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September 2002
Vol. 23 No. 9

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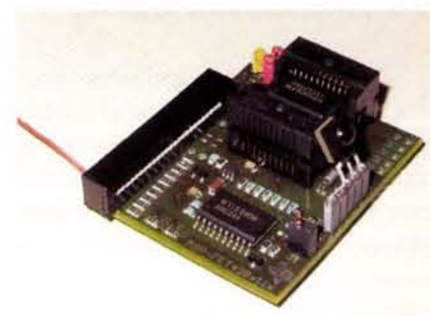

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About the cover ... *The cover was designed by computer artist Matthew Roddy (roddy@juno.com). To create the cover, a still image of Walt Noon's "Cyber Reaper" robot (www.noonco.com/cyberreaper) was merged with a heavily-modified photo of Redland's historic "Kimberly House." The Kimberly House is the mirror image of Hollywood's famed Magic Castle. The software used was Corel Photo Paint 10. Matthew is a director and 3D artist/animator in the cable industry, as well as a freelance videographer.*

DEPARTMENTS

COLUMNS

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Build a TV Infrared Remote Control Decoder — Part 1

By Mark Buccini

Explore how TV IR remote control works ...

How many infrared (IR) remote controls are lying around your house? Been curious on how they work? Or have you ever just wanted to add remote control to one of your very own projects? In the first of a two-part series, we'll explore how TV IR remote control works with an easy-to-build project that decodes the information packets used to control your TV and other electronic equipment. Control for our project comes from a 20-pin MSP430F1121 Flash-MCU. Add a three-pin IR sensor, and a complete TV IR decoder can be constructed in minutes, as shown in Figure 1.

TV IR Remote Basics

There are many industry protocols for encoding TV IR remote control signals — serial infrared control (SIRC) is one of the most common. SIRC is used with most Sony equipment. Like all IR protocols, SIRC transmits packets of information serially using a 38-40kHz modulated IR carrier. A logical "1" is the presence of modulated IR, and a "0" the absence. The modulation is used to filter out naturally occurring sources of background infrared such as office florescent lights or even sunlight. While there are many sources of infrared, it is very unlikely any are naturally occurring with 38-40kHz of modulation.

Circuit Description

In order to decode SIRC information packets, the 38-40kHz of modulation must first be removed to expose the actual serially-transmitted data bits. A simple three-pin TELEFUNKEN TSOP1840SS3V or TSOP1838SS3V 3V integrated sensor is used in this project to amplify, filter, and demodulate the IR signal. The sensor outputs clean logic-levels. With no 38-40kHz IR modulation present, the sensor output is high, when 38-40kHz is present, the output is low. Thus, the sensor also has the effect of inverting the original transmitted data in addition to removing the modulation — the data seen at the MCU is inverted from that transmitted. The IR sensor output is connected directly to MSP430F1121 input pin P2.2. P2.2 is configured by software as a capture/compare function for timer_A3 capture/compare register 0 (CCR0) using the port 2 option select (P2SEL) register. For feedback, if a channel "+" code is received, an LED on P1.0 is illuminated.

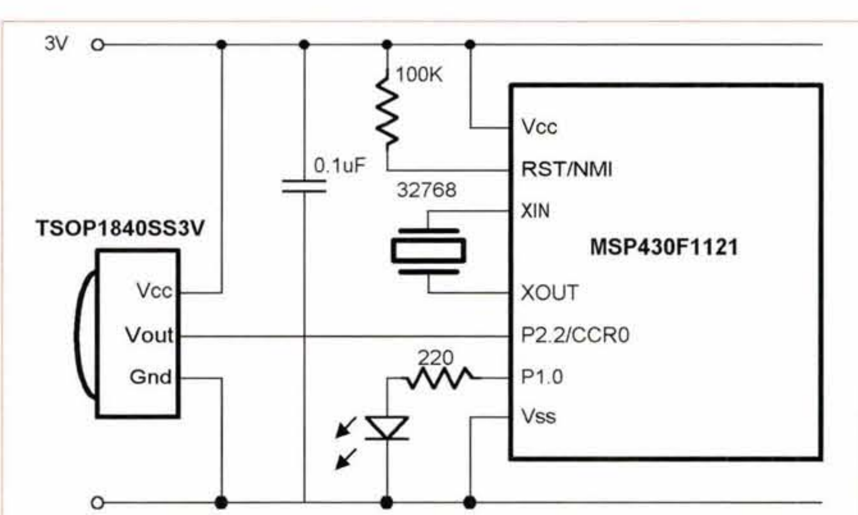

Figure 1. MSP430 Remote Control Decoder Circuit.

Bit timing for IR remote control is relatively slow compared to the operation of the MSP430. The decoder circuit uses a common 32,768 Hz watch crystal as the source for the MCU auxiliary clock (ACLK), which is also selected as the timer_A3 clock source. With this clock source, timer_A3 has a resolution of 30.5uS — more than accurate enough to resolve the SIRC protocol with no bit errors. The MSP430's on-chip digitally-controlled oscillator (DCO) is used at the default frequency of ~ 1MHz for the CPU master clock (MCLK). As the 32,768 Hz watch crystal sources the clock for timer_A3 and, in effect, IR decoder function, CPU speed is not critical. The CPU needs to only operate fast enough to manage the tasks required. Using the slower ACLK for the IR decoder and the faster MCLK for CPU, both ultra-low power stand-by and fast burst code execution are enabled.

SIRC Protocol

The SIRC protocol uses a data packet with an encoding scheme of variable bit-length or pulse width modulation. The length of a bit determines its logical value. The start bit is 2.4mS of modulated IR, a "0" 600uS, and a "1" 1.2mS. All data bits, excluding the start bit, also include a 600uS sync pulse, or lack of IR presence. The total length of a received "0," including the sync pulse, is therefore 1200uS, a "1" 1800uS. Figure 2 shows the format of a complete SIRC data packet. An SIRC packet consists of the start bit and 12 data bits. The 12 data bits are comprised of a five-bit device code (D4 to D0) and seven-bit command code (C6 to C0). Table 1 shows a few of the most-used device codes and Table 2 common command codes. The SIRC protocol sends data LSB first. Following the start bit, C0 is the first bit received.

Remote Control 101 — Example fet110_sirc.s43

The software example fet110_sirc.s43 will decode SIRC packets. Three CPU registers are used in the example fet110_SIRC.s43: IRData (R6) receives the IR data; IRBit (R7) is used to track bits as received; and IRlength (R8) is used to store the length of the data bits as received.

```
#define    IRData    R6
#define    IRBit     R7
#define    IRlength  R8
```

Three variables are defined: IR_Mid is 1/2 of an SIRC bit length in timer_A3 clocks; IR_Start approximately 2.3mS in timer_A3 clocks (the minimum length of a valid start bit); and IR_Start2 approximately 2.5mS in timer_A3 clocks (the maximum length of a valid start bit).

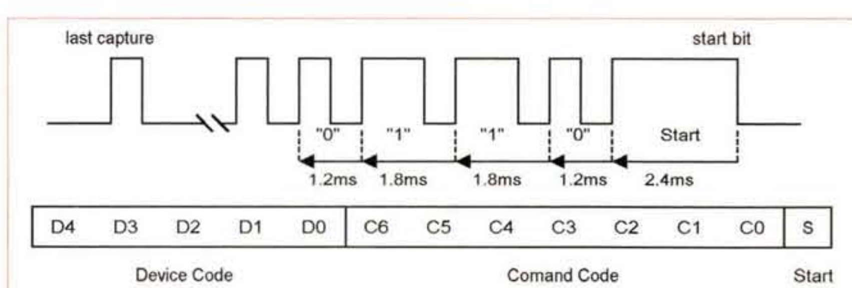

Figure 2. ISIRC Data Packet As Transmitted.

```
IR_Mid      equ   49      ; 1500uS @ 32768Hz ACLK
IR_Start    equ   75      ; 2300uS @ 32768Hz ACLK
IR_Start2   equ   82      ; 2500uS @ 32768Hz ACLK
```

The Mainloop is very short with activity driven in interrupts and by subroutine functions. This type of programming activity allows for easier code understanding and modification compared to old-style "straight-line" programming.

```
Mainloop call   #IR_Ready       ; Ready IR decoder
         bis.w  #LPM3,SR        ; Enter LPM3, stop, save power
         call   #LED_Disp       ; Test for Channel +
         jmp    Mainloop        ;
```

The IR decoder function using the timer_A3 capture compare function is enabled in the Mainloop by calling the IR_Ready subroutine. The subroutine IR_Ready enables CCR0 to capture on a falling edge from the IR sensor connected to P2.2. Next, software in the Mainloop sets bits in the CPU status register (SR) to put the system into low-power mode 3 (LPM3). In LPM3, the CPU and DCO are off, but timer_A3 is still counting from the ACLK with CCR0 interrupt logic fully active.

Though the MSP430 is in LPM3, the timer_A3 driven decoder will run interrupt driven as a secondary task. Using capture/compare features of timer_A3 enables much easier decoding of the IR data. CCR0 does the IR data receive bit latching in hardware independent of CPU and other system activity. The architecture of the MSP430 automatically enables the CPU and DCO when any enabled interrupt is requested in less than 6uS. So during CCRO interrupts, the CPU will run in very short "bursts," requiring very little time and power consumption.

On the first falling edge or P2.2, indicating the beginning of the start bit, a CCR0 capture occurs capturing TAR into CCR0 and interrupt TA0_ISR is requested. The count in TAR is automatically captured and stored in CCR0 by hardware, no software is required. Software will store CCR0 in IRLength inside of the TA0_ISR. After the first falling edge, CCR0 capture edge is switched to rising edge that will capture at the end of the start bit and all following bits.

The length of the SIRC data bit is calculated by subtracting the current TAR capture stored in CCR0 from the previous saved in IRLength. A start bit length validation between 2.3mS and 2.5mS is done assuring a good start bit. The decoder software will reset if a valid start bit is not received, assuming that an error has occurred. A valid start bit should be approximately 2.4mS. Inside of the TA0_ISR, IRBit is used to count down the 12 data bits as received. Each data bit is calculated by comparing its bit length to IR_Mid. IR_Mid is 1500uS which is half of the difference between a "1" and a "0." A bit length greater than IR_Mid is decoded as a "1," less than IR_Mid is decoded as a "0."

Hardware capturing of timer_A3 insures that software interrupt latency does not affect the accuracy of the captured timer value and the calculated bit length. Software does not directly read timer_A3, but instead the latched timer value in CCR0. The system stack is also used to temporarily save the current CCR0 value to be subtracted from the previous in IRlength.

Table 1. SIRC Device Codes

Code	Device
1	TV
2	VCR 1
3	VCR 2
17	CD

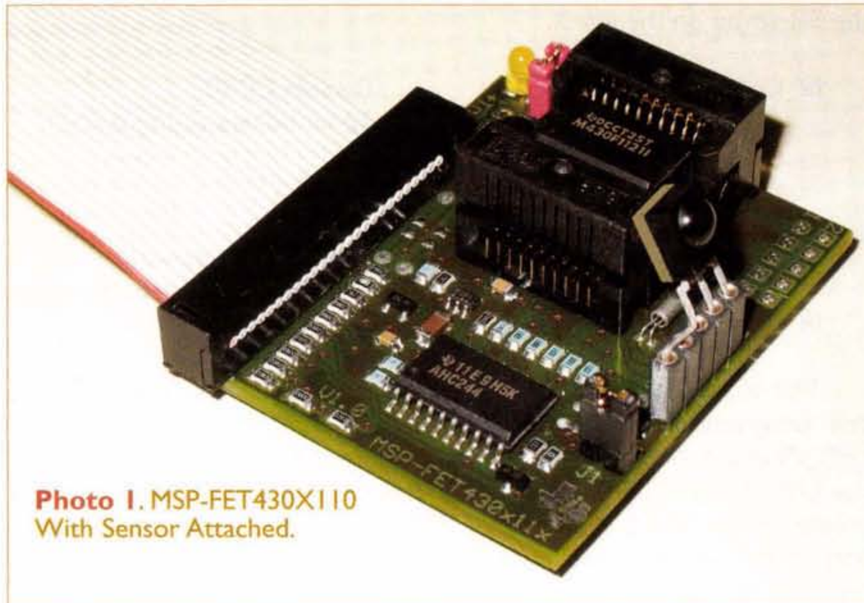

Photo 1. MSP-FET430X110 With Sensor Attached.

```
IR_ST_Test push.w &CCR0         ; Save to stack CCR0count
     sub.w   IRlength,0(SP)     ; Time length last capture
IR_Bit    cmp.w   #IR_Mid,0(SP) ; C=1 if IR RXed bit = 1
IR_Shift  rrc.w   IRData        ; Carry ->IRData
```

With CCR0, hardware capturing the timer_A3 value exactly when edges occur on P2.2, other real-time activities can occur simultaneously with the IR decoder should the application need to be expanded. The IR decoder software runs interrupt-driven in the background. Data are shifted into IRData bit-by-bit by software after each bit has been received.

To return the Mainloop to active, consider that every enabled ISR saves the SR on the stack and clears the SR low power bits inside of the interrupt service routine. After the interrupt service routine has been processed, the return from interrupt (reti) instruction pops the original SR off the stack. The system returns to the previous operating mode prior to the interrupt service routine — unless the SR on the stack is modified inside of the interrupt service routine. In this application, after a complete IR packet has been received and cleaned up, software returns the CPU to active in the Mainloop by clearing the LPM3 bits from

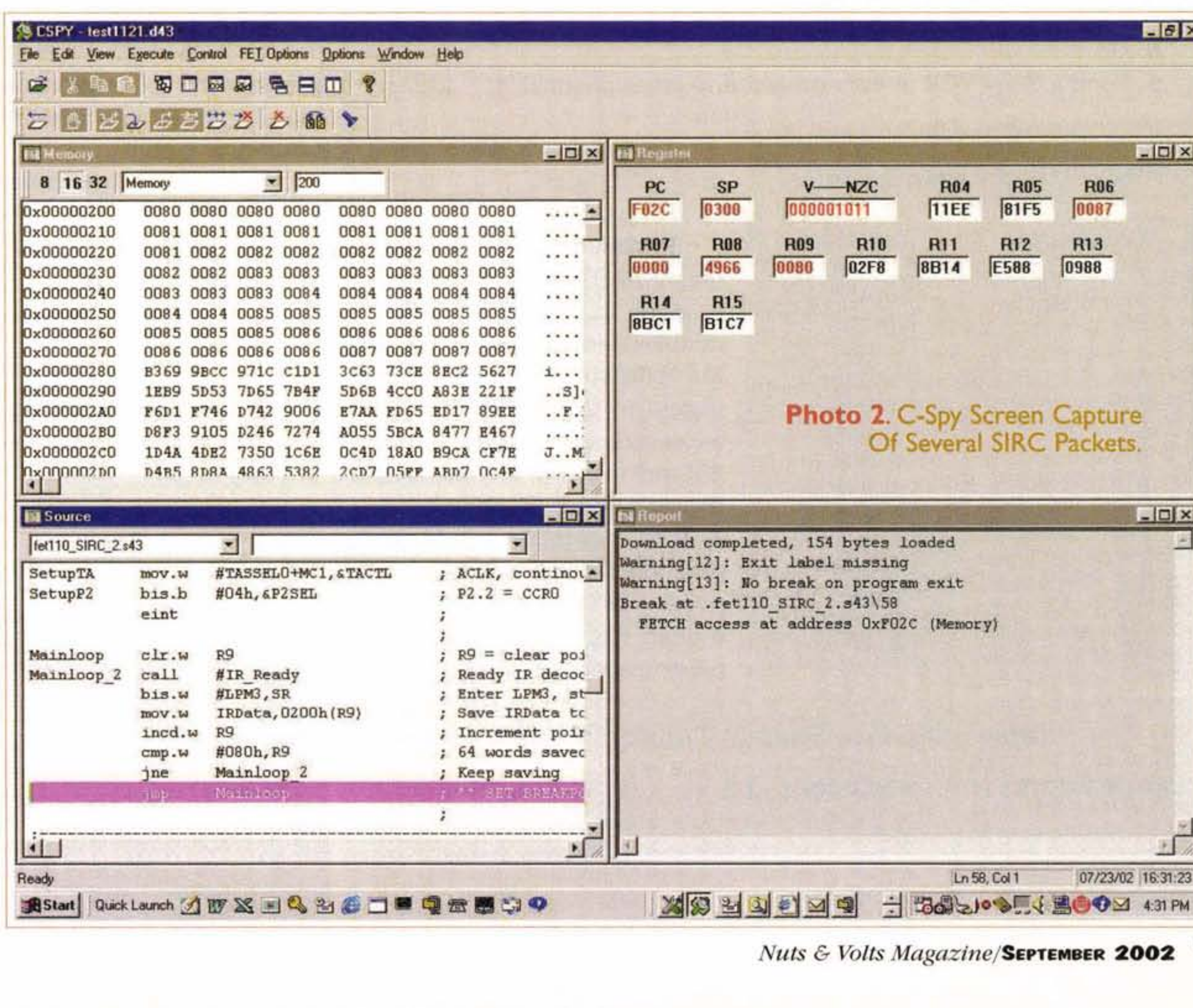

Photo 2. C-Spy Screen Capture Of Several SIRC Packets.

the SR saved on the stack.

```
IR_Comp   clr.w  &CCTL0          ; Disable CCR0
          rrc.w  IRData          ; 12-bit IRData right justified
          rrc.w  IRData          ;
          rrc.w  IRData          ;
          rrc.w  IRData          ;
          and.w  #0FFFh,IRData   ; Isolate 12-bit packet
          mov.w  #GIE,0(SP)      ; Decode Byte = Active in Mainloop
IR_Cont   reti                   ;
```

This is a convenient way of managing the Mainloop with event-driven programming. The active Mainloop completes by calling the LED_Disp subroutine. The LED_Disp subroutine will set P1.0 to power the LED if the IR data packet is a channel "+ " command. Setting a breakpoint on the first line of the LED_Disp subroutine allows inspection of the received packet in IRData (R6), if desired. The Mainloop repeats, waiting in LPM3 for the next IR data packet.

Project Construction

The project was developed with an MSP-FET430X110 Flash Emulation Tool (FET). See Photo 1. The FET's target board is used as-is. The installed 32,768Hz watch crystal is used for timing and the installed LED on P1.0 is used for the channel "+" indicator. The three sensor pins VCC, OUT, and GND are directly connected to the FET as shown in Table 3. The FET and sensor are powered directly from the PC parallel port.

Operation

Operation is now pretty straightforward.

1. Insert an MSP430F1121 into the FET socket.
2. Attach the sensor to the FET.
3. Connect the FET to a PC installed with the FET software.
4. Create a new assembler project.
5. Add FET110_sirc.s43 to the project.
6. Make the project.
7. Launch the C-spy debugger — this programs the MSP430 Flash also.
8. Go.
9. Point a Sony VCR at your project and press channel "+" = LED is on.
10. Press any other channel — LED is off.

Table 2. SIRC TV Command Codes

Command	Function
0	Number 1
1	Number 2
2	Number 3
3	Number 4
4	Number 5
5	Number 6
6	Number 7
7	Number 8
8	Number 9
9	Number 0
16	Channel +
17	Channel -
18	Volume +
19	Volume -
21	Power

Problems — Check that the MSP430F1121 is installed properly in the FET socket, double-check the pin 1 indicator. Make sure the sensor connected to the FET is exactly as described in Table 3. The 200mS margin between IR_Start and IR_Start2 for start-bit validation could be widened, if needed, to support poor quality transmitters — though this modification was never necessary during any project development or testing.

Table 3. FET to Sensor Connections

MSP-FET430X110	MSP430F1121	SOP1840SS3V or TSOP1838SS3V
J2-2	VCC	VCC
J2-4	VSS	GND
J2-10	P2.2/CCR0	OUT

The project was demonstrated with several off-the-shelf remote controls including an RCA universal remote RCU300T. The RCU300T was programmed with Sony 002 for SIRC.

Example fet110_SIRC_2.s43 — Need Mode Data

Want to see some more data? The easiest way to do this is to use the MCU's on-chip RAM. There are 256 bytes of RAM available starting at 0200h. The second example fet110_sirc_2.s43 uses 128 bytes of RAM to store 64 words or packets of 12-bit SIRC data. Register R9 is used as a pointer to RAM, the instruction "mov.w IRData,0200h(R9)" does the trick. The Mainloop is modified:

```
Mainloop    clr.w  R9                 ; R9 = clear pointer
Mainloop_2  call   #IR_Ready          ; Ready IR decoder
            bis.w  #LPM3,SR           ; Enter LPM3, stop, save power
            mov.w  IRData,0200h(R9)   ; Save IRData to RAM
            incd.w R9                 ; Increment pointer
            cmp.w  #080h,R9           ; 64 words saved?
            jne    Mainloop_2         ; Keep saving
            jmp    Mainloop     ; ** SET BREAKPOINT HERE **
```

Also, it is not necessary for software to setup P1 or make a call to the subroutine LED_Disp. The LED on P1.0 is not used in this example program.

Modify your project by replacing fet110_sirc.s43 source with fet110_sirc_2.s43. Make sure you remove fet110_sirc.s43. Rebuild your project and re-launch the C-spy debugger. Open a memory window in 16-bit word mode initialized to 0200h. Set a breakpoint on the "jmp Mainloop" instruction in the Mainloop. Go. Point a Sony remote control at the FET and press several keys.

After 64 packets of SIRC information have been received, the breakpoint is hit. Look at the RAM window. You'll see the received packets in RAM. See Photo 2. Keys will show up in RAM repeating. This is because most remotes send the same command packet several times to make sure the electronic equipment absolutely receives the command.

Going Further

The project presented here is very easy to build, and a great analysis tool. As a matter of fact, the exact project in this article was used as a foundation to develop many more sophisticated applications. Using decoded IR data exchange wireless control is now possible for any project, big or small.

We'll use what we learned in this month's project to springboard into next month's "Ultra-low Power TV Infrared Remote Control Transmitter" that will allow direct control of electronic equipment or other "IR enabled" gadgets. **NV**

Parts List

MSP-FET430X110 — MSP430x11x1 Flash Emulation Tool
Available from Texas Instruments
TSOP1838SS3V — TELEFUNKEN
Available from Newark Electronics

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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.

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.**

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**

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

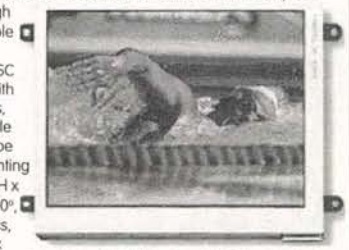
A fantastic lens with a current replacement cost of $20K. Extremely flat field and extemely high quality.

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

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**

***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.



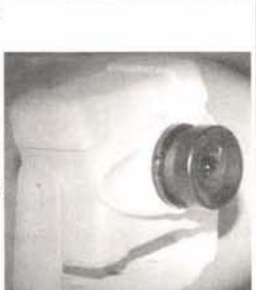
BRAND NEW, FIRST QUALITY. GMTFT68.......$169ea.
Regulated 12 VDC/110VAC power supply.......$8.95ea.

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

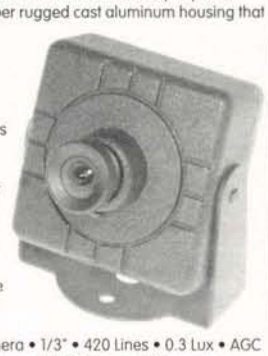


Yes 470 lines with a 60db S/N ratio to back it up! That's 16X better than a typical 46dB standard camera! The GM-4500, CCD camera with its' DSP technology provides high speed white balance with no color rolling. Auto shutter speed of 1/60 to 1/120,000 second. Truly state of the art. Sleek cast aluminum 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! 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, PRICE BUSTER, GM-210 "MINI CCD STEALTH CAM" Top quality, black and white, mini CCD camera at a super price. Packaged in a super rugged cast aluminum housing that fits like a glove! (Not flimsy sheet metal) Removeable mounting bracket included as well as an 8", plug in cable with BNC video & DC power jack for, no sweat hook up. Why fool around with an open P.C. board? Now you can have the GM210 for the same price as a simple board camera • 1/3" • 420 Lines • 0.3 Lux • AGC • Auto Shutter • Power, 12V @100mA • 270k pixels • Standard 4 mm, 78° FOV lens • Focus from 10mm to infinity • NTSC video • 2 ounces • Size: 1.8" Square x 1.3" deep, including lens, **GM-210 STD........$49ea**



QTY SPECIALS.... 5 for $220......10 for $390
SPECIAL camera & 9" Monitor only $135

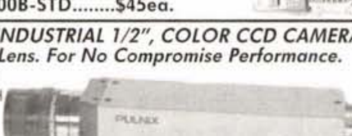
NEW! WEATHERPROOF B&W mini TUBE CAMERA Industrial strength, solid machined housing.

Sleek black anodized, BRASS, housing is O-Ring sealed & WATERPROOF. Adjustable 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, 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! 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**

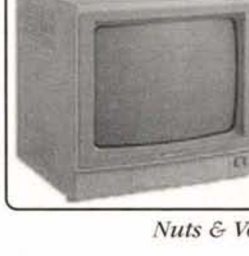
NEW! 0.01 Lux, COLOR NIGHT VISION CAMERA! FANTASTIC LOW LIGHT PERFORMANCE. Exclusive ON SCREEN, menu driven setup of all camera parameters. NEW, STATE of the ART, GMV-35KOSD,

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, 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.

Circle #51 on the Reader Service Card.

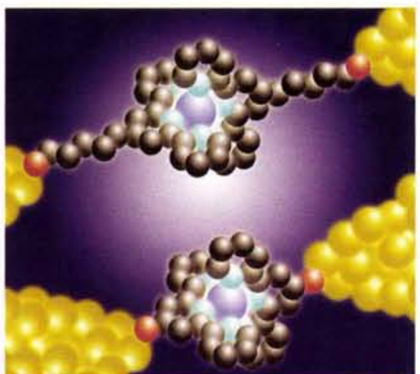
Events, Advances, and News From the Electronics World

by Jeff Eckert

TechKnowledgy 2002

Advanced Technologies

Single-Atom Transistor Hits Reduction Limit



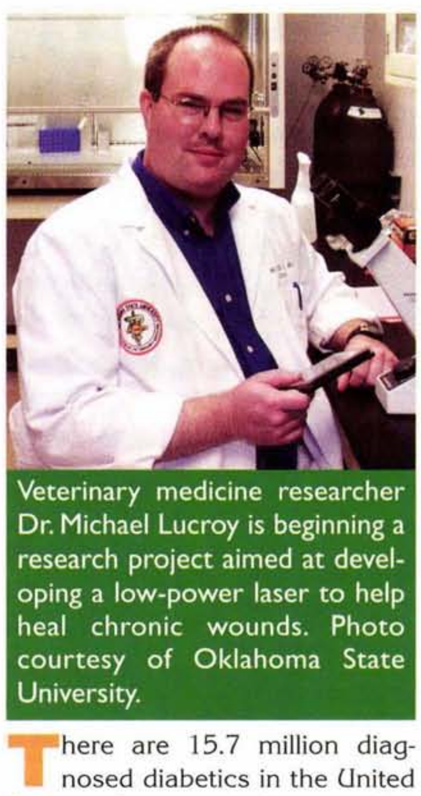
Artist's conception of the two molecules used by Cornell scientists to create a single-atom transistor. Electrons flow from one electrode to the other by hopping on and off the cobalt atom. The upper, longer molecule includes a chain of carbon and hydrogen atoms at either end. Photo courtesy of Cornell Center for Materials Research, copyright Cornell University.

A perennial goal in the electronics industry has been to reduce the size of the transistor, which is the basic circuit building block of electronic circuits. Recently, Cornell University **(cornell.edu)** scientists reported reaching the smallest possible limit: a transistor in which electrons flow through a single atom.

The device was created by implanting a "designer" molecule between two gold electrodes or wires to create a circuit. When voltage is applied to the transistor, electrons flow through a single cobalt atom within the molecule. At present, the device does not perform all traditional transistor functions. For example, it cannot provide amplification. But the inventors believe that it has potential applications as a chemical sensor, because a change in the device's environment can cause a measurable change in its conductance.

At the heart of the transistor is what the design group terms a "designer molecule," consisting of a cobalt atom surrounded by carbon and hydrogen atoms. It is held in place on either side by molecular "handles" made of pyridine, a relative of benzene. On their outer side, the "handles" are attached to sulfur atoms that act like "sticky fingers" to bond the molecule to the gold electrodes. Two different molecules have been studied — one with longer "handles" than the other. The shorter molecule was found to be a more efficient conductor. The Cornell group's next goal is to engineer a molecule with two different geometries that could act as a switch, changing between the two forms with the application of a voltage.

Study of Laser Healing Commences



Veterinary medicine researcher Dr. Michael Lucroy is beginning a research project aimed at developing a low-power laser to help heal chronic wounds. Photo courtesy of Oklahoma State University.

There are 15.7 million diagnosed diabetics in the United States alone, and that number grows by an average of 800,000 per year. Many of those diabetics suffer chronic wounds on the feet that can lead to leg amputation. But Dr. Michael Lucroy, a veterinary researcher at Oklahoma State University's College of Veterinary Medicine, recently won a $134,000.00 competitive research award from the Oklahoma Center for the Advancement of Science and Technology (OCAST) to study the mechanisms of laser-stimulated wound healing. The results of the study will be readily applicable to human health, as well as animal health, according to Lucroy.

In addition to diabetics, another group that could be affected by this research is people who have acquired chronic wounds from radiation therapy. According to Lucroy, "Radiation changes the tissue, so you get a fibrosis, or thickening of the skin, and in some people, a sort of chronic ulcer develops because the skin has been damaged and doesn't want to heal normally. In some cases, one would have to wonder if this complication might be more detrimental to the patient's quality of life than the cancer."

The doctor said the project continues research he participated in while at the University of California at Davis. There, low-level laser light was found to stimulate growth of new skin cells in dogs that had chronic wounds. While it is known that low-power laser light can stimulate cell growth, very little is known about why and how this happens. The first year of Lucroy's project will systematically examine the results of using differing color lasers and differing light intensities to determine the most effective combination. He will be using in-vitro skin cells for the study. The following two years will be dedicated to studying the cell changes brought about by the laser at the molecular level.

"The bottom line is quality of life," he said. "Our ultimate goal is to develop a small, hand-held light-emitting device as a minimally invasive yet effective method for treating chronic wounds in animals and people."

Computers and Networking

Junk Email Costs Reach $10 Billion

According to a recent report commissioned by the European Commission, junk email ("spam") now costs Internet users $10 billion worldwide. The study, which includes detailed information on both the US and European markets, is part of the EC's ongoing effort to ensure that e-commerce development does not undermine European rules on Internet privacy and data protection.

According to Internal Market Commissioner Frits Bolkestein, "The exponential growth of junk email in recent years is a fact of life. Current technology allows a single cyber-marketing company to send half a billion personalized ad mails via the World Wide Web every day. Consumer information gleaned from individual web transactions/consultations can be sold for large sums of money, and yet many individual subscribers are unaware of the scale and implications of these developments. We aim to encourage the continued development of Internet services without weakening the individual's right to privacy."

In response, the European Parliament approved a directive that calls for an "opt-in" system for emails, faxes, and automated calling systems and requires marketers to receive permission from recipients before they make unsolicited commercial pitches. It also requires companies to provide computer users with "clear and precise information" regarding the use of cookies and prohibits them from placing cookies on an individual's computer without that person's permission.

In the USA, several anti-spam measures have been introduced in Congress, but none have become law. A list of related laws in Europe, the USA, and other countries can be accessed at **www.spamlaws.com/**.

If you are frustrated by dozens of daily unsolicited commercial messages in your mailbox, you can **(1)** write to your legislators and urge support of anti-spam measures; **(2)** support organizations like the Coalition Against

Unsolicited Commercial Email (CAUCE, **www.cauce.org**) and Junkbusters (**junkbusters.com**), the latter of which provides information in 15 different languages; and **(3)** avoid patronizing any company that sends you spam.

iPod Now Available for Windows

The latest iPod audio players work with Windows, as well as Mac systems. Photo courtesy of Apple Computer.

At the recent Macworld Expo in New York, Apple Computer **(www.apple.com)** introduced the latest version of its iPod™ audio player in three versions, with storage capacities of 5 GB ($299.00), 10 GB ($399.00), and 20 GB ($499.00). The 20 GB version will store approximately 4,000 songs. For the first time, versions are available for both Windows and Mac OS users.

iPod is packaged with Auto-sync software, a feature that automatically downloads an entire digital music library into the iPod and updates it whenever the iPod is plugged back into the PC.

Using the built-in FireWire® port, a 4,000 song library can be downloaded in just over 30 minutes vs. the 13+ hours it would take with USB-based devices. The iPod's battery provides up to 10 hours of continuous music and recharges automatically whenever iPod is connected to a FireWire cable.

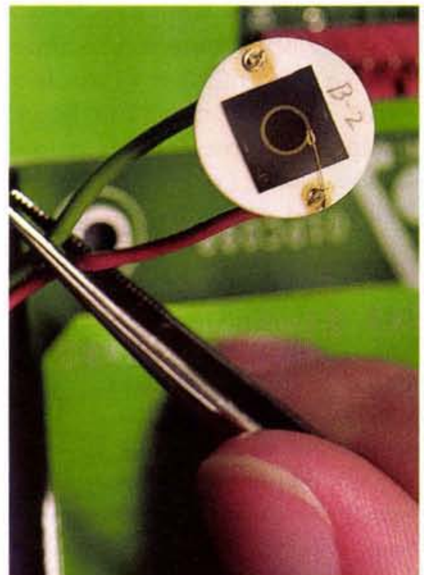
Windows users must have a machine that is equipped with a FireWire port, also known as a 1394 or iLink port. These can be added for about $50.00. iPod works with MUSICMATCH Jukebox, the best selling music software for PCs. iPod provides Windows customers with Apple's Auto-sync technology, and users also have the option to manually transfer individual songs or playlists from their MUSICMATCH library to their iPod.

All iPod models include ear-bud headphones, Apple iPod Power Adapter, and FireWire cable. The 10 GB and 20 GB iPod models include a carrying case and wired remote; an optional remote and carrying case are available for 5 GB iPod models. iPod for Windows also includes a four-pin to six-pin FireWire adapter. iPod for Mac includes iTunes 3; iPod for Windows includes MUSICMATCH Jukebox software.

iPod for Mac requires Mac® OS X version 10.1 or Mac OS 9.2, iTunes 2.0.4 and a Macintosh with a built-in FireWire port. iPod for Windows requires a PC with built-in FireWire or a Windows-certified FireWire card and Windows Me, Windows 2000, or Windows XP Home or Professional.

Circuits and Devices

Device Detects Hidden Nuclear Weapons



This small wafer could become the key component in small, portable detectors for finding concealed nuclear weapons and materials. Photo courtesy of Argonne National Laboratory.

Researchers from the US Department of Energy's Argonne National Laboratory **(www.anl.gov)** have built a portable neutron detector designed to spot the clandestine presence or transport of nuclear materials. When fully developed, the device could assist international inspectors in tracking down smugglers of nuclear weapons and materials.

The heart of the device is a small gallium arsenide (GaAs) wafer. When coated with boron or lithium, GaAs can detect neutrons such as those emitted by the materials that fuel nuclear weapons. Patents are pending on several detectors and their components.

The wafers are small, require less than 50V of power, and operate at room temperature. They also can withstand relatively high radiation fields and do not degrade over time.

According to Argonne group leader Raymond Klann, "The working portion of the wafer is about the diameter of a collar button, but thinner. It is fairly straightforward to make full-sized detector systems the size of a deck of cards, or even smaller. Something that small can be used covertly, if necessary, by weapons inspectors to monitor nuclear facilities."

The wafers are made using inexpensive, conventional microchip-processing techniques, and they can be customized for specific applications by varying the type and thickness of the coating. The development group has built and demonstrated prototype detectors. Argonne is now looking for commercial partners who are interested in developing the detectors for commercial applications.

Processor Targets Cheaper Portable Music Players

A new music processor from Cirrus Logic **(www.cirrus.com)** should allow manufacturers of consumer electronics to create portable audio players that hold nearly a full day of music and sell for less than $50.00. The CS7410 processor is a scalable single-chip digital audio processing device that supports CD-DA, MP3, and Windows Media Audio (WMA), and is adaptable to future compression standards. Using the WMA format, a player can hold more than 22 hours of music storage on a single CD. The CS7410 is a hardware/software combination aimed at various CD-based audio systems, including portable CD players, boom boxes, and bookshelf audio systems. The CS7410 includes a 32-bit RISC core, a 16-bit audio DSP, an 18-bit delta sigma DAC, 256k of ROM, and 80k of RAM on a single 100-pin chip. Available now, the CS7410 in a MQFP package is priced at $8.62 in quantities of 10,000. The part is also available in LQFP packages.

The device has the potential for broad acceptance. A prominent research firm has predicted that US shipments of CD-based compressed music players will surpass those of every other portable compressed music player category in 2002, and that sales will grow from about one million units in 2001 to more than 18 million units in 2006 (an annual growth rate of 77 percent).

LED Displays Feature IC Drivers

Offering a means of reducing the number of components required in circuit board designs, American Bright Corporation **(www.americanbrightled.com)** has introduced LED displays with built-in IC drivers. Available in both two- and three-digit configurations, the "smart" displays make it easier to design displays, particularly in areas with limited space constraints. The LED IC driver displays are suited for applications in process industries, digital indicators, household appliances, and exercise equipment.

Designed in 0.54- and 0.56-inch packages, these devices feature CMOS technology and offer continuous brightness control. The LED IC driver displays can operate within a power supply range of 3.5 to 10V, are TTL compatible, and feature 34 or 35 outputs with 20 mA sink capability. The model BD-E522RI-DR1 offers a two-digit LED display with alphanumeric or numerical digits, and Model BT-M522RD-DR1 features three-digit numeric display capabilities from zero to nine. Multiple chips can be placed together for longer display requirements.

The displays are priced from less than $3.00 each in large quantities. Small quantities are available from Turbo Electronics, Inc., www.turbo-electronics.com.

Industry and the Profession

Virtual Museum Introduces Edison Exhibit

The Institute of Electrical and Electronics Engineers (IEEE) History Center has added "Thomas Edison: A Lifetime of Invention" to its exhibits on the IEEE Virtual Museum web site **(www.ieee-virtual-museum.org)**, which was established in February. The exhibit explores both the highlights and missteps of Edison's career. It also reexamines his most famous inventions while shedding light on his lesser-known achievements. The exhibit, sponsored by the Charles Edison Fund, uses interactive and other techniques to show how Edison's technologies actually work.

Developed by engineers and historians, the museum is designed for educators, students, and the general public. It explores the history of electrical engineering using animation, sound and video, photos, and links to other museums around the world. Other exhibits in the constantly-expanding museum now include an introduction to electricity and a section that explains how sounds are recorded and played. **NV**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Reader Feedback

Dear Nuts & Volts:

"Anonymous" and his comments about the building of regenerative receivers has missed the whole point. It is a hobby. Building regens is a wonderful way to introduce youngsters to the hobby of electronics. I would suggest that he read the QRP columns, especially the New Jersey QRP Homebuilders column. They have sponsored scouts and others in projects to build regens.

Bill Stratton has some designs for one transistor regens to receive aircraft frequencies that are fun to build and perform very well. (See *Nuts & Volts*, Feb. 2002, page 13.) Paul Harden of the Nor Cal QRP club has written some excellent tutorials on electronics around regens. There are some very good electronic engineers that design and build regens, too. I built my first regen 60 years ago and my last one in May of this year.

Ken Mills, Pullman, MI

Dear Nuts & Volts:

Thanks for publishing the two June articles about radios. Frenzel's compare and contrast of the Ramsey and Ten-Tec kits was informative. The schematics were a further treat, and I studied them. The designers had severe feature versus cost challenges. William's receiver article was also welcome due to its unusual design (an active filter instead of a regenerative detector).

August's anonymous critic of regenerative receivers is too focused on performance. Although finicky, a regenerative receiver offers high gain and selectivity with few parts. Regenerative receivers are simple and the builder should succeed. More complex designs risk failure. Although I sympathize with the August critic's views, building (or even just reading about) lower performance projects has value. The simple crystal and one transistor radios I built decades ago gave me some valuable perspective.

Gerald Roylance
Mountain View, CA

Dear Nuts & Volts:

I just got my August issue and I love the robotics supplement. I subscribed to that other new robotics magazine — the name escapes me just now (*RS&T?*) — but they never really made it. Your "first" effort, on the other hand, is great! Please keep them coming!

Please don't be afraid to devote at least part of the magazine to higher-level articles. So much of what is out there in the way of robotics articles spends way too much time talking about how to connect a switch to a digital input of your micro — as if by doing so one achieves Nervana — and not enough time talking about what you can do "after" the switch is connected and how far one can go in robotics. Sorry to see Bob Nansel dropping out. I know him personally and will miss his input in the magazine. Keep up the good work.

Tom Maier via Internet

Dear Nuts & Volts:

Thanks for the courtesy copy of the July issue. I was well pleased to see I can read all the articles again, the color backgrounds of some of the old issues were miserable to read through. Perhaps you could answer a puzzle, I equipped a decent EE laboratory here with used gear from your ads, where have they all gone? Same problem with Shutterbug, no more ads for used camera equipment from individuals.

The three laws of robotics were a hoot! I'm tempted to subscribe again, the articles are generally not quite deep enough for me (retired senior EE), but the article on Bluetooth had interesting-looking references, I'll work with them a little and see if your guiding hand is a good start. Best wishes from old millionmiler Art.

Art Hogrefe via Internet

Dear Nuts & Volts:

I just finished reading the Amateur Robotics insert that came with the latest *N&V*. I emailed Dan Danknick because I know him but he said I should tell you. So ... this is the type of thing that needs to stick around. I realize that the audience for such things may not be big enough yet to carry a full magazine (evidenced by the failure of *RS&T*), but it is growing. Anyway, thanks for the extra work you guys put into the insert and please keep it up. It's this kind of dedication that keeps me as a subscriber. Thanks again.

Chris Hannold via Internet

Editor's Note:

We invite you to drop us a note and let us know *your* response to the Robotic supplement that accompanied the August issue of *Nuts & Volts*.

Did you like it? Would you like to see it published on a regular basis?

If so, what topics would you like to see covered?

We value your opinion and look forward to hearing from you!

Send to:
editor@nutsvolts.com

MASKING UNWANTED SOUNDS

By Ron Tipton

If you are regularly or occasionally bothered by unwanted noise, you might try sound masking before listing your home for sale.

Unwanted sounds when you are reading or studying can be irritating, and sound invasion at night when you are trying to sleep can be especially annoying. Unwanted sounds from a neighbor's stereo, TV, or even conversation can wake you or keep you awake. If you can't shut the sound out by closing windows or doors, you may want to consider masking it with a monotonous, relaxing sound such as ocean surf, a babbling brook, or steady rain.

DIGITAL STORAGE

One approach to producing a masking sound is to program a WAV file into an EPROM. Then generate sequential EPROM addressing with discrete logic or a microprocessor, and finally, convert the digital samples to sound with a digital-to-analog converter (DAC).

To avoid hearing the "splice" that occurs when the EPROM address loops back from the end to the beginning, the stored sound duration should be at least 60 seconds. If the sound effect was sampled at 22 kHz, 60 seconds of 16-bit words takes 2.64 MB of EPROM. We are looking at a cost of $50.00 or so for components to build this circuit. Let's look at an alternate approach that is less expensive.

ANALOG STORAGE

Information Storage Devices, Inc. (ISD) **[1]**, manufactures analog storage integrated circuits (ICs). This chip samples the analog signal and store the samples in a multilevel array so it's sort of digital. But all the conversion is handled internally so, to the user, it's analog in and analog out. Their ISD2560 is a 28-pin IC that holds 60 seconds of sound with a 3.4 kHz bandwidth and needs only +5 volts for operation. This bandwidth is lower than we would have using the EPROM circuit, but the ISD2560 costs only $10.00 and best of all, it sounds okay. Programming is straightforward and I have developed a circuit board that makes it downright easy.

THE MODEL 803

The circuit board **[2]** shown in Figure 1 programs, tests, and plays back the whole ISD25xxx family. It features an automatic recording mode which is especially useful when you are programming from a computer sound card. And this is the easiest way to program the chip. I'm going to describe the board's operation first; then we'll look at the circuit.

AUTOMATIC RECORDING MODE

When power is applied, the firmware in the PIC microprocessor initializes the ISD control lines and turns on the green READY LED. With toggle switch S3 in the RECORD position, recording starts when an input signal of one millivolt peak or greater is detected. The READY LED goes off and the red RUN LED is lighted. When the ISD2560 is full, programming stops and the RUN LED goes off. Simply press the play button on your sound card software and recording starts. Before recording, you will need to play the input signal and monitor its level with a peak-to-peak voltmeter. Be sure it doesn't exceed 50 mV pk-pk when using the "ANA IN" (analog input) or 20 mV pk-pk when using the "MIC IN" (microphone input). Figure 2 is a photo of a recording session using a TDL model 412 audio attenuator/amplifier and a model 517 audio peak-to-peak voltmeter.

To listen to what you have recorded, press CONTINUE. (The switch positions, push buttons, LEDs, and terminal blocks are all labeled on the top side of the board.) The yellow WAIT LED will light and the PIC will be inactive. Then push toggle switch S3 to PLAY, press RESET to reset the ISD's address counter, and then press START. Adjust the volume control for the desired level. For continuous or loop playback, set toggle switch S2 to LOOP.

If you are satisfied with your recording, disconnect DC power and remove the ISD chip from its ZIF socket. To record again, set toggle switch S3 back to RECORD and press the CONTINUE switch. The green READY LED will light and the PIC will be waiting for an input signal to start programming.

Rotary switch S1 selects either the ANA IN or MIC IN pin on the ISD. S1's position also sets the gain of amplifier U1B so the peak detector input

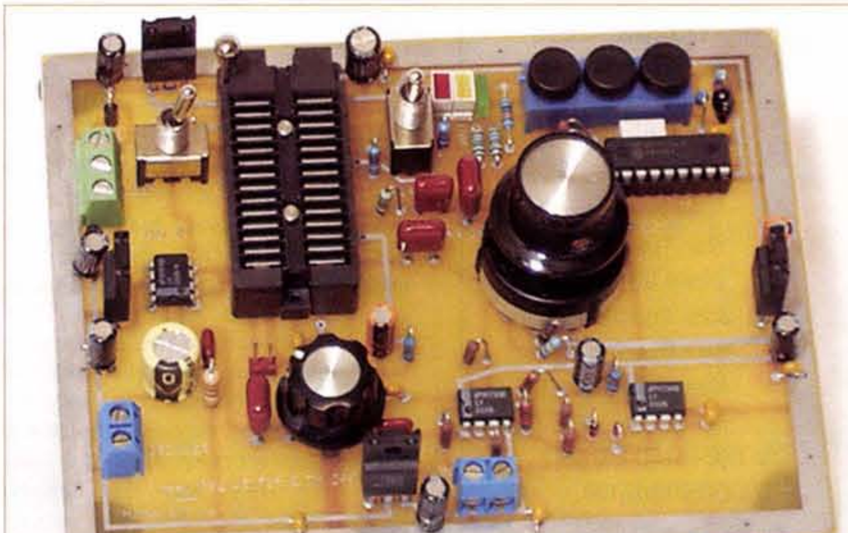

Figure 1. The 803 board is double-sided with plated through holes and all switch positions and LEDs are labeled on the top side.

Figure 2. An ISD2560 programming session. The surf waveform is visible on the computer screen in Cool Edit 2000.

stays constant. This is needed because of the different maximum input voltages mentioned above. According to the ISD Data Book, the analog input provides lower distortion, but with a lower dynamic range. The microphone input has a higher dynamic range, but also higher distortion. You may want to try recording through both inputs to compare output sound quality. (I found ocean surf sounds record better through the microphone input.)

