0.01mA. The gain-bandwidth of the circuit is thus directly proportional to the $I_{set(in)}$ value.

Note that the gain-bandwidth product of the IC is also inversely proportional to the op-amp's C_{comp} value (see *Figure 11*), which is a fixed 12pF, but which can be increased by wiring an external capacitor between the 'comp' terminal and ground. Thus, the gain-bandwidth values can be halved by doubling the effective C_{comp} value via an external 12pF capacitor wired between these two points.

The slew rate (see *Figure 17*) of the op-amp is also directly proportional to $I_{set(in)}$, but inversely proportional to C_{comp} and can thus be varied via either of these quantities. The inverting input bias current values (*Figure 18*), on the other hand, are independent of C_{comp} and depend solely on the $I_{set(in)}$ values. The output sink current (*Figure 19*) is variable via the pin 1 $I_{set(out)}$ current and is roughly 10 times that value.

Note that, as already mentioned, the I_{set} values can either be set via individual resistors or, if both I_{set} values are equal, can be set by a single resistor wired between pins 1 and 8. If individual resistors are used, each value is determined by:

$$R_{set} = (V/I_{set}) - 500R$$

where V = V+ - 0.6V. In this case, the total current consumption of the IC (of the two op-amps) is roughly equal to:

$$I_{supply} = (27 \times I_{set(out)}) + (11 \times I_{set(in)})$$

If only a single programming resistor is used, its value is determined by:

$$R_{set} = (V/I_{set}) - 1k0$$

where V = V+ - 1.2V. In this case, the total current consumption of the IC roughly equals 37 x I_{set}. *Figure 20* shows the typical consumption graph when using a 12V supply.

WIDEBAND AMPLIFIERS

The most important application of the LM359 is as a video or wideband amplifier, and *Figures 21* to *23* show three practical circuits of this type. The basic design principle of these circuits is as follows:

The *Figure 21* circuit is designed to be powered from a 12V supply, and to act as an x10 (= 20dB) inverting amplifier that gives a bandwidth of at least 20MHz when driven via a terminated 75-ohm (75R) line. This last requirement sets the R1 value at 75R. The input is then AC-coupled via C1, which is shunted by C2 to minimize its high-frequency impedance. R2-R4 set the circuit's voltage gain. R2 must be small, but must not significantly shunt the R1 value; this gives R2 a sensible compromise value of 750R. To give a voltage gain of x10, R4 must be 10 times greater than R2, and this sets the R4 value at 7.5k.

To give maximum output voltage swing the op-amp output must be DC biased to a quiescent value slightly below half-supply volts, and this is achieved by making R3 a bit more than twice the R4 value. A good compromise is 20k, which sets the output at 5.1V.

To give the required gain and bandwidth, the op-amp needs a minimum gain-bandwidth product of 200MHz. An I_{bias} value of 0.5mA gives a gain-bandwidth of 400MHz, which gives a good margin of safety, and this can be programmed by giving R5 a value of 20k.

To ensure a good high-frequency performance, the pin 12 supply pin is RF-decoupled to ground via C4. To give maximum bandwidth, C3 (two twists of insulated wire) is adjusted on test. In practice, this circuit gives a 3dB bandwidth that extends from 2.5Hz to about 30MHz, and is absolutely flat up to 20MHz.

Figure 22 shows a non-inverting version of the wideband amplifier. In this case, the gain is determined by the R2-R4 ratio, and the DC biasing value by the R3-R4 ratio. The 3dB bandwidth of the circuit extends from 2.5Hz to 30MHz, and is almost flat to 20MHz.

Finally, to complete this look at Norton amplifier ICs, *Figure 23* shows how both op-amps of an LM359 IC can be cascaded to make a general-purpose wideband amplifier with a nominal gain of x1000 and a 3dB bandwidth that extends from 10Hz to 8MHz. In this case, the op-amps are each wired in the inverting mode, with a x33 gain set by the R3/R1 or R6/R4 ratio, and use N x V_{be} biasing, with the N ratio set by R3/R2 or R6/R5. **NV**

We often have subscribers ask how to read their mailing label so they can tell when their subscription expires. To read the label, the first set of numbers is your account number which is then followed by a set of four numbers. This is the expiration date: year first, then month. For example, if the second set of numbers reads 0207, then your subscription expires with the July 2002 issue.
Better hurry and renew!

by Stanley York

Laser Insight

A couple of issues back, I described a simple dye cell you could use in conjunction with the nitrogen laser that was described earlier this year. This time, I want to show you another approach to exciting a dye cell, using instead a flashlamp.

If you have a still camera, there's a good chance that at some time you have used a flash attachment and taken pictures in dim lighting situations. These camera flash units can put out quite a bit of optical power, and I have done some experiments with flash units on various dyes, with some quite interesting results.

Did you know, for instance, that the dye found in washing powder fluoresces in the blue/green region of the optical spectrum? You can easily see this if you put a small quantity of dry washing powder in a shallow dish (use the kind of powder that has the blue specks in it), and go into a dark corner of your house. When your eyes have become dark-adjusted, take a camera flash and hold it in contact with the dish, such that the washing powder is exposed to the light when the flash is fired. Don't look at the dish when firing, because when you remove the flash unit, you will want to be able to see the afterglow of the dye (Figure 15-1). The fluorescence doesn't last long, so you have to be fairly quick to expose the powder, then remove the flash unit. You'll see that not just the blue specks glow!

I suspect that the dye involved here is one of the Coumarin variety, but none of the washing powder manufacturers will tell me. In any case, this dye is worthy of investigation as a laser dye, and I want to propose here that the system I am about to describe may be used to excite the dye, thereby forming a simple pulse-pumped dye laser.

This is only an experiment, I haven't tried it myself yet, so I cannot guarantee that it will work, but it will make a very interesting challenge. So, you pioneers out there, test your ingenuity, build this system, and make it work. Share your achievements with all our readers. There are no prizes, just the satisfaction of achieving something noone has done yet. Who knows? We may be looking at a whole new breed of laser system ...

To dissolve the dye and separate it from the soap is the first challenge, because the dye solution will be a weak transparent color, and must not be contaminated by soap or water. Some of the solvents mentioned in the previous dye laser article may be tried. I suggest trying methanol first.

When you dissolve the dye, try to use fresh solvent, and if you can get it, use spectrophotometric grade. If you use solvent that's been sitting around for a while, it may have become contaminated by water. Most alcohols will pull water in from the air and quickly become saturated, rendering them useless for laser work.

If you have an old camera flash unit you can afford to sacrifice, you can try to convert it into a small laser. You'll have to disassemble the unit and modify the flash, because you need to mount a small glass tube parallel to the flashlamp (Figure 15-2).

Figure 15-1. Exciting the powder with a camera flash.

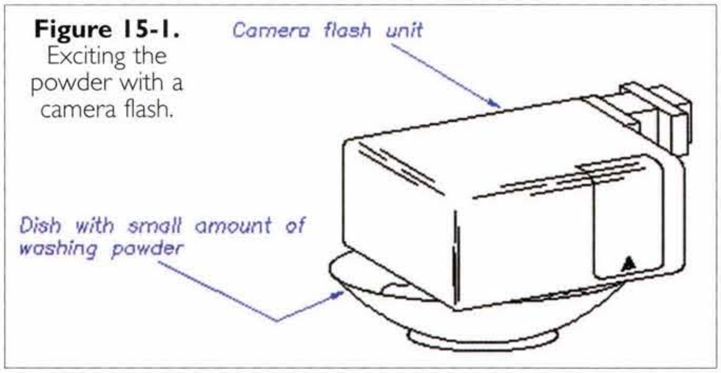
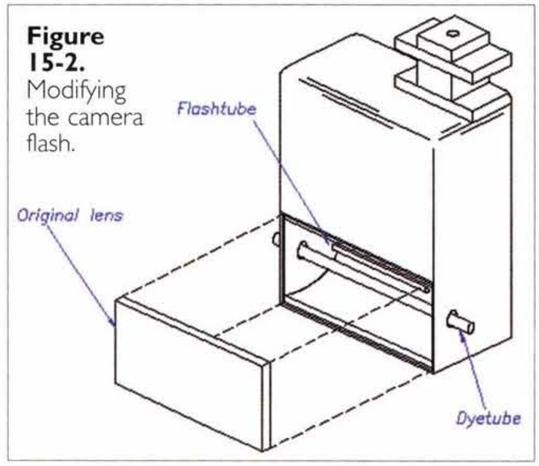


Figure 15-2. Modifying the camera flash.



Remove the existing lens carefully, because you will need to replace it. Careful with the reflector too, it is very thin and fragile. Drill a hole through the side of the flash unit as close to the lamp as you can without touching it or the wiring to it. This will provide maximum optical coupling into the glass tube when it is mounted. As flash units vary widely in their construction, I'm using a simple type for illustration only. Your unit may be different, but you should follow the same basic modifications.

The glass tube running parallel to the flashlamp should be approximately the same size as the flashlamp itself, and should extend about 1/8"-1/4" beyond the flash housing on both sides.

Find a piece of 3/8" thick plexiglass, and make two blocks as shown in Figure 15-3. The only dimensions I will give here are for the thickness of the material. Other dimensions will vary, depending on your flash unit and glass tube. Drill the hole in the block for a snug fit around the glass tube. You will need to epoxy the glass into the blocks to prevent loss of dye solution, and epoxy the blocks to the side of the flash unit. Keep the glass tube approximately centered between the blocks, and make sure the dye entry and exit holes are not plugged with epoxy, and that the glass tube does not obstruct the holes.

Look at the enlarged section in Figure 15-3 for details of the tube placement. Put a bead of epoxy around the glass tube/Plexiglass interface, and a thin layer on the flash case, and hold the assembly together with tape or rubber bands until the epoxy sets. Figure 15-4 shows the assembly.

It is very important to get the two blocks as parallel as possible, as they will form the support for the end mirrors of this laser. Since

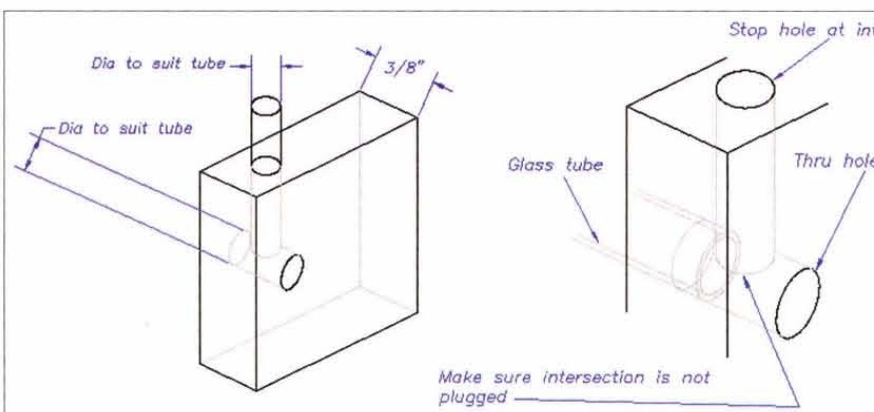


Figure 15-3. Dyetube holder and mirror mounts.

this is such a small laser, there cannot be any adjustments on the end mirrors. If there is a slight misalignment, the laser may still work, but at reduced output.

If you have some small pieces of first-surface mirror available, now you can put them to good use. If not, you may have to sacrifice one. Epoxy a piece of first-surface mirror to one block, so that the hole in the block is facing the silvered surface of the mirror. Place a bead of epoxy around the mirror, making sure to fill every small crevice. Be careful not to get epoxy on the mirror surface that faces the glass tube, though.

If you look down the opposite end of the glass tube, you should see your eye reflected in the piece of mirror epoxied to the far side. On the other end of the tube, epoxy a small piece of plain microscope slide.

When the epoxy has set, fit the glass tubes with some flexible plastic tubing to serve as a dye feed. The flexible tubing should be a snug fit around the glass to minimize leakage. Get two glass jars, and partly fill one of them with plain solvent. Follow the arrangement in Figure15-5 to siphon the solvent back and forth between the jars to make sure there are no leaks. When the upper jar is almost empty, reversing the positions of the jars should allow the solvent to flow in the opposite direction. If you make the two flexible tubes the same length, you'll be able to control the flow much easier.

You should adjust the heights of the two jars until you get a slow uniform flow in each direction. Use books or pieces of wood as spacers. The flow should be enough to cause a change of liquid volume during the flash recharge period. The flow should not be turbulent,

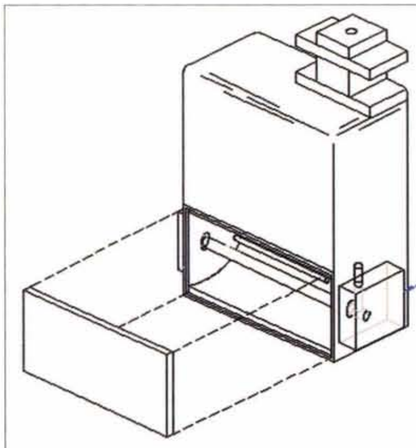


Figure 15-4. Assembling the flashlamp laser.

as this will retard laser action.

If you have no leakage problems with the dye solvent, the next thing to do is replace the front lens on the flash unit. Before you do however, you should cover the inside face of the lens with a couple of layers of kitchen foil, shiniest side out. This will prevent the flash from interfering with any testing or experiments you may be doing, and it will also couple more of the emitted light back into the dye tube. Be careful when you add the foil. Don't let it get too far inside the flash housing, or you run a risk of shorting to the flash tube. Glue it to the lens so that it cannot fall off or move around after you reassemble the flash unit.

If you have a military background, you may have used (or heard of) an infrared (eyesafe) laser rangefinder. These devices use an arrangement very similar to this set-up, but instead of using a dye solution, they use an Erbium-doped YAG rod as the laser medium. Erbium is one of the so-called rare-earth materials. This particular type of laser puts out an infrared beam at 1530-1660 nM. This wavelength is less likely to cause retinal damage to the eyes, and is favored for the use of laser rangefinders used by the military. This wavelength is generally referred to as the eye-safe region of the infrared. You may want to try other materials too. There are dyes in many household products, and some of these may fluoresce if driven hard enough. The difficult part is trying to extract the dye in its purest form from the host material.

Have fun with this project, but remember, it is a laser no matter how low the output power is, and it is still dangerous. The power supply in the flash unit is quite powerful, and can give a nasty shock if you aren't careful.

Next month, I'll discuss a few methods of aligning a laser, and give a few tips and tricks that I have learned over the years. **NV**

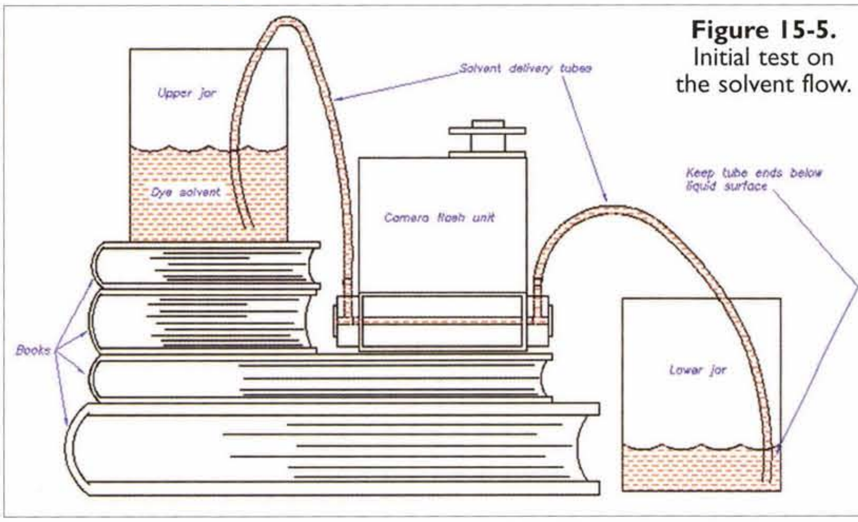


Figure 15-5. Initial test on the solvent flow.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News Bytes

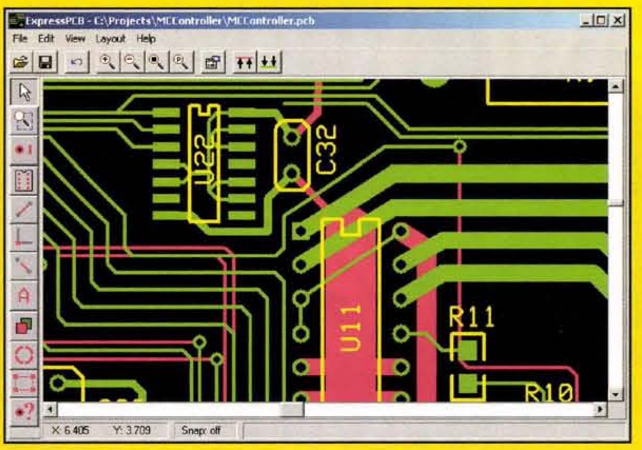
LULU ENTERPRISES ANNOUNCES LULU TECH CIRCUS — A THREE-DAY TECHNOLOGY EVENT

Lulu Tech Circus to be a place where Technology Lovers can Engage, Learn, and Interact in a Unique, Cutting Edge, and Entertaining Environment.

Lulu Enterprises announces Lulu Tech Circus, a three-day, multi-ring technology event targeted at technology enthusiasts, hobbyists, user groups, and IT professionals who work and play in arenas as diverse as super-computing, animation, robotics, and wireless communications.

Lulu Tech Circus events will be scheduled throughout North America. The first Lulu Tech Circus event will be held in Raleigh, NC, from September 27-29, 2002.

"Lulu Tech Circus can meet the needs of the 'inner geek in all of us'



to get out and share experiences, advancements, and ideas," said Bob Young, CEO, Lulu Enterprises (also, co-founder of Red Hat, Inc.). "From Princeton mathematicians to the guy who keeps your office network running — the technology enthusiast market is a vast and underserved one.

