

**ROBOTICS MICROCONTROLLERS COMPUTER CONTROL LASERS**

**Everything For Electronics**

# **Nuts & Volts**

**February 2003**

**Add a wireless live video  
system to your R/C airplane**

**Add a web interface  
to your X10-based  
home control system**

**The Gadget-O-Rama 2002  
1st Place Winner!**

**The Multi-Functional  
Accelerometer**

**Build The  
LaneAlert -  
A Driver's Best Friend**

U.S. \*\*\*\*\*AUTO\*\*3-DIGIT 543  
220378 0407  
THOMAS T LORITZ  
424 WILSON AVE  
GREEN BAY WI 54303-4115

S203





**INTRODUCING**

# CALS-2000™

## Computer Aided Learning System

**A College  
in a Case™**

- Quickly Learn Electronics on the Job or at Home.
- Videos Provided Show Analogies for Electronic Components.
- Calculators that Eliminate Mathematics on Every Experiment.
- Oscilloscope and Spectrum Analyzer.
- Over 500 Experiments Provided on CD.
- Money Back Guarantee.

Over 150 Parts Included  
for More Than 500  
Experiments!



Trainer & Parts

**\$399.00**

Software

~~\$199.00~~

Introductory Offer

**TOTAL**

**\$399.00**

+ Tax & Shipping Charges

Magnetic  
Storage Area

Autoranging  
Digital Meter for  
Voltage, Current,  
Resistance,  
Frequency, and  
Capacitance

8 Data Switches

Battery Pack

Six Parts  
Storage Areas

Sockets for 8 to 24-Pin  
Integrated Circuits

Magnetic Sockets Hold Components on Conductive  
Paths Using Patented Process for Fast Assembly

Circuit Sheet Printed  
on Your Printer

8 Tri-Level LED  
Logic Indicators

AC Adaptor

Serial Computer  
Interface

8Ω Speaker and  
Earphone Jack

Power Supply  
Inputs

Two 7-Segment  
LED Displays for  
Digital Readouts

Frequency  
Generator  
0.1Hz to 1MHz  
in 3 Ranges

Steel Tabs and  
Sheet Attracts  
Magnetic Holders

**ORDER AT: [emailschool.com](http://emailschool.com) or BY PHONE: CALL C&S SALES at 1.800.292.7711**



### Video Players!

#### 12VDC & 120VAC Built-In!

- ◆ Model No. VHS-10S player deck
- ◆ Std NTSC VHS format, frmt-pnl cntrls
- ◆ Perfect for on the road!
- ◆ Working pulls, HSC 90-day warranty

**HSC# 19048**  
**\$19.95**



#### 115VAC Unit

- ◆ Magnavox video player, working pulls
- ◆ Standard 'F' & RCA connectors
- ◆ Switch selected Ch. 3 or Ch. 4 output
- ◆ Working pulls, HSC 90-day warranty

**HSC# 19152**  
**\$17.50**



### Disk Drive Deals!

#### 9.1GB ULTRA SCSI

- ◆ Seagate ST19171WC, 80-pin
- ◆ 7200RPM, 4.6ms av. latency
- ◆ **Wide to std. SCSI adapters - \$7.50!!**
- ◆ HSC 90-day warranty

**HSC# 18753**  
**\$19.95!**



#### 4.3 GB SCSI 1/2 HEIGHT

- ◆ ST15150N hard drive
- ◆ 21 Hds, 11 Disks, 3,711 Cyl.
- ◆ 7,200 RPM, 9.0 ms avg. seek
- ◆ HSC 90-day warranty

**HSC# 18412**  
**\$14.95!**



### RF Goodies!

#### 50 Ohm cable assemblies

- ◆ RG-58 size coax - two lengths avail.
- ◆ Male TNC to male SMA connectors



**HSC#19438 13" \$4.50**

**HSC#19439 18" \$4.95**

- ◆ 1/8" high-quality 50 ohm
- ◆ Male to male SMA conn.
- ◆ 18" long

**HSC# 19440 \$9.95**

#### 50 Ohm Attenuator

- ◆ Mini-Circuits Model No. SAT-20
- ◆ 20dB atten. - 0 to 1500MHz, 50 ohm
- ◆ Male-to-male SMA connectors
- ◆ Cable assembly pulls, 90-day warr.

**HSC# 19441 \$9.95**

### LCD Displays!

#### ◆ 20 char. x 24 display

- ◆ 2.36"H x 3.86"W, 0.55" max. depth
- ◆ Data sheet @ <http://www.halted.com/online/index.htm>
- ◆ New, 90-day warranty

**HSC# 19399 \$12.95**

### Win-based Terminal

- ◆ WYSE 'Winterm 2315SE'
- ◆ Virus-proof - high security
- ◆ Easy access to server apps.
- ◆ Up to 32 users/servers, tiny footprint
- ◆ VT220, VT100 and VT52 emulation
- ◆ Mouse, keyboard power supply incl!

**HSC#19346 \$89.50**

### Rack Mount Cabinet

- ◆ 1U (1-3/4") high 19" quality-made
- ◆ 15-5/8"W x 16"D - outside dimensions
- ◆ Reversible mounting flange
- ◆ Pulls from working svc. some scratches

**HSC#19437 \$19.95!**



### Adaptec ISA SCSI Cntrlr.

- ◆ AHA-1535/1535A - SCSI1/SCSI2 conn.
- ◆ **Special!! - \$17.50 with any SCSI HD!**
- ◆ New units, OEM pkg, 90-day warranty

**HSC#19397 \$24.95!**



### PCI to SCSI Host

- ◆ DTC '3130B' - Plug 'n Play adapter
- ◆ SCSI-1, SCSI-2 and Fast SCSI-2
- ◆ 50-pin low & high density conn.
- ◆ 133mB/s (host bus), 10mB/s (sync burst)
- ◆ Multi-platform compatibility
- ◆ New, 90-day warranty

**HSC#19434 \$24.95**



### PCMCIA Card Reader

- ◆ SSP Argus 2000 ISA-type reader/writer
- ◆ Dual PCMCIA Type I/II, or one Type III
- ◆ DOS/W3.1 driver diskette included
- ◆ Win95/98/NT ready
- ◆ New, w/interface, manual & cables

**HSC# 19410 \$24.95**



### Bargain DMM!

- ◆ 3 1/2 digit, 19 range multimeter
- ◆ 1000VDC, 750VAC
- ◆ 1 Megohm input impedance
- ◆ 200 uA to 200 mA + 10Amp
- ◆ 200 to 2 Megohm scales
- ◆ Transistor & diode checker
- ◆ New - 90-day warranty

**HSC# AEEC1504 \$14.95**



### SCA to SCSI 1 Adptr

- ◆ Converts SCSI1 to SCA wide
- ◆ Standard 4-pin power connector
- ◆ Jumpers for LED, SYN, DLY, MTF, ID0-3
- ◆ Jumpers & config sheet incl.
- ◆ New, 90-day warranty
- ◆ **Special!!...just \$7.50 w/any SCSI H. Drive**

**HSC#SCS3700 \$12.50!**



### 12X SCSI-2 CD Drive

- ◆ Sony CDU415
- ◆ Up to 1800KB (P-CAV) rate
- ◆ Plays 11 CD types
- ◆ Brand new drive
- ◆ OEM packed
- ◆ 90-day HSC warranty

**HSC#19463 \$17.50!**



### Call Recorder

- ◆ Store 1000s of calls on your hard drive
- ◆ Replay, sort, email, copy & transfer calls
- ◆ Adapter goes btw phone & PC
- ◆ Win95/98/ME/XP/NT ready
- ◆ Retail boxed, w/CD, manual, cables
- ◆ Factory refurb. FIVE YEAR warranty!

**HSC# 80649 \$49.50**



### DMM w/Tilt Display!

- ◆ Wide range measurement of voltage, current, frequency, capacitance.
- ◆ Measures temperature - probe incl.
- ◆ Non-slip 'boot', std banana jacks
- ◆ Handy easy view tilt-up LCD
- ◆ New, 90-day warranty

**HSC# AEEC2890 \$39.95**



### SmartCard Reader

- ◆ Fits in PCMCIA slot
- ◆ For sensitive files/databases
- ◆ Personal access security system
- ◆ Restricts unauthorized access
- ◆ Comes with 2 cards, diskette, manual
- ◆ New, retail-boxed, 90-day warranty

**HSC# 19433 \$19.95**



### Compact Solder Pot!

- ◆ Handy desktop size
- ◆ Perfect for small jobs, hobby
- ◆ Operates on 110VAC
- ◆ New - 90-day warranty

**HSC# AEEC10P \$32.00**



### Lab-Quality Power

- ◆ 0-50VDC @3 Amp
- ◆ 110VAC, 60Hz - 150VA
- ◆ Short-circuit protected
- ◆ Digital meters for voltage & current
- ◆ New, w/IEC power cord, manual
- ◆ 90-day warranty

**HSC#AEEC350 \$109.00**



### 500W Transformer!

- ◆ 110VAC input, 0-130VAC output @ 5A
- ◆ 7" dia. (8.5" w/ext) 6.5" high.
- ◆ Large knob & scale settings
- ◆ Meter shows output level
- ◆ Illuminated power switch
- ◆ New - 90-day warranty

**HSC# AEEC590 \$45.00**



### RAID Controller!

- ◆ 'Mylex' Model No. 960P-3
- ◆ Up to 32MB, 36-bit SIMM, (4MB min.)
- ◆ 1 to 45 drives as one logical drive
- ◆ Can co-exist with 3 more (180 drives!)
- ◆ Pulls, online support info

**HSC# 19427 \$29.50**



### Compact Keyboard!

- ◆ 88/89 enhanced key layout
- ◆ Finger glide mouse function
- ◆ Space Saving design
- ◆ Only 8.5" x 11.28"
- ◆ Free PS/2 connector adapters!
- ◆ New, w/mouse driver diskette and manual

**HSC# 19328 \$14.95!**



### Compact Power

- ◆ 'Copper Com' AC/DC adapter
- ◆ Input: 120VAC, 60Hz, 70W
- ◆ Output: 12VDC @ 3.4A @ full load (~16.3VDC unloaded)
- ◆ Useful for many applications
- ◆ New units, in OEM package

**HSC# 19312 \$9.95!**



**HSC Electronic Supply**

3 Retail/Wholesale Locations:

Main Office - Mail Orders...

3500 Ryder St. Santa Clara, CA 95051

Santa Clara 1-408-732-1573

Sacramento 1-916-338-2545

Rohnert Park 1-707-585-7344



## Silicon Valley's Electronic Marketplace

Since 1963!...

Order Toll-Free: 1-800-4-HALTED(442-5833)

or...ONLINE, AT: [www.halted.com](http://www.halted.com)

Terms: Some quantities limited; all items are subject to prior sale. **Minimum order: \$10.00 plus shipping.** Orders under \$20.00 subject to \$2.00 handling fee, in addition to shipping. All orders shipped by UPS Surface unless otherwise specified. \$6.00 UPS charge added for COD. Visit our website for detailed information on domestic and international shipping methods.

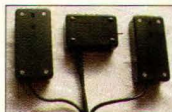


## PROJECTS

### ON THE COVER

#### 42 LaneAlert — A DRIVER'S BEST FRIEND

Employing some readily-available and relatively-inexpensive components, you can create your own lane-detection system.  
by Ken Delahoussaye



#### 47 BUILD A POOR MAN'S METAL DETECTOR

Search for buried treasure with this easy-to-build, low-cost device.  
by Anthony J. Caristi

#### 52 BUILD THE CF-MOSFET AUDIO POWER AMPLIFIER — PART I

Construct an audiophile-quality amplifier of several configurations, many applications, and surprisingly low cost.  
by G. Randy Slone

## COLUMNS

#### AMATEUR ROBOTICS 26

Modifying an R/C servo for continuous rotation the easy way.

#### ELECTRONICS Q & A 12

What's Up: This month is audio/visual. Two audio test instruments and two ways to get stereo from mono. Two LED projects: colorimeter and auto taillights. And a new antique radio supplier category for the FINDPART file.

#### IN THE TRENCHES NEW COLUMN 83

For Design Engineers facing real-world problems. This month: Why good ideas aren't good enough.

#### JUST FOR STARTERS NEW COLUMN 93

Get a good "grounding" in the basics as you begin your journey into the world of electronics. This month, take a close-up look at desoldering.

#### LASER INSIGHT 86

Interferometers, interference fringes, and their interpretation.

#### OPEN COMMUNICATION 90

As we continue our broadband modulation discussion, this time learn a technique which lets you send even higher data rates for any given bandwidth.

#### ROBOTICS RESOURCES 80

A round-up of sources for serial servo controllers.

#### STAMP APPLICATIONS 20

Gettin' MIDI With It. Put the new PBASIC to work for a rockin' good time.

#### TECHKNOWLEDGEY 2003 6

New world's smallest transistor; Making ice cream with sound waves; Audio card provides tube sound; Top 10 viruses for 2002; Clothing with a brain; Electronic voice changer; and IEEE Medal of Honor winner.

# Everything For Electronics Nuts & Volts

Vol. 24 No. 2

#### 34 MULTI-FUNCTIONAL ACCELEROMETER

The Gadget-O-Rama 2002 1st place winner. This device can detect accelerations caused by either an object's motion or the earth's gravity.  
by Jingxi Zhang, Yang Zhang, and Huifang Ni



#### 63 FLAT PANELS VS. THE PARABOLA

Flat-panel technology is becoming an important factor as we go higher up the microwave spectrum to pull in satellite signals.  
by Gordon West



#### 67 HOME AUTOMATION VIA THE WEB

Add a web interface to your X10-based home control system.  
by Michael Gardi



#### 72 A RADIO-CONTROLLED AIRBORNE-VIDEO SYSTEM

Add a wireless live video system to your RC airplane and get a bird's eye view at a reasonable cost.  
by Phil Blake



## DEPARTMENTS

- |                           |                    |
|---------------------------|--------------------|
| 97 Advertiser's Index     | 10 NV Bookstore    |
| 76 Classified Display Ads | 5 Publisher's Info |
| 32 Electro-Net            | 5 Reader Feedback  |
| 60 Electronics Showcase   | 94 Tech Forum      |
| 40 New Product News       |                    |

Nuts & Volts (ISSN 1528-9885) is published monthly for \$24.95 per year by T & L Publications, Inc., 430 Princeland Court, Corona, CA 92879. PERIODICALS POSTAGE PAID AT CORONA, CA AND AT ADDITIONAL MAILING OFFICES. POSTMASTER: Send address changes to Nuts & Volts, 430 Princeland Court, Corona, CA 92879-1300.



Published Monthly By  
**T & L Publications, Inc.**  
 430 Princland Court  
 Corona, CA 92879-1300  
**(909) 371-8497**  
 FAX **(909) 371-3052**  
**editor@nutsvolts.com**  
**www.nutsvolts.com**

Subscription Order ONLY Line  
**1-800-783-4624**

**PUBLISHER**  
 Jack Lemieux N6ZTD

**EDITOR**  
 Larry Lemieux KD6UWV

**MANAGING EDITOR**  
 Robin Lemieux KD6UWS

**CONTRIBUTORS**  
 Jon Williams  
 Jeff Eckert  
 TJ Byers  
 Stanley York  
 Gordon West  
 Gordon McComb  
 Gerard Fonte  
 George Whitaker  
 Michael Gardi  
 Phil Blake  
 Ken Delahoussaye  
 Randy Slone  
 Anthony Caristi  
 Louis Frenzel

**SHOW COORDINATOR**  
 Audrey Lemieux N6VXW

**STAFF**  
 Natalie Sigafus, Mary Gamar  
 Michael Kaudze  
 Shannon Lemieux

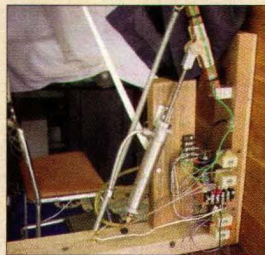
Copyright 2003 by  
**T & L Publications, Inc.**  
 All Rights Reserved

All advertising is subject to publisher's approval. We are not responsible for mistakes, misprints, or typographical errors. *Nuts & Volts Magazine* assumes no responsibility for the availability or condition of advertised items or for the honesty of the advertiser. The publisher makes no claims for the legality of any item advertised in *Nuts & Volts*. This is the sole responsibility of the advertiser. Advertisers and their agencies agree to indemnify and protect the publisher from any and all claims, action, or expense arising from advertising placed in *Nuts & Volts*. Please send all subscription orders, correspondence, UPS, overnight mail, and artwork to: **430 Princland Court, Corona, CA 92879.**

*Dear Nuts & Volts:*

I just completed the Martha Project. Everything went per your instructions or as I interpreted them. I made some substitutions and added some things.

The really hard part was getting the sounds to work to my satisfaction. I thought that I had a tape player that would stop and start with the closing of a switch, no luck there. I am going to leave the continuous tape running with the scream going and turn on the sound with a relay. I am using a set of computer speakers with amplifiers. I have four relays: one drives the LEDs for the eyes, one turns on the black light, and one for the sound. That leaves one for something I may have forgotten. This project has been fun, I may do the seagull later.



**Don**  
**via Internet**

*Dear Nuts & Volts:*

I liked your article on building a Jacob's Ladder in the Dec. '02 issue.

However, there is one glaring omission in the circuit: A bypass capacitor across the 12-volt supply. All electronic circuits should be properly bypassed to prevent interaction between sections of the circuit. In this application, the requirement for a capacitor is much more severe, since the AA battery supply is required to supply perhaps six amperes of pulse current into the ignition coil primary, which may be only two ohms. The only way to get a decent current into

the coil is through a charged capacitor. For a typical three-millisecond pulse width, the value of the capacitor should be at least 3,000 microfarads.

**Joe Dean, via Internet**

*Dear Nuts & Volts:*

Your magazine is *great*. That is why I'm not only renewing *my* subscription, I'm giving the gift sub to my friend. Keep up the good work. I would like to see a little more OOPIC.

**Edward Carty, Jr., via Internet**

*Dear Nuts & Volts:*

Kudos, dittos, and all that stuff ... we really like your new format! It's finer than frog hair!

**Vern Killion W5UYF**  
**DOE KRVN/NRRA/NE State SECC-EAS**

*Dear Nuts & Volts:*

Neat magazine, greatly enhanced by the new size. It was difficult to take the larger format on trips. Fitting it into a briefcase or on a bookshelf was also a problem. Thank you.

**Robert Mitchell, via Internet**

**LASERS**

**superbrightleds.com**

**super bright leds and super bright led products**

**68HC11 & 68HC12 Microcontroller Modules!**

Unique design-- just plug them right into your solderless breadboard!

**MicroStamp11™**  
 • tiny 1-inch x 1.4-inch 68HC11 module from \$49

**MicroCope-11™**  
 • compact 2-inch x 2-inch 68HC11 module from \$68

**Adapt-11™ Family**  
 • 68HC11 modules with lots of I/O lines from \$63

**Adapt812™ Family**  
 • based on 68HC812A4  
 • from \$79

**Adapt912™ Family**  
 • choice of B32, D60, DG128  
 • from \$99

**MicroBOM912™**  
 • lowest-cost BDM pod!  
 • only \$79!

**Application Cards Available:**  
 • stepper motor driver  
 • voice record/playback  
 • LCD/keypad/PC keyboard  
 • data acquisition • DAC  
 • CAN • ethernet • more!

**Toll-free: 1-877-963-8996**

**Technological Arts**

Phone: (416) 963-8996 Fax: (416) 963-9179

**www.technologicalarts.com**

Visa/MasterCard  
 Discover/Amex



# TechKnowledge

## 2003

Events, Advances, and News From  
The Electronics World

### Advanced Technologies New World's Smallest Transistor

In 2001, the Consortium of International Semiconductor Companies projected that transistor dimensions will need to shrink to less than 9 nm by 2016 or current performance trends in digital equipment cannot be maintained. IBM ([www.ibm.com](http://www.ibm.com)) seems to have crossed that hurdle about 13 years early and recently announced the development of a working-gate transistor that can be built with a body length of only 6 nm — is approximately one-tenth the size of the smallest devices in production today.

According to an IBM representative, "The ability to build working transistors at these dimensions could allow us to put 100 times more transistors into a computer chip than is currently possible. Moreover, this achievement underscores the fundamental challenges of scaling — namely power density — that must be addressed as silicon is pushed to molecular dimensions."