MANUAL PROGRAMMING MODE

You can use the push button or manual mode by pressing CONTINUE to turn on the yellow WAIT LED as this makes the PIC inactive. To record in this mode, insert the ISD in the ZIF socket and apply DC power. Set toggle switch S3 to RECORD and press RESET to zero the ISD address counter. Choose the analog or microphone input pin with the rotary switch, connect the input signal and press START. The red RUN LED will go on during recording because it is controlled by the ISD and not the PIC.

Now let's look at how the circuit works.

CIRCUIT DESCRIPTION

In Figure 3, U1A is a voltage follower to provide a low source impedance to drive the ISD input pins. Rotary switch section S1B selects either the analog or microphone input pin. S1A connects the C6-R11 network between the analog in and analog out pins when the mic input is being used. Capacitor C5 reduces the ISD clock noise pick-up during programming. U1B is a variable gain amplifier driving the U2 peak detector circuit. Switch S1C sets the U1B gain to either 80 or 200, so recording starts at a peak detector output of about 100 mV regardless of which ISD input pin is selected. An LMC6482 was chosen for U1 because of its low DC offset voltage.

The peak detector output goes to one of the analog-to-digital converter inputs of the PIC as shown in Figure 4. When DC power is applied or whenever the READY LED is on, the PIC initializes the ISD PD and CE* lines. If S3 is in the RECORD position, and a 100 mV DC signal is detected at PIC pin 1, programming starts automatically. Push-button switches CONTINUE, RESET, and START control manual programming and playback as previ-

PARTS LIST

Model 803 ISD 25xxx Programmer and Tester

MAIN803.PCB Ver 1.2, 4 September 2001

R1, R2, R3, R9	10K, 1%, 1/4W, metal film
R4	49.9, 1%, 1/4W, metal film
R5	124, 1%, 1/4W, metal film
R6, R7, R8	20K, 1%, 1/4W, metal film
R10	22.1K, 1%, 1/4W, metal film
R11	5100, 1%, 1/4W, metal film
R12	10, 1%, 1/4W, metal film
R13	10K, single-turn pot, audio taper
R14, R16, R17, R22, R25	100K, 1%, 1/4W, metal film
R15, R23, R24	261, 1%, 1/4W, metal film
R18	470K, 1%, 1/4W, metal film
R19, R20,	1000, 1%, 1/4W, metal film
R21	4700, 1%, 1/4W, metal film
C1, C2, C10, C12, C14, C18, C21, C23	0.1 uF, 50V, ceramic
C3, C16, C17, C20, C22, C24	10 uF, 35V, radial electrolytic
C4, C9, C25	0.47 uF, 50V, polyester film
C5	0.001 uF, 50V, polyester film
C6	0.1 uF, 50V, polyester film
C7	470 uF, 16V, radial electrolytic
C8	0.047 uF, 50V, polyester film
C11	22 uF, 35V, radial electrolytic
C13, C19	4.7 uF, 25V, radial electrolytic
C15	2.2 uF, 25V, dipped tantalum electrolytic
U1	LMC6482 dual opamp, 8-pin DIP
U2	LF353 dual opamp, 8-pin DIP
U3	LM386N-4 power amplifier, 8-pin DIP
U4	Device to be programmed
U5	PIC16C71 or PIC16C711 microprocessor with control firmwave
U6, U7, U8	7805A +5V regulator
U9	7905A -5V regulator
D1, D2	Silicon diode, 1N4148
D3	LED, rectangular PC mount, red
D4	LED, rectangular PC mount, yellow
D5	LED, rectangular PC mount, green
D6, D7	Schottkey diode, 1N5819
H1	Two-pin straight header, Molex WM4000 or equal
TB1, TB2	Terminal block, 2-pins, PC mount
TB3	Terminal block, 3-pins, PC mount
S1	Rotary switch, 3-pole, 2-position, Mouser 105-2455 or equal
S2, S3	SPDT minature toggle switch, PC mount
S4, S5, S6	Momentary contact single-pole switch, PC mount, Mouser 10KB032

28-pin ZIF socket for the device to be programmed, U4
18-pin socket for the microprocessor, U5
Four stick-on rubber feet
Knob for rotary switch, S1
Knob for volume control, R13
Circuit board, MAIN803

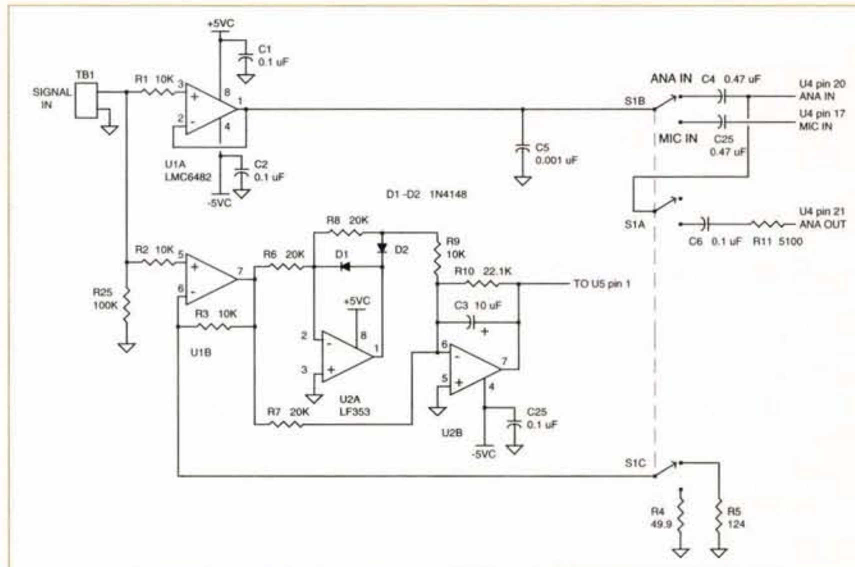

Figure 3. Opamp U1 must have low DC offset voltage because its gain is 200 when the microphone input is being used.

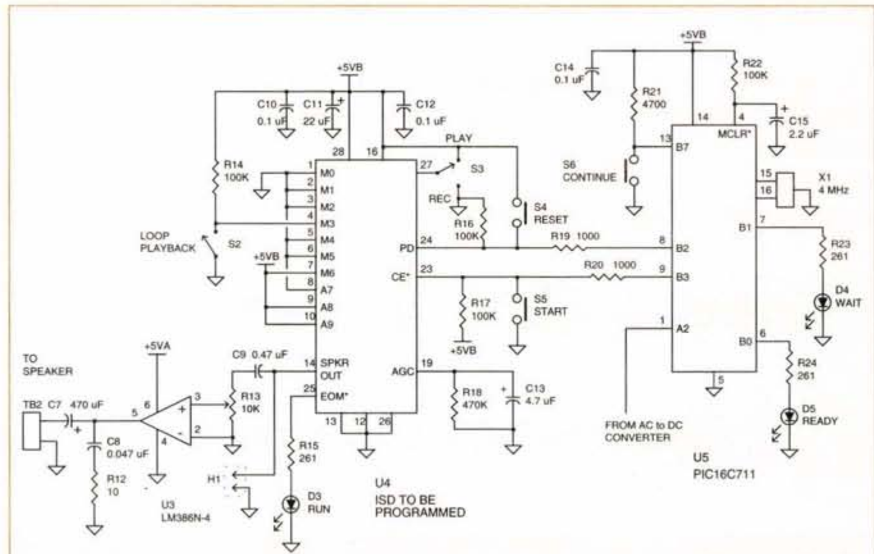

Figure 4. Isolation resistors R19 and R20 allow either the PIC or the push-button switches to set the level on the ISD control lines.

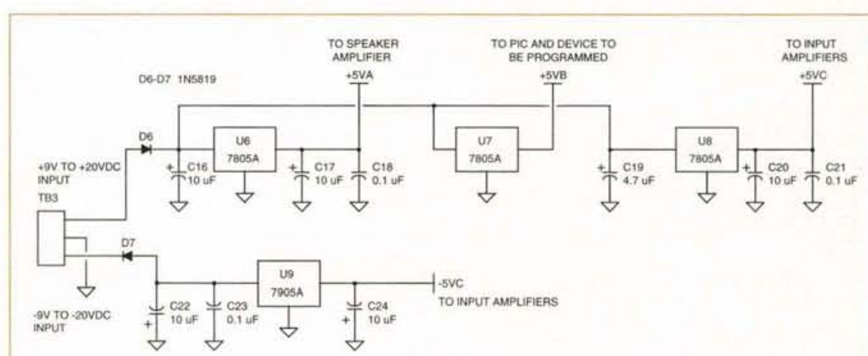

Figure 5. Three separate +5 volt regulators insure good isolation between the analog and digital parts of the circuit.

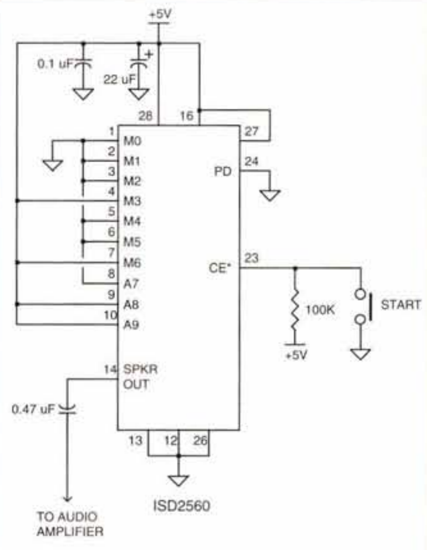

Figure 6. This simple circuit is all that's needed for continuous loop playback.

ously described. The U3 circuit is an audio power amplifier for driving an external speaker during playback. Its maximum output is about 200 MW and R13 is the volume control. Header H1 is for connecting an external sound system for "higher fidelity" playback.

Figure 5 shows the on-board voltage regulators. Three separate +5 volt regulators are used to provide maximum isolation between the digital and analog parts of the circuit. Positive input voltage should be between 9 and 20 volts; maximum current is about 100 mA and depends on the playback volume. The negative input should be between -9 and -20 volts; current is a constant 10 mA. D6 and D7 are Schottky diodes to prevent damage in case the power supply is incorrectly connected.

SOUND-EFFECT SOURCES

There are lots of sound-effect files on the Internet. One site I especially like is www.ultimatesoundarchive.com. They have a huge selection and everything I've downloaded can be freely used both privately and commercially. The downside is you do pay a fee: $15.00 I think for three months of unlimited access. You can download lots of sound files in three months!

Another useful site is www.partnersinrhyme.com. They too have a large selection, but no fee. They also say "they cannot give permission to use the sounds for any commercial purpose," but this won't be a problem for private, home use. If you look around, you may find a site you like better than either of these.

SOUND SOFTWARE

There's a lot of sound software, too, on the Internet, but I'm in love with Cool Edit 2000 **[3]**. It is fairly inexpensive, has lots of features, and is easy to learn to use. Rain and babbling brook sounds are a sufficiently-constant amplitude that it doesn't matter where the splice occurs. But ocean surf has a wide dynamic range, so the splice needs to occur at times of about equal amplitude.

I first measured the actual playback time of the ISD2560 I intended to use for the ocean surf file. According to the data sheet, this time can vary from 58 to 62 seconds. To make this measurement, I connected a time interval counter between pin 25 (EOM*) and common (see Figure 4). This pin controls the RUN LED and goes high when the ISD is active. I put the board in playback mode, pressed RESET and START and measured 59.46 seconds. (I put this on a small label which I stuck to the IC for future reference.) **[4]** Using Cool Edit 2000, I selected and trimmed until I had a file length of 59.5 seconds between two points of minimum amplitude. The splice isn't audible in the playback.

CHOOSING A PLAYBACK SYSTEM

I remember staying in a cottage perched on a rock less than 100 feet from the ocean. And I recall the sound of the waves breaking on shore. It was a relaxing sound and I never slept better. We were immersed in that sound and it was almost like a physical presence. If you have ever lain in bed listening to the sound of steady rain on the roof, you know what I mean. The sound comes through the roof and through the walls. The sound becomes your environment.

This is the effect we want to try to create for sound masking: low to moderate volume but lots of presence. A three-inch speaker in a small enclosure won't do it. On the other hand, a whole wall covered with 8- or 10-inch speakers in good enclosures is impractical for most of us. One or two good speaker/enclosures work pretty well if properly placed. You want to place them as far from your bed, armchair, or desk as possible. The goal is to fill the room with fairly low volume sound. Even placing the speakers in another room facing the common wall can be very effective **[5]**.

The amplifier should have a graphic equalizer or at least a tone control to adjust the frequency spectrum of the masking sound. Although Cool Edit 2000 has a built-in FFT analyzer, it doesn't do third-octave band analysis which I prefer for these noise-like signals. So I used a shareware program named Spectrogram **[6]**. This program shows the brook file to have most of its energy between 400 and 3,500 Hz so the 3,400 Hz bandwidth of the ISD2560 matches it pretty well. A flat equalizer setting or maybe a bit of treble boost should give a natural sounding brook.

The surf file looks like pink noise to within 4 dB from 100 Hz to 5 kHz, that is, it has equal energy in each third-octave band. This file sounds most natural with quite a lot of treble boost. There's no way for me to be more quantitative because the best equalizer setting will depend on your sound file, your speakers, and your room acoustics. While the 803 board is fine for programming and testing, a circuit for continuous loop playback can be much simpler (see Figure 6). A reset switch isn't needed because it doesn't matter where in memory playback starts.

A FINAL THOUGHT

If you are regularly or occasionally bothered by unwanted noise, you might try sound masking before listing your home for sale. **NV**

NOTES

[1] Information Storage Devices, Inc., 2045 Hamilton Ave., San Jose, CA 95125. 408-369-2400, www.isd.com. The ISD2560 is stocked by Jameco Electronics, 1355 Shoreway Rd., Belmont, CA 94002. 800-592-8097, www.jameco.com.

[2] The model 803 board is available fully assembled for $97.00 plus shipping from TDL Technology, Inc., 5260 Cochise Trail, Las Cruces, NM 88012-9736. 505-382-3173, www.zianet.com/tdl. Data sheet and User Guide in pdf format can be downloaded.

[3] Syntrillium Software Corp., P.O. Box 62255, Phoenix, AZ 85082. 480-941-4327. www.syntrillium.com.

[4] If you don't have a time interval counter, we can supply an ISD2560 labeled with its record time. Price is $13.00 if prepaid by check or money order or $13.00 if prepaid online using PayPal. Price includes postage in the US. Address and web site as above.

[5] For a large selection of speakers, enclosures, enclosure kits, and amplifiers see Parts Express, 725 Pleasant Valley Dr., Springboro, OH 45066. 800-338-0531, www.partsexpress.com.

[6] Spectrogram is a shareware program written by Richard Horne. You can download it from www.visualizationsoftware.com/gram.html.


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- 140A 1st four cameras/windows
- 140B 2nd four cameras/windows (expands to = 8 windows)
- 140C 3rd four cameras/windows (expands to = 12 windows)
- 140D 4th four cameras/windows (expands to = 16 windows)
Cards MUST be utilized in this order.
System Requirements:
- Windows 98/ME/2000/XP
- Pentium III-550Mhz or higher with free PCI slot(s)
- 128 MB+ System Memory
- PCI/AGP bus graphics card (24 bit high color or 64 bit
- Sound Card (optional)
- Hard Disk Space - 1 GB+ per camera; 10GB+ is recommended
- Microsoft DirectX or higher version
- CD-ROM / DVD-ROM device
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Exploring and Experimenting With Lasers and Their Properties

by Stanley York

Laser Insight

Many readers have written to me asking for an easy and quick way to align a laser. Of course, there can be no simple procedure that would apply to all lasers, but there are several techniques that are commonly applied during the alignment procedure. This month, I'd like to pass on a few tips about laser alignment that I have learned over the years, and perhaps a few shortcuts to get the laser producing a beam.

Frequently, lasers can be picked up on the internet or through many liquidation companies and laser reselling businesses. I know I have bought a couple of lasers this way for my own business. These lasers represent a good investment, because they can be obtained very cheaply, and with a bit of cleaning and some minor repairs, can be brought back to good working (or workable) condition.

To clean a laser thoroughly, and to restore or repair optical rail components, it is inevitable that you will need to realign the optics before you will get any useful laser light from the machine.

When I first got involved with lasers, one of my early tasks was to align an old HeNe laser that someone had taken the mirrors off to clean. When they put the mirrors back, they were very disappointed to see that the laser output was now worse than before they had cleaned the mirrors! Obviously, the problem was not with dirty mirrors, but with the optical alignment. Needless to say, they '... adjusted the mirrors just a little ...' and succeeded in losing the beam altogether.

HeNe laser alignment

With a HeNe laser, the alignment of the mirrors is more critical than with other types of laser. Earlier in this series, I presented a drawing of a HeNe laser in cross sections, indicating all the internal parts of a typical modern HeNe tube (Figure 1-3). If you missed this article, the drawing is reproduced here as Figure 16-1.

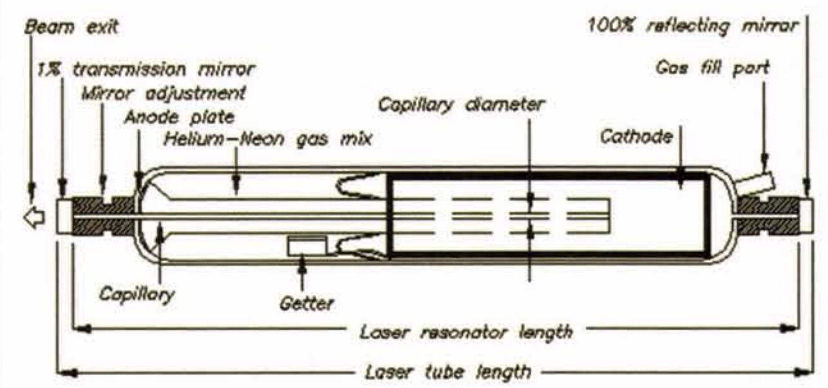


Figure 16-1. Basic assembly of a modern HeNe laser.

If you look at this drawing, you'll notice that there is another tube running down the center of the main tube. This tube is called the capillary, and is the place where the actual laser action occurs in the HeNe laser. The capillary is about 0.5-1mm in diameter. In order for laser action to take place, the laser beam formed must travel perfectly parallel down this fine tube, and incur no losses (through sidewall reflections, misalignment, debris in the tube, or moisture). The HeNe laser is very inefficient, and typically shows about 0.1-0.5% wall plug efficiency. Any losses in such a weak system would result in complete loss of laser action.

With the old laser I was dealing with, the end mirrors were not an integral part of the laser assembly as shown in Figure 16-1, but were separated from the tube body. I couldn't use an autocollimator (see sidebar) to align the mirrors, so I had to be creative.

If you follow the method described below for other laser types, keep these thoughts in mind. Make sure the table or support you use to set the alignment is stable. You don't want the table or laser to move while you work on the alignment. Stability is crucial.

I set up the old laser tube on a firm stand, and strapped it down securely. In aligning a laser this way, you will be setting up some pinhole targets in precise locations, and you don't want anything to move.

Look down the bore of the HeNe tube (no power on, of course) and set up a small light bulb and battery arrangement, so that you can turn the bulb on and off without disturbing its position. The bulb should be about a foot or so away from the near end of the laser, and you should place it so that you see a bright glow when it is on (Figure 16-2). Next, punch a pinhole through a piece of stiff card, and position it on a heavy support between the bulb and the laser as shown. The hole in the card should be smaller than the bore of the capillary in the HeNe tube, so try to get it as small as possible, but still allow enough light through for this task. When I did my laser, I found it best to turn off the room lights when doing this exercise. It makes viewing the reflected light spot easier.

Turn on the bulb and position the new target between the laser and the bulb, as shown in Figure 16-2. Look down the bore of the tube and move the card around until you see the brightest glow from the bulb. When you see this, you know that the bulb and pinhole are exactly aligned with the HeNe capillary. You also know that light from the bulb is traveling parallel to the axis of the capillary.

Place the far end laser mirror in position and adjust its orientation until the light falling on its surface is reflected back down the capillary onto the surface of the paper target.

This will be difficult to see, and perhaps you should turn off the room lights, as I had to.

Perhaps you can begin to understand now the reason for the stability I mentioned earlier.

To get the mirror roughly aligned, place a piece of paper near the mirror to see where the reflections are going, and get a feel for how much optical leverage the adjustment screws give you.

When the beam is close to going down the capillary, you will begin to see a glow around the hole in the target. When the mirror is perfectly aligned however, the reflection may disappear altogether! It really depends on the relative sizes of the capillary and target hole. The smaller you make the hole in the target, the easier you will able to align the laser, but at the same time, if you make it too small, there may not be enough reflected light to see! You have to try different combinations to see what works best for you.

Let's assume for now that you were able to set the first mirror without too much problem. Now for the second mirror. Without disturbing the arrangement, install the second mirror.

There may or may not be enough light leakage through the mirror to see at the other end of the laser. Let's make another assumption, and say there is not enough light coming through the assembly to be useful. The light spot from the target will be reflected back to the target at the two mirror faces (front surface, back surface). However, the back surface reflection will be darker,

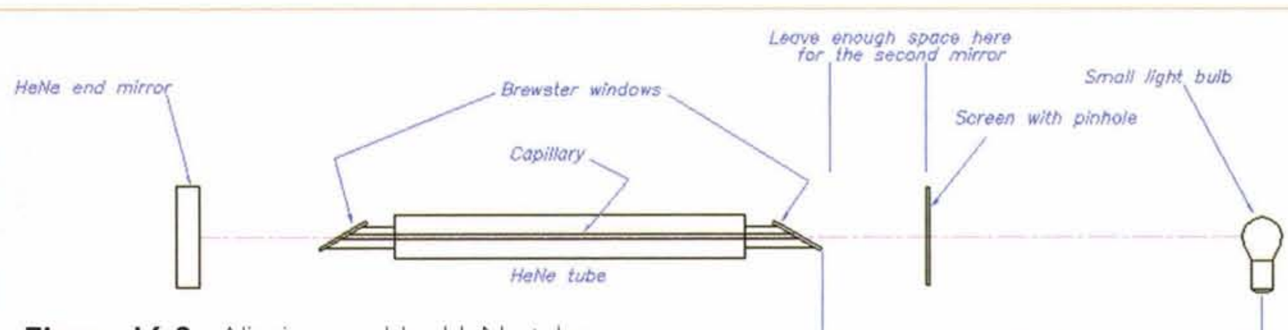


Figure 16-2. Aligning an older HeNe tube.

or colored, or both, due to being reflected from a wavelength selective surface coating. Try to determine which reflection is from the back surface (i.e., the surface closest to the laser tube), and adjust the mirror angle until this reflection also returns through the hole in the target.

This procedure should get the HeNe mirrors very close. Do not remove the bulb and target at this stage. Turn on the laser and see what it produces. If any adjustments are required, make them to the last mirror you worked on. This mirror is likely to have the greatest position error because of its proximity to the target. The first mirror — being much further away, and reflecting the beam down the capillary — is likely to be accurately aligned, and should not be touched. In fact, once it is set, you should regard the first mirror as your reference for the remainder of this exercise.

Aligning a larger system using a HeNe or diode laser

If you have a larger system, say a small CO2 laser or an Nd:YAG system, you could follow the procedure above and get fairly accurate results. However, if your system has a HeNe or diode laser as a pointer, the task is much simpler.

Begin by removing as many components as possible between the resonator mirrors, so that you begin with a basic laser (Figure 16-3). If your laser was originally supplied with any kind of laser pointer, then you have the best of all situations, and aligning your system will be easy. If your system does not have a pointer, you will have to make some kind of adjustable mount to hold a HeNe or laser diode firmly on the optical rail. Figure 16-4 shows a suitable mount suggestion. You'll need two of the rings, cut to a size to suit your laser. The three holes are the laser adjustment screws, while the fourth hole holds the mounts to a flat base.

The base plate you use will depend on the type of laser rail your machine has, so only a general base is depicted here. I used a piece of 3/8" Plexiglas to make this kind of mount a couple of years ago, and I have never had to go back and readjust the HeNe, so this material is fairly stable. I cut the rings using a scroll saw, and the base plate was cut using hand tools. Just make sure that the overall height of the assembly allows the laser to sit centrally in the rings for the greatest amount of movement in the X, Y, Yaw, and Pitch axes. (See sidebar for a brief explanation of these terms.)

> An autocollimator is used extensively in the laser industry for aligning laser resonator mirrors. It is an optical device similar in principle to a small telescope, and has a built-in light source and targeting mechanism allowing multiple reflections from mirror surfaces to be overlapped. When the overlapping reflections are reduced to the minimum size, the laser mirrors are properly aligned. This instrument can only be used on mirrors with parallel or nearly parallel surfaces.

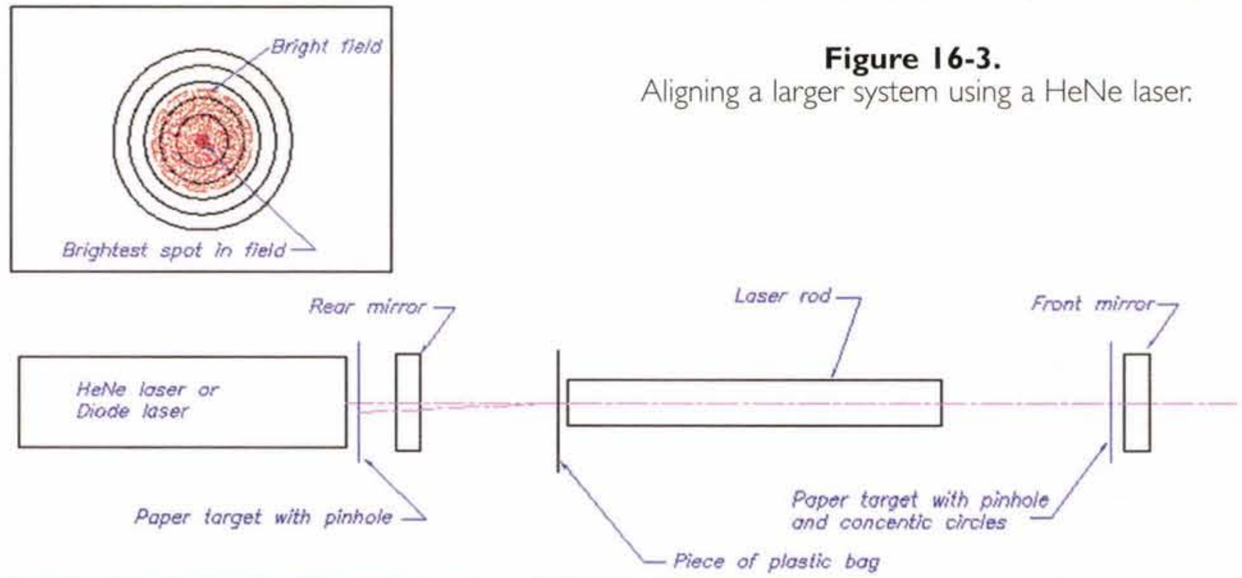


Figure 16-3.
Aligning a larger system using a HeNe laser.

Aligning the laser to the rod

Set up two paper targets as shown in Figure 16-3. The target nearest the HeNe laser should have a pinhole punched through it to allow the HeNe beam to pass through without shadowing (i.e., the beam should pass through without hitting the paper). This target may be stuck to the front of the HeNe laser using double-sided sticky tape. The second target should have a pinhole with concentric circles drawn using a compass.

Align the beam using the adjustment screws until the beam hits the laser rod in the center of the near end. The laser should be positioned so that the beam hits the end of the rod perpendicularly. If the beam is not hitting the center of the rod perpendicularly, the reflected beam will be seen on the paper stuck to the front of the laser, a clear indication that the beam is not shooting squarely down the rod (shown exaggerated in Figure 16-3). Adjust the position of the HeNe laser in the mount using the Yaw and Pitch axes, until the reflected beam returning to the front of the laser goes back through the hole in the paper target.

When the laser beam hits the end of the laser rod, and the reflection returns back through the hole in the paper target stuck to the front of the HeNe, you can be sure that the beam is hitting the end of the laser rod perpendicularly. Look carefully at the end of the rod. Is the beam going down the center? Possibly it is, more likely it is not. To test this, get a piece of polyethylene bag (a sandwich bag is fine), but don't punch any holes in it, and hold it in the position shown in Figure 16-3.

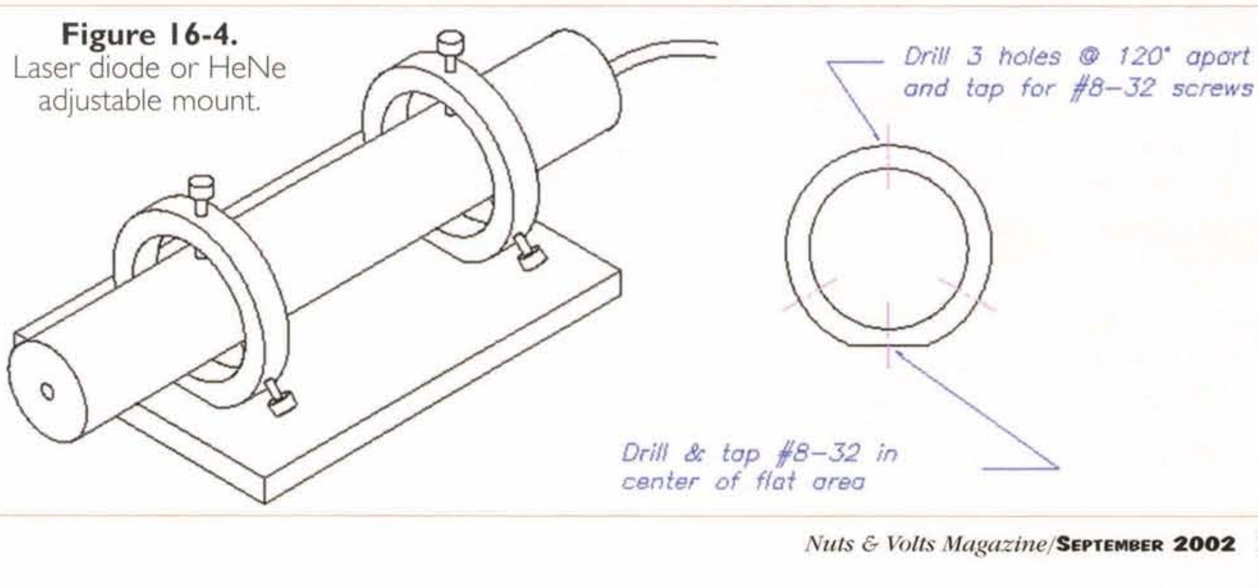
Observe the second paper target. The plastic bag will scatter the laser beam, and cause it to illuminate the entire laser rod. There will be some vignetting (shadowing) by the rod, and it will clearly define the edges of the rod on the target paper. The center of the bright field will be most strongly illuminated by the HeNe though, as there is not a total diffusion by the plastic bag. The brightest spot should be in the center of the bright field. Move the second target so that the bright field is concentric to one of the circles drawn on the paper. The pinhole defines the center of the bright field and the location of the brightest spot within the field. If the brightest spot is not in the center of the field, then adjust the X and Y HeNe axes to get the bright spot central (see inset, Figure 16-3). Be sure to maintain the perpendicularity to the rod though.

This is a tricky procedure if you haven't tried to do it before, and it seems almost impossible to get everything in the right place at the same time, but don't give up. The time you spend to get the HeNe alignment right is time well spent, because you can use the transmitted beam to accurately set up your experiment prior to turning on the main laser. Later, I will suggest a way to get more accurate main beam/HeNe beam alignment, but for now this should be good enough.

Aligning the laser mirrors

Now that the laser rod axis is

Figure 16-4.
Laser diode or HeNe adjustable mount.



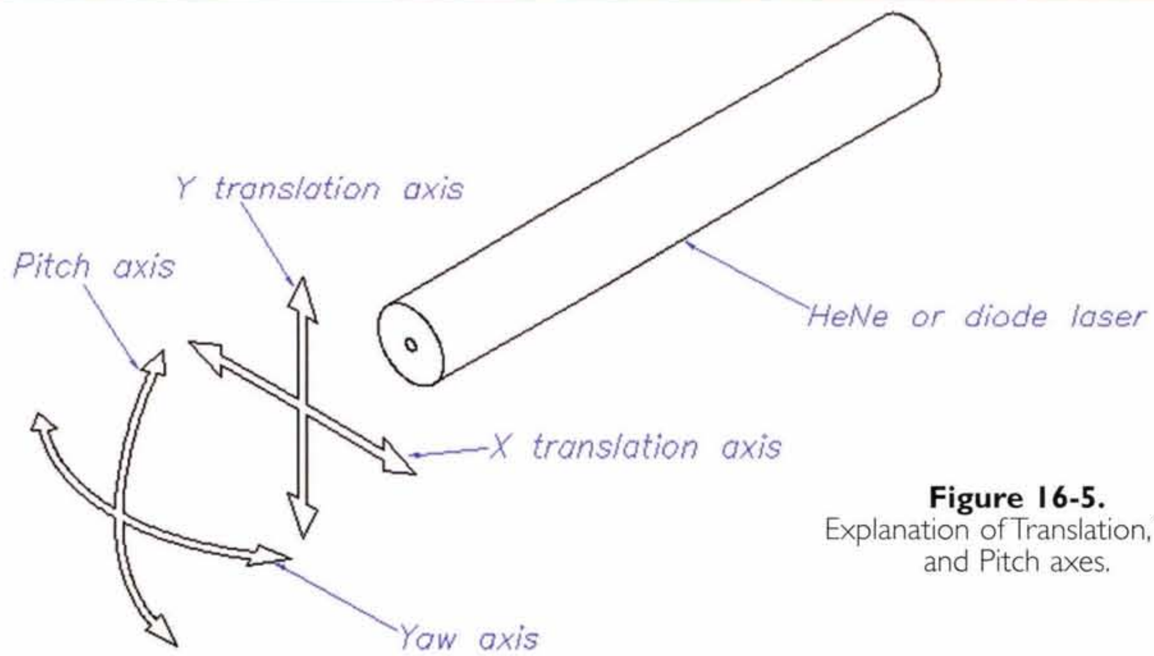


Figure 16-5.
Explanation of Translation, Yaw, and Pitch axes.

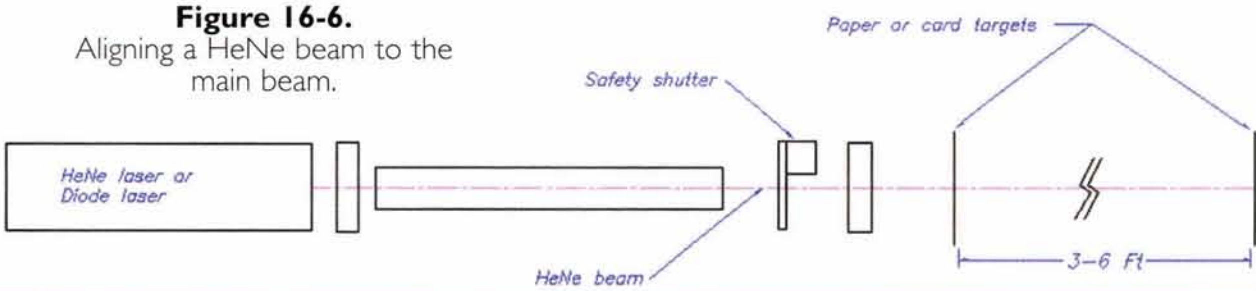


Figure 16-6.
Aligning a HeNe beam to the main beam.

defined by the HeNe laser, setting up the two end mirrors will be a piece of cake.

Remove the paper targets and the plastic bag diffuser from the laser resonator (between the mirrors), but leave the target stuck to the front of the HeNe laser, and allow the HeNe beam to hit the two mirrors. Adjust the mirror nearest the HeNe laser first, and make the reflected beam again disappear back down through the pinhole in the target. This mirror is then perpendicular to the optical axis of the laser rod. Adjust the far mirror in the same manner, and the two mirrors will be parallel to each other.

When this condition is achieved, the laser should produce close to maximum power when fired up, and only minor adjustments should be required to reach peak power. When making the final adjustments, work on the mirror closest to the HeNe laser first, as this is the most likely to be slightly off. The mirror furthest away from the HeNe laser is more accurately set because of the optical leverage afforded by the distance between the mirror and target.

Aligning the HeNe laser to the main beam

After the final adjustments have been made, and you are satisfied that the laser is putting out close to its rated output, you can more accurately align the HeNe laser to the main beam. Proper alignment in this manner is essential if you will be conducting any optical experiments with your laser, or you may use it as a guide in a cutting or welding application, for example.

Set up some burn paper targets, or laser absorbing paper or card targets as shown in Figure 16-6. ("Zap-it" burn paper may be obtained from Kentek. They have a very useful booklet that should be of great assistance to anyone involved with lasers. See their web site at www.kentek-laser.com.)

Before you start, make sure the safety shutter works properly, otherwise, you will run the risk of starting a fire. You should also wear safety goggles, and keep all unauthorized people out of the room.

Start with the target farthest from the laser. Set up the target using the HeNe guiding laser, and make sure the target cannot move. Close the shutter and start the laser. Turn up the power to the level you expect to use, and quickly open the shutter and close it again.

The burn paper is very sensitive and will quickly burn if you expose it to the beam for too long. The central part of the laser beam will be the hottest, and will leave a scorched or discolored spot where the laser beam hit it.

You may be disappointed to see an oval spot, or slightly misshaped spot, rather than a perfectly round spot. This condition is usually due to poor alignment, and if you see this, you may want to try readjusting the mirrors to reduce the deformation. Sometimes, however, it is due to the design of the laser pump chamber, and there's not a lot you can do to improve the situation. Don't be put off by a bad beam shape though; a lot of useful work can be done by a misshapen beam.

If you were successful, and made a decent burn on the farfield target, put the nearfield target in place about a foot from the end of the laser, and repeat the exposure at the same power setting. Again, quickly open and close the shutter.

Turn down the laser power, and shut the power off. The rest of the exercise can be done without the laser being on.

Without moving the targets, make a small hole in the center of the nearfield burn spot with a pin, and enlarge the hole slightly with a pencil point. Open the laser shutter and let the HeNe beam come through. Ideally, the HeNe beam should pass through the hole in the nearfield target, and hit the farfield target in the center of the burn mark. If it does not, then you should make some fine adjustments to the position of the HeNe in the mounts until this condition is met. Then your system will be ready for any task. You can then use the HeNe laser to aim precisely where the main beam will hit.

That about wraps up this little briefing on laser alignment. Next month, I will go a stage further with this theme and describe in more detail how an autocollimator works, and see if we can't come up with a design for a simple one you can make.

As always, if you have any questions regarding lasers and their use, or if you have any suggestions for future columns, please send me some email. I always answer everyone who contacts me, even though it sometimes takes a while. My email address is: stanley.york@att.net. **NV**

The X and Y axes mentioned here refer to the horizontal and vertical directions of movement of the HeNe or diode laser when the complete laser is moved in the same axis. The movement is a straight translation of the laser as a whole, without any tilt or skew in any axis.

Yaw motion, or adjustment in the Yaw axis, is a partial rotation or twist of the HeNe laser about the vertical axis.

Pitch motion, or adjustment in pitch, is a partial rotation or twist about the horizontal axis. See Figure 16-5 for illustration of these movements.

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:

This month's theory: resettable fuses, power FET selection chart, and all about DC motors. ***This month's circuits:*** dissecting a PIR, a tach calibrator, and an electrolytic cap healer. ***On the lighter side:*** Cool Web Sites! Finally, a serious Klez threat.

Polly Want A Fuse?

Q. With regard to the electronic fuse you described in the April 2002 issue, Digi-Key sells several semiconductor-based resettable fuses. Might they solve his problem better?

Shawn Jordan
via Internet

Q. While looking through the latest issue of Jameco's catalog, I noticed on page 65 some devices called resettable fuses. Can you describe what these devices do and how they are typically used in a circuit?

Dave Moorhouse
via Internet

A. What you refer to is called the PolySwitch from RayChem. PolySwitches are a special type of positive temperature coefficient (PTC) resistor, made from a conductive polymer mixture. At normal room temperature, the conductive particles in the polymer form a densely-packed, low-resistance crystal that allows current to flow freely. However, as the current increases, so does the internal temperature of the PolySwitch.

Eventually, the internal temperature reaches a critical point, at which time the polymer's crystalline structure suddenly changes into an expanded, high-resistance amorphous state with a sharp reduction in the current flow. This is called the trip point current. After changing states, a small amount of current still flows, enough to maintain the PolySwitch's amorphous state. If the voltage or load is removed, the PolySwitch quickly cools and returns to its low-resistance crystalline state, effectively resetting the "fuse."

Generally, PolySwitches are used in low-voltage applications that require short-circuit or overload protection, such as PC interconnections, audio speaker protection, and so forth. Figure 1 shows a few of those applications.

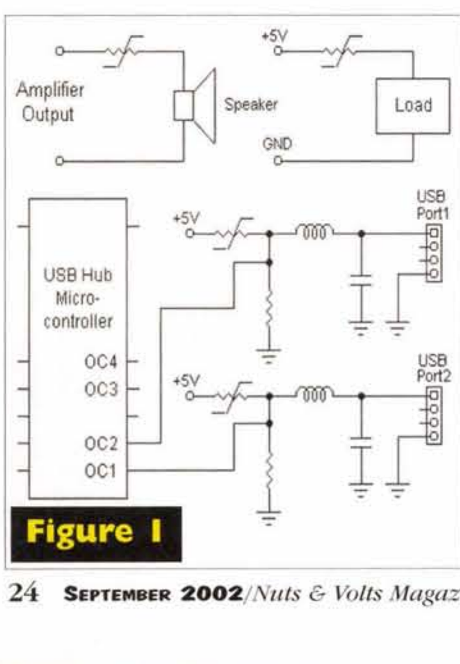


Figure 1

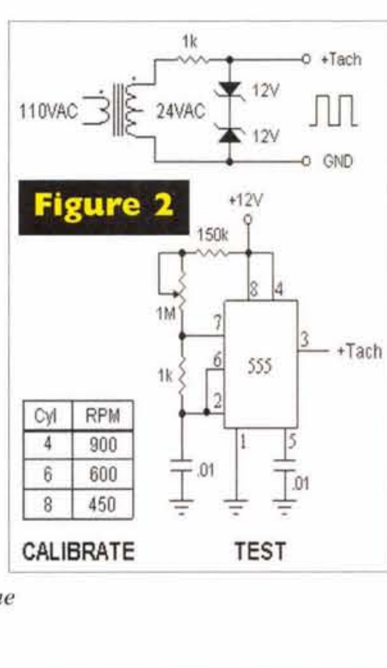
Tach Calibrator

Q. I need a circuit that will allow me to test an automotive analog tachometer. The tach is not the inductive type, but rather hooks up to the "TACH" connector on an HEI coil. I want to test the tach over its full range of 0-5000 RPM before installing it into the dash. It would also be nice if the tester could be used as a calibrator.

Niles Russell
via Internet

A. Actually, the calibration circuit is simpler than the one that moves the needle to full scale. Both are shown in Figure 2. The calibrator uses back-to-back zener diodes across a 24-volt transformer to produce a 12-volt squarewave, and uses the highly-accurate 60-Hz power line frequency for its clock reference. The actual RPM reading will depend on the number of engine cylinders. The more spark plugs you have, the more pulses you get per revolution, and the lower the meter will read. The attached chart in Figure 2 shows the relationship between the cylinder count and RPM.

The "Test" circuit is a pulse generator built around a 555 timer. The resistor and capacitor values are adjusted for a full-scale of 4500 RPM on a tach set for eight cylinders.



Cyl	RPM
4	900
6	600
8	450

Figure 2

Cap, Heal Thyself

Q. I'm trying to reduce the ripple in some high-voltage DC supplies by hanging extra electrolytics on the output. Because the capacitors I intend to use are surplus (450 volts), I'd like to verify that they're okay and won't blow. I'm sure I saw an electrolytic reformer construction article somewhere, but I can't find it. Do you have one in your bag of tricks?

Nick
via Internet

A. Just so happens I do. First, some background. The high-voltage electrolytic capacitors used in older vacuum tube equipment tend to deteriorate if the equipment isn't used for an extended period. This deterioration takes the form of reduced capacitance and greatly increased leakage current. In some cases, the capacitor will become a virtual short circuit. If full voltage is suddenly applied, the high current draw caused by this depleted condition could cause the capacitors to overheat and possibly explode.

The circuit shown in Figure 3 is designed to pass a controlled low current (about 25 mA) through the capacitor, allowing the internal chemical composition to reform gradually without the risk of overheating.

Here's how it works. At initial power on, the voltage across the electrolytic under test (Cx) is at zero and the voltage across R2 is equal to 450 volts, which lights the neon lamp. If Cx is anywhere near healthy, it will slowly start to reform and charge up.

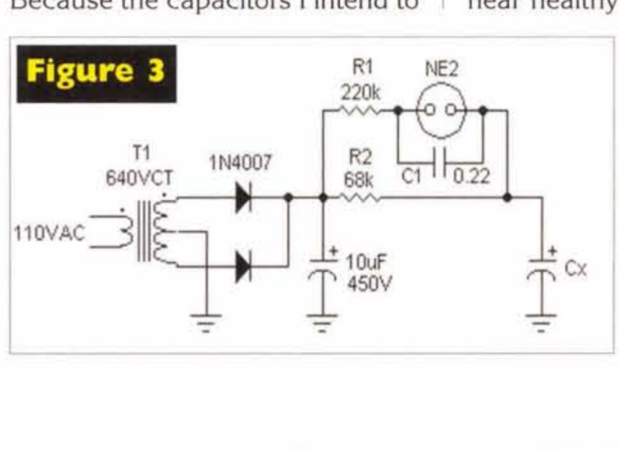


Figure 3

As the process continues (which can take hours), the voltage across R2 falls to the point where it is insufficient to keep the neon continuously lit, at which time it begins to flash at a rate proportional to the amount of current flowing through Cx. Once the neon lamp stops flashing, the voltage across R2 is too low to light the lamp, and it can be assumed Cx is fully charged and successfully reformed. For lower-voltage electrolytics, adjust the transformer secondary voltage according to the equation:

Voltage of Cx = T1 VCT x 0.707

Caution! Remove the power and discharge Cx via a resistor before removing Cx from the restorer. A shock from a large, high-voltage electrolytic can be lethal!

One PWM Controller Fits All

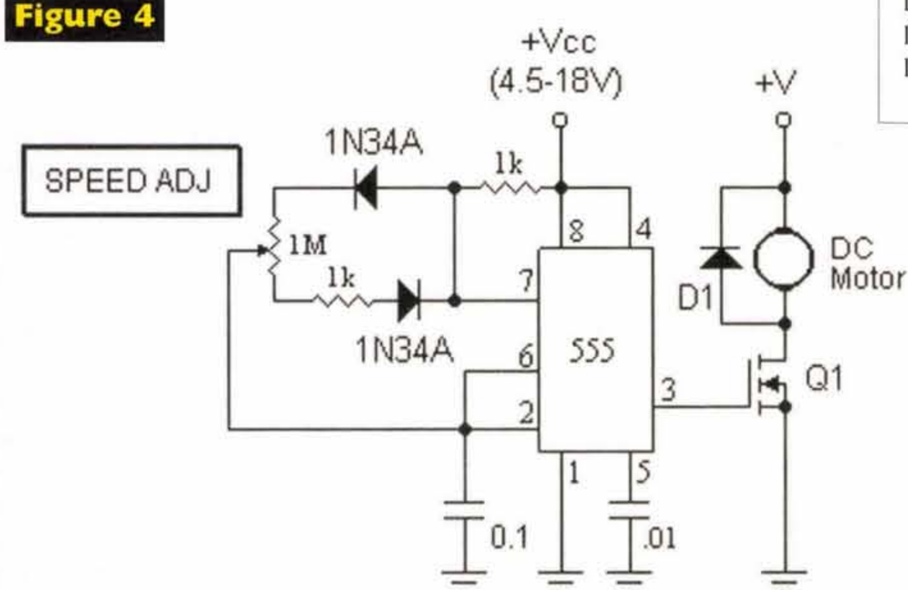
Q. In a recent column, you described a PWM controller for a small DC motor. This sounds like the perfect solution to my problem of a dizzy bot. I have a bot with two-wheel drive — one motor per wheel. Unfortunately, the wheels aren't in sync and the bot keeps going in circles. If I could control the speed of one wheel, not only could I make it walk a straight line, but I could use that speed controller as a steering mechanism. Now my problem, my motors are a lot bigger than the one you describe. What does it take to up the control current to about 10 amps?