"Let's face it, bass fishermen are better served by user-driven events than the much larger and more important technology user community. There are lots of technology events, but they are just too focused on the needs of the vendors and exhibitors to be much use or fun for the typical technology user. The mission of Lulu Tech Circus is to bring together the extraordinary people, innovations, and concepts that define technology culture today," said Young.

Plans for the first edition of Lulu Tech Circus include a wide variety of live and interactive experiences from which attendees can design their personalized days at the Circus — everything from master classes with animation experts and digital film screenings, to networking certification

Continued on Page 87

Build the Cook-Out Companion

By Anthony J. Caristi

The Cook-Out Companion allows you to play your stereo system indoors while listening to the same music outside. It's a wireless system that doesn't require you to set up speakers in your backyard.

Many of us like to cook lunch or dinner in the backyard, or have a barbeque with friends during the nice weather. Usually music is part of the scene. But suppose you are not exactly fond of what is being heard on commercial radio stations, and would much prefer to hear your favorite CDs? The answer to this is to build the Cook-Out Companion, which allows you to play your stereo system indoors while listening to the same music outside. It's a wireless system that doesn't require you to set up speakers in your backyard.

This method of transmitting music is accomplished by taking advantage of a miniature, low-power, VHF oscillator chip that operates in the FM broadcast band. Its power is low enough to be perfectly legal, and it will not disturb your neighbor's FM reception. Your music is heard on any portable FM receiver(s) that you bring outside. Of course, you will be able to hear just monaural, and not stereo sound.

Another use of this miniature FM transmitter is to use it to transmit voice and other sounds such as those in the bedroom of a sleeping baby or toddler. This is accomplished by adding a microphone to the circuit. This might come in handy if you have a small child and wish to listen in when he or she is sleeping in the bedroom.

A common nine-volt transistor radio battery powers the circuit. Current draw is a scant four milliamperes, which allows many hours of pleasant listening.

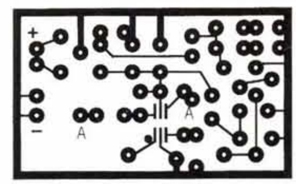


Figure 1. Printed layout of the PC board shown full size, as seen from the copper side.

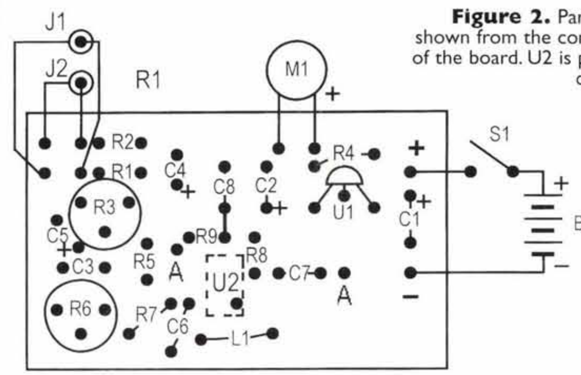


Figure 2. Parts placement shown from the component side of the board. U2 is placed on the opposite side.

ABOUT THE CIRCUIT

Refer to the schematic diagram. Power to operate the circuit is provided by a common nine-volt transistor radio battery. Other DC sources that supply at least seven volts, and up to 12 volts, may also be used. The battery is used to drive U1, a fixed five-volt linear regulator IC, which powers the oscillator.

The heart of the circuit is U2, a six terminal, miniature, surface mount integrated circuit developed by MAXIM. This is a self-contained VHF oscillator chip that contains the necessary elements of a voltage controlled Colpitts oscillator. The only external tuning component is the inductor, L1. A built-in varactor is included on the chip so that frequency control and modulation is easily accomplished by applying a DC plus AC (audio) voltage to pin 3.

Choosing the correct value of inductance sets the operating frequency to within the FM transmitting band, 88 to 108 MHz. In this circuit, an inductor with a value of 390 nanoHenries (0.39 microHenries) allows the frequency of operation to occur near 100 MHz. R6 — the tuning control potentiometer — provides adjustment of the operating frequency within the FM broadcast band.

Since U2 is a voltage-controlled oscillator (VCO), any modulation present on pin 3 of the chip will cause its frequency to shift in accordance with the amount of voltage variation. The audio signal is provided by either the stereo system, or the output of the microphone (if so equipped).

The audio is presented to U2 through capacitor C5, where it is added to the DC bias provided by tuning potentiometer R6. The AC signal — riding upon the DC bias — will frequency modulate the oscillator. A nearby FM receiver, tuned to the carrier frequency, will be able to detect the modulation and recover the audio.

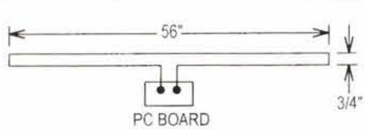


Figure 3. A half-wave folded dipole antenna, driven by C7 and U2 pin 4. May be used to transmit the RF signal.

The output circuit of the chip consists of a differential output amplifier that is driven by the oscillator. This provides isolation between the two sections of the circuit and offers a differential output mode (pins 4 and 6) that can be used to drive a balanced antenna. Alternatively, a single wire, driven by one of the output terminals of the chip, can also be used as a quarter-wave whip antenna.

CONSTRUCTION

Since this circuit operates in the VHF band, printed circuit construction is mandatory. Figure 1 illustrates the printed layout of the PC board, shown full size as seen from the copper side of the board. An etched and drilled board is available from the source indicated in the Parts List.

The first component that should be mounted to the board is U2, the oscillator chip. This is a surface mounted miniature component that is soldered to the bottom of the board. Use the following procedure:

1. Gently clean the PC board using a steel wool pad. Be sure there are no contaminants, opens, or short circuits at or near the printed wiring. Pay special attention to the spaces between the copper pads for U2. Rinse and dry the board thoroughly.

2. Locate pin 1 of U2, which may be indicated by a small dot on the top side of the chip. Pin 1 will always be in the lower left-hand corner of the chip as you hold it so that you can read the ID lettering of the part. Pin 1 of the corresponding copper pattern is indicated by a small dot.

3. Place U2 in position, directly over and centered among the foil pattern.

4. Using a low-powered pointed soldering iron tip, carefully apply heat and solder between pin 1 of the module and the foil pad. Allow the melted solder to flow, ensuring a good connection. CAUTION: Do not use too much heat or too much solder; to do so may cause the foil to lift off the board or form a short circuit between adjacent foil pads.

5. Examine the assembly to be sure that all terminals of U2 are in the proper position over the pads. If not, repeat Step 4.

6. Solder the remaining terminals of U2 as described in Step 4.

7. Examine the assembly very carefully to be sure that all connections are solid, and there are no short circuits between adjacent foil pads.

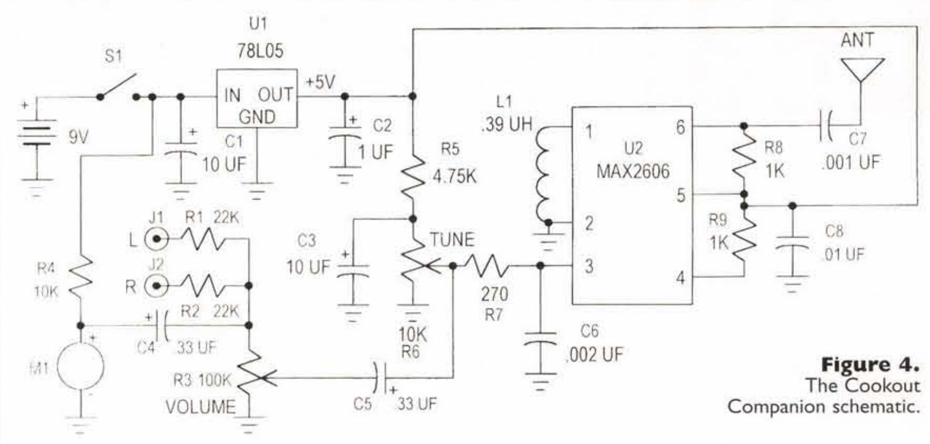


Figure 4. The Cookout Companion schematic.

The remaining through-hole components may be inserted in the board and soldered in place as indicated in Figure 2. Use very short lead lengths for L1, C6, and C8. Be sure to observe proper orientation for U1. An error here will result in an inoperative circuit and possible damage to U1 and U2.

Be sure to observe proper polarity of the electrolytic and tantalum capacitors, which are plainly marked on the body of the part. Follow Figure 2, which shows how these components are mounted to the board.

Note: If the microphone part of the circuit is not going to be used, do not install M1, R4, and C4. If the circuit is to be used as a microphone transmitter only, do not install R1 and R2. The electret microphone cartridge is polarized; be sure to observe proper polarity as indicated in the schematic diagram and Figure 2.

Use a clip for the battery. This may be obtained from electronic parts distributors. Alternatively, you can salvage a connector from an old nine-volt battery and solder a red (+) and black (-) wire to the terminals. When doing so, remember that the polarity of the clip will be opposite to that of a battery. When finished, attach a new battery to the clip and use a DC voltmeter to be sure that the polarity of the wiring is correct.

When the PC board is completed, check it carefully for any possible opens, shorts, errors, and bad solder connections. Any joint that is not shiny and smooth is suspect and should be redone by removing the old solder with braid. It is easier to correct mistakes now rather than later on if you discover that your transmitter does not work.

A small enclosure may be used to house the printed circuit board if the quarter-wave antenna option is chosen. The left and right audio connectors and S1 may be mounted to the enclosure. The battery may be secured inside the enclosure using a suitable battery holder.

PARTS LIST

B1 — Nine-volt alkaline transistor radio battery
C1, C3 — 10 uFd 25-volt radial electrolytic capacitor
C2 — 1 uFd 50-volt radial electrolytic capacitor
C4, C5 — 0.33 uFd 16-volt tantalum capacitor
C6 — 0.002 uFd 50-volt polyester or mylar capacitor
C7 — 0.001 uFd 50-volt ceramic disc capacitor
C8 — 0.01 uFd 50-volt ceramic disc capacitor
J1, J2 — Mouser 164-4215 or similar
L1 — 390 nanoHenry inductor, Mouser 70-IM2-.39 or equal
M1 — Electret microphone Mouser 25LM040 or similar
R1, R2 — 22K 1/4 watt carbon resistor
R3 — 100K potentiometer, PC mount
R4 — 10K 1/4 watt carbon resistor
R5 — 4.75K 1/4 watt 1% metal film resistor
R6 — 10K potentiometer, PC mount
R7 — 270 ohm 1/4 watt carbon resistor
R8, R9 — 1K 1/4 watt carbon resistor
S1 — SPST toggle or slide switch
U1 — 78L05 regulator IC
U2 — MAX2606 VHF oscillator IC

Misc: Antenna, audio cables

SOURCES OF SUPPLY

Mouser: 1-800-346-6873; **www.mouser.com**
Digi-Key: 1-800-344-4539; **www.digikey.com**

Note: The following parts are available from **A. Caristi, 69 White Pond Road, Waldwick, NJ 07463**. Etched and drilled PC board @ $12.75, U1 @ $3.00, U2 @ $9.75. Please add $6.00 shipping/handling.

ANTENNA

The builder has two options for an antenna. One choice would be to use a quarter-wave whip, composed of a straight piece of stiff wire about 28 inches long and fed from pin 6 of U2 through C7. Another method is to use a folded dipole half-wave antenna as depicted in Figure 3. This is a balanced antenna and is driven by the differential output of U2, terminals 4 and 6 (through C7). Using the dipole version provides twice the available RF driving voltage, and should provide greater operating range.

It is best if the dipole antenna is driven directly by the circuit without any connecting cable. This is accomplished by constructing the antenna on a flat piece of lumber about five feet long, and securing the printed circuit board in the center.

Once the antenna style is chosen and wired to the circuit, the transmitter is ready for test.

CHECKOUT

When you are certain that the circuit is properly wired, connect a source of audio (monaural or stereo) to one or both of the audio input jacks using the proper cable(s). If the microphone version of the circuit is to be tested, no audio source is required.

Clip on a fresh nine-volt battery to the circuit. Alkaline types will provide greater operating time.

Set up a portable FM radio nearby, and tune to the middle of the FM band where there are no broadcast stations operating.

With S1 turned on, adjust the tuning control, R6, until you hear the audio come through to the FM receiver, or you hear just silence if no audio is being applied to the transmitter. In this case, speak into the microphone to produce sound from the receiver. U2 requires a DC voltage level at pin 3 of about 1 to 2-1/2 volts. Adjust the volume control, R3, for best audio fidelity.

Once this adjustment is made, the checkout is complete and you may determine the operating range of the system by separating the FM receiver from the transmitter. Remember that best operating range will be attained when the transmitting antenna and receiving antenna are each oriented in the same direction, for identical polarization.

If you are not able to obtain an RF signal that can be detected by the FM receiver, the oscillator is either not working at all, or its frequency is out of the FM band. Measure the battery voltage to be sure it is at least eight volts. Check the voltage at pin 5 of U2. Normal indication is between 4.75 and 5.25 volts. If not, check U1, C1, and C2.

Check the value of L1. Check all components for the correct value and location in accordance with Figure 2. Examine U2 for solid solder connections, and be sure there are no solder bridges between adjacent foil pads and closely spaced conductors.

A new alkaline battery will provide many hours of use. At the end of battery life, the operating frequency may drift or the audio may become distorted. At this time, replace the battery with a new one. **NV**

Learning RVK-Basic Part 8

By Bob Vun Kannon

RVK-Basic is a free Basic compiler for the Atmel AVR line of microcontrollers. You can download a copy of this compiler from the Nuts & Volts web site (www.nutsvolts.com). With this compiler, you can write and compile very fast, efficient programs for most of the AVR microcontrollers.

In this month's article, we will investigate the question of how to generate Pulse-Width Modulation (PWM) from your AVR microcontroller using RVK-Basic. Also this month, we will investigate the generation and use of random numbers.

What is PWM?

Figure 1 shows how PWM can be generated from a free-running timer. If an eight-bit counter runs freely, its states in time will be 0,1,2 ....254,255,0,1,... This is shown in the picture as a ramp function or saw-tooth waveform at the top of the picture. In reality, there is no smooth, continuous ramp inside the microcontroller, just a series of well-defined states of the counter. It is very useful, however, to think of the counter state as being a ramp function.

Superimposed on the drawing of the Timer Counts are horizontal lines representing two different specific counter states. The two I have chosen for purposes of this example are 95 and 190.

I have constructed two possible output waveforms, which correspond to the two different horizontal lines. Both output waveforms are constructed such that the output is low whenever the Timer Counts are greater than the state chosen to produce the PWM. For example, the 95 OUTPUT is low whenever the Timer Counts are greater than 95.

It is obvious that the 95 output produces less time high than low, while the 190 output is high more than it is low. Clearly then, the choice of where we place the horizontal line allows us to change the output waveform. It should be obvious then that by controlling horizontal line position (or PWM Command), we could make the output vary from low all the time to high almost all the time or anywhere in between.

If we were using a microcontroller running on five volts, this would allow us to control the average output voltage from zero to essentially five volts, just by controlling the PWM command.

Why would we want PWM?

DC motors turn when you apply voltage to them. In general, the speed of the motor is proportional to the voltage you apply. That is, if you get X RPM at two volts, you should get 2X RPM at four volts.

When we consider the average voltage of a PWM signal, we will quickly realize that the average voltage is the percentage of the time the PWM spends high times the peak value of the signal. For example, if you're using a 5V AVR and the PWM Command can range between 0 and 255, the average voltage at the output of the PWM can be expressed by:

Average Voltage = (PWM_Command / 256) * 5 volts

It is not generally practical to drive a motor from the raw output of the microcontroller. But it is very practical to buffer the raw output with a transistor that connects to the motor and the motor is connected to a higher voltage rail. In this situation, the PWM command will vary the voltage to the motor between 0 and almost the voltage rail, whatever it may be. A possible way to do this is shown in Figure 2. For the MOS-FET, the choice will depend on the voltage and current it must handle, but you will generally want to choose a logic-level FET, perhaps an IRLR3410 might be considered. You might also want to put a small resistor — like 10 ohms — in series with the gate of the FET to damp ringing at the PWM output. A diode could also be placed on the output with its anode to ground to clamp ringing below ground.

Another use for PWM driving a motor is to control the torque from a Torque Motor (a type of DC motor). This is commonly done in automobiles to implement a Cruise Control. With a Torque Motor, the more voltage you supply to it, the more torque it produces and thus pulls harder on the throttle. So by controlling the PWM output of a microcontroller, you could control the speed of your car.

In general, any gadget that can be controlled by voltage can possibly be controlled by PWM. So, if we can easily produce PWM from an AVR chip, we can control lots of things like cars, robotic arms and fingers, battlebots, aircraft, and even spaceships. With PWM, even the sky is not the limit.

How to generate PWM

RVK-Basic has two PWM commands. One statement — PWM — uses the TIMER1 which is available in all AVR chips to produce PWM. TIMER1 is actually a 16-bit timer, but the INIT mode of the statement allows you to set up the timer to be 8, 9, or 10 bits. There is also a PWM2 statement, which uses TIMER2, an eight-bit timer. TIMER2 is not generally available on all chips.

Let's suppose that we want to generate a PWM output of about 400 Hz from a 4 MHz processor, and we want it to be an eight-bit timer. The command to set this up is:

```
PWM INIT 400,8
```

Now to set the PWM to, let's say 50%, we would write

```
PWM THRESHOLD 127
```

We could also use an integer variable to do the same thing.

TABLE 1

Prescale Value	8-bit counter	9-bit counter	10-bit counter
1	15.6 KHz	7.81 KHz	3.91 KHz
8	1.95 KHz	977 Hz	488 Hz
64	244 Hz	122 Hz	61.0 Hz
256	61.0 Hz	30.5 Hz	15.25 Hz
1024	15.25 Hz	7.6 Hz	3.81 Hz

```
p% = 127
PWM THRESHOLD p%
```

That's how easy it is to control PWM.

It should be fairly noted that the PWM command cannot generate just any old frequency. The possible frequencies are limited by the prescaler for the counter timer and the clock frequency of the microcontroller. Table 1 is a simple example of what frequencies can be obtained when using a 4 MHz clock for the processor.