For decades, the chip industry has been challenged by the limitations of scaling, especially because

smaller transistors are more difficult to turn on and off. Reportedly, IBM has been able to solve the problem by reducing the silicon thickness on the silicon-on-insulator (SOI) wafers. The devices are produced on bonded SOI wafers using halo implants and 248-nm wavelength lithography. The silicon body of the device is only 4 to 8 nm thick, which results in proper turn-on and turn-off behavior. (In case you are wondering, "halo implant" refers to a high-angle implant introduced after silicon pre-amorphousization and performed in the same lithography step in which the source/drain extension regions are doped.)

### Making Ice Cream With Sound Waves

In a weird variation on your home stereo system, Pennsylvania State University ([www.psu.edu](http://www.psu.edu)) acoustic engineers have developed a concept for a compact ice cream freezer case based on environmentally-safe technology that substitutes sound waves for chemical refrigerants. According to Dr. Steven Garrett, head of a research team financed by Ben & Jerry's ice cream company, the team's thermoacoustic chiller uses a

souped-up loudspeaker to generate high-amplitude sound energy in an environmentally-safe gas (air) that is converted directly into useful cooling. The high amplitude sound levels are hundreds of thousands of times beyond even rock concert levels — up to 173 dB.

The loudspeakers used in thermoacoustics do not need to produce a range of frequencies or tones like a radio, so Garrett's group improves their efficiency by operating them at resonance or at the tones they produce by the natural free oscillation of the system. The Penn State group has developed loudspeakers that not only operate near their natural resonance frequencies, but also use metal bellows that replace loudspeaker cones to compress the air.

In a proof-of-concept test system, the process was used to cool a piece of window screen. Reportedly, the test equipment pushed the screen down to -8°F (-22°C). Garrett commented, "What began as basic research on the fundamental connections between sound waves and heat transport — funded by the Office of Naval Research — is getting closer to providing an environmentally-benign substitute for traditional engine and refrigeration technology."

### Computers and Networking

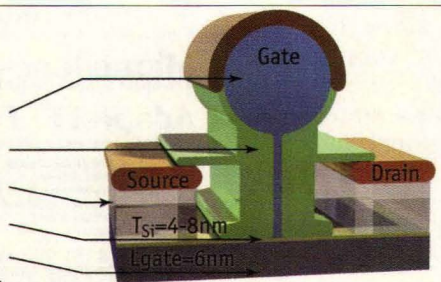
#### Audio Card Provides Tube Sound

If you are a musician or a passionate audiophile, you undoubtedly understand that digital electronics simply cannot provide the warm,

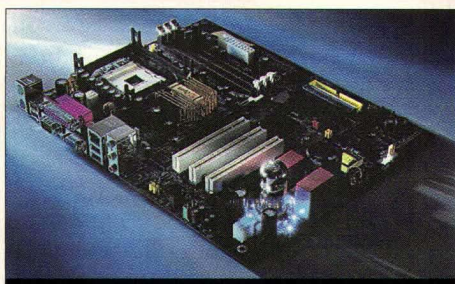
Illustration of IBM's "world's smallest transistor." Courtesy of International Business Machines Corporation. Unauthorized use not permitted.

Region	Material
Gate:	Polysilicon
Spacers:	Dielectric
RSD:	Silicon
Channel:	Silicon
Box:	Oxide

RSD stands for "Raised Source Drain"







**AOpen's AX4GE/PE sound cards provide old-fashioned tube audio from your PC.**  
Courtesy of AOpen, Inc.

fuzzy tones that you get with vacuum tubes. If you overdrive the input of a transistor, it disappears in a puff of smoke. If you overdrive the input of a vacuum tube, you get a wonderfully rich distortion. This is why electric guitar players still love their 40-year-old Fender Twin Reverb amps and many music lovers cling to their noisy old tube amplifiers. Apparently, it is now possible to get the same sound from your PC using one of the recently-introduced AOpen AX4GE/PE sound cards. The sound is created not by exotic digital processing, but by a real SOVTEK 6922 dual triode vacuum tube that operates as part of the amplification circuitry. The result is more pleasant sound for musical audio applications and more robust sound-effect reproduction for video games.

Several versions are available. Based on the Intel® 845PE chipset, the AX4PE model can be obtained with Serial ATA and Ultra ATA 133 hard drive interfaces. The AX4PE Tube-G version excludes these options. The AX4GE card, based on the 845GE chipset, adds Intel's "Extreme Graphics" core, which offers realistic 3-D graphics for gaming. All models support Intel's Hyper-Threading technology and Dolby Digital 5.1 surround sound. Reportedly, the street price runs from \$180.00 to \$220.00. To find a dealer in your location, log onto the AOpen web site at [www.aopen.com](http://www.aopen.com).

## Top 10 Viruses for 2002

**T**he results have been tabulated, and the top 10 computer viruses

of 2002 have been announced. According to Sophos, a UK-based developer of anti-virus software ([www.sophos.com](http://www.sophos.com)), the Klez worm holds the dubious honor of being the world's most prolific virus, being the object of 24.1 percent of all complaints recorded by the company's customer-service department.

Transmitted via email, it substitutes an incorrect (but real) return address for the address of the real sender, making it appear that the worm was sent by a third party. According to Sophos, "This has led to a flurry of accusations that innocent computer users have sent the worms to customers, suppliers, and colleagues. In some cases, Mac users have been blamed for sending the Klez worm, even though it is impossible for Macs to be infected. This has caused embarrassment to some managed email security companies that have been falsely accusing users of forwarding viral code." In fact, nine of the viruses in the 2002 top 10 are mass mailing Windows 32 viruses, the exception being the Elkern virus, which is carried by Klez. Approximately 87% of all infection reports during 2002 concerned Windows 32 viruses.

The number two and number three bugs in the top 10 list are Bugbear (17.5 percent) and Badtrans (14.6 percent). The remaining viruses logged less than five percent of the total complaints. In 2002, Sophos detected 7,189 new viruses, worms, and Trojan horses, bringing the total to more than 78,000. On average, the Sophos-virus labs produce detection routines for more than 25 new viruses every day.

## Circuits and Devices

### Clothing with a Brain

**U**S-based clothing manufacturers are rapidly losing ground to low-

## Tools for the Imagination

**Micro Modules**

**Specialty Products**

**RTC Processor Boards**

Celebrating Embedded Controllers for Over 20 YEARS

With dozens of embedded controllers and countless configurations, we can help you turn your imagination into reality. For a complete look at our product line, visit our website at [www.micromint.com](http://www.micromint.com).

**Micromint**

[www.micromint.com](http://www.micromint.com)
(800) 635-3355

Circle #46 on the Reader Service Card.

# USB DAQ

## LabJack U12

Available now for only ...

**\$119 qty 1**  
**(\$95 qty 10+)**



USB Data Acquisition  
& Control

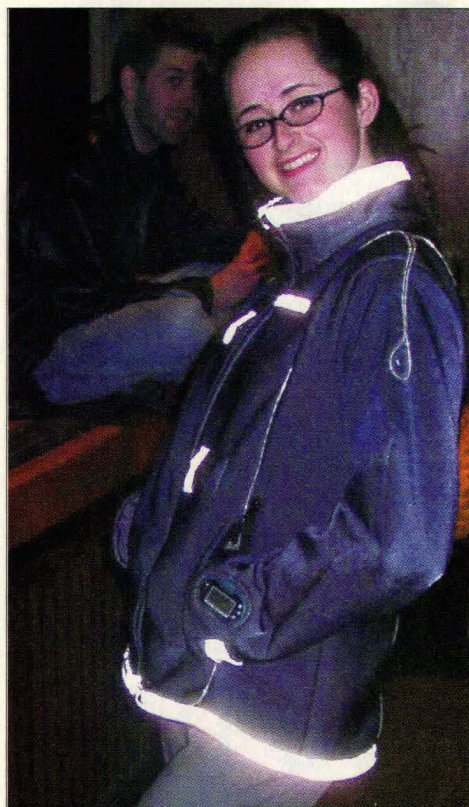
- \* Built-in screw terminals
- \* Easy-to-use USB
- \* Everything included
- \* Use with C, VB, LabVIEW, etc.
- \* Windows 98SE/ME/2000/XP
- \* 12-bit analog inputs (8)
- \* 10-bit analog outputs (2)
- \* 20 digital I/O
- \* 32-bit counter

**Made in Colorado, USA, by LabJack Corp.**  
info@labjack.com, (303) 942-0228

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

cost Asian producers, but a ray of hope can be seen in the creation of Lucy Dunne, a graduate student at Cornell University ([www.cornell.edu](http://www.cornell.edu)). In the photo, (next page), she shows a jacket that automatically lights up in the dark and produces heat when the temperature drops. It also incorporates a pulse monitor to measure activity levels for people who jog or walk for exercise. Heat is





Lucy Dunne of Cornell University models the smart jacket she designed, which automatically heats and lights up in the cold and dark, and features a pulse monitor to measure activity level for recreational athletes. Photo credit: Komposite.

produced by an electroconductive cloth in the upper back section, and light emanates from electroluminescent wires attached at strategic locations. This prototype jacket is powered by AA cells, so it presumably isn't very effective at arctic temperatures. But a commercial version might use lithium batteries, or perhaps the wearer could drag around a wagon full of automotive batteries.

More importantly, this is but one example of a developing "smart clothing" market that employs microprocessors and other electronics for specific purposes. Products that may appear in your local department store soon include snow suits with embedded GPS receivers, shirts with integrated cell phones, bikinis with built-in audio players, and undershirts with various remote physiological monitoring devices. Perhaps, we can look forward to hats

that convert into umbrellas when they sense rain, shoes that spray salt on icy surfaces, and pants that automatically fall down when you enter a crowded elevator. The possibilities for appearing ridiculous seem endless.

If you are seriously interested in the subject, you may want to attend the next IEEE International Symposium on Wearable Computers. (The sixth annual event was held last October in Seattle, WA.) Updated information is available at [iswc.tinmith.net/](http://iswc.tinmith.net/). You can even have information about the conference emailed to you on a regular basis. Just send an email with the key words "subscribe iswc" in the body of the message to [majordo mo@iswc.tinmith.net](mailto:majordo mo@iswc.tinmith.net).

## Electronic Voice Changer

**T**ronic Ace Technology, Inc. ([www.unitone.com.tw](http://www.unitone.com.tw)) is a manufacturer of security and novelty electronics ranging from talking alarm clocks and ultrasonic animal repellers to mobile phone accessories, which are sold under the Unitone brand name. One of the company's more interesting products is the Televoicer, which is used to disguise your voice when talking on the telephone. Several versions are available. For example, the LG-206A (left photo) is the portable version, and you just tape it to the mouthpiece of a telephone to allow it to operate. You can select from eight levels of voice modificaon. The LG-

215A and LG-215B models are connected between the telephone body and handset, providing 8 and 16 different modification levels, respectively.

There is also the LG-510A, a miniaturized version designed for use with cell phones. But the most intriguing has to be the LG-301 (right photo), which is built into a rubber mask and requires no telephone at all. The manufacturer advises that it is highly useful during the Easter holidays, but offers no explanation of that concept. It does seem like a useful item if you plan to rob your local convenience store. A quick Internet search turned up several web sites offering the Televoicer at prices starting at about \$29.00. Tronic Ace is also looking for distributors, so contact them right away if you think you can sell these products.

## Industry and the Profession

### IEEE Medal of Honor Winner

**N**ick Holonyak Jr. — a John Bardeen Professor of Electrical and Computer Engineering and Physics at the University of Illinois at Urbana-Champaign — has been selected as the 2003 recipient of the Institute of Electrical and Electronics Engineers (IEEE) Medal of Honor. The award, which recognizes Holonyak "for a career of pioneering contributions to semiconductors, including the growth of semiconductor alloys and heterojunctions, and to visible light-emitting diodes and injection lasers," will be presented at the IEEE's annual honors ceremony in June 2003.

The son of Slavic immigrants who settled in southern Illinois, Holonyak earned his bachelor's degree in 1950, his master's in 1951, and his doctorate in 1954, all in electrical engineering from the University of Illinois. Holonyak was the first graduate student of two-time Nobel laureate John Bardeen, an Illinois professor who participated in the



The Televoicer voice changer comes in several versions, including a mask. Courtesy of Tronic Ace Technology, Inc.



invention of the transistor. An early researcher in semiconductor electronics, Holonyak gained eminence through his numerous inventions and contributions to advances in semiconductor materials and devices.

At the University of Illinois, Holonyak and his students demonstrated the first quantum-well laser, creating a practical laser for fiber-optic communications, compact disc players, medical diagnosis, surgery, ophthalmology and many other applications. In the early 1980s, his group introduced impurity-induced layer disordering, which converts layers of a semiconductor structure into an alloy that has important electronic properties. In one use, this discovery was used to improve a laser's reliability to make it applicable for use in DVD players and other optical storage equipment.

Among Holonyak's other awards are the Frederic Ives Medal of the Optical Society of America (2001), the Japan Prize (1995), the National Academy of Sciences' Award for the Industrial Application of Science (1993), the Optical Society's Charles Hard Townes Award (1992), and the US National Medal of Science (1990). He is a member of the National Academy of Engineering and of the National Academy of Sciences, and a fellow of the American Academy of Arts and Sciences, the American Physical Society, the IEEE, the Optical Society of America, and is a foreign member of the Russian Academy of Sciences. **NV**

Visit [www.lynxmotion.com](http://www.lynxmotion.com) for more information!



**Completely Redesigned! Assembles in minutes using hand tools!**

**Control using PC, BS2, Atom, Oopic, or any device capable of serial comm.**

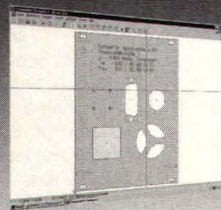
Lynxmotion, Inc.  
PO Box 818  
Pekin, IL 61555-0818  
[www.lynxmotion.com](http://www.lynxmotion.com)

**Lynxmotion**

Tel: 866-512-1024  
Tel: 309-382-1816  
Fax: 309-382-1254  
[sales@lynxmotion.com](mailto:sales@lynxmotion.com)

## Front Panels?

Download the free 'Front Panel Designer' to design your front panels in minutes



Order your front panels online and receive them just in time

**[www.frontpanelexpress.com](http://www.frontpanelexpress.com)**

Circle #53 on the Reader Service Card.

**ORDERS. 800.810.4070**  
**Tech 603.668.2499**

# RESOURCES UN-LTD.

**Fax 603.644.7825, All CCards, COD,**  
**300 Bedford St. Manchester, NH 03101**

**[WWW.RESUNLTD4U.COM](http://WWW.RESUNLTD4U.COM)**

**NOW, EVEN MORE, POWER to SPARE!**  
**FANTASTIC, 12 VOLT, 28 Amp Hour, PANASONIC**  
**LC-X1228P, SEALED RECHARGEABLE BATTERY.**



holes. Use two in parallel for 56Ah! **PANA-1228P..\$39ea. 2 for \$59**

We carefully removed these, sealed lead acid batteries from unused 4 battery "trays" intended as part of a power backup system. They are in mint condition. Regular price of this battery is about \$90ea. Now is your chance to perk up those heavy duty power projects. Perfect for powering battle bots, telescopes or as part of a solar power system. Even your fish finder, underwater camera or smaller trolling motor. The list is endless. The size is a manageable 6.5"W x 6.9"H x 4.9"D, weight is 22 lbs. Heavy duty, lead post type connections with 6mm bolt

**NEW & IMPROVED, SONY EX-VIEW, 0.003Lux,**  
**WEATHERPROOF or UNDERWATER,**  
**B&W CAMERA, 16X MORE SENSITIVE.**  
**Now with 10 INTERNAL, INFRARED LEDs!**



Sleeve black anodized, BRASS, housing. O-Ring sealed & WATERPROOF down to 60feet. Adjustable mount included. Specs: 1/3" CCD, 400 Lines res., super 0.003 Lux sensitivity, AGC, Auto Shutter. 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. Perfect as a remote area, pipe or ductwork inspection camera. Excellent for general covert outdoor use.

**SPECIAL, GM-300KX-10.....\$169**

**SONY EX-VIEW CCD for the best "ASTRONOMICAL" PERFORMANCE available in an uncooled affordable camera! With 600 Lines Resolution. NEW! 0.00005 Lux.** Black and white, state of the Art Video, Our GMV-EX-6K, Takes the Prize. For covert, military & scientific applications, this is it. Unbelievable 0.00005Lux @ 10.8 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 X128. Frame rates of 60, 15, 8, 4, 3, 2, 1 and 0.5 per second. Auto/off 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, 12VDC ±1V@200mA, S-VIDEO on 4pin DIN connector. Std. video out on BNC. Size: 51mm x 51mm x115mm long. Regulated power supply incl. All functions externally controlled. C-mount lens not included.

**GMV-EX6K...\$529 Super, 6mm, f1.2 Manual Iris Lens...\$69**

**NEW, ULTRA LONG RANGE, 2.4GHz 500mW Video/Audio MINI-TRANSMITTER with EXTERNAL ANTENNA RECEIVER, Provides FOUR user selectable channels as well! YAGI or PARABOLIC ANTENNA INCLUDED!**

Simply connect ANY standard NTSC VIDEO to the self contained, 500mW, mini (3" x 2.5" x 0.75") transmitter. Omnidirectional patch antenna included inside transmitter. Now you can transmit up to several miles clear line of sight! Using the companion, external antenna receiver is a simple connection to the attached 36" long cable, terminated in a male N connector. Receivers video output works with any TV or VCR. Receiver is powered by 12DC @300mA. Receiver size is: 6"L x 3"W x 1.5"H. The transmitter is powered by 5VDC @ 450mA. (all AC power supplies and cables included). Choose your choice of a 14dB YAGI antenna or a 24dB Parabolic antenna. (see antennas at [WWW.RESUNLTD4U.COM](http://WWW.RESUNLTD4U.COM))  
**AST-LR-YAGI.....\$329 set. AST-LR-PARABOLIC.....\$369 set.**



**STEPPER MOTORS, NEMA 34, HEAVY DUTY, NEW! STEP-SYN, type 103-820-0241 Stepper Motor from SANYO DENKI.**

A three piece set of Nema size 34 flange, Heavy duty, Brand new, 2deg. per step, six wire steppers. Superior, dual sealed ball bearings for heavy loads and long life. Marked for 4.5V @ 1.4Amps. We do not know the official torque spec. We believe it to be 150 to 200 oz/in if you know, please let us know. Overall size is: 3.4" Diam. x 2.5" Deep with a 0.375"D shaft that is 1.1"L. Weigh 2.5 lbs. each. A very nice DIY stepper with a lot more to offer than the usual nema 23's.



**SANYO-3.....3 motors for \$59ea.**

Circle #54 on the Reader Service Card.



Selected Titles for the Electronics Hobbyist and Technician—

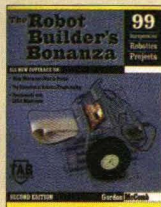
# The Nuts & Volts Hobbyist Bookstore

## 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

### Programming & Customizing the HC11 Microcontroller

by Tom Fox

Applications bazaar for the 68HC11 microcontroller. Squeeze every 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**



### 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**



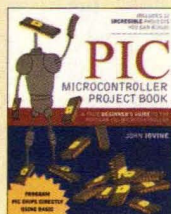
**WE ACCEPT VISA, MC, AMEX**  
Prices do not include shipping and may be subject to change.  
**Ask about our 10% subscriber discount on selected titles.**

Call 1-800-783-4624 today! or  
order online at [www.nutsvolts.com](http://www.nutsvolts.com)

### 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. **\$49.95 both volumes**

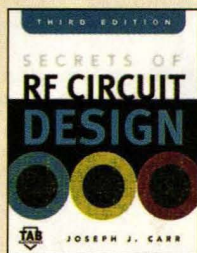


## Radio & RF

### 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**

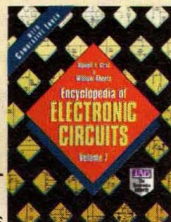


## Electronics

### Encyclopedia of Electronic Circuits Vol. 7

by Rudy Graff

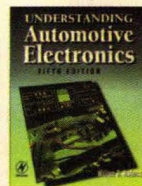
Designed for quick reference and on-the-job use, the Encyclopedia of Electronic Circuits, Volume 7, puts over 1,000 state-of-the-art electronic and integrated circuit designs at your fingertips. This collection includes the latest designs from industry giants such as Advanced Micro Devices, Motorola, Teledyne, GE, and others, as well as your favorite publications, including Nuts & Volts! **\$39.95**



### Understanding Automotive Electronics Fifth Edition

by William B. Ribbens

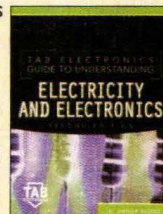
This edition of Understanding Automotive Electronics covers the most recent technological advances in operation and troubleshooting of electronic systems and components. This is a practical text, suitable for the automotive technician, student or enthusiast. It includes low-emission standards, on-board diagnostics and communications, digital instrumentation, and digital engine control. **\$34.99**



### 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**

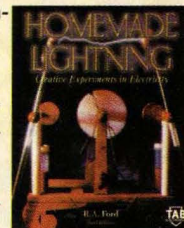


## High Voltage

### 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**

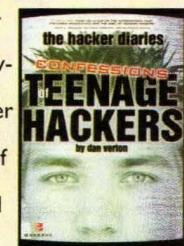


## Miscellaneous

### 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**





# Polaris Industries - The Solution To Your 2003 Security Needs!

## MICRO-COMPACT CONE-LENS CAM

The LP-700C Color Lipstick Camera is our 4.3 pin-hole camera that offers 78 degrees of viewing angle. The image device is a Sony 1/3" Super HAD CCD. This color camera comes complete with stand, video and power cables. The unique cone lens provides for easy covert installation. The LP-700B offers you the same great features in Black & White with 420 TVL.