Ben Adler
Manchester, NH

A. The circuit you describe was originally run in the Sept. 2000 column. I've reprinted it in Figure 4, with a few changes to make it more universal. For example, this time I don't specify the drive transistor, which is an enhanced mode FET. To make a long story short, this particular transistor is voltage operated. That is, when there's no voltage on the gate, no current flows. When the voltage on the gate exceeds a threshold point, the FET goes into full conduction — it turns on. Herein lies the real story of which transistor to use.

There are three parameters you have to consider: drain current (ID), breakdown voltage (VDSS), and gate voltage (VGS). The current must equal or exceed the current of the motor, taking into account the surge current on start-up. A rule of thumb is to overrate the drain current by 50%; this should accommodate both surge and running currents nicely. Same goes for breakdown voltage — it has to equal or exceed the +Vc voltage.

Figure 4



P/N	ID	VDSS	VGS
2N7000	200 mA	60V	6V
VN2106	250 mA	60V	5V
VN4206	600 mA	60V	4V
IRF510	5.6A	100V	10V
IRF520	9.2A	100V	10V
IRL520	7.7A	100V	4.5V
IRL530	11A	100V	4.5V
IRL540	36A	100V	4.5V
IRF840	8A	500V	10V

The gate threshold voltage is a whole different story. Some of the earlier FETs had a threshold voltage as high as 10 volts. Obviously this transistor won't work with a six-volt Vcc. The table above shows the gate voltages at the current listed for some popular FETs.

Under The Hood Of A PIR

Q. Fry's Electronics sells the Driveway Patrol, a wireless infrared alert system. The sensor appears to be too sensitive, so I am looking for a schematic and hacking information, because I want to use it as a base for a portable wireless infrared sensor to trigger a camera for shooting wildlife.

Warren Shedrick
via Internet

A. Hacking is such a harsh word. What you really want to do is modify an existing product to meet your specific needs — taking pictures. Fortunately, most of these devices are based on a very similar schematic, shown in Figure 5 (courtesy Glolab, **www.glolab.com**).

The part numbers may vary, but the concept is the same. The first op-amp (IC1A) amplifies the signal, and IC1B conditions it for further processing. IC1C and IC1D steer the signal to IC2, a monostable flip-flop, which determines the "lamp on" duration. If you think the circuit is too sensitive, all you have to do is reduce the amount of signal going from IC1A to IC1B.

It can be done two ways. The preferred way is to reduce the gain of IC1A by lowering the value of R4. As it stands, the gain is 100 (R4/R3). If you reduce R4 from 1M to 500K, the gain will be cut in half to 50. Another method is to insert a "volume" control between the output of IC1A and IC1B. This is done by breaking the wire between pin 1 and R5, and wire it according to Figure 6. R5 is changed from a fixed resistor to a pot and Cx is added. You can now adjust the sensitivity like the volume of a radio.

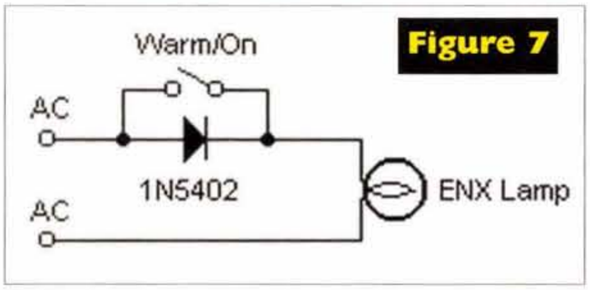


Figure 7

FET Cookbook

Q. Can you provide me with Cookbook-style or other such reference material covering FETs, in general, and MOSFETS, in particular?

Phil Corso, PE
Boca Raton, FL

A. Most theory and application of FETs is buried in older basic electronics books, most of which are out of print. (I suggest you check your public library.) Virtually all of today's learning focuses on MOSFET ICs. Fortunately, we published a series of articles by Ray Marston titled "FET Principles And Circuits" that should answer most of your questions. It's a four-part series that ran from May 2000 through Aug. 2000. You can order back issues from our web site **(www.nutsvolts.com)** for $5.00 each plus shipping. Also check out the answer to the question above, "One PWM Controller Fits All."

Longer Lasting Lamps

Q. I have a video projector that uses an ENX projection lamp. The lamps are rated for, say 50 to 75 hours, but they rarely last that long. Most blow from the start-up inrush current rather than burning out while in use. Can you come up with a circuit that will warm up the filament slowly to prevent this expensive problem?

Mike Tewksbury
via Internet

A. Go to your local hardware store and buy a dimmer switch (be aware this lamp draws 360 watts). Wire it to the projector's lamp circuit and use it to slowly heat the filament. Alternatively, wire a diode/switch combination in series with the hot wire of the lamp, as shown in Figure 7.

Building A Bag Sealer

Q. I'm trying to find what kind of wire I need to buy as a heating element so that I can build a plastic bag sealer. I was planning to build a power supply to plug from the wall, but a friend of mine told me that I could use batteries. Is that true? What kind of batteries should I use? I'd like to use the rechargeable ones. What do you think?

Gill Nascimento
via Internet

A. I don't know who told you that a hot wire would work for sealing a plastic bag, because it won't do what you expect. Sealing a plastic bag takes a lot of heat control and precise timing, which requires protection from direct contact with the hot wire. I

suggest you get a parts replacement kit (about $7.00) for a commercial bag sealer and start from there. The kit contains the heating wires and the thermal shields that you need to do a neat job of it. I find Hillas Packing Network (800-952-7424; **www.hillas.com/Heat_Sealers/AIE_Parts/Default.asp**) and ABTEC (800-832-0077; **www.abtec.com/sealers.php#parts**) to have the best selection and prices. If you're looking for a battery-powered bag sealer, there are a few "cheapies" on the market, most of which sell for about $10.00. Check out InstaSeal at **www.storeshop.com/bag_sealer.html** and Salton Sealer at **www.salton.com/bs-12.html**.

All About DC Motors?

Q. My question is: How can I get started on learning everything about DC motor controls? I have a background in electronics, but don't know how to break into this area. Any help would be greatly appreciated.

Gary Jones
via Internet

A. Everything about DC motor controls? Let me know when you learn it all, and I'll get you a job with a six-digit annual salary. Seriously, this is a very large field, so I'm assuming you want to apply this knowledge to small DC motors (less than 1 HP) for robotics control. In this group, DC motors fall into three categories: brush, brushless (a.k.a., stepper), and servo. Each requires a different controller.

You can begin by studying the information provided in the following web sites.

www.srl.gatech.edu/education/ME3110/primer/motors.htm

www.me.ua.edu/ME360/weblinks.htm

www.boondog.com/%5Ctutorials%5C2993pwm%5C2993pwm.htm

www.trainweb.org/girr/tips/tips5/motor_tips.html

www.eio.com/stprhist.htm

www.stanford.edu/class/ee281/handouts/lecture10.pdf

MAILBAG

Dear TJ:

In the August 2002 issue, you answered a question from Bernie Petrasek who was looking for a way to determine if a remote control was working. You provided two excellent answers, but I have a much simpler solution. The imaging chips used in almost all video and digital still cameras can "see" into the infrared spectrum. All you have to do is point the remote at the camera and operate the remote. The flashing IR LED will show up on the screen as a bluish/green blob of light. It doesn't matter if it's in focus or not. The only limitation is that your camera must have an electronic viewfinder, not an optical one — otherwise, you'll have to photograph the test and play back the tape or view the digital photo to see the result.

Jim Cassedy
San Francisco, CA

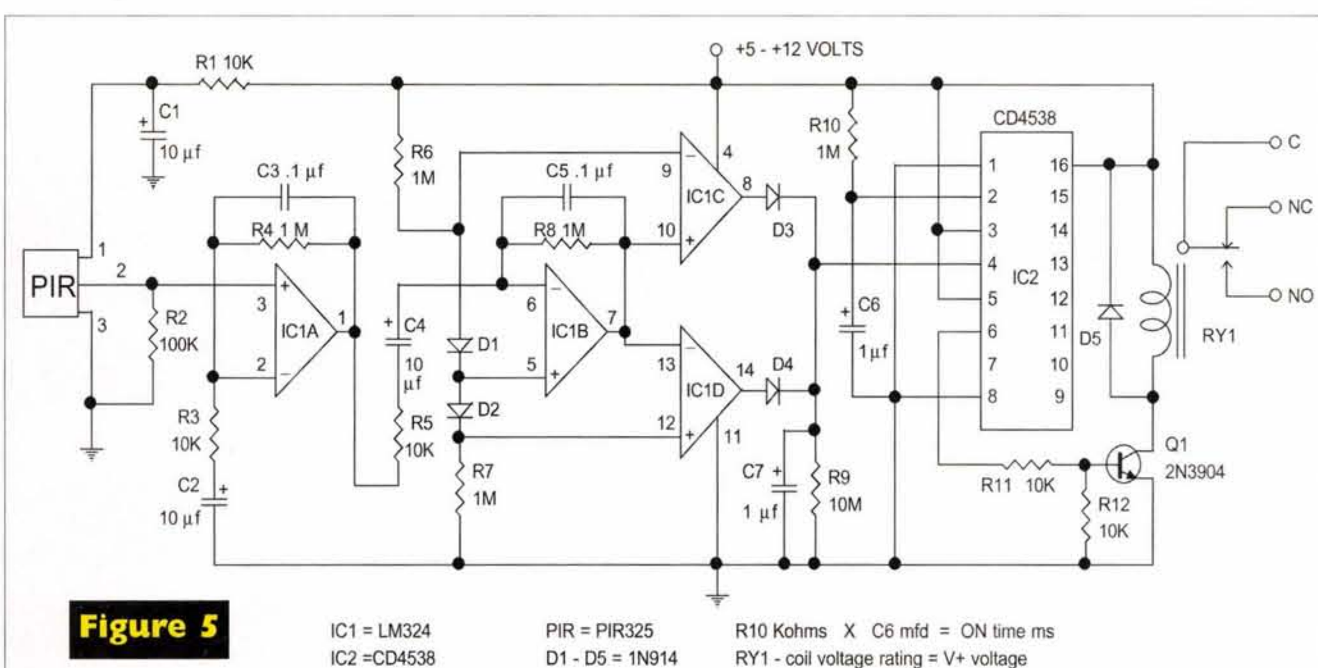


Figure 5

MOTION DETECTOR

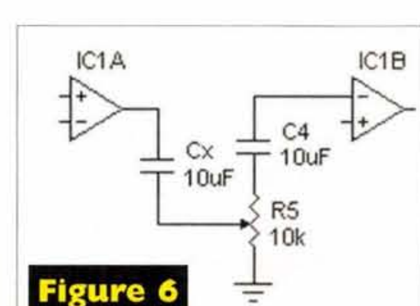


Figure 6

Cool Web Sites

Drawing Hand Creations is a shareware screen saver that educates, entertains, and relaxes. Unlike other screen savers, Drawing Hand Creations draws pictures right before your eyes. Watch as an artist's hand moves around your screen, drawing and blending, to create works of art.

www.drawinghand.com/

Who said chemistry has to be boring? Amuse yourself with The Periodic Table of Comic Books.

http://chemistry.about.com/gi/dynamic/offsite.htm?site=http%3A%2F%2Fwww.uky.edu%2FProjects%2FChemcomics%2F

Dumb warning labels.

http://rinkworks.com/said/warnings.shtml

For years, the cartoons of S. Harris have added humor to innumerable magazines, books, newsletters, ads, and web sites. Now these cartoons are available at:

www.sciencecartoonsplus.com/gallery.htm

Editor's Tip: Klez.E Worm Immunity Hoax

You've heard of the Klez worm, right? What's happening now is some warped mind has created an antivirus scam — an alleged immunity for the Klez worm. The message (see it below) says it has a DOS batch file (typically "Class.bat") attached to it, which isn't a batch file at all. It's a Visual Basic program with the Klez Worm built in. Click on the file and zap, you're infected with Klez.

I want to make sure you understand what's happening. The "free immunity tool" IS the virus. It actually contains the Klez worm! Here's how the message reads.

Subject: Worm Klez.E immunity
Date: Thu, 09 May 2002 05:17:17 -0700

Klez.E is the most common world-wide spreading worm. It's very dangerous by corrupting your files. Because of its very smart stealth and anti-anti-virus technic [sic], most common AV software can't detect or clean it.

We developed this free immunity tool to defeat the malicious virus. You only need to run this tool once, and then Klez will never come into your PC. NOTE: Because this tool acts as a fake Klez to fool the real worm, some AV monitor may cry when you run it. If so, Ignore the warning, and select 'continue.' If you have any questions, please mail to me.

The above message is a scam! If you receive this e-mail, delete the message and its attachment immediately! Don't follow the instructions. Note: If you're using Outlook/Outlook Express and aren't using IE6 (full) or have IE patched up to the latest, you're infected the instant you click on the message.

If you do happen to pick up Klez, don't panic. Simply grab a copy of Symantec's W32.Klez Removal Tool from its web site and follow the directions.

http://securityresponse.symantec.com/avcenter/venc/data/w32.klez.removal.tool.html

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SIGNAL GENERATORS

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GIGATRONICS 6061A-830 Signal Generator, 0.1-1050 MHz, 10 Hz res., AM, FM, GPIB $1900.00
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HP 8660C/603A/633B Signal Generator, 1-2600 MHz, 1 or 2 Hz res., AM, FM $3250.00
HP 8660D/603A-002 Signal Generator, 1-2600 MHz, FM/PM, includes 86635A $6000.00
HP 8671A Signal Gen., 2.0-6.2 GHz, 1 kHz res., CW, FM, +8 dBm, HPIB $2750.00
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HP 8673H-212 Signal Generator, 2.0-12.4 GHz, 1 kHz res., AM, FM, +8 dBm $8500.00
HP 8673M Signal Generator, 2-18 GHz, 1 kHz res., AM, FM, +8 dBm $9500.00
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HP 8683D Signal Generator, 2.3-13.0 GHz, cavity tuned, AM/ WBFM/ Pulse $3750.00
HP 8684B Signal Generator, 5.4-12.5 GHz, cavity tuned, AM/ WBFM/ Pulse $2250.00
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HP 8350B/ 83522A Sweep Oscillator, 10-2400 MHz, +13 dBm levelled $3750.00
HP 8350B/ 83525A Sweep Oscillator, 10 MHz-8.4 GHz, +13 dBm levelled $5000.00
HP 8350B/ 83540A-002 Sweep Oscillator, 2.0-8.4 GHz, 70 dB step atten. $3250.00
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HP 8350B/ 83550A Sweep Oscillator, 8-20 GHz, +20 dBm levelled output $5000.00
HP 8620C Sweep Oscillator Frame $500.00
HP 86222B-002 RF Plug-in, 10-2400 MHz, +13 dBm, 70 dB step atten. $1250.00
HP 86222B-E69/8620C Sweep Osc. & frame, 0.01-2 GHz & 2-4 GHz bands $1200.00
HP 86241A RF Plug-in, 3.2-6.5 GHz, +8 dBm unlevelled $250.00
HP 86245A RF Plug-in, 5.9-12.4 GHz, +16 dBm unlevelled $400.00
HP 86251A RF Plug-in, 7.5-18.6 GHz, +10 dBm levelled $500.00
HP 86260A RF Plug-in, 12-18 GHz, +10 dBm unlevelled $400.00
HP 86260A-H04 RF Plug-in, 10-15 GHz, +10 dBm unlevelled $400.00
HP 86290B RF Plug-in, 2.0-18.6 GHz, +10 dBm levelled $1500.00
HP 86290C RF Plug-in, 2.0-18.6 GHz, +13 dBm levelled $1750.00
WAVETEK 2001 Sweep Generator, 1-1400 MHz, +10 dBm, 70 dB atten. $750.00
WAVETEK 2002B Sweep Generator, 1-2500 MHz, +13 dBm, GPIB $1750.00
WILTRON 6647M Sweep Generator, 10 MHz-20 GHz, +10 dBm, GPIB $4500.00
WILTRON 6669B-02,03 Sweep Gen., 0.01-26.5 GHz/ K conn.& 26-40 GHz/ WR28 ..... $7500.00
WILTRON 6717B-20 Synthesizer/ Sweeper, 10 MHz-8.4 GHz, +13 dBm,GPIB $6000.00

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BOONTON 42B/ 41-4E Analog Power Meter, with 1 MHz-18 GHz sensor $400.00
HP 11683A Range Calibrator, for HP 435/6/7/8 ..... $750.00
HP 435B/8481A Power Meter, -30 to +20 dBm, 10 MHz-18 GHz $900.00
HP 436A-022/ 8481A Power Meter, -30 to +20 dBm, 10 MHz-18 GHz, HPIB $1200.00
HP 436A-022/ 8482A Power Meter, -30 to +20 dBm, 100 kHz-4.2 GHz, HPIB $1200.00
HP 436A-022/ 8484A Power Meter, -70 to -20 dBm, 10 MHz-18 GHz, HPIB $1200.00
HP 436A-022/ 8485A Power Meter, -30 to +20 dBm, 50 MHz-26.5 GHz, HPIB $1500.00
HP 436A-022/ 8485D Power Meter, -70 to -20 dBm, 50 MHz-26.5 GHz, HPIB $1700.00
HP 438A Dual Channel Power Meter $3000.00
HP 8477A Power Meter Calibtator, for HP 432 series $400.00
HP 8487D High Sensitivity Sensor, -70 to -20 dBm, 50 MHz-50 GHz, 2.4mm $1850.00
HP 8900D/84811A Peak Power Meter, 0.1-18 GHz, 0-20 dBm peak $2500.00
HP Q8486A Power Sensor, 33-50 GHz, -30 to +20 dBm, for 435/6/7/8 ..... $1500.00
HP R8486A Power Sensor, 26.5-40 GHz, -30 to +20 dBm, for 435/6/7/8 ..... $1500.00
HP R8486D Power Sensor, 26.5-40 GHz, -70 to -20 dBm, for 435/6/7/8 ..... $1750.00

RF MILLIVOLTMETERS

BOONTON 92C RF Millivoltmeter, 3 mV-3 V f.s., 10 kHz-1.2 GHz $500.00
RACAL-DANA 9303 RF Millivoltmeter, -70 to +20 dBm, 10 kHz-2 GHz, GPIB $750.00

AMPLIFIERS, MISCELLANEOUS

AMPLIFIER RES. 50AR15 Amplifier, 50 Watts, 46 dB gain, 0.1-15 MHz $1000.00
BOONTON 82AD Modulation Meter, AM/ FM, 10-1200 MHz $500.00
HP 11713A Switch / Attenuator Driver, HPIB $800.00
HP 11729B-003 Carrier Noise Test Set, 5 MHz-3.2 GHz $1900.00
HP 3730B/3738B Downconverter, 5.9-8.9 GHz & 8.7-11.7 GHz $1200.00
HP 415E SWR Meter $200.00
HP 8347A RF Amplifier, 25 dB gain, 100 kHz-3 GHz, +20 dBm, HPIB $2750.00
HP 8349A Amplifier, 15 dB gain, 2-20 GHz, +20 dBm output $1650.00
HP 8349B Amplifier, 15 dB gain, 2-20 GHz, +20 dBm output $3250.00
HP 8403A-002 Pulse Modulator, 0.8-2.4 GHz, 80 dB dynamic range $450.00
HP 8406A Comb Generator, 1/ 10/ 100 MHz increments, to 5GHz $500.00
HP 8447A-001 Dual Amplifier, 20 dB, 0.1-400 MHz, +6 dBm Po, NF <7 dB $650.00
HP 8447D-010 Preamplifier, 25 dB gain, 0.1-1300 MHz, <8.5 dB NF $750.00
HP 8447E Amplifier, 22 dB, 0.1-1300 MHz, +13 dBm output $650.00
HP 8447F-H64 Dual Amp., 0.01-50 MHz 28 dB & 0.1-1300 MHz 25 dB $900.00
HP 8901A Modulation Analyzer, 150 kHz-1300 MHz, HPIB $1350.00
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MPD LAB-1-510-10 Amplifier, 48 dB gain, 500-1000 MHz, 10 Watts $750.00
RACAL 9009 Modulation Meter, 30-1500 MHz, AM, 1.5-100 kHz pk FM $350.00
RF POWER LABS ML50 Amplifier, 2-30 MHz, 47 dB gain, 50 Watts, metered, 28 V $200.00
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HP 11691D Directional Coupler, 22 dB, 2-18 GHz, N connectors $450.00
HP 11692D Dual Directional Coupler, 22 dB, 2-18 GHz $800.00
HP 33327L-006 Prog. Step Attenuator, 0-70 dB, DC-40 GHz, 2.9mm $1000.00
HP 778D-011 Dual Dir. Coupler, 20 dB, 0.1-2.0 GHz, APC7 ..... $450.00
HP 8498A-030 30 dB Attenuator, 25 Watts, DC-18 GHz $500.00
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HP K532A WR42 Frequency Meter, 18.0-26.5 GHz $450.00
HP K752C WR42 Directional Coupler, 10 dB, 18.0-26.5 GHz $450.00
HP K752D WR42 Directional Coupler, 20 dB, 18.0-26.5 GHz $450.00
HP K870A WR42 Slide Screw Tuner, 18.0-26.5 GHz $275.00
HP K914B WR42 Moving Load, 18.0-26.5 GHz $250.00
HP Q752D WR22 Directional Coupler, 20 dB, 33-50 GHz $650.00
HP R281A WR28 x 2.4mm(f) Adapter $600.00
HP R422A WR28 Crystal Detector, 26.5-40 GHz $400.00
HP R752A WR28 Directional Coupler, 3 dB, 26.5-40 GHz $450.00
HP R752D WR28 Directional Coupler, 20 dB, 26.5-40 GHz $450.00
HP R914B WR28 Moving Load, 26.5-40 GHz $250.00
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HP V752D WR15 Directional Coupler, 20 dB, 50-75 GHz $650.00
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HUGHES 45714H-1000 WR15 Frequency Meter, 50-75 GHz $900.00
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HUGHES 45724H-1000 WR15 Direct Reading Attenuator, 0-50 dB, 50-75 GHz $1000.00
HUGHES 45732H-1200 WR22 Level Set Attenuator, 0-25 dB, 33-50 GHz $250.00
HUGHES 45752H-1000 WR22 Direct Reading Phase Shifter, 0-360, 33-50 GHz $1400.00
HUGHES 45772H-1100 WR22 Thermistor Mount, -20 to +10 dBm, 33-50 GHz $400.00
HUGHES 47316H-1111 WR10 Tunable Detector, 75-110 GHz, pos. polarity $600.00
HUGHES 47741H-2310 WR28 Phase Locked Gunn Osc., 32 GHz, +18 dBm $2000.00
HUGHES 47742H-1210 WR22 Phase Locked Gunn Osc., 42 GHz, +18 dBm $2750.00
KRYTAR 201020010 Directional Detector, 1-20 GHz, SMA(f/f)/SMC $200.00
KRYTAR 2616S Directional Detector, 1.7-26.5 GHz, K(f/m)/SMC $200.00
M/A-COM 3-19-300/10 WR19 Directional Coupler, 10 dB, 40-60 GHz $450.00
NARDA 3000-series Octave Band Directional Couplers, N connectors $150.00
NARDA 3024 Bi-Directional Coupler, 20 dB, 4-8 GHz $375.00
NARDA 3090 Precision High Directivity Couplers $225.00
NARDA 368BNM Coaxial Hih Power Load, 500 Watts, 2-18 GHz, N(m) $500.00
NARDA 3752 Coaxial Phase Shifter, 0-180 deg./GHz, 1-5 GHz $900.00
NARDA 3753B Coaxial Phase Shifter, 0-55 deg./GHz, 3.5-12.4 GHz $950.00
NARDA 4000-series Octave Band Directional Couplers, SMA connectors $75.00
NARDA 4247-20 Directional Coupler, 20 dB, 6.0-26.5 GHz, 3.5mm(f) $200.00
NARDA 5070-series Precision Reflectometer Couplers $300.00
NARDA 562 DC Block, 10 MHz-12.4 GHz, 100 V max., N(m/f) $65.00
NARDA 765-10 10 dB Attenuator, 50 Watts, DC-5 GHz, N(m/f) $165.00
NARDA 791FM Variable Attenuator, 0-37 dB, 2.0-12.4 GHz $500.00
NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz $375.00
NARDA 793FM Direct Reading Variable Attenuator, 0-20 dB,4-8GHz $225.00
NARDA 794FM Direct Reading Variable Attenuator, 0-40 dB,4-8GHz $375.00
OMNI-SPECTRA 2085-6010-00 Crystal Detector, 1-18 GHz, neg. polarity, SMA m/f $50.00
PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz $250.00
SONOMA SCI. 21A3 WR42 Circulator, 20 dB, 20.6-24.8 GHz $75.00
TEKTRONIX 2701 Step Attenuator, 0-79 dB, DC-1 GHz $150.00
TEKTRONIX WM782U WR19 Harmonic Mixer, 40-60 GHz $1500.00
TRG B510 WR22 Direct Reading Attenuator, 0-50 dB, 33-50 GHz $900.00
TRG V551 WR15 Frequency Meter, 50-75 GHz $600.00
TRG W510 WR10 Direct Reading Attenuator, 0-50 dB, 75-110 GHz $1000.00
TRG W551 WR10 Frequency Meter, 75-110 GHz $750.00
WAVELINE 100080 WR28 Terminated Crossguide Coupler, 30 dB $200.00
WEINSCHEL 150-110 Programmable Step Atten., DC-18 GHz, SMA $450.00
WEINSCHEL DS109 Double Stub Tuner, 1-13 GHz, N(m/f) $150.00
WEINSCHEL DS109LL Double Stub Tuner, 0.2-2.0 GHz, N(m/f) $150.00

COMMUNICATIONS

HP 37204A-003 HPIB Extender, fiber-optic connection *unused* $250.00
HP 4934A-J02 TIMS; CCITT option; battery power $1650.00
HP 59401A HPIB Bus Analyzer $375.00
TAMPA MW. LAB BUC1W-02W-CST Ku band Upconverter, 1 Watt 14.0-14.5 GHz WR75 *NEW* $150.00
TEKTRONIX 1411R-opt.04 PAL Test Gen.,w/SPG12,TSG11. TSP11,TSG13,15,16 ..... $1400.00
TEKTRONIX 147A NTSC Test Signal Generator, with noise test signal $800.00

MISCELLANEOUS

EG&G/ P.A.R. 5302 / 5316 Lock-in Amplifier, 100 mHz-1 MHz, GPIB / RS232C $2250.00
FLUKE 2180A RTD Digital Thermometer $500.00
HP 59307A HPIB VHF Switch $200.00
P.A.R. 5206-95.98 Two-Phase Lock-in Amp., 2 Hz-100 kHz, GPIB $1250.00
TEKTRONIX TM5003 TM5000-series 3-slot Programmable Power Module $450.00
TEKTRONIX TM5006 TM5000-series 6-slot Programmable Power Module $500.00
TEKTRONIX TM503 TM500-series 3-slot Power Module $150.00
TEKTRONIX TM504 TM500-series 4-slot Power Module $175.00
TEKTRONIX TM506 TM500-series 6-slot Power Module $250.00
TEKTRONIX TM515 TM500-series 5-slot Portable Power Module $250.00

Circle #47 on the Reader Service Card.

Computer Interfacing: Part 4

Grading on the Curve, Interfacing with Analog Devices

By David A. Ward

What happens when a temperature transducer — a device which converts a temperature into a voltage — is connected up to a computer? We need to be able to convert that analog voltage which represents the temperature into a suitable digital format for the computer to input and work with. This process is referred to as analog-to-digital conversion.

Many things in the real world are not merely on and off or digital in nature. Take for instance, the temperature. It may range anywhere from a low of say -10°F up to perhaps a high of 100°F in a particular area during the year. The temperature also progresses through that entire range; this is known as an analog measurement. What happens then when a temperature transducer – a device which converts a temperature into a voltage – is connected up to a computer? We now need to be able to convert that analog voltage which represents the temperature into a suitable digital format for the computer to input and work with. This process is referred to as analog-to-digital conversion or simply A-to-D conversion. The A-to-D converter that will be introduced in this article is the ADC0804 eight-bit SAR (successive approximation register) IC, see Figure 1.

The circuitry necessary to interface the ADC0804 to the computer is shown in Figure 2. To begin with, a 10KW calibration potentiometer can be connected to pin 6, VIN+, to make sure that everything is functioning correctly. Later, this is where the analog sensor outputs will be brought into the ADC0804. Note that the data output lines, DB0 through DB7, can connect directly to the computer's buffered data lines BD0 through BD7. This is allowed since the data output lines on the ADC0804 are tri-stated, therefore, no other ICs are required. The ADC0804 is shown in Figure 2 in its free-running mode, meaning that as soon as it completes one conversion, it starts another one and continues on as long as power is applied to the IC. It is put into free-running mode by connecting pin 5, INTR (interrupt), to pin 3, WR (write). When a conversion is complete, the INTR pin goes low which takes the WR pin low which causes the IC to begin another conversion. A resistor, R2, and a capacitor, C2, are connected to pin 3, WR, so that it is pulled low during power-up to improve the start-up reliability. Resistor R1 and capacitor C1 are used to provide the clock signal. The acceptable clock frequency for the IC can run anywhere from a low of 100KHz up to a maximum of 1.46MHz.

The SAR process of A-to-D conversion is not too difficult to follow if you keep the number of bits to a minimum. Let's go through a three-bit A-to-D SAR conversion. The A-to-D converter starts with the MSB (most significant bit) and makes it a "1," therefore, it approximates that the incoming voltage is "100 binary." It then feeds this number into an internal D-to-A (digital-to-analog) converter and compares its voltage against the incoming voltage. If the incoming voltage is higher than "100 binary," then the "1" is placed into the SAR in the MSB place; if the incoming voltage is lower, then it stores a "0." It then moves to the next bit and sets it at a "1," so that the reading is now "110 binary." Again, this value is fed back into a D-to-A converter and compared with the incoming voltage. If the incoming voltage is higher than the "110 binary" voltage, it places a "1" in the SAR in the next place down; if the voltage is lower, it stores a "0" instead.

Finally, the LSB (least significant bit) is compared and its "1" or "0" is placed into the SAR in the LSB place. When all of the bits are compared, then the ADC0804 takes pin 5, INTR, low to signal that it has completed its conversion. Of course, since the bits are tested one at a time, it takes time to complete a conversion, and the more bits that you have, the more time it takes. The data sheets for the ADC0804 state that it takes 64 clock periods to complete an eight-bit A-to-D conversion, and the fastest clock speed listed for the IC is 1.46MHz, therefore each complete conversion should take about 43.836mS to complete with the fastest possible clock.

Another important item to consider when dealing with A-to-D converters is their resolution or sensitivity. In other words, what is the minimum voltage change that the converter can sense before it changes its digital output to the computer up or down one count? The resolution of an A-to-D converter is calculated by taking the full scale voltage (FSV) that can come into the converter and dividing it by the maximum possible digital outputs it can produce (2^N), where N is the number of binary bits that the converter can output (resolution = FSV / 2^N). Therefore, with the circuit shown in Figure 2, the resolution becomes 5V/256 or 19.531mV. The resolution for the three-bit A-to-D converter discussed earlier would only be 5V/8 or 0.625V. From these calculations, you can see that the more bits an A-to-D converter has, the more sensitive it is. An eight-bit A-to-D converter is considered fairly course, as far as A-to-D converters go, but since we are dealing with an eight-bit PC expansion slot, it is the easiest and most straightforward converter to work with.

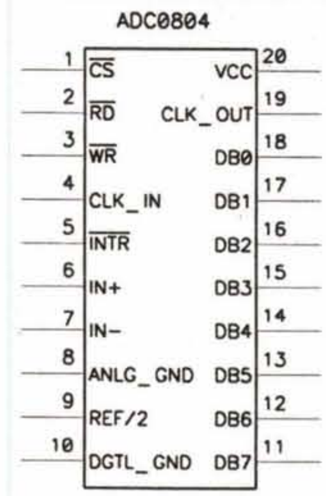


FIGURE 1

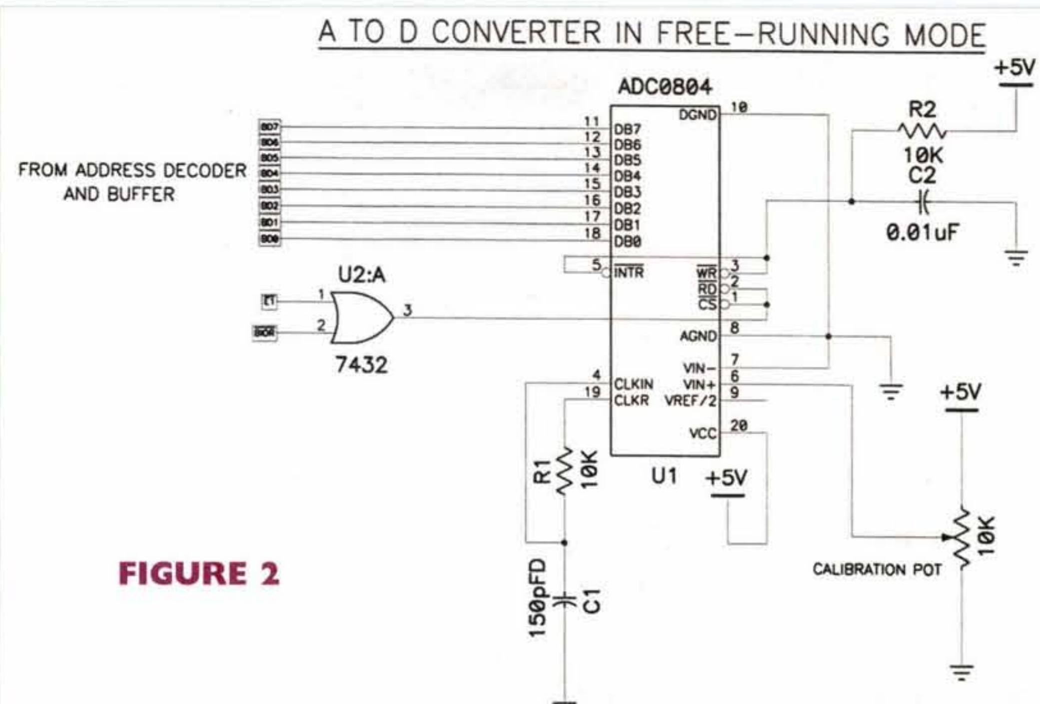


FIGURE 2

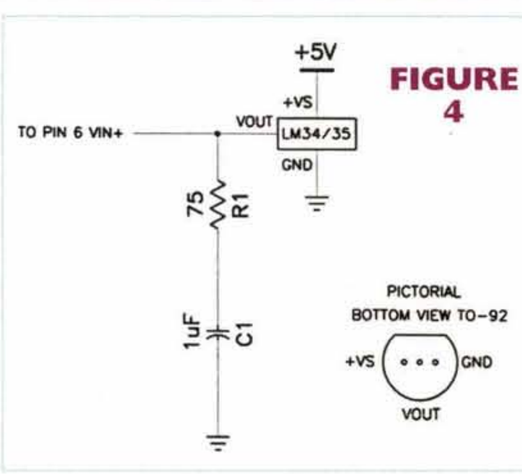


FIGURE 4

Voltmeter	Digital Value
0V	0
0.5V	26
1.0V	51
1.5V	77
2.0V	102
2.5V	128
3.0V	154
3.5V	179
4.0V	205
4.5V	230
5.0V	255

FIGURE 3

PHOTO 1

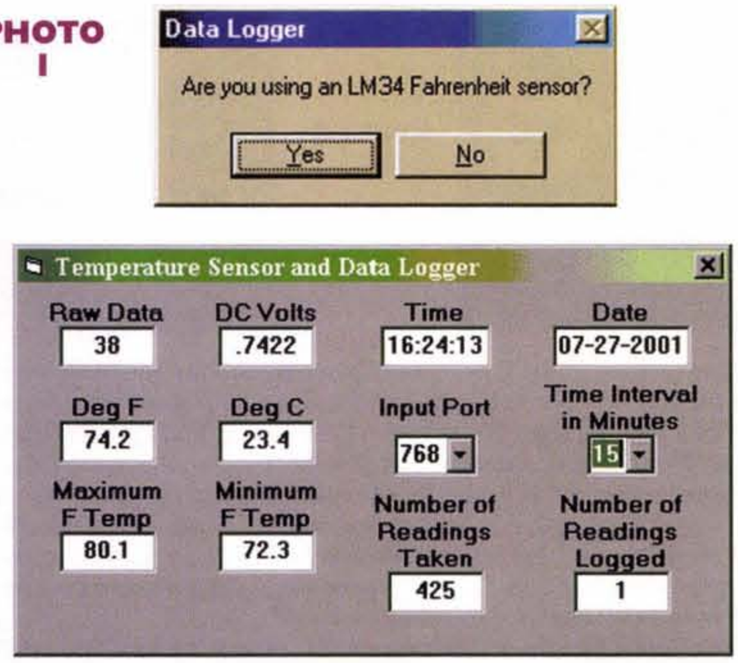
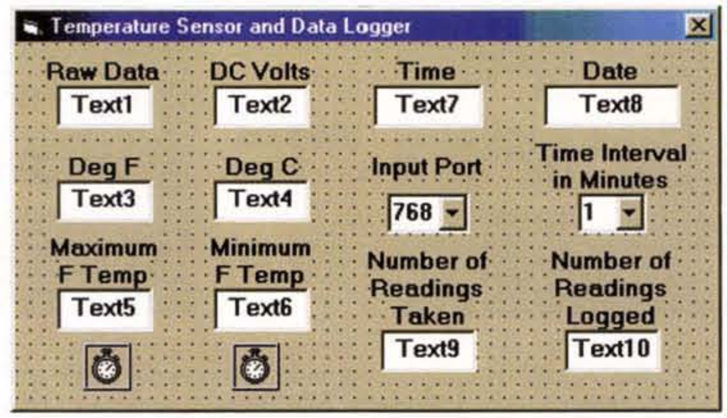


PHOTO 2



Probably the best way to test the operation of the A-to-D converter is to begin with a potentiometer and a voltmeter. Connect the voltmeter's positive lead to pin 6, VIN+, and the negative lead to ground. As the potentiometer is turned through its range, you should see the voltmeter readings go from a low of 0V up to a maximum of 5V. You can now run a simple program and see if the input numbers agree with those in Figure 3 as you adjust the potentiometer to get the voltages listed. The QBASIC program listed below will simply input the value from the A-to-D converter and display it on the monitor.

```
CLS
PRINT "Press any key to exit"
WHILE LEN(INKEY$) = 0
  X = INP(769) 'E1
  LOCATE 10, 10
  PRINT X
WEND
```

LISTING 1

```
'Temperature data logging application by David A. Ward July 2001.
'The circuit works with an LM34 Fahrenheit sensor or an LM35 Celsius sensor.
'The application writes data to C:\TEMP_LOG.TXT.
'The previous file is erased first, so rename old files to keep them.

Option Explicit  'Requires that all variables be defined first

Dim Counter_1 As Double   'Keeps count of each reading (every 3 seconds)
Dim Counter_2 As Integer  'Keeps count of each file write
Dim Counter_3 As Integer  'Keeps count of minutes for file writes
Dim LM34_35 As Integer   '= 6 then LM34 is used, = 7 then LM35 is being used

Dim Raw_Data, DC_Volts, Deg_F, Deg_C, Max_Temp, Min_Temp As Single

'Initialize timers, counters, and file C:\TEMP_LOG.TXT

Private Sub Form_Load()

  Open "C:\TEMP_LOG.TXT" For Output As 1  'Clear out the old file
  Print #1, ""
  Close #1

  'Message box to see if they are using an LM34 or an LM35
  LM34_35 = MsgBox("Are you using an LM34 Fahrenheit sensor?", vbYesNo)

  Counter_1 = 0: Counter_2 = 0: Counter_3 = 1  'Initialize counters

  Timer1.Interval = 3000   'Set Timer1 to 3 seconds
  Timer2.Interval = 60000  'Set Timer2 to 1 minute to check for file writes
  Raw_Data = Inp(Combo2.Text)  'Get an initial reading to set the Min_Temp1
  Min_Temp = Raw_Data * 0.019531 * 100  'Intitialize Min_Temp F

  If LM34_35 = 7 Then Min_Temp = (Min_Temp * 1.8) + 32

  Call Get_Data   'Get the first reading to save to file
  Call Write_data  'Save that reading to the file

End Sub

'If user changes file saving intervals make the changes to Counter_3

Private Sub Combo1_Change()
  Counter_3 = Combo1.Text
End Sub

'Get new data every 3 seconds

Private Sub Timer1_Timer()
  Text7.Text = Time$  'Update clock
  Counter_1 = Counter_1 + 1  'Keeps track of number of readings
  Call Get_Data
End Sub

'Data readings are taken and displayed on the form

Private Sub Get_Data()

  Text9.Text = Counter_1  'Increment number of readings counter
  Text7.Text = Time$  'Display the real time
  Text8.Text = Date$  'Display the date

  Raw_Data = Inp(Combo2.Text)   'Raw digital data inputted
  Text1.Text = Raw_Data  'Display the raw data number

  DC_Volts = Raw_Data * 0.019531  'Calculate the DC voltage from the raw data
  DC_Volts = Format(DC_Volts, "#.####")
  Text2.Text = DC_Volts  'Display the DC voltage

  If LM34_35 = 6 Then Deg_F = DC_Volts * 100: Deg_F = Format(Deg_F, "###.0"): _
    Text3.Text = Deg_F

  If LM34_35 = 7 Then Deg_C = DC_Volts * 100: Deg_F = (Deg_C * 1.8) + 32: _
    Deg_F = Format(Deg_F, "###.0"): _
    Text3.Text = Deg_F  'Display the current temperature in F

  If Deg_F > Max_Temp Then Max_Temp = Deg_F  'See if there is a new Max_Temp
  Max_Temp = Format(Max_Temp, "###.0")
  Text5.Text = Max_Temp  'Display the Maximum Temperature taken
  If Deg_F < Min_Temp Then Min_Temp = Deg_F  'See if there is a new Min_Temp
  Min_Temp = Format(Min_Temp, "###.0")
  Text6.Text = Min_Temp  'Dsiplay the Minimum Temperature taken

  If LM34_35 = 6 Then Deg_C = (Deg_F - 32) * 0.555556 'Degrees C are calculated

  Deg_C = Format(Deg_C, "###.0")
  Text4.Text = Deg_C  'Display the curretn temperature in C

End Sub

'This sub routine writes data to C:\TEMP_LOG.TXT

Private Sub Write_data()

  Counter_2 = Counter_2 + 1
  Text10.Text = Counter_2  'Keep track of number of file writes

  Open "C:\TEMP_LOG.TXT" For Append As 1  'Change the file name here "in
quotes"

  'Log the data to the file
  Print #1, "Reading #"; Counter_2; ","; "Date:"; Date$; ","; "Time:"; Time$; _
        ","; "Raw Data:"; Raw_Data; _
        ","; "Degrees F:"; Deg_F; ","; "Degrees C:"; Deg_C
  Close #1

End Sub

'Tests every 1 minute to see if it is time to write data

Private Sub Timer2_Timer()

  If Counter_3 = Combo1.Text Then Call Write_data: Counter_3 = 1: Exit Sub
  Counter_3 = Counter_3 + 1  'Increment Counter_3 if the interval is more than 1
minute

End Sub
```

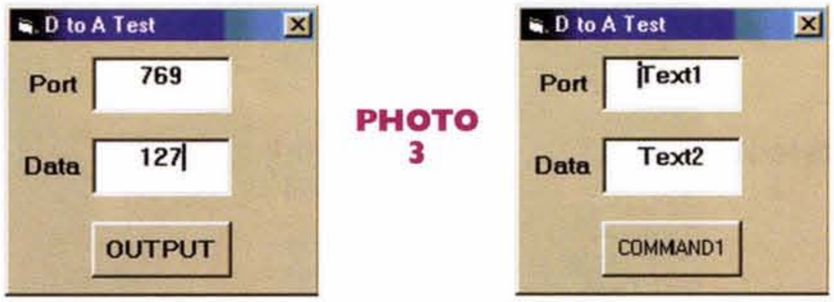


PHOTO 3

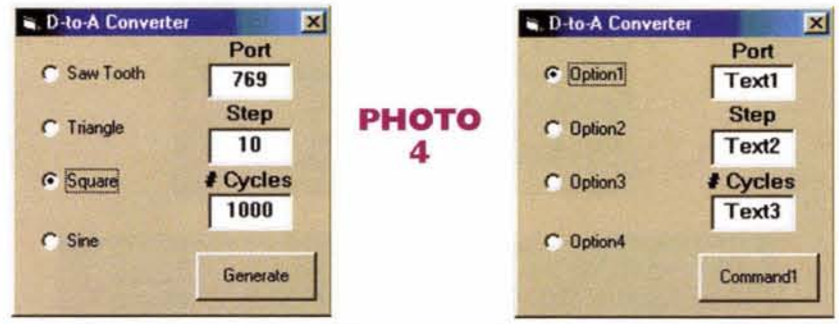


PHOTO 4

If the A-to-D circuitry is operating correctly with the calibration potentiometer connected to the ADC0804, it is time to connect a temperature transducer in its place and make a digital temperature sensor and data logger. There are two simple and inexpensive temperature transducers available: the LM34 and the LM35. Each device is housed in a TO-92 three-lead package. The LM34 is a Fahrenheit sensor and the LM35 is a Celsius sensor, see Figure 4. The LM34 puts out 10mV for every degree Fahrenheit and the LM35 puts out 10mV for every degree Celsius. The LM34 can sense from -50°F up to +300°F and can operate from 5 to 30 volts. So, at a normal room temperature of 72°F or 22°C, the voltage output of the LM34 should be 720mV and the output of the LM35 should be 220mV. This corresponds to digital inputs of 37 (decimal) for the LM34 and 11 (decimal) for the LM35. There's really no need in using both the LM34 and the LM35 since the computer can easily convert either °F to °C or °C to°F once a number has been input into the computer. I prefer using the LM34 since its resolution is finer than the LM35, 180° versus 100° between the freezing point and boiling point of water. Now all that is needed is software to make the system function as we desire. Photo 1 is a picture of a data logging program that is written in Visual Basic 6.0. A message box will first appear and ask the user if they are using an LM34 Fahrenheit sensor. If they answer yes, the program will calculate for a Fahrenheit sensor. If they answer no, then the program will calculate for a Celsius sensor.

Photo 2 is a picture of the form used for the program. The text located above each text box are simply labels. There are two timers located on the form: the one on the left below text5 is timer1, and the one on the right below text6 is timer2. The Input Port selection box is Combo2, the Time Interval selection box is Combo1. The code for this project is shown in Listing 1.