The RVK-Basic compiler will choose the prescale value for you that gives the frequency closest to and above the frequency you specify in the PWM INIT statement. To avoid surprises, check the ASM file produced after you compile your program. There the actual output frequency will appear as a comment next to your PWM INIT statement.

The pin for PWM output will vary from processor to processor. RVK-Basic always uses OC1 or OC1A for the PWM output.

A light dimmer

As an example of PWM control, I will write a program to control one LED on a development board. This will work on either the STK200 or STK500 boards.

What the program does is to gradually vary the brightness of the LED from off to on every 1.5 seconds. I have chosen a 2313 processor for this demonstration because it seems to be the smallest available, which has TIMER1.

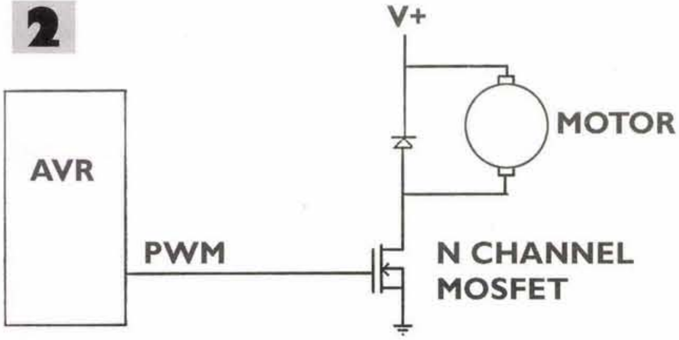
```
DEVICE 2313


    MHZ    3.68
    REVISION RB8.BAS 011202.0-rvk

    EQU "B,3","PWMOUT"
    MAKEOUT "PWMOUT"

    PWM INIT 200,8  '..8 bit counter at 400 Hz...

    DO
     INCR var
     p% = var
     PWM THRESHOLD p%
     PAUSE 6      '...0.006 * 256 = 1.5 second repetition period..
          LOOP
```

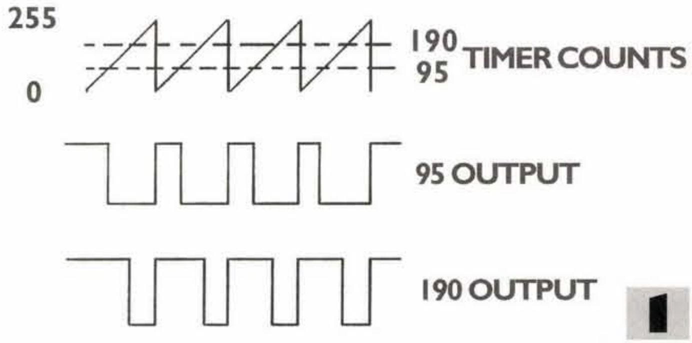
The reader is encouraged to change the INCR statement to a DECR statement and predict what the observable result will be before he actually runs the code on the development board.

The reader is also encouraged to look in the ASM file to see that the PWM INIT statement produces an output frequency of about 244 Hz. Then actually look at the PWM output from the AVR on an oscilloscope and verify its frequency.

The reader could change this program to run on a larger processor, perhaps an 8535, if he has one lying around. If so, don't forget to include an "XMEM OFF" statement for this processor. See RB.TXT for details. Also remember that OC1A comes out on pin D,5 of the 8535.

2





1

It is also very possible to produce PWM in software for situations where you might need multiple PWM outputs. Just set up a timer to free-run at as slow a repetition rate as your application can handle. Then in software, write a routine to read the timer and compare it to your PWM command value and either set or reset the appropriate output bit based on the comparison. If you call this routine at least as often as the timer changes state, you will have PWM. So it is perfectly possible to turn a lowly AT90S1200 into a PWM engine with multiple outputs.

With PWM control in hand, the reader is now considered armed and dangerous and able to control large motors with a tiny chip.

Generating and using random numbers

Christmas at my parents' house means the inevitable and perhaps interminable game of Aggravation with my sisters. This might be all fine and good except that I am convinced that one of my sisters cheats with a die. I do not understand how she consistently rolls all those sixes. So this year, I did something about it! Warm up your STK500 development board and continue reading.

Why random numbers?

The ideal die, when rolled by normal people, will randomly produce an even distribution of numbers in the range of 1 through 6 (unless my sister is rolling). Such random numbers are the very basis of many games, Aggravation being only one of them.

Random numbers are also very useful in robotics. Consider an autonomous robot faced with an obstacle directly ahead of him. Should he turn right or left? Having the robot always turn right might work, but having him randomly choose a direction is much more interesting. And why not have the robot travel for a random amount of time before turning in a random direction?

How to generate random numbers

There is a conceptually simple method of generating apparently random numbers using a shift register and feedback.

The shift register is a simple idea, implemented in RVK-Basic with a SHIFT instruction. A picture of a shift register will show you exactly how one behaves. In the following table, each successive row shows the state of the register after a shift to the left. That is, on each shift, each bit moves one position to the left and a zero is filled in the LSB (Least Significant Bit).

1	0	1	1	0	0	1	1
0	1	1	0	0	1	1	0
1	1	0	0	1	1	0	0
1	0	0	1	1	0	0	0
0	0	1	1	0	0	0	0

Clearly, if this shifting process were carried on four more times, the shift register would become filled with zeros and remain in that dull state forever. So let's introduce a rule that will save the shift register from terminal boredom.

Instead of always putting a 0 in the LSB when we shift, let's put in the exclusive OR of the two most significant bits. That way, the bit introduced in the LSB will sometimes be a 0, and other times a 1. Then the shifting table would look like the following.

1	0	1	1	0	0	1	1
0	1	1	0	0	1	1	1
1	1	0	0	1	1	1	1
1	0	0	1	1	1	1	0
0	0	1	1	1	1	0	1

In this case, it is not at all clear where the shift register is going. Remember that interesting shift registers are happy shift registers!

In theory, if we use a shift register N bits long and apply proper feedback, the register can be shifted 2^N-1 times before it repeats a single state. So, using one byte for a shift register we could get 255 different numbers from it before it repeats. A 16-bit register could give us a sequence of 65,535 apparently random numbers before it repeats. Unfortunately, it's not always quite that simple.

In the example just given, we performed an exclusive-OR on bits 7 and 6 and fed that back into bit 0. In reality, this would give a sequence length of 63, not 255. If we had chosen bits 7 and 5 we would get a length of 30, while bits 7 and 4 give a length of 217. It is a very non-trivial problem to locate which configuration of feedback points will give a maximum length sequence

For my needs for a dice simulator, I chose a 16-bit pseudo-random sequence generator (PSRG). I readily found two feedback configurations that would both give a maximum non-recursive length sequence. These are indicated in the source code for the program.

I am reproducing the program here in Listing 1. I wrote the program for an 8515 because that chip is normally supplied with each STK500 kit and it has a full eight bits for both the B and D ports.

To make the STK500 work for this program, you must plug the B port to the LEDs and the D port to the switches. (This should also work on the older STK200 boards.)

The first new thing the reader of RVK-Basic will notice is the EEDATA statement. This statement simply places a byte or more of data in the EEPROM of your chip. This data will be read later in the program. Note well, that the very first EEDATA statement assigns a label "FIRST:" to the first byte of EEPROM DATA. This will be used later as a base address when reading the data.

The EEPROM in this program contains two tables for the use of the program: referred to as "FIRST:" and "PATRN:". "FIRST:" is the table of which lights to turn on for each of the six possible results from rolling the die. A 1 indicates a lighted LED. "PATRN:" is the table of light patterns for display while the user has a key depressed. This is just a light show.

The main program is very simple. Wait for a key press, then compute a random number in the range of 1-6, then display the result.

The GETKEY routine deserves only a small comment. It waits until a key is pressed and while waiting, it continuously calls random numbers from the PRSG. This makes it impossible to predict the next number because the number depends both on the sequence produced by the PRSG and on the length of time the user holds the key down.

The RND routine simply calls the SHFGEN routine and returns a number in RND%.

SHFGEN is where the real work is done. It first uses fbmask% to look only at the bits in prsgen% which are required for feedback, then counts the number of those bits that are set and complements the actual feedback element, fb2~, each time a 1 is found. This is the equivalent of performing an exclusive-OR on all the bits indicated by fbmask%. The actual generator — prsgen% — is then shifted one left and feedback is applied to the LSB.

If you have a sister who cheats with the die at Aggravation (or Monopoly or whatever), just compile, assemble, and then download this program (both the program and the EEPROM data too) into an 8515 and you will put a stop to her shenanigans.

I found that this greatly reduced the occurrence of sixes that my sister rolled, but she still managed to win anyway. Some things never change.

I trust you will find ample use for this PRSG in many other projects, especially ones like BattleBots where your sister is not involved.

I also used the pseudo-random generator from the DICE program to create a Simple Simon program (see sidebar). In this one, the controller shows you increasingly complex patterns of lights and you are required to echo the pattern by pushing the buttons in the same order. When you get it right, lights race up and down the display. Get any but-

LISTING 1

```
DEVICE 8515
    MHZ   4
    XMEM OFF
    REVISION DICE REV. 011224.0-rvk

    DIRPORT D,IN          '..pushbuttons
    OUTPORT D,&HFF        '..set pull-up resistors

    DIRPORT B,OUT         '..LED output
    GOSUB LITEOFF         '..all LEDs off


prsgen% = &HFFFF          '..initialize pseudorandom
                          '..sequence generator
prsmsk% = &H9C00          '..initialize prs gen mask for
                          '..max length sequence
                          '..&H801C will also work...
    EEDATA FIRST:,&B00000001
    EEDATA ,&B00000011
    EEDATA ,&B00000111
    EEDATA ,&B00011011
    EEDATA ,&B01101011
    EEDATA ,&B01110111
    EEDATA ,&B01111111
    EEDATA ,&B11111111

    EEDATA PATRN:,&B01111110
    EEDATA ,&B10111101
    EEDATA ,&B11011011
    EEDATA ,&B11100111
    EEDATA ,&B11011011
    EEDATA ,&B10111101

    patcnt = 0

MAIN: DO
     GOSUB GETKEY     '..wait for new keypress ==> key
      DO
       GOSUB RND       '..get random number in rnd%
       rnd% = rnd% AND 7
       num = rnd%
       IF num > 5 THEN '..num must be 0 -5 only
       ELSE
         EXIT DO
        END IF
       LOOP
          '....now display num on lites...
       READ disp,FIRST:,num
       disp = disp XOR &HFF
       OUTPORT B,disp
       pause 300
      LOOP


'=====BEGIN GETKEY===============================
'     output: key                   =
'     uses:  gkey~                  =
'     waits for key release         =
'================================================
      STACK 2
GETKEY: DO              '...wait for any key press
       INPORT key,D
       GOSUB RND      '...scramble generator..
       IF key | &HFF THEN
        EXIT DO
       END IF
      LOOP

      DO                          '..wait for release...
       GOSUB RND                  '...scramble generator..
       INCR patcnt
       IF patcnt > 5 THEN
        patcnt = 0
       END IF
       READ temp,PATRN:,patcnt
       OUTPORT B,temp      '...display pattern while
                           '...waiting..
       PAUSE 100
       INPORT gkey~,D
       IF gkey~ = &HFF THEN
        EXIT DO
       END IF
      LOOP
RETURN
'=====END GETKEY=================================

'===BEGIN LITEOFF================================
'     output: port B                =
'================================================
      STACK 2
LITEOFF: OUTPORT B,&HFF
RETURN
'=====END LITEOFF================================


'======BEGIN RND=================================
'     output  = rnd%                =
'================================================
      STACK 2
RND:   GOSUB SHFGEN    '..shift the generator
      rnd% = prsgen%
RETURN
'======END RND===================================


'======BEGIN SHFGEN==============================
'     output  = prsgen%             =
'     uses: fb% fb2~ fb1%           =
'================================================
      STACK 2
SHFGEN: fb% = prsgen% AND prsmsk%
      fb2~ = 0
      FOR shfgn1~ = 1 to 16
       fb1% = fb% AND 1
       IF fb1% | 0 THEN
        fb2~ = fb2~ XOR 1
       END IF
       SHIFT fb%,1,RIGHT
      NEXT
      SHIFT prsgen%,1,LEFT
      IF fb2~ | 0 THEN
       prsgen% = prsgen% OR 1
      END IF
RETURN
'=====END SHFGEN=================================
```

ton wrong and the controller squawks at you by flashing all the lights. Try this on your STK500 board. By all means have your sister play the game. That will put her in her place. Better still, have my sister play the game! Happy computing! **NV**

SIMPLE SIMON PROGRAM

```
DEVICE 8515

   MHZ    3.68

   XMEM OFF
   REVISION SIMPLE SIMON REV. 020103.0-rvk

   DIRPORT D,IN            ..pushbuttons
   OUTPORT D,&HFF          '..set pull-up resistors

   DIRPORT B,OUT           '..LED output
   GOSUB LITEOFF           '..all LEDs off

   DIM lites@[20]          ..record of lite numbers...

   prsgen% = &HFFFF        '..initialize pseudorandom
                           '..sequence generator

prsmsk% = &H9C00           '..initialize prs mask for max
                           '..length sequence

                           '..&H801C will also work...

   oldkey = 0

  maxgam = 20 '...max number of lites allowed in game

MAIN:  DO
     GOSUB getnky '..wait for new keypress ==> key

     numlit = 0        '..start a new game
     DO
       INCR numlit
       IF numlit > maxgam THEN
         numlit = maxgam
       END IF

                   '.......Set up a new game......
       oldnum = 15 '...any illegal number will work
       GOSUB LITEOFF   '...clear display
       PAUSE 400
       FOR i = 1 to numlit  '...init the array lites@[]
         DO
         GOSUB GETNM7   '..get rnd number 0-7 in nm7
           IF nm7 | oldnum THEN
             EXIT DO
           END IF
         LOOP
         oldnum = nm7    '..remember last number
         ptr = i - 1
         lites@[ptr] = nm7
         GOSUB DISPNM '..display the light for nm7...
         PAUSE 400
         GOSUB LITEOFF
         PAUSE 200
       NEXT

                          '.........Play the game.........
       FOR i = 1 TO numlit
         ptr = i - 1
         curnum = lites@[ptr]
         lost = 0
         oldkey = 0
         GOSUB GETNKY '...wait for keypress into key..
         GOSUB KEYPSN '...convert key to its position
         IF key | curnum THEN
           lost = 1
           EXIT FOR
         END IF
       NEXT

                          '.......end game...............
       IF lost | 0  THEN   '...display a lost game...
         OUTPORT B,0
         PAUSE 500
         GOSUB LITEOFF
         PAUSE 200
         OUTPORT B,0
         PAUSE 500
         GOSUB LITEOFF
         IF numlit >2 THEN '...next game easier...
           numlit = numlit - 2
         END IF
       ELSE                  '...display a won game....
         temp = 1
         FOR i = 1 TO 7     '...walk light up...
           bout = temp XOR &HFF
           OUTPORT B,bout
           PAUSE 100
           SHIFT temp,1,LEFT
         NEXT
         temp = &H80
         FOR i = 1 TO 7    '..walk light down...
           bout = temp XOR &HFF
           OUTPORT B,bout
           PAUSE 100
           SHIFT temp,1,RIGHT
         NEXT
         GOSUB LITEOFF
       END IF
     LOOP
   LOOP

'=====BEGIN DISPNM===========================
'     output: port B                    =
'     input: nm7                        =
'     uses: ctrdpn~                     =
'==========================================
      STACK 2
DISPNM: bout = 1
     ctrdpn~ = 0
     DO
       IF ctrdpn~ = nm7 THEN
         EXIT DO
       END IF
       INCR ctrdpn~
       SHIFT bout,1,LEFT
     LOOP
     bout = &HFF XOR bout
     OUTPORT B,bout
RETURN
'=====END DISPNM=============================

'=====BEGIN GETKEY===========================
'     output: key                       =
'     uses:  gkey~                      =
'     waits for key release             =
'==========================================
      STACK 2
GETKEY: DO
       INPORT key,D
       GOSUB RND              '...randomize generator
       IF key | &HFF THEN
         OUTPORT B,key        '...display the key
           EXIT DO
         END IF
       LOOP
       key = key XOR &HFF

       DO                    '..wait for release...
         INPORT gkey~,D
         IF gkey~ = &HFF THEN
           GOSUB LITEOFF      '...clear the display
           EXIT DO
         END IF
       LOOP
RETURN
'=====END GETKEY=============================

'====BEGIN GETNKY============================
'     output = key                      =
'     input    oldkey                   =
'  Gets any new keystroke into key          =
'==========================================
      STACK 2
GETNKY: DO
       GOSUB GETKEY
       IF key | oldkey THEN
         oldkey = key
         EXIT DO
       END IF
     LOOP
RETURN
'=====END GETNKY=============================

'=====BEGIN GETNM7===========================
'     gets a number 0-7 into nm7        =
'     uses: nm7 temp%                   =
'==========================================
GETNM7: FOR inm7 = 1 TO 3
       GOSUB RND
     NEXT
     temp% = rnd% AND 7
     nm7 = temp%   '..random number, 0-7, in nm7
RETURN
'=====END GETNM7=============================

'=====BEGIN KEYPSN===========================
'     output: key                       =
'     input: key                        =
'     uses: kp1~ kp2~                   =
' converts position to a number. if bit 5 is  =
' pressed (key = &H20) key will become 5.     =
'==========================================
      STACK 2
KEYPSN: kp1~ = 0
     FOR kp2~ = 0 TO 7
       TEST kp3~, key, 0
       IF kp3~ | 0 THEN
         key = kp2~
         EXIT FOR
       END IF
       SHIFT key,1,RIGHT
     NEXT
RETURN
'=====END  KEYPSN============================
===

'===BEGIN  LITEOFF===========================
===
'     output: port B                    =
'==========================================
      STACK 2
LITEOFF: OUTPORT B,&HFF
RETURN
'=====END  LITEOFF===========================
===

'======BEGIN RND=============================
'     output  = rnd%                    =
'==========================================
      STACK 2
RND:   GOSUB SHFGEN    '..shift the generator
       rnd% = prsgen%
RETURN
'======END RND===============================

'======BEGIN SHFGEN==========================
'     output  = prsgen%                 =
'     uses: fb% fb2~ fb1%               =
'==========================================
      STACK 2
SHFGEN: fb% = prsgen% AND prsmsk%
     fb2~ = 0
     FOR shfgn1~ = 1 to 16
       fb1% = fb% AND 1
       IF fb1% | 0 THEN
         fb2~ = fb2~ XOR 1
       END IF
       SHIFT fb%,1,RIGHT
     NEXT
     SHIFT prsgen%,1,LEFT
     IF fb2~ | 0 THEN
       prsgen% = prsgen% OR 1
     END IF
RETURN
'=====END SHFGEN=============================
```

Events 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, name of the person to contact, and phone number. While we strive for accuracy in our calendar, we cannot 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.