LP-700C \$149.95

LP-700B \$89.95

## 4-CHANNEL 2.4 GHz WIRELESS CAM

- 1st Wireless Camera Designed For Extended Operation on Battery (15 hours!!!)
- Four Channels with Audio
- Four LED Channel Indicators
- Built-in High Gain Antenna
- Ultra Compact Design (Smaller Than a 9 Volt Battery)
- Excellent Choice For Your Covert Applications

IN STOCK NOW!



MWC-01 \$189.95

## 5" MONITOR / 2.4 GHz RECEIVER



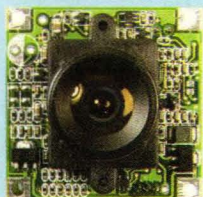
**WM-2400** The 5" Active Matrix TFT provides exceptional brightness and contrast for one of the widest viewing angles of any TFT. An internal 2.4GHz Wireless Receiver with 4 channel selection adds even more to this great deal. The monitor/receiver also comes with an Audio/Video input jack.

WM-2400 \$249.95

## BOARD CAMERAS

20 Different Models Available

**MB-780U**  
B/W BOARD CAMERA  
\$29.95



VISIT OUR WEBSITE!!!

IP View Applications:  
Supports OS

Win 98  
Win 98 SE  
Win 2000  
Win Me  
Win XP



## DIGITAL MONITORING & RECORDING SYSTEM

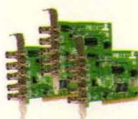
The PV-140 Series turns your PC into a commercial grade digital security system in a few minutes. This incredible series integrates a color quad processor, multi-zone video motion detector, multiplexer, and a real time digital video recorder (DVR). By ordering additional cards, you can increase your surveillance up to 16 different cameras.

Software  
Included!!!

PV-140A/B/C/D \$299.95

PV-140 PACK  
4 Pieces/One Pack  
\$1099.95

SAVE \$100



Real-Time Video Digital Recorder

## 1/3" COLOR IR DOME CAMERA WITH PTZ

The SSD-DM1 Dome Camera, measuring in at 109 mm x 89 mm, is the smallest PTZ camera available on the market today. This Speed Dome Camera can pan 355 degrees, tilt 85 degrees, and has a 3X digital zoom. A built-in microphone adds more functionality for one-way audio monitoring. The SSD-DM1 System utilizes a 1/3" Sony CCD chip, which provides 470 TVL of high resolution with a 3.8 mm lens.

SSD-DM1 \$399.95

Complete Package Pictured Here!



## 1/3" HIGH RESOLUTION COLOR CAMERA

The ILC-600 Color Lipstick Infrared Camera is our highest resolution Lipstick Camera currently available. Along with its incredibly high resolution (480 TVL), it is rated with a 0 Lux. The ILC-600 measures 1.63" x 3.93", yet is small enough to fit into most applications. If you want a Lipstick Camera that is compact, high resolution, and can see in total darkness, this is the camera for you.

ILC-600 \$199.95



## WIRELESS INTERNET CAMERA

### Specifications:

**Video**  
Resolution 640 x 480 pixels  
Sensor 1/3" Color CMOS  
Shutter Electronics 1/60 ~ 1/15000 sec  
**Image**  
Image Compression JPEG  
Frame Rate 30fps  
Compression Rate Selection 5 Levels  
Video Resolution 160x120, 320x240, 640x480

### System Hardware

LAN Connector One RJ-45 port to connect to 10/100Mbps Ethernet, auto-sensed  
Wireless LAN Built-in 802.11b wireless LAN module (Wi-Fi compliant)  
Generic I/O Port Input Port x 2 & Output Port x 2  
Power Supply DC 5V/2.4A, switching type; 6.5 Watt  
Antenna Connector 2 connectors

### Communication Support

10/100TX Ethernet Only  
10/100TX Ethernet & 802.11b Wireless LAN  
802.11b Wireless LAN Only  
Encryption: 64 bit, 128 bit or OFF  
Communication Protocol: HTTP, FTP, TCP/IP, UDP, ARP, ICMP, BOOTP, RARP, DHCP, PPPoE

### System Requirements for IP View

CPU - Pentium III, 450 MHz or above  
Memory - 28 MB (256 MB recommended)  
VGA Card - 800 x 600 or above

Remote/Local Monitoring  
Still Image Capture  
Video Recording  
Event Trigger Email

WIC-10 \$499.95



### Package Content:

Wireless Internet Camera  
Wireless Antenna (two)  
Camera Stand Accessory (one)  
Power Adapter (one)  
CD-Rom - User's Guide  
Xplug Control (ActiveX module)  
IPView Application Software  
Quick Installation Guide

800-308-6456

WWW.POLARISUSA.COM

800-308-6456

Circle #73 on the Reader Service Card.



# Electronics Q&A

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.**

## What's Up:

This month is audio/visual. Two audio test instruments and two ways to get stereo from mono. Two LED projects: colorimeter and auto taillights. And a new antique radio supplier category for the FINDPART file.

## Audio Wattmeter Uses DMM

**Q.** I am in need of a direct-reading analog audio wattmeter capable of indicating RMS power up to 100 watts (or more) using a 4-, 8-, or 16-ohm dummy load. I have searched the Internet to no avail. Can you help?

**John Pinto  
Morgan Hill, CA**

**A.** If you have a DMM (digital multimeter), you can calculate the power output of an audio amplifier. The RMS power rating of an audio amp is measured by applying a sinewave at the input of the amplifier and measuring the AC voltage at the output using the AC settings of the DMM. The power output can then be simply calculated from the equation:

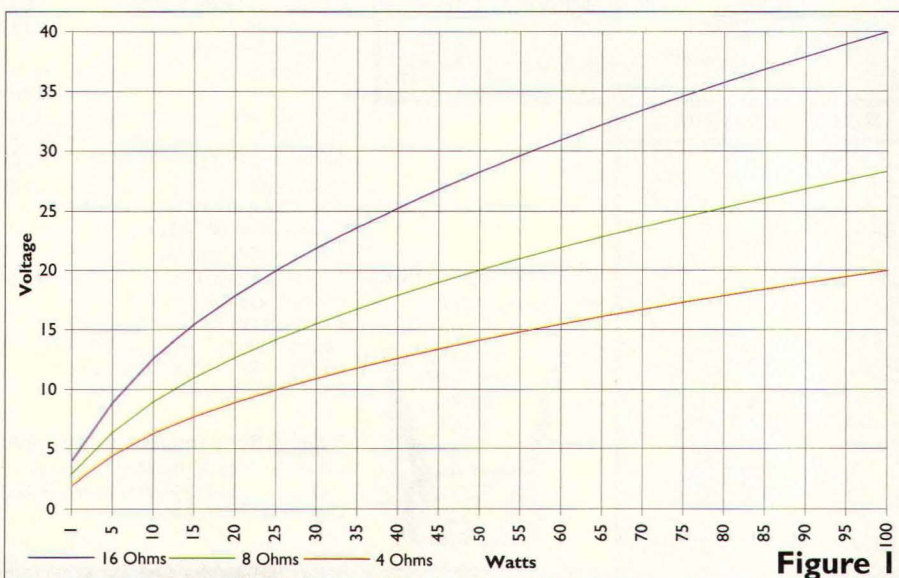
$$\text{Power (RMS)} = \text{Volts}^2 \text{ (RMS)} / \text{Impedance}$$

For example, the wattage of an amplifier with an output of 20 volts across a four-ohm load is:

$$\text{Power} = 20^2 / 4 = 400 / 4 = 100 \text{ watts}$$

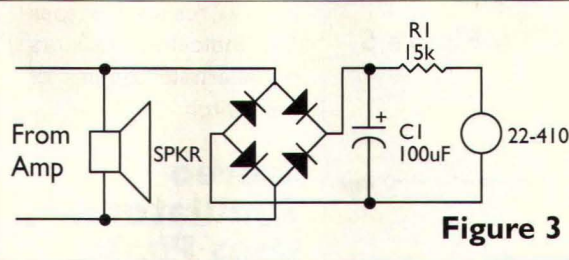
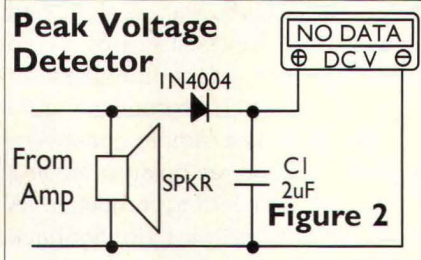
What is the wattage of 36 volts across an eight-ohm load? Rather than hauling out the calculator, I looked it up using the chart in Figure 1.

However, RMS amplifier power shouldn't be confused with the Peak Music Power (PMP) rating. PMP takes into account that music isn't a continuous sinewave, but contains sudden sharp peaks within the music content. At an output level where these sudden peaks just begin to distort, the underlying music level will be a mere percentage of this — typically 40%. That means the demand on the power supply will also only be 40% of its rated value. Most audio systems take this into account and specify their power output ratings in peak watts rather than RMS — that is, they are taking advantage of the average power of the power supply. An audio amplifier rated at 100 watts PMP will actually be about 70 watts peak, and



**Figure 1**





35 watts RMS.

For this, you need some way of measuring peak voltage using your DMM. Here's a simple circuit that will do just that (Figure 2). The response time of this circuit should be about one second (assuming you have a one-megohm DMM). This can be changed by decreasing (faster response) or increasing (slower response) the value of C1. You can use the same chart in Figure 1 for the calculations.

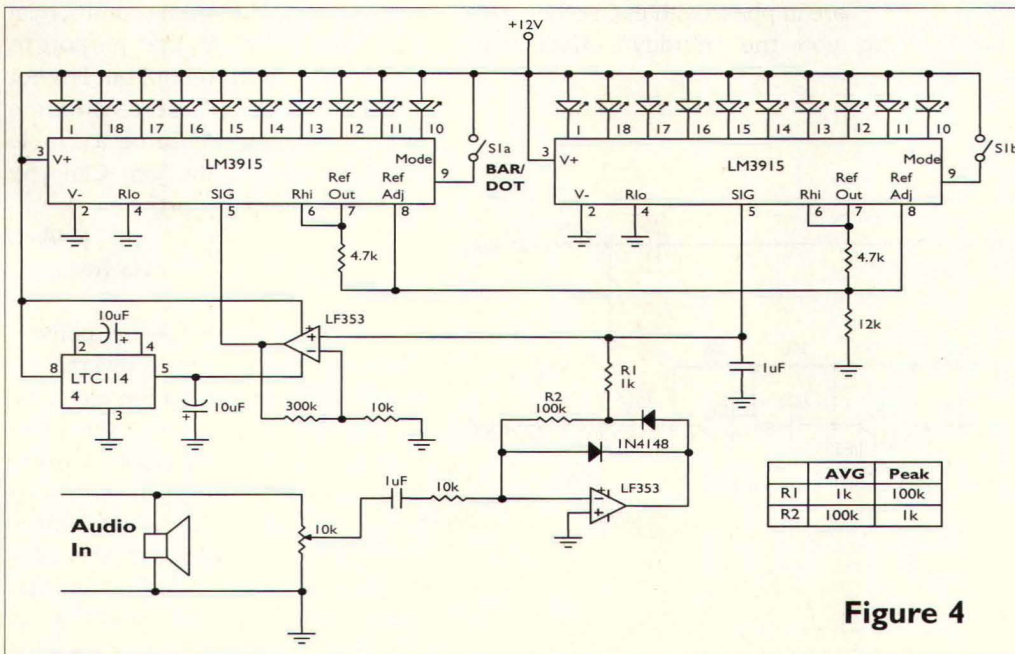
Still want an analog meter? No problem — except for the calibration of the scale. Simply replace the DMM with the circuit in Figure 3. I used a RadioShack 15-volt panel meter (22-410) for my experiments. Using the values shown, full scale will be 55 watts into a four-ohm load. You'll have to adjust the value of R1 for other speaker impedances. For 55 watts at 16 ohms, R1 is 30k. Use the chart in Figure 1 for the R1 calculations (hint: use Ohm's Law) and scale calibration. You'll probably want to flip the scale over and use a marker pen or decals to create a new meter face.

## Audio Level Meter Uses LEDs

**Q.** I would like a circuit design that would indicate the peak voltage of an audio signal, and display it on a trio of LED bar-graph devices, like the Mouser 351-2403. It would be desirable to acquire the input signal directly from the speaker wires, but monitoring the output of the pre-amp output of my stereo receiver is acceptable. While the peak-hold feature is desirable, it isn't absolutely necessary.

**Dale L. Smith  
Lafayette, NJ**

**A.** To begin with, you really don't need 30 LEDs — which equals 90dB — to measure most audio signals. To reduce circuit complexity (which is already complex enough for this column), I set the range to 60dB by reducing the number of LEDs from 30 to 20 (two bar display devices). The circuit (Figure 4) uses two LM3915s log dot/bar display drivers that are easily cascaded.



**Figure 4**

# DMOS & JFETS & MOSFETS & TRANSISTORS

@  
**LINEAR SYSTEMS**

Second Source Replacements  
for Interfet, Motorola,  
National, Siliconix

- ◆ Custom Screening
- ◆ Die, SMT, Thru-Hole

**LINEAR SYSTEMS**

Full Service U.S. Manufacturer  
of Specialty Linear Products

4042 Clipper Court  
Fremont, CA 94538

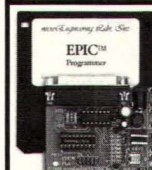
(TEL) 510-490-9160

(FAX) 510-353-0261

JFETS@LINEARSYSTEMS.COM  
WWW.LINEARSYSTEMS.COM

Circle #55 on the R/S Card.

## PICmicro MCU Development Tools



**EPIC Plus**  
PICmicro MCU  
Programmer

**\$59.95**  
Assembled

EPIC Bundle with  
cable, AC adapter, and  
40-pin ZIF - \$99.95

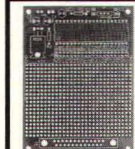
## BASIC Compilers for PICmicro MCUs

PicBasic Compiler - \$99.95  
PicBasic Pro Compiler - \$249.95

## LAB-X Experimenter Boards

Pre-assembled  
hardware for testing  
and development.

LAB-X1 - \$199.95  
LAB-X2 - \$69.95  
LAB-X3 - \$119.95



**PICProto**  
Prototyping  
Boards

selection from  
\$8.95 to \$19.95

microEngineering Labs, Inc.

Phone: (719) 520-5323  
Fax: (719) 520-1867  
Box 60039, Colorado Springs, CO 80960

Complete product information and online  
ordering at: [www.melabs.com](http://www.melabs.com)

Circle #56 on the R/S Card.



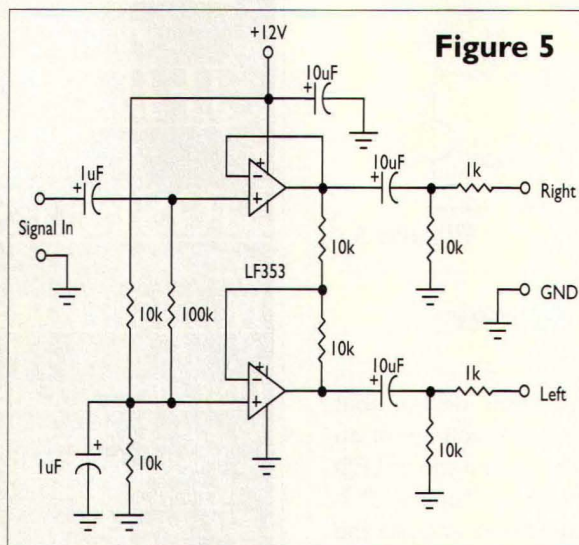


Figure 5

1k resistor across the indicated resistors on alternate toggles of the switch.

## Stereo Simulator Uses Phase Inverter

**Q.** I saw your solution to the "Speaker Mixer" question in the Dec. 2002 issue, and was reminded of a similar problem I have. My PC has a stereo capture card that

I use for digitizing videos. The problem is that my analog camcorder is mono, so only one channel of the audio gets connected to the capture card. I've tried using a "Y-adapter" to share the audio signal on both the left and right channels, but the audio sounds like it's under water. Can you suggest a simple audio splitter circuit that would allow me to feed the audio signal from the camcorder to both the left and right channels of the capture card?

**Kelly Small  
Phoenix, AZ**

**A.** The problem is that the signals are in phase with each other, giving you the "muddy" effect you

describe. What you want is simulated stereo. The simplest form of stereo simulation is to reverse the phase of one channel, as I have done in Figure 5. The circuit is a simple non-inverting voltage follower op-amp feeding a unity-gain inverting amplifier. A small 12-volt wall-wart (RadioShack 273-1773 or equivalent) is all the power supply you need for this design.

Reversing the phase of the outputs produces the out-of-phase relationship needed to generate a stereo image, and tends to spread out the sound, giving a very basic form of pseudo stereo. While this isn't the perfect stereo simulator (you'll probably notice a hole-in-the-middle effect), it's certainly the easiest to construct and use. If it's better stereo you want, check out the design in the answer below, "Stereo Simulator Uses Phase Shifter."

## Stereo Simulator Uses Phase Shifter

**Q.** I am presently transferring my collection of classical 78 records to CDs for my grandchildren. The problem is that they sound flat when played on their new stereo equipment. I suspect they would appreciate the music more, if I could convert it to stereo. I've seen commercial units, like the AN-2, that purport to make stereo from mono, but I'm not made of money. These records are exactly hi-fi, and I assume a simple circuit should do the job. Can you show me where to start?

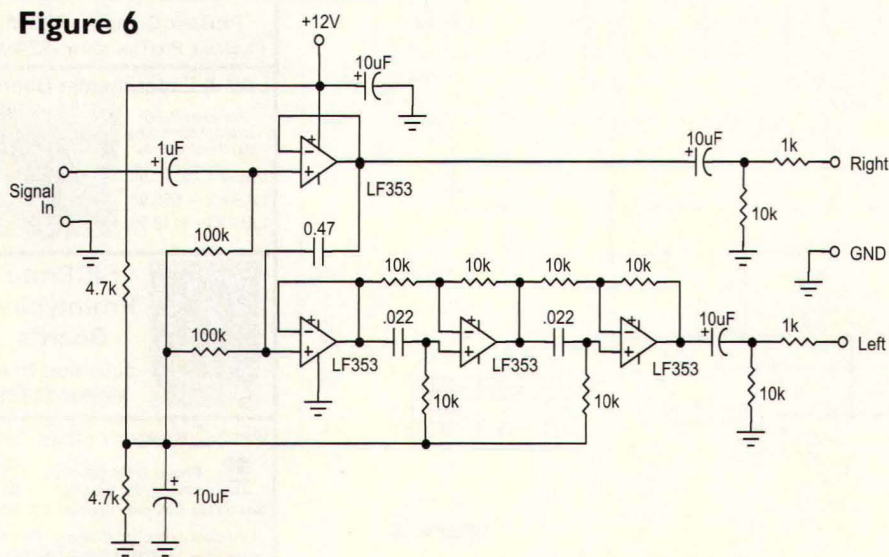
**A. J.  
via Internet**

**A.** The simplest way to convert mono to stereo is to reverse the phase of the signals. In the old days, we did this by reversing the loud-speaker wires. Today, I do it using op-amps, as shown in the previous answer ("Stereo Simulator Uses Phase Inverter"). However, this play leaves a lot to be desired in that there's a noticeable absence of sound between the speakers, called

The display driver part of the circuit is the classic dot/bar display driver as outlined in the LM3915 datasheet. All that is needed is an interface to the speaker, which was also shown on the datasheet, but not in full detail. To make this circuit work, a split power supply is needed for the LM353 op-amp. To increase accuracy, I used an LTC114 voltage inverter. In this design, any change in the source voltage (V+) is automatically mirrored in the V- line so that the zero reference point won't drift.