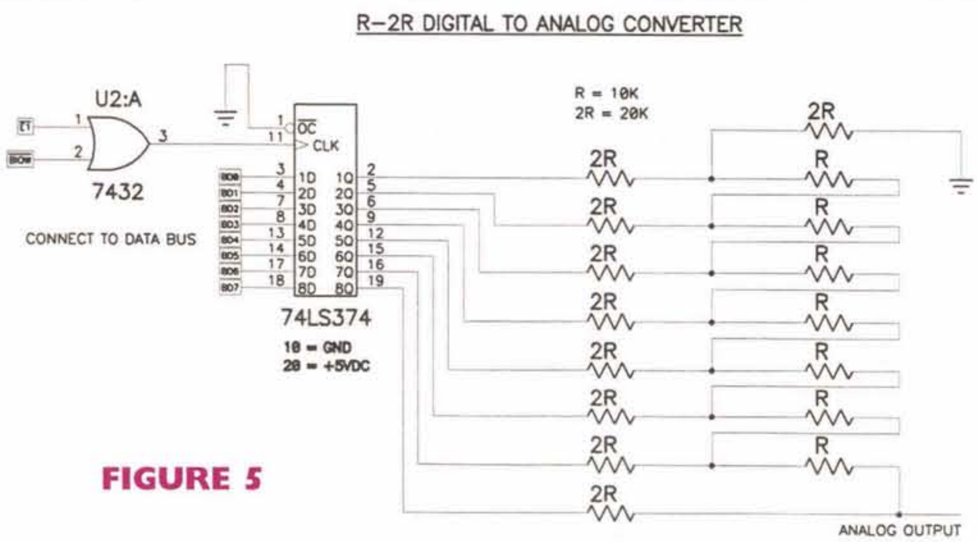


FIGURE 5

The process of D-to-A conversion can now be examined. There are devices that need an analog voltage rather than a digital "on" or "off" to control them. There are two D-to-A conversion circuits that will be presented here: the first is the R-2R D-to-A converter (see Figure 5), and the second is the DAC0800 D-to-A converter IC (see Figure 6).

The R-2R D-to-A converter circuit employs a 74LS374 octal D flip-flop that was introduced in Part 1 as a latching digital output port. Seven resistors, labeled R, with a value of 10KW each, and nine resistors, labeled 2R, with a value of 20KW each, are connected in series and parallel to the outputs of the 74LS374, as shown in Figure 5. This circuit will actually allow you to do the reverse of what the ADC0804 A-to-D converter circuit did that was introduced earlier. In other words, you can output a number from 0 (decimal) to 255 (decimal) and see an analog voltage from 0VDC (outputting a 0) up to a high of 5VDC (outputting a 255) in increments of 19.531mV. This isn't really a true AC voltage in every

LISTING 2

```
'This program will generate waveforms when connected to a 74LS374 R-2R D-to-A
'converter circuit or to the DAC0800 circuit

Option Explicit  'Requires that all variables be defined
Dim X, Y As Integer
Dim Z, T As Double

'Menu to select waveform shape
Private Sub Command1_Click()
  If Option1.Value = True Then Call Saw
  If Option2.Value = True Then Call Triangle
  If Option3.Value = True Then Call Square
  If Option4.Value = True Then Call Sine
End Sub

'Sawtooth pattern
Private Sub Saw()
  For X = 0 To Text3.Text   'Determines how many cycles
    For Y = 0 To 255 Step Text2.Text   'Determines step values
      Out Text1.Text, Y
      DoEvents   'Will let the program be broken if interrupted in loop
    Next Y
    DoEvents
  Next X
End Sub

'Triangle pattern
Private Sub Triangle()
  For X = 0 To Text3.Text
    For Y = 0 To 255 Step Text2.Text   'Increments step values, wave goes up
      Out Text1.Text, Y
      DoEvents
    Next Y
    DoEvents
    For Y = 255 To 0 Step -Text2.Text   'Decrements step values, wave goes down
      Out Text1.Text, Y
      DoEvents
    Next Y
    DoEvents
  Next X
End Sub

'Square pattern
Private Sub Square()
  For X = 0 To Text3.Text
    Out Text1.Text, 255   'Turn wave on
      For Y = 0 To Text2.Text   'Determines time that wave is on
      DoEvents
      Next Y
    Out Text1.Text, 0   'Turn wave off
      For Y = 0 To Text2.Text   'Determines time that wave is off
      DoEvents
      Next Y
      DoEvents
  Next X
End Sub

'Sinusoidal pattern
Private Sub Sine()
  For X = 0 To Text3.Text
    For Z = 1 To 360 Step Text2.Text   'Increment through 360 degrees
          T = Sin(Z * (3.1416 / 180))   'Convert from radians to degrees
        If T > 0 Then T = (T * 128) + 127   'Positive half cycle
        If T <= 0 Then T = (T * 128) - 127   'Negative half cycle
        Out Text1.Text, T
      DoEvents
    Next Z
      DoEvents
  Next X
End Sub
```

sense of the term, since it cannot reverse its polarity and go negative. The second D-to-A circuit, the DAC0800, however, can output a negative voltage and produce higher peak voltages, as well.

Once the R-2R circuit is bread-boarded, the easiest way to check its operation is to compare the numbers output with the voltages read and compare these to Figure 3. The Visual Basic program shown in Photo 3 will allow you to enter a number into the text box and to click on the command button to output that number.

The code for this project is quite simple and is listed below.

```
Private Sub Command1_Click()
  Out Text1.Text, Text2.Text
End Sub
```

If the circuit operates as it should, you can then try the next Visual Basic program shown in Photo 4 to make several interesting waveforms that can be observed on an oscilloscope. The code for this project is shown as Listing 2.

If your bread-boarding skills passed the muster on the R-2R converter circuit, you're ready to put the DAC0800 circuit shown in Figure 6 together. Please note that this circuit requires both a positive +10VDC voltage source, as well as a negative -10VDC voltage source. If you don't have two power supplies available, you could substitute two 9V batteries instead, although it is not certain how long the circuit will operate. If you are not familiar with how negative power supplies are made, simply connect the positive lead from one power supply to the negative lead of the other supply. This connection becomes the common or ground connection and should connect to the bread-board and computer ground. The remaining unconnected positive lead becomes the positive +10V source and the remaining unconnected negative lead from the other power supply becomes the negative -10V source.

Connect an oscilloscope probe to pin 2 and its ground clip to pin 4 to observe the voltage outputs, if you don't have a scope available you can observe the voltage levels with a voltmeter while outputting numbers from the computer. Outputting a 0 (decimal) will cause the DAC0800 to produce an output of -10V. Outputting a 128 (decimal) will cause the circuit to output 0V, and outputting a 255 (decimal) will cause the circuit to output +10V. Therefore, outputting a number from 0 (decimal) to 127 (decimal) will produce a negative voltage and outputting numbers from 129 (decimal) through 255 (decimal) will produce a positive voltage.

The Visual Basic D-to-A waveform generating project that was shown earlier will work on the DAC0800 circuit as well, with some differences. The DAC0800 can output a negative voltage, whereas the R-2R circuit couldn't; also the DAC0800 will reach peak voltages of +10V and -10V, where the R-2R circuit could only hit +5V. Another difference is in the resolution of the two circuits. The R-2R circuit has a resolution of 5V/256 or 19.531mV, the same resolution as the eight-bit A-to-D converter would have. The DAC0800 circuit, however, has to cover a wider voltage spread of 20V (+10V to -10V) still using only eight bits, therefore, its resolution is 20V/256 or 78.125mV.

Well, that concludes an introduction to computer interfacing with A-to-D and D-to-A converters. The next and final article in this five-part series will cover control of motors, as well as stepper motors that can be used for precise positioning. **NV**

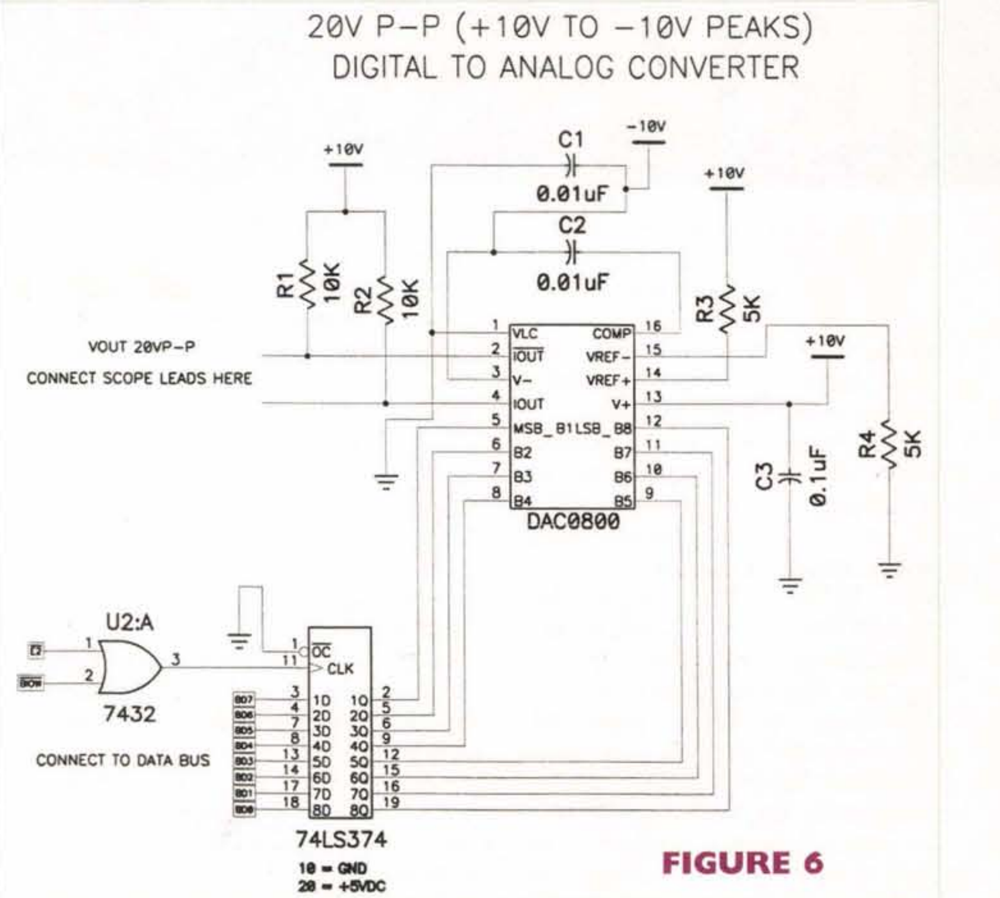
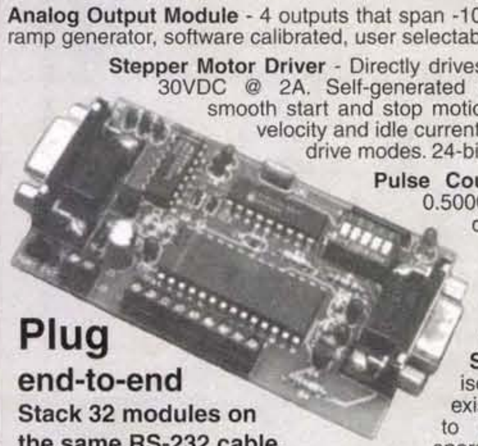


FIGURE 6



How The Inventor Of The HAL 9000 Came To Love His IBM PCs

by Edward B. Driscoll, Jr.

Micro Memories

When you've created the world's most famous mainframe, what do you do for a home PC? That's the dilemma that Stanley Kubrick found himself in, in the early 1980s.

In 1968, of course, Kubrick and Author C. Clarke, his co-screenplay writer, released *2001: A Space Odyssey*, which introduced us to Hal, whose full name was HAL 9000, short for Heuristically Programmed Algorithmic computer, model number 9000. Hal was a talking, seemingly intelligent computer who ran the Discovery — a large, nuclear-powered manned spacecraft on its way to Jupiter. He was a classic Kubrick character — an evil and merciless antagonist (killing 4/5ths of the Discovery's crew) who was simultaneously the most sympathetic and "human" of all of the characters in 2001.

A number of 60s hipsters noted that the letters that make up HAL are one letter off from IBM. Kubrick and Clarke both swore up and down that this was purely a coincidence, and noted that IBM was an important technical advisor on the film. (Several of the computers on the other spacecraft shown in the film have prominent IBM logos on them.)

In any event, Kubrick thought enough of IBM to remain loyal to them for his subsequent computer purchases. In the mid-1970s, he installed an IBM Series/1 in EMI's Elstree Studios to crunch the accounting and payroll numbers on his films.

The Artistic Pause

Kubrick was known for taking immense amounts of time between films both to spend time with his family and to research background material for his films, or solve technical challenges that needed to be overcome in his film-making. In the early 1970s, he used the time after 1972's *A Clockwork Orange* to research and have modified a Zeiss 35mm still camera lens developed for NASA into a motion picture lens with an aperture large enough to successfully film in nothing but candlelight. This lens would, of course, be used to photograph the night sequences in 1975's *Barry Lyndon*, which won an Oscar for cinematography.

In the early 80s, having just completed *The Shining*, and only having vague plans to make a war picture next (which would eventually develop into 1987's *Full Metal Jacket*), Kubrick decided to use his time between films to computerize his home office, which was in a large, old English country home known as Childwick Bury, located on a 120-acre estate near St. Albans, an hour north of London.

He had two goals in mind: computerize his screenwriting process, and have a system to sort and catalog his immense pool of ideas and film concepts.

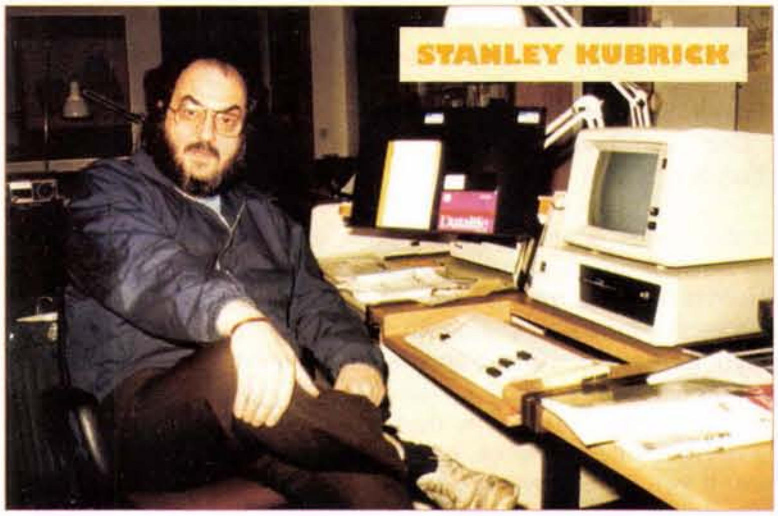
The War Room

Kubrick's computers would eventually be housed in his home office in Childwick Bury, which was informally known as "the War Room," after the similar command center in his 1964 classic, Dr. Strangelove.

Michael Herr, who co-wrote *Full Metal Jacket* with Kubrick (and who had previously written the non-fiction *Dispatches*, an excellent study of the Vietnam War, and would go on to write a short but warm and perceptive profile of Kubrick, published in 1999) described the War Room in the time leading up to the shooting of *Full Metal Jacket* as "a large space on the ground floor which would have been airy if it weren't crammed with desks and computers and filing cabinets, long trestle tables littered with sketches, plans, contracts, hundreds of photographs of weapons, streets, pagodas, prostitutes, shrines, signs."

Herr wrote that the walls of the room were basically one giant shooting schedule, filled with lists, schedules, names, dates, equipment, and locations; "except for one crowded wall, which seemed to be devoted to Stanley's investments."

The computers inside the War Room were initially selected and installed by Alan Bowker. At the time, Bowker was a 30-something recording engineer and a consultant to Dolby Laboratories, Inc., in San Francisco. (Dolby sound was used on all of Kubrick's post-2001 films.) He would later become an IT administrator for several Silicon Valley start-ups.



STANLEY KUBRICK

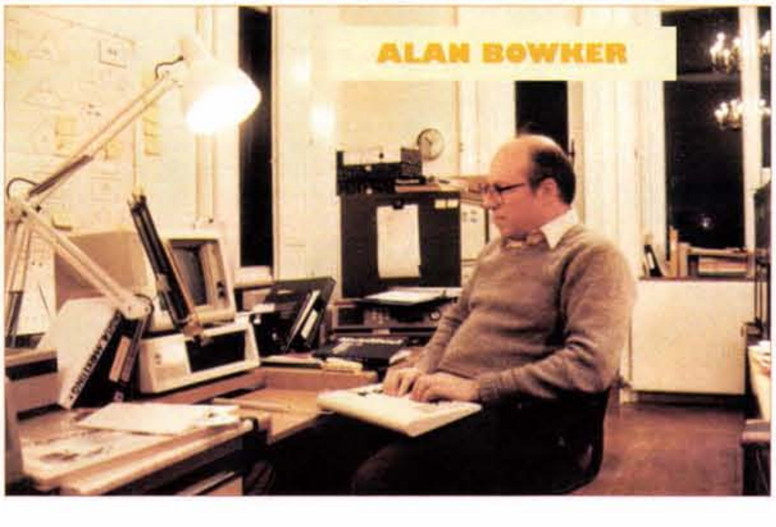
"Honey, I Don't Pay List for Anybody!"

In 1983, Bowker received a phone call from Kubrick. "Uh, Alan, this is Stanley ... do you have a few minutes?" As just about everybody who worked with Stanley would attest in books, interviews, and articles, "a few minutes" on the phone with Kubrick actually meant a few hours. ("An hour was nothing, mere overture, or opening move, or gambit, a small taste of his virtuosity," Herr wrote in Kubrick.) "The writer Gustav Hasford claimed that he and Stanley were once on the phone for seven hours, and I went over three with him many times."

For Bowker, those several hours turned into a month of regular phone calls, followed by two trips to England in 1983 and 84 to install Kubrick's first home PCs. (Bowker's web site, at http://www.bowkera.com/ has several pages and photographs archiving his experiences with Kubrick.)

Kubrick and Bowker visited several computer venders in

THE WAR ROOM



ALAN BOWKER

London. "We spent the afternoon," Bowker says. "He just basically wore everybody down. I had to get him back on track. I said, 'Let's just get a PC with a fixed disk in it, and get WordStar going for you, and get you set up.' So he said okay."

Herr's book reveals one particular aspect of Kubrick that was rarely, if ever touched upon before: his thrift, which apparently was legendary (if rarely discussed in public by people who wanted to work with him again!). Bowker scored major points by haggling with dealers on Kubrick's behalf.

"Afterwards, Stanley and I went to the Indian restaurant there in St. Albans, had some curry, and he said, 'Alan, you're the first guy who's ever worked for me who's asked for a discount.'"

Bowker replied, "Yes, I understand." He later said, "You know, I had been used dealing with computer venders, and honey, I don't pay list for anybody!"

Bowker feels that Kubrick's tightness is a result of his background as a self-taught independent filmmaker in the early 1950s, a period when he was largely self-funded. "He once said to me that the idea in making movies and controlling budgets is to know when to control: there are times when it makes sense to get the best price, and there are times when you've just got to open up the checkbook and spend the money."

HAL's Successor: The XT

The computers that Bowker helped Kubrick acquire for his War Room, and on which Kubrick would eventually write Full Metal Jacket, were a couple of IBM XTs. The XT initials stood for Extended Technology.

The XT line was introduced in early 1983 as the successor to the two-year-old PC, the machine that beat Xerox Parc (see the March 2002 Micro Memories), and helped launch Microsoft, who produced the PC's Disk Operating System, or DOS (Windows 1.0 wouldn't be released until 1985).

Gates' insistence on an open software license for DOS helped create the market for IBM clones which, of course, eventually resulted in the IBM PCs and their clones far surpassing the sales of Apple, as well.

Compared to the original IBM PC, the XT had some enhancements: a CGA graphic card, a 10 or 20 megabyte hard disk (hard disks weren't standard on the first PCs), more RAM (up to 640K, depending upon the model), and no cassette port, since the unit came with a 5.25" floppy disk drive. The XT was powered by an Intel 8088 chip, which ran at a 4.77 MHz.

"They Like To Be Left On"

Bowker says, "The last time I worked with him was January of 1984.

They were using both WordStar and WordPerfect in the PCs there in the office," connected via an early networking arrangement a good decade before home networking of PCs became commonplace.

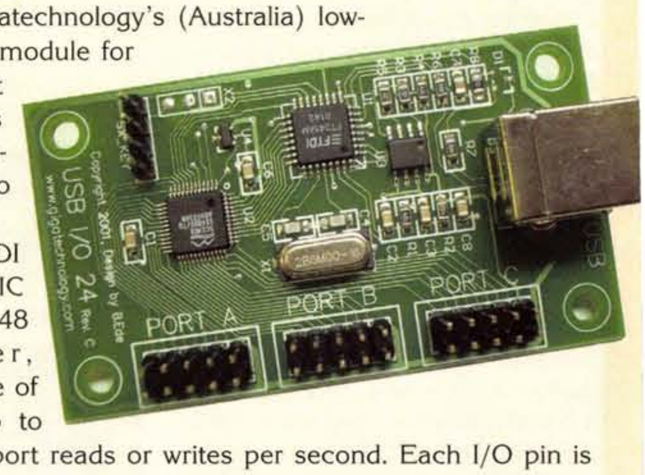
Kubrick was also an early proponent of the "don't turn your computers off" school of ownership. Herr said that at the end of one day of writing, when Kubrick's wife Christiane told them that dinner was ready, he reminded Kubrick that he hadn't turned his PCs off.

The father of HAL, and the man responsible for his famous onscreen 'death' replied, "They like to be left on," in a tone that Herr described as "ironically, factually, tenderly." **NV**

New Product News

EASY-TO-USE USB-POWERED 24-LINE GENERAL-PURPOSE I/O MODULE

USBI/O24 is Gigatechnology's (Australia) low-cost integrated module for the input and output of digital signals from a computer system by connection to the USB port.



Based on the FTDI FT8U245AM USB IC and the UBICOM SX48 microcontroller, USBI/O24 is capable of transfer rates of up to 250,000 x eight-bit port reads or writes per second. Each I/O pin is individually configurable as an input or output. Input pins are TTL level compatible and the output pin can each sink or source up to 30mA per pin.

The 24 I/O pins are independently programmable in three groups of eight to form a single high-speed module which can be a building block for fast computer I/O needs.

Based on FTDI FT8U245 high-speed USB IC and the UBICOM SX48, it's easy to connect to 0.1" pitch headers which fit standard IDC connectors. With an integrated type-B USB connector onboard, the unit includes serial number EEPROM and FLASH microcontroller. Both USB Enumeration information and the microcontroller can be re-programmed to suit the customer's needs. Moreover, the module is powered from USB bus (up to 450mA from USB for user application) so no external power supply is required.

Module firmware and software supplied includes a virtual comm port driver which allows access as a regular serial port, or DLL drivers allow direct access by DLL calls. USBI/O24 is easy to program from popular languages: C, Basic, Delphi, etc., with a simple command set for east control of ports and data transfer. Drivers for Win98/Me/XP, 2000, Linux, and iMAC are free.

USBI/O24 is $69.00 from stock.

For more information, contact:

SAELIG CO., INC.
1 Cabernet Circle, Dept. NV
Fairport, NY 14450
716-425-3753 Fax: **716-425-3835**
Email: **saelig@aol.com**
Web: **www.saelig.com**

MOTOR MIND C DC MOTOR CONTROLLER

The Motor Mind C has been designed to function as a versatile DC motor control system for controlling one or two motors. The module is ideal for use in small robotics projects for controlling two-wheel axles. The motor connections may also be tied in parallel to control a single larger motor.

The Motor Mind C comes in a 40-pin DIP package with motor connections, mode settings, and control inputs all accessed through this packaging.

Three modes of operation are available in the Motor Mind C. Each mode can be used to control one or two brushed DC motors. The current rating of the Motor Mind C is 2.5A with no cooling, and 4.0.A with cooling. Motor voltages ranging from 10-24V can be used with this product. Over-current and over-temperature protection features are included.

In serial mode, the user has direct control over the motor speed and direction. When configured for two motors, the motor speed and direction for each motor is controlled independently. The user can also modify the PWM step limit (1-255), the PWM dead-band, and brake mode (dynamic or free spinning). Various other registers may be read and displayed including the approximate operating current of both H-bridges on the Motor Mind C.

The Motor Mind C is also equipped to operate in analog or R/C pulse input modes. Both modes can be used to control one or two brushed DC motors.

Pricing in single unit quantities is $59.00.

For more information, contact:

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256 E. First St., Dept. NV
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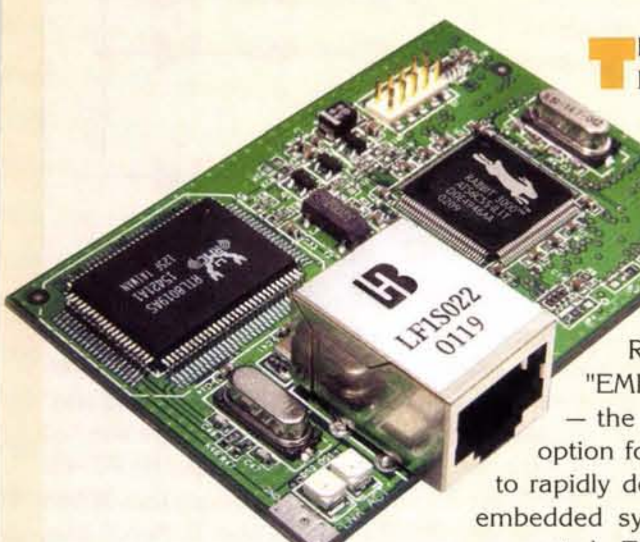
POWERFUL RCM3000 MICROPROCESSOR CORE MODULE FOR RAPID EMBEDDED SYSTEMS DEVELOPMENT



The new RCM3000 RabbitCore is Rabbit Semiconductor's most powerful and feature-packed microprocessor core module. Powered by the new Rabbit 3000™ — the "EMI-Free microprocessor" — the RCM3000 is the ideal option for designers who want to rapidly develop and implement embedded systems with fully integrated Ethernet connectivity. RabbitCores mount directly on a user-designed motherboard and act as the controlling microprocessor for the user's system.

Measuring only 2.73" x 1.85", the RCM3000 operates at 3.3V (with 5V tolerant I/O) and features six serial ports. Built-in low-EMI features, including a clock spectrum spreader, help designers eliminate troublesome EMI problems that often threaten to derail tight development schedules.

Available in two models, the RCM3000 is equipped with 10Base-T Ethernet, up to 512K each of Flash and SRAM, quadrature encoder inputs, PWM outputs, and pulse capture and measurement capabilities. Two 34-pin connection headers provide 52 digital I/O shared with the six serial ports. The integrated Ethernet port allows instant local or worldwide connectivity, and a pin-compatible RCM3100 without Ethernet is available for parallel development and cost-effective implementation of both Ethernet and non-Ethernet systems.

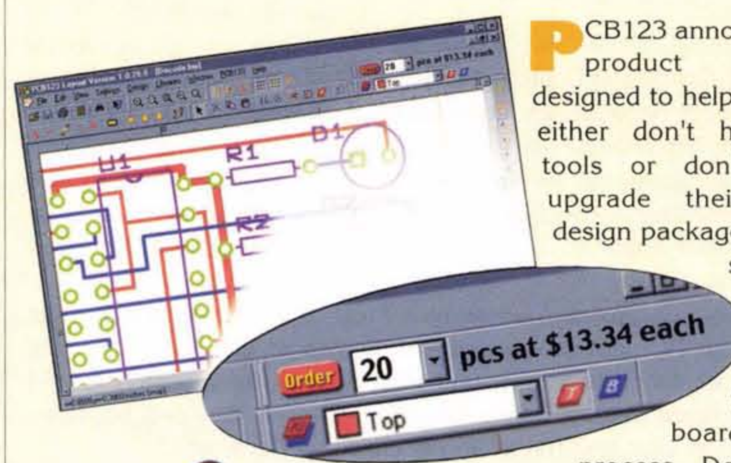
The RCM3000 features a battery-backable real-time clock, glueless memory and I/O interfacing, and ultra-low power "sleepy" modes. A fully enabled slave port permits easy master-slave interfacing with another processor-based system. The Rabbit 3000 processor's compact, C-friendly instruction set and high clock speeds produce exceptionally fast results for math, logic, and I/O.

RCM3000 models are priced from $43.00 (qty. 1,000). A complete RCM3000 Development Kit is priced at only $299.00 and includes RabbitCore module (RCM3010 with 256K Flash/128K SRAM), prototyping board, AC adapter (US only), serial cable for programming and debugging, Getting Started manual, and complete Dynamic C SE software development system (not a trial version) with royalty-free TCP/IP and documentation on CD-ROM.

For more information, contact:

RABBIT SEMICONDUCTOR
530-757-8400 Fax **530-757-8402**
Email: **rabbit@rabbitsemiconductor.com**
Web: **www.rabbitsemiconductor.com**

THE COMPLETE PCB SOLUTION FROM DESIGN THROUGH ORDER



PCB123 announces a new product specifically designed to help people who either don't have design tools or don't want to upgrade their complex design package — yet need something quick and easy to get through the board design process. Developed for two- and four-layer boards, it's free and offers everything needed to design your circuit boards.

Prior to download, a review of the website **(www.pcb123.com)** provides information that links the strength of the product to your needs. The free design software package can then be downloaded easily for immediate design.

Whether a "first timer" or designer/hobbyist/inventor, this free design software provides seamless integration with its own board fabrication service.

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by Jon Williams

Stamp Applications

Data Exchange With Visual BASIC

*Last month, we created a little self-contained digital data recorder with the BASIC Stamp that used **DEBUG** to provide a user interface. Well, what if we want to get a bit more fancy and, say, create a nice GUI application with Visual BASIC? The trick is to allow the Stamp to do its thing until our VB application wants to send or receive some data. Okay ... how do we do it?*

In past Stamp-to-VB projects, we've used the Stamp's programming port because it's convenient. Convenience has its price, though. When using the programming port to communicate with other applications, we have two issues to contend with: **1)** The programming port echoes everything sent to it so we have to filter that out of our application's receive stream and; **2)** There is no flow control.

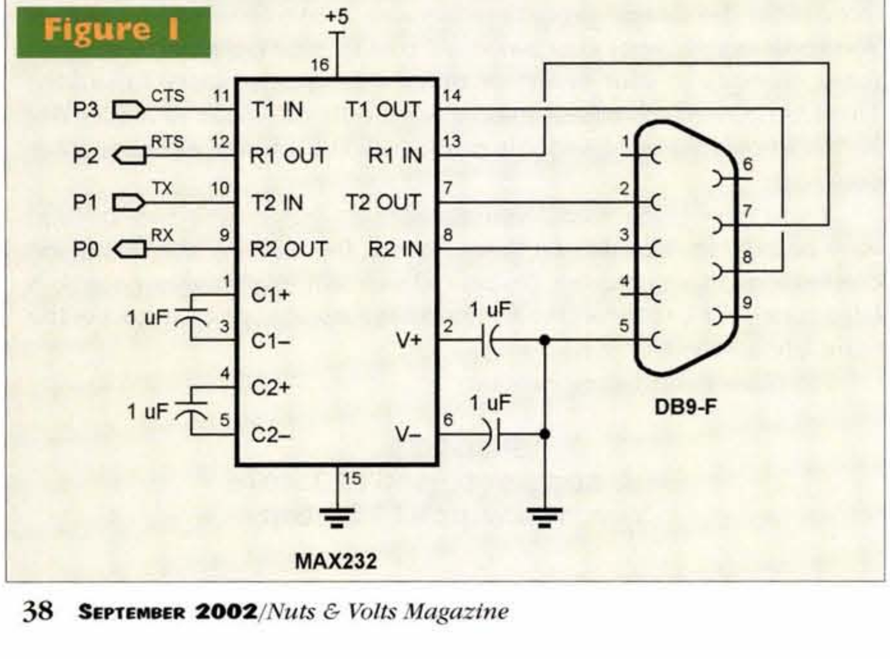
Without flow control and we have a busy Stamp program like the data logger, our PC application would be forced to send some kind of query character until the Stamp had time to look for it, catch it, and respond to indicate it's now ready for an exchange. This can be done, but it's tedious at best and the timing is always problematic.

Problems Solved

We can solve these problems with a bit of hardware and a few Stamp pins. The hardware is a standard MAX232 serial interface chip, a handful of capacitors, and a DB9-F connector (see Figure 1). The MAX232 is a level-shifter. It converts the RS-232 level signals from our PC to the TTL levels required by the Stamp — and goes the other way, too. The capacitors are used by its charge-pump to create the negative voltages required by the RS-232 standard. Using proper RS-232 levels is especially important when there is a lot of distance between devices.

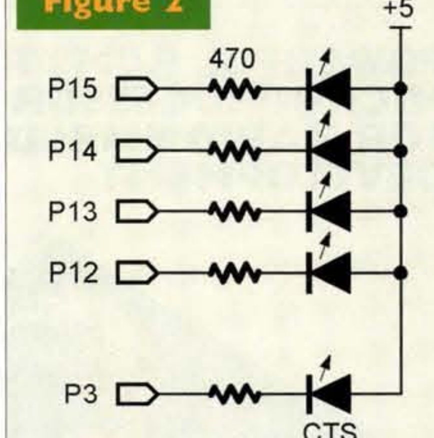
You can assemble the circuit on a breadboard, but to make things easy, my Texas buddy Al Williams created a neat little kit called the RS-I. This is a breadboard-friendly device that just takes a few minutes to assemble with your soldering iron.

Figure 1



When using the MAX232, we're using separate transmit and receive pins so there is no longer a problem with data being echoed back to our VB application. Our next challenge is flow control. Well, as you can see in the schematic, the MAX232 has enough drivers to handle a couple flow control pins, as well.

Figure 2



Going With The Flow

Long before the BASIC Stamp, engineers encountered the issue of two devices wanting to "talk" to each other, but one or the other not being ready. One of the solutions developed — the one we'll use here — is called Hardware Flow Control. The concept is actually pretty simple. When one device wants to talk to another, it sends a "request" signal then waits for the "all clear" from the other device. Once the "all clear" signal is detected, the data can be sent. In our set-up, the PC will signal its desire to send data with the RTS (Request To Send) line. When the Stamp is ready, it will indicate this with the CTS (Clear To Send) line. At this point, the PC will start transmitting data.

Let's make it work, shall we? Wire up the circuit in Figure 2, so you can watch the Stamp code at work and the activity of the CTS line.

A Simple Plan

In my book, simple is better and generally more reliable, so we're going to handle this PC-to-Stamp data exchange in the simplest possible manner. When it comes right down to it, there's really only two things we can exchange: numbers and text. With that in mind, let's build a little VB app that will allow us to exchange numbers and text.

Author's Note: This column is about BASIC Stamps, not Visual BASIC so I am going to skip the contruction details of the VB app and just focus on important aspects of the code.

Figure 3 shows a simple VB app that lets us handle the exchange from the PC end. Numbers are selected with a scrollbar, text is entered into a box. Simple. Now, let's go under the hood.

To perform serial communications with Visual BASIC, we have to add the MSComm control to our project. For the settings critical to operation, my preference is to set them in code. For this project, here's what we're going to do (in the Form_Initialize() event handler):

```
With MSComm1
   .Settings = "9600,N,8,1"
   .DTREnable = False
   .Handshaking = comRTS         ' use hardware flow control
   .RTSEnable = True
   .InputMode = comInputModeText
End With
```

Notice that we've selected hardware handshaking via the RTS pin and enabled the RTS line so we can use it. What this means is that when we put data into the output buffer of the MSComm control, it will exert the RTS line and send it when it detects the CTS signal.

Before we get too far ahead of ourselves, let's define our data exchange strategy. The PC will initiate the exchange by sending a command byte that tells the Stamp what it wants to do: **1)** Send a number to the Stamp; **2)** Retrieve a number from the Stamp; **3)** Send a string of characters to the Stamp, or; **4)** Retrieve a string of characters from the Stamp.

Now don't get the idea that with flow control, we can simply stuff the MSComm output buffer full of data and let the handshaking handle it — the unbuffered Stamp still needs us to help it a bit, especially since we don't know what's coming after the command byte until we've looked at it.

From the PC side, we'll send the command and make sure it's gone before sending anything else. What this does is let the Stamp receive the command and get ready without us having to resort to padding the PC program with artificial delays. Here's how it's done:

```
Private Sub FlushTxBuf()
  Do
    DoEvents
  Loop Until (MSComm1.OutBufferCount = 0)
End Sub
```

Using this strategy, the Stamp will be able to receive the command, then remove the CTS signal while it figures out what to do. Before we start sending information, let's examine the Stamp side of things to see how command reception works.

The Stamp program is constructed in a manner that allows us to break it up into small, discrete sections and to check for a serial input in between them — the task switcher design we've used many times before. This allows us to check the serial input fairly frequently so we don't keep the PC waiting.

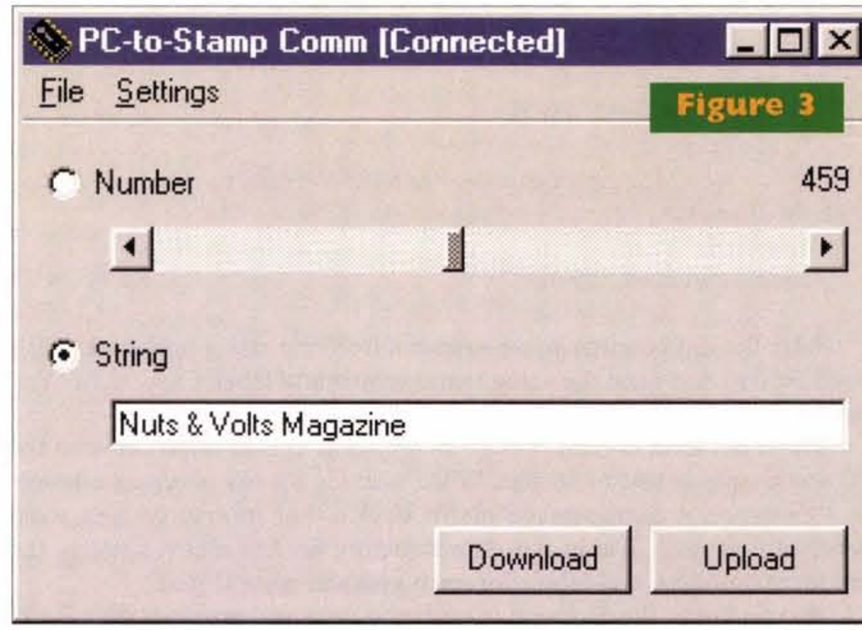
The bulk of our main code looks like this:

```
Main:
  SERIN RX\CTS, Baud, 5, Do_Task, [cmd]
  LOOKDOWN cmd, [RxNum, TxNum, RxStr, TxStr], cmd
  BRANCH cmd, [RX_Number, TX_Number, RX_String, TX_String]

Do_Task:
  BRANCH task, [Task_0, Task_1, Task_2, Task_3]
  task = 0                        ' fix bad task spec
  GOTO Main

Task_0:
  LEDs = %1110                    ' show current task
  PAUSE 250                       ' take some time doing it
  LEDs = Off
  task = task + 1 // NumTasks     ' point to next task
  GOTO Main
```

Notice that the **SERIN** code specifies the [defined] CTS pin for flow control and it really doesn't wait around long; only five milliseconds. Even at 9600 baud, this is plenty of time for the PC to detect the CTS signal and send the command. If a command is received, it is decoded with a **LOOKDOWN** table and **BRANCH** is used to call the code for the command that was sent. If there is no command or it's bad, the code finds its way to Do_Task and the Stamp runs the next chunk of task code.



For our little test program, each task lights a given LED. When the program is running, you'll see the LEDs light sequentially with a quick blip of the CTS LED in between.

Back to our VB app. Let's say we want to send a number to the Stamp. We'll select the Number radio button, move the slider to the value we want, then click the Download button. This will send the command, then the number, low byte first. I decided to use 16-bit variables because that is the largest single value that the Stamp can handle. If you create an application that only needs to send bytes, the process is simpler ... there's no need to extract individual bytes from the larger value.

```
' send number command
MSComm1.Output = Chr$(CmdTxN)
Call FlushTxBuf
' send word value; low byte first
MSComm1.Output = Chr$(scrValue.Value Mod 256)_
               + Chr$(scrValue.Value \ 256)
Call FlushTxBuf
```

Notice that the MSComm transmit buffer is flushed after the number, as well. What this does is make sure the Stamp has had a chance to receive the value before we send it anything else.

The reception side is equally straightforward:

```
RX_Number:
  SERIN RX\CTS, Baud, [aNumber.LowByte, aNumber.HighByte]
  GOTO Do_Task
```

As soon as the number comes in, we get back to work by jumping to **Do_Task**. When the next task is complete, we'll be back at the top and looking for another command.

While we're focused on this process, let me point something out. Did you notice how we put two bytes into the MSComm output buffer and the Stamp **SERIN** command was constructed to accept two bytes? Follow this rule: Only put as many bytes in the MSComm output buffer as the [active] **SERIN** command is set up to handle. As I told you earlier, this will allow the Stamp to receive the data without problems and then remove the CTS while it's working with what it just received.

Receiving a number from the Stamp is not complicated at all: We send the command then wait for two bytes to show up in the MSComm input buffer.

```
' send command
MSComm1.Output = Chr$(CmdRxN)
Call FlushTxBuf
' wait for two-byte value
Do
```

```
        DoEvents
    Loop Until (MSComm1.InBufferCount = 2)
    ' grab input buffer
    rxBuf = MSComm1.Input
    ' display it
        scrValue.Value  =  Asc(Mid$(rxBuf,  1,  1))  +
(Asc(Mid$(rxBuf, 2, 1)) * 256)
    ' update scroller
    Call scrValue_Change
```

After the data comes in, we extract it from the string buffer with VB's Asc function and send the value to the scoller and label. Easy, right? You betcha.

The other kind of data that we might want to exchange between the PC and Stamp is text or strings. While working for my previous employer, I designed a Stamp-based alarm device that monitored four independent channels. Within the data structure for the alarm system, the site location name and labels for each channel were stored.

As you know, the Stamp has no string type and precious little RAM, so we've got to construct a strategy around these limits. Don't worry, it's not tough. What we're going to do is send the string one byte at a time. This will allow the Stamp to receive the byte and store it in its EEPROM. We'll tell the Stamp that we've finished by sending a zero. Some would suggest using a CR as the terminator, but using a zero allows us to embed carriage returns in our string.

Here's the PC side of sending a string:

```
    ' send string command
    MSComm1.Output = Chr$(CmdTxS)
    Call FlushTxBuf
    ' send one character at a time
    For chrPos = 1 To Len(txtStringData.Text)
      MSComm1.Output = Mid$(txtStringData.Text, chrPos, 1)
      Call FlushTxBuf
    Next
    ' send terminating character
    MSComm1.Output = Chr$(0)
    Call FlushTxBuf
```

By now, this should be fairly self-evident. We send the command and flush the buffer to let the Stamp get ready to receive the string. Then, one character at time, we send the string. Finally, we send a zero to complete the process.

The Stamp side is easy too, but a little more involved since it has to accept a character then examine to see if anything else is coming from the PC or not.

```
RX_String:
  idx = 0                         ' reset address pointer

RX_Char:
  SERIN RX\CTS, Baud, [dByte]     ' receive char from PC
  WRITE (Msg + idx), dByte        ' save it to EEPROM
  IF (dByte = 0) THEN RX_Str_Done      ' wait  for  another
if not 0
  idx = idx + 1                   ' update address pointer
  GOTO RX_Char

RX_Str_Done
  WRITE StrLen, idx               ' save string length
  GOTO Do_Task
```

The variable called idx is going to be used to keep track of the length of the string that comes in. We'll see why we need this in just a moment. The core of the code is at RX_Char. A byte is taken in, written to the Stamp's EEPROM and, if not zero, the idx variable is updated. Once a zero is received, the string length is written to the EEPROM and the program resumes at the next task.

Sending a string from the Stamp to the PC is a two-step process. First, we'll send the string length (now you know why we saved it), so that the PC knows how many characters to look for in the input buffer. We then wait for a second "send string" command before sending the actual string data.

```
TX_String:
  READ StrLen, idx              ' get string length
  SEROUT TX\RTS, Baud, [idx]    ' send string length
  SERIN RX\CTS, Baud, 100, Do_Task, [cmd]' wait for restart
  IF (cmd <> TxStr) THEN Do_Task       ' abort if bad com-
mand
  idx = Msg

TX_Char:
  READ idx, dByte               ' get char from EEPROM
  IF (dByte = 0) THEN TX_Str_Done      ' check for end
  SEROUT TX\RTS, Baud, [dByte]         ' send char
  idx = idx + 1                 ' point to next
  GOTO TX_Char

TX_Str_Done:
  GOTO Do_Task
```

Notice that we do give the PC just a bit of time to send the second string command. If that command never comes, we abort the process and go back to running tasks. Once we do get the command, idx is used as a pointer to characters in the string. We loop through and transmit each character to the PC until we find a zero.

Other than dealing with visual controls, the PC side matches up identically:

```
    ' clear text box
    txtStringData.Text = ""
    ' send string command
    MSComm1.Output = Chr$(CmdRxS)
    Call FlushTxBuf
    ' wait for string length
    Do
      DoEvents
    Loop Until (MSComm1.InBufferCount = 1)
    ' extract string length
    rxBuf = MSComm1.Input
    strLen = Asc(Mid$(rxBuf, 1))
    ' resend command to start upload
    MSComm1.Output = Chr$(CmdRxS)
    Call FlushTxBuf
    ' wait for string
    Do
      DoEvents
    Loop Until (MSComm1.InBufferCount = strLen)
    ' show it
    txtStringData.Text = MSComm1.Input
```

The code listing should make it pretty clear. We send the command, wait for the length, resend the command to start the actual string upload, and then wait for the proper number of characters to show up. Once they do, we move them to the text field for display.

Okay, that wasn't bad, was it? Keep in mind that there are many ways to handle the process we've described here; this just happens to be a very simple method. It is particularly suited to those times when the PC program is requesting specific information from the Stamp, or wants to send specific data to it. Experienced VB programmers will have noticed that we didn't bother with the OnComm event handler.

OnComm is useful when the Stamp is spontaneously sending data or there are a lot of other things going on with the PC while data is being sent. That wasn't the case with this project.

If you end up creating a project where the Stamp and the PC are always sending the same kind of information back and forth, you can simplify things by creating a fixed-length protocol. The first byte would be the command/identifier and the other bytes would be the data. By doing this, you can have one **SERIN** line to take in the data, then deal with it as dictated by the first [identifier] byte. On the PC side, OnComm can handle the data reception in the background and deal with the data based on the identifier.

Data Collection For Non-PC Programmers

There's probably more than a few of you who want to collect and analyze Stamp data, but don't have the skills or choose to do custom programming in Visual BASIC. Well, you're in luck. Long-time user, teacher, guru and all-around nice guy, Marty Hebel, has created a neat little product for Parallax called StampDAQ. StampDAQ is a special macro embedded in a Microsoft Excel spreadsheet that allows the spreadsheet to collect data from the Stamp. Once it's collected, you can use Excel for analysis and display with the various tools available in Excel.

Marty has created a special control that deals with the peculiar aspects of communicating via the Stamp's programming port, and has even created a simple language that the Stamp uses to control the spreadsheet. For those of you who have used StampPlot Lite or Pro, it works very similarly — StampDAQ comes from the same creator.

Best of all ... it's free. You can download StampDAQ from the Parallax web site. You'll need Microsoft Excel 2000 or later to run it. Sorry, but it won't run in Excel97 ... yet. I don't think Marty has given up on making that work, but there are no promises that it ever will.

Have fun with your Stamp-to-PC experiments. Oh ... one last thought. If you only have one serial port (like me), you can easily add a second with the BAFO USB-to-Serial converter. It works great with the Stamp and is generally easy to find. If you can't find it locally, you can order directly from Parallax. Having a second serial port sure makes serial experiments easy to troubleshoot since one port can be used by your VB app and the other one by the Stamp to send messages and information to its **DEBUG** window.