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Phone 909-371-8497
Fax 909-371-3052
Email
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Aug-Oct

AUGUST 2002

AUGUST 2-3-4

OH - MIDDLEBURG HEIGHTS - Convention. Buckeye Belles, 440-327-3832. Email: kc4iyd@arrl.net Web: www.geocities.com/kc4iyd
OR - PORTLAND - Convention. Willamette Valley DX Club, 360-256-7437. Email: k7ar@arrl.net Web: www.wvdxc.org

AUGUST 3

MI - ALPHA (UPPER PENINSULA) - Hamfest. Iron Range ARC, 906-875-3803
NY - ITHACA - Hamfest. Tompkins County ARC, 607-257-6066. Email: jdreid@lightlink.com Web: www2.compcenter.com/~tcarc/
OH - COLUMBUS - Hamfest. Voice of Aladdin ARC, 614-846-7790. Email: kb8kpj@cs.com
PA - LEWISTOWN - Hamfest. Decatur Township Fire Co. grounds. JVARC & the Decatur Township Fire Co. 717-242-1882

AUGUST 3-4

KY - LEXINGTON - Convention. National Guard Armory. Bluegrass ARS, Inc., 859-253-1178. Email: jrbarnes@iglou.com
OH - CAIRO - Hamfest. Cairo Community Center. Northwest OH ARC, 419-641-5623. Email: w6mdn@hotmail.com

AUGUST 4

NY - WILLIAMSVILLE - Convention. Lancaster ARC, 716-683-8880. Email: luke@towncountryflorist.com Web: http://hamgate1.sunyerie.edu/~larc

AUGUST 10

IL - QUINCY - Hamfest. Western IL ARC, 217-222-4467. Email: w9awe@arrl.net Web: www.qsl.net/w9awe
MI - JACKSON - Hamfest. Jackson Community College. CARS, Inc., web: www.w8jxn.org
WI - BARABOO - Circus City Swapfest. Sauk County Fairgrounds, Hwy. 33. Yellow Thunder ARC, Inc., 608-356-2313, email n9udo@arrl.net or 608-643-6908 days, 608-643-6453 eves. Web: www.qsl.net/ytarc/hamfest.htm

AUGUST 11

IA - AMANA - Hamfest. 38th Ave., Summerfest grounds. 319-247-0558 eves. Email: kc0ek@mchsi.com Web: www.cvarc.rf.org
IL - PEOTONE - Hamfest. Hamfesters Radio Club, 708-756-7984. Email: wb9wfr@arrl.net Web: www.hamfesters.org
IN - GREENTOWN - Hamfest. Kokomo & Grant County ARCs, 765-668-4814. Email: k9nqw@arrl.net Web: www.grantarc.com/greentown.html
MD - WESTMINSTER - Hamfest. Carroll County Ag Center, Email: n3sb@qis.net Web: www.qis.net/~k3pzn/tailgate.htm
PA - MATAMORAS - Hamfest. Matamoras Airport Park. Tri-State Amateur Radio Assn., 570-491-4808. Web: www.qsl.net/k3tsa/
PA - SHREWSBURY - Hamfest. Email: w3pn@yahoo.com

AUGUST 16-17-18

CA - ESCONDIDO - Convention. San Diego AR Council, 858-566-8887. Email: gwroos@aol.com Web: www.hamcon.net/sd2002/index.html

AUGUST 17

FL - FT. PIERCE - Hamfest. Indian River Community College, 3209 Virginia Ave. 561-465-5204, email: KD4SPW@arrl.net
KS - CHANUTE - Hamfest. Zion Lutheran Activity Center, 1202 W. Main. Chanute Kansas AARC, 620-431-6402 or 620-431-0930.
OH - FRIENDSHIP - Hamfest. Portsmouth Radio Club, 740-456-1616. Email: kj8ww@zoomnet.net

AUGUST 17-18

AL - HUNTSVILLE - ARRL Alabama Section Convention. Von Braun Center, 700 Monroe St. 256-880-8004. Web: www.hamfest.org

AUGUST 18

IN - LAFAYETTE - Hamfest. Tippecanoe Country Fairgrounds. Tippecanoe ARA, 765-743-8305. www.w9reg.org
MA - CAMBRIDGE - Hamfest. MIT Radio Society/Harvard Wireless Club/MIT UHF Repeater Assn., email: w1gsl@mit.edu (617-253-3776 9am-5pm.) Web: http://web.mit.edu/w1mx/www/swapfest.html
OH - WARREN - Hamfest. Trumbull Campus Kent State Univ. Work Force Bldg. Warren ARA, 330-847-8478. Email: mccaman@cboss.com Web: www.onecom.net/wara/

AUGUST 24

IN - LAPORTE - Hamfest. County Fairgrounds. LPARC, 219-324-7525. Web: www.k9jsi.org

AUGUST 24-25

MA - BOXBORO - Convention. Holiday Inn Conference Ctr. ARRL New England Division. www.boxboro.org

AUGUST 25

IL - CATLIN - Hamfest. VCARA Communications Center, Harrison

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Web: ncshows.com

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Web: www.petertrapp.com

Park W. Addition.
Email: VCARA@Talk.to
MI - LAPEER - Hamfest. Lapeer Center Bldg., 425 County Center Dr. LCARA, 810-245-3907,
Email: w8lap@arrl.net
Web: www.w8lap.com

AUGUST 31-SEPTEMBER 1

NC - SHELBY - Hamfest. Cleveland County Fairgrounds. SARC, 704-462-4910.
Email: w4jl@shelby.net

SEPTEMBER 2002

SEPTEMBER 7

KY - LOUISVILLE - Hamfest. Bullitt County Fairgrounds. Greater Louisville Hamfest Assn., Inc., 812-294-4905. Email: wd4ixl@juno.com
Web: www.thepoint.net/~glha
NY - BALLSTON SPA - Hamfest. Saratoga County Fairgrounds. Saratoga County RACES Assn., Inc., 518-587-2385.
Email: lake@capital.net
PA - BARTONSVILLE - Hamfest. Monroe County Vo-Tech. Eastern PA ARA & Pocono AR Klub, 570-424-2174. Web: www.qsl.net/n3is

SEPTEMBER 8

OH - FINDLAY - Hamfest. 419-423-3402

SEPTEMBER 13-14-15

IL - PEORIA - Hamfest. Exposition Gardens Fairgrounds, 1601 W. Northmoor Rd. 309-692-3378.
Email: w9uvi@arrl.net
Web: www.w9uvi.org

SEPTEMBER 14

MI - GRAND RAPIDS - Hamfest. Forest Hills Northern High School. GRARA, 616-458-9029.
Email: hamfest@w8dc.org
Web: www.w8dc.org/swap.htm

SEPTEMBER 15

MA - CAMBRIDGE - Hamfest. MIT Radio Society/Harvard Wireless Club/MIT UHF Repeater Assn., email: w1gsl@mit.edu (617-253-3776 9am-5pm.) Web: http://web.mit.edu/w1mx/www/swapfest.html
NY - BETHPAGE - Hamfest. Briarcliffe College. LIMARC, 516-520-9311. Web: www.limarc.org

SEPTEMBER 21

FL - NEW PORT RICHEY - Hamfest. New Port Richey Recreational Center, 6630 Van Buren Rd. Suncoast ARC, 727-848-0353. Email: trobin@homemail.com
PA - SCHNECKSVILLE - Hamfest. Schnecksville Fire Dept. The Delaware-Lehigh ARC, Inc., 610-258-9802.
Email: malcolm4@ptd.net
http://www.dlarc.org

SEPTEMBER 21-22

IL - GRAYSLAKE - Radio Expo. Lake County Fairgrounds. Chicago FM Club,
Web: www.chicagofmclub.org

SEPTEMBER 22

CT - NEWTOWN - Hamfest. Edmond Town Hall. Candlewood ARA, 203-438-6782.
Email: w1jma@aol.com
OH - BEREA - Hamfest. Cuyahoga County Fairgrounds. Hamfest Assn., of Cleveland, Inc., 216-999-7388 or 1-800-CLE-FEST. Email: info@hac.org Web: www.hac.org

SEPTEMBER 28

NJ - LAWRENCEVILLE - Hamfest. NJ National Guard Armory, Eggerts Crossing Rd. DVRA, 609-882-2240.
Email: abbott0903@aol.com
Web: www.w2zq.com

NY - HORSEHEADS - Hamfest. Chemung County Fairgrounds. ARAST, Inc., 607-738-6857. Email: info@arast.org Web: www.arast.org

SEPTEMBER 28-29

VA - VIRGINIA BEACH - Hamfest. Pembroke Mall. Email: hamfest@exis.net Web: www.vahamfest.com

OCTOBER 2002

OCTOBER 6

IA - WEST LIBERTY - Hamfest. Muscatine County Fairgrounds. ICARC, 309-537-3678. Email: kc0aqs@qsl.net Web: www.qsl.net/kc0aqs

IN - BEDFORD - Hamfest. Lawrence Co. Fairgrounds. 812-849-0095. Email: chairman@hoosierhillshamfest.org Web: www.hoosierhillshamfest.org

OH - MEDINA - Hamfest. County Career Center, 1101 W. Liberty St. Medina Hamfest Committee, 330-273-1519 after 7pm. Email: n8tzy@m3net.net

OCTOBER 12

NJ - WASHINGTON TOWNSHIP - Hamfest. Westwood Regional Jr/Sr High School, 701 Ridgewood Rd. BARA, 201-664-6725. Email: k2zo@arrl.net Web: www.bara.org

TX - DENTON - Hamfest. Denton Civic Center, 321 E. McKinney St. Denton County ARA, 940-390-5338. Email: kd5kjz@yahoo.com

OCTOBER 19

FL - JACKSONVILLE - Hamfest. Morocco Shrine Auditorium, 3800 S. St. Johns Bluff Rd. Greater Jacksonville Hamfest Assn., 907-269-8714. www.jaxhamfest.com

FL - ORLANDO - Hamfest. Bahia Shrine Center, 2300 Pembrook Dr. Bahia Shrine, Bob KG4ECC, 407-834-9481

MI - SAULT STE. MARIE - Hamfest. Chippewa County Fairgrounds. Eastern Upper Peninsula Amateur Radio, 906-635-0215. Email: wa8old@sault.com

TN - OAK RIDGE - Hamfest. Fraternal Order of Eagle's Bldg., 1650 Oak Ridge Tpke. Oak Ridge ARC, 865-670-1503. Email: d.bower@ieee.org

OCTOBER 20

IL - GODFREY - Hamfest. Lewis & Clark Community College. Lewis & Clark RC, 618-462-4212. Email: n9fhh@exi.com

MA - CAMBRIDGE - Hamfest. MIT Radio Society/Harvard Wireless Club/MIT UHF Repeater Assn., email: w1gsl@mit.edu (617-253-3776 9am-5pm.) Web: http://web.mit.edu/w1mx/www/swapfest.html

NY - QUEENS - Hamfest. NY Hall of Science parking lot, Flushing Meadow Corona Park, 47-01 111th St. The Hall of Science Amateur Radio Club, 718-898-5599. Email: WB2KDG@Bigfoot.com

PA - SELLERSVILLE - Hamfest. Fire House, Rt. 152. RH Hill ARC, 215-679-5764. Web: www.rfhill.ampr.org

OCTOBER 26

MN - ST. PAUL - Hamfest. Touchstone Energy Place, Rivercentre. 763-535-0637. www.hamfestmn.org

MO - KIRKWOOD - Hamfest. Community Center, 111 S. Geyer Rd. St. Louis ARC & Gateway to Ham Radio, 314-638-4959. Email: slw@partyline.net

OCTOBER 27

MD - WESTMINSTER - Hamfest. Carroll County Ag Center, Email: n3sb@qis.net Web: www.qis.net/~k3pzn/tailgate.htm

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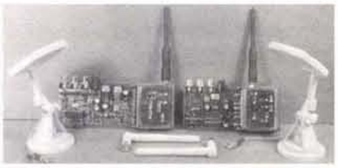

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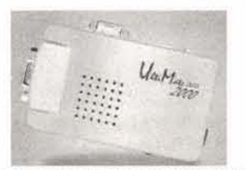

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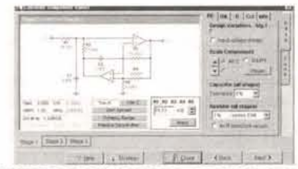

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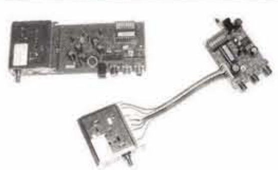

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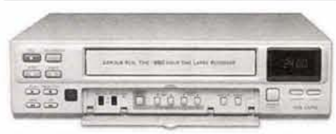

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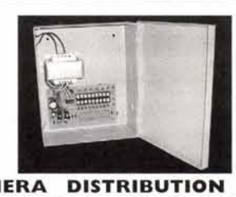

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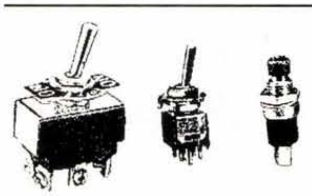

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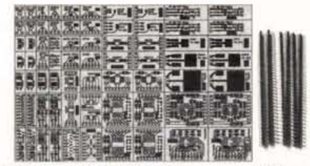

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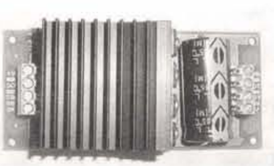

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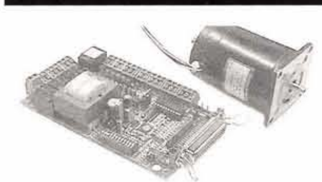

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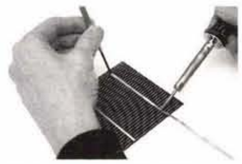

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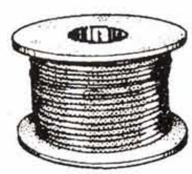

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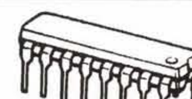

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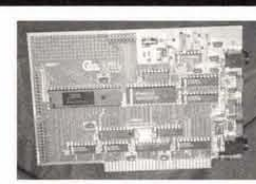

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September Is Back-To-School Time

By Gordon West

... You get to write next year's Technician test ...

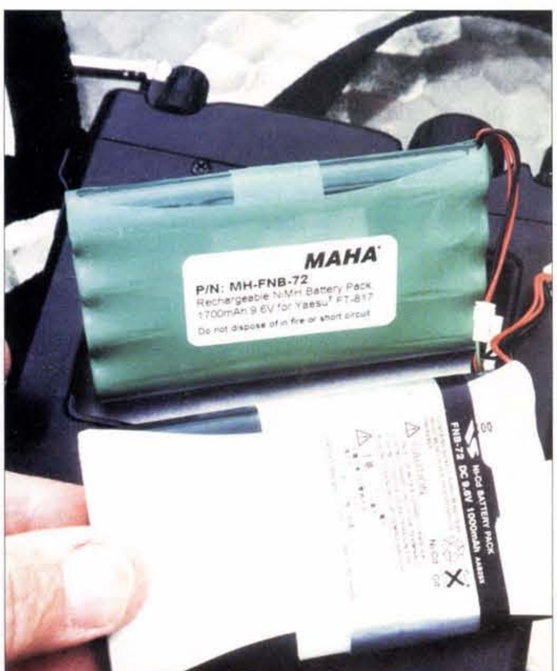
Federal Communications Commission (FCC) Rule 97.503(b) indicates that a written examination for an entry-level ham license and an upgrade must be constructed as to prove that the examinee possesses the operational and technical qualifications required to properly perform the duties of an amateur service licensee. FCC Rule 97.507(b) states that each question set administered to an examinee must utilize questions from the applicable question pool. FCC Rule 97.523 indicates that it is the responsibility of all of the Volunteer Examiner Coordinators to cooperate in maintaining the question pools, and this responsibility is carried out in the VEC's Question Pool Committee (QPC).

The QPC is presently soliciting Technician class Element 2 questions and answers from the general public and ham radio operators for the new Technician class entry-level test that goes into effect July 1, 2003.

The process of rewriting an entire examination is enormous. It is carried out by the following QPC members:

- Scotty Neustadter W4WW, Chairman
- Bart Jahnke W9JJ
- Fred Maia W5YI
- John Johnston W3BE

The submission of new-ham, entry-level, Technician class, Element 2 questions for consideration by the QPC must be accomplished immediately! Licensed ham operators who wish to submit questions or suggestions to the QPC may do so at **qpc@arrl.org**. This will send their proposed questions and/or suggestions to all of the committee, and the QPC indicates they have received some initial inputs on the proposed question pool syllabus, and are hopeful they will get more input to the actual question writing.