You'll also notice that I've included resistance values for both peak and average measurements. If you wish to switch between them, simply use a DPDT switch to insert a paral-

Figure 6





the hole in the middle. A better method is to separate the frequencies, as well as the phase. Stereo simulators like the AN-2 do it using highly-refined comb filters which are expensive and complex in design. Over the years, I've discovered that if you place the low frequencies on the left channel and the higher frequencies on the right, the stereo effect is improved. But the drawback is a boom-box sound to the left coupled with a loud hiss on the right. A compromise between a true comb filter and simple frequency separator is to use a frequency-sensitive phase shifter. (See Figure 6.)

In this design, there are two cascaded phase shifters that work in combination of inverting and non-inverting modes, resulting in unity voltage gain somewhere between zero and 180 degrees of phase shift. By using double inversion, low-end frequencies give no phase change. At middle frequencies, there is about 90 degrees of shift, which is fed to both the left and right speakers to give the stereo effect and, at the same time, fill in the "hole." The center frequency of the phase shifters is about 1 kHz, a frequency to which the human ear is most sensitive.

## Colorimeter Uses RGB Sensors

**Q.** I want to build a circuit like the one at this link: [www.electron-ic-circuits-diagrams.com/sensor-images/sensorsckt3.shtml](http://www.electron-ic-circuits-diagrams.com/sensor-images/sensorsckt3.shtml). I think I can handle the electronics (I'm sort of a beginner), but I'm having a problem finding the color filters. Do you know of an electronic color sensor that can be substituted for the lenses and filters?

**Scott via Internet**

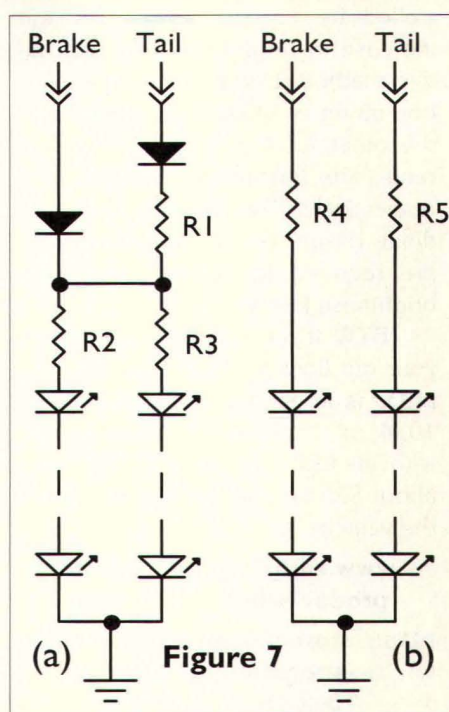
**A.** As a matter of fact, I recently ran across just what the doctor ordered for this design (Figure 8). Taos makes a family of sensors with a built-in color filter of red, blue, and green ([www.taosinc.com/pressre](http://www.taosinc.com/pressre)

[lease\\_100102.htm](#)). The output is a linear voltage of 0 to 5 volts, depending on the amount and color of the light falling on the sensor. The logic inputs are configured with inverters to detect the colors the outputs represent. For example, magenta is the presence of red and blue, and the absence of green. By inserting an inverter in the green output, it becomes a logic high when there is no green light, causing the output of the 4073 to go high and light the magenta LED.

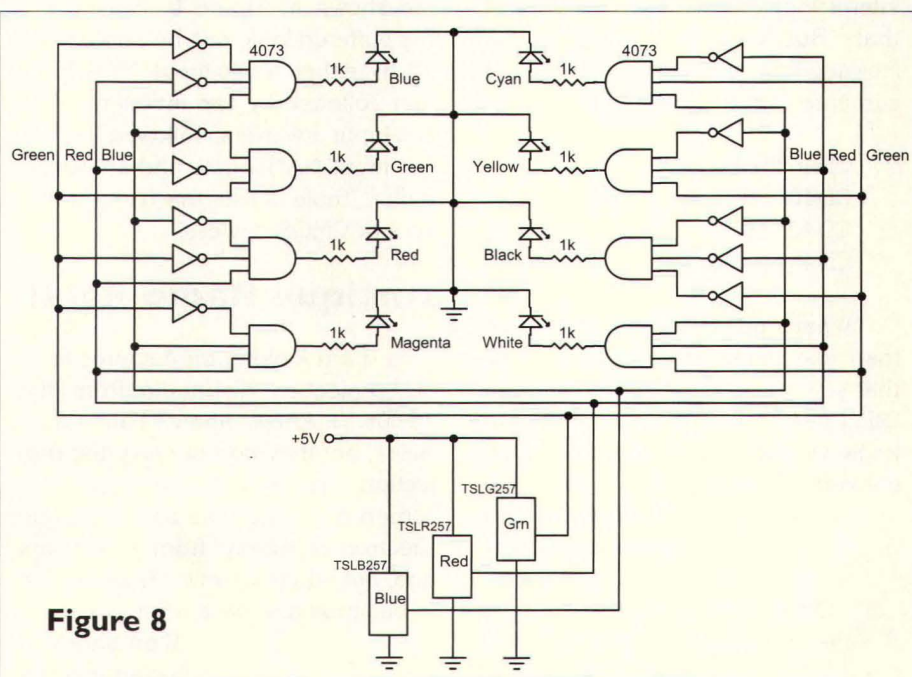
## LED Auto Taillights

**Q.** I am making LED taillights for my motor home. It's an older model that has bad wiring, with all the light sockets in bad shape. Besides that, I just like the LED taillights I have seen on trucks and buses. I've been to the truck-repair places and parts houses, but they just don't have what I want. I did learn something that puzzles me, though. On inspection of the units available, I noticed that along with the LEDs and resistors that you would expect, they have a diode 1 or 2. What are they for?

**Don McRae via Internet**



**A.** My guess is they are steering diodes used to control the taillight brightness between running and braking. Let me demonstrate using Figure 7. The circuit in (a) is probably what you are referring to. When the taillights are on, the current is limited by resistors R1, R2, and R3. When the brake light is applied, the current is limited by R2 and R3, thus bypassing R1. Since LED brightness is con-



**Figure 8**



trolled by current, the LEDs will increase in brightness. The alternative method, circuit (b), is to assign one string of LEDs for taillights and the other for brake lights. The currents are limited by R5 and R4, respectively. The advantage of the diode design (a) is that fewer LEDs are required to achieve the same brightness levels.

BTW, if you can repair or replace your old light sockets, upgrading to LEDs is as simple as replacing the 1034 or 1157 incandescent lamps with an LED equivalent. They cost about \$25.00 and will last the life of the vehicle. You can buy them from:

[www.signaldynamics.com/  
products/bulbs/1157.asp](http://www.signaldynamics.com/products/bulbs/1157.asp)

[http://store.valueaccessories.net/  
subcatmfgprod.asp  
?0=222&1=316&2=-1](http://store.valueaccessories.net/subcatmfgprod.asp?0=222&1=316&2=-1)

[www.graphicartmotodesign.com  
/lights/led\\_e.htm](http://www.graphicartmotodesign.com/lights/led_e.htm)

## IC Markings Defined

**Q.** I am writing to you from the wilds of North Dakota! I use the 4000 series of CMOS integrated circuits, and found your recent comments about changing a sine wave into a square wave using a CD4011 interesting, and I am going to try just that. But when I looked in my Newark catalog for a CD4011, I came up with these choices.

CD4011BE  
CD4011BF  
CD4011BM  
CD4011UBE

What's going on here? It's more than just packaging because I see that several of these numbers are in DIP. I can find no one that seems to know why there are so many different versions of the same chip.

**Lyle A. Nelson**  
Devils Lake, ND

**A.** Other than temperature range, the biggest difference between the different types of CMOS gates is

Designation	Temperature Range	Comment
4011BC	-40C to +85C	Commercial version
4011BE	-55C to +125C	Industrial version
4011BF	-40C to +85C	SOIC package
4011BM	-55C to +125C	SOIC package
4011BT	-55C to +125C	Radiation hardened, SOIC
4011UBE	-55C to +125C	Unbuffered version

**Table 1**

in the outputs. Devices with a "B" suffix have buffered outputs and those with a "UB" suffix are unbuffered. What's the difference?

A buffered-CMOS device is one that has an additional gate following the logic device. It exhibits output ON impedance that is independent of any and all valid input logic conditions. Buffered gates have higher gain and noise immunity, but the added buffer increases propagation time (the time it takes the output to react to a change on the input).

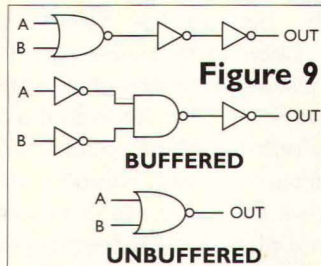
Unbuffered-CMOS devices are functionally identical to B-series devices, except that the logical outputs are not buffered and the VIL (logic LOW) and VIH (logic HIGH) specifications are 20% and 80% of VDD, respectively. Unbuffered gates have lower propagation times and faster rise/fall rates.

Logic examples of the buffered and unbuffered two-input NOR gates are shown in Figure 9. Notice that the buffered logic can be implemented by either a two-input NOR function, followed by two inverters or by two-input inverters, followed by the two-input NAND gate and an output buffer. Table 1 lists the different flavors of CMOS devices.

## Antique Radio Parts

**Q.** I am looking for a source for a projection dial radio from the 1930s. I know about Fair Radio Sales, but they do not carry the projection dial film or other parts. I remember the name "Antique Electronics Supply" from a few years ago, but I do not know if they are still in business and have what I need.

**Don Sands, II**  
Davenport, IA



**Figure 9**

**BUFFERED**

**UNBUFFERED**

**A.** Rock Sea Enterprises (<http://members.aol.com/rockseaeant>) and D'Antiques Radio/TV ([www.dantiques.com/radio.htm](http://www.dantiques.com/radio.htm)) are your best bets. You'll find a comprehensive list of antique radio suppliers below. This list is also posted in the PARTFIND file available on our web site ([www.nutsvolts.com](http://www.nutsvolts.com)).

### All Things Radio

A comprehensive resource for the antique radio enthusiast.  
[www.allthingsradio.com](http://www.allthingsradio.com)

### Antique Electronic Supply

800-706-6789

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

### D'Antiques Radio/TV hardware items — just what it says.

[www.dantiques.com/radio.htm](http://www.dantiques.com/radio.htm)

### Fabius Antique Radio

<http://members.aol.com/GDevine396>

### Radio Trader

[http://members.aol.com/  
OLRTmag/main.htm](http://members.aol.com/OLRTmag/main.htm)

**Links, links, and more links**  
[www.mindspring.com/~cacutts/radio/li  
nk/link.html](http://www.mindspring.com/~cacutts/radio/link/link.html)

### Nostalgia Air

free on-line schematics and manuals.  
[www.nostalgiaair.org](http://www.nostalgiaair.org)

### Radio Electric Supply

Vacuum tubes  
352-332-8881

[www.vacuumtubes.net/page/  
indexc.html](http://www.vacuumtubes.net/page/indexc.html)

### Rock Sea Enterprises

dial scales, decals, plastic overlays from originals.  
805-646-7362

<http://members.aol.com/rockseaeant/>

## MAILBAG

Dear Mr. Byers:

You had a question in a recent



issue about the "retired guy who fixes scopes," especially Tektronix. That is my close friend, Bob Garcia KD4JRT, of Marietta, GA. They call him "The Scope Man" in hamfest circles. Bob's email is [esaronel@bellsouth.net](mailto:esaronel@bellsouth.net). He is very active in both doing expert repair and selling used scopes and test equipment, and his reputation and guarantee are beyond compare.

**Allen Bond WB4GNT**  
via Internet

Dear TJ:

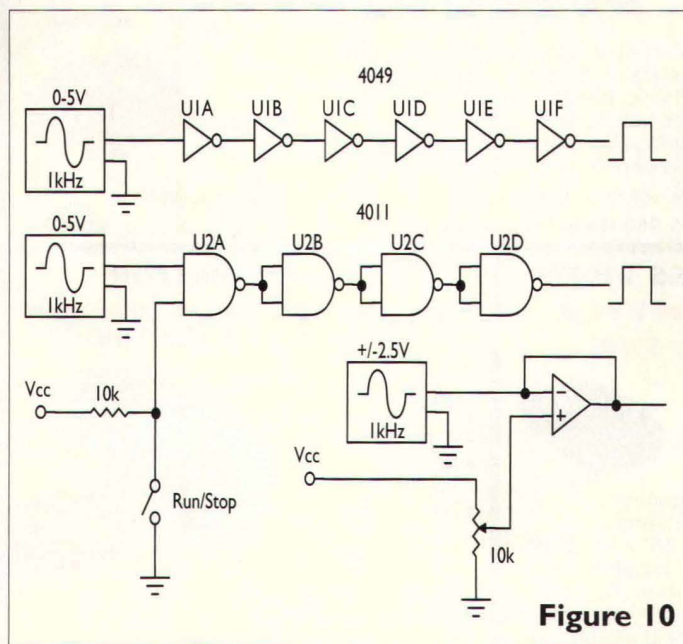
I have a couple of comments for you about the "Sine-to-Square Wave Converter" circuits you proposed in your Dec. 2002 column.

The  $\pm 1V$  swing of the sinewave doesn't provide enough amplitude to get a solid logic 1 into a TTL or CMOS device. It may work under some circumstances, but I wouldn't rely on this type of circuit, even in a hobby circuit. Also, TTL devices — like CMOS chips — shouldn't have their inputs connected to voltages below ground.

You mentioned using an op-amp to offset the  $\pm 1V$  sinewave, and that's a good idea. But instead of simply offsetting the sinewave, amplify it so it swings from, say, 0 to between 4V and 5V. The amplification and offset puts the signal solidly in the logic 0 range and into the logic 1 range for TTL and CMOS chips. Using the amplified sinewave to drive a TTL Schmitt trigger such as an 7414 would do the trick, too.

**Jon Titus**  
Milford, MA

*Editor's reply: Hello Jon, long time no hear. Actually that's a typo. I forgot to turn off the default settings on my schematic capture program before submitting this circuit. I caught this right away — in print, the same as you did. Figure 10 is a corrected schematic.*



**Figure 10**

## Do You Repair Electronics?

For only \$9.95 a month, you'll receive a wealth of information:

Repair data for TV, VCR, monitor, audio, camcorder, & more.

Over 100,000 constantly updated problem/solutions plus...

- TechsChat live chat room.
- UL/FCC number lookup.
- Private user discussion forums.
- Hot tips bulletin board.
- Automated email list server.
- Manufacturer information.

To access RepairWorld, direct your internet browser to <http://www.repairworld.com>

# RepairWorld.com

Electronix Corp. 1 Herald Sq. Fairborn, OH 45324 (937) 878-9878

Circle #57 on the Reader Service Card.

**Weeder Technologies**

[www.weedtech.com](http://www.weedtech.com)  
DATA SHEETS

**RS-232 Stackable**

1710-B Brighton Cove, Ft Walton Beach, FL 32547

850-863-5723

**Digital I/O Module** - 14 I/O channels individually configured for input or output. Turn on/off relays. Sense switch transitions, button presses and 4x4 matrix decoding using auto-debounce and typematic repeat with adjustable delay. One-shot pulse output. **\$59**

**Analog Input Module** - 8 single-ended or 4 differential inputs. Self-calibrated, 12-bit ADC, reads voltages from 0 to 4095 mV. High & Low alarm trip-points for each input. **\$69**

**Analog Output Module** - 4 outputs that span -10 to +10 volts using 12-bit DAC. Built-in ramp generator, software calibrated, user selectable POR defaults for each channel. **\$89**

**Stepper Motor Driver** - Directly drives a unipolar stepper motor rated up to 30VDC @ 2A. Self-generated S-curve accel/decel profiles provide smooth start and stop motion. Software programmable ramp-rate, velocity and idle current. Single-phase, dual phase, & half-step drive modes. 24-bit absolute motor position counter. **\$69**

**Pulse Counter/Timer** - Read frequency from 0.50000 Hz to 1,500,000 Hz using floating decimal point and 5-digit resolution throughout range. Measure period, RPM, duty cycle, pulse length, the velocity of a projectile using a pair of trip wires. 24-bit pulse count accumulator for event counting. **\$79**

**Plug end-to-end**  
Stack 32 modules on the same RS-232 cable.

**Solid State Relay Module** - 5 opto isolated relays can be wired directly to existing low-current buttons and switches to provide software control of their operation. Built-in event sequencer. **\$69**

Dear TJ:

Please consider us for your list in PARTFIND.DOC? We are sellers of surplus and refurbished equipment including repair/replacement/experimenter parts and accessories.

We have many hard-to-find electronic items and parts, including a large selection of original manufacturer service manuals and much more geared towards the hobbyist — all at reasonable prices. We are a small family-owned business in operation since 1975 and on the web since 1997. Our web site and catalog is at [www.smcelectronics.com](http://www.smcelectronics.com).

**Steven Carlozzi**  
**SMC Electronics**

## Cool Web Sites!

A jukebox loaded with pop hits from the 50s, free for listening or download in WindowsMedia format. Tunes by Buddy Holly, Fats Domino, The Coasters, and many more.

[www.bobforrest.com/JukeBox.htm](http://www.bobforrest.com/JukeBox.htm)

A nice selection of free traditional Chinese music in MP3 format. This music is still played throughout China during celebrations, festivals, and holidays. All tracks feature the basic gongs and drums sound of old traditional Chinese music.

[www.chinesepaintings.com/music/music.htm](http://www.chinesepaintings.com/music/music.htm)



# World's Smallest Video Cameras • Wireless Video

## SUPERCIRCUITS

### HOT VALUE CAMERA



**World's Best Video Camera Value!**

- Tiny .95" Square
- 86 Degree F.O.V.
- 240 Line Res, 0.5 Lux
- Latest Gen CMOS Imager
- Auto Shutter, Gain, Backlight
- Low Smear & Blooming Suppression
- Draws Only 20 mA At 12 Volts DC
- Plug And Play Cables
- 1 Year Warranty And 30 Day MBG

PC166XS B/W Video Camera ..... \$19.95

### MICRO AUDIO SYSTEM

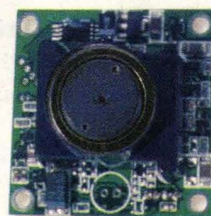
**Super High Gain Preamplifier!**



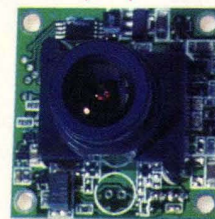
- Built-in preamp for low noise, high gain and auto level adjustment by the on-board IC
- The weight is under 1/2 ounce
- Output is line level
- Runs on 6-15 volts DC at 20 mA
- Comes with 6 ft. power/audio cables and a 30 day MBG

PA3 Micro Audio System ..... \$12.95

### PC-100 SERIES MICROVIDEO CAMERAS



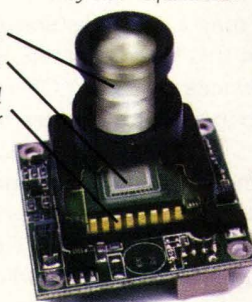
**From Only \$27.95!**



Tiny 1.25" square size!

PC-100XS (right and cut-away view below) uses a precision 5 element microlens. Both PC-100XP (above) and PC-100XS feature Samsung video chipset with 250,920 pixels.

Precision 5 Element Microlens  
High Performance CCD  
On-Board Advanced Signal Processor



- High 410 Lines Res.
- Low Light Ability- .5 Lux
- Samsung Chipset
- Plug and Play Cables
- 1 Year Warranty
- 30 Day MBG
- Excellent Value

Comes with easy connection instructions, pre-installed plug and play video and power cables, 1 year warranty and 30 day money-back satisfaction guarantee.