Oh, oh, oh ... one more thing before I sign off. For those of you who read the article and are thinking to yourself, "Geez, I wish PBASIC had IF-THEN-ELSE and DO-WHILE loops and all that neat control structure stuff ..." Good news! It's coming! Soon! Very soon.

Until next time, Happy Stamping. **NV**

A Different Kind Of Experiment

Larry (the editor of this great magazine) and I had a conversation a few days back and concluded that nobody — well, almost nobody — actually types in the listings from the text, especially since they can be downloaded from the *Nuts & Volts* web site. With that in mind, we've tried a slightly different, space saving, approach. This month, instead of printing the entire listing, we've only printed the portions that the text focuses on. Using this format, we can print the actual "snippet" right along with the text that describes it. Hopefully, it will prevent you from having to constantly search through the entire listing(s) to follow the explanation.

We create this column for you, the Stamp user. Please let us know how you like this new style and share any comments that we can use to improve it.

Resources:

Jon Williams
jwilliams@parallaxinc.com

Parallax
www.parallaxinc.com

Al Williams
RS-1
www.al-williams.com/awce/rs1.htm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Electronics Showcase

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BAIT AND SWITCH

By Walt Noon
Graphics by Matthew Roddy

If you enjoy taking a little break from sanity at Halloween time, I'd like to suggest an unusual project with one gentle warning: This year's project might be a bit more devilish than those we've chatted about in the past!

Every Halloween the black lights come out, the strobes fire, and the fog machines fog. All this serves to restore our neighborhoods to the creature-ridden phantasms we all enjoy! Personally, I don't know why we can't have black lights, strobes, and fog in our houses most days, but I suspect there may be some reason related to common sense or sanity ...

If you enjoy taking a little break from sanity this time of year as well, I'd like to suggest an unusual project with one gentle warning: This year's project might be a bit more devilish than those we've chatted about in the past!

However, as a haunter, I've come to philosophically believe that our friends and neighbors secretly want and need to have a good fright this time of year. In fact, I tremble to think of the psychological damage that could be done if we shirked our sacred responsibility once a year!

Well, that's my story and I'm sticking to it.

This article also covers some really entertaining animatronic principles and characters that make wonderful projects any time of year, even without the scare.

The Set-up for "Delight and Fright"

"Delight and Fright" is an animatronic project designed to use a little psychological game to surprise your friends and neighbors (in an entertaining way). It has an element of a "con" to it, which is something I always like.

The idea is very simple, and consists of two easily constructed, yet lifelike characters. The first character's job is to intrigue your audience. He's what we'll call "the bait." For this, we'll construct Sigmond the animatronic seagull. (Sigmond is one of my favorite projects for any time of year.)

Sigmond's motions are random and mesmerizing. In this scenario, Sigmond is carefully lit and operating in a tree or bush. His head, neck, and beak move in a very lifelike way. Your victims — I mean neighbors — upon seeing him will be quickly drawn in and intrigued.

I've seen groups of people clamor up to within a few feet of Sigmond and be completely mesmerized for 10 minutes at a time!

After Sigmond draws them in, they will relax and be completely disarmed seeing this cute little creature chattering away in your tree ... little do they suspect that Sigmond is just our "set-up guy" for our "evil" plan! Lurking below innocent Sigmond's perch is "Martha" a fast-moving, high-jumping ghoul!

When your audience is in just the right position, Martha shoots out from behind her tombstone with a blood curdling shriek and scatters your guests in the best Halloween style.

Martha is what is called a "pop-up" in the animatronic business. This is a simple robot that springs from behind a tombstone or the like. Martha is a bit more complex than the simple "head on a stick" pop ups you may have seen, and her design will allow her to actually leap up and over the front of her tombstone!

An important note: With careful button control, Martha can be brought up very slowly (when needed) so as not to scare the very little ones who might attend your haunting. Often times, I've found the youngest visitors are the first to befriend Martha and delight in the fright she gives their parents! Martha also makes a good dancer for the little ones if she's bounced up and down to some Halloween music.

Seagull Electronics

Figure 1 shows the basic schematic for our animatronic seagull. This circuit will provide random, interesting, and lifelike movement for your gull. (It can also be used as a "look alive" type circuit for a variety of other creatures who you might want to assemble with similar motors.) The circuit is simple enough for ordinary perfboard construction (Figure 5), and fits easily in a small enclosure.

Any general-purpose transistors and blocking diodes can be used. Voltage isn't critical. I happened to use six volts. We'll go into greater detail on the gull robot itself (shown in Figure 3) but, in general, our circuit will need to control two small hobby motors and a solenoid to accomplish all our actions.

A quick look at the circuit shows how this is accomplished. IC1 is a 555 which will send a stream of slow pulses at a rate determined by the 2-meg potentiometer. Each pulse will trigger one movement of the character, so by adjusting the 2-meg pot, you can dial in what seems the most lifelike rate of motion. (A bird moves pretty quickly, so don't be shy in turning this up.)

IC2 is also a 555, and serves as a "randomizer." Each pulse from IC1 briefly turns on IC2, which sends a rapid stream of pulses to the 4013 dual flip-flop. The 33uF capacitor holds a small charge which very briefly powers IC2 between pulses from IC1. This bleed off of the 33uF cap is erratic enough to make each flip-flop wind up in a random position every time!

Four LEDs are attached to the 4013 and display the random positions selected. I think this is a lot of fun to watch. You'll notice that with each pulse from IC1, the LEDs leap to random, irregular positions.

Note: I hooked this same circuit up to a 4017 decade counter and

FIGURE 2

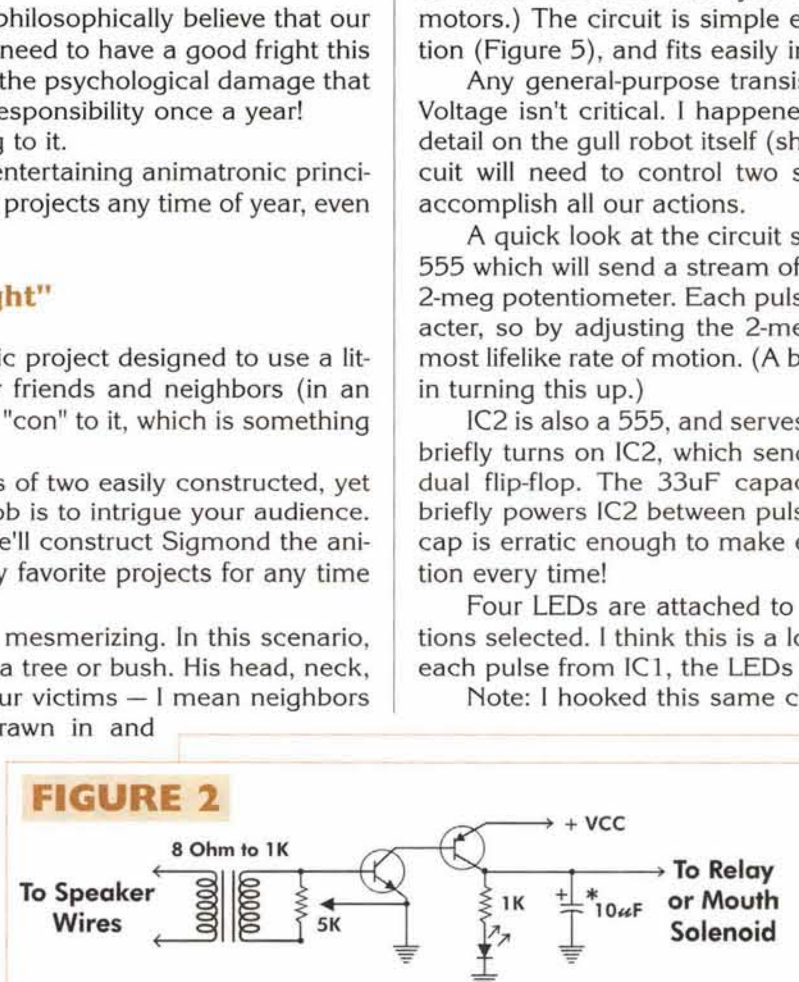
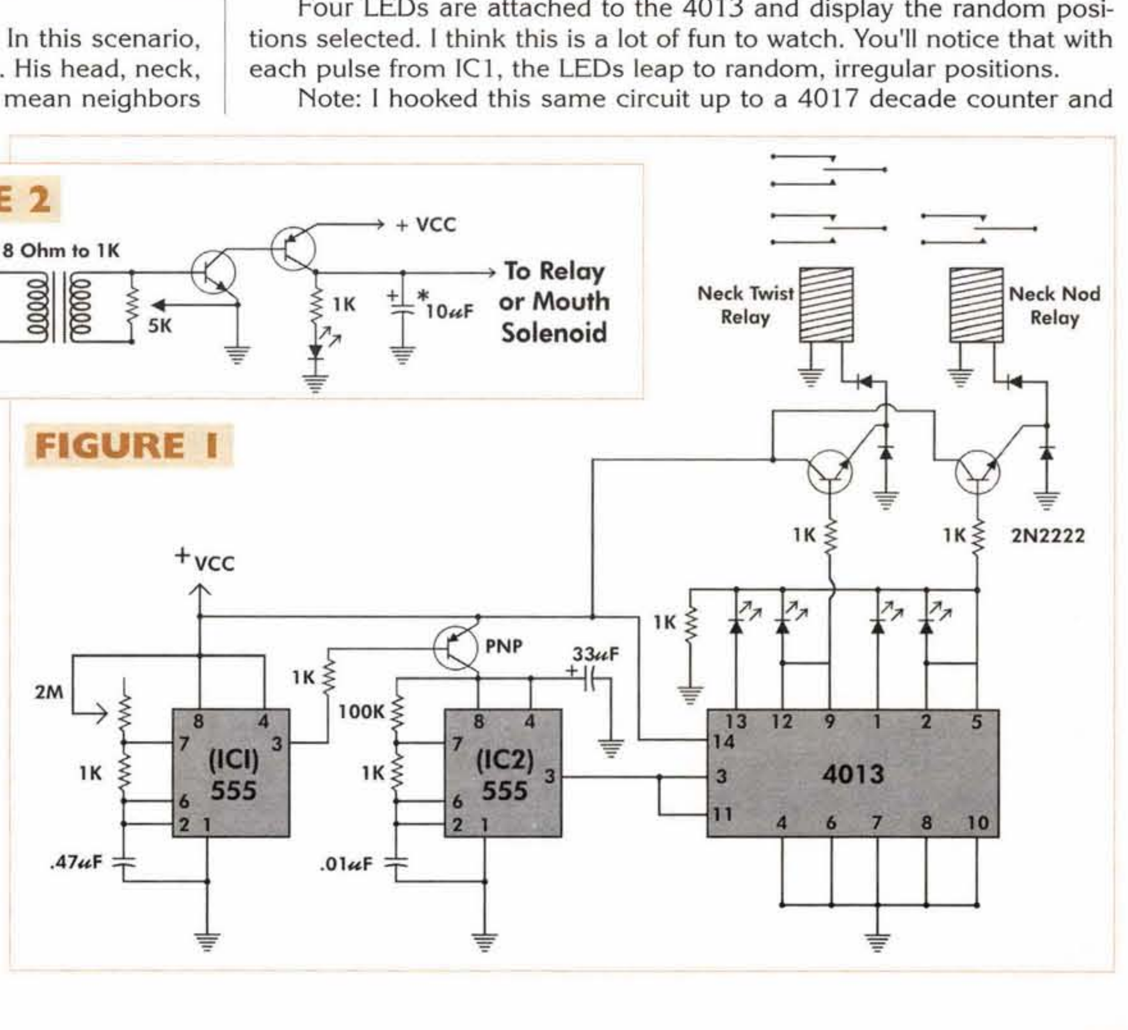


FIGURE 1



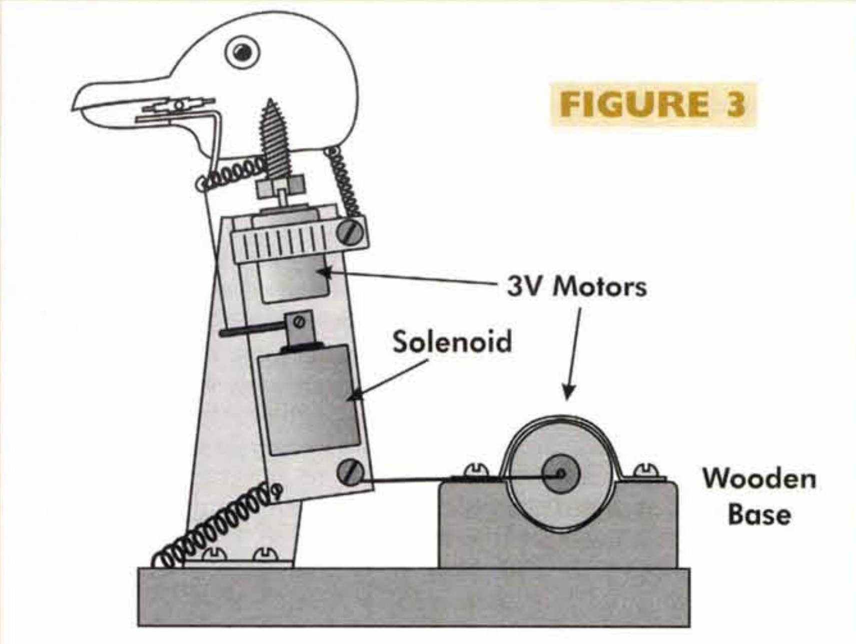


FIGURE 3

found its outputs to be randomized as well. I think this would be very useful for a variety of applications from an eye-catching display, to controlling the random position of a servo (with a third 555 configured for PWM).

The 4013 controls two small relays. One relay (DPDT) operates the motor for neck twist; the second relay (SPST) operates the neck nod.

The neck twist relay is a double pole, double throw relay. You should configure this relay so that when the contacts switch, they alter the direction of travel of the neck motor by reversing its polarity. This is easily done by first attaching the motor leads to the common or swing arm connections on the relay.

Next, attach the + and - leads of your power source to the outside relay contacts in such a way as to reverse voltages to the motor when the relay moves from its open to closed position.

The neck nod relay should simply be connected so that power is sent to the neck nod motor when the relay contacts close.

If your relays are fairly loud, you will need to locate the circuit board some distance from Sigmond. Background music and a box for the circuit usually takes care of any unwanted clicking.

You can certainly substitute power transistors, MOSFETs, or any other solid-state device for the relays, if you choose.

You will need to have some speed control of the motors to prevent damage. Rheostats will work fine, or one of the many motor controls seen in kits in *Nuts & Volts*. What I actually did for speed control was extremely simple.

I just grabbed a handful of big power resistors (from 1 to 25 ohms) and while the gull moved, I played with putting them in series with each motor until I found a perfect resistance/speed. This being determined, I then bought a power resistor of the right value to go in line with the motor.

Even though the motor is only 3V, use beefy power resistors (at *least* 10 watts or better) when doing this. One problem with power resistors is if they get hot, their resistance will change and bang the gull's head around.

The Seagull's Mouth Circuit

In order to pull off the "bait and switch" routine, it's not really necessary to have your bird's mouth move and, in building the robot itself, this is probably the only delicate mechanism to assemble. So, you may decide to skip the moving mouth if this is strictly a Halloween quickie.

If you'd like a bird that serves other animatronic purposes (perhaps far beyond Halloween), I do think your bird should do some talking for himself.

Figure 2 shows a simple circuit to turn audio pulses into mouth movements.

A speaker output is connected to one side of an eight-ohm to 1K audio transformer. A 5K pot on the other side controls sensitivity. The 10uF capacitor smoothes out pulses. (You may want to experiment with *much* larger caps here depending on what you're driving.)

The entire circuit can be connected to a small relay to drive your seagull's mouth solenoid.

Note: You can use a power transistor or MOSFET instead of a relay,


FIGURE 4

if desired. Simply replace the PNP transistor with this device. Your MOSFET will need a "pull down" resistor of perhaps 10K at its gate. Also, a small electrolytic cap might be needed between the NPN transistor's collector and +VVC to smooth out the response.

In the case of Sigmond, his mouth closes when the solenoid is on. So, I used the normally-closed contact on the relay to invert the output of the circuit. If driving a relay or solenoid directly, I'd also recommend adding a blocking diode to the output of the circuit to protect it from a voltage spike.

After assembling the circuit, I usually hook up the eight-ohm side of the transformer to the speaker leads of a stereo. I then tune in an all news channel and adjust the potentiometer until the LED flickers well with the voice. Leaving your talking seagull connected to the radio for a few hours makes a great "burn in" test and is often very funny. Dr. Laura's domineering delivery works particularly well using this circuit, and I think she makes a good seagull.

Over time, I've built a lot of mouth circuits, some better than others. I'll be putting additional mouth circuits and ideas up for *Nuts & Volts* readers at http://www.noonco.com/cyberreaper.

The Seagull Body

Figure 3 shows the simple mechanical construction of the seagull. You certainly don't have to stick to my exact design.

My seagull's head was constructed by purchasing a block of balsa wood from the local hobby store and carving it into the shape of a head. Even if you've never done this kind of thing before, I'd suggest you give it a try. This gull was my first carving and I found it astoundingly easy! A few pieces of sand paper will shape a large block of balsa wood in no time!

Other options are to find ready-made heads at craft stores or even

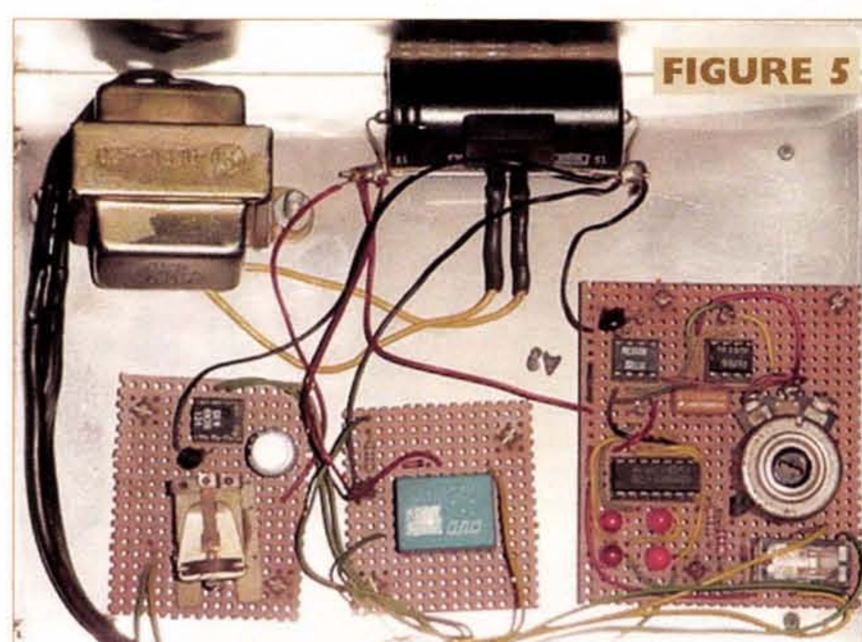
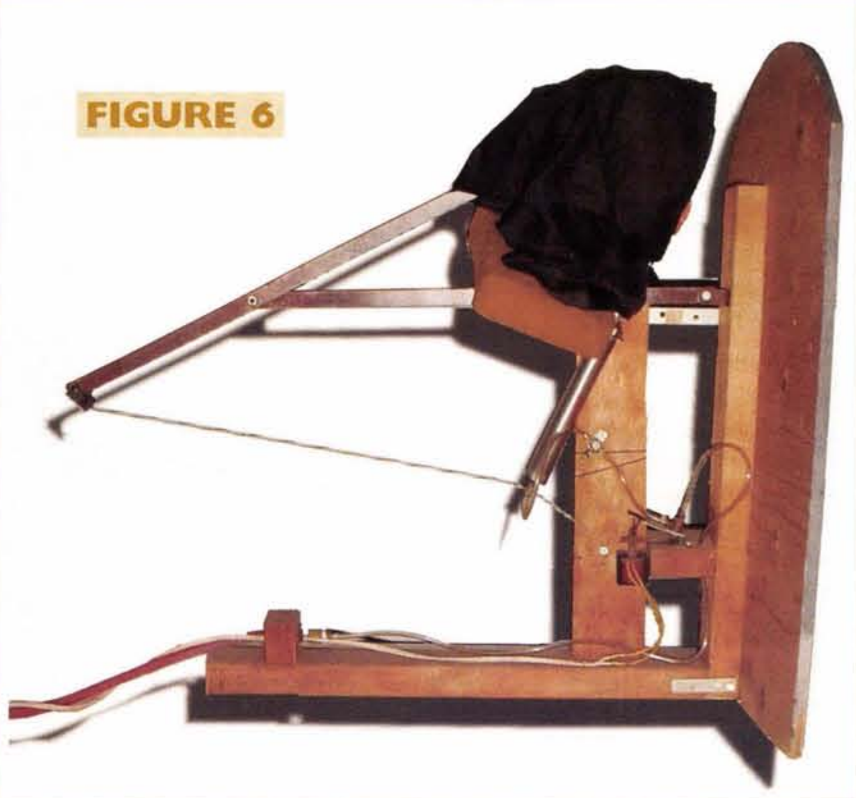


FIGURE 5

FIGURE 6



sporting goods stores (where they are sold as decoys).

The gull's eyes are sold at any craft store and the gull's body is simple papier-mâché. Adding a section of fur from the craft store conceals the gap between the gull's neck and body.

The seagull's upper beak was carved and attached with glue, and his lower beak was attached to the head with a small hinge.

Better hobby stores sell little hinges (resembling hose barbs) that can be stuck into wood such as balsa.

Also pushed and glued into the lower beak is a short piece of coat hanger wire. When the solenoid pulls a string attached to this wire, the seagull's mouth will close. A small spring pulls the mouth open when the solenoid is off.

The gull's head is attached to a small hobby motor by a screw. The motor is attached to the screw by first drilling a tight fitting hole in the head of the screw, adding a drop of super glue to the hole, then tapping the motor axle into the hole with a small hammer. The neck motor is secured to a thin, flat piece of metal with a hose clamp. A solenoid was also attached to the same metal with a few screws from behind. This whole assembly is attached to a second metal plate behind it by a single screw (behind the neck motor) that acts as a pivot point.

For both metal plates, I used very thin high carbon steel that I got from "tie straps" placed around some lumber. By keeping these very thin, the head will bounce a bit from side to side creating additional motion. A small spring at the back of the gull's head limits the motion of the head from left to right to prevent any Linda Blair action from the gull.

Again, if this is a "Halloween quickie," you can always substitute elastic for the springs.

Last, a second hobby motor is mounted on the wooden base. This motor has a small belt that goes from its axle to the bar to which the motor and solenoid are mounted. When this motor spins, it winds the belt around its axle and causes the gull's head to nod forward. A spring returns the head to an upright position when the motor is off.

The belt can be constructed by cutting a strip from an old cotton tee shirt or like material. To prevent it from unraveling, I rub in a little silicone glue on one side of the belt. The belt is attached to the motor axle with a few wraps and a little glue. The motors I used were low torque 3V hobby motors (.50 each). These are good for several hundred hours of operation. Don't use motors that are too strong or you may tear your belt or stretch a spring.

Martha's Body

I've always been very annoyed by unimaginative "pop ups" that just have a head on the end of a cylinder. Martha is a lot more fun. She also shows how an air cylinder with just a few inches of travel (called stroke) can move a character several feet, and in an interesting pattern. Martha's head is made from a Styrofoam "wig stand" available at any better wig supply. The Styrofoam head is attached to the metal bars by first sinking the bar into the Styrofoam, then holding it in place with silicone glue. Any Halloween mask can be fitted over her face.

Martha's swing pattern will not only allow her to jump up several feet, but will actually bring her up and over the front of the tombstone. Figure 6 shows Martha in the crouched position, and Figure 7 shows her completing her jump. (I've pulled back Martha's long flowing cowling so you can see the mechanism.) A piece of foam rubber glued to the bottom of her head forms her shoulders. Figure 8 shows a front view of Martha completing a jump.

The mechanism is very simple. Two metal bars are attached by a bolt at a pivot point as shown. The back of the top bar is attached to the wooden frame by a cable. The air cylinder itself is attached at the nose with an "L" bracket. (This bracket must be able to swivel.)

When the cylinder extends, the bars and cable make a "floating quadrilateral" and lift the head up and over the tombstone, exaggerating the motion of the cylinder greatly.

FIGURE 7

Air Cylinder Basics

If you're interested in any kind of robotics, and have never worked with air cylinders before, have I got a treat for you! Air cylinders are easy to hook up. To have a complete system, you only need a compressor, a hose, a flow control, and a valve! (A water trap and in line oilier should also be used if the cylinders will be in long-term operation. These are available anywhere air tools are sold.) A small cylinder, perhaps just 3/4 inch in diameter can exert a force of 40 pounds at 100 PSI. Air cylinders are clean (no oil like hydraulics) and will probably outlast you and me if just used seasonally!

Martha uses a single air cylinder for her jump. I happened to use a 3/4 bore, four-inch stroke cylinder. These dimensions are not critical since you can change the point at which the cylinder attaches to the bar to get more or less angle/jump.

I would recommend using a home air compressor with a tank of eight gallons or more. With an eight-gallon reservoir, you will get *dozens* of jumps between times the compressor must run to charge the tank.

However, if you don't have a compressor, never fear, Wal-Mart and just about any auto parts store have 12V compressors for between $10.00 and $25.00. I've hooked these compressors up directly to single cylinders and have been able to operate the cylinder nicely!

A real Halloween "quickie" set-up is to run the hose from the 12V compressor right to the cylinder. Poke some holes in the hose with a needle. Now, when the compressor starts, up goes the cylinder! When the compressor stops, the air leaks out the holes in the hose and down comes the cylinder. If you want her to come down faster, poke more holes!

Remember to keep the hose between the 12V compressor and the cylinder short or there will be a delay in jumping. And don't worry too much about compressor noise, the sound of the compressor is usually covered by the screams.

The "right" way to hook things up is almost as simple as the quickie: Connect the air hose from your compressor to what's called a "three-way valve." Pneumatic three-way valves provide air to the cylinder when activated, and allow air from the cylinder to exit when it is turned off. Next, run the line from the three-way valve to a flow control or needle valve. (These usually screw right into the cylinder.)

That's all there is to it! When the three-way valve is turned on, up goes Martha at a rate determined by your flow control (this is adjusted with a screw). When the valve is turned off, down comes Martha. Three-way valves can be manual or 12, 24, or 120V in operation.

The best prices I've seen on fittings, hoses, and valves are from "Joint Air" (http://www.JointAir.com/). They usually sell to industry and average about half of what most suppliers charge. I wrote them to ask if they'd fill individual orders, and they said "sure." So, let them know you're building the ghoul. Air cylinders can be purchased from most industrial supply houses or even the net.

Note: I have about 20 air cylinders here that are used, but in excellent condition. (Price new about $35.00.) I'll make these available to *Nuts & Volts* readers who'd like to make a ghoul for $10.00 plus $2.00 postage! I can be contacted by email at **walt@noonco.com**.

The Scariest Effect!

One friend who I built a "Martha" character for said she experienced the scariest effect! When I shipped Martha to her, I removed Martha's head so it wouldn't be damaged. In replacing her head, my friend forgot to use glue.

Martha behaved herself for most of the evening scaring crowds as expected. However, a group of "tough" kids showed up and began causing trouble. Right on cue Martha "popped up" and due to the lack of glue, her head flew off and landed in the lap of a tough kid! My friend said the whole group ran screaming from the yard!

This made me think about having the head fly off, but I haven't tried it yet. Let me know if you do!

On with the Show!

You could easily rig Martha to jump using a motion detector, however, I believe that automatic mechanisms lack the finesse for the perfect scare. They just never seem to trigger at the perfect time.

I personally like a set of push buttons to control any and all jumpers in a show. With Martha jumping by push button, and Sigmond moving and cawing away, you're ready!

The last two elements to be added are sound and lighting. With Martha, a shriek is *critical* to a good scare. I've often just attached a *loud* buzzer or cassette player (with an endless scream) to the same wires as her solenoid air valve.

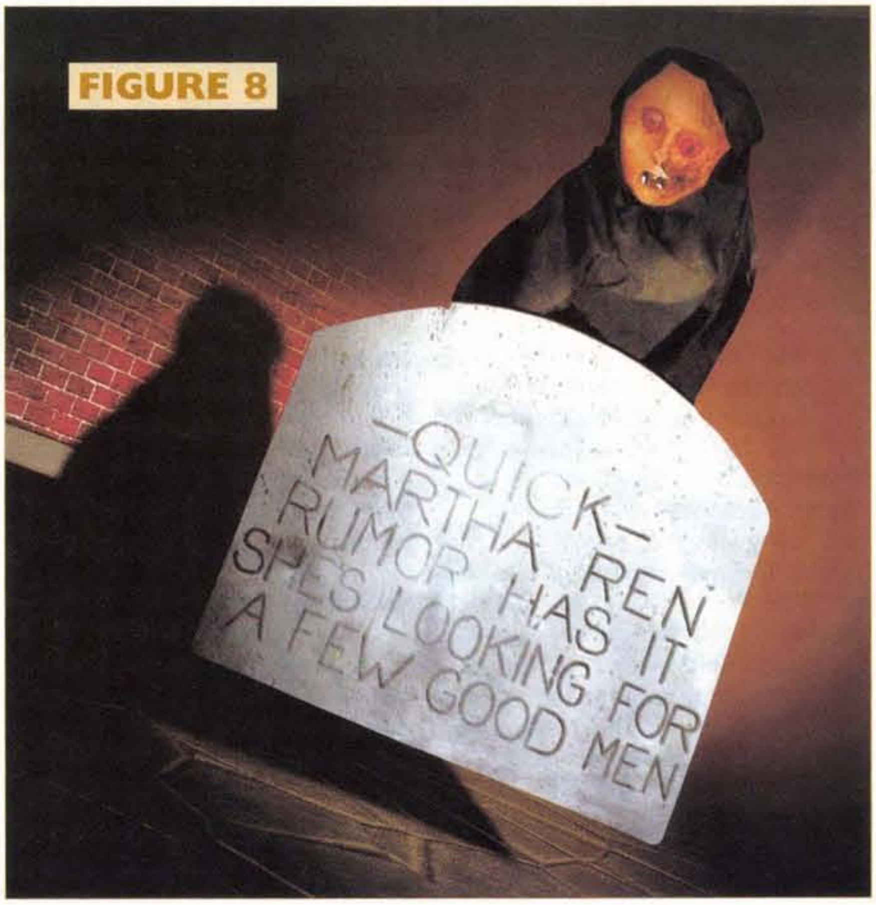
Sigmond's cawing is usually accomplished by a small cassette recorder and an "endless loop" cassette tape. (Endless loop cassettes are used in telephone answering machines and are available from any RadioShack.) The speaker output from the recorder is attached to both the eight-ohm transformer on Sigmond's mouth circuit and to a speaker hidden in his nest. (It's also possible to have Sigmond talking or singing, as well!)

Finally, you'll want some background music playing, and the usual Halloween touches to set the overall mood.

With this, you've armed your haunt with good bait, and a big surprise!

Happy Hunting! **NV**

FIGURE 8



Parts List

Seagull Motion and Mouth Circuit Parts

(7) 1K resistors
(1) 100K resistor
(1) 2 Meg potentiometer
(1) .47 uF capacitor
(1) .01 uF capacitor
(1) 33 mfd electrolytic capacitor
(2) 10 uF capacitor
(1) 8 ohm to 1K transformer
(5) Red LEDs
(6) diodes (any general-purpose blocking)
(3) NPN transistors (2N2222 or any general-purpose)
(2) PNP transistors (any general-purpose switching. If driving a relay or mouth, use a transistor rated for your load.)
(2) 555 timers
(1) 4013 flip-flop
(2) 5V SPST relays
(1) 5V DPDT relay
(1) 12V continuous duty solenoid
(2) 3V hobby motors

Misc. Six-volt power source, a rubber washer (capable of handling some heat) to attach to the solenoid rod to prevent "clicking," hardware seen in Figure 3 and discussed.

Martha Pneumatic Parts

(1) push button, wire and power source (for air valve)
(1) three-way air valve
(1) flow control
25' airline tubing
(2) 3/4-inch bore, 4-inch stroke pneumatic cylinder (or similar)

Misc. Buzzer, Styrofoam wig stand, plywood, 2 x 4 and all other hardware seen and discussed.

Note: Valves, airline and flow controls can be purchased from **http://www.JointAir.com/**.

Cylinders can be purchased from Grainger (**www.grainger.com**) or McMaster-Carr (**http://www.mcmaster.com/**) and even eBay on occasion!

The author also has a limited number of used cylinders available for $10.00 plus $2.00 shipping. He can be contacted at **walt@noonco.com.**

Amateur Robotics

Dampen Your Enthusiasm — or — Hints On How To Get A Head!

I saw an interesting product on the internet and decided to go ahead and build one on my own. The project is an animatronic head, like the kit "Alex" from Milford Instruments, Ltd. (www.milinst.com). I had seen a favorable review of the kit on "The Robotic Club of Yahoo" website (www.trcy.org) and thought I could make one using a scroll saw, four servos, and some plastic. To drive the servos, I planned to hotwire them to a robot chassis to get the head working quickly (Libby from www.bluebelldesign.com). While building the head, I learned some things that can be useful not only for building heads, but other robotic mechanicals, as well. This article is therefore presented not as a finished polished product to build, but more as a documentary on how I prototyped this head and some ways to help you do it too.

I had not planned to do a real design analysis on this because first, the project really was just to be built for grins. And second, I am not that fond of doing rigorous math analysis on mechanical systems. While most times it is better to properly design a product before prototyping, there are other times where you just want to go ahead and try something out. Of course, if the project is for work, you'd probably use different guidelines in your decision than if you were just going to make one for your hobby.

For a while, I toyed with the idea of adding more motions to the eyes. Finally, I decided to just build it as it appeared to see what I would have to work with. The non-reclaimable parts are very inexpensive, so I could start again, if and when I got the inspiration to build my next world's greatest animatronic head.

Getting Started

I drew the head parts on paper and then used rubber cement to stick the pages to 1/8" clear polycarbonate sheet purchased from a window glass company. The glazing material at home centers is typically only 0.93" and I wanted thicker material. I cut the parts using a scroll saw and started experimenting with it. When cutting and drilling polycarbonate, keep the speed down for a clean cut. After some part adjustments, everything seemed to move smoothly and I adjusted the lengths of the servo connecting rods with power off until they were about right.

Smoke Test

I connected the servos to the robot and started testing. The eyes worked okay, but were pretty sloppy. More importantly, the head had a very choppy movement as it went left to right and was quite wobbly on the neck.

Eye Surgery

To solve the eye issue, I removed the tie rod ends I had made from wire loops and splurged ($3.00) on two threaded ball links (Du-Bro190 from a hobby shop). Note the new linkage in Figure 2. One other thing to notice is the flexible link leading to the servo. Remember, the servo swings in an arc that does not match the left/right motion of the 1/16" piano wire eye-connecting bar. A .039" (1mm) music wire link takes up the difference. If you have not worked with music wire before, use caution. It is very hard and will ruin your electronic cutters.

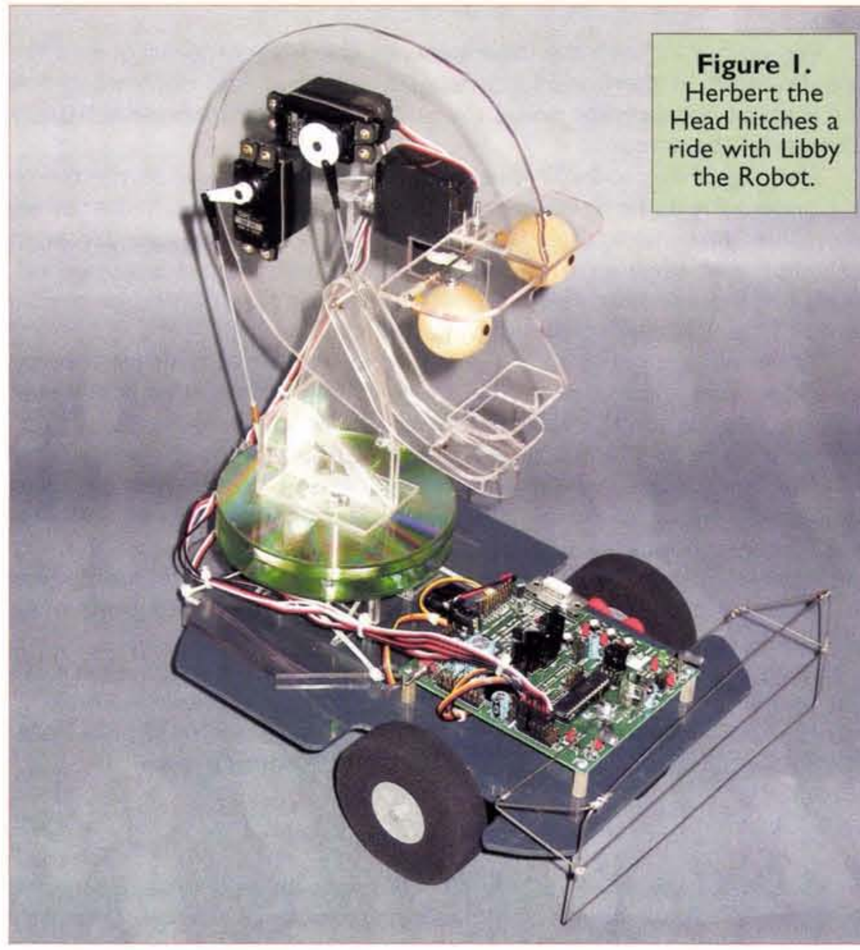


Figure 1. Herbert the Head hitches a ride with Libby the Robot.

One way to cut it is with a motorized hand tool with a cut-off wheel. Eye protection is always a good idea when working with music wire. By the way, the eyes are 1.25" diameter wooden balls from a craft store. The neat little wood screws holding them to the eyebrow are the mounting screws that come with the servos. Spacing the servo down from the eyebrow and adding the studs out the back helped the clearance between the linkage and servo horn. Much better now!

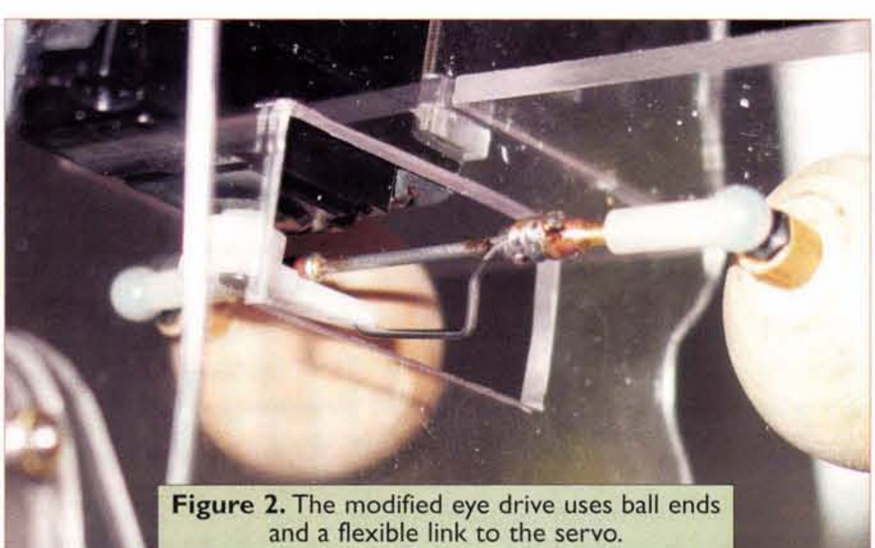


Figure 2. The modified eye drive uses ball ends and a flexible link to the servo.

Stop the Shakies

I didn't follow the exact head size of the kit. I made mine about 11-1/2 inches high overall. I also didn't know the torque of the servos, so I used standard servos all around as that was all I had in stock at the time. The shakiness of the head made me think I had used servos that were too small for the left/right movements. (Hey, when it doesn't fit, use a bigger hammer!) I then ordered some nice big servos and figured when I got time, I'd retrofit them. I also bought a ball bearing to make a "lazy Susan" type of support so the head would be more solid and less of a load on the servo bearings.

Before I got the chance to do the modifications for the new servos, I started thinking about the problem a little more. (This is often better before you reach for the bigger hammer.) If you do a thought experiment, it makes sense that a bigger/stronger servo would stop the vibration of the head. The whole thing is perched on a single servo output pin and has a series of masses that work at a distance on the springiness of the plastic pieces. That little head on a four horsepower servo with a 1" output shaft wouldn't make a difference. On the other hand, based on the wiggling motions, the mass and size of this head seemed to definitely be affecting these servos.

Back to School — Look Ma, No Equations!

Remember the problem in physics class where there was a mass hanging on the end of a spring? Without friction, if it were ever disturbed, it would oscillate forever. In the real world, there is always friction, but it comes in varying amounts. If the block is hanging in the air, there isn't much friction and the block takes quite a while to settle. If you put the block in oil, settling happens much faster. The friction of the oil adds what is called "damping." In a car, the shock absorbers do that. If you have ever been in a car with bad shocks, you know the bouncing that happens as you go down the road. (I understand the British call them "dampers" since they don't really absorb shock.) What I needed might not be a stronger servo, but more damping in the head mounting. In an experiment on the unmodified head, I used my fingers to add a bit of resistance as the head moved to see if that stabilized it out. It worked! I then figured if I could redesign things to add some damping and, at the same time, add support to get some of the load off the servo output shaft, I'd be home free.

New Head Support

The original head support is shown in Figure 3. All the weight is on the servo output shaft. My first attempt at redesigning a head support used three CDs. They are already round, made of 0.047" thick polycarbonate, and those with write errors from my CD burner are free. That version wasn't stiff enough. The damping worked, but the head was still wobbly. I then decided to replace each of the CDs with a laminated pair. Join their label sides together using gel super glue. The data side has a protection ring around the center that would keep the discs apart. Of course, you can't have a paper label on the CDs or that would weaken the bond.

Figure 4 shows the CDs and the base. Clockwise from the hexagonal base are the servo, the CD pair that attaches to the base, the pair for the adjustable damping and support (the friction deck), and finally the pair that attaches to the servo horn on the head. The six friction pads are "heavy duty" 3/4" felt pads used to protect wood floors from furniture legs. They are available from a home center. The final head support is in Figure 5.

After first reassembly, I found I needed to cut away the friction pad CD pair around the servo so I could back it off enough. A motorized hand tool with a cut-off wheel will make the cutout without having to take everything apart again. This tool totally violates my suggestion to keep the tool slow. When cutting at these high speeds, you will get a gummy, melting cut. But it isn't too hard to clean up so it works for a quick fix. By the way, when working with CDs, remember — they are very tough and flexible but, when flexed too far, they suddenly snap and propel sharp shards everywhere! Be safe.

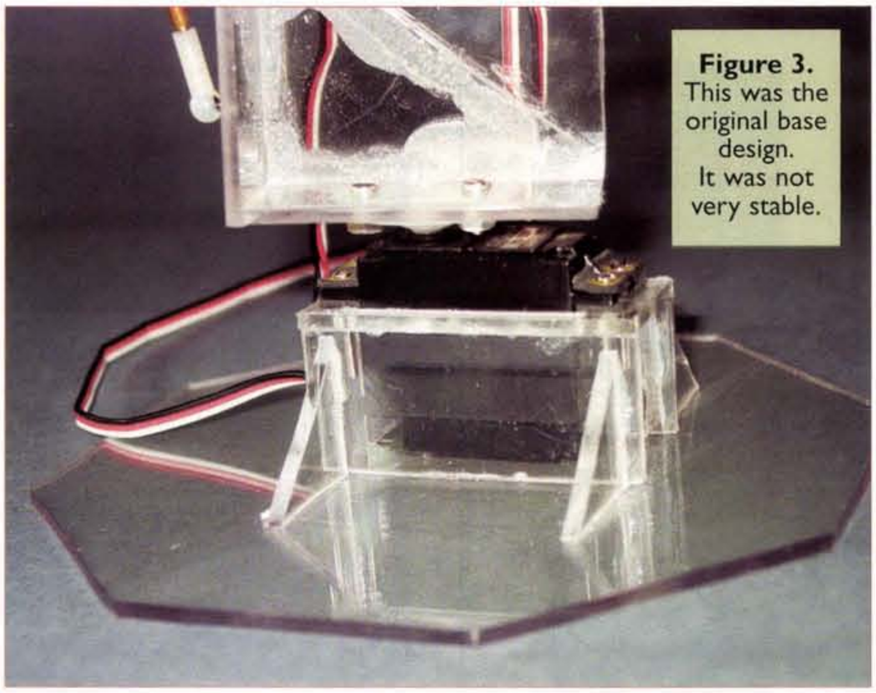
During assembly, I started wishing my fingers were long, thin, and sticky at the ends. This was to get those tiny 2-56 nuts to start on the servo mounting screws. Some transparent tape rolled into a tube and flattened came to my rescue. Stick the nut to the flattened end and it holds the nut until the screw grabs it. I also taped the screws to the underside of the servo horn so they would stay put during assembly.

How Much is Too Much?

Damping can be overdone. If you have too much, you will find that the servo will try to go to the commanded position, but won't quite get there. The motor will then keep trying to move that last bit, but the starting friction won't let it. What you'll notice is that the motor won't shut off completely when it's done moving. It is especially noticeable when slowly ramping to a position. To fix it, adjust the nuts to lower the friction (middle) deck. When adjusted correctly, most of the weight of the head is still on the servo output shaft. The friction pads are just touching the top CD pair. If the head starts to rock, the friction deck will still add a lot of support.

Electronics

Driving a servo isn't generally too difficult. Pulse the control line for one to two milliseconds depending on where you want the servo positioned. Repeat the pulse every 20 milliseconds. Even if you just want a servo to stand still, you should keep sending it the pulses. On a single-minded processor like a Stamp, the four servos can start to eat up the compute power quickly. It can also be tricky to get back every 20 milliseconds. You aren't always sure how long the rest of the program loop takes, so the refresh times can go way off. A servo controller co-processor is a real help here because you just tell it a position value for each servo and it automatically resends all the servos the correct pulses every 20 milliseconds. Ramping is a co-processor feature where you not only tell it where to put the servo, but also how fast to get it there. When doing animatronics, like this head, that is very helpful because most times, you are trying to move at less than full speed. Ramping saves you from having to calculate the servo intermediate positions during the movement time. You just "set and forget."

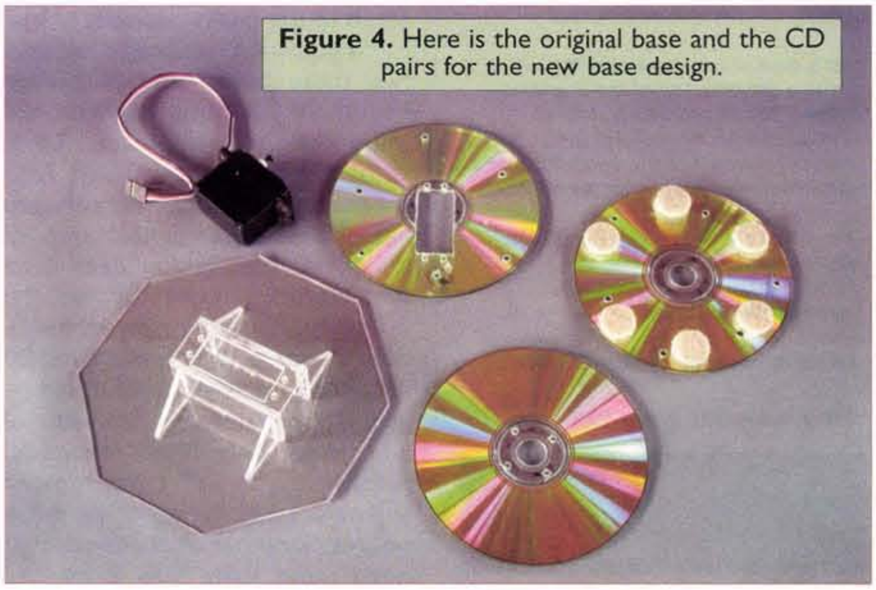


Meet Herbert

Now that the prototype mechanics are finished, he needs a name. How about "Herbert?" That's it, Herbert the Head! As you can see in Figure 1, I mounted Herbert on the back of Libby the robot. Libby's electronics can easily drive the robot base, Herbert's four servos, and a lot more.