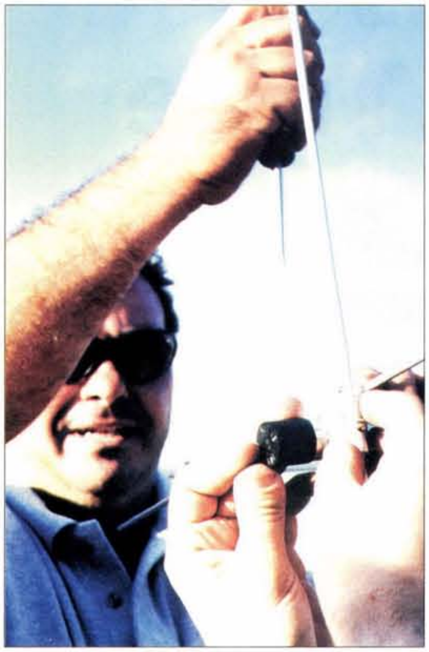
Maybe some test questions on how long portable batteries last ...

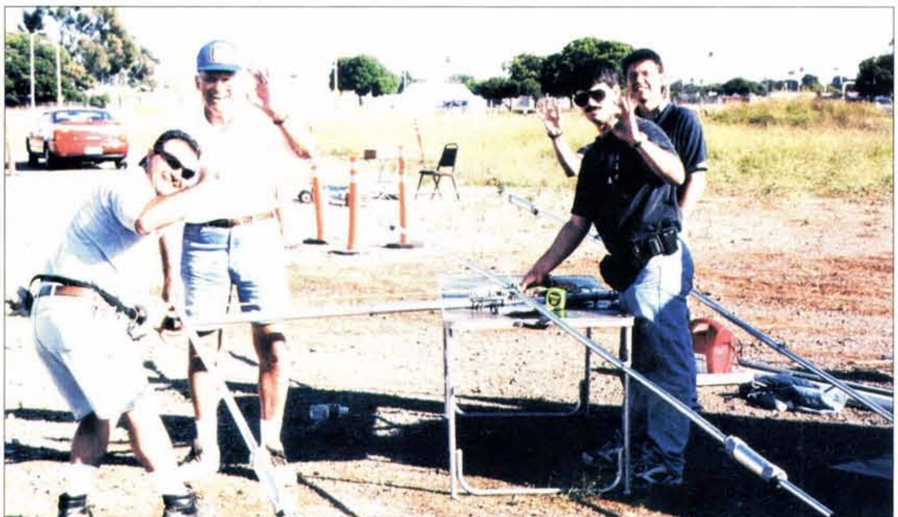
Write questions about guest operations at another ham station. Gordo (left) at the United Nation's station.

The proposed draft syllabus for the new Element 2 amateur radio examination was released for public comment a few months ago with a closing date of May 9, 2002. The closing date for question input to the QPC is August 31, 2002. This leaves us with not much time to get busy creating new, fresh, entry-level, Technician class questions that will fit into the following subelement sections:

Subelement T1	FCC Rules, five questions on the examination
Subelement T2	Methods of Communication, two questions on the examination
Subelement T3	Radio Phenomena, two questions on the examination
Subelement T4	Station Licensee Duties, three questions on the examination
Subelement T5	Control Operator Duties, three questions on the examination
Subelement T6	Good Operating Practices, three questions on the examination
Subelement T7	Basic Communications Electronics, three questions on the examination
Subelement T8	Good Engineering Practice, six questions on the examination
Subelement T9	Special Operations, two questions on the examination
Subelement T0	Electrical, Antenna Structure and RF Safety Practices, six questions on the examination

For every one possible test question on the exam, the pool may contain up to 10 possible questions to study. With 35 test questions, the pool must contain at least 350 test questions. You may see the draft syllabus in detail with additional explanations of each group by logging onto the ARRL web page at www.arrl.org.





Write some test questions on antenna assembly techniques.

Double-check the date that questions are due and make sure you are within the time frame for your question and four possible answers to be considered. FCC Rule 97.507(b) indicates that General and Technician class operators may prepare question sets for Element 2 exams. Grandfathered Advanced class operators and Extra class operators may also submit test questions.

If you're not a licensed amateur operator, I encourage you to take part in this Technician class examination rewrite by logging onto the ARRL web page, downloading the new Element 2 syllabus, and emailing the Question Pool Committee at qpc@arrl.org. Your suggestions to the committee will certainly be appreciated since they are coming from someone with a technical background who has not yet passed their entry-level Technician class ham test. So even though you are not a licensed amateur operator, your suggestions to the overall question pool for obtaining a brand new ham license will certainly be reviewed.

Suggested questions should specifically spell out exactly where in the syllabus the question is intended. The question is emailed to the QPC in your own words, as clear and as short as possible. You would then supply four multiple-choice answers which places a heavy burden on the author. It requires writing one absolutely correct answer, and three absolutely wrong, but very plausible, answers.

Further, each question and answer set must also indicate where the QPC may look up a reference to this question for authentication. This is a job in itself; and unless the question you submit is really off the wall, I wouldn't worry about pouring over a textbook to find an exact match. Just get the question and four possible answers into the QPC within the time frame.

If you wish to view the present Element 2 entry-level Tech test, you can see it at www.hamtest.com, or www.arrl.org/arrlvec/pools.html.

John Johnston of the QPC comments, "... The questions should be such as to encourage learning of the material. Making the questions harder than required not only discourages possible candidates, it encourages rote memorization of the correct answers. An increasing number of successful examinees appear to openly admit they learned nothing from the qualifying examination experience. This development could be the underlying reason why there is so much concern about the exam being dumbed down." Johnston was formerly with the FCC and helped construct the brand new Element 2 entry-level examination syllabus with Fred Maia W5YI.

"The questioners, apparently, do not accept the notion that memorizing the answers to a series of questions is a valid way to learn how to operate an amateur station properly," adds Johnston, who wants to encourage all licensed ham operators to beat the deadline and propose new entry-level Element 2 Technician class questions that will replace old Element 2 Tech questions due to expire June 30, 2003.

So the new July 1, 2003, entry-level Tech test depends on input from both licensed amateur operators, as well as suggestions from those of you with a technical background who have yet to take your entry-level exam. The QPC members are a divergent group of individuals with backgrounds ranging from rocket scientists to retired FCC G-men. The committee, in my opinion, has become so rigid in the past to work with new ideas that all of the present question pools have become stagnant. For the past several years, each question pool receives a topical review and small change here and there, but no pool in the past — under the control of the QPC — has ever undergone a complete rewrite that is now before us for our comments, suggestions, and new-question input. The Question Pool Committee must spend hundreds of collective hours pouring over the old and newly suggested questions, all this without pay and in between their normal work week. While any and all questions are appreciated, the QPC asks each question submitter to review the style of how old questions and answers have been incorporated in the old pool, and follow this style for new questions and answers. The more professional your question input, the greater chance of that question appearing on next year's entry-level examination.

If ever you wanted to make a difference on the ham radio entry-level

Write some test questions on RF safety procedures — very important on microwave X band frequencies.

How to Submit Suggested Element 2 Questions.

(1) All proposed questions must be no longer than 210 characters including spaces and punctuation. (Three lines of 70 characters each.) This requirement exists to facilitate implementation of computer testing and use of software-generated examinations by VE teams. Try to be concise as much as possible.

(2) Each question must be accompanied by four possible multiple-choice answers only one of which is correct. Be certain that the three incorrect answers are definitely wrong and cannot be construed as correct. Each multiple choice answer is limited to 140 characters. (Two lines of 70 characters.)

(3) Include any schematic diagrams or symbols that are necessary to answer the question. It is desirable to have more than one question relating to a single diagram. A text-only version of the question also would be helpful for use in examinations for the sight impaired.

(4) The question comprehension level should be on the Middle or Junior High School reading and math skills level. Remember that many youngsters are administered the beginning Technician Class examination.

(5) It is very helpful to include a reference from a published source confirming the correct answer. Questions on FCC Rules should reference the appropriate regulation.

(6) All suggested questions should be on the topics included in the syllabus (outline) listed here. Indicate the "Subelement" and "Topic" number at the top of the question. For example, a question on Ohms Law would list "Subelement: T7, Topic: T7A" above the question.

(7) Here is an example of a properly submitted question:
Subelement: T7, Topic: T7A
Correct Answer: D
Reference: Part 97.3(b)(6)

What is the term for the average power supplied to an antenna transmission line during one RF cycle at the crest of the modulation envelope?

A. Peak transmitter power
B. Peak output power
C. Average radio-frequency power
D. Peak envelope power

(8) If you are offering a suggested revision to an existing question, indicate the number of the question your are revising. The current Element 2 question pool may be found at: www.arrrl.org/arrlvec/pools.html.

(9) Suggestions for new multiple choice questions should be directed to each of the following four QPC members:
Scotty Neustadter W4WW — w4ww@arrl.net
Bart Jahnke W9JJ — vec@arrl.org
Fred Maia W5YI — w5yi@w5yi.org
John Johnston W3BE — Johnston.John1@worldnet.att.net

The ten topics and questions currently in effect are:

(1) FCC rules, nine questions; **(2)** Operating procedures, six questions; **(3)** Radio propagation, three questions; **(4)** Amateur radio practices, four questions; **(5)** Electrical principles, three questions; **(6)** Circuit components, two questions; **(7)** Practical circuits, two questions; **(8)** Signals and emissions, two questions; **(9)** Antennas and feed lines, two questions; and **(10)** Radio frequency safety, three questions. (Total: 35 questions)

The ten topics in new Element 2 syllabus are:

(1) FCC rules, five questions; **(2)** Methods of communication, two questions; **(3)** Radio phenomena, two questions; **(4)** Station licensee duties, three questions; **(5)** Control operator duties, three questions; **(6)** Good operating practices, three questions; **(7)** Basic communications electronics, three questions; **(8)** Good engineering practice, six questions; **(9)** Special operations, two exam questions, and **(10)** Electrical, antenna structure, and RF safety, six questions. (Total: 35 questions.)

There will be approximately 350 to 400 questions in the new Element 2 pool. It will be released to the public on December 1, 2002 and the new Element 2 questions must be used in all Technician Class examinations administered on or after July 1, 2003.

examination beginning next July 1, 2003, *now is the time.* You have only a few days to meet the deadline for submitting your new Element 2 Technician class questions and answers to the Question Pool Committee. If every ham submitted just one or two questions for the entire pool, the QPC would have more than enough material to work with.

Let's hear from you all, ham and non-ham alike! **NV**

NEW EXTRA CLASS STUDY MATERIALS

Gordon West WB6NOA announces the release of his new Extra class Element 4 FCC license preparation book and six long-play audio cassettes. Both the book and tapes cover the new Extra class test questions effective July 1, 2002, through June 30, 2006.

"My book and tapes will instantly explain that the new longer Extra class question pool is absolutely no harder to learn than the original question pool," comments West, well known for his humorous style of amateur radio and commercial radio training books and audio cassettes.

"The all new Extra class test is actually easier to prepare for because some of the complicated old questions were eliminated, and all new questions are actually reworked Advanced class and old Extra class questions," adds West, who has identified the most new questions on the Extra class test as the simple new rules and regulation topics.

The West six-tape audio course parallels the book and adds all of the radio sounds behind many topic areas within the question pool. You will hear the sounds of PSK-31, get a laugh out of some repeater calls, and you won't believe your ears when you hear the incredible sounds of phantom voices bouncing off an aurora.

The book and tapes cover all 801 questions, answers, and an upbeat description of the correct answer. West also reveals some of his classroom secrets on how to spot many of the technical correct answers before you begin to work out the problems on your calculator. All calculator keystrokes are clearly explained for those hams who may be a little rusty with trigonometry!

"I make the learning process fun — passing the Extra class test is simply a formal pre-requisite to the real learning that takes place after our students get onto their new privileges on the airwaves," adds West, best known for his training of eight out of 10 newly licensed hams and upgrade students with his nationwide classes, books, and audio tapes over the past 35 years.

All Gordon West training materials are published by **Master Publishing, Inc.**, and all of his materials are available at ham radio dealers throughout the country and mail order from the W5YI Group by calling 1-800-669-9594. Gordon West Technician and General class books for beginners are available at all RadioShack stores throughout the country.

West regularly travels throughout the country attending hamfests and offering training classes, and his on-the-air activities exemplify his active participation in the amateur radio service.

Part 1: Baseband Communications

by Louis E. Frenzel

Open Communication

HOW TO PUT 10 POUNDS INTO A FIVE-POUND BAG Or Squeezing Higher Data Rates Into Narrower Bandwidths

Today, most communications and all networking are done digitally. The main exceptions are conventional telephones, AM/FM/TV broadcasting, and most two-way radio. But plans are already under way to make these digital before long. Most new cell phones use digital technology for voice. High definition (digital) TV is here now. Satellite TV is digital as are the new satellite car radios. And we will soon be getting Voice over IP (Internet Protocol) phones that transmit voice in digital packets via the Internet.

The essence of all this digital transmission technology is that information (voice, video, etc.) is translated into digital form and sent serially over some communications medium. The medium can be a twisted-pair cable, a coax cable, a fiber optic cable, or free space radio waves. Whatever.

The key specification of any data transmission system is speed, that is, how fast the bits can be streamed out over the transmission medium. And it is the bandwidth of the medium that really limits how fast the data can be transmitted. Bandwidth refers to the range of frequencies that the medium covers.

This article and the one to follow, explain how maximum speed is obtained with minimum bandwidth. **And you really need to know this**! The concept of how bandwidth and data rate are related is fundamental to the understanding of all modern communications systems and products. And knowing this explains so much about what is going on in all communications devices and services whether it is cell phones, home networks enterprise networks, wireless radio, or the Internet. The really good news is that if you know this, all the future columns here and articles on communications in this magazine will be easier to understand and enjoy.

In this first part, "Baseband Communications," I explain about digital data, data rate, bandwidth, and how data is transmitted directly over a cable. In the second part (which will appear in the October issue), "Broadband Communications," I cover modulation techniques that not only speed up data on cables, but also make high-speed wireless data transmission possible.

Digital Data

Data communications take place by sending the binary 1s and 0s serially (one bit at a time) over some transmission medium like a cable or by radio. Figure 1 shows how the eight-bit word 10101100 is sent electronically with two voltage levels. The key characteristic of this serial bit-by-bit scheme is the data rate or speed of transmission. Data rate is expressed in terms of bits per second (bps), kilobits per second (Kbps), megabits per second (Mbps), or gigabits per second (Gbps). This speed or data rate is directly related to the time of occurrence of one bit (t).

Data rate = 1/t

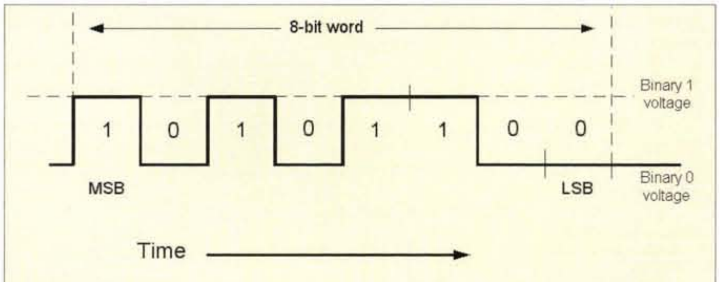


Figure 1. A binary serial data signal. Each bit is transmitted one at a time. This one shows the most significant bit (MSB) being transmitted first, but in some schemes, the least significant bit (LSB) is sent first.

If the bit time is 1 microsecond (1×10^{-6}), then the data rate is

Data rate = $1/1 \times 10^{-6}$ = 1,000,000 bps or 1 Mbps

If you happen to know the data rate and want to know the bit time, you just rearrange the formula:

t = 1/data rate

A data rate of 9600 bps has a bit time of

t = 1/9600 = .000104 second or 104 microseconds (µS)

A good way to analyze a serial data stream like this is to assume alternating binary 0s and 1s so the signal looks like that in Figure 2. You can see that adjacent bits form one cycle (one positive pulse and one zero period) of a squarewave. The total time for this cycle (T) is called the period of the wave and is equal to two bit times or T = 2t. If we have a signal with a data rate of 50Kbps, the bit time is 20 microseconds. The period T then is 40 microseconds. Remembering the relationship between period and frequency — f = 1/T — you can quickly figure out that we are dealing with a squarewave with a frequency of

f = $1/(40 \times 10^{-6})$ = 25,000 Hz or 25 kHz

Now, the big question is how much bandwidth does it take to transmit this signal with minimum distortion and attenuation (loss)? Duh ... what is bandwidth?

Bandwidth

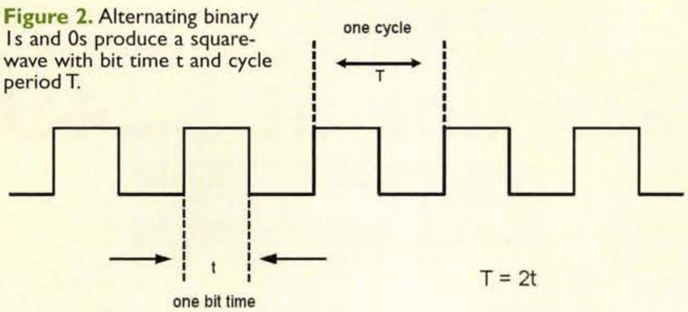
Bandwidth is the frequency range passed by a given circuit or medium. Or it refers to the amount of frequency spectrum occupied by a specific signal, like the squarewave we just discussed. It is equal to the difference between the upper and lower cut-off frequencies of the circuit. BW = (f2 - f1). See Figure 3. The lower (f1) and upper (f2) cut-off frequencies are those frequencies where the output voltage drops to 70.7% of its value over the pass band. Also known as the half-power or 3 dB sown points, these frequencies define the upper and low limits of the circuit bandwidth.

For instance, bandwidth is the same as the frequency response of a circuit. A stereo amplifier may have a frequency range from 30 Hz to 22000 Hz. The bandwidth is 22000 - 30 = 21970 Hz. Or, we can just round this off to 22000 Hz or 22 kHz. The amplifier passes audio signals with frequencies in this range.

Or consider the bandwidth of the ordinary telephone line which is from about 300 to 3000 Hz. That is a bandwidth of 3000 - 300 = 2700 Hz. The frequency of voice fits in this range.