PC-100XP Pinhole Microvideo Camera ..... \$29.95

PC-100XS Microvideo Camera ..... \$27.95

### DAY AND NIGHT COLOR INFRARED CAMERAS

**See up to 50 feet in total darkness!**

- Weatherproof Case
- Built-in Photocell
- 400 Lines Of Resolution
- 0 Lux Rating
- 1/3" Color Sony Super HAD CCD
- 70° Field Of View
- 12 Volts DC, 500mA
- 1 Year Warranty



**NEW!**

Comes with easy instructions, 1 year warranty and 30 day money-back satisfaction guarantee.

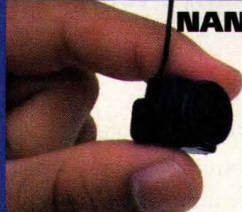
PC177IR-1 Color Day/Night Video Camera 12 FT ..... \$159.95

PC177IR-2 Color Day/Night Video Camera 35 FT ..... \$179.95

PC177IR-3 Color Day/Night Video Camera 50 FT ..... \$199.95

### NANOBUG WIRELESS ATV VIDEO CAMERA

**Incredible tiny size- weighs less than an ounce, runs on a 9 volt battery!**



- Size is a amazing .88" X .57" X .92"
- Latest 1/4" B/W CMOS imager
- Receives video just below channel 14 on a slide rule hand held TV
- Transmitting frequency is 434MHz
- Range is up to 1500 feet
- Runs on 9 volts at 50 mA
- 1 year warranty/30 day MBG



AVX434-S1 Wireless Camera ..... \$249.95

### 960 HOUR TIME LAPSE VCR-- ONLY \$299.95

**1 Year Warranty!**



**This security VCR lets you record up to 960 hours on a T-160 videotape --That's a whole month!**

- Selectable Modes 2 Hours Through 960 Hours
- Easy-To-Use On Screen Programming
- Alarm, Panic, Repeat and Timer Options
- Diamond Like Carbon Coated Head For Super Durability
- 24 Hour Real Time Recording Mode
- Endless Loop Recording--Set It And Forget It

Comes with easy connection instructions and a one year manufacturers warranty.

VCR960-5 960 Hour Time Lapse VCR ..... \$299.95

**Under \$300!**

### 2.4 GHz WIRELESS UTILITY BOX CAMERA 700 foot range weatherproof wireless video security system.

- B/W 1/3" CCD, 410 lines res
- Color 1/4" CCD, 380 lines res
- 0.5 low light rating for both
- 3.7MM lens, 70° field of view
- Transmitter uses 2.4GHz band
- Tiny 1/16" pinhole lens
- Both run on 12 volts DC
- 1 year warranty/30 day MBG



Comes with camera, transmitter, easy instructions and 1 year manufacturer's warranty.

CVL50 Mini B/W 2.4 GHz TX/RX System .. \$229.95

CVL51 Mini Color 2.4 GHz TX/RX System \$319.95

### WIRELESS VIDEO 700 Foot Range, Under \$110!



- FCC Part 15 Approved
- Transmits Video And Audio
- Transmitter Is 2.5" x 3.2" x .65"
- Four Channel Operation
- Both Units Operate With The Included 12 Volt Power Supplies
- 1 year warranty/30 day MBG

MVL10 Wireless Link ... \$109.95

### 1" MINI MONITOR Perfect for set-up and alignment of cameras in the field

- Black and white display
- 76,800 pixels
- 320 X 240 resolution
- Solid state LEDs
- Runs on 2 AA batteries
- 4.4" X 1.7" X 1.3"
- 1 year warranty
- 30 day MBG



**NEW!**

Comes with easy connection instructions, 30 day money back guarantee and 1 year manufacturer's warranty. Batteries not included.

MON-1 Mini Monitor ..... \$119.95



# Complete Video Security • Amazing Covert Video

## 4 CAMERA B/W VIDEO SECURITY SYSTEM

**Gives You Complete Surveillance and Protection For Under \$500!**



- View all 4 cameras on one screen
- Professional quality equipment
- Custom lenses and cable lengths to fit your installation
- 2 year warranty on cameras and quad
- Lifetime free technical support



Comes with 4 of our PC-152C video cameras and lenses, a realtime quad processor, a high resolution 12" monitor, and much more.

VSSI-HG 4 Cam B/W Video System ... \$499.95

## VIDEO SECURITY

### WIRELESS COVERT VIDEO CAMERA SYSTEMS Great for homes, offices, warehouses & factories!



Pen has remote transmitter. Others are built-in.

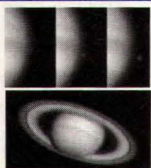


High quality pinhole cameras provide excellent video in nearly undetectable concealments. Range is up to 700 feet with the included receiver. You get the "locked on" crystal clear performance of an IC controlled FM synthesized transmitter design, the efficient 900 megahertz band, combined with the drift-free signal reception of a phase lock loop receiver. All units are operate on 9 volts and use a high quality Panasonic CCD camera. License required for legal operation.



Comes with concealed camera/transmitter, matching receiver, 1 year warranty, and 30 day MBG. Lens not included.

WCV9-PG Color Covert Phone Camera ..... \$549.95  
WCV10-PG B/W Covert Pen Camera ..... \$449.95  
WCV8-PG Color Covert Cigarette Camera ..... \$399.95  
WCV12-PG Color Covert Calculator Camera ..... \$559.95



### SUPER LOW LIGHT CAMERAS

**Announcing a breakthrough camera that virtually sees in the dark!**



Actual PC-164C images of Saturn and Jupiter's moon shot through a telescope by James Ferreira of Livermore, California.

Because of the PC-164Cs incredible low light abilities it has been widely used in amateur astronomy. The super low 0.0003 lux rating means that it can see objects at least two magnitudes fainter than the super sensitive 0.04 lux PC-23C. In addition, a number of deep sky objects can now be observed in real time with moderate to large aperture scopes. This new camera has quickly been embraced by amateurs, particularly those doing planetary, lunar, and asteroid imaging. Resolution is an excellent 420 lines and color has 350 lines of resolution.

Comes with easy connection instructions, 1 year warranty, and 30 day MBG. Lens not included.

PC164C B/W Ex-View Camera ..... \$129.95  
PC165C Color Ex-View Camera ..... \$229.95

### DIGITAL VIDEO RECORDER

**Only \$399.95! Our Lowest Priced DVR Ever!**

- Single channel digital video recorder
- 60 images per second
- Playback search
- RS232 compatible
- Alarm inputs
- Time/Date stamp
- Password protection
- Video loss detection
- NTSC/PAL compatible
- Rack mountable



**NEW!**

Comes with easy connection instructions, and 1 year warranty.

DVR-7 DVR ..... \$399.95  
DVR7-80 DVR with 80GB Hard Drive ..... \$499.95  
DVR7-160 DVR with 160GB Hard Drive .... \$649.95

### WORLD'S SMALLEST VIDEO CAMERA

**Tiny 0.375" Square by 0.625" Size-- Ultra Mini Pinhole Video Camera!**

**NEW!**



- Incredible 0.375" square X 0.625"
- 380 Lines horizontal resolution
- 0.5 Low lux rating
- Built-in 3.5MM pinhole lens
- Latest generation 1/7" CMOS
- 12 Volts DC at only 20mA
- One year warranty and a 30 day MBG

Comes with power cable, complete instructions, 1 year manufacturer's warranty and 30 day money-back satisfaction guarantee.

PC206XP 12 Volt Monochrome Video Camera .... \$99.95

### SPECIAL INTEREST CORNER: R/C AIRBORNE VIDEO

#### COMPLETE 900 MHZ WIRELESS SYSTEMS

IC controlled FM synthesized transmitter with up to two miles of range

High resolution camera w/ enclosure

Phase lock loop receiver

Systems includes camera, antennas, battery pack, power supply, camera housing, 6 month warranty and 30 day MBG



Live R/C airborne video puts you in the aircraft. Thrilling, live cockpit video is now a practical reality. We are proud to present the spectacular videotape from Dave Upton Productions, IN-CAB R/C VIDEO LINK. No other videotape offers more information on the "how-to's" of live airborne video, and you'll be blown away by the amazing aerial video footage shot off the rugged Oregon coast. VHS, 70 minutes.

Our new wireless systems are designed especially for radio-controlled airplanes, cars, helicopters, boats, rockets and other hobbyist applications. Imagine getting a bird's eye view as you guide your plane or helicopter through the sky! It's great fun and a wonderful educational experience for the youngsters. The tiny transmitter is smaller than a Zippo lighter and weighs 1.6 ounces. The tiny high resolution CCD cameras, with automatic signal processing, give you great performance in nearly all lighting conditions. Requires an amateur radio license for legal operation.

AVX900S8-V 900 MHz Wireless B/W Video System ..... \$249.95  
AVX900S9-V 900 MHz Wireless Color Video System ..... \$349.95  
RCINCAB Videolink Incab Video ..... \$24.95

**FOR MORE INFORMATION, LOG ON TO OUR WEBSITE!**

## SUPERCIRCUITS

Buy Online At [www.supercircuits.com](http://www.supercircuits.com)  
or Call Us Today To Order  
or Request A Free Catalog

**1-800-335-9777**

One Supercircuits Plaza, Liberty Hill, TX 78642  
Phone 1-512-778-6950 Fax 1-866-267-9777

Prices, specifications and availability are subject to change without notice. Published Terms & Conditions Apply. Copyright 2002 Supercircuits, Inc.



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

# Stamp Applications

## Gettin' MIDI With It

Well, last month I introduced you to the new PBASIC compiler, so now it's time to have some fun and put it to work. Even though we're going to keep things simple, you'll be able to see that PBASIC 2.5 lets you write cleaner code that's even easier to maintain. You'll probably find — as I have — that you can actually write programs a bit faster because there is no more forward-thinking about **GOTO** labels for **IF-THEN**. Let's get started.

**Y**ou'd be hard-pressed to find anyone who doesn't like music; in fact, most of us like several varieties. Having experienced the late 60s and early 70s as a youngster, I lean toward what is now called "classic" rock (Led Zeppelin, Jimi Hendrix, etc.), but I also like Classical, Grunge, and even a bit of Rap. Music is probably as old as mankind and is unique in that it not only helps define cultures, it easily crosses cultural boundaries.

Music and electronics go way back, too. Pop quiz: What was the first electronic musical instrument? If you said the theremin, go get yourself a cookie — you win. The theremin was invented in 1919 by Russian physicist Lev Termen (who became Leon Theremin). The theremin became very popular for music and sound-effects in horror

and science fiction movies, and even found its way into popular music. (The Beach Boys used a theremin-like instrument on "Good Vibrations" and Led Zeppelin guitarist Jimmy Page frequently used a theremin on stage.)

Since I like music (I can even thrash out a couple Counting Crows songs on my guitar) and I love BASIC Stamps, it just makes sense that I should work with both at the same time. And, in December, I was out in our Rocklin office and saw a Stamp-controlled xylophone that one of my colleagues (Stephen) had created. That same week, I assisted a New York professor who has the interesting occupation of teaching music and technology. Music and technology ... that sounds like a lot of fun.

### Musical Connections

While the theremin was the first electronic musical instrument, it was (and still is) a specialty device and never became mainstream. The electronic synthesizer, however, is a different story altogether. In the early 1980s, a group of synthesizer manufacturers got together to create a standard that would allow various instruments to connect to and control each other. The standard they created is called MIDI: Musical Instrument Digital Interface.

The MIDI specification (see [www.midi.org](http://www.midi.org)) actually has three components: the

protocol, the connection, and a file format. For our part, we're going to focus on the protocol. Of course, we'll also take a look at the connection since our goal is to have the BASIC Stamp play music on a MIDI-compatible instrument.

The MIDI protocol — as it turns out — is very straightforward and easy to implement; even on a small micro like the BASIC Stamp. The protocol transmission scheme is straight serial at 31.25 kBaud; a value we're not generally used to, but not a problem for the BASIC Stamp, since we can calculate and set the *baudmode* parameter of **SEROUT**. For the BS2, the calculation of the *baudmode* parameter is:

$$\text{INT}((1,000,000 / \text{baud}) - 20)$$

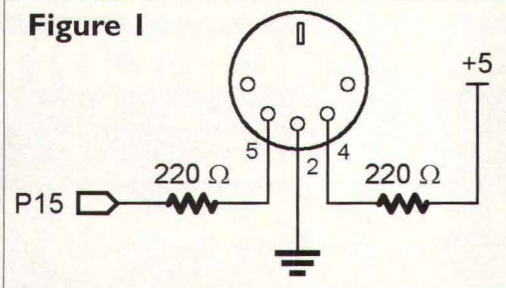
For MIDI we get:

$$(1,000,000 / 31,250) - 20 = 12$$

Since the MIDI interface standard uses an optical-isolator on the input that is pulled up by the connecting device, we can run in "open" mode. To do this, we'll add \$8000 to the *baudmode*.

Figure 1 shows the connection to the BASIC Stamp. As you can see,

Figure 1





the hardware is a cinch: a couple 220-ohm resistors and a five-pin DIN socket (female). This interface will let you connect your BASIC Stamp to any MIDI instrument using an off-the-shelf MIDI cable (you can pick one up at RadioShack®).

## MIDI Messages

MIDI message packets are small; usually a command followed by two data bytes. Since our goal this month is to allow the BASIC Stamp to play music through a MIDI instrument, the two messages we are going to be concerned most with are "Note On" (\$90) and "Note Off" (\$80).

Here's the syntax:

Note On: \$90, note (0 - 127), velocity (0 - 127)

Note Off: \$80, note (0 - 127), velocity (0 - 127)

If, for example, we want to send a "Note On" for Middle C at the loudest volume, we would do this:

```
SEROUT 15, $8000+12, [$90, $3C, $7F]
```

Pretty simple, isn't it? Yes, it is. Let's go ahead and create a program to experiment with sending MIDI messages.

Of course, you'll need an instrument to play. I used a MIDI-compatible keyboard (that, until I started this project, was the most expensive guitar tuner I owned ...).

Our program should let us specify a number of bytes to send (1 to 3), then accept the data, and transmit it as a packet when we're ready. If you're new to BASIC Stamps, this may sound a bit complicated, but as you'll see, this is actually a very simple application.

The first part of our program simply clears the **DEBUG** window and displays the title. Notice that there is a short **PAUSE** before the title display. This momentary blank screen serves as a visual cue. We'll get into that more in just a second.

Main:

D0

DEBUG CLS

PAUSE 500

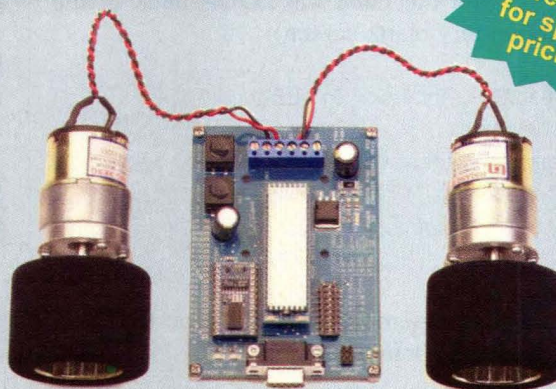
DEBUG "MIDI Explorer", CR

DEBUG "-----"

As I may have mentioned last month, the new compiler supports some new named constants; many that are used specifically with **DEBUG**. The first that we'll use is **CrsrXY** which positions the **DEBUG** cursor at the column and line values that follow. The next is **ClrDn**. This causes

# Get your motor running

Visit our  
website  
for special  
pricing!



Shown Here: BS2 Carrier Board, Motor Mind C, 2 Easy Roller Wheel Kits

Solutions<sup>3</sup>

Solutions Cubed  
(530) 891-8045  
[www.solutions-cubed.com](http://www.solutions-cubed.com)

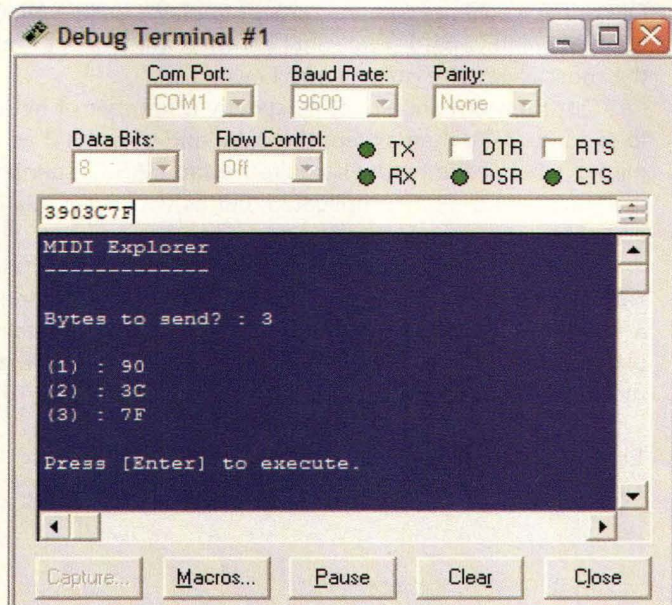
**Motor Mind C**

Up to 4.0A Current • 10-24VDC Motors  
Controls 1 or 2 Motors • 40 Pin DIP Package  
Serial, Analog or R/C Pulse Control

**Easy Roller Wheel Kit**

Simple & Sturdy  
Robot Wheel Kit





the **DEBUG** window to clear from the cursor line down.

After clearing any old input, we prompt ourselves for the number of bytes to send, then accept that value from the **DEBUG** window (**SERIN** on pin 16 at 9600 baud).

```
DEBUG CrsrXY, 0, 3, ClrDn
DEBUG "Bytes to send? : "
SERIN 16, 84, [DEC1 nBytes]
```

The following section does most of the work. First, we'll test for a legal *nBytes* value. If the value is okay, we'll loop through the number of bytes and take each one in as a two-digit hex value. Note the use of **CrsrXY** again and accepting serial data from the **DEBUG** window. If the *nBytes* value is out-of-range, the **THEN** portion of **IF-THEN** won't run and the code will **LOOP** back to the beginning (momentary blank screen).

```
IF (nBytes > 0) AND (nBytes <= 3) THEN
  FOR idx = 1 TO nBytes
    DEBUG CrsrXY, 0, (idx + 4)
    DEBUG "(", DEC1 idx, "): "
    SERIN 16, 84, [HEX2 midi(idx - 1)]
  NEXT
```

With the packet in memory, we'll **WAIT** on the Enter (CR) key to be pressed before sending it.

```
DEBUG CrsrXY, 0, (nBytes + 6)
DEBUG "Press [Enter] to execute. "
SERIN 16, 84, [WAIT (CR)]
```

The last step then, is to send the data. The **STR** modifier and **\Length** parameter make it easy to send the MIDI data. This works particularly well for us since we may want to change the number of bytes to send.

```
SEROUT MidiOut, MidiBaud, [STR midi\nBytes]
ENDIF
LOOP
END
```

Figure 2 shows the program in action. Something interesting that you may find with your instrument that I found with mine is that two consecutive Note On commands for the same note require two Note Off commands. This becomes very apparent with voice selections that don't have natural decay (volume fade).

Okay, if you were able to turn a note on and off, then you can actually play music via your BASIC Stamp. Why would you want to do this? Well, there are a lot of reasons including the fact that there is hardware available that responds to MIDI control signals (lighting, for example).

## Stamp-Made Music

If we can send one note at a time, we can send a whole bunch — in a specific order — to play music, right? You betcha.

Like the first, our second program is fairly short (the working part), but this one is just a bit more sophisticated. The purpose of this program is to play music stored in BASIC Stamp **DATA** statements.

The **DATA** statement is one of those features that migrated from "classic" PC BASIC implementations, though the Stamp makes it easier and more functional. Remember that the BASIC Stamp compiler writes the program's **DATA** statements to EEPROM, beginning at address 0 (unless specified otherwise) and building up. Program tokens are stored in the top of the EEPROM and build down. If there is a class between **DATA** and program tokens, the compiler will let you know.