The Program

During the prototype stage, I used the servo controllers available on Libby. You can find the driving program Herbert.BSP on the *Nuts & Volts* website (www.nutsvolts.com) or the Blue Bell Design site (www.bluebelldesign.com). Most of the time on a project like this, the Stamp 2p processor would be waiting. Do this, wait, do that, wait, etc. The easy way to wait a Stamp is with a PAUSE statement. If I had nothing else to do, that's fine. Libby has three available switches on the PCB and I wanted to use one of them to cause Libby to go into robot mode so he'd drive off and be a robot while the head was still running its program. This means the program has to be looking at a switch at the same time it is pausing. That could be done with a loop using small delays and a counter. Besides adding complication, the switch gets sluggish if the delay is too long. Instead, I used



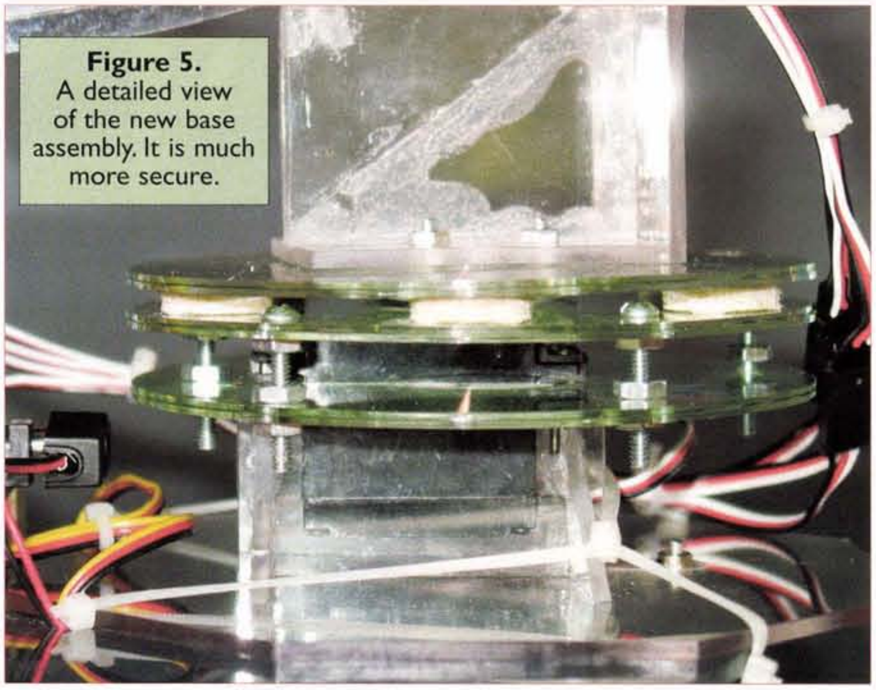


Figure 5. A detailed view of the new base assembly. It is much more secure.

one of the eight timers built into Libby's co-processor to do the waiting. The Stamp processor goes into a loop (wait4it) where it does whatever else it wants and only has to periodically check a timer done line (input X11) to see when the timer has timed out. This means, instead of being stopped, you still have almost the full power of the Stamp while waiting. Other things you might want to be doing could include moving the mouth to music or controlling a speech box and moving the mouth with the speech ("Help! Help! How do you stop this thing!").

Some explanation might help you better understand the program. The Stamp processor in Libby is a 2p40 (32 I/O lines), so it uses the second set of 16 I/O (addressed by the AUXIO instruction) to talk to the co-processor. The eight servo outputs initialize to an output = 0 state, with the ramping feature off. Sending two serial bytes, the first addresses the particular servo, the second tells the position you want causing the co-processor to start servo mode for that channel and to move the servo to the given position.

If you want ramping, just send two more bytes, one addresses the channel's ramp register and the second tells the value. Ramp values range from 0-31. Zero means no ramping. A non-zero value is four times the amount added to the position each time the co-processor goes through the 20 ms loop. Position values are 0-255. A value of 1 takes over 20 seconds to go over the full range, while the maximum ramp value of 31 takes only 0.66 seconds. Another bit in the ramp register selects a wider range for the pulse outputs for those applications that need more than 1 to 2 ms. All eight channels have separate ramp rates and servo controls.

After initialization, the program starts in main by exercising each servo in turn. Commenting out GOSUBs lets you set up the program to loop only on the specific function(s) you want to see. This allows you to adjust your servo linkages for each movement.

The program finishes with this neat trick:

1. Start with the eyes and head facing front.

2. The eyes turn quickly to the side as if seeing something.

3. After a short pause, the head turns slowly toward what it sees while re-centering the eyes. (A great effect, yet ramping servo controllers make it very easy to do.)

4. Pause again, then the eyes look quickly back toward the front.

5. Then the head follows the eyes back to front and center.

6. Repeat for the other direction.

Now What?

Herbert shouldn't stay mute for much longer so that could be another addition. Libby's PCB without the chassis could be used for a less mobile Herbert. An advantage of Libby's PCB is that there is a separate voltage regulator for the servo channels. That let me use an AC adapter while experimenting and adjusting without the worry of frying my servos or eating up batteries.

A separate Libby co-processor chip could be dedicated to Herbert. It could even be mounted on a small PCB on the side of his head. Besides driving the servos, the built-in IRPD control could then be set up with IR LEDs and a sensor on the eyebrows to let Herbert have vision. Then, when he sensed something left or right, he could turn to look at it. The A/D channels could even be used for sensing light in the room so

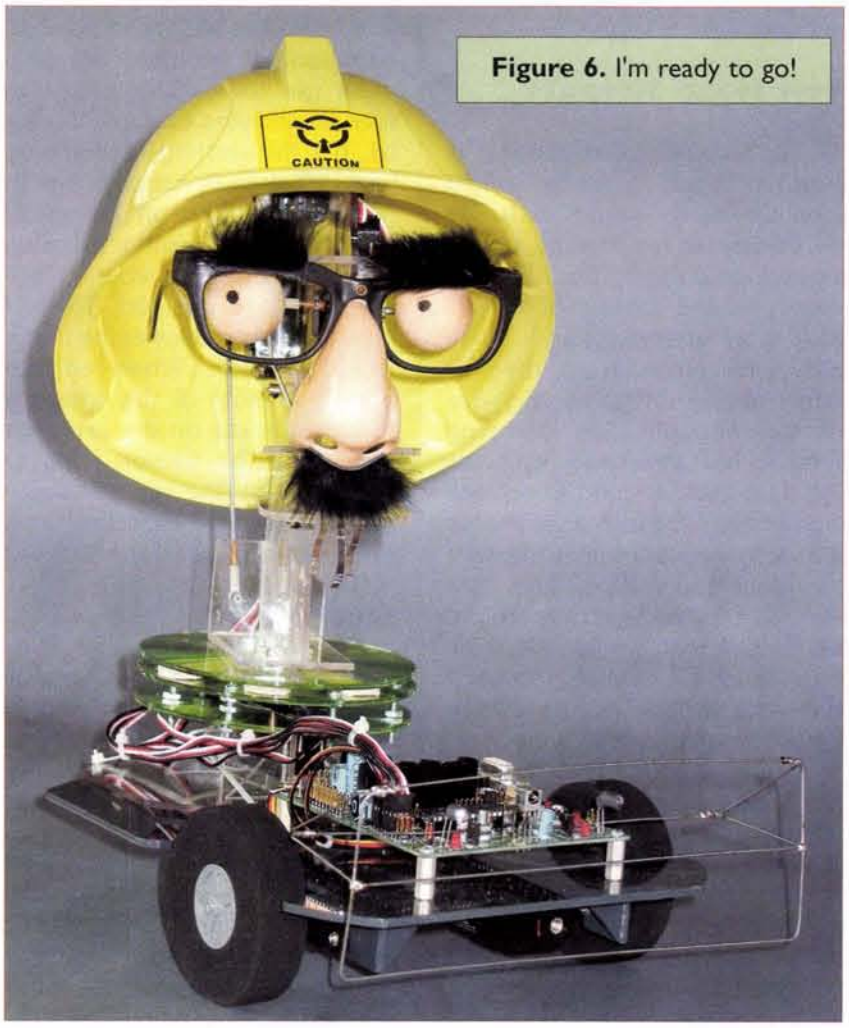


Figure 6. I'm ready to go!

Herbert could follow or avoid the sun. Hey, he's an animatronic flower.

That's it for now. I still have those high-power servos I mentioned earlier. They seem to be calling to me to become a robotic arm. Here the high power would be helpful for load capacity. This time, I'll think of adding damping into the original design. After all, isn't an arm also a case of a weight at a distance? **NV**

About Author Harry W. Lewis
Harry's passion for electronics started at age 14 as a hobbyist and avid reader of anything about electronics. Since earning a BSEE from Carnegie Mellon University, he has designed a wide variety of products ranging from a mainframe computer subsystem to telephone caller ID adjuncts. Besides electronic design, many years were also spent in semiconductor sales and field applications engineering. The past four years have been full time with Blue Bell Design, Inc., an electronic design consulting firm that has started producing a hobby robotic product line. He can be reached at: **Blue Bell Design, Inc.**, P.O. Box 446 Gwynedd Valley, PA 19437-0446; email **harry_w_lewis@hotmail.com**.

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Emma Marion Ltd.
2677 E. Hastings St.
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3214 Douglas St.
Victoria, BC V8Z 3K6

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Colorado Springs 80909
Tower Records/Video
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Denver 80206

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Washington 20006

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Miramar 33023
Clarks Out of Town News
303 S. Andrews Ave.
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Mike's Electronic Distributing Co.
1001 N.W. 52nd St.
Fort Lauderdale 33309

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Ocean View 96737
Tower Records
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Honolulu 96816

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Boise 83706

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Schaumburg 60173

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Indianapolis 46222

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Overland Park 66212

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Metairie 70002

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Purchase Radio Supply, Inc.
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Ann Arbor 48104
Spectrum Electronics, Inc.
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Grand Rapids 49504

MINNESOTA
Radio City, Inc.
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St. Louis 63114

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Boulder City 89005
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Winston Salem 27101
United Electronic Supply
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Charlotte 28204

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204 S. 3rd St.
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oklahoma City 73102

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7940 S.W. Nimbus Ave. Bldg. 8
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Seattle 98109

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Milwaukee 53223

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News Bytes

Bush Administration Expands Efforts to Improve Citizens' Ability to Interact With Government

GSA Administrator Stephen Perry has announced the creation of the US General Services new Office of Citizen Services and Communications (OCSC). Perry said this move is closely tied to President Bush's management agenda which calls for making government more citizen-centered, results-oriented, and expands the use of Internet technology for e-government. Additionally, the new initiative will streamline the way citizens will have access to information about government services.

"The new Office of Citizen Services and Communications opens the way for the public to interact with government by creating a single front door to the services and information they require in the medium they prefer," Administrator Perry said.

Resources from the Office of Communications, Federal Consumer Information Center (FCIC), Office of Intergovernmental Solutions, the Office of Information Technology, as well as the Office of FirstGov operations in the Office of Governmentwide Policy are being consolidated into the newly established OCSC.

"The need to provide the American people with fast, accurate and easy-to-use information about government services and activities has been steadily accelerating," Perry said. "The Office of Citizen Services and Communications streamlines the way citizens, businesses, state and local governments, and the media can get the information they need regarding the federal government on the web, over the telephone, and in print — and soon via e-mail and fax — more efficiently and effectively."

The new OCSC websites provide the public with information in direct, simple language that is convenient and easy-to-use. By searching millions of federal, state, and local government web pages, these sites get citizens what they want when they want it. OCSC also offers citizens the opportunity to call toll-free 1-800-FED-INFO (1-800-333-4636) and get the same federal information.

And to get information in print, citizens can write for the free Consumer Information Catalog, Pueblo, CO 81009. The catalog features hundreds of low-cost federal publications on everything from housing and car buying, to health and financial questions.

With the new office, emergency services will also be more readily available. "Our goal is to swap red tape for a red carpet that will allow Americans to step up and get the information they need," Mary Joy Jameson, new Associate Administrator for OCSC, said.

Wells Fargo Introduces Electronic Signature Option for PLUS Loans

Wells Fargo Education Financial Services (EFS), one of the nation's leading student loan providers, has announced that parents can now complete the entire Federal PLUS loan application process online using their electronic signature.

"Wells Fargo's goal is to make the student loan process as easy

and fast as possible," says Jon Veenis, president of Wells Fargo EFS. "PLUS loan interest rates are at historic lows — just 4.86 percent — and our new e-signature option for PLUS loans makes it even more convenient for our parent customers to take advantage of this low rate."

With Wells Fargo, parents have the option to use the Department of Education's (DOE) personal identification number (PIN)-based electronic signature. Parents also can choose to use Wells Fargo's e-signature process, which allows applicants to establish their own personal PIN in real-time and eliminates the need to wait for a PIN to be assigned by the DOE. For enhanced security, Wells Fargo authenticates the applicant's identity using a third party. With either process, parents can apply online and use their electronic signature to complete the PLUS loan application immediately.

PLUS loan e-signature is available at http://www.wellsfargo.com/per/student/loans/parent_plus.jhtml. In the coming months, Wells Fargo also will offer electronic signature for Federal Consolidation loans and private loans.

New Product Reduces Risk of Permanent Hearing Loss Suffered By Children and Teens

CDC States That More Than Five Million Children Suffer Permanent Hearing Loss From the Use of Personal Stereos

The advent of CD players and other portable audio devices over the past decade has often been cited as a prime factor in the substantial increase of hearing loss in children and teens. Because youngsters often raise the volume of these devices to damaging levels, they subject their ears to an assault that can cause a lifetime of hearing loss, also know as noise-induced hearing loss (NIHL). NIHL is permanent and irrepairable.

While some hearing experts believe that the use of headphones can substantially increase the risk of adolescent hearing damage, the Kid's Ear Saver Company has recently introduced a product that can help reduce this risk.

The Kid'sEarSaver® (patent pending) is an easy-to-use adapter that employs micro-electronic technology to restrict the volume of any connected audio device to a safer level. Because the Kid'sEarSaver is permanently attached to the headphones, it cannot be removed or bypassed.

The Kid'sEarSaver works with all audio devices — whether or not they are portable — including CD and DVD players, stereos, computers, games, and televisions. These devices can emit as much as 115 decibels of sound, and is equivalent in volume to an ambulance siren, sandblaster, or rock concert. According to OSHA, sound entering the ears at 115 decibels can cause significant hearing damage in as little as 15 minutes.

Tom Metcalfe, president of the Mississippi-based company, invented the device while observing his son at play with his own CD Player. "I could hear the music screaming out of his headphones from across the room, which wasn't safe at all."

The Kid'sEarSaver sells for $19.95 plus shipping and handling, and is available for secure ordering online at http://www.kidsearsaver.com/. **NV**

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MSP430

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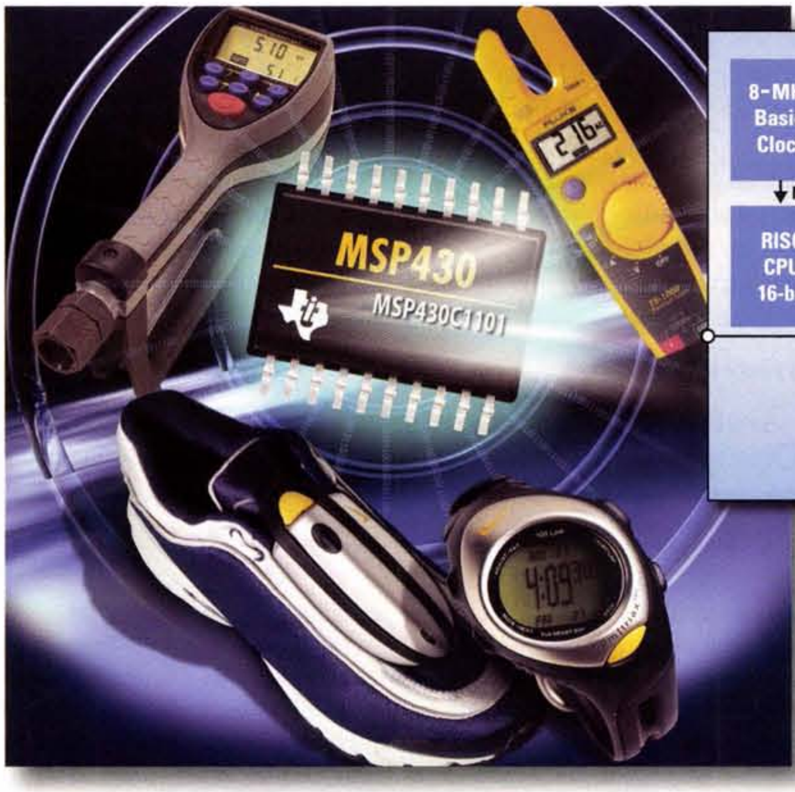

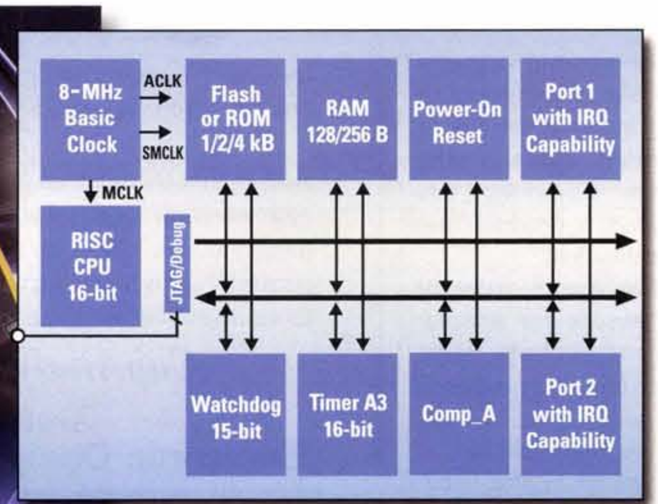

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MSP430C1121	–	4	256	14	✓	✓	✓	$1.12
MSP430F1101	1	–	128	14	✓	✓	✓	$0.99
MSP430F1111	2	–	128	14	✓	✓	✓	$1.24
MSP430F1121	4	–	256	14	✓	✓	✓	$1.62

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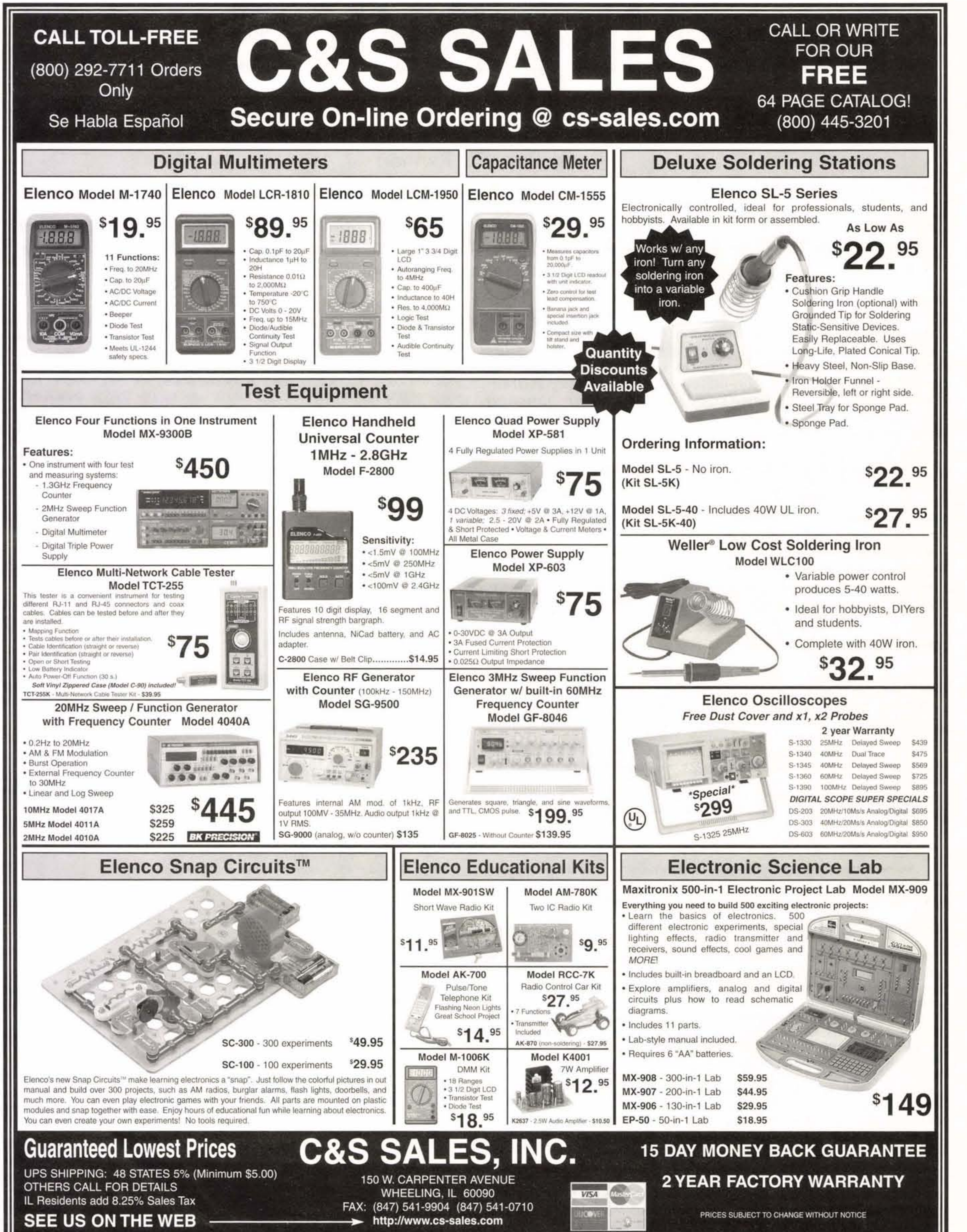


Circle #35 on the Reader Service Card.

Learning RVK-Basic
Part 9

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 last installment, we will be covering three different topics. First, we will develop a new way to generate Pulse Width Modulation (PWM) which will even work on chips that do not contain PWM generators. Next, we are going to learn how to handle non-linear transfer functions (transcendental functions) in RVK-Basic. We will be handling very general cases, including using look-up tables, which will enable us to make very complex calculations very rapidly.

Lastly, we are going to learn how to measure temperature using AVR microcontrollers. We will use two different devices, the LM74 from National and the DS1820 from Dallas. Both are inexpensive integrated circuits, which measure temperature and report the temperature digitally. Both parts are easy to interface to a microcontroller (connect three pins to the LM74 and only one pin to the DS1820 plus a pull-up resistor). As we will soon see, the software for the LM74 is much simpler than for the DS1820.

PWM In General

PWM can be used for many different purposes. As I discussed in a previous installment, PWM is often used to control motors. It can also be used with a resistor-capacitor filter (see Figure 1), as a poor man's analog-to-digital converter. It is common to command model aircraft servos with a DC voltage, and a filtered PWM output can do just that for us.

In general, the average DC voltage coming out of any PWM signal can be calculated as follows. Where PWM is the fraction of the time that the signal is high, and VMAX is the maximum voltage from the output of the processor (usually five volts or whatever you're running the processor on), then VAVG — the average output of the PWM signal — will be given by:

VAVG = PWM * VMAX

Some of the Atmel AVR processors have one or more PWM generators on the chip. How to use these was also covered previously. You can also read the RB.TXT file for details on the PWM and PWMB commands.

Interrupt-driven Code

Now we are going to develop code that will output PWM on any AVR processor, and can output PWM out of any output pin. Furthermore, the code will be rather simple and will not get in the way of the rest of your program because it is interrupt driven.

The idea is simple but elegant. I am happy to express my sincere thanks to Glen Aidukas, who wrote me and suggested this approach.

We will run a timer-counter (TIMER0, in this particular example) and let it interrupt the program every time it overflows. Each time we get an interrupt from TIMER0, we will increment a PWM counter. During the handling of that interrupt, we will simply compare the PWM counter to each of the commanded values for each PWM output channel. In the example below, there will be four PWM outputs from one little 2313. Whenever the commanded value exceeds the PWM counter, we set the output bit for that channel, otherwise we reset the output. This is all performed in the INTERRUPT T0 routine below.

I've also included a variable RTC% in the interrupt handler, which could be used as a real-time clock for the system. You don't have to use it if you don't need it, just as you can easily change the number of PWM outputs to suit your application. In using TIMER0 to generate the interrupts for PWM, we have lost the ability to use a PAUSE statement anywhere else in the program. This loss is compensated by the availability of a real-time clock.

In the example below, I have simply set the four PWM commands to constants. It's up to you to vary the commands as your application requires. I've also put in an empty DO LOOP where you could fill in your program code. You will notice that I have scaled the command to be in range of 0 to 99. You can change this by altering the final IF statement in the interrupt handler.

If you run the program just as is, you will see four PWM signals coming out of ports B0, B1, B2, and B3 from your 2313. These could be controlling just about anything, perhaps rudder, elevator, ailerons, and throttle for an aircraft. Or they could be four motor commands for a robot.

A Working Example

Here's how simple the program is.

```
 DEVICE 2313
     MHZ  8
     REVISION PWM_DEMO


     DIRPORT B,OUT
     OUTPORT B, &B11111111

     '..the following define the PWM output channels...
     EQU "B,0","PWMB0"
     EQU "B,1","PWMB1"
     EQU "B,2","PWMB2"
     EQU "B,3","PWMB3"

     INTERRUPT T0, ON'..enables interrupt on TIMER0 overflow.
     TIMER0 ON 8    '..clk for timer0 is 1 MHz. Timer overflows
               '..1 MHz/256 = 3906 Hz....................

     cmda = 10  '..dummy value for PWMB0
     cmdb = 97  '..dummy value for PWMB1
     cmdc = 25  '..dummy value for PWMB2
     cmdd = 45  '..dummy value for PWMB3
     pwmctr = 0
     rtc% = 0

MAIN:  DO
            '..more code can go here...
     LOOP


'=====BEGIN INTERRUPT HANDLERS========================

INTERRUPT T0
     PUSHREG
     PUSHFLAGS

     IF cmda > pwmctr Then
       SETBIT "PWMB0"
     ELSE
       CLRBIT "PWMB0"
     END IF

     IF cmdb > pwmctr Then
       SETBIT "PWMB1"
     ELSE
       CLRBIT "PWMB1"
     END IF
```

```
        IF cmdc > pwmctr Then
          SETBIT "PWMB2"
        ELSE
          CLRBIT "PWMB2"
        END IF

        IF cmdd > pwmctr Then
          SETBIT "PWMB3"
        ELSE
          CLRBIT "PWMB3"
        END IF

        INCR pwmctr
        IF pwmctr > 99 THEN
          pwmctr = 0
        END IF
                        '..pwmctr variable will overflow every 100
                        '..counts, so the PWM frequency will be
                        '..8 MHz/8/256/100 = 39.0 Hz with a
                        '..resolution of 1% of full scale

        INCR rtc%           '..a real-time-clock counter for program use

        POPFLAGS
        POPREG
    END INTERRUPT
    '=====END INTERRUPT HANDLERS==========================
```

By all means, run this on your development board and watch the PWM come out of four different pins of a 2313 on your oscilloscope. It's a wonderful sight.

Theoretical Limits

There are limits to interrupt-driven PWM, and we should be aware of them. As is obvious from the code above, the PWM is being generated by software. So it requires processor time to perform the PWM interrupt routine.

By compiling and assembling the program, we can create a LST file, which will show us where every instruction is located in flash memory. A quick look at this code will show us that the interrupt handler uses 56 words of flash and that this will require 60 clock ticks to execute. As I have written the code above, this means that an interrupt will be processed every 8 * 256 clock ticks or every 2048 clocks.

Thus we see that the processor is spending 60 / 2048 * 100% of its time doing PWM, or 2.9%. We could make the PWM output frequency eight times faster by changing the "TIMER0 ON, 8" to "TIMER0 ON, 1." In this case, the PWM will be running at about 312 Hz and the processor will be spending 23.4% of its time handling PWM. This still means that we have over 75% of the processing capability left to use and that's a very respectable margin!

Thus we have found a limit for interrupt-driven PWM. We won't be able to make it go much faster than 300 Hz (unless we can get a faster processor clock). By way of comparison, when we use the hardware PWM generators in an 8535 with a clock frequency of 8 MHz, we can get a 60 KHz output for eight-bit PWM.

The RC Filter

Now to actually use this system, we need to calculate the RC filter values.

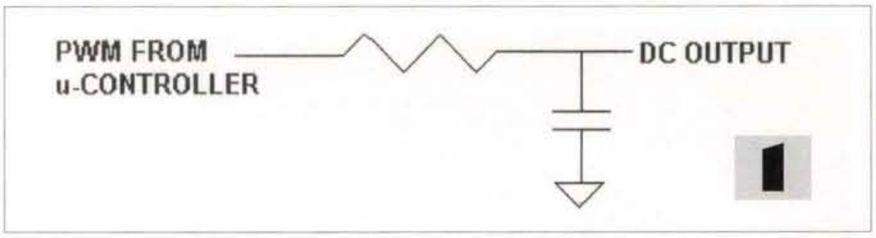
Since we are using PWM with a resolution of 1%, it would seem desirable to have the ripple output from our RC filter about 1%. In this case, we need to set the pole location for the filter to 1% of the PWM frequency. I'll use 312 Hz PWM as an example. Set the filter pole to 3.12 Hz.

1 / (2 * PI * R * C) = 3.12

Choosing C to be 10 uF yields a resistor value of 5.1K ohms. You can build this filter and observe that the output ripple is about 1% of full scale when the PWM frequency is 312 Hz. This is left as an exercise for the diligent student.

In some cases, a simple RC filter won't do the job because the component values become unreasonably large. We could use a two-pole passive filter as shown in Figure 2 to filter the 312 Hz PWM input. (Don't let the terminology throw you. If you haven't studied Operational Calculus, you can't be expected to know what a pole is, but you can still calculate useful filters following the examples I give.)

If we choose R to be 1.2K ohms and C to be 10 uF, we will get a double pole location at about 13 Hz. When we apply a 5 Vpp PWM input, we



will see about .009 Vpp ripple at the output.

By way of comparison, the single pole filter gave us about .05 Vpp ripple at its output and twice the output resistance. Clearly the two-pole filter does a much better job.

I have written a very small program to calculate the response using a two-pole passive filter. You can run it under QBASIC or QB45 or Power Basic. Here it is.

```
    '..transfer response for an RCRC filter

        DEFSNG A-Z

        pi = 4 * ATN(1)

        INPUT "R (ohms)"; r
        INPUT "c (uF)"; c
        c = c / 1000000

        PRINT "Pole location is "; 1 / pi / 2 / r / c; "Hz"

        INPUT "Input frequency (Hz)"; f
        w = 2 * pi * f
    w0 = 1 / r / c
        g = w0 ^ 2 / SQR((w0 ^ 2 - w ^ 2) ^ 2 + 9 * w0 ^ 2 * w ^ 2)

        PRINT "Gain of filter is "; g
        INPUT "Input voltage"; vin

        vout = vin * g

        PRINT "Output ripple is"; vout; "volts"
        END
```

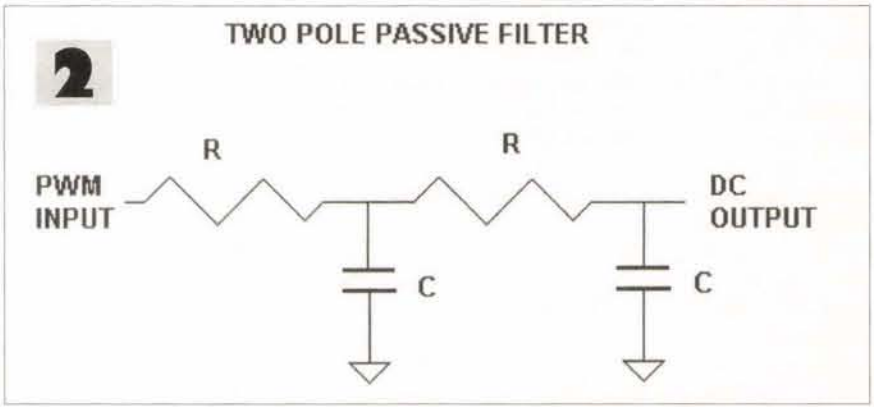
I think it should be evident that other types of low-pass filters could be used here, particularly active filters, but a discussion of active filters would get me in trouble for taking up too much space. Besides, a passive filter will work quite well for many applications and is simpler to build.

The Real-time Clock

Built into the interrupt handler, there is a variable called RTC%. This is the real-time clock. This can be used for timing in your program anywhere you need it.

A common task is to make the main loop (DO - LOOP) run at a constant repetition rate. This can be done by reading or setting RTC% at the top of the loop and then waiting for RTC% to increase by a constant number of counts at the end of the loop.

Suppose you're running an 8 MHz processor clock with a TIMER0 prescaler of 1. The interval between interrupts is then 1/8MHz*256 = 32 usec. Now further suppose that you want your loop to run once every 10 milliseconds. RTC% would advance 10 msec/32usec or 312.5 counts in this interval. So let's reset the real-time clock at the top of the loop and then wait for 312 counts to elapse at the bottom of the loop. This will effectively make the loop repeat about every 9.98 msec. Here's how the code would look.



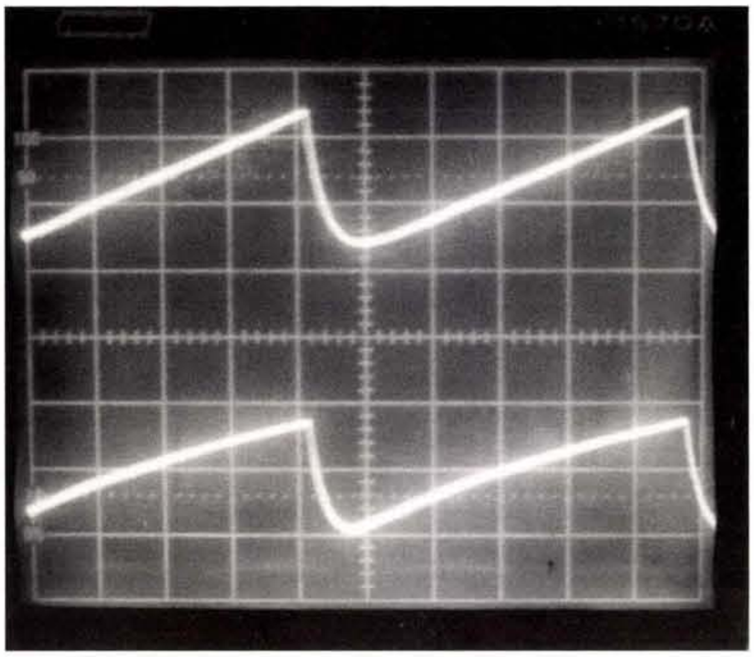


PHOTO 1

```
DO
  rtc% = 0

  '... the rest of your code goes here...

  DO
   IF rtc% > 312 THEN
        EXIT DO
   END IF
  LOOP
LOOP
```

Now that was easy. Obviously, in this example, the time for the main loop could be theoretically extended out to a maximum of (2^16)*32usec or two seconds. If you ever need a real-time clock that is that slow or slower, I would recommend incrementing a second integer on the overflow of RTC% inside the interrupt handler. This would push the time capability out to 38 hours.

How To Handle Non-linear Transfer Functions

You may never have thought about it, but you live in a non-linear world. Anyone who has ever stuck his hand out the window of a moving car has noticed that at low speeds, there is very little pressure on the hand, but the pressure builds up very rapidly as speed increases. In fact, the pressure is essentially proportional to the square of the speed. This square-law phenomenon is one fly in the ointment of life for designers of airspeed sensors and air data computers.

Since the impact pressure of air (Qc) is a square of the velocity (for airspeeds well below the speed of sound, and my Chevy won't get anywhere near that), let's solve the problem of calculating indicated airspeed (IAS).

I'll assume that we've purchased two pressure sensors, such as P/N MPXM2202DT1-ND and MPXM2202A-ND from www.digikey.com. We'll connect the high pressure side of the differential sensor (the first part number) to a tube pointing straight out the front of my Chevy (yes, this will work on Chrysler products, as well) and its low pressure port to a tube going straight out the side of the car. We'll call that pressure reading Qc (differential pressure). The second sensor (the second part number) — an absolute sensor — will also be connected to the tube pointing out the side of the car and we'll call that pressure Ps (static pressure). The maximum pressures we can expect to see are Ps = 29.927 In. Hg and Qc = 2.4175 In. Hg. That corresponds to driving 255 MPH at sea level. (I don't expect my Chevy to go any faster than that.)

I'll also assume that we put an amplifier after each sensor so that at full-scale pressure, we get 5.000 volts out of the amplifier (which will give a reading of 1023 on the Atmel onboard A/D converter).

IAS can be computed as a square root of the ratio of Qc to Ps (we'll ignore temperature effects for the purpose of this article). So now all we need is to scale Qc up to a full 16-bit number (shift left six times; the maximum value now is &HFFFF) and scale Ps down two bits (shift right twice; the maximum value is now &HFF). The maximum ratio of Qc/Ps would then be about &HFF. The reason for this is that this ratio, which may vary between 0 and &HFF, gives us a resolution of one part in 256, or roughly 1 MPH out of 255. That's good enough for any Chevy.

Now let's go one more step. Let's scale the Qc/Ps ratio up by shifting it left eight times, making the maximum value &HFF00. The reason for this is that the square root of &HFF00 is 255. Thus, if we take the square root of this shifted Qc/Ps ratio, we will get airspeed in MPH.

The following program shows exactly how to do this in RVK-Basic. The two A2D statements read the pressure sensors. The use of the BYTES statement is a clever way to shift left eight times. The IAS variable at the end contains the true airspeed in MPH. The reader is permitted to marvel at the brevity of the code.

```
A2D ps%, 0, IDLE
A2D qc%, 1, IDLE
SHIFT qc%,6,LEFT
SHIFT ps%,2,RIGHT
Psb = ps%
IDIVB rat,qc%, psb
zero = 0
MAKEINT ratio%,zero,rat
SQR ias, ratio%
```

If we needed to get True Airspeed, which is Indicated Airspeed corrected for temperature, we would also measure the outside air temperature (OAT) and then multiply IAS by the square root of the ratio of OAT to standard temperature (273.1 K).

I bring all of this complex, square-law stuff up to the reader's attention because these are common cases of non-linearities in real life.

In general, a linear relationship is one that can be plotted on a graph as a straight line. Non-linear relationships look like curved lines. In Photo 1, you will note the linearity of the rising portion of the top trace. That was created by simply incrementing a byte variable and sending that data out as PWM (Pulse Width Modulation, as discussed previously). The actual curve was fed to my oscilloscope by filtering the PWM with an RC filter. The point is that the line is quite linear and shows up as a straight line.

The bottom line is obviously curved. It starts off rising faster than it rises near the top of the line. This is a square-root function of the top line, which was similarly processed as PWM and filtered for the scope.

Now let us consider how to solve the problem of generating just any old wave shape we can imagine.

The most general way to generate a non-linear transfer function is to use a look-up table. This can be implemented in either of two different ways in RVK-Basic, by placing the table in flash memory with the FDATA statement, or in EEPROM using the EEDATA statement. The disadvantage to using the EEDATA statement is that there is usually only a small amount of EEPROM available on a chip. So unless you have a very small table, you'll probably want to use the FDATA statement.

In one project, I needed to generate a half-sinusoid. So, I stored a data table in EEPROM and then read the data as I needed it.

```
'======BEGIN DATA TABLE FOR WAVEFORM======
   '...table has 22 states in it....
   EEDATA VTABLE:, 0                  EEDATA , 127
   EEDATA , 19                        EEDATA , 124
   EEDATA , 37                        EEDATA , 118
   EEDATA , 55                        EEDATA , 110
   EEDATA , 72                        EEDATA , 99
   EEDATA , 86                        EEDATA , 86
   EEDATA , 99                        EEDATA , 72
   EEDATA , 110                       EEDATA , 55
   EEDATA , 118                       EEDATA , 37
   EEDATA , 124                       EEDATA , 19
   EEDATA , 127                       EEDATA , 0
'======END DATA TABLE FOR WAVEFORM======
```

To read any element from the EEPROM table, we simply use the READ statement. For example, to read data point 3 we could

```
I = 3
READ x,VTABLE:,I
```

This would return a value of 55 (remember that the very first element in the table has an offset of 0).

To do the same thing in flash memory, the table would be:

```
FDATA ATABLE:, 0               FDATA , 127
   FDATA , 19                  FDATA , 124
   FDATA , 37                  FDATA , 118
   FDATA , 55                  FDATA , 110
   FDATA , 72                  FDATA , 99
   FDATA , 86                  FDATA , 86
   FDATA , 99                  FDATA , 72
   FDATA , 110                 FDATA , 55
   FDATA , 118                 FDATA , 37
```

```
FDATA , 124                    FDATA , 19
FDATA , 127                    FDATA , 0
```

We would read from this table using the TFLOOK statement.

```
I = 3
TFLOOK x%, ATABLE:, I
```

This would also return a value of 55, but the value will be an integer. FDATA is always integer data and EEPROM data is always byte data. The other significant difference is that EEDATA must be placed in your program before you reference it in a READ statement. FDATA can be placed almost anywhere in the program, but you will generally find it most convenient to place it at the end of the program.

In Photo 2, I have used an 8535 to generate two half-sinusoids out of phase with one another. The data used was from one of the previous tables.

This demonstrates that you can generate any waveform mathematically or by table look-up. The most practical way to send the data out would be via PWM or RS-232. But in general, you may not need to send the raw data out at all. It may just be one step in a more complex process.

How to Debug

In general, it is a very good idea to debug as little code as possible. I usually try to execute 50 or less lines of code and see an output to prove that that section of code is working. Then, when that works, add another function to the existing "good" code and test again. This really pays dividends in the very short run.

For example, to get a sinusoid in PWM working, let's first get the simplest possible function running, a sawtooth. Our code would be

```
    DEVICE 8535
    MHZ  8

    DIRPORT B,OUT
    OUTPORT B, &B11111111

 DO
   INCR cmda

  DO
      IF rtc% > 127 THEN
        rtc% = 0
        EXIT DO
      END IF
     LOOP
 LOOP

'=====BEGIN INTERRUPT HANDLERS========================

INTERRUPT T0
    PUSHREG
    PUSHFLAGS

    IF cmda > pwmctr Then
      SETBIT "PWMB0"
    ELSE
      CLRBIT "PWMB0"
    END IF

 INCR pwmctr
    INCR rtc%          `..a real-time-clock counter for program use

    POPFLAGS
    POPREG
END INTERRUPT
'=====END INTERRUPT HANDLERS==========================
```

Now, when that works, we can stick something more complicated in the DO LOOP, like this (along with the corresponding ATABLE).

```
   DO
IF rtc% < 45 THEN
 Temp% = rtc%
 SHIFT temp%,1,RIGHT
        TFLOOK thrsh%, ATABLE:, timecnt
        Cmda = thrsh%
      ELSE
        cmda = 0
      END IF
  LOOP
```

And when you've done that, you'll find you have half-wave sinusoids coming out your PWM.

The LM74

The simplest digital temperature sensor, as far as software goes, is the LM74. It comes in an SO-8 package (sorry, no DIP available here). Three pins (plus power and ground) need to be connected to the AVR. I've chosen to run this demonstration using an AT90S2313, but you can make this work in most any AVR device just by changing the DEVICE statement in line 1. (It won't run on a 1200 because you do need a little RAM.) Table 1 shows the connections required between the AVR and the LM74.

Table 1

Signal Name	LM74 Pin	AVR Pin
Data	1	D,2
Clock	2	D,1
Chip Select	7	D,0
VCC	8	VCC
GND	4	GND

The software for reading the LM74 is very straightforward because the LM74 powers up in a continuous conversion mode. So all we need to do is bring the Chip Select low, read the data — MSB first — one bit at a time, on the leading edge of the clock while providing 13 clock pulses, and then raise the Chip Select. When this is completed, the resulting number is the temperature, with the LSB representing 1/16 degree C.

One comment about using the LM74 versus the DS1820 is that the LM74 can be read much, much faster than the DS1820 can. The LM74 can be read at about 1 MHz while the DS1820 cannot be read faster than 15 KHz. Furthermore, the LM74 does not require any data to be sent to it, while the DS1820 requires a couple of extra bytes per transaction. The result is that the LM74 is about 100 times faster to interface with than the DS1820.

For demonstration purposes, where we only have eight LEDs on our development board, I have chosen to rescale the data so that the LSB represents one degree C.

```
DEVICE 2313
MHZ   8
   REVISION LM74 020320.0-rvk

   EQU "D,0","CS*"       '..LM74 chip select
   EQU "D,1","SCK"       '..LM74 clock
   EQU "D,2","LM74"      '..LM74 data
   MAKEOUT "CS*"
   MAKEOUT "SCK"
   MAKEIN  "LM74"
   SETBIT "CS*"
   CLRBIT "SCK"

   DIRPORT B,OUT   '..output for LEDs
```

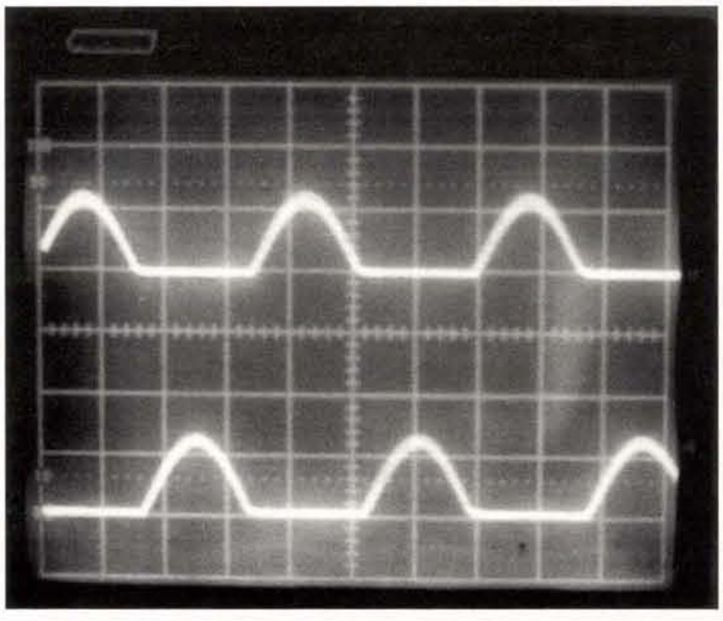


PHOTO 2

```
    DO
      PAUSE 100
      GOSUB READ74  '..read temperature
      SHIFT c16th%,4,RIGHT '..scale LSB to 1 C..
      tempC = c16th% AND &HFF
      OUTPORT B,tempC '..display result..
  LOOP


'/////begin subroutines/////////////////////
'====BEGIN READ74========================
'=  inputs "CS*" "SCK" "LM74"          =
'=  output c16th%                      =
'=  uses: rd74_a~ rd74_b~              =
'========================================
    STACK 2
READ74: CLRBIT "CS*"
    c16th% = 0
    FOR rd74_a~ = 1 TO 13
      SHIFT c16th%, 1, LEFT
      SETBIT "SCK"
      INBIT rd74_b~,"LM74"
      IF rd74_b~ | 0 THEN
        c16th% = c16th% OR 1
      END IF
      CLRBIT "SCK"
    NEXT
    '... LSB is now 1/16 of a degree C
    SETBIT "CS*"
RETURN
'====END READ74==========================

'/////end subroutines///////////////////////
```

If you hook up an LM74 and run this software, you will be able to watch the LEDs show you the temperature in binary degrees C. If you take the sensor below 0 C — such as in your freezer — the temperature is displayed in two's complement (1111111 is minus 1, 11111110 is minus 2, etc.).