A low pass filter, or one that passes all frequencies up to an upper cut-off value including DC or 0 Hz, has a bandwidth equal to the upper cut-off frequency. An example is a voice filter that cuts off all frequencies over 4 kHz. Its

Figure 2. Alternating binary 1s and 0s produce a squarewave with bit time t and cycle period T.



bandwidth is 4000 - 0 = 4000 Hz or 4 kHz.

In radio or wireless, the bandwidth refers to the amount of electromagnetic spectrum assigned to a specific service. AM radio stations get 10 kHz, FM stations get 200 kHz, and TV stations get 6 MHz of bandwidth. Cell phones get 30 kHz, 270 kHz, or 1.25 MHz depending upon the type of system used.

Oh No ... Not Fourier!!

Okay. You now know about the speed of serial binary signals and bandwidth. Now let's put them together to see how they are related.

If you ever had any formal education in electronics, you have probably heard about the Fourier theory. Back in the 1700s, this French guy Fourier figured out that any non-sinusoidal wave can be described as being made up of a sinewave (called the fundamental) with a frequency equal to that of the frequency of the non-sinusoidal wave to which has been added one or more harmonic waves.

A harmonic is a sinewave that is some integer multiple of fundamental. For example, the second harmonic of a 1 kHz fundamental sinewave is a 2 kHz sinewave, the fifth harmonic is a sinewave with a frequency of 5 kHz, and so on. Fourier provided us with some higher level math that lets us figure out just what the frequency content is for any given non-sinusoidal wave.

The squarewave or alternating 1s and 0s we talked about earlier (Figure 2) is a classical Fourier case. It is made up of a fundamental sinewave to which has been added an infinite number of odd harmonics (3, 5, 7, etc.). Think of it as a signal generated by multiple signal generators all connected in series so that all the different sinewaves add together algebraically in phase. The composite output wave is the squarewave.

The higher frequency harmonics are responsible for the fast rise and fall times of the squarewave. But as it turns out, the higher harmonics have such low amplitude that we usually ignore them since they have such a small influence on the actual shape of the composite signal. Yet, when you see a squarewave, you should automatically think Fourier. That is, don't just see a squarewave, instead, imagine that what you have is a bunch of harmonically related sinewaves traveling together. The best way to visualize this is in the frequency domain as Figure 4 illustrates. (See the sidebar on Time vs. Frequency Domains.)

Now, here is the point. If you want to transmit or amplify this squarewave, the transmission medium or amplifier must pass not only the fundamental sinewave, but most of the harmonics. Good squarewave transmission or amplification results if at least the 7th to 9th harmonics are passed.

Going back to the 50 kbps signal described earlier, remember that its frequency is 25 kHz. Let's assume that we get a good squarewave if we transmit up to the 7th harmonic or 7 x 25 kHz = 175 kHz. What this means is that the bandwidth of your transmission medium or amplifier must be at least 175 kHz. This is a pretty wide bandwidth. Bummer ...

If you limit the bandwidth by cutting off the higher harmonics, what happens is that the signal becomes rounded off. The rise and fall times of the squarewave increase and the abrupt changes of voltage levels are smoothed over resulting in a signal that looks more analog than digital. Figure 5 shows what happens as the upper cut cut-off frequency is lowered and bandwidth is narrowed. If you reduce the bandwidth to a frequency equal to the signal frequency, you effectively eliminate all harmonics from the output resulting in a sinewave of that frequency, in our case here 25 kHz.

In communications electronics, the major goal is more bandwidth. But so often, the case is we have no control over the bandwidth. We take what the cables give us or the spectrum assigned to us by the FCC.

You should realize that nearly all transmission media such as cables and most electronic circuits essentially act as low pass filters. All have some upper cut-off frequency because of the circuit or media characteristics. If that cut-off frequency is too low compared to the frequency content of the signal you are transmitting or amplifying, you eliminate or at least greatly attenuate the higher order harmonics and therefore distort the signal.

A quick, simple measure of the upper cut-off frequency and bandwidth of a circuit or medium is to put a squarewave with a very fast rise time through it. Remember that the rise time (t_r) of a rectangular wave is the time it takes the signal to rise from its 10% amplitude point to its 90% amplitude point as Figure 6 shows. Then, measure the rise time of the squarewave at the output of the circuit or medium with an oscilloscope. Plug the output rise time value into the formula below to get the real bandwidth.

$$BW = .36/t_r$$

If the measured rise time is 80 nanoseconds, the bandwidth of the medium or circuit is:

$$BW = .36/(80 \times 10^{-9}) = 4.5 \text{ MHz}$$

To summarize the basic principle here, we can say that the wider the bandwidth, the higher the data speed can be before the filtering action of the medium or circuit rounds off the signal into a sinewave and begins attenuating the daylights out of it.

Narrower bandwidths can only accommodate lower frequencies and slower data rates. Limit the bandwidth and you limit the speed. This is important to know because invariably it seems like virtually anything you do in electronics tends to limit or reduce bandwidth.

On the other hand, electronics is an on-going quest for higher speeds. Every engineering design battle being fought today has to reconcile this speed-bandwidth trade-off.

What Shannon Discovered

Earlier, we said that if the bandwidth was equal to 25 kHz, we could transmit a 50 kbps signal through it although the output will be a sinewave rather than a squarewave. Nevertheless, we could rejuvenate this signal by squaring it up in comparator or Schmitt trigger. This relationship holds up for any bandwidth and speed so we can express it mathematically as

$$C = 2B$$

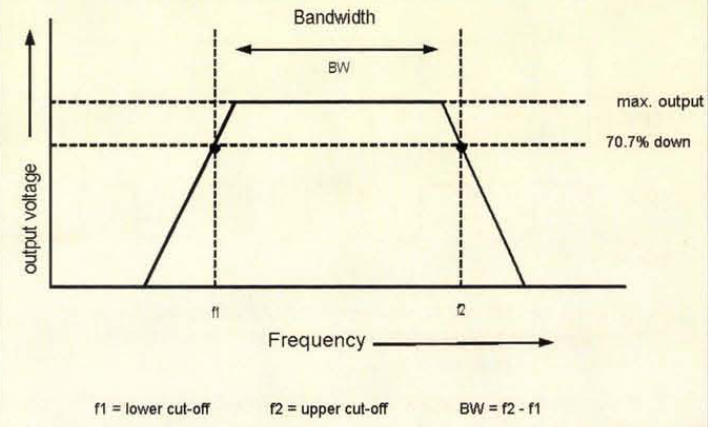


Figure 3. Bandwidth is the range of frequencies covered by a circuit or transmission medium and is the difference between the upper and lower cut-off frequencies.

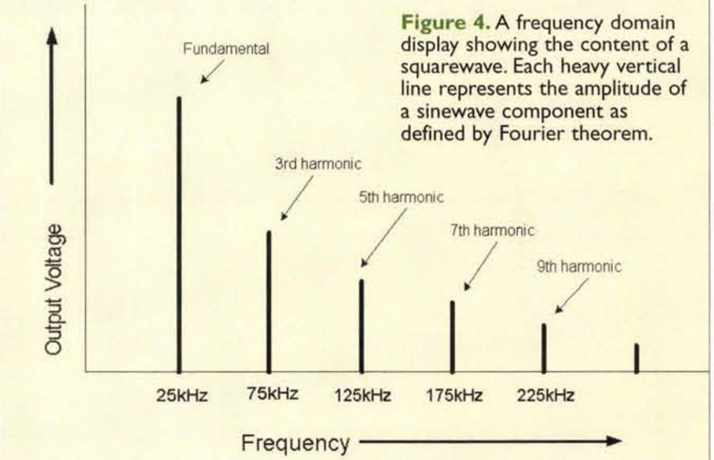


Figure 4. A frequency domain display showing the content of a squarewave. Each heavy vertical line represents the amplitude of a sinewave component as defined by Fourier theorem.

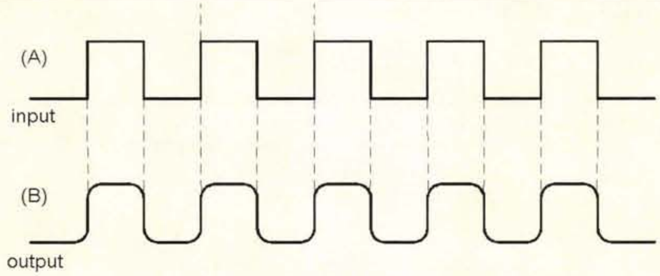


Figure 5. A squarewave or data signal is distorted by the circuit or medium and shows up as a rounding of the signal at the output.

C is the channel capacity or data rate in bps. B is just the bandwidth in Hz of the communications channel. If the bandwidth is 25 kHz, the data rate is

C = 2(25 kHz) = 50 kbps

You can rearrange this to find bandwidth from data rate or:

B = C/2

To transmit a 10 Mbps signal, you must have a bandwidth of at least:

B = 10 Mbps/2 = 5 MHz

This simple relationship pretty much defines the outer limits of data speed. In reality, the data rate is not only affected by the bandwidth, but also the noise in the system. Remember that noise is any random interference that occurs in a circuit or along a cable used for transmission. The greater the noise, the lower the speed for a given bandwidth. The relationship above just assumes no noise which is never the real case.

This basic relationship between speed, bandwidth, and noise has been known for about 54 years since Claude Shannon of Bell Labs (now Lucent Technologies) discovered it and published it in 1948. Mathematically, it says that:

C = 3.32Blog(1 + S/N)

C and B are as defined earlier, while S/N is the power signal to noise ratio. The expression log means the common logarithm easily found on a calculator. For example, if the bandwidth is 25 kHz as before, but the signal-to-noise ratio is 1000/1 — which is sort of typical for a communication system — the maximum data rate would be:

C = 3.32 (25,000)log (1001) = 249,036 Hz or about 249 kbps

Yikes! Adding in the effect of noise seems to give us even higher speeds in a given bandwidth. Unfortunately, Shannon's law gives us a maximum theoretical value that in reality cannot be achieved with a binary signal. As you will learn in the next article, it will take a multilevel signal to get that kind of data rate in a narrow bandwidth with noise.

TIME DOMAIN VS. FREQUENCY DOMAIN

There are two basic ways to look at a complex electronic signal. First, you can view the signal on an oscilloscope. What you see is the signal voltage varying over (with respect to) time as in Figure 2. This is how we normally look at or see signals in our minds. But there is another way.

Remembering that a complex, non-sinusoidal signal is made up of a fundamental sinewave plus many higher order harmonics, we can visualize the signal as a composite of individual sinewaves at different frequencies. This is what we call a frequency domain display. The squarewave in Figure 2 is made up of a fundamental sinewave plus odd harmonics. A frequency domain display is shown in Figure 4. Note that the display shows the amplitude of each sinewave as a line at its specific frequency. In many fields of electronics, a frequency domain display actually gives a better picture of what the signal really represents. This is especially true in communications.

To get a real frequency domain display, all you have to do is use a piece of test equipment called a spectrum analyzer. It looks like an oscilloscope in that it has a cathode ray tube (CRT) display. But what you see on the screen is frequency on the horizontal axis instead of time. You will actually see something like that in Figure 4 if you apply a squarewave.

Another way to get a frequency domain output is to use what is called the Fast Fourier Transform (FFT). This is a mathematical procedure carried out on a computer to give the frequency content of a signal. The complex signal is first digitized by a fast analog-to-digital converter. The binary output is then processed by a FFT algorithm program in a computer, usually a fast digital signal processor (DSP) chip. The output is a plot of the signal frequency spectrum. DSP FFT is widely used in communications applications.

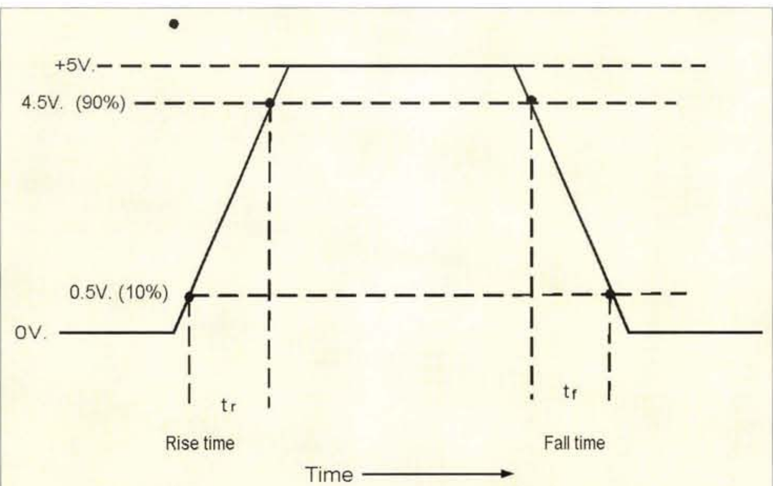


Figure 6. The way to figure the rise and fall time of a pulse.

Baseband Transmission

So, let's apply what you now know. First of all, baseband transmission is the process of applying the serial binary data signal directly to a cable so that it travels from transmitter to receiver. Much of network communications uses this method. The telephone system uses baseband. Ethernet local area networks (LANs) and SONET (synchronous optical network) fiber metro and wide area networks, and the Internet backbone use baseband. RS-232, USB, and IEEE1394 computer interfaces are baseband.

When you apply a high-speed digital signal to a cable, the cable has a major effect on the signal. The most commonly used cables are twisted-pair and coax. These cables are not just connecting wires as in AC power cords or speaker cables. Network cables are transmission lines. When the length of the cable is greater than about .1λ (one-tenth wavelength) of the signal to be transmitted, the cable becomes a transmission line and acts like a complex reactive circuit rather than just wire with resistance. (Note: One wavelength (λ) is equal to 300 divided by the frequency in MegaHertz or $\lambda = 300/f_{MHz}$) The equivalent circuit of a transmission line is shown in Figure 7. You may recognize it as a big low pass filter with series inductances and resistances and parallel or shunt capacitance.

Just imagine what happens when you apply pulses to this. The shunt capacitances charge through the series resistances and inductances. Because of that thing called time constant, it takes a finite amount of time for the cable capacitance to charge. If the speed of the pulses is too fast, the capacitance will not fully charge before the pulse shuts off and the next one comes along. Therefore, the output of the cable is a somewhat rounded version of the input.

The cut-off frequency of a transmission line depends upon many factors such as the inductance and capacitance per foot and the length. Type of insulation (dielectric) in the cable has a major impact. In any case, twisted-pair telephone cable and category 5 (CAT5) Ethernet cable can handle low speeds nicely and high speeds over shorter lengths. Coax has a huge bandwidth and can handle signals up to almost 1 GHz depending upon length, but the attenuation is enormous for higher frequencies and greater lengths. But because both types of lines are low pass filters, they do filter out the higher-level harmonics in any digital signal applied to them.

The cut-off frequency of the equivalent low pass filter varies with the length. The result is severe rounding of the signal. As long as cable lengths are kept reasonably short (less than about 100 feet or so), the digital data shows up at the other end without too much attenuation, distortion and rounding. Now you can see why cable length and type are so important in any data transmission scheme.

To transmit data over longer distances, the signal can be rejuvenated every 100 feet or so, and reshaped and then retransmitted. This is a real pain and very expensive so we do everything we can to avoid this, but it is done.

Another approach is to switch to fiber optic cable where the digital data turns a laser off and on and transmits the data as infrared light pulses. Or finally, you can modulate the data onto a carrier and transmit it on a cable or by radio (wireless). Transmitting data by modulating it on a carrier is known as broadband, and that is the subject of Part 2 of this article. **NV**

Open Communication is a bi-monthly column. Part 2 will appear in the October 2002 issue.

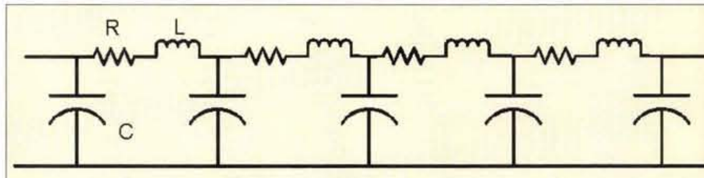


Figure 7. The equivalent circuit of a transmission line is a low pass filter whose cut-off frequency is determined by the cable length and characteristics and the signal frequency.

TECH FORUM

QUESTIONS

I need an RF generator for an AM radio and one for a two-meter radio. A chip is okay.

#8021 **Steven Sabean**
El Centro, CA

I am still using my Commodore 64C. I have a Memory Expander (COMMODORE 1764), but no program for using it. Can someone tell me where to get a program or give me the listing for a basic program?

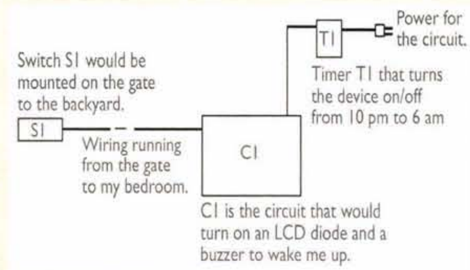
#8022 **Robert W. Ritchey**
via Internet

I need a high voltage power source, similar to what my high school chemistry teacher had, to conduct some electrical experiments. He could adjust the voltage and current using knobs and had various connectors for different implements. The voltage range was 10,000 to 250,000 volts and ran on a 120 volt outlet. I cannot locate this in any lab supply books or in any electronics supply places. Please help me so I may do some of the experiments in your magazine.

#8023 **David Laney**
daffet1968@hotmail.com

I would like to build a buzzer circuit that would wake me up at night whenever someone enters our backyard through our side gate.

I've provided a schematic of what I think it might look like and would be very thankful for any help.



George Peschke
hueygeorge@attbi.com

Does someone have a schematic and parts list of a LED third brake light that flashes a few times and then is on? Or where can I find a kit?

#8024 **Dorian Pond**
via Internet

I need to be able to measure and record the voltage coming into my house with my PC. I'm looking for a circuit that will translate 240 Vac into something that I can read through the serial port of my PC.

#8025 **Duncan Hudson**
Chagrin Falls, OH

I have an LED sign by Dynasty Classics in Compton, CA. It has a serial port on the back for the keyboard. Can it be interfaced to the serial port of a PC and what program would I need to change the message? I wrote to them, but didn't receive any response.