There are several key features of the BASIC Stamp **DATA** statement that make it more flexible than past PC implementations. The feature I take most advantage of is the ability to name DATA locations. Look at this code:

```
Name DATA "Jon Williams", 0
Location DATA "Dallas, TX USA", 0
```

What we've done here is defined two zero-terminated strings. To print a string in the **DEBUG** window, we can use this subroutine:

```
Print_String:
  READ eePntr, char
  IF (char <> 0) THEN
    DEBUG char
    eePntr = eePntr + 1
    GOTO Print_String
  ENDIF
  RETURN
```



The subroutine needs to know where to get characters — the address of the string is put into the variable *eePntr*. So, if we do this:

```
eePntr = Name
GOSUB Print_String
```

... what's actually happening is that the compiler is evaluating the **DATA** statement labels into constant values that represent the EEPROM location of the first character in each string. Given no other **DATA** statements, *Name* evaluates to zero and *Location* evaluates to 13.

Another neat thing about BASIC Stamp **DATA** statements is the ability to store any kind of information that we want. Here's another example:

Name	DATA	"Jon Williams", 0
Birthday	DATA	7, 25
YrOfBirth	DATA	1962

As you can see, we've got a string, two Bytes, and a Word (and yes, that's really my birthday — don't forget the cards and gifts!). Actually, all data is stored as Bytes. For character and string data, the ASCII value is stored. For Words, they're stored Little-Endian — that is — low-byte first. As I pointed out last month, PBASIC 2.5 allows us to **READ** a Word with just one operation.

Finally, the information in our **DATA** statements is stored in EEPROM, which means we can change it at run-time with **WRITE**. This allows our program to change information and maintain it even when power is lost.

## Sing Me A Song, You're The Stamp-Man

Okay, let's play some music. The reason I spent a moment discussing the details of the **DATA** statement is that's where we're going to keep our song information. The key to this program is *how* we're going to store the song information.

While experimenting, I found that I could actually

**\$199**  
**SPECIAL OFFER**  
**Proteus PCB Starter Kit**  
 (Manual on CD)

# PROTEUS

## VSM

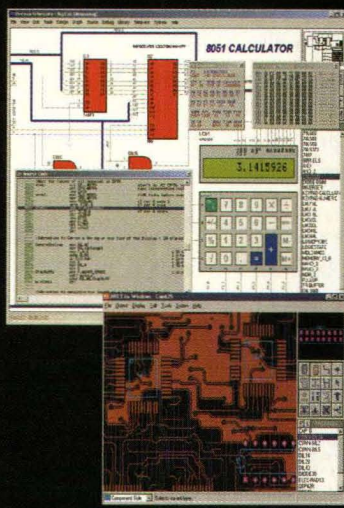
Virtual System Modeling

**Build It In Cyberspace**

**Web: [www.labcenter-electronics.com](http://www.labcenter-electronics.com)**


**Develop and test complete micro-controller designs without building a physical prototype. PROTEUS VSM simulates the CPU and any additional electronics used in your designs. And it does so in real time.\***

- CPU models for 8051/8052, Mc68hc11, PIC and Atmel AVR series micro-controllers available now. More CPU models under development. See website for latest info.
- Interactive device models include LCD displays, RS232 terminal, universal keypad plus a range of switches, buttons, pots, LEDs, 7 segment displays and much more.
- Extensive debugging facilities including register and memory contents, breakpoints and single step modes.
- Source level debugging supported for selected development tools.
- Integrated 'make' utility - compile and simulate with one keystroke.
- Over 4000 standard SPICE models included. Fully compatible with manufacturers' SPICE models.
- DLL interfaces provided for application specific models.
- Based on SPICE3F5 mixed mode circuit simulator.
- Integrates with PROTEUS PCB design to form a complete electronics design system.
- VSM integrates with LabCenter's Schematic Capture tool **ISIS**, the Mixed Mode Circuit Simulator **PROSPICE** and the PCB design tool **ARES**.



\*E.g. PROTEUS VSM can simulate an 8051 clocked at 12MHz on a 300MHz Pentium II.

LabCenter products distributed in the USA, Canada and Mexico by R4 Systems Inc.



Write, phone or fax for your free demo CD - or email [info@r4systems.com](mailto:info@r4systems.com).  
 Tel: 905.898.0665, Fax: 905.898.0683 Web: [www.labcenter-electronics.com](http://www.labcenter-electronics.com).



cause more than one note to play with the same "Note On" command. I simply stacked the note and velocity bytes behind it. Like this:

```
$90, note1, velocity1, note2, velocity2, note3, velocity3
```

By playing three notes at a time, I could play simple chords and make something a bit more musical. Okay! In the end, I came up with this storage strategy:

```
command, notes, timing, note1, velocity1 {, note2,
velocity2, note3, velocity3}
```

Note that the items in curly braces are optional. Here's an actual line from the program's **DATA** table to illustrate:

```
DATA NN, 3, Word N01, 060, 100, 064, 100, 067, 100
```

A few constants are used here. NN is the constant value for Note On (\$90). N01 is the constant value for a whole-note duration. This line of **DATA** represents a simple chord made up of the notes C4 (middle C), E4, and G4. All three notes are played at a velocity (volume) of 100.

All right, it's time to look at the program in action. Here's the main program code:

```
Main:
  eePntr = Mystery
  GOSUB Play_Song
  END
```

Really, that's the program — clearly all the work is done in Play\_Song and our previous discussion explains the use of *eePntr* and how it indicates one song from many stored in memory. Let's have a look at Play\_Song, then we'll go through it step-by-step.

```
Play_Song:
  READ eePntr, cmd
  IF (cmd < $FF) THEN
    READ (eePntr + 1), notes
    READ (eePntr + 2), Word nTime
    FOR idx = 0 TO (notes * 2 - 1)
      READ (eePntr + 4 + idx), midi(idx)
    NEXT
    SEROUT MidiOut, MidiBaud, [cmd, STR midi\ (notes * 2)]
    PAUSE nTime
    eePntr = eePntr + 6 + ((notes - 1) * 2)
    GOTO Play_Song
  ENDIF
  RETURN
```

This code is actually quite simple, even if it doesn't appear that way at first glance. We start by reading the

command byte. The program will use \$FF as an end-of-song indicator, so we have to test for that first. If the command byte is not \$FF, the rest of the subroutine will run, otherwise, we **RETURN** to the caller.

Assuming we have a valid command, next up is the number of notes (1 to 3) to play. After the notes is the timing for them. As you can see, we're taking advantage of the new Word modifier for **READ**. The timing value represents the last piece of fixed information. The number of bytes (for notes and velocities) varies; we could have two bytes, four bytes, or six bytes.

A **FOR-NEXT** loop is used to iterate through to the end of this line and store the notes and velocities in an array called *midi*. All that's left to do now is to send the command and data to our MIDI device. Once that's taken care of, we'll use **PAUSE** to create the note duration. We've got music. The last step is to update *eePntr* and go back to the top of Play\_Song.

To be honest, the trickiest part of this whole process was converting music into the **DATA** statements. If, for example, we needed to play a C4 and a D4 at the same time, with the C4 being a quarter-note long and the D4 being a half-note long, the **DATA** looks like this:

```
DATA NN, 2, Word N04, 060, 100, 062, 100
DATA NX, 1, Word N04, 060, 000
DATA NX, 1, Word 000, 062, 000
```

Can you see what's happening? The first line strikes both notes and holds them for a quarter-note duration. The second line stops the C4 and holds for an additional quarter-note duration. Remember, the D4 is still playing, so it is now a half-note long. Finally, the D4 is stopped.

I used a demo version of Sonar (from [www.cakewalk.com](http://www.cakewalk.com)) to read a MIDI file and display it in standard musical notation. Thankfully, Sonar has this really neat feature that displays note properties and velocity. The notes are shown as C4, G6, etc. To convert to numeric values, I used a table found at this link:

[www.harmonycentral.com/MIDI/Doc/table2.html](http://www.harmonycentral.com/MIDI/Doc/table2.html)

I'll tell you what ... the first person to identify the song in the main program will win a BASIC Stamp — a brand-new BS2pe-24. How about that? What that means is you have to download the code, build the interface and let it play. Send me an email with your answer.

Until next time, Happy Valentine's Day and Happy Stamping. **NV**

## Resources

**Jon Williams**  
[jwilliams@parallax.com](mailto:jwilliams@parallax.com)  
**Parallax, Inc.**  
[www.parallax.com](http://www.parallax.com)



# ALL ELECTRONICS

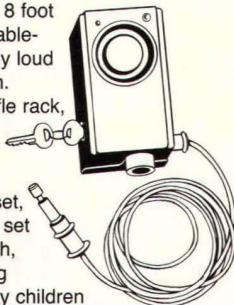
C O R P O R A T I O N

QUALITY Parts  
FAST Shipping  
DISCOUNT  
Pricing

CALL, WRITE, FAX  
or E-MAIL For A  
**Free 96 Page**  
CATALOG.  
Outside the U.S.A.  
send \$3.00 postage.

## Cable-Lock with 110 db Electronic Siren

Made by Masterlock. 8 foot vinyl-covered steel cable-lock with an extremely loud motion-sensing alarm. Designed to lock a rifle rack, the cable can be passed through the trigger guards of several guns. Once set, any slight motion will set it off. It is loud enough, 110 dB, and annoying enough to scare away children or others who might tamper with it. There is an 8 to 10 second delay before the alarm goes off to allow user to unlock the cable without being exposed to the loud siren. Could be used to protect cabinets, bicycles or machinery. Not designed for outdoor use. Includes two keys.



CAT # SW-625

**\$7<sup>95</sup>**  
each

10 for \$7.45 each  
Case of 54 pcs \$6.45 each

## Incredible Price! 12 Vdc 120mm Cooling Fan w/ Screen

JMC# 1225-12HBA  
120 mm (4.72") square x 25 mm (1") wide cooling fan. Dual ball bearing fan provides reliable output of 88 CFM @ 2600 RPM. 12 Vdc @ 0.6 Amps. 45 DbA max @ 1M. Designed for 50,000 hours @ 25 deg. C. Thermoplastic housing and 7 blade impeller. Three 7" pigtail leads with 3-pin connector (0.1" cntrs). Third lead is for sensing rotation. Prepped with metal finger guard. UL, CSA, CUL, CE. Large quantity available.



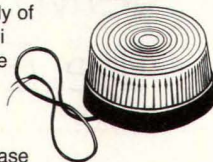
CAT# CF-153

**\$4<sup>00</sup>**  
each

90 for \$3.00 each  
450 for \$2.25 each  
990 for \$1.50 each  
1980 for \$1.00 each

## Special 12 Vdc Strobe Deal

We have a limited supply of this 12 Vdc 150 mA mini strobe. Available in three colors: red, blue and amber (yellow). 90 flashes per minute. Strobe is 2.65" dia. at base and is 2.44" at top. Overall height is 1.57". Black bezel is 2.89" dia. x 0.42". Only one hole needed for both mounting and wiring. Built-in 0.235" diameter screw has hollow center that allows power wire to pass through. Includes weather-resistant gasket and mounting nut.



RED CAT# STROBE-4R \$ 6.00 each  
BLUE CAT# STROBE-4B \$ 6.00 each  
AMBER CAT# STROBE-4Y \$ 6.00 each

## 24 Character X 2 Line LCD with LED Backlight

0.21" high characters. 5 X 8 dot format. LED backlight. Optrex # DMC24201. 0.63" x 3.7" viewing area. 1.53" x 4.7" module size. Removed in good condition, from new equipment. Prepped with 4" wire leads terminated with 15 pin socket connector (0.075" centers). Includes hook-up diagram.

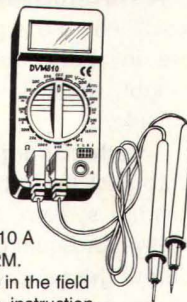


CAT # LCD-74

**\$9<sup>50</sup>**  
each

## Economy Digital Multimeter

Velleman #DVM810. Economical and compact multimeter with a 3 1/2 digit LCD for measuring DC and AC voltages, DC currents, resistance, diodes and transistors (hFE). Features overload protection. Ranges: DC and AC voltage, 500 volts, DC current, 0.2 A (fused), 10 A (not fused), resistance to 2M. Ideal for hobbyists, for use in the field and workshops. Test leads, instruction book included. 3.70" x 1.81" x 1.03" high.



CAT# DVM-810 **\$7<sup>95</sup>**  
each

## Color Video Camera w/ Audio



Here's one of the best deals we've seen on a "plug-and-play" color video camera with audio. The Corel CC2000 camera was designed for video conferencing. Its unusual housing was designed to sit on top of a monitor facing the operator. The lens swivels about 30 degrees in any direction and has settings for normal or wide angle viewing. The camera also has a threaded fitting for mounting on a tripod or camera bracket. Beige housing with a built-in lens cover that can slide closed when not in use. Overall dimensions 7" x 3.6" x 3.25." 6' cord with adaptor has RCA plug outputs for video and audio and a coax jack for DC power. Includes 9Vdc 1.5 Amp power supply. Works with any NTSC monitor or video recorder.

CAT# VC-127

**\$49<sup>00</sup>**  
each

## The Brightest!!! Super-Ultrabright Red LED

6000 mcd. Brighter than our ultrabright LEDs, this is the brightest 5mm red LED we've ever sold. Clear in the off-state. Standard T 1-3/4 package.

CAT # LED-94

**75¢**  
each

10 for 65¢ each  
100 for 50¢ each  
1000 for 35¢ each



## 12 Vdc 1.25 AMP Power Supply

DVE # DSA-0151-12  
2.1mm I.D. coax power plug. Center positive. UL, CSA.

CAT # PS-1215

**\$7<sup>25</sup>**  
each



10 for \$6.95 each • 100 for \$6.50 each

ORDER TOLL FREE **1-800-826-5432**  
Shop ON-LINE [www.allelectronics.com](http://www.allelectronics.com)

MAIL ORDERS TO:  
ALL ELECTRONICS CORP.  
P.O. BOX 567 • VAN NUYS, CA 91408-0567

FAX (818) 781-2653 • INFO (818) 904-0524  
E-MAIL [allcorp@allcorp.com](mailto:allcorp@allcorp.com)

NO MINIMUM ORDER • All Orders Can Be Charged to Visa, Mastercard, American Express or Discover • Checks and Money Orders Accepted by Mail • Orders Delivered in the State of California must include California State Sales Tax • NO C.O.D • Shipping and Handling \$6.00 for the 48 Continental United States • ALL OTHERS including Alaska, Hawaii, P.R. and Canada Must Pay Full Shipping • Quantities Limited • Prices Subject to change without notice.

**MANUFACTURERS - We Purchase EXCESS INVENTORIES... Call, Write, E-MAIL or Fax YOUR LIST.**





Understanding, Designing, and Constructing Robots & Robotic Systems

# Amateur Robotics

## Modifying an R/C Servo for Continuous Rotation — the Easy Way!

**W**ant a great drive motor for your robot? Look no further than your neighbor's R/C airplane! Inside that exact replica of a Fokker D. III are compact, yet powerful servo motors designed to operate the plane's rudder, ailerons, and other control surfaces. Though intended to be used with a radio transmitter and receiver, these same servos can be controlled electronically using the BASIC Stamp, OOPic, IsoPod, BASIC Atom, BasicX, or most any other microcontroller.

Why an R/C servo motor? They tend to be less expensive than comparable DC gearmotors of the same specification, and they come with their own driver electronics (more about this in a bit). They're definitely worth considering for your next robot.

As it comes out of its packaging, an R/C servo is limited to rotating just half a circle. That's handy for some robot applications, but not too helpful for driving a robot across the floor. Fortunately, it's possible to modify a servo to allow for full continuous rotation. There are a number of methods you can use; the one described here is my favorite. It's relatively quick and easy, requires no soldering or unsol-

dering, and needs only a minimum number of basic tools.

### Inside an R/C Servo

Before getting to the fun hacking bit, let's take a moment to look under the hood of the typical R/C servo. The average, standard-sized R/C servo (see Figure 1) is comprised of three major parts, all contained within a housing that measures 1-1/2 x 3/4 x 1-3/8 inches. While not all servos are this same size, they each contain these three major parts: motor, reduction gear, and control circuit.

**Motor.** The motor is a small DC-operated permanent magnet unit, capable of reversing direction. This motor may use the common iron core construction, or it may be "coreless," where the permanent magnets are in the center, and the lighter-weight windings rotate around the outside.

**Reduction gear.** The high speed output of the motor is reduced by a gearing system. Many revolutions of the motor equal one revolution of the output gear and shaft of the servo. In most servos, the output gear turns no more than 90 degrees in either direction. In fact, the final (output) gear of the servo contains a raised nub that physically prevents a larger arc. The typical output speed of an unloaded servo is around 1.0-1.4 revolutions per second. That's about right for the average desktop 'bot.

**Control circuit.** The output gear is connected to a

**Figure 1.** An R/C servo motor. Photo courtesy Hitec/RCD.

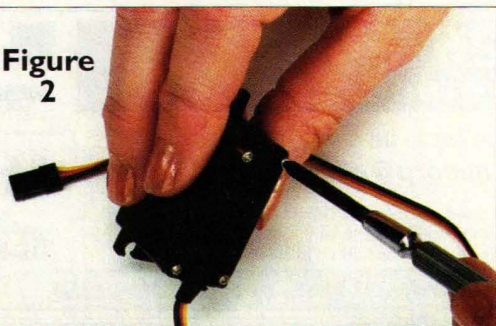


potentiometer — a common electronic device very similar to the volume control on a radio. The potentiometer connects with a control circuit, and the position of the potentiometer indicates the position of the output gear. Most potentiometers have a limited rotation of something less than 360 degrees; the raised nub in the output gear prevents the servo from turning beyond the limits of the potentiometer, which would otherwise damage it.

In a radio-control application, the receiver — mounted someplace in the airplane or vehicle — both powers and controls the servo. Most servos made today use a three-wire connection: ground, V+, and signal. The wires are color-coded to identify them, but the colors are not standardized. Usually — but not always — black or brown is ground, red is V+, and the remaining color (white, yellow, orange, blue, etc.) is signal.

All except certain Airtronics servos employ the same wiring sequence, with V+ in the center. In

**Figure 2**





this way, damage to the servo is unlikely if the three-pin connector is reversed. The "old style" Airtronics connector placed ground in the center. Reversing the connector could lead to servo damage. Note that Airtronics makes servos with the older style, as well as a standard wiring configuration. The company refers to the latter as "Z style."

Some of you may know this already, but it's worth reviewing. The control signal for the servo is in the form of a series of pulses. The duration of the pulses is what determines the desired position of the servo. Specifically, the servo is set at its center point if the duration of the control pulse is nominally 1.5 milliseconds (one millisecond is one-thousandth of a second, or 1,000 microseconds). Durations longer or shorter command the servo to turn in one direction or the other. A duration of 1.0 milliseconds (mS) causes the servo to turn all the way in one direction; a duration of 2.0 mS causes the servo to turn all the way in the other direction.

Note that the pulse width variance of 1.0 to 2.0 mS is nominal for most R/C servos, and that the full rotation of a servo is typically 130 to 180 degrees, depending on its mechanical design. Therefore, the actual pulse length of a servo commanded to rotate its full arc will likely extend beyond 1.0-2.0 mS. For example, full rotation (to the stop) for one given make and model of a servo might be 0.730 milliseconds in one direction, and 2.45 milliseconds in the other direction.

The nominal 1.5 millisecond pulse may also not precisely center all makes and models of servos. Slight electrical differences even in servos of the same model may produce minute differences in the centering location.

## Modifying Servos for Continuous Rotation

R/C servos are intended for such applications as controlling the steer-

ing in a car, or the ailerons in an airplane. They don't need to turn more than 90 or 180 degrees. When a drive motor is required — for the airplane propeller or the rear wheels of a car — a different type of motor is used. For small tabletop robots, these drive motors tend to be both too fast and too expensive. An alternative is to take an R/C servo, and modify it for continuous rotation by removing its internal stops.

By removing the mechanical stops and making a change in the electrical connections inside, it's possible for the output of the servo to turn continuously in either direction. Modified servos are often used for the drive wheels of small robots because their use simplifies both the mechanics and the control electronics of the robot. The servo package includes motor, reduction gearing, and power drive electronics, and can be directly connected to a microcontroller, computer port, or other digital interface.

Alas, while this might sound easy in theory, in practice, the specific design of the various servos on the market can make the modification process a real chore. Not only must the internal stops be disengaged, the potentiometer in the servo must either be removed, or its shaft locked into place.

There are many ways to modify R/C servos:

- **Power-train-only mod.** For this modification, the control electronics are removed completely, and the motor is driven by an external H-bridge. Any stops are removed from the power train, and the potentiometer is either removed or its shaft otherwise disengaged from the servo drive.