The DS1820

Dallas Semiconductor makes a line of "One-Wire" products. One of these is the DS1820 temperature sensor.

The One-Wire sensors are all designed to be hooked together on just one wire (plus one for ground). The one data wire is a bidirectional one-bit data bus. The bus controller — our AVR microcontroller — controls all data flow on the bus. It initiates all data transactions on the bus by a strict time control of low pulses, and it reads the data sent back by the target device by reading the bus in particular time slots.

If this type of protocol sounds rather complex, it is, but I've already solved most of the problem for you. As far as a hardware hookup goes, it could not be simpler. Just hook the data pin of the DS1820 to Port C,0 and put a 4.7K pull-up resistor on it to +5 volts.

In the example I have presented here, there is only one One-Wire device on the bus — the DS1820 — and I display the temperature on PORT B (for LEDs) in binary with a resolution of 1/2 degree C.

The reader may be interested to note how I synthesize an open-drain output for this type of bus. I write a 0 to the output data register with a CLRBIT statement. Then to pull the bus low, I use a MAKEOUT statement, and to release the bus, I use a MAKEIN statement.

In order to actually get data from the DS1820, it is necessary to first send it a couple of bytes as a command, using the WRBYTE routine, and then I can read data from the DS1820 using the RDBYTE routine.

I have also included the code in the form of comments for you to use a DS18B20. This device gives much finer temperature resolution than the DS1820.

As you inspect the code and consider using it in an application, please pay attention to the comment in the TK1U routine. If you are going to slow down to around 4 MHz, you will want to comment out the indicated statement in that routine. TK1U is designed to provide a one-microsecond delay in the program.

```
    DEVICE 8535
    MHZ 8

    EQU "C,0","1WIRE"
    MAKEIN "1WIRE"        '..release the bus
    CLRBIT "1WIRE"
    DIRPORT B,OUT         '..for LED display
```

```
  DO
    '.....convert Temperature using the 1-wire
    GOSUB INIT_T  '..start a conversion...
    PAUSE 500
    DO
          '....now wait for conversion to finish..
      GOSUB RDBYTE
      IF data1 = &HFF THEN
      EXIT DO
      END IF
    LOOP
    GOSUB W1MR   '..reset
    data1 = &HCC  '..skip rom
    GOSUB WRBYTE
    data1 = &HBE  '..read scratchpad
    GOSUB WRBYTE
    GOSUB RDBYTE  '..read low byte of temp in data1
    halfC = data1


    GOSUB RDBYTE
    '..delete the following statement for DS18B20 code...
    signC = data1 AND 1

    '...BEGIN DS18B20 CODE..............................
    'Remove or comment out this block for the DS18S20 or DS1820S
    'MAKEINT cjc%,low,data1
    '..cjc% now has temperature scaled 2^(-4) with sign in the
    '..upper 5 bits..........................................
    'SHIFT cjc%,3,RIGHT
    'degC = cjc%
    'BYTES cjc%
    'signC = cjc%
    'signC = signC AND 1
    '...END DS18B20 CODE................................

    '....temperature is now in halfC, lsb is 1/2 degree C....
    '....sign bit is in signC...............................

    OUTPORT B, halfC '..display temperature on port B..
  LOOP

'//////BEGIN 1-WIRE BLOCK////////////////////

'=======BEGIN INIT_T=====================
'= Initiates a Temperature Conversion  =
'= on the 1-wire bus, "1WIRE".          =
'= Affected: rd1wt0~, rd1wt1~, rdbt0~  =
'= rdbt1~, w1mrt~, w1mrt1~, w1mrt2~,   =
'= wrbtm0~, wrbtm1~, data1.            =
'========================================
    STACK 2
INIT_T: GOSUB W1MR    '..reset
    data1 = &HCC  '..skip rom
    GOSUB WRBYTE
    data1 = &H44  '..convert T
    GOSUB WRBYTE
RETURN
'=======END INIT_T=======================


'=======BEGIN READ1W=====================
'=  Implements 1 READ SLOT on the 1WIRE=
'=     output: rd1w~                   =
'=     reads:  "1WIRE"                 =
'=     uses: rd1wt0~, rd1wt1~          =
'========================================
    STACK 2
READ1W: GOSUB W1LOW
    GOSUB TK1U
    GOSUB W1HIGH
    GOSUB TK1U
    GOSUB TK1U
    rd1w~ = 1
    FOR rd1wt0~ = 1 TO 4
      GOSUB TK1U
      INBIT rd1wt1~,"1WIRE"
      IF rd1wt1~ = 0
        rd1w~ = 0
      END IF
```

```
    NEXT
    PAUSE .05
RETURN
'=======END READ1W=====================


'=======BEGIN RDBYTE=====================
'= Reads 1 byte from the 1WIRE bus      =
'=     output: data1                    =
'=     uses: rdbt0~, rdbt1~             =
'=========================================
    STACK 2
RDBYTE: FOR rdbt0~ = 1 TO 8
      SHIFT data1,1,RIGHT
      GOSUB READ1W
      IF rd1w~ | 0 THEN
        data1 = data1 OR &H80
      END IF
    NEXT


RETURN
'=======END RDBYTE=====================


'=======BEGIN TK1U=====================
'=     WAITS 1 uSEC                     =
'=     WRITTEN FOR 8 MHZ CLOCK          =
'=========================================
    STACK 2
TK1U:
    'enable the following for 8 MHZ
    cjtmp% = cjtmp%
RETURN
'=======END TK1U=====================


'=======BEGIN W1HIGH=====================
'=     places "1WIRE" HIGH              =
'=========================================
    STACK 2
W1HIGH:
    MAKEIN "1WIRE"

RETURN
'=======END W1HIGH=====================


'=======BEGIN W1LOW=====================
'=     places "1WIRE" LOW               =
'=========================================
    STACK 2
W1LOW:  CLRBIT "1WIRE"
    MAKEOUT "1WIRE"
    'END
RETURN
'=======END W1LOW=====================

'=======BEGIN W1MR=====================
'=     Sends a MASTER RESET on the      =
'=     1-wire bus. Collects result      =
'=     in prsnt~                        =
'=     Uses: w1mrt~, w1mrt1~, w1mrt2~   =
'=========================================
    STACK 2
W1MR:   GOSUB W1LOW
    PAUSE .580
    GOSUB W1HIGH
    PAUSE .010
    prsnt~ = 0
    FOR w1mrt~ = 1 TO 10
      INPORT w1mrt1~,C
      TEST w1mrt2~,w1mrt1~,0
      IF w1mrt2~ = 0 THEN
        prsnt~ = 1
      END IF
      PAUSE .038
    NEXT
RETURN
'=======END W1MR=====================
```

```
'=======BEGIN WRBYTE=====================
'      Writes a byte serially on         =
'      the 1wire bus.                    =
'      input: data1                      =
'      modifies: data1                   =
'      uses: wrbtm0~, wrbtm1~            =
'=========================================
    STACK 2
WRBYTE: FOR wrbtm0~ = 1 to 8
      TEST wrbtm1~,data1,0
      IF wrbtm1~ = 0 THEN
        GOSUB WRITE0
      ELSE
        GOSUB WRITE1
      END IF
      SHIFT data1,1,RIGHT
    NEXT
RETURN
'=======END WRBYTE=====================


'=======BEGIN WRITE0=====================
'=     PERFORMS A "WRITE 0" TIME SLOT   =
'=     ON THE 1WIRE BUS                 =
'=========================================
    STACK 2
WRITE0: GOSUB W1LOW
    PAUSE .066
    GOSUB W1HIGH
    GOSUB TK1U
RETURN
'=======END WRITE0=====================


'=======BEGIN WRITE1=====================
'=     PERFORMS A "WRITE 1" TIME SLOT   =
'=     ON THE 1WIRE BUS                 =
'=========================================
    STACK 2
WRITE1: GOSUB W1LOW
    GOSUB TK1U
    GOSUB W1HIGH
    PAUSE .066
RETURN
'=======END WRITE1=====================

'///////END 1-WIRE BLOCK//////////////////////
```

The user should be aware that it is possible to put more than one One-Wire device on the bus, but if you do, this code — as I have presented it — won't work. If you do have a need for multiple devices on the bus, you will need to rework the code to read the IDs of each device and then talk to each device by ID number. This is a tedious chore that I gladly assign to the diligent student. If you do get code working for multiple devices on the bus, I would love to have a copy for my records.

Happy computing! **NV**

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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Sep-Nov

SEPTEMBER 2002

SEPTEMBER 7

KY - LOUISVILLE - Hamfest. Greater Louisville Hamfest Assn., Inc., 812-294-4905. Email: wd4ixl@juno.com Web: www.thepoint.net/~glha
NY - BALLSTON SPA - Hamfest. 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. 309-692-3378. Email: w9uvi@arrl.net Web: www.w9uvi.org

SEPTEMBER 14

MI - GRAND RAPIDS - Hamfest. 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. LIMARC, 516-520-9311. Web: www.limarc.org

SEPTEMBER 21

FL - NEW PORT RICHEY - Hamfest. Suncoast ARC, 727-848-0353. Email: trobin@homemail.com
PA - SCHNECKSVILLE - Hamfest. The Delaware-Lehigh ARC, Inc., 610-258-9802. Email: malcolm4@ptd.net http://www.dlarc.org

SEPTEMBER 21-22

IL - GRAYSLAKE - Radio Expo. Chicago FM Club, Web: http://www.chicagofmclub.org

SEPTEMBER 22

CT - NEWTOWN - Hamfest. Candlewood ARA, 203-438-6782. Email: w1jma@aol.com
OH - BEREA - Hamfest. Hamfest Assn., of Cleveland, Inc., 216-999-7388 or 1-800-CLE-FEST. Email: info@hac.org Web: www.hac.org
OH - SHARONVILLE - Hamfest. 513-459-1661, k8je@arr.net

SEPTEMBER 28

NJ - LAWRENCEVILLE - Hamfest. DVRA, 609-882-2240. Email: abbott0903@aol.com Web: www.w2zq.com
NY - HORSEHEADS - Hamfest. ARAST, Inc., 607-738-6857. Email: info@arast.org Web: www.arast.org

SEPTEMBER 28-29

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

OCTOBER 2002

OCTOBER 5

FL - JACKSONVILLE - Hamfest. Email: n4uf@nofars.org Web: www.nofars.org
TX - TEMPLE - Hamfest. Temple ARC, 254-773-3590, email: hamexpo@tarc.org

OCTOBER 6

IA - WEST LIBERTY - Hamfest. ICARC, 309-537-3678. Email: kc0aqs@qsl.net Web: www.qsl.net/kc0aqs
IN - BEDFORD - Hamfest. 812-849-0095. Email: chairman@hoosierhillshamfest.org Web: www.hoosierhillshamfest.org
OH - MEDINA - Hamfest. Medina Hamfest Committee, 330-273-1519 after 7pm. Email: n8tzy@m3net.net

OCTOBER 12

NJ - WASHINGTON TOWNSHIP - Hamfest. BARA, 201-664-6725. Email: k2zo@arrl.net Web: www.bara.org
NY - LAKE PLACID - Hamfest. 518-827-4800, email: valosin@midtel.net
TX - DENTON - Hamfest. Denton County ARA, 940-390-5338. Email: kd5kjz@yahoo.com

OCTOBER 13

CT - WALLINGFORD - Hamfest & Computer show. Email: nutmeghamfest@qsl.net Web: www.qsl.net/nutmeghamfest

COMPUTER SHOWS

ACP Computer Show & Swapmeet 714-558-8813
jferguson@acpsuperstore.com
www.acpsuperstore.com

AGI Shows, 317-299-8827
E-Mail: info@agishows.com
http://www.agishows.com

Blue Star Productions
612-788-1901
www.supercomputersale.com

Computers And You
734-283-1754
www.a1-supercomputersales.com

Computer Central Shows
630-782-4625
Fax 630-834-2594
E-Mail: cc@gats.com
www.computercentralshows.com

Computer Country Expo
847-662-0811
Web: www.ccxpo.com

Five Star Productions
810-379-3333
E-Mail: jeff@fivestar
www.fivestarshows.com

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734-287-2000 Taylor, MI
E-Mail: taylor@gibraltartrade.com
www.gibraltartrade.com

Gibraltar Trade Center, Inc.
810-465-6440 Mt. Clemens, MI.
mtclemens@gibraltartrade.com
www.gibraltartrade.com

KGP Productions
1-800-631-0062, 732-297-2526
E-Mail: kgp@mail.com

MarketPro, Inc., 201-825-2229
www.marketpro.com

MarketPro, Inc., 301-984-0880
E-Mail: md@marketpro.com
http://marketpro.com

ComputerShow, 770-663-0983
E-Mail: narisaam@aol.com
Web: www.shownsale.com

Northern Computer Shows
978-744-8440
E-Mail: inquiries@ncshows.com
Web: ncshows.com

Peter Trapp Computer Shows
603-272-5008
Web: www.petertrapp.com

MI - EAST LANSING - Hamfest. 989-725-1853, email; kc8dbp@arrl.net

OCTOBER 19

CO - GOLDEN - Hamfest. 303-985-8692, n0mqj@attbi.com
FL - JACKSONVILLE - Hamfest. Greater Jacksonville Hamfest Assn., 907-269-8714. Web: http://www.jaxhamfest.com
FL - ORLANDO - Hamfest. Bahia Shrine, Bob KG4ECC, 407-834-9481
MI - KALAMAZOO - Hamfest. 616-337-7602. Email: hamfest@kalamazoohamradio.com Web: www.kalamazoohamradio.com/hamfest
MI - SAULT STE. MARIE - Hamfest. Eastern Upper Peninsula Amateur Radio, 906-635-0215. Email: wa8old@sault.com
TN - OAK RIDGE - Hamfest. Oak Ridge ARC, 865-670-1503. Email: d.bower@ieee.org

OCTOBER 20

IL - GODFREY - Hamfest. 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. The Hall of Science Amateur Radio Club, 718-898-5599. Email: WB2KDG@Bigfoot.com
PA - SELLERSVILLE - Hamfest. RH Hill ARC, 215-679-5764. Web: www.rfhill.ampr.org

OCTOBER 26

MN - ST. PAUL - Hamfest. 763-535-0637. www.hamfestmn.org
MO - KIRKWOOD - Hamfest. St. Louis ARC & Gateway to Ham Radio, 314-638-4959. Email: slw@partyline.net
OR - SALEM - Hamfest. Mid-Valley ARES. 503-540-3270, Email: ki7or@arrl.net Web: www.qsl.net/w7oem/swaptobe.html

OCTOBER 27

MD - WESTMINSTER - Hamfest. Email: n3sb@qis.net Web: www.qis.net/~k3pzn/tailgate.htm
OH - CANTON - Hamfest. Massillon ARC. Web: www.qsl.net/w8np

NOVEMBER 2002

NOVEMBER 2-3

GA - LAWRENCEVILLE - Hamfest. Alford Memorial Radio Club, 770-663-4244 x3989.

NOVEMBER 9

OH - GEORGETOWN - Hamfest. Grant ARC, 937-446-2338. Email: WD8CTX@juno.com

NOVEMBER 16-17

IN - FORT WAYNE - Hamfest. ACARTS, 260-484-1314. Web: www.fortwaynehamfest.com

DECEMBER 2002

DECEMBER 7-8

FL - PALMETTO - Hamfest.

Email: info@fgcarc.org Web: www.fgcarc.org

DECEMBER 8

IN - GREENFIELD - Hamfest. HARC, 317-326-1659. Email: kb9vzl@msn.com

Robotic Events 2002

Sep 2 — **DragonCon Robot Battles** www.scenic-city.com/robot/

Sep 13-15 — **BotBash** http://www.botbash.com/

Sep — **Central Jersey Robot Conflict** http://robotconflict.com/cjrc901.shtml

Sep — **Robotics Society of Southern California Robot Talent Contest** http://www.dreamdroid.com/talentshow.htm

Sep — **San Francisco Robotics Society Robot Games** http://www.robots.org/

Oct 18-20 — **Critter Crunch** http://www.milehicon.org/contests32.htm#critter

Oct 26-27 — **Eastern Canadian Robot Games** http://www.robotgames.ca

Oct — **METU Robot Games** http://robot.metu.edu.tr/

Nov — **All Japan MicroMouse Contest** http://www.bekkoame.ne.jp/~ntf/mouse/mouse-e.html

Nov 9 — **CIRC Autonomous Sumo Robot Competition** http://www.circ.mtco.com/02smenu.htm

Nov 2-3 — **Olimpiada Robotica** http://www.geocities.com/olimpiadarobotica2002/

Nov 22-23 — **Texas BEST Competition** http://www.texasbest.org/

Dec — **Penn State Abington Robo-Trailblazers** www.ecsel.psu.edu/~avanzato/robots/contests/

2003

Jan — **Robot Wars** http://robotwars.com

Feb 9-13 — **APEC Micromouse Contest** http://www.apec-conf.org/

Feb — **Atlanta Robot Rally** www.botlanta.org/Rally/

Feb — **DPRG Fire-Fighting Robot Contest** http://www.dprg.org/

Feb — **Yantriki** www.me.iitb.ernet.in/yantriki/

Mar 14-15 — **AMD Jerry Sanders Creative Design Contest** http://dc.cen.uiuc.edu/

Mar — **ASCE Lunar Robotic Construction Contest** www.spaceandrobotics.org/

Mar — **BattleBots** http://www.battlebots.com/

Mar — **Canada First Robotic Games** http://www.canadafirst.org/

Mar — **Hobby Show Robot Conflict** http://robotconflict.com

Mar — **Indonesian Robot Contest** www.eepis-its.edu/irc2002/

Mar — **Penn State Abington Fire-Fighting Robot Contest** http://www.ecsel.psu.edu/~avanzato/robots/contests/

Mar — **RoboFlag** http://roboflag.carleton.ca/

Apr — **Acroname Robotics Expo and Contest** http://www.acroname.com

Apr — **DPRG RoboRama** http://www.dprg.org/

Apr — **Manitoba Robot Games** www.scmb.mb.ca/mrg.html

Apr — **The Tech Museum of Innovation's Annual Tech Challenge** www.thetech.org/exhibits_events/competit/tech_challenge/

Apr — **Micro Air Vehicle Competition** www.byu.edu/me/mav/index2/htm

Apr — **Carnegie Mellon Mobot Races** www.cs.cmu.edu/~mobot/

Apr — **RoboRodentia** www.ieee.calpoly.edu/cs/RoboRodentia.html

Apr — **UC Davis Picnic Day MicroMouse Contest** http://www.ece.ucdavis.edu/

Apr — **Trinity College Fire Fighting Home Robot Contest** www.trincoll.edu/events/robot/

Apr — **DTU RoboCup** http://www.iau.dtu.dk/robocup/about_robocup.html

Apr — **Micro-Rato** http://microrato.ua.pt/

Apr — **Alcabot** http://www.depeca.alcala.es/alcabot/alcabot2002/index

Apr — **FIRST Robotics Competition** http://www.usfirst.org/

Apr — **SAE Walking Machine Challenge** http://www.sae.org/STUDENTS/walking.htm

Apr — **LEGO MY EGG-O Robotic Egg Hunt** http://www.eecs.cwru.edu/courses/lego375/egghunt.html

Apr — **Singapore Inter-School Micromouse Competition** http://www.np.edu.sg/alpha/mice_hp.htm

Apr — **Northwest Robot Sumo Tournament** www.sinerobotics.com/sumo/

Apr — **National Festival of Robotics** http://www.robotica.dei.uminho.pt/robotica2001/

May — **Robothon** www.seattlerobotics.org/robothon/

Classifieds

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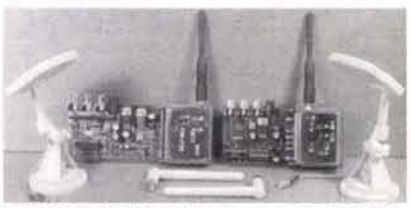
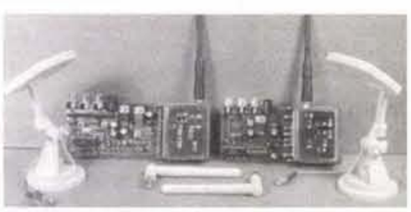


2.4GHz ATV — 8 channel TRANSMITTERS AND RECEIVERS. 35mW output power, 1 video channel, 2 audio. SMA connectors. NTSC/PAL compatible. Includes 1/4 wave rubber duck antenna. Standard frequencies are: 2398, 2405, 2412, 2416, 2420, 2428, 2435, 2442 MHz. Custom frequencies are available. See ad in this section for power amplifier. **$79/each for transmitter. $79/each for receiver**. EzATV. Visit our web-site for dealers or order on-line at www.4atv.com



1.2GHz ATV — 8 channel TRANSMITTERS and RECEIVERS. 75mW output power, 1 video channel, 2 audio. SMA connectors. NTSC/PAL compatible. Includes 1/4 wave rubber duck antenna. Standard frequencies are: 1250, 1255, 1260, 1265, 1270, 1275, 1280, 1290 MHz. Custom frequencies are available. **$79/each for transmitter. $79/each for receiver**. EzATV. Visit our web-site for dealers or order online at www.4atv.com

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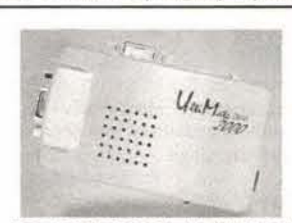

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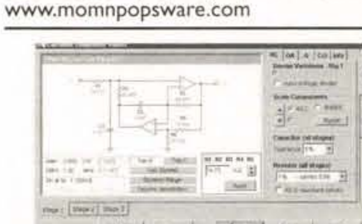

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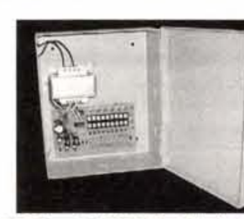

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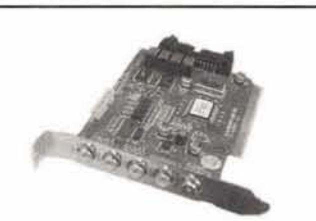

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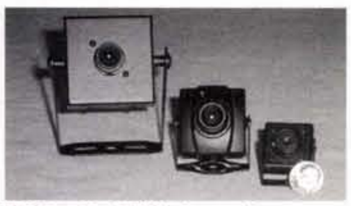

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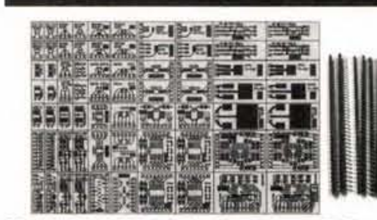

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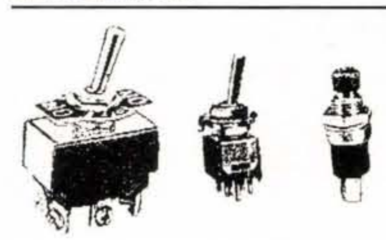

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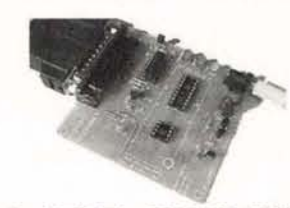

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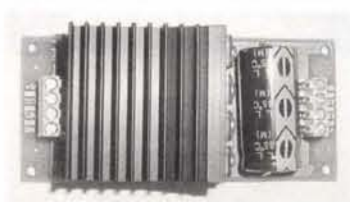

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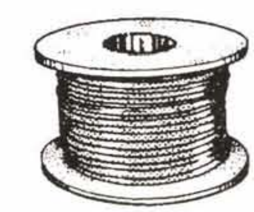

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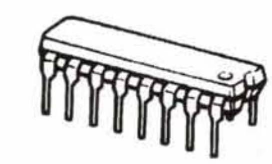

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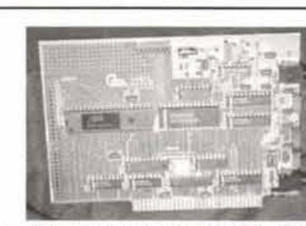

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GROUNDING FOR BOATS AND RVs

By Gordon West

Okay all you hamsters, time to go out on the water ... You'll be very surprised how powerful the signal can be!

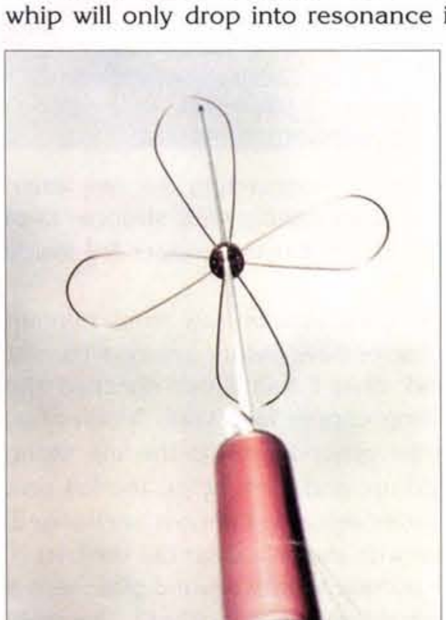
Okay all you hamsters, time to go out on the water and get some fresh air from your ham radio station. But bring along your worldwide high-frequency equipment. You will be very surprised how powerful your signal may be.

Aboard boats, a high-frequency ham radio station may use simple mobile whip antennas, or a non-resonant long wire pulled up to the top of a sailboat mast. Both of these antenna systems require a good ground, and many of the same marine grounding principles also apply to portable operation in an RV, or out in your backyard.

High-frequency mobile whip antennas are electrically one-quarter wavelength long. They work well on a boat without any manual or automatic antenna tuner if properly installed. The quarter-wave mobile antenna is only effective and resonant when mounted on top of a stainless steel horizontal boat rail, or mounted to the side of an aluminum skiff. The quarter wavelength mobile whip antenna will only achieve a proper impedance match when mounted directly to the metal below. In other words, it just won't work at all if you take the mobile whip antenna, mount it to the side of a fiberglass cabin, and then run some heavy copper wire down to sea water or the metallic hull below. While it has a good low-resistance ground, the ground is too far away for the whip to work directly off of a 50-ohm coax cable without a manual or automatic antenna tuner.

When thinking of mounting a mobile, quarter-wavelength, high-frequency whip antenna on a boat, always choose a mobile mounting bracket that puts the antenna directly at rail level. The antenna will only resonate near a 50-ohm match if the metal it is mounted to goes off to each side at either 90 degrees out or sloping down 45 degrees. The horizontal ground plane must directly couple to the base of the mobile whip in a marine installation.

And the same thing for an RV installation — the quarter-wavelength whip will only drop into resonance if it is mounted directly over some horizontal metal. Many times, RVers will use the aluminum ladder at the rear of the coach as a good ground plane — while there's more vertical structure than horizontal, most mobile whip antennas will perform well if mounted at the tip top of the ladder. However, mounting the mobile, high-frequency whip antenna halfway down the ladder will lead to no-tune-up conditions because the RV bounces back a lot of the radiated energy right next to the whip.



A capacity hat will increase your whip performance by reducing the number of needed coil turns to achieve resonance.

Same thing with a pick-up truck installation I worked on the other day — the whip was professionally mounted on an L-bracket, just behind the cab of the pick-up, two feet below the pick-up truck roof. The performance was terrible, the SWR sky high, and no matter what band we tried to tap into, our MFJ SWR analyzer indicated almost no dip in resonance. Yet our ground was excellent — all the metal of the pick-up truck bed.

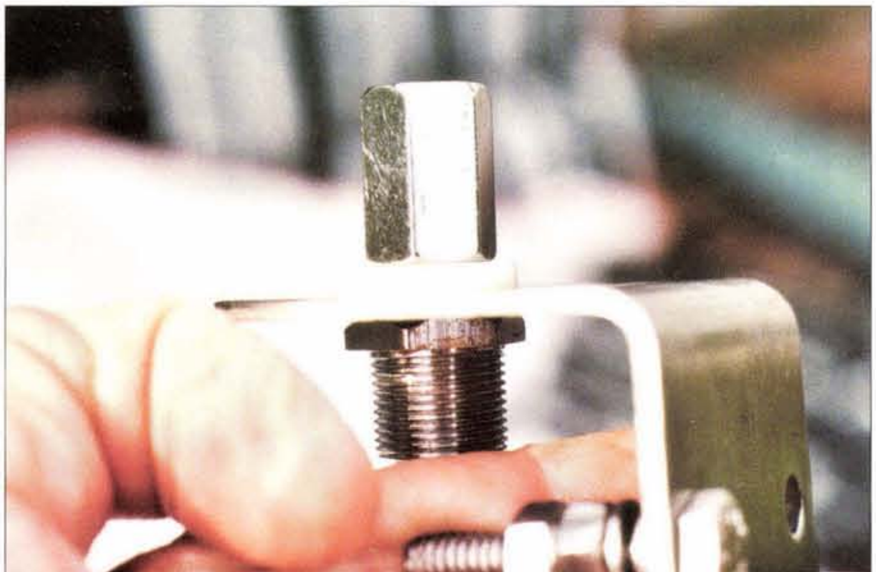
Poor location for the whip.

Best location for the whip.

As you can see by the photos, we moved the high-frequency antenna feedpoint to the rear left rail of the pick-up, and the antenna immediately popped into resonance on each and every band. And wowzers, what a signal! All of the metal directly below the base of the quarter-wavelength whip gave us outstanding performance.

Some marine installations may allow the set-up of a long-wire antenna. This could be a sailboat where wire is run from the stern up to near the masthead with a pulley. In permanent installations, sailboat operators will insulate their backstay with two professional marine insulators, and attach their single wire to the insulated portion of the stainless steel stay. On power boats, some mariners may wire up a bamboo pole by

Poor ground on the left, seawater ground on the right.

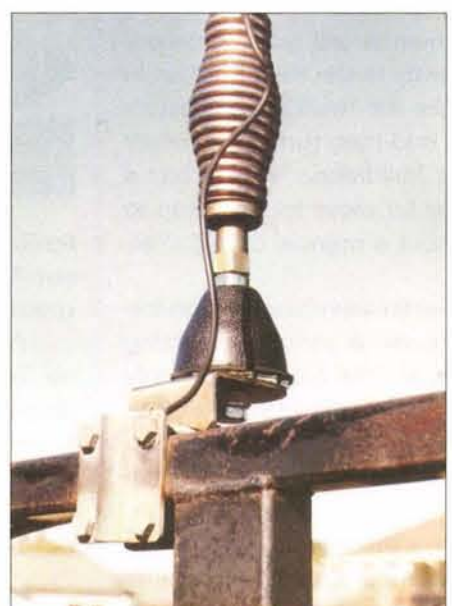


The stainless steel whip bracket for RV and maritime mobile installations.

simply wrapping the pole with #14 gauge wire, or they may use a white fiberglass non-resonant whip antenna, manufactured by Shakespeare Electronics. This whip is not particularly resonant at any frequency, and must be driven with an automatic antenna tuner. Same thing with the sailboat backstay or long-wire antenna system — an automatic antenna tuner mounts at the antenna feedpoint back aft, and electronically selects various amounts of capacitance and inductance in order to deliver as much transmitter power into the actual antenna wire.

We can measure the amount of antenna RF current with a relatively inexpensive RV current meter from MFJ Electronics, Model #854. The MFJ radio frequency antenna current indicator has a snap-on pick-up assembly at the top of the device, and it inductively measures the amount of current going into the active part of the antenna system.

The automatic antenna coupler must see the equivalent of a one-quarter wavelength counterpoise in order to generate any meaningful antenna current along the long wire or insulated stay. The greater the counterpoise, the greater the amount of current on the antenna line and the increased signal strength noted by the distant skywave station.



RV mounting of the quarter-wave whip on top of roof rack.

Maritime and vehicle mobile coax connections need to be waterproofed with Coax Seal™.

"In aircraft, we ground the tail-mounted coupler to the aluminum aircraft skin, and the long wire extends between the vertical stabilizer and out to the wing tips or to an insulated connection just aft of the cockpit," explains a ham operator whose signal is potent as he flies from Texas to South America servicing missionaries.

Just a few inches in the seawater was all we needed to get a solid ground.

"One time I lost the connection from the ground lug on the automatic antenna tuner; and while everything looked normal up here in the cockpit, everyone complained about how poor my signal was. Once I found the bad connection, I was instantly strong again on the air."

Aboard boats, an original concept of grounding the automatic tuner was to fashion a minimum of two one-quarter wavelength radials per band, and run them in the bilge area — that's the area below the water line, inside the hull, in and around all of the tanks onboard. Some marine electronic technicians figured that more ground was better than just the ground radials, so there was a period of 15 years of copper screen going into new-boat hulls as the vessels were getting the interior hull fiberglassed. This would create additional potential for a capacitive ground.

About 10 years ago, there were two manufacturers of "magic" ground plates — a porous bronze grounding plate that would be mounted on the outside of the hull, with two gold-plated bolts to tie the internal tuner into this grounding system. These ground plates were considered a breakthrough in getting a jump of RF current when the technician switched from the internal ground quarter-wave radials over to the massive ground plate in connection to the sea water.

Many of these ground plates carried literature that supported their size and were 20 to 50 times greater than their physical characteristics because of the porosity of the area within the inside of the plate. However, one ham operator doubted these claims, and made comparison studies of current passing through sea water from the small ground plate and a huge metal slab, and the current passing through the sea water from the huge metal slab was much greater than the small amount of current pulling through the ground plate.

Until recently, most manufacturers of marine SSB high-frequency equipment all had statements in their installation manual about a minimum of 100 square feet of counterpoise required for the system to work well. Few installers really knew where the 100 square foot requirement came from, but it allowed them to show this "requirement" to the customer and spend two or three days down in the hull, laying out copper foil, meeting these requirements. Good money for the technician wiggling around inside a boat, laying down copper strips.

But the best signals I could hear from boats thousands of miles away were always those with ground plates contacting the sea water. Their skywave and groundwave signals were dramatically stronger than other boats with similar power equipment, but using copper foil inside the hull as a counterpoise.

In a series of tests, I decided to find out exactly how much contact to the sea water must a copper conductor have before antenna current couldn't be raised substantially. And what I found out shocked the marine electronics industry — attaching copper foil, 3-mil, 3-inch-wide, to a ground plate, and just dipping the ground plate in the sea water, and antenna current instantly jumped up, and then letting the foil sink further into the sea water, and the current remained almost unchanged. Just making that single point contact with the sea water did the trick!

Next, I substituted the expensive porous bronze ground plate with a simple underwater bronze through-hull, and guess what? The submerged through-hull was just as effective as the very expensive ground plate. This means a boat owner who has the hull made of fiberglass needs only to locate a bronze underwater through-hull, and make an attachment to the neck of that through-hull to develop a powerful sea water ground connection. If there are one or two additional through-hulls nearby, these, too, would be picked up with the hose clamp to the 3-mil, 3-inch-wide copper foil to back up the first ground. Even though each bronze through-hull probably has the flange external to the hull painted, the inside portion of the through-hull valve or water intake makes excellent contact to the sea water. And other shipboard metallic objects that contact the sea water might be a rudder post, prop shaft with a wiper brush, or a nearby bronze intake to the engine cooling system.

Trunk lid ground for this big coil whip.

For temporary grounding to an automatic antenna tuner, copper foil itself may be lowered into the sea water; and as soon as you have about 12 inches below the surface of the water, antenna current in the long wire pretty well maxes out. In fact, go ahead and lower another 20 feet of foil into the sea water, and see how little the antenna current will change. This again validates that just a small amount of surface area contacting sea water provides an excellent high-frequency ground counterpoise to an automatic or manual antenna tuner.

In recreational vehicles, metal-skinned vehicles may offer an excellent ground plane. In fiberglass vehicles, the tuner must be grounded to the metal chassis with copper foil.

And what are you going to ground to when the tuner is up in your condo or apartment attic for that hidden antenna system? If the side of your dwelling is stucco, ground to the massive chicken-wire screen that is easily accessible on the inside wall of the attic. Talk about a terrific ground counterpoise!

In fresh water, you will need to experiment to see how much foil you need to let out to achieve a good rise in antenna current. Depending on the lake or river mineral content, you may need as much as 5 to 10 times the amount of copper foil in the water to achieve a reasonable ground plane. In a river, just stream the foil out. In a lake, drop the foil down as deep as you can.

If you don't own one of those MFJ antenna current meters, get a new flourescent tube, and watch the tube glow at night for a good, healthy, 100-watt signal. I have found that holding one end of the tube and slowly pulling it away from the antenna wire on a constant CW carrier will lead to about three feet of separation as the tube still glows. If the tube immediately goes out after you move it away by just an inch or so from the long wire, you don't have much antenna current for a 100-watt radio. Three feet away and still glowing at the base of the tube near your hand is a good sign. Do this only for brief periods so as to not exceed RF safety guidelines.

So have fun out on the water on high frequency. Forget about that 100 square feet of ground plane that you read about in the marine SSB antenna tuner installation manuals. If you're out on the ocean, you are sitting on a salt water ground plane that is just as effective as if the ocean were a thin sheet of copper foil. No wonder maritime mobiles have such strong signals! **NV**

Avoiding PIC-falls

By John Patrick

If you haven't used the PIC processor yet, make sure you read this before starting, as it is sure to cut some head-scratching time from the development process. If you are an experienced PIC developer, this article may help you stop from making certain blunders again.

Microchip's PIC line of microcontrollers is a popular choice for embedded design both in the professional arena, as well as the home hobbyist. However, most embedded developers would agree that the PIC is not the most intuitive processor to pick up from ground zero. Its RISC architecture, page and bank bits, and additional hardware components can cause developers — even seasoned PIC experts — to get caught by one of the PIC's dreaded "gotchas." If you haven't used the PIC processor yet, make sure you read this before starting, as it is sure to cut some head-scratching time from the development process. If you are an experienced PIC developer, this article may help you stop from making these blunders again.

Therefore, it is with much hope, however futile, that this article will help you to improve your hardware design and software development. I can't say that I've experienced every gotcha listed here, or have run into every problem, but these are the ones that seem to rear their ugly head more often than not.

The gotchas can be categorized into three different sections: hardware, software, and device programming. This last one may sound a bit weird, but bear with me, as you'll soon understand what I mean by this.

Why PIC?

But first, why choose the PIC? The PIC microcontroller has earned its popularity due to several key features. Foremost is the broad range of varieties that it comes in. From eight-pin DIP and SOIC to 44-pin PLCC and TQFP, there's almost any size that can fit your physical limitations. They also come with many different peripherals, including U(S)ART, I2C™, and SPI™ communication interfaces, timers, analog-to-digital (A/D) converters, internal oscillators, brown-out resets — the list is almost endless.

Another key reason is that Microchip has realized that tools sell micros and give away their MPLAB development IDE for free, complete with modules such as the MPASM assembler and the MPSIM software simulator. This last component allows a software developer to test program flow and execution before putting it to real hardware. Now, it does currently have its limitations in its simulation capability, especially when interfacing with some of the on-chip peripherals, but an engineer can work around those with minimal intrusion. Even with the limitations, MPSIM can greatly reduce your hardware/software integration time.

One of the few PIC attributes that many people have problems with is its reduced instruction-set computer (RISC) architecture. The 12-bit core versions (each RISC instruction is 12-bits wide) contain only 33 opcodes, each containing the data needed for that operation; no opcode compiles to more than one 12-bit word. This is a paltry number when compared to CISC-rich instruction sets such as the 8051 family. Even the larger 14-bit cores only contain 35 instruction words. For people who've programmed extensively on CISC micros like the 8051 and 68HC11, this smaller opcode list can take some getting used to. However, one benefit of this is that every opcode takes one instruction cycle to execute, except for opcodes that modify the program counter, which take two. This makes program execution time very easy to compute, and delay cycles very easy to create.

Hardware PIC-falls

Missing RA3 Pull-up: One of the most common mistakes is forgetting that pin RA3 is an open-drain pin, and that it requires a pull-up resistor to act as an input. This problem surfaces itself several times a year on the online discussion groups (see Online References).

Uncovered UV-erasable Window: When using a UV-erasable version for development, remember to cover the window during testing. Stray light falling on the die can cause RAM locations to zero-out automatically. If you don't properly initialize your registers — especially the STATUS register — this can cause your software to behave correctly in a windowed part, and not in an unwindowed one-time programmable (OTP) unit.

Unused Pins as Floating Inputs: When you have unused I/O pins, make certain that you don't leave them as floating inputs. Pins default to inputs to prevent line contention when powering up, so failure to pull them either low or high via a resistor (10k ohms is appropriate) can result in the inputs floating, which will cause the PIC to draw excess current due to the I/O FETS being in an indeterminate state. Another solution is to declare them as outputs and set them high or low. My practice is to use a pull-up or down resistor especially when prototyping, as it gives a PCB location where a wire or other connection can later be connected. When declared as an output, the unused pin can give status signals. In this case, if you've already designed in a pull-down resistor, you can simply measure the voltage on the pin, and still give a wiring point if that pin needs to be converted into an input at a later date in the prototyping stage.

Software PIC-falls

Read/Modify/Write Problem: The PIC processor uses a read/modify/write (RMW) method of I/O. This means that if you wish to modify an I/O port, a read of that port is done first; that state is modified and then written to the I/O port. This "feature" seems to bite every PIC software developer. An example of this follows: You set Port B as all outputs and write 0xFF to the port. Next, you need to read pin B5, so you turn it into an input. Before you read the pin, you decide to clear bit B7 (BCF PORTB,7) and set pin B5 to an output. However, before the BCF instruction, pin B5 goes low. When you switch B5 back to an output, the state of the pin is not high (as it was originally), but low, since the BCF command did a read of Port B prior to setting it as an output.

END Command Isn't Halt: This is a common mistake, one that everyone who has started with the PIC and MPASM has made. You write your code, put an END command at the end, then wonder why the code seems to be running in circles. The END in MPASM is simply a command to tell the assembler to stop parsing, not to halt execution. Once your program hits the end of your code, the processor continues to parse the (unprogrammed) opcodes, "falls off" the program area, and wraps from the last instruction word to the first. If you wish your program to reach a certain point and stop, put a GOTO $ command, which causes program execution to branch to itself — an infinite loop.

Incorrect Program Page Bits and Incorrect RAM Bank Bits: The PIC processor uses the Harvard architecture where data and code space is accessed on separate busses, as opposed to the von Neumann architecture where data and code reside on the same bus. As such, you can have an instruction at address 0x23 in code space and data in 0x23 in data space. But due to the 12- or 14-bit words, not all addresses (both data and code) are available for all operations. In order to get around this, the PIC uses paging bits for code space and bank bits for RAM locations. This means that a RAM address to 0x70 and 0xF0 will result in the same opcode on a 12-bit core, and the correct bank bit must be set to access the correct data. This "feature" is one of the most common plagues on PIC assembly programmers, and many different approaches can be used to help avoid this problem, from macros to always declaring bank/page bits during any operation that would require them. The best advice I have is for you to always pay special attention to your bank and page bits, and be sure to look for problems with them when debugging.

Forgetting TRIS: On the PIC, the tri-state register (TRIS) for each port sets each pin as either an input or an output (a one in the TRIS register indicates an input, while a zero indicates an output). Failure to set the TRIS value to the proper state can generate contention problems (an input set as an output) or floating inputs (an output set as an input, see below). Both of these can cause problems that can be difficult to track down and, in the instance of the PIC trying to drive an output against the wrong rail, possible hardware failure. On the older devices, the TRIS command was used to access the TRIS register; however, newer devices have done away with the TRIS command and allow you to simply perform a MOVWF to the correct register. This also allows the program to look at the current TRIS state, something that was not possible before. If you are porting a program from an older PIC to a newer one, make sure that you remove the TRIS command and replace it accordingly.

A/D Pins Default to Analog: Many of the PIC lines contain analog-to-digital (A/D) capability, which is multiplexed onto several general-purpose I/O lines. Often you don't need to use the A/D ability and just need the digital input. When doing this, remember that it takes more than just setting the tri-state register to input: ADCON0 controls whether or not the pins are analog or digital, and it defaults to analog.

Comparitor Pins Default to Analog: Much like the A/D problem above, PICs that have comparitors on their multi-function I/O pins default to the comparitor, not digital I/O. The proper register to modify for this is CMCON.

Missing or Incorrect .INC File: Quite a few PIC (and MPLAB) neophytes do not properly use the include file for their processor, and instead redefine the special file registers each time they write a program. While this is foremost a waste of time, a mistyped EQU line can cause havoc with the code; defining a RAM location incorrectly can make the code look proper, but assemble incorrectly. As such, ensuring that you've used the proper .INC file cannot only save you time, but lessen your errors.

This is also important when porting code from one PIC processor to a different PIC. Failing to change the include file can cause problems, especially if you're changing between the 12- and 14-bit families.

Subroutine Doesn't Start in First 256 Words of Page: On the 12-bit core PICs, care must be taken as to where your subroutine starts. The CALL instruction only stores the lower eight-bits of the address of the subroutine, and clears bit 8 of the program counter while fetching bits 9 and 10 from the page bits in status. Since bit 8 is cleared, the subroutine must start within the first 256 words of the page. If a subroutine started at address 0x0280, a call to this subroutine would result in the program counter being set to 0x002A. On the 14-bit cores, this is not a problem as the CALL instruction stores bits 10-0 within the instruction.

Ignoring Calibration Word: Some of the PIC line, most notably the 12C series, can run off of an internal RC oscillator. In order to run with a fairly reliable clock and handle manufacturing tolerances with the internal network, each of these devices contain as their last program word the calibration data needed for that part. It is up to the programmer, however, to put that data into the OSCCAL register. Quite often, the developer of the software forgets to use this calibration data. A simple MOVWF OSCCAL before your code changes the W register is all it takes.

Improper Save/Restore of Registers at Interrupt: The PIC processor has a limited call stack that's only used for the program counter, even when an interrupt has occurred. As such, you must save and restore your registers properly, especially STATUS and W, or program flow may not resume correctly after the interrupt has been handled. Microchip recommends the following code to save and restore W and STATUS:

```
        MOVWF      W_TEMP         ; Copy W to W_TEMP register
        SWAPF STATUS,W            ; Swap status to be saved into
                                  ; W
        BCF   STATUS,RP0          ; Change to bank zero
        MOVWF      S_TEMP         ; Save status to bank zero
                                  ; S_TEMP
;
; Interrupt Service Routine goes here.
;
        SWAPF S_TEMP,W            ; Swap S_TEMP into W
        MOVWF      STATUS         ; Move W into STATUS register
        SWAPF W_TEMP,F            ; Swap W_TEMP
        SWAPF W_TEMP,W            ; Swap W_TEMP into W
```

The use of the SWAPF instructions may seem odd, but it prevents accidental modification of the STATUS register that might result when a MOVF instruction is used.