#8026 **Robert W. Ritchey**
via Internet

Does anyone have a cheap and dirty design for an analog video signal level monitor. I would like to use it with my CCD cameras to detect motion in their field of view. Any help would be appreciated.

#8027 **Norm Walton**
KB0SAX
nw2258@micoks.net

ANSWERS

[5029 - MAY 2002]

Looking for a 230V circuit to raise the current into a lamp at dusk, and also remove the current surge into the filament and prolong its life.

Referring to "Edison" type lamps with tungsten filaments. To prolong your lamp life, lower the operating voltage. A 10% lower voltage will double the lamp's life; a 20% lower voltage will quadruple the lamp's life. This can be done with a small transformer that bucks out 10% of the voltage fed to the lamp. If you want to make your lamps last forever, connect two same-wattage lamps in series, so they run on half the voltage. They are not as bright, so use bigger lamps.

You can buy devices that stop the inrushing current when the lamp is turned on. PowerMizer is a disk that is inserted under each bulb, allowing the lamp to light more gently. On the web, go to: **Galaxymall.com/products/EverlastProducts/PowerMizer.html**.

Joseph Kish
Clackamas, OR

[6024 - JUNE 2002]

I have an application for salvaged motors from hard drives.

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!

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

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 email or we can not send payment.
- Your name, city, and state, will be printed in the magazine, unless you notify us otherwise. If you want your email address printed also, indicate to that effect.
- 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

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, Phone Number, and email. Only your name, city, and state will be published with the question, but we may need to contact you.

TECH FORUM

[7026 - JULY 2002]

I'm trying to build a remote control circuit to toggle four relays on/off using a Linx Technologies Keyfob CMD-KEYX-418 transmitter/encoder and a matching Linx RXD-418-KH receiver/decoder. Could someone design a circuit to do this or give me some suggestions.

The Apr. '02 issue of *Nuts & Volts* contained a remote control article that used Linx RF modules with Motorola encoder and decoder. The receiver circuit illustrated how a relay can be toggled on and off by the transmitter.

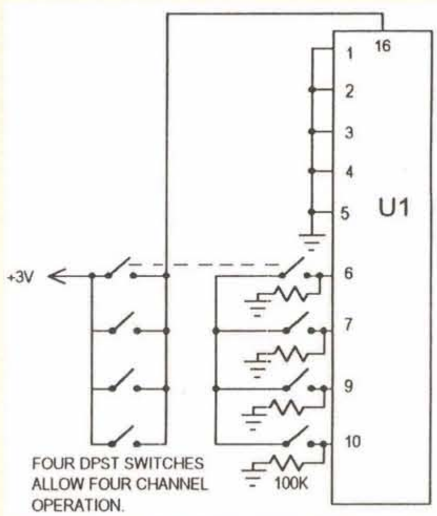
The MC145027 decoder contains four data output terminals (pins 15, 14, 13, and 12) that correspond to the four data inputs of the encoder chip in the transmitter.

When one of the four switches is closed to transmit, one of the address lines of U1 is set to logic one for a unique data configuration. The corresponding data output terminal of the MC145027 in the receiver (pins 15, 14, 13, and 12) will then go to logic one. This voltage can then be used to operate a JK flip-flop — as shown in the article — to toggle the desired relay.

Anthony Caristi
Waldwick, NJ

The Linx modules specified, include a different encoder and decoder, but the principle of operation is the same.

If a MC145027 decoder is used instead of the MC145028 as shown in the Apr. '02 article, four relays can be toggled on and off by the transmitter. To accomplish this, the transmitter should be equipped with four DPST push-button switches as shown in the accompanying diagram.



My problem is that I don't know how to wire them. They appear to have some control circuitry built in, and have several connecting wires. For example, a Nidec 4515-3BCA-01 (P/N004060802) has six connecting wires. I'd like to get this motor to run at full speed.

The six wires indicates that it is most likely an electronically commutated DC motor. Three wires are for a three-phase brushless stator winding in delta connection and the other three are for the rotor position sensors.

There are several integrated brushless commutator ICs, such as the LM621 or MC33035 on the market, specifically designed to do just that. Look at which IC is being used and get the data sheet from the manufacturer.

Another approach is to find units where the motor control circuitry is on a separate board and use it with the motor (you need to identify power, enable, forward, and maybe other signals).

Walter Heissenberger
Hancock, NH

[7028 - JULY 2002]

I'm looking for a parts source for a projection dial radio from the 1930s. Fair Radio Sales does not carry the projection dial film or other parts. I remember the name "Antique Electronics Supply" from a few years ago, but I do not know if they are still in business and have what I need.

Antique Electronics Supply is alive and well and can be found at: phone 480-820-5411; web **www.tubesandmore.com**.

Another company which may be more helpful is Rock-Sea Enterprises, who specializes in dial scales for antique radio gear. Their address is:

Rock-Sea Enterprises
323 E. Matilija St., #110-241
Ojai, CA 93023

[6026 - JUNE 2002]

I was wondering what circuit is behind the flash trigger on a 35mm SLR camera. I measured the flash trigger and it read around 0-.05 VAC. When I press the shutter button it jumps to .33 VAC, then trickles back down.

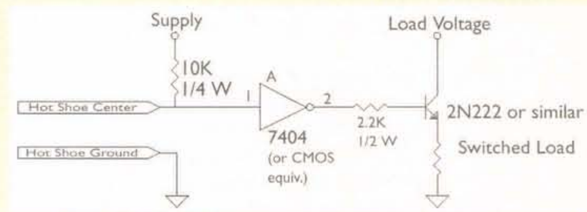
I would like to trigger a relay or turn on a transistor, but this AC voltage is so low. What kind of simple circuit do I need?

#1 A simple non-contact device that will provide a switched output is a slave strobe module, which should be available from better camera stores. Or, you could roll your own. Home-made or store bought, these devices utilize a phototransistor which detects the flash from the camera being fired and turns on an output transistor briefly, which fires a slave strobe connected to the module. Or any other low-voltage, low-current apparatus attached to it. You will find "light detector" circuits in just about any electronics hobbyist magazine, including *Nuts & Volts*, or check RadioShack for any simple projects books. They are a good source for many parts also, should you wish to build your own.

Lee
via Internet

#2 The flash trigger (hot shoe or "coaxial" contact) is a simple low-current Normally-Open switch contact that closes when you depress the shutter. Just feed that contact into a TTL or CMOS inverter (i.e., 7404) and have the inverter drive the transistor (or other driver) controlling your "high current" device.

Ken Simmons
Auburn, WA



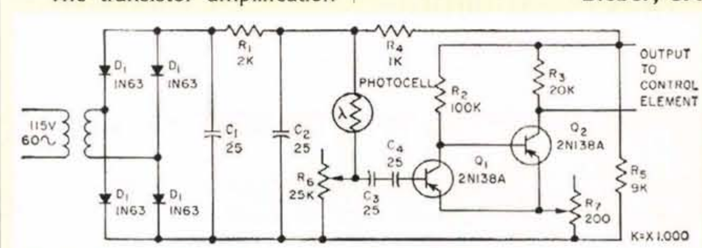
[6025 - JUNE 2002]

Cadmium zinc telluride (CZT) devices make great nuclear radiation detectors, but I've been unable to find any circuit diagrams to build one. Has anyone had any experience with these?

A radioactive source changes the resistance of the cadmium sulfide photocell.

The transistor amplification converts the variation into a signal that actuates a relay or other control element. You can use more sensitive [or larger sensors] like the Cadmium Zinc cell and also increase the gain on the transistor amplifier circuit by using additional stages or higher gain transistors to increase the sensitivity.

Chris
Bieber, CA



A web site that will also point you to other sources is: **www.antiqueradios.com/**.

Phil Shewmaker
Louisville, KY

[5022 - MAY 2002]

I need a circuit to convert component video (Y,Pb,Pr) from my HDTV display in the living room to standard NTSC output, to display on my standard analog color TV in the kitchen, via its component video inputs.

There are four questions in this Tech Forum that revolve around converting video from one format to another and it's no wonder. Movies, television, and cameras developed as inventors sought ways of producing visual information or conveying it from one location to another or storing

[6023 - JUNE 2002]

I'm looking for a high-voltage circuit tied to a car spark plug, to be used as an ignitor on a gas cooking grill. The unit I remember ran on a 12-volt, one-amp battery and used a car automotive coil.

#1 Here is a circuit which I built a few years ago as a tester for automotive ignition coils. It should work as a gas grill ignitor. It is similar to the circuit used in the old "breaker points and condenser" ignition systems.

S1, a normally open push-button switch, replaces the points. The plug will fire each time the switch opens. (The circuit for electronic ignitions is almost the same, but the points are replaced by a power transistor. The electronics controls the power transistor.) S1 should be a large-type switch, as the current is fairly high while the switch is closed.

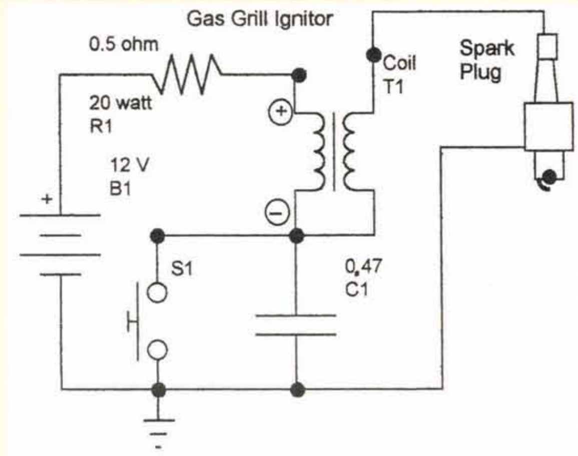
R1 can be 0.5 or 0.47 ohms, or two 1 ohm, 10-watt resistors in parallel.

The value of C1 was determined by measuring the capacitance of a cap used in an old "points and condenser" car. C1 reduces sparking of the points and increases the high voltage produced.

T1 can be almost any car ignition coil, for either a "points and condenser" or electronic system, if it is easy to mount and connect.

One type which looks good is the one used on many Chrysler vehicles in most of the 80s, specifically on the 1983 Chrysler LeBaron, the 1987 Plymouth Caravelle, and the 1987 Dodge one-half ton full-size van.

This coil is a cylindrical shape with the + and - terminals clearly marked and easy to connect to. (If the + and - terminals are reversed, the circuit will still work, but the spark will be weaker.) If this coil is used, it will be necessary to make or buy a mounting clamp. If one is purchased, the type used on the 1983 Chrysler and the 1987 Plymouth should be easy to mount (the one on the 1987 Dodge van is not).



Possible modifications include a larger resistance for R1 to reduce the current drawn and still get a satisfactory spark; changing the value of C1, which might make a better spark; and increasing the gap of the spark plug from that usually used in an engine.

An idea for improving the circuit — which I don't have time to try — is to use a solid-state circuit. A power transistor would replace S1, and be driven by a simple pulse generator. There have been circuits published for a single 555 IC with variable pulse rate and variable pulse width (duty cycle), which would drive the power transistor.

I think I would start with a pulse rate of about 20 Hz with a 50% duty cycle. It would be necessary to protect the transistor from pulses generated in the coil. To find a suitable protective circuit, I would start by looking at circuits for automotive electronic ignition. Several were published in electronic magazines in the 60s and 70s. If power to the circuit is switched by a push-button switch, a "continuous" spark will be produced as long as the switch is closed.

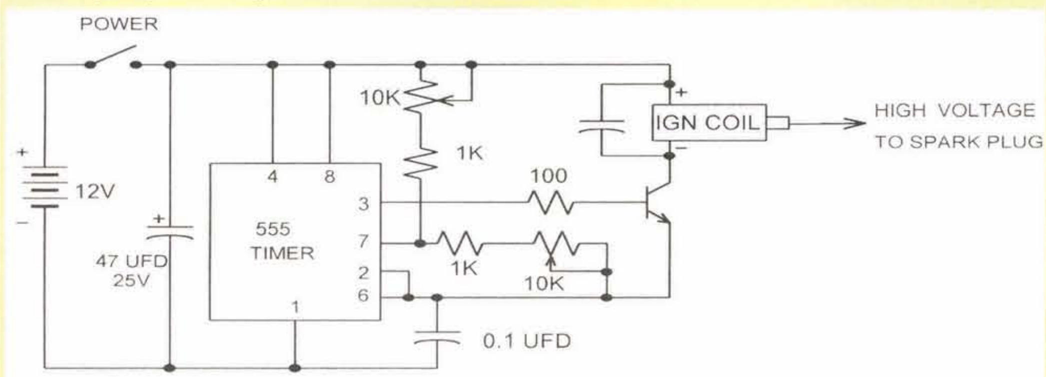
Bill Stiles
Hillsboro, MO

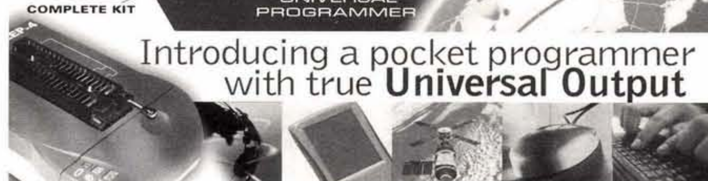
#2 A 555 timer chip operating in astable mode, driving an NPN power transistor such as 2N3055, makes a good driver circuit for an automobile ignition coil.

The timer chip generates a non-symmetrical squarewave at pin 3, which simulates the opening and closing of the breaker points of an automotive ignition system. The values of the resistors, and the timing capacitor connected to pins 2 and 6, determine the duty cycle and frequency of the squarewave. By experimenting with the resistor and capacitor values, the spark characteristics can be controlled. A capacitor placed across the primary of the coil as shown may help in producing a stronger spark.

The high-voltage output of the ignition coil can be fed to an ordinary spark plug, which produces the spark. The body of the plug must be connected to circuit common (battery negative).

Anthony Caristi
Waldwick, NJ





TECH FORUM

[7022 - JULY 2002]

Years ago, before complex counter chips, dividing a frequency was done with RS or JK flipflops. It's easy to divide by a multiple of two, but 3, 5, or 7 required special configurations of the FFs. I wonder if anyone has retained these odd configurations so I don't have to reinvent them.

#1 Digging through dusty files, I found an article that answers your exact question: how to configure divide by N counters, using discrete flip-flops (and gates) for arbitrary N.

"Divide-by-N Circuit has 50/50 duty cycle" by David A Scott, Naval Weapons Center, China Lake in *EDN* magazine for July 5, 1973, pages 95 and 97.

This article provides a design technique, and demonstrates it for N = 3,4,5,6,7, and 11.

Other articles from the 70s show division techniques using shift registers (7496), presettable synchronous counters (74LS191), or CMOS counters (40161).

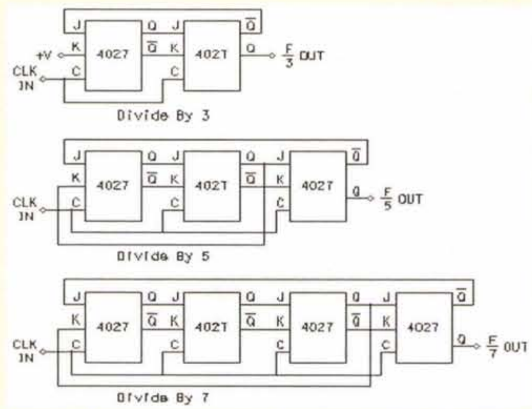
If you will send me an email address, I can scan it and email it to you.

Chuck
mcgregorc@yahoo.com

#2 It really makes no sense to use J-K flip-flops to do this sort of dividing. However, here are the schematics to accomplish your task. Keep in mind the output is not a single clock pulse in width. For example, the divide by 5 circuit has a 3:2 duty cycle. Also, in order for these circuits to function, all of the Set and Reset pins must remain at ground potential.

A better way to accomplish this type of division would be to use 4017 counter. That way your output pulse would be 1 clock pulse in width for counts 0 through 9. The divide by 10 output has a 50% duty cycle.

Raymond Buck
Phoenix, AZ



it for future use.

Industries grew up around these inventions using incompatible means to accomplish what on the surface seems to be a similar function.

Today "video" means NTSC, PAL, SECAM, DSS, composite, S-video (Y/C), YUV, RGB, and those are just some of the analog "standards."

"Video" also means HDTV, DTV, MPEG-2, YCrCb, and a few assorted digital "standards."

"Video" also means the signal we send to our computer monitors such as CGA, DVI, EGA, MDA, VGA, MAC, etc. "Video" even means the different resolutions possible on the same monitor (640 x 480 "video" is different from 800 x 600 "video").

Finally when you rent a "video" you are referring to a medium that can be VHS tape, DVD, or a pay-per-view video "stream" from a satellite.

Murphy's Law rules this entire kingdom and very few "standards" are easily inter-converted. Moreover, with 26 letters of the alphabet capable of forming over 17,000 three-letter acronyms (TLAs), I'm inclined to believe the number of types of "video" will increase for several years to come (and that ignores NTSC, MPEG, HDTV, and SECAM who have all broken through the three letter barrier).

[6028 - JUNE 2002]

I have heard that it's possible to control an air conditioner or other large motor, with PWM. I'd like to build a circuit that takes a TTL level PWM signal and switches 230 volts DC 20 or 30 amps at a 20 kHz rate to add specialized speed control to my table saw.

I've had IGBTs mentioned as a solution, but I don't know what they are.

#1 You are indirectly describing an inverter, a device which takes AC, converts it to DC and then back to AC, allowing you to vary the frequency. The bad news is that most inverters have a limited frequency range and current on output. Most inverter applications I've seen, involve modest speed control, are three phase, and handle 10-15 amps maximum.

In addition, many motors for these applications are listed as "inverter rated," and while I am not sure just what that means, I suspect it includes different construction techniques to allow the motor to perform well over a varied frequency range.

Inverters usually contain a modular IGBT (Insulated Gate Bipolar Transistor) array to perform the power switching function, with a microprocessor controlled front end to determine frequency, control voltage and current, and monitor parameters such as phase loss, motor overload, etc. While it would be possible to control a table saw motor via inverter, it might be much cheaper to go "low-tech" and swap pulleys. Search the Internet for "inverters" and you will find a wealth of detailed information for your application.

Lee
via Internet

#2 First of all, you need to find out which motor is in your table saw. If it is an inexpensive one, with integral motor, you have most likely an AC series motor. Then you can use an inexpensive TRIAC type variable speed control (they are typically made for routers). These units sell for about $25.00 and it will be hard to beat this. If you have an induction motor, then I suggest you read Electric Motors and Control Techniques by Irving M. Gottlieb. You will find all the necessary information there.

IGBT's are Insulated Gate Bipolar Transistors and are specifically designed for switching applications and have low drive requirements.

Walter Heissenberger
Hancock, NH

TECH FORUM

[6029 - JUNE 2002]

I have a portable CD player I'd like to play through the radio speakers in my car. I thought of buying a FM transmitter that would allow the player to act like another FM station – but they seem way overpriced.

Can someone provide me an inexpensive, circuit I can build?

#1 I think you are overlooking several limitations of your FM transmitter idea to transmit your CD player to your car radio.

1) Most of the FM transmitters you will find or can build are mono transmitters with only "phone" audio quality. **2)** Even if you can find a stereo FM transmitter, you will have to modify it to accept a much higher level of audio from your CD earphone output.

You did not mention what kind of car radio you have. If your radio has a built-in cassette player as most standard car radios in the past 10 years are, your solution is much simpler. All you need is a simple Cassette Adapter ($10-$20), which is designed specifically for this purpose.

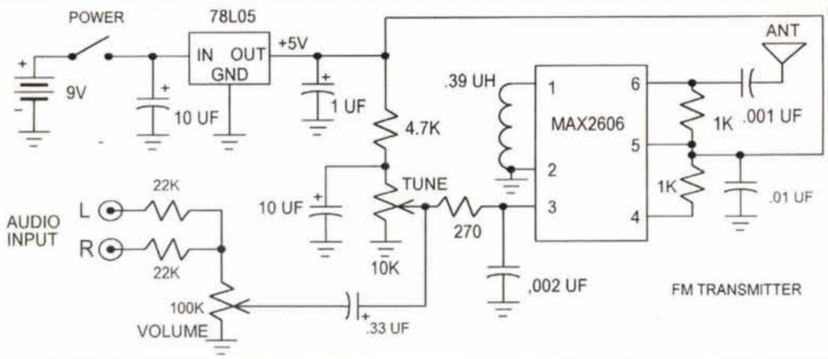
If your radio doesn't have a cassette player, you can probably replace the radio with a new one with a built-in CD player for about $100.00, which is probably cheaper than your original FM transmitter idea.

Haim Sandel
Phoenix, AZ

#2 A simple FM transmitter can be constructed using a Maxim MAX2606 integrated circuit, as shown in the diagram. The MAX2606 is a voltage-controlled VHF oscillator chip that operates in the FM broadcast band. A nine-volt battery supplies power to the circuit.

The Left and Right audio output of the CD player is coupled to the voltage control input of the chip, where it will frequency modulate the oscillator. Two potentiometers are included in the circuit to control volume and oscillator frequency. Since this will be used inside of a vehicle, only a very short wire will be needed for an antenna.

Anthony Caristi
Waldwick, NJ



In short, a sense of humor and a sense of history are helpful in dealing with the present confusion.

I agree the MC1377 won't work and you are going to need some kind of scaling to get the 16:9 HDTV picture to look decent on your 4:3 TV. You face the same choice as broadcasters. Do you "chop off" the left and right sides of the screen or do you produce "letter box" video for the kitchen? Most video conversions are not do-it-yourself projects, but that's for you to decide based on your own skill and desire.

Check the companies and sites below. This list spans $89.00 to $1,000.00+ products and some of the web sites have tutorials explaining the theory and trade-offs to various conversions.

Standards Organizations

www.atsc.org
www.fcc.gov
www.mpeg.org
www.smpte.org

Affordable Converters

www.aitech.com
www.focusinfo.com
www.jandr.com (PSC-1106 PC to TV $90.00)
www.matco.com (UL-2000 VGA to Composite $99.00)
www.polarisusa.com

Broadcast Quality Converters

Communication Specialties, Inc.
55 Cabot Court
Hauppauge, NY 11788
Tel: (631) 273-0404
Fax: (631) 273-1638
www.commspecial.com
"Scan Do" video converters & "Deuce" video scalers

Analog Way
75 Maiden Ln.
New York, NY 10038
Tel: (212) 269-1902
Fax: (212) 269-1943
www.analogway.com

Extron Electronics
1230 S. Lewis St.
Anaheim, CA 92805
Tel: (714) 491-1500
Fax: (714) 491-1517
www.extron.com

FOCUS Enhancements
1370 Dell Ave.
Campbell, CA 95008
Tel: (408) 866-8300
Fax: (408) 866-4859
www.focusinfo.com

Folsom Research
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Tel: (916) 859-2500
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www.folsom.com

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244 Bergen Blvd.
West Paterson, NJ 07424
Tel: (973) 785-4347
Fax: (973) 785-4207
www.fsrinc.com

Bob Miller
Trenton, NJ

News Bytes

Continued from Page 59

and Local-Area-Network Gaming tournaments. Lulu Tech Circus also plans to actively involve user groups in the event via special meeting places and presentation opportunities.

Keeping with the circus theme, the event is divided into five rings — Artis Teka (Graphic and Media Arts), Expansive Education, Gear and Gadgets, Fun and Games, and Extreme Computing. More information specific to these "rings" can be found at **www.lulutechcircus.com**.

The format of Lulu Tech Circus gives attendees the freedom to focus on their area of interest, yet have the opportunity to experience the expanse the event has to offer in other technology areas. A signature feature is the Village Green, a gathering place for user groups and technology lovers of all ages. Information tables and meeting facilities are part of the Village Green, and are featured at each Circus event.

"Holding the first Lulu Tech Circus in Raleigh reflects on the overall health of the technology sector in the Southeast. For all the bad news about this industry recently, the number of new ventures and successful technology companies in the Research Triangle area is a positive statement for North Carolina," said Will Jahnke, President of Lulu Tech Circus, Inc.

Registration, future venues, and more information are available via the website at www.lulutechcircus.com.

Show hours and location for the Raleigh edition of Lulu Tech Circus: September 27-29, 2002; Friday 12-9, Saturday 10-9, and Sunday 10-6 at the North Carolina Fairgrounds.

CIRC Hosts New Remote-Controlled Robot Competition Series

The Central Illinois Robotics Club (CIRC) will be hosting Kilobots™ — a new RemoteControlled Robot Competition Series, November 9th. 'Kilo' refers to the robot's mass limit of 1kg (2.205 lbs).

There is no size limit; however, the robots will need to negotiate 12" wide halls, so a design of 7" to 9" wide would be a good idea.

There will be three main events the robots can compete in. The events are: Kilobot Challenge™, Kilobot Bash™, and Kilobot Sumo™. Each one is slightly different, but with a little ingenuity, one robot could easily compete in all three events.

Robots can be a modified RC car or toy, a modified robot kit, or a totally homemade creation. Weapons will be allowed for most of the arenas, so builders can be creative. For more details, check out the CIRC website at http://www.circ.mtco.com.

Selected Titles For The Electronic Hobbyist and Technician —

The Nuts & Volts

Robotics

The Robot Builder's Bonanza
by Gordon McComb

A major revision of the bestselling "bible" of amateur robotics building — packed with the latest in servo motor technology, microcontrolled robots, remote control, Lego Mindstorms Kits, and other commercial kits. ***$24.95***

Microcontrollers

Handbook Of Microcontrollers
by Myke Predko

This reference is the first guide to cover all the most common types of microcontrollers. With its from-the-bottom-up approach, this book/CD-ROM package gives you all the information you need to simplify the job of selecting the right microcontroller and writing an application for it. ***$54.95***

Programming & Customizing the 8051 Microcontroller
by Myke Predko

Programming and Customizing the 8051 Microcontroller puts you in control of the 8051's architecture and instruction set — and even supplies a baker's dozen of ready-to-build example applications, programs, and circuits. Best of all, the included CD-ROM supplies source code for the book's experiments and applications. ***$39.95***

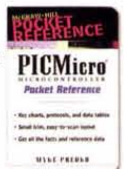
Programming & Customizing the HC11 Microcontroller
by Tom Fox

Applications bazaar for the 68HC11 microcontroller. Squeeze every last drop of power out of Motorola's wildly popular family of 68HC11 true 8-bit single chip computers! From basics to complete applications. ***$39.95***

Programming & Customizing PICmicro Microcontrollers
2nd Edition
by Myke Predko

This book is a fully updated and revised compendium of PIC programming information. Comprehensive coverage of the PICMicro's hardware architecture and software schemes complement the host of experiments and projects making this a true, "learn as you go" tutorial. ***$49.95***

PICmicro Microcontroller Pocket Reference
by Myke Predko



Designed to complement Programming & Customizing the PICMICRO, this book contains a minimum of verbiage and serves as an immediate device, code and circuit look-up for experienced PICMICRO applications designers. **$29.95**

Programming & Customizing the BASIC Stamp Computer
by Scott Edwards

This edition moves you briskly from electronic foundations through BASIC Stamp "Boot Camps" and an intelligent traffic signal simulation to build a robotic bug with whisker sensors, a time/temperature display, and a data-logging thermometer. ***$39.95***

PIC Microcontroller Project Book
by John Iovine

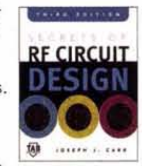
This project-oriented guide gives you 12 complete projects, including: using transistors to control DC and AC motors, DTMF phone number logger and distinct ring detector and router ... home automation using X-10 communications ... digital oscilloscope ... simulations of fuzzy logic and neural networks ... and many other applications. ***$29.95***

The Nuts & Volts of BASIC Stamps Vol. 1 & 2

In 1995, Scott Edwards began authoring a column on BASIC Stamp projects in *Nuts & Volts Magazine*. The column quickly became a favorite of *Nuts & Volts* readers and continues today with Jon Williams at the helm. *The Nuts and Volts of BASIC Stamps* is a collection of about 75 of these columns.

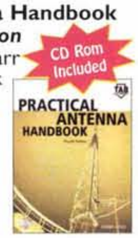
Radio & RF

Secrets of RF Circuit Design
3rd Edition
by Joe Carr



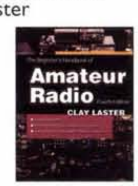
This revised and updated guide gives you the best ways to design, build, and test today's radio frequency circuits. It's filled with projects and experiments that make it easy to apply RF principles to real-life applications. ***$39.95***

Practical Antenna Handbook
4th Edition
by Joe Carr



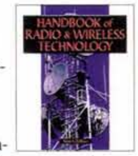
The most popular book on antennas ever written. This edition blends "the theoretical concepts that engineers and others need to design practical antennas, and the hard-learned practical lessons derived from actually building and using antennas." ***$49.95***

Beginners Handbook of Amateur Radio *4th Edition*
by Clay Laster



The revised edition of the most trusted guide in ham radio is here. This edition delivers all the guidance you need — from radio and electronics fundamentals needed to set up a transmitter to the newest equipment to revisions to the FCC rules and tests. ***$34.95***

Handbook of Radio & Wireless Technology
by Stan Gibilisco



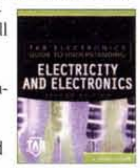
Containing more than 1,000 concise articles, this one-stop source of user-friendly insight provides blanket coverage of one of the fastest-growing areas in communications from antennas and transmission lines, to analog and digital modulation techniques, to satellite, space, and laser communications. ***$44.95***

Electronics

Practical Electronics For Inventors
by Paul Scherz

This experiment-oriented guide is loaded with over 750 hand-drawn images that support author Paul Scherz's crystal-clear, fully detailed instructions, showing you how to turn theoretical ideas into real-life gadgets. ***$39.95***

Guide To Understanding Electricity & Electronics
by Randy Slone



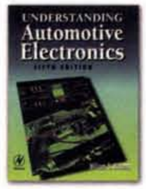
For the true beginner, there's no better introduction to electricity and electronics. You'll also find 25 complete projects that enhance your electricity/electronics mastery, including 15 new to this edition, and appendices packed with commonly used equations, symbols, and supply sources. ***$24.95***

Digital Electronics Guidebook: With Projects
by Myke Predko

Perfect for electronics hobbyists and students — even complete beginners — who want to understand digital logic and build their own low-cost logic circuits. Featuring more than 20 projects with step-by-step directions for designing, constructing, and interfacing easy-to-do TTL (Transistor-Transistor Logic) circuits. ***$34.95***

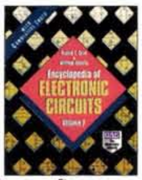
Hobbyist Bookstore

Understanding Automotive Electronics *Fifth Edition*
by William B. Ribbens



This edition of *Understanding Automotive Electronics* covers the most recent technological advances in operation and troubleshooting of electronic systems and components. This is a practical text, suitable for the automotive technician, student or enthusiast. It includes low-emission standards, on-board diagnostics and communications, digital instrumentation, and digital engine control. ***$34.99***

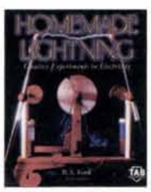
Encyclopedia of Electronic Circuits Vol. 7
by Rudy Graff



Designed for quick reference and on-the-job use, the *Encyclopedia of Electronic Circuits*, Volume 7, puts over 1,000 state-of-the-art electronic and integrated circuit designs at your fingertips. This collection includes the latest designs from industry giants such as Advanced Micro Devices, Motorola, Teledyne, GE, and others, as well as your favorite publications, including *Nuts & Volts*! ***$39.95***

High Voltage

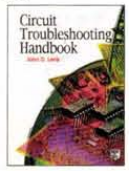
Homemade Lightning: Creative Experiments in Electricity
by R.A. Ford



Enter the wide-open frontier of high-voltage electrostatics with this fascinating, experiment-filled guide. You'll discover how to make your own equipment, how electricity is used in healing, and the workings of many experiments in high potential physics! ***$24.95***

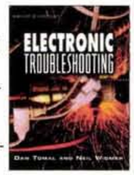
Troubleshooting

Circuit Troubleshooting Handbook
by John D. Lenk



Heavily illustrated with diagrams and schematics, it uses a standard, easy-to-follow format to help readers understand and troubleshoot a wide range of circuit types, and provides proven circuit testing techniques for all levels of instrumentation. ***$39.95***

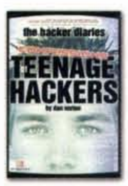
Electronic Troubleshooting *2nd Edition*
by Dan Tomal and Neil Widmer



This updated tool gives all the fundamentals needed to do successful servicing and repair work, blending traditional theory with the very latest insight into modern electronics technology. Time-saving tables, charts, and illustrations pinpoint equipment problems in a snap. Numerous reference guides, rules of thumb, and tricks of the trade all combine to assist in troubleshooting the full spectrum of devices and products more easily than ever before. ***$39.95***

Miscellaneous

The Hacker Diaries: Confessions of Teenage Hackers
by Dan Verton

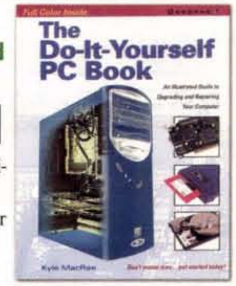


Through fascinating interviews with FBI agents, criminal psychologists, law-enforcement officials—as well as current and former hackers—you'll get a glimpse inside the mind of today's teenage hacker. Learn how they think and understand the internal and external pressures that pushed them deeper and deeper into the hacker underground. ***$24.99***

This Month's Featured Titles

The Do-It-Yourself PC Book
An Illustrated Guide to Upgrading and Repairing Your PC
by Kyle MacRae

$24.99



This highly illustrated full-color guide is the easiest way to master the art of upgrading, maintaining, and repairing your PC. Written with humor and simplicity, *The Do-It-Yourself PC Book* demystifies and explains the inner workings of your computer and makes it easy for anyone to give their old machine a boost or keep their new one in perfect working order. Each chapter features clear explanations and step-by-step instructions while the accompanying full-color photographs show you every procedure and component.

PICMicro Microcontroller Pocket Reference
by Myke Predko

$29.95

Designed to complement *Programming & Customizing the PICMICRO*, this book contains a minimum of verbiage and serves as an immediate device, code and circuit look-up for experienced PICMICRO applications designers.

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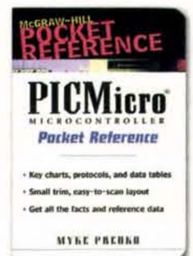

Conventions Used In This Book.
PICmicro MCU Park Number Feature Comparison.
Device Pinouts.
PICmicro MCU Instruction Sets.
PICmicro MCU Processor Architectures.
PICmicro MCU Register Mappings.
Built-In Hardware Features.
PICmicro MCU Hardware Interfacing.
PICmicro MCU Programming.
PC Interfaces.
Useful Code Snippets.
16-Bit Numbers.
PICmicro MCU Operations Tables.
PICmicro MCU Application Debugging Checklist.
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Educators stock their classes with the **Board of Education Full Kit** (28102). The Board of Education is the project board for BASIC Stamp microcontroller projects, including the Stamps in Class curriculum. The board was designed in coordination with our educational customers to teach microcontroller interfacing and programming. Even if you aren't using the Parallax published curricula, the Board of Education is still an ideal set of hardware for instructor-authored lessons. The Board of Education is available in a Full Kit that includes a BS2-IC module, power supply, and serial cable, or may be purchased individually (#28150).

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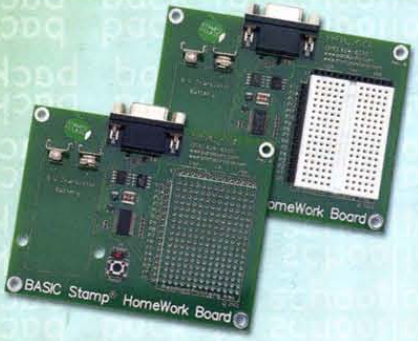

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