- **Signal tap-in mod.** In this conversion, the electronics of the servo remain, but as usual, the mechanical stops are removed and the potentiometer is disengaged. In this variation, the robot's computer or

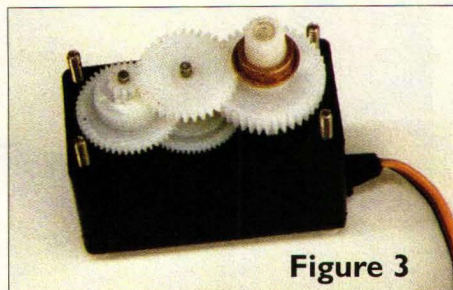


Figure 3

microcontroller is connected to the H-bridge chip within the servo's circuitry. Not all servos are so adaptable, however. Several Internet sites detail this tapping-in process for the BAL6686 H-bridge IC, used in Futaba and other servos. Do a google.com search for "BAL6686" for a number of useful sites that describe this.

- **Potentiometer mod.** Here all the control circuitry is left in place, but the potentiometer is either removed completely, or disengaged from the power train. If the potentiometer is removed, a new trimmer pot, or series of two 2.2K ohm resistors, takes its place.

The latter modification is by far the most common. Variations on it have been published in print and on the Internet for over 10 years. The most cited approach involves the Futaba S148 servo (still made, but they are getting harder to find); its potentiometer is replaced by two resistors. A good overview of this approach can be found on the Seattle Robotics User Group web site here: [www.seattlerobotics.org/guide/servohack.html](http://www.seattlerobotics.org/guide/servohack.html).

Most potentiometer mods call for soldering in addition to any mechanical changes. However, the design of many servos made today allow for a far less-invasive modification technique, where no soldering or unsoldering is required, and the potentiometer



Figure 4





**Figure 5**

is left in place. Alterations are made only to the output gear of the servo. After you get the hang of it, this mod takes only a minute or two, and requires only basic tools.

The no-solder process involves these basic steps:

1. Remove the four case screws of the servo.
2. Remove just the top case of the servo.
3. Remove the output gear, and cut off the stop nub on its top side.
4. Remove the potentiometer shaft clip from the underside of the output gear. Or, for servos that don't have a shaft clip (these use a molded-in socket that engage with the potentiometer shaft), drill out the bottom of the output gear. This removes the socket so that the potentiometer rotates freely.
5. Make sure the potentiometer is centered.
6. Replace the top of the case and the four screws.

Do note that this modification is not practical with all servos. If the output gear of the servo is supported only by the potentiometer shaft — there's no lower ball bearing or bushing — then this modification isn't recommended. Such servos tend to be

the least expensive, and aren't really suitable for modification, anyway. As you can imagine, modifying a servo for full rotation makes it work a lot harder than its manufacturers intended. A servo with no lower bearing or bushing will wear out much faster.

(A lower ball bearing or bushing is merely a metal or even plastic bearing on the underside of the output gear of the servo. This bearing supports the output gear so that the potentiometer does not have to support the load from anything attached to the servo shaft. Servos may also have an upper ball bearing or bushing, which is located on the top of the output gear. Throughout this text, I differentiate between a ball bearing and a bushing, the latter has no rotating parts, and is merely a smooth surface. Bushings can be made of metal, brass, oil-impregnated brass, nylon, and Teflon.)

## Hands On: Modifying the Hitec HS-422

The Hitec HS-422 is a good example servo to demonstrate the no-solder modification process. The HS-422 is widely available, and retails for under \$15.00. It employs both a top and bottom oil-impregnated brass bushing (often referred to as Oilite, a trade name) and a potentiometer shaft clip on the underside of the output gear. Tools needed are:

- #0 Phillips screwdriver
- 1/8" or smaller flat-bladed screwdriver
- "Nippy" cutters, X-ACTO blade, or razor saw
- Small flat jeweler's file

Here are the steps. Before performing the modification, however, test the servo for proper operation, just to be sure it's not bad to begin with. Though rare, some servos fail to work right out of the box.

Throughout the following, use care to avoid wiping off or absorbing through your skin too much of the lubricant used for the servo's internal gears. If you think too much of the lubrication has been lost, you can always add more just prior to re-assembly. Clear (or white) gear grease is available at any hobby store that sells R/C parts.

1. Using the Phillips screwdriver, remove the control wheel if it's attached to the output gear/shaft.

2. Untighten the four casing screws from the bottom of the servo (see Figure 2). I recommend you remove the screws completely, so that you can set the servo base down on the table while working inside it. Note that on a few servos, notably the Cirrus CS-71, the case screws are removed from the top.

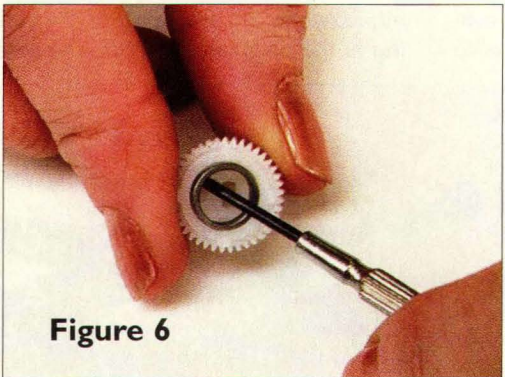
3. Observe the orientation of all the gears (Figure 3). Remove the center gear, being careful not to unseat its metal shaft. On the HS-422, the center gear cannot be easily removed without also lifting up the output gear. Do so, if needed. Place the center gear aside.

4. Remove the output gear.

5. Using the nippy cutters, X-ACTO blade, or razor saw, remove the nub on the top side of the output gear (refer to Figure 4). I like using the nippy cutters myself, but exercise caution! The harder the plastic, the more likely the nub will break off at high speed. Wear eye protection. Always nip first on the long side, to prevent possible breakage of the output gear. When using an X-ACTO blade or razor saw, the obvious precautions against cutting your fingers off should be observed. Work slowly.

6. Odds are no matter what cutting technique you use, a small portion of the nub will remain. This can be filed down with a small flat file (see Figure 5).

7. Use the small-bladed screwdriver to remove the metal retaining ring from the underside of the output gear (Figure 6). This ring retains the potentiometer shaft clip and serves



**Figure 6**



as a bearing surface.

8. Use the small-bladed screwdriver once more to remove the potentiometer shaft clip. See Figure 7.

9. Replace the metal retaining ring back into the output gear.

10. Align the potentiometer shaft so that it's centered (Figure 8). If needed, rotate it back and forth to find the center.

11. As an optional step, you may want to connect the servo to your control circuit. Apply 1.5 mS pulses. If the motor turns (even slowly), rotate the potentiometer shaft until all rotation is "nulled out."

12. Once set to its center, you can leave the shaft as-is, or apply a very small dab of cyanoacrylate glue (Super Glue™) to keep the shaft in place. Do not apply too much glue, or the potentiometer may be damaged.

13. Reassemble by placing the output gear on its seat over the potentiometer. Replace the middle gear, and observe that all gears properly mesh. Add more grease at this point, if needed. Finally, replace the top case and the four case screws.

Test the servo for proper operation by connecting it to your control circuit. A series of 1.5 mS pulses should stop the servo. A nominal signal of 1.0 mS pulses should rotate the servo in one direction; 2.0 mS pulses should rotate the servo in the other direction.

## Choosing a Servo to Modify

Now that you know the process of the non-solder servo hack, you can more readily determine which servos are suited to the job. The best servos, from a standpoint of easy modification:

- Use a lower ball bearing or bushing that supports the output gear. At the very least, the output gear should be supported by a molded-in ledge, rather than directly on the potentiometer

Figure 8

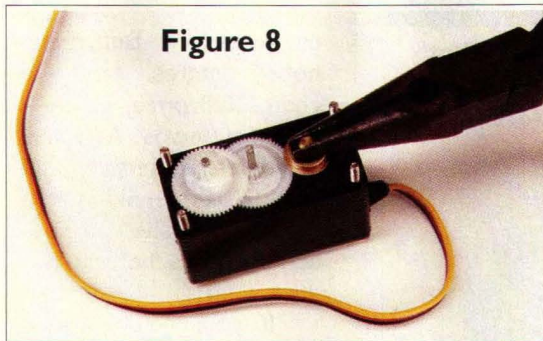
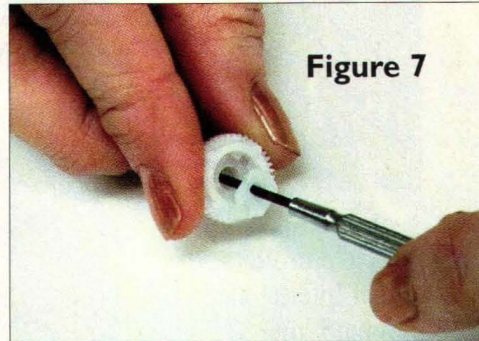


Figure 7



ter shaft.

- Use a removable potentiometer shaft clip. The clip can be readily removed in order to disengage the output gear from the potentiometer shaft. Servos that lack a removable clip will use instead a molded-in channel that the potentiometer fits into. This is the case of the Hitec HS-300 and HS-311, and the Futaba S-3003 and S-3004. If your servo is so constructed, you'll need to carefully drill out the bottom of the output gear in order to remove the channel. It's always best to start with small drill bits and work up.

- Use a plastic output gear, rather than a metal gear. The better, heavy-duty servos use a metal output gear. While the metal is able to handle increased stress, it's significantly harder to modify. If your servo of choice uses a metal output gear, a motorized hobby tool such as the Dremel will make the job of grinding down the nub much easier.

## Even More Servo Mods

The Internet provides a number of sources for information on how to modify popular standard-size servos. Many are based on removing the potentiometer. In addition to the Seattle Robotics User Group URL noted previously,

check out the following:

**AI's Robotics**  
[alsrobotics.botic.com](http://alsrobotics.botic.com)

**Lynxmotion**  
[www.lynxmotion.com/smodh1.htm](http://www.lynxmotion.com/smodh1.htm)  
[www.lynxmotion.com/smodh2.htm](http://www.lynxmotion.com/smodh2.htm)

**Robot Store**  
[www.robotstore.com/download/Servo\\_Mod\\_Notes\\_1.0.pdf](http://www.robotstore.com/download/Servo_Mod_Notes_1.0.pdf)  
(the above requires Adobe Acrobat)

**UI Robotics Club**  
[www.indiana.edu/~roboclub/info/servos.html](http://www.indiana.edu/~roboclub/info/servos.html)

## Sources for Inexpensive Servos

The local hobby store is a great place to find that little do-dad, wheel,

Do you remember the nights you  
laid awake asking yourself  
"What ever happened to the CueCats?"  
It's Simple

**We  
Got'EM!!**

CueWho?? CueCat a Simple  
Low Cost Barcode Scanner

Keyboard or USB Interface  
Electro Mavin 42 years of Bargains,  
Quality, and Customer Satisfaction  
800-421-2442 or FAX 310-632-9867

E-Mail [john@mavin.com](mailto:john@mavin.com)  
<http://www.mavin.com>

We Buy New Unused Technical Product,  
Military and RF Connectors Our Specialty





## Mobile Robotics

Used world wide for research!



Mobile Robots  
Micro Controllers  
Artificial Intelligence  
Sonar Units  
Optics  
Vision Systems



Zagros Robotics  
PO Box 460342  
St. Louis, MO 63146-7342  
Phone (314)768-1328 Fax (314)576-5568  
<http://www.zagrosrobotics.com>  
[info@zagrosrobotics.com](mailto:info@zagrosrobotics.com)

Circle #38 on the R/S Card.

## QUICK and PAINLESS Programmable Robotics!

**Have Your Robot  
Walk AND Chew Gum  
AT THE SAME TIME!**



Our Co-Processor adds  
**SUPER NEW FEATURES** to  
the best of the usual ones.  
Really Steps UP a Stamp.  
See how far our Products  
take YOU!

Blue Bell Design Inc.  
[www.bluebelldesign.com](http://www.bluebelldesign.com)

Circle #39 on the R/S Card.

## Amateur Robotics

or accessory. But many hobby stores tend to charge full price, or close to it, for servos. A typical standard-size servo might cost \$20.00, making it a rather expensive proposition to outfit a 'bot with two drive wheels.

If your neighborhood hobby store offers discount prices, all the better. But if it doesn't, you can turn to mail order and online buying. As we wrap up this month's Amateur Robotics column, I leave you with some online stores that sell servos at a discount:

**Balsa Products**  
[www.balsapr.com](http://www.balsapr.com)

Reseller of the low-cost Grand Wing servos, including the powerful (but slow)

BP148T, rated at 100 oz.-in.

**Budget Robotics**  
[www.budgetrobotics.com](http://www.budgetrobotics.com)

Limited selection, but discount prices. Also sells pre-modified servos at a discount. (Disclosure note: this is my company.)

**Servo City**  
[www.servocity.com](http://www.servocity.com)

Reseller of Hitec and Futaba servos.

**Tower Hobbies**  
[www.towerhobbies.com](http://www.towerhobbies.com)

Slightly higher prices than the others, but they have a good selection and customer service. **NV**

Gordon McComb can be reached at [www.budgetrobotics.com/](http://www.budgetrobotics.com/) or [robots@robotoid.com](mailto:robots@robotoid.com).

## STEEL IMPERIUM

SOUTHERN CALIFORNIA'S  
FIRST OFF-ROAD ROBOT  
FIGHTING EVENT!

- Dirt
- Mud
- Fire
- Strategy
- ... Glory

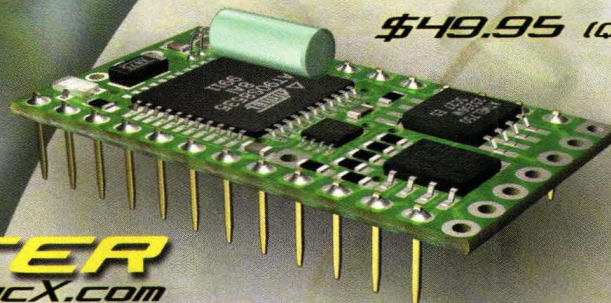
[WWW.STEELIMPERIUM.COM](http://WWW.STEELIMPERIUM.COM)





**ANYTHING THEY CAN DO...**  
**WE DO...**

**BASICX24™**  
**\$49.95 (Qty 1)**



**...FASTER**  
**WWW.BASICX.COM**

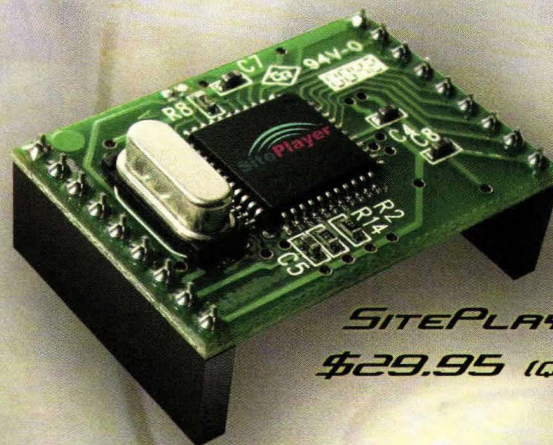
Executing 65,000 lines of Basic code per second the BasicX-24 is the KING of Basic programmable microcontrollers.

400 bytes RAM.  
32K User program area.  
19 I/O lines with 8 10Bit ADC's.  
Real multitasking and Serial UARTs.

**...SMALLER**  
**WWW.SITEPLAYER.COM**

Siteplayer is a true stand-alone mini web server.

Super easy to use.  
Standard RJ-45 network interface.  
Control or monitor anything over the web.



**SITEPLAYER™**  
**\$29.95 (Qty 1)**

**...BETTER**  
**WWW.BASICX.COM**

High quality serial 2x16 LCD with backlight

Easy to use.  
2400 & 9600 Baud support  
Software controllable backlight and contrast.

**2x16 SERIALLCD™**  
**\$39.95 (Qty 1)**



Circle #60 on the Reader Service Card.

**NETMEDIA INC. 10940 NORTH STALLARD PLACE TUCSON ARIZONA 85737**  
**WWW.NETMEDIA.COM 520.544.4567**



**Amazing Devices from the Future  
See on [www.amazing1.com](http://www.amazing1.com)**

Build and use spectacular and fascinating devices from novelty products to electronic weapons including lasers, ultrasonic, electrokinetic, antigravity Tesla, high voltage, plasma, surveillance and hundreds more. Plans, kits assembled. Many in live video clips. Information Unlimited Amherst NH. 03031 Tel# 1 603 673 4730

**[www.gatewaylex.com](http://www.gatewaylex.com)**

(Electronically Speaking, Gateway's Got It!)

MAIL ORDERS CALL TOLL-FREE-1-800-669-5810



**INDUSTRIAL  
UPGRADERS  
CORPORATION**  
[www.iucorporation.com](http://www.iucorporation.com)

OPEN COLLECTOR  
DC OUTPUT MODULE  
4 Points of DC Output to 1 Amp  
Connect Directly to PICs & Stamps  
Drive Lamps, Relays, and other  
DC Loads  
Assembled or Kit Form



*For all your  
soldering needs*

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

**[www.web-tronics.com](http://www.web-tronics.com)**

OVER 8,000 ELECTRONIC ITEMS ONLINE

DEALS YOU WON'T BELIEVE!

**C & S SALES**

**[WWW.CS-SALES.COM](http://WWW.CS-SALES.COM)**

Digital Multimeters, Soldering Stations, Test  
Equipment, Snap Circuits, Educational Kits

**PARALLAX**

Your BASIC Stamp Headquarters  
**[www.parallax.com](http://www.parallax.com)**

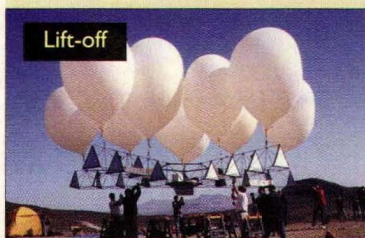
Smart Battery Charger &  
More Ham Radio Accessories  
[www.a-engineering.com](http://www.a-engineering.com)

Square I Electronics  
PIC Microcontroller Books  
[www.sq-i.com](http://www.sq-i.com)



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

**America's Other Space Program  
Launches a Rocket and Balloon to  
Open a New Spaceport**



and will be conducting several more test flights there in the next few months.

**PongSats to the Edge of Space**

One of the most remarkable ways in which JP Aerospace is opening the space frontier is through its PongSat Program. A PongSat is a science experiment that fits inside a ping-pong ball. Students from grade school through college use their imaginations to create all sorts of science experiments and then seal them inside ping-pong balls. JP Aerospace flies these ping-pong ball "satellites" to the edge of space by balloon or launches them in sounding rockets. After the flight, the experiments are returned to the students. The PongSat Program is an easy and inexpensive way to get students excited about

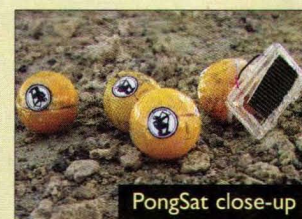
science and engineering. Even the youngest students can be space scientists.

**MicroSat Launcher Rocket  
Lifts Off**

The opening of the spaceport was culminated by a launch of the MicroSat Launcher Rocket. The purpose of this launch was to work through the regulatory issues governing launches from the spaceport, so that future launches can be expedited. The 12-foot rocket is constructed entirely of carbon fiber except the nose cone, which is a combination of carbon fiber and Kevlar.

When the ignition command was sent, the solid propellant rocket motor provided 4,496 pounds of thrust sending the vehicle to an altitude of 20,000 feet. When the rocket reached peak altitude, it deployed its large black and orange parachute, then floated gently back to Earth. The entire flight lasted just over 10 minutes. The rocket reached a speed of just under Mach two (Mach 1.7).

The MicroSat Launcher Rocket is not destined to take off from the ground. Its launch pad will sit at the edge of the atmosphere at 100,000 feet up. The rocket and the entire 60-foot wide launch platform are carried aloft by 10 helium balloons. When the platform reaches 100,000 feet, the rocket is remotely launched by a ground control station. The rocket will be used to launch small satellites into orbit. This was the third flight of the MicroSat Launcher Rocket.



JP Aerospace / [www.jpaaerospace.com](http://www.jpaaerospace.com)

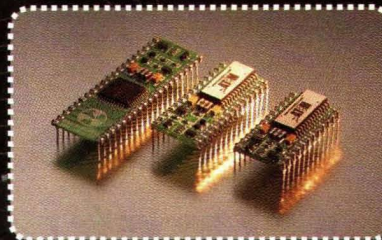


## Basic Atoms

The Basic Atom is a self contained microcontroller, which includes everything needed to get started. The Basic Atom is programmed in an easy to use expanded BASIC and comes standard with our exclusive debugging-feature.

Stop wasting time strategically planting debug statements throughout your entire program. Bring your projects to life quicker and easier with our exclusive built-in In-Circuit-Debugger (ICD). Monitor your program variables, SFRs and RAM values on screen as each line of code executes on the Basic Atom. The Basic Atom ICD is so easy to use, even a first time user can have it up and running in minutes!

Develop **better** projects **today** with the Basic Atom.



## Basic Atom

- \* Built-in Analog-to-Digital converter
- \* 32 Bit Integer & Floating Point Math
- \* Lots of built-in hardware
- \* Includes easy to use O'Scope & ICD
- \* Pin Compatible with the BS2p
- \* 368 Bytes of RAM (room for over 300 variables)

Atom 24 - \$49.95

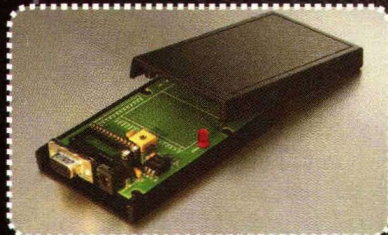
Atom 28 - \$54.95

Atom 40 - \$69.95

Pin compatible  
with the BS2p

## Development Enclosures

- \* Inexpensive and convenient
- \* Fits several different case styles
- \* Easy to wire LCD interface
- \* Cases can be ordered precut



## Development Enclosures

One Size Fits All, yeah righhhht. Project Boxes come in all sizes, but ours fits like a glove. When your project is finished, put it in our new Development Board Enclosure solution. Now you can build your project on a board specifically designed to fit into a plastic enclosure.

Each part is also available separately - so you can keep on developing.

Develop projects **easier** with the Basic Atom.

Starting at \$7.95

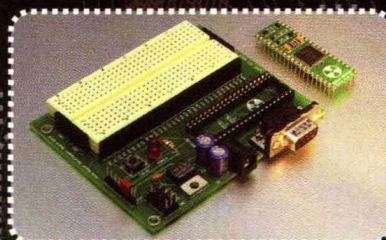
- 1) Develop quicker
  - 2) Develop easier
  - 3) Develop more powerful products
- today** with  
Basic Atoms!

## Atom Super Development Board

Whether you are in a classroom or flying solo and building your newest invention - develop in a fraction of the time using Atom Development boards. With solderless prototyping these boards can be used again and again.

From the power regulator to a DB9 connector for programming the Basic Atom, all basic hardware is provided. Optional features include Servo connectors, 1.0 Amp Power regulator, Battery connectors and more.

Develop **more efficiently** with Basic Atoms.



## Atom Super Development Board

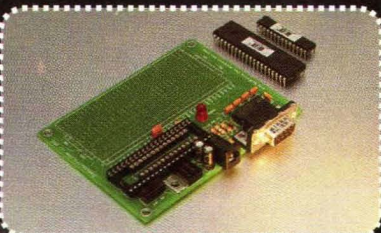
- \* Plug and Play
- \* Wire your project up in seconds
- \* All necessary hardware built-in
- \* Easy Connectors for Servos
- \* Easy Battery Connectors/Reset Button
- \*\* Shown with optional Basic Atom

Starting at \$59.95

Come and check-out  
our full line of products  
on our NEW website  
[\[www.basicmicro.com\]](http://www.basicmicro.com),  
and see for yourself how  
much time you can save  
by building with  
Basic Atoms.

## Basic Atom Interpreter

- \* Low Cost / Very Flexible
- \* Several Development boards available
- \* Easy to design into products
- \* Fully documented
- \*\* Shown with optional Interpreter Chips
- \*\* Available Assembled or as a Kit



## Basic Atom Interpreter

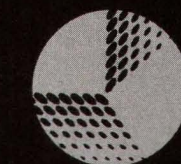
At the heart of the Basic Atom is our Basic Atom Interpreter Boards - combined with the interpreter chip you can prototype almost any solution extremely quickly. We offer these interpreters as a low cost solution to incorporate the Basic Atom in your next project or even your next great product. We also offer easy to use prototyping boards that can make your projects easy to finish.

Pssst - our proto-boards are cheap enough that they can even be used for your commercial products.

Develop projects **cheaper** with Basic Atoms.

Starting at \$8.95

The Basic Atom is a  
registered trademark of Basic Micro Inc.  
BasicStamp is a registered trademark of Parallax Inc.



**BASICMICRO**

Circle #61 on the Reader Service Card.





## Texas Instruments and Nuts & Volts 2002 MSP430 Ultra-low Power Flash MCU Design Contest 1st Place Winner

# Multi-functional Accelerometer

by Jingxi Zhang, Yang Zhang,  
and Huifang Ni

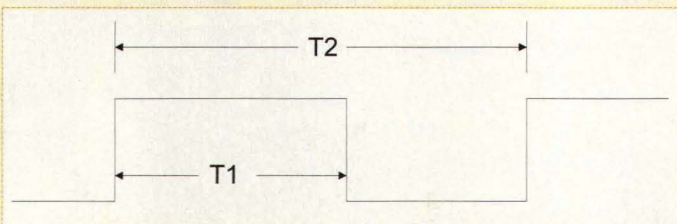
## Introduction

**T**he accelerometer sensor is a device which can detect accelerations caused by either the object's motion (dynamic acceleration) or earth's gravity (static acceleration). It can be packaged as a one-axis, two-axis, or three-axis device to detect linear, two-dimensional, or three-dimensional accelerations, respectively. Combined with a microcontroller, the sensor can be made into a smart device used in many different applications, including orientation detection, security, and computer peripherals.

We constructed a battery-powered, low-cost, handheld multi-functional accelerometer device using a two-axis accelerometer sensor — the ADXL202E from Analog Devices — and an ultra-low power, 16-bit RISC microcontroller — the MSP430F413 from Texas Instruments. The device provides the following six functions, accessible by a selection button:

1. Accurate tilt-angle meter (inclinometer) ranged from  $-180^\circ$  to  $+180^\circ$  with a resolution of  $0.1^\circ$ .
2. Electronic two-axis bubble level with nine directional indicators.
3. Motion alarm to detect tiny movements or shakes.
4. Pedometer to detect and record a user's walking/running steps.
5. Countdown timer, beeping when the preset time expires.
6. Stopwatch to record time lapse precisely in fractions of seconds.

The low-power ADXL202E is a Micro-Electro-Mechanical System (MEMS) chip. It can measure both dynamic and static acceleration. Besides the analog signal



**Figure 1.** Accelerometer DCM output. Period T1 changes while period T2 keeps constant. The T1/T2 ratio is proportional to the acceleration value detected.

*"Texas Instruments congratulates these winners. Their creative ideas took maximum advantage of the ultra-low power Flash memory, high-performance analog peripherals, and modern 16-bit RISC CPU that make the MSP430 unique," states Sara Heaton, Texas Instruments.*

output for each axis, it also contains an output circuit to convert the analog signal to a duty cycle modulated (DCM) signal. The acceleration force (within  $\pm 2g$ ) is linearly proportional to the percentage of the duty cycle of the output signal — T1/T2 — as shown in Figure 1.

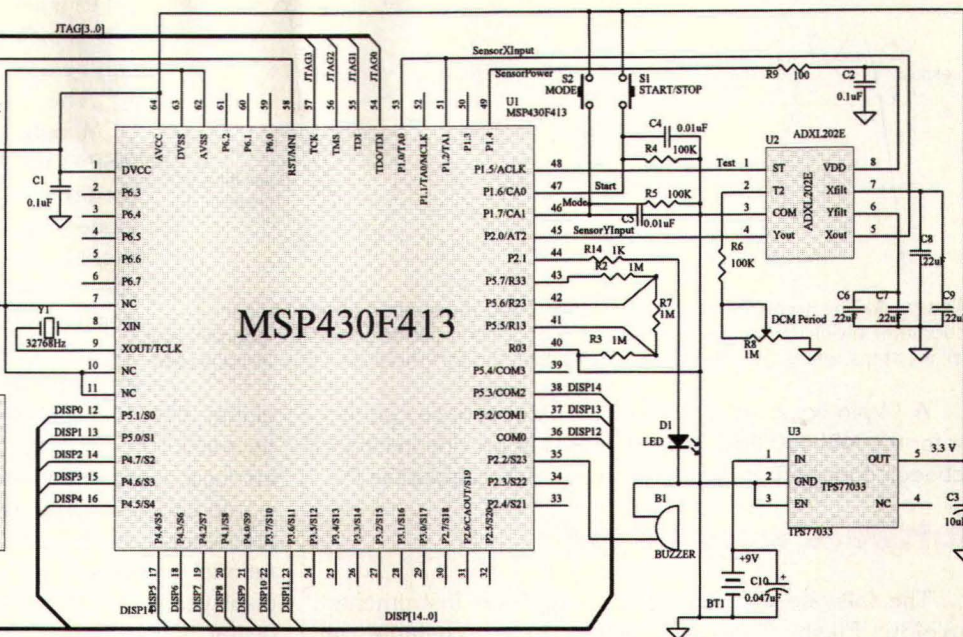
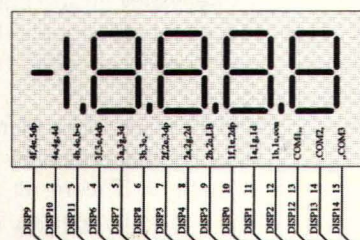
Texas Instruments' MSP430 mixed-signal microcontrollers are a family of ultra-low power, 16-bit RISC microcontrollers. The MSP430F413 microcontroller used in this project is one member of the family. It is equipped with a low-power processor (can run up to 8 MHz), 8 KB of instruction flash memory, two segments of 128-byte data flash memory, 256 bytes of RAM, and many peripheral modules. One of the peripheral modules is the versatile, general-purpose, 16-bit timer (Timer\_A). The timer can be programmed in capture mode or compare mode. Interrupt events are generated under various conditions. The microcontroller also contains an LCD display driver which handles the analog voltage required for low-voltage LCD displays.

## Circuit Description

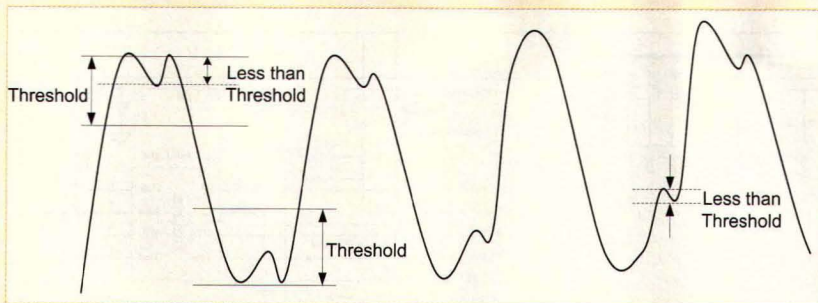
The circuit schematic is shown in Figure 2. At the center of the circuit is the 64-pin Texas Instruments MSP430F413 microcontroller, U1. The microcontroller provides many built-in peripheral modules. Therefore, very few external components are required to make the circuit work. A low-cost, 32,768 Hz watch crystal, Y1, is used to provide a stable, low-frequency clock reference and synchronize the higher-frequency, on-chip, digitally-controlled oscillator (DCO). The DCO is set to 2 MHz so that a high clock cycle count is provided for Timer\_A to capture the accelerometer signals. Because the accelerometer's DCM cycle period is set to 5 mS, the 2 MHz DCO clock rate can provide a maximum of 10,000 clock cycles in T2 — a very high temporal resolution, but one without the need to worry about the clock cycle count overflowing the 16-bit capture register.



**Figure 2.** Multi-functional accelerometer circuit schematic. Get the hi-res PDF at [www.nutsvolts.com](http://www.nutsvolts.com).







**Figure 4.** The accelerometer's y-axis output and threshold discrimination in pedometer mode. The movement outputs that exceed the threshold are counted as walking steps, while the small fluctuations under the threshold are considered noise.

A 14-pin box header JP1 is the JTAG interface connector for the MSP430 flash emulation tool to provide in-circuit debugging and programming using an IBM-compatible PC.

## Software Description

The software was developed using Texas Instruments' MSP430 Flash Emulation Tool (FET; available at [www.ti.com](http://www.ti.com)). The assembly source code is available at the FTP site. Because the program contains digital filtering and trigonometric calculations, the TI floating point package

(FPP) is required in the linking procedure. The FPP is included in the development toolkit and can be downloaded for free from TI's website.

The ADXL202E accelerometer dual-axis DCM outputs' on and off edges trigger the MSP430F413 Timer\_A (it is set to capture mode). The clock-cycle count of each output is logged into a capture register, and an interrupt event is generated to evoke the interrupt service routine (ISR). The duty-cycle percentage represented in clock-cycle counts is converted to acceleration. Dependent on the operation mode, a second-order Chebyshev IIR low-pass

digital filter is applied to the acceleration signals to decrease the accelerometer's floor noise in order to increase its resolution and accuracy.

In tilt-angle meter mode, the dual-axis filtered acceleration signals are converted to an angle measurement by a rational arctangent approximation method. The result is displayed in the LCD module as the tilt angle in degrees. In digital bubble-level mode, the dual-axis accelerations are compared to values pre-stored in Flash memory during the calibration procedure. The resulting differences drive the LCD module to display one of nine directional symbols to indicate the bubble direction. The motion alarm operation uses unfiltered, raw accelerations to preserve the wider frequency response for higher-frequency movement.

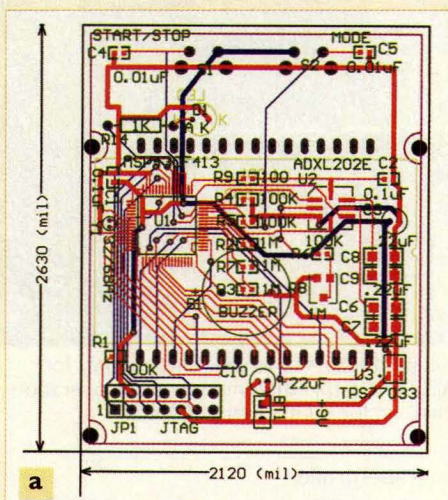
To prolong the battery life, the microprocessor sleeps in low-power mode (LPM3) and wakes up for 40 mS to detect the acceleration changes repeatedly in 500 mS intervals (Figure 3). In pedometer mode, only one axis — the y-axis — detects the user's up-and-down movement during walk or run.

The low-pass filtered signal goes through a peak detection procedure. After a peak is detected, a preset threshold is used to determine if the movement wave is noise or a true walking movement (Figure 4). Since the device implements many basic functions — such as independent virtual timers, the buzzer driver, the binary-to-BCD converter, and the LCD display driver — it is very easy to reuse these function

blocks to add countdown timer and stopwatch operations, although they do not use the accelerometer sensor.

## Project Construction

All parts (see Parts List), except the accelerometer ADXL202E can be purchased from Digi-Key ([www.digikey.com](http://www.digikey.com)). The accelerometer can be obtained from Analog Devices, Inc. ([www.analog.com](http://www.analog.com)). The total cost of the parts is under \$50.00. The electronics compo-



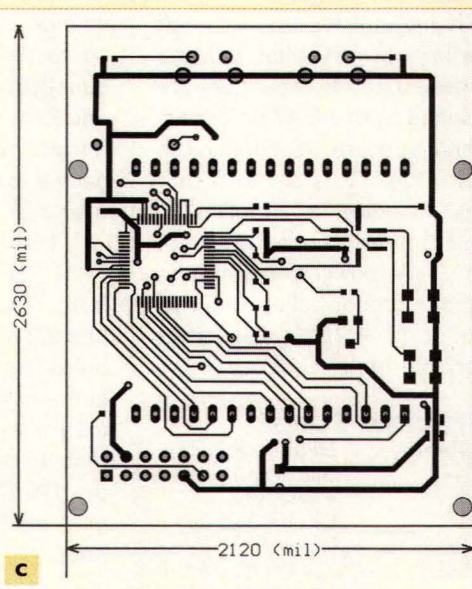
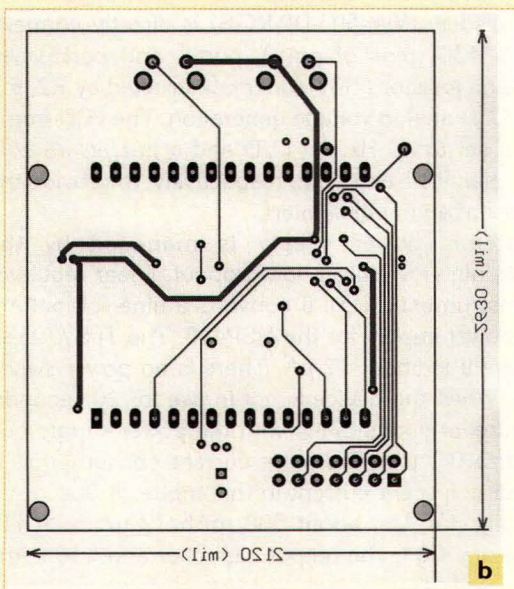
**Figure 5.**

Printed circuit board layouts.

**5a** is the multi-layer printout as a parts placement guide.

**5b** is the top layer (component side) foil pattern.

**5c** is the bottom layer foil pattern.





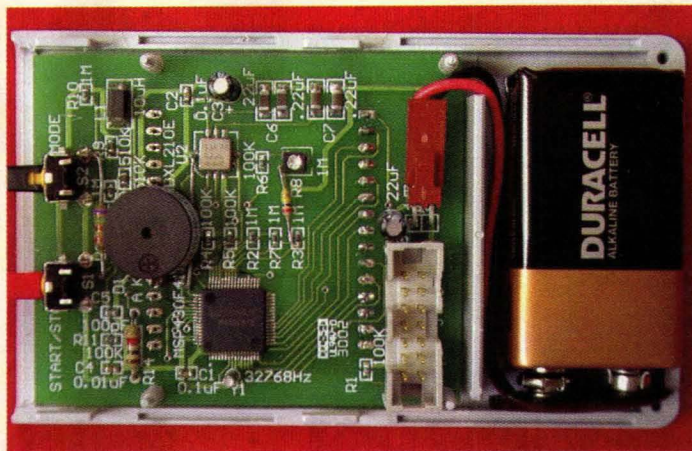
nents are mounted on a 2.12 x 2.63 inch, two-layer printed circuit board (PCB). Figure 5 is the PCB layout. The LCD is mounted on the circuit side. The plastic enclosure is Serpace M-6 mode, which contains a nine-volt battery compartment. A window is cut out on the front panel for the LCD display.

Surface-mount (SMT) components are used in this project (Figure 6). A fine-tip solder gun and a lamp with magnifier lenses are suggested for soldering the components on the PCB. First, solder all the surface-mount components, including the microprocessor MSP430F413, accelerometer ADXL202E, linear regulator TPS77033, chip capacitors, and resistors on the PCB's top side. Apply a small amount of flux onto the pads before soldering. Keep soldering time short to avoid damaging the parts.

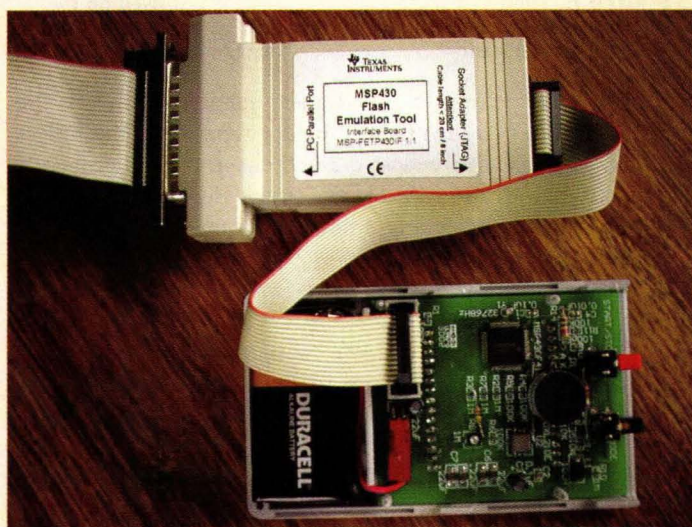
Because the MSP430F413 is packaged with a very fine pin pitch, care should be taken when the chip is