Changing Prescalar Assignment: Each PIC has a single variable prescalar that can be assigned to either the TMR0 timer or the watchdog timer. This prescalar assignment can be changed at will, however, Microchip warns programmers that if care is not taken, changing prescalar assignment can result in a watchdog reset. Microchip recommends the following code to switch from TMR0 to watchdog:

```
BCF       STATUS, RP0      ; Set to bank 0
CLRF      TMR0             ; Clear TMR0 and prescaler
BSF       STATUS, RP0      ; Set to bank 1
CLRWDT                     ; Clear WDT
MOVLW     b'xxxx1xxx'      ; Set new prescaler value and WDT
MOVWF     OPTION_REG       ; Write OPTION
BCF       STATUS, RP0      ; Set to bank 0
```

To switch the prescalar from the watchdog timer to TMR0, Microchip recommends:

```
CLRWDT                     ; Clear WDT and prescaler
BSF       STATUS, RP0      ; Set to bank 1
MOVLW     b'xxxx0xxx'      ; Set new prescale value and TMR0
MOVWF     OPTION_REG       ; Write OPTION
BCF       STATUS, RP0      ; Set to bank 0
```

Disabling the Global Interrupts: On some of the older PIC devices, when you want to disable global interrupts, simply clearing the GIE bit in INTCON may not work. If an interrupt occurs right when the BCF INTCON,GIE command was being executed, the GIE bit could result in being set after the interrupt service routine has completed. In order to get around this, Microchip has recommended the following code, which will continually attempt to clear the bit until successful:

```
    BCF      INTCON,GIE
    BTFSC    INTCON,GIE
    GOTO     $-2
```

According to my research, all of the newer, flash-based processors have this fixed. Using this on a newer PIC might be a good idea in the event of porting the code to an older processor, but that is up to the individual developer.

Table Reads Across Boundaries: One of the things you can do with the 12- and 14-bit PIC cores is table reads by using a call followed by a computed GOTO. However, due to the fact that the ADDWF PCL can only affect the bottom eight bits of the program counter (no carry happens), you can only do a computed jump within the same 256-byte page. As such, you need to ensure that your table does not extend beyond a 256-byte boundary. If this happens, you can relocate your code to bring it into the same 256-byte page, or if this is impossible or you need more than a 255-byte table, you'll have to use one of the extended table read algorithms available (see the Online References section).

Over- and Under-running the Stack: The PIC processor differs from many of the other small microcontrollers in the fact that it does not use RAM locations for the program counter stack during a call, but instead uses a limited-size hardware stack. On the 12-bit cores, this is a two-level stack, while it is eight levels on the 14-bit core. Care must be taken to ensure that your worst-case call stack (including interrupts) does not exceed this number. When a program counter value is pushed on an already-full stack, the bottom value is simply discarded. When a program counter value is popped from the stack of a 12-bit core, the hardware simply leaves this bottom value there, in effect duplicating the address. This will cause a RETLW instruction to repeatedly return to the same location it returned to before and cause an infinite loop. Similarly, a RETLW without a preceding CALL will also cause an infinite loop. On a 14-bit core, however, the eight level stack acts as a circular buffer, such that the ninth consecutive RETURN or RETLW instruction will result in the top-most address stored on the stack to be placed into the program counter.

Bit-Test-and-Skip Instruction Before a Multi-Instruction Macro: Two of the most heavily used (and somewhat abused) PIC instructions are the BTFSC (Bit Test File and Skip on Clear) and BTFSS (Bit Test File and Skip on Set) instructions. These are used to skip the next instruction based on a bit being set or clear.

```
            BTFSC       STATUS,Z
            ; If zero jump to IS_ZERO
            GOTO        IS_ZERO
            ; Else continue to NOT_ZERO
NOT_ZERO    ...
            GOTO        CONT
IS_ZERO     ...
CONT        ...
```

In the above snippet, the STATUS file is tested to see if the zero (Z) flag is clear. If the bit is clear, the code skips the goto instruction and goes to the NOT_ZERO label. If the bit is set, however, the goto instruction is executed, and the PIC jumps to the IS_ZERO label. This is fairly straightforward, until you get the following code:

```
_BANK0      macro
            BCF    STATUS,5
            BCF    STATUS,6
            endm

            BTFSC FIELD,7
            _BANK0
            ; Mess with RAM
```

The intent of the BTFSC section of code is to set the bank bits to access RAM bank 0 if bit 7 of FIELD is clear, and leave them alone if set. Unfortunately, the BTFSC and BTFSS instructions are meant to skip only one instruction. At first glance, the above instructions look fine. However, the assembler expanded the macro to:

```
BTFSC FIELD,7
BCF    STATUS,5
BCF    STATUS,6
; Mess with RAM
```

Notice that the BCF STATUS,6 instruction is run even when bit 7 is clear, which may cause a serious problem. As such, care must be taken to prevent the skip instructions from preceding a multi-instruction macro.

Device Programming PIC-falls

Code-Protecting UV-Erasable Parts: This is an expensive mistake that many people make, though thankfully only once. If you program a UV-erasable (windowed) PIC with the code-protect bits on, you have just made your windowed PIC an expensive OTP part, as UV-erasing the PIC does not undo the code-protect. It happens to the best of us, just swallow your pride and buy a new windowed part and don't code protect it, or buy one of the new flash varieties, which don't suffer from this.

Wrong Oscillator Selection: Irregular and unstable operation can sometimes be explained by having the wrong oscillator declared in your configuration word. Ensure that you use the correct arguments on the __CONFIG assembler instruction.

Watchdog Accidentally On: Does your processor seem to reset every 18 ms or so? Or perhaps it seems to only be doing the first part of the program over and over? If so, you probably left the watchdog on in the configuration word, as it is enabled by default in the configuration word. Either disable the watchdog (__CONFIG instruction), or properly use the watchdog in your program.

Incorrect PicStart Plus Power Supply: There have been several reports of people damaging their flash-based PICs when using the PicStart Plus programming system with a "wall-wart" power supply with a higher voltage than the one supplied with the system. It seems that if too high of a voltage is supplied to the programmer, a Vpp that is damaging to the device will be present. As such, use only the supplied power cube or an identical one.

Online References

There are several useful online references for PIC designers to check out from time to time. Microchip has a set of web-based forums available on their website (http://www.microchip.com/1010/faqs/) that cover PIC processors, their development tools (including MPLAB and MPASM), their line of memory devices, and others. A decent amount of message traffic can happen over a week, so I make it a point to check them out at least twice a week. The main benefit of the Microchip boards is that several Microchip engineers respond to questions posted here, and many experienced engineers also answer your questions.

If you want loads of PIC information (sprinkled liberally with EE-related topics, as well as off-topic discussions), nothing comes close to the PIClist (http://www.piclist.com). If you feel that your email in-box is too empty, the PIClist will solve your worries with over 500 messages a week! Don't let this email barrage overwhelm you; when you sign up, you can have it filtered by subject tags, as well as receive just a daily digest. Also available on the website is a large amount of source-code to help you figure out those "can it be done?" questions. But the best part of the PIClist has to be the searchable archives, making available the entire PIClist message history. If it's PIC-related, bets are that you'll find it here.

Conclusion

If you're like many other PIC developers, you've been "got" by one or more of these "gotchas" and can relate to the antagonizing that they can present. Odds are, however, that you have yet to experience all of them. If you're new to the PIC microcontroller, then this article may save some time learning this processor. Either way, it is my hope that this list can help you succeed in your next PIC-based project. **NV**

About the Author
John Patrick is an embedded systems engineer from the Chicago area, an amateur radio operator (N9OU), combat robot builder, and involved in too many other hobbies to mention here. John can be contacted at j.s.patrick@ieee.org.

TECH FORUM

QUESTIONS

I'm looking for a source for a "soft-start" controller for a 3 hp, three-phase, 240-volt water well pump motor.

I have a 3 hp submersible water well pump hanging on 120 feet of plastic pipe. When it starts, it puts a high torque on the plastic pipe.

I would like to avoid twisting and breaking my plastic pipe. It cost big $$$ to pull and replace a broken pipe.

9021 Stuart Wahlberg Blythe, CA

I currently have in place a DC/DC power regulator circuit to generate a 3.3V DC signal from a 5V DC power supply.

I am looking for an IC for overvoltage protection on the 5V input supply for protection up to 12-16V. I've seen the circuit consisting of a zener diode/SCR with a fuse on the input, however, it seems that there must be something ready in an IC. Do you have any other suggestions for ICs or other circuits?

9022 M. Raymond via Internet

In a common emitter, BJT amplifier design (four resistors, RC, RE, and the two base resistors/voltage divider), what determines the computed IB static-bias current with respect to known input signal strength? I cannot find an answer to this.

Basically, since IB(Hfe)=IC, then 2[IB(Hfe)]=2(IC). Thus, if IB=1ma, and Iin=1ma, then IC=100% increase above static bias conditions? For purposes of Vc linearity, IB would be set at, say 110% of expected Iin?

9023 Paul Hillman via Internet

A few years ago, I installed a touch switch module in a couple of my metal desk type lamps. They start out dim, then brighter, and then brightest, then off. I recently changed all my light bulbs to the newer florescent type. The dimming touch switches don't work well with these bulbs. I would like to get a schematic or a touch switch module that would only go on/off (no dimming) and still works with the line voltage to the lamp, and is compatible with fluorescents.

9024 Terry Arnall tarnall@juno.com

I am looking for a low-cost method of short-range remote control for three DC motors. I think that the IR remotes for a TV would be a reasonable way. The problem being the receiver end and how to decode the signals to perform the individual on/off control of each motor. It would also be helpful if one of the motors was reversible.

9025 Dale Guenther wrenchten@aol.com

I am looking for a way to use my DSL connection on four floors (third floor, second floor, first floor, and basement). I have an access point connected to my computer on the third floor and I am able to connect okay on the second floor, but I am not getting any trace of a signal in the basement. What would be the best way to accomplish this? Would a high-gain antenna help?

Does anyone have a plan for building a high-gain antenna?

9026 Don Parisian dparis01@softhome .net

To get older PCs running, it's sometimes necessary to boot up with a DOS floppy. The trouble is, the hard drive C: disappears! There are drivers to install CD-ROMs, but there are no drivers for the hard drive.

There must be commands for the Config.sys or Autoexec.bat to activate the hard drive. Even the DOS manual dosen't explain.

What installs the hard drive in DOS?

9027 Joseph Kish joekish@attbi.com

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!

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- Include the question number that appears directly below the question you are responding to.
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- 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.

ANSWERS

[8022 - AUG. 2002]

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?

#1 No program is needed to use the 1764 Memory Expander. Just plug it in and use it. You can find a user's manual at: **http://project64.c64.org/hw/peri.html.**

Some other C64 sites: **www.hut.fi/Misc/cbm/**.

www.cae.wisc.edu/˜conover//c64.html.

Russ Kincaid

#2 There is a basic program and a readme file called **www.funet.fi/pub/cbm/c64/programming/restrings** which allows programming the Commodore 17xx Ram Modules in Basic.

There is also information on programming it in Assembly language at **‹www.hut.fi/Misc/cbm/docs/reu.programming.html›**. The information presented here is said to have been taken directly out of the owners manual.

I also found that **‹www.ibiblio.org/pub/micro/commodore/demodisks/other/›** has the actual disk images available containing the files that orginally came with the Ram Module itself.

The Technical Manual for the C64 1764 Ram Module can be viewed at **‹http://staff.washington.edu/rrcc/›** along with several other of the Commodore Peripherals.

Other websites that provide a wealth of Commodore information are:

‹www.faqs.org/faqs/commodore/›, Frequnetly Asked Questions on Commodore Computers.

‹http://stekt.oulu.fi/˜mysti/the_sharks/Files/Docs/1764_expansion.doc›, Tells how to expand the 1764 from 256k to 512K.

‹http://webs4u.co.nz/museum/mylinks.html›, An Online Commodore Museum with lots of Information and Links to some other sites, as well.

That should provide Mr. Ritchey with plenty of resources to obtain what he needs to utilize his Commodore 1764 Ram

[8024 - AUG. 2002]

Need details of an LED third brake light that flashes a few times and then is on? Or where can I find a kit?

#1 The exact part is manufactured by **Amperite Co. Inc.**, 600 Palisade Avenue, Union City, NJ 07087. Telphone **800-752-2329**.

It is their part number Stop-Alert 2 which is designed for vehicular use.

It will flash the third brake light a few times and then stay on as long as the brake pedal is depressed. The Stop-Alert 2 is low in cost.

Amperite Co. does not have a minimum order and will take credit cards.

Anthony Caristi
via Internet

#2 Since Mr. Pond asked via the Internet, I will provide a site that gives full details on constructing exactly what he asked for in his question, **‹www.uoguelph.ca/˜antoon/circ/flashing.htm›**, as per text on the site: This flasher gives three or four flashes at reduced intensity, and then goes solid.

Below is a copy of the webpage referenced above from the website: **www.uoguelph.ca/˜antoon/circ/circuits.htm**.

Pulsing third brake light **‹www.uoguelph.ca/˜antoon/circ/flashing.gif›**.

Caution: I'm checking into the legalities of this particular circuit at this time. Any type of flashing light on the main brakelights is prohibited and illegal in most states of the USA. I'm verifying for the same here in Canada. In the mean time, use this circuit at your own risk and be aware that the possibility exists to be stopped by law enforcement if you implement this circuit in your vehicle.

Used in my motorcycle: Several years ago, these flashers were introduced in the automotive industry as part of the third brake light (and were flashing continuously), but were abandoned sometime later because of the 'strobe' effect it has on some people. However, there is a major difference between this flasher and the ones from the automotive industry and others. This flasher gives three or four flashes at reduced intensity, and then goes solid. They do not have the 'strobe' effect in any way or form, in my opinion. My main concern, when driving my motorcycle, is to be seen early enough. Seems to work.

Q1 is a PNP Silicon Audio Power Out/Medium Power Switch Transistor, 7A, with a TO-220 case. As long as you have a transistor which is close, it will work fine. The SCR is a 100VRM, 0.8A, sensitive gate with a TO-92 case. Diodes D1, D2, and D3 are standard small signal diodes. Power diodes D4 and D5 are the 6A, 50PRV types, cathode case. The 60VRM type will work as well. I used for IC1 and IC2 the LM555 type. P1 controls the 'on' and pulse-duration, P2 controls the pulse-timing.

Applying the Brakes: When you first press the brakes, this circuit will turn on your third brake light via the main brake lights. After about a second, a series of short pulses occur. The number of pulses can range from approximately 1 to 10, depending on the setting of P1/P2 and when the brake pedal was applied last. After the pulses have been applied, the third brake light assumes normal operation. The prototype was set for five flashes which seemed more than enough. Two days later, I readjusted the trimmer potentiometers for four flashes. Looks pretty cool!

Circuit Description: The schematic consists of two 555 timer/oscillators in a dual timer configuration both set up in astable mode. When power is applied via the brake pedal, the brake light driver Q1 is switched on via the low-output pin 3 of IC2, and timer IC1 begins its timing cycle. With the output on pin 3 going high, inhibiting IC2's pin 2 (trigger) via D2, charge current begins to move through R3, R4, and C2.

When IC1's output goes low, the inhibiting bias on pin 2 of IC2 is removed and IC2 begins to oscillate, pulsing the third brake light via the emitter of Q1, at the rate determined by P2, R6, and C4. That oscillation continues until the gate-threshold voltage of SCR1 is reached, causing it to fire and pull IC1's trigger (pin 2) low. With its trigger low, IC1's ouput is forced high, disabling IC2's trigger. With triggering disabled, IC2's output switches to a low state, which makes Q1 conduct turning on the third brake light until the brakes are released. Obviously, removing the power from the circuit at any time will reset the Silicon Controlled Rectifier SCR1, but the RC network consisting of R4 and C2 will not discharge immediately and will trigger SCR1 earlier. So, frequent brake use means fewer flashes or no flash-

Expander to its full potential.

Wesley K. Miller
Camp Hill, PA

[6022 - JUNE 2002]

Are there any circuits out there or a device that could convert an infrared signal to a serial and analog output? I would like to convert the infrared signal that is coming out of a cellular phone to a serial port so that I could connect other custom devices to and including a computers serial input.

Most cell phone IR signals are IRDA signals. IRDA is a comprehensive standard and very complicated. For reference on IRDA, visit www.irda.org.

Given its complexity, simply decoding an IR signal is not enough. Usually it requires a great deal of resource to implement an IRDA compliant device. However, a chip MCP2150 (Digi-Key part number MCP2150-I/P-ND for an 18-pin DIP version) made by Microchip Technology implements a subset of IRDA standard as a secondary device. I believe it is secondary IRDA-Lite compliant.

With this chip, you can build a device that at one end communicates with cell phone via IR, and the other end with a PC through RS232 line driver (it support RS232 at TTL level). Of course, you will need an integrated IRDA physical layer compliant IR module for the chip to pick up and decode IR signals. You can use Agilent Technologies' HSDL-1001 (Newark part number HSDL-1001#004 for front mount version) for this.

A complete design probably requires at least seven components (crystals, etc). Check out some of the reference designs at both Microchip Technology www.microchip.com and Agilent Technologies www.agilent.com websites for details.

Peter Y. Lin
pylin@pylin.com

[8023 - AUG. 2002]

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 connecters 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

es at all. But I think that's okay. You already have the attention from the driver behind you when you used your brakes seconds before that.

The collector/emitter voltage drop accross Q1 together with the loss over the series fed diodes D4/D5, will reduce the maximum available light output, but if your car's electrical system is functioning normally in the 13-14 volt range, these losses are not noticeable.

Building Tips: You can easily build this circuit on perfboard or on one of RS/Tandy's experimentors boards (#276-150), or use the associated printed circuit board listed here.

Keep in mind that Q1 will draw most likely two or three amps and mounting this device on a heatsink is highly recommended. Verify that the SCR is the 'sensitive gate' type.

In incandecent bulbs, there is a time lag between the introduction of current and peak brightness. The lag is quite noticeable in an automotive bulb, so the duration of a squarewave driving such a bulb should be set long enough to permit full illumination. For that reason, and because lamps and car electrical systems vary, adjustment via P1 and P2 is necessary to provide the most-effective pulse timing for your particular vehicle.

The reason that the third light is connected to both brake lights is to eliminate the possibility of a very confusing display when you use your turn signal with the brakes applied.

The cathode of D4 and D5 are tied together and go to point 'B' of the third brake light in the component layout diagram. Point 'A' goes to the other leg of the third brake light. Most, if not all, third brake lights in Canada and the USA have two wires, the metal ones also have a ground wire which obviously goes to ground. I don't know the wiring scheme for Australian and European third brake lights.

Don't forget the three jumpers on the PCB; two jumpers underneath IC1/IC2 between pin 4/8 and the one near Q1/R6.

If you use a metal case, don't forget to insulate the D4/D5 diodes. (For motorcycles, you can eliminate D5.)

Some 90's cars, like my 1992 Mercury Sable, have two bulbs inside the third brake light, each bulb is hooked up separately to the left and right brake light for reasons only Ford knows. Click here **<www.uoguelph.ca/~antoon/circ/flshbulb.gif>** for a possible two-bulb hookup. It shows how I modified mine to get it working; and that was easier than I expected. Current draw with the two bulbs was measured at 1.85 amps (1850 mA). Even with double the current none of the circuit components were getting hot. I had to readjust the two pots to make it flash since the bench testing was done with one bulb.

Bench Testing: I tested different semiconductors like the 1N5401/1N5404, NTE153, and 4A type powerdiodes for D4/D5. All worked very well. As expected, Q1 is getting very hot. Current draw was measured between 680-735mA with a regular automotive 'headlight' bulb, extra heavy duty to make sure the circuit was safe. I tested several other power transistors including some Darlingtons like the TIP125 and the TIP147. I eventually settled for the TIP125 myself because I had it available, but anything with 5A or more will do fine.

The actual third brake bulb is a lot smaller. Adjusting the trimpots (P1/P2) may take a bit of patience, but really fine-tunes the circuit well. The only drawback of this circuit is the discharge lag coming from the electrolytic capacitor C2 and the R4 resistor. Especially if the brakes are used often or at short intervals, the third brake light will not flash or maybe flash once or twice. Again, this is because the R-C combo does not have enough time to discharge in between braking. It takes about 12 seconds to discharge C2.

PCB

<www.uoguelph.ca/~antoon/circ/flashpcb.gif>.

The PCB measures 2 x 2.5 inch (5 x 6.4cm or 170 x 200 pixels) at two colors and is shown smaller when you print these pages.

If you need a direct, full size copy of the PCB, I suggest to load the gif file into a program like Paint Shop Pro or one of the many gif viewers available. This PCB was modified by Bert Vogel and eliminates the jumpers. Click on **<www.uoguelph.ca/~antoon/circ/third.jpg>**. Good stuff; thanks Bert.

Layout

<www.uoguelph.ca/~antoon/circ/flashlay.gif>.

The layout is enlarged a bit for a better component view. Note that Q1 is drawn soldered on the PCB, but if you have a metal case, you can put it anywhere on the metal case (as a coolrib) and use havy-duty wiring between Q1 and the PCB.

CORRECTION: SCR1's anode/kathode were shown reversed (fixed: 2-26-2000).

Wesley K. Miller
Camp Hill, PA

Parts List

Semiconductors:

IC1,IC2 = 555 Timer, RS #276-1723
SCR1 = NTE/ECG5402, RS #276-1067, EC103A, MCR104, etc.
Q1 = NTE/ECG197, SK3083, TIP125, or equivalent
D1,D2,D3 = 1N4148, 1N914, NTE/ECG519, RS #276-1122
D4,D5 = 1N5400, NTE/ECG5850, RS #276-1141, or equivalent

Resistors:

R1 = 18K (Brown-Gray-Orange)
R2 = 330 ohm (Orange-Orange-Brown) (RS #271-1315)
R3 = 270K (Red-Violet-Yellow)
R4 = 82K (Gray-Red-Orange)
R5,R6 = 1K2 (Brown-Red-Red) (1200 ohm)
R8 = 100 ohm (Brown-Black-Brown) (RS# 271-1311)
P1 = 50K, 10-turn
P2 = 10K, 10-turn

Capacitors:

C1 = 100µF/16V (RS# 272-1016)
C2 = 22µF/16V (RS# 272-1014)
C3 = 220µF/16V (RS# 272-1017)
C4 = 10µF/16V (RS# 272-1013)

TECH FORUM

[8027 - AUG. 2002]

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.

I don't know if these can be called "quick and dirty," but I think they'll do the trick.

The "digital" meter uses the LM3914 linear dot/bar display chip to display a "running dot" of the video signal. If you'd rather have a "moving bar," simply tie pin 3 ("MODE" pin) to Vcc. When "calibrated" (via the "REF ADJ" pot), the LEDs will light in 1V steps, corresponding to .1-1V video level variations.

The analog meter uses a simple DC "needle" voltmeter. Again, the deflection will be from 0-12 VDC, representing a 0-1.2VDC video level (0 IRE to 100+ IRE).

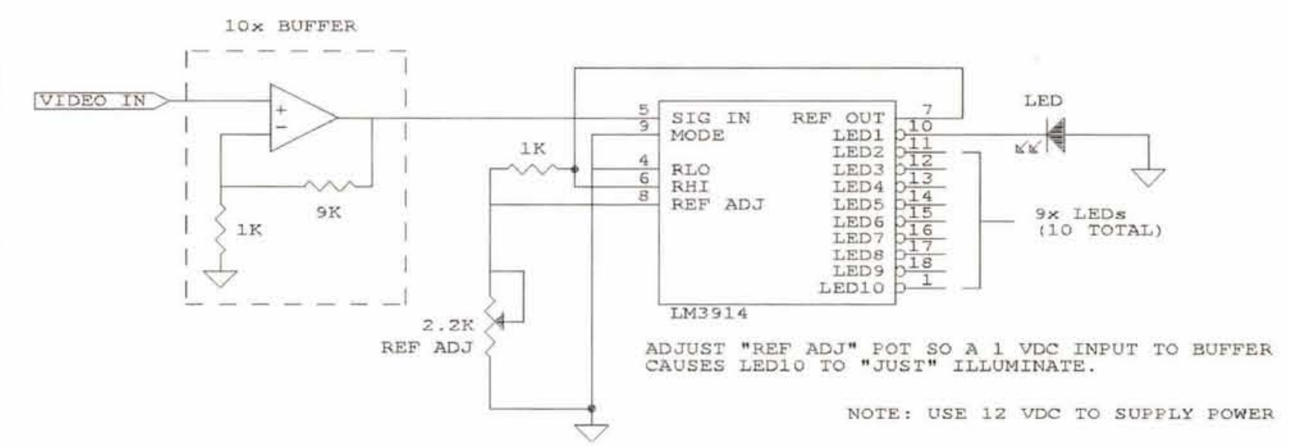
In both cases, any DC bias on the video signal will be amplified by the buffer — a DC blocking cap or input level pot may be needed on the amp's input.

The op-amp can be any chip capable of single-ended supply operation (i.e., LM301).

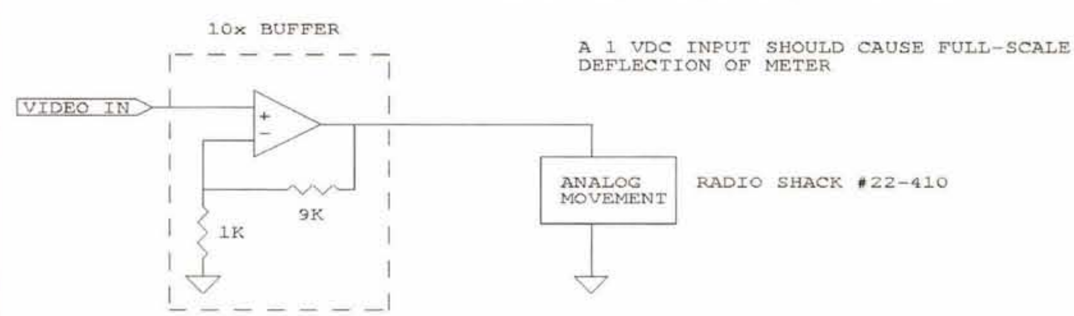
I assumed you didn't need any real "resolution" in the level monitoring, so component tolerances aren't critical. The typical NTSC video signal ranges from 0-1Vpeak (0-100 IRE), so a 12 VDC battery supply should be more than adequate to handle the video range.

Ken Simmons
Auburn, WA

"DIGITAL" VIDEO LEVEL METER



"ANALOG" VIDEO LEVEL METER



in any electronics supply places.

I am providing two websites for Mr. Laney to check out that give details on working with high voltage and ways to construct such power supplies he is seeking from common items that should be easily obtainable. They are: **<http://www.geocities.com/CapeCanaveral/Lab/5322/hv2.html>** or **<http://www.kronjaeger.com/hv/>**.

These websites also have links to several other websites that can provide the wealth of information that Mr. Laney needs to obtain or build the high-voltage power supply he seeks.

Wesley K. Miller
Camp Hill, PA

[7024 - JULY 2002]

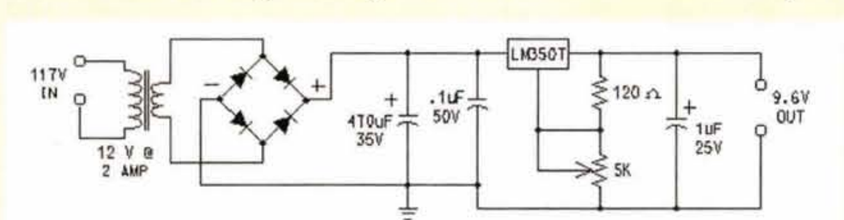
I need to build a power supply that will have an output of 9.6 volts DC current at 1800mA.

This power supply circuit will provide an adjustable output from about 1.2 volts to about 10.5 volts at almost two amps of current. If you replace the transformer with a three-amp, unit you will be able to get almost three amps of current. Make sure the LM350 has a large enough heatsink.

Both the transformer and the LM350T are available from Jameco Electronics. The transformer is part number 29225. The LM350T is part number 23940.

You didn't say whether the 9.6 volts had to be regulated at 1800 ma. In most cases, this would not be necessary. If the current needs to be regulated, the circuit would be more complicated.

Raymond Buck
Phoenix, AZ



[George Peschke- AUG. 2002]

I would like to build a buzzer that would wake me up at night whenever someone enters our side gate.

#1 I would purchase a wireless doorbell unit (for under $20.00) and a outlet timer, like that which is used for Christmas lights.

Put the doorbell chime unit in your bedroom and plug it into the outlet timer.

I'm not sure how the chime unit is powered ... if by a battery, then replace the battery with a "wall-wart" transformer that is then plugged into the outlet timer.

The doorbell button switch is a transmitter. It can sound the door chime unit for about 100 feet I believe. You won't have to run any wires from the fence to your house.

Take apart the doorbell button switch (which has a small battery inside) and figure out a way to create a new switch on your fence. Maybe you can find a small normally closed "reed relay" at RadioShack. A tiny magnet glued to your fence post will normally keep the reed relay opened. When the gate opens, the magnet moves away from the reed relay and it closes. Wired in parallel to the doorbell button ... the doorbell unit chimes in your bedroom.

Or, replace the existing normally opened switch inside the doorbell button with a normally closed switch and position it so that the fence gate presses on the button when closed ... thus holding the switch opened.

Just an idea ... you could do the whole thing for under $30.00.

This idea is also commonly used to signal when the mail arrives at your mailbox located at the end of a driveway. When the mailman opens the box, a doorbell unit chimes in the kitchen. Same idea ... the doorbell button switch is modified on the mail box cover.

Max Seim
Cottage Grove, MN

#2 If you're good at "hiding"

[8025 - AUG. 2002]

I need to be able to measure and record with my PC, the voltage coming into my house. I'm looking for a circuit that will translate 240 Vac into something that I can read through the serial port of my PC.

#1 You can easily accomplish this through a DMM (Digital Multimeter) with a computer interface. But you need one with isolation (most of them are, but make sure).

You will be able to read the voltage or the current — typically two-three times per second. The DMM's hook-up to the serial port and software is typically included allowing to generate lists, which can then be read into spreadsheets such as Excel and allow all kinds of further manipulation. If you are interested in the harmonics and power, there are industrial-type power analyzers available (single phase and three phase).

Walter Heissenberger
Hancock, NH

#2 A quick, easy, and safe solution to measuring 220VAC from your PC is found on the inside of the back cover of *Nuts & Volts* Aug. 2002 issue. Circuit Specialists offers a digital multimeter (DMM) with an RS-232 PC interface for only $44.50. Using a digital multimeter for your interface saves you from problems of isolation and user safety. As a bonus, you have all the other measurement capabilities of the meter accessible from your PC, too !

Chuck
via Internet

the gate detector, consider getting a wireless door alarm like RadioShack #980-0772 ($39.99, special order). This way, there'll be no "overt" sign of a surveillance monitor. The only drawback is the aforementioned unit doesn't have a light, but I think one can be added, if necessary.

For powering, a suitable DC "wall wart" can be connected to an off-the-shelf AC timer module (i.e., RadioShack #61-1068, $7.99) programmed to run the receiver during the desired time range. Of course, periodic checking of the gate "transmitter" battery is required and, if necessary, the transmitter might need some "weatherproofing."

Ken Simmons
Auburn, WA

[7025 - JULY 2002]

We had our dog implanted with an AVID pet ID micro chip and I wondered if it would be possible to make a scanner to read it? Possibly using a Basic stamp or something. Could this be used to warn us if our dog was to leave our yard?

It is possible to make a scanner for your pet's micro chip ID, but it will not serve your purpose. These need to be in very close proximity of the embedded chip (less than a foot), because of the low power.

Preventative medicine is much more effective here, since it is cheap to find an alarm that senses its partner out of range. This, of course, only works if you tag the pet before your dog leaves. There are also perimeter alarms available that give a small shock or high pitched tone, if the animal leaves a fixed area. This strongly discourages wandering.

Barry Cole
Camas, WA

Replacement Graphics

From Robert Nansel

Correction to August Amateur Robotics

Some days it just doesn't pay to get up in the morning. As many of you have already noticed, the figures for my final Amateur Robotics column in August were, well, a little screwy. Okay, they were a lot screwy. In fact, Figures 1-4 were the exact same illustrations as for my July column. This came about from a single keystroke error — I typed a "7" instead of an "8" when I sent the compressed set of files. My brain at fault here.

A small gremlin also sneaked into the equations sidebar, which should have shown a function box at the top with R, G, and B signals leading in, and H, S, and I signals leading out. It looked fine in my file, but somewhere between my computer and the printing plant the "I" signal got moved over to the left a bit so it overstruck its output arrow. With humblest apologies for any confusion, here are the correct illustrations. Please refer to last month's text for the full explanation behind them. **NV**

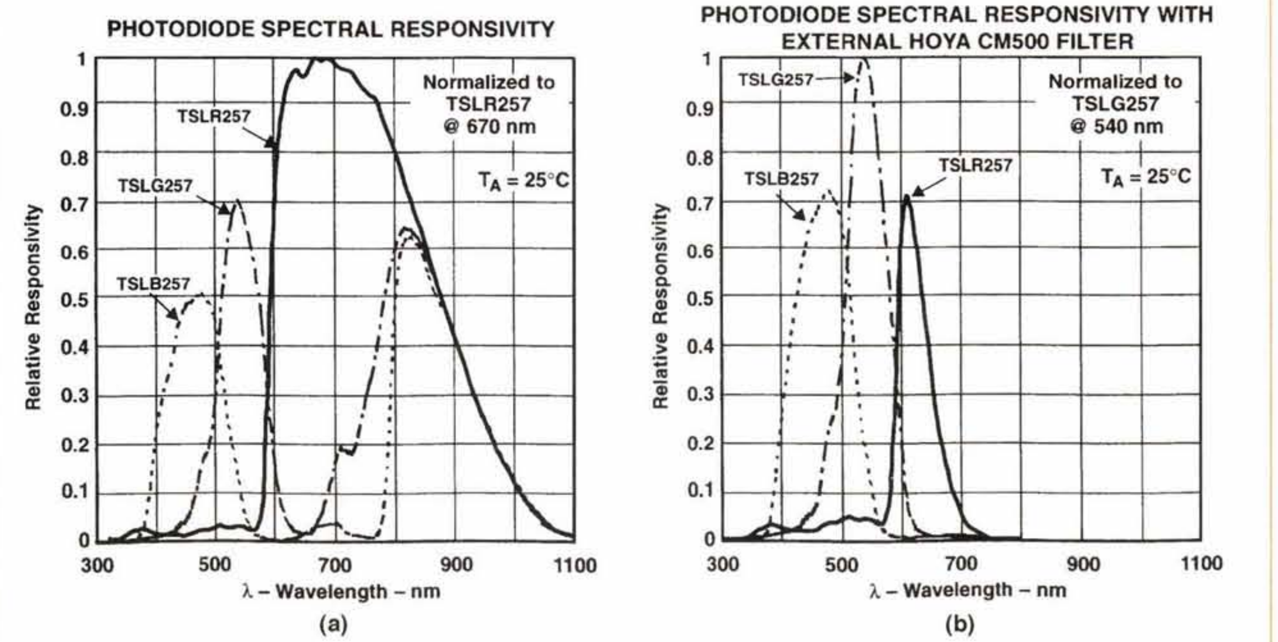
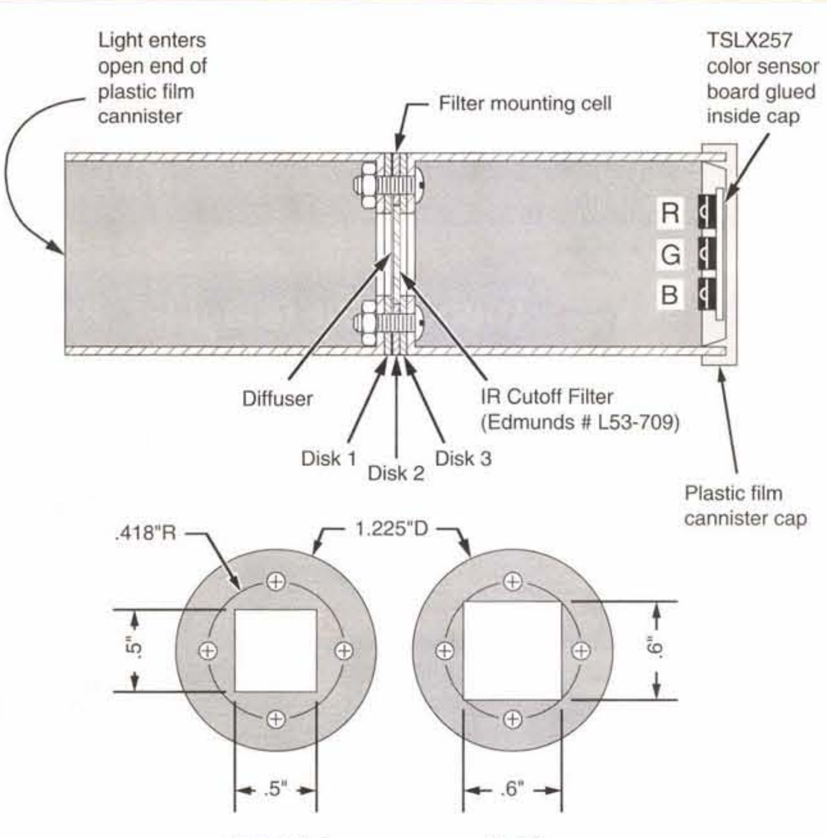


Figure 1: (a) TSLx257 spectral responsivities with no external filter; **(b)** spectral responsivities with external IR cutoff filter. (Graphs from TAOS, Inc., TAOS027A datasheet, p5.)



- Cut mounting cell disks from 1.1 mm thick cardboard & paint flat black both sides.
- Use disk 1 or 3 to scribe screw hole locations and outlines of window cutouts on bottoms of opaque plastic film cannisters.
- Diffuser made from two .75" wide strips of Scotch tape stuck back-to-back.
- Sandwich the IR cutoff filter and diffuser in disk 2 between disks 1 and 3, and mount modified film cannisters on both sides with 4-40 hardware.
- Wrap the mounting cell joint with black tape to seal out stray light.

Figure 2: Experimental RGB Color Sensor

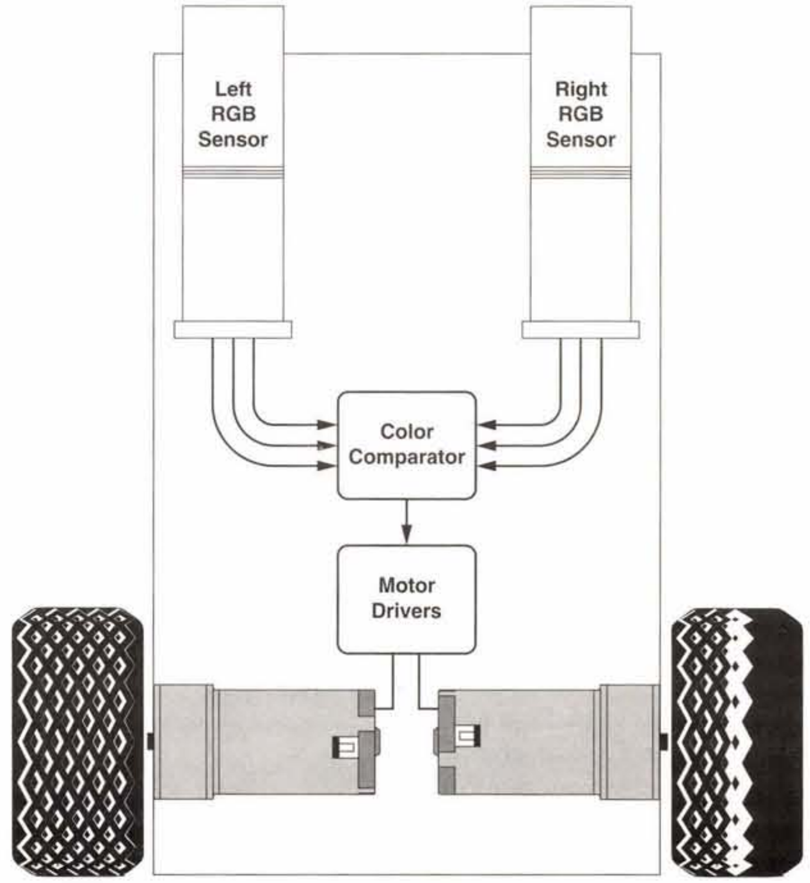


Figure 3: Conceptual Color Tracking Robot

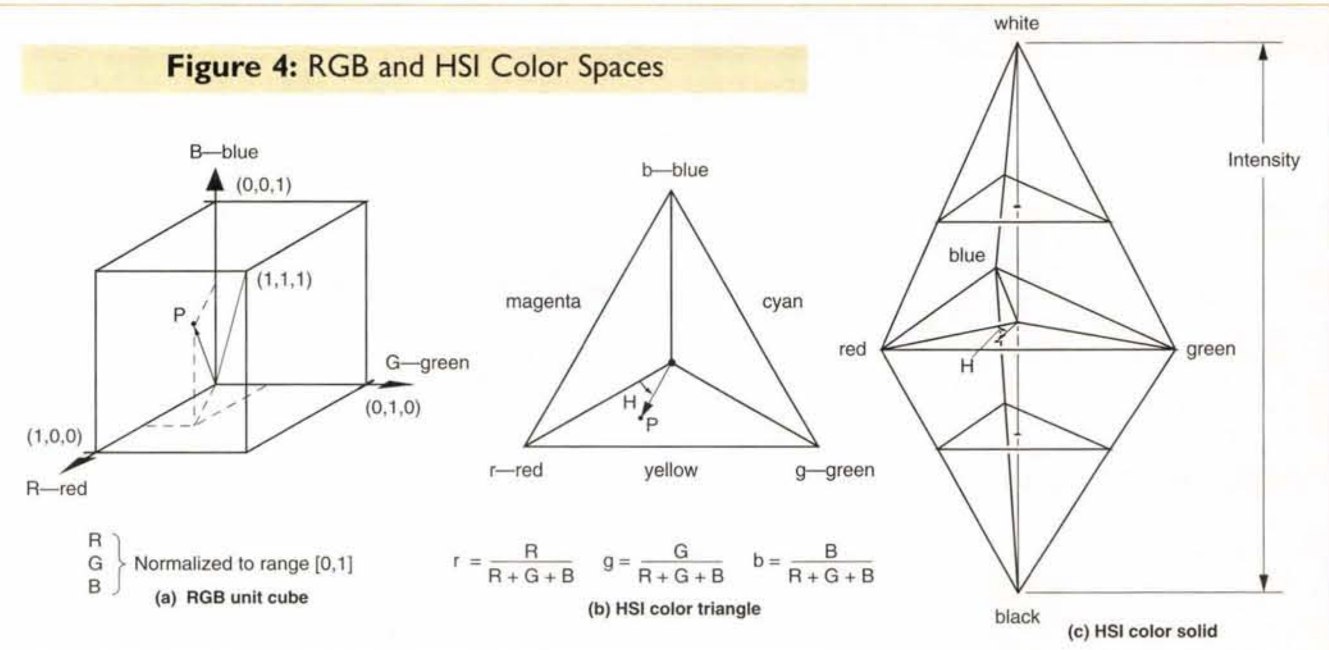
Replacement Graphics

If you have suggestions, questions, or comments, as always you can reach me at:

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

By the beginning of September you can also check out my new website: **www.countryrobot.com**

Figure 4: RGB and HSI Color Spaces



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***

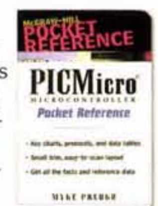
Programming & Customizing the HC11 Microcontroller
by Tom Fox

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

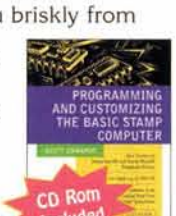
This book is a fully updated and revised compendium of PIC programming information. Comprehensive coverage of the PICMicro's hardware architecture and software schemes complement the host of experiments and projects making this a true, "learn as you go" tutorial. ***$49.95***

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
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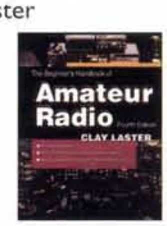
by Joe Carr

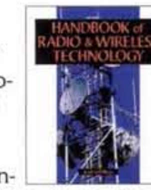
The most popular book on antennas ever written. This edition blends "the theoretical concepts that engineers and others need to design practical antennas, and the hard-learned practical lessons derived from actually building and using antennas." ***$49.95***

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

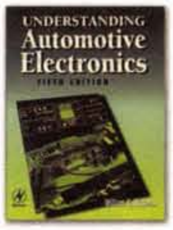
For the true beginner, there's no better introduction to electricity and electronics. You'll also find 25 complete projects that enhance your electricity/electronics mastery, including 15 new to this edition, and appendices packed with commonly used equations, symbols, and supply sources. ***$24.95***

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***

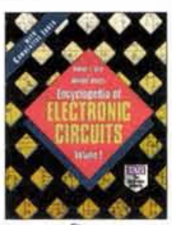
Hobbyist Bookstore

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***

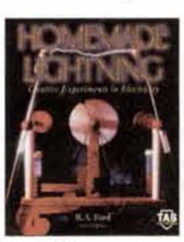
Encyclopedia of Electronic Circuits Vol. 7
by Rudy Graff



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

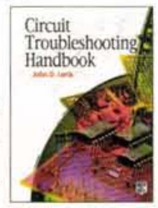
Homemade Lightning: Creative Experiments in Electricity
by R.A. Ford



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***

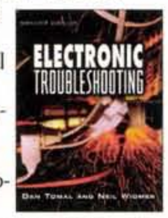
Troubleshooting

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***

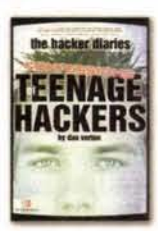
Electronic Troubleshooting *2nd Edition*
by Dan Tomal and Neil Widmer



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

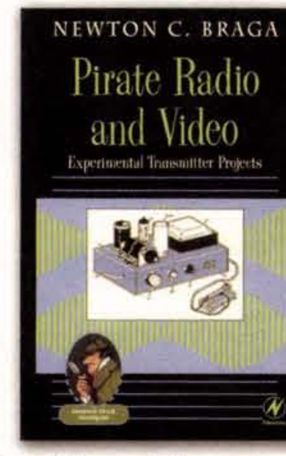


Through fascinating interviews with FBI agents, criminal psychologists, law-enforcement officials—as well as current and former hackers—you'll get a glimpse inside the mind of today's teenage hacker. Learn how they think and understand the internal and external pressures that pushed them deeper and deeper into the hacker underground. ***$24.99***

This Month's Featured Titles

Pirate Radio and Video
Experimental Transmitter Projects
by Newton C. Braga

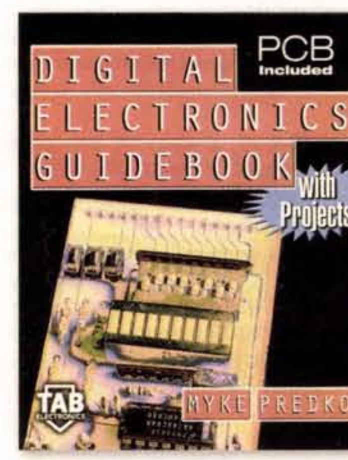
$24.99



Now that the FCC has changed the laws governing pirate radio and video stations, more and more people across the country are starting broadcasts from their homes. Of course, transmitting equipment is very expensive, but now you can build your own transmitters for a fraction of the cost of purchasing. By reading about and building the over 30 projects in Pirate Radio and Video, you can construct your own station with a minimum investment for maximum learning. With projects for UHF, VHF, AM, and FM transmitters, this book covers the gamut of popular bands and outputs. Not only will you learn how to build your own transmitters, but also how to troubleshoot problems, test outcomes, and even synthesize several types of equipment into a powerful and unique system.

Digital Electronics Guidebook With Projects!
by Myke Predko

$34.95



Here's the perfect tool for electronics hobbyists and students — even complete beginners — who want to understand digital logic and build their own low-cost logic circuits. You get more than 20 projects for designing, constructing, and interfacing easy-to-do TTL (Transistor-Transistor Logic) circuits. This guidebook provides everything from directions for setting up your own digital electronics lab to explanations of needed math and basic electronics. Construct your own simple eight-bit computer. Find tips for making circuits that switch, count, time, measure, control, combine input and output, switch-bounce, think, and much more, along with the reusable printed circuit board included with the text.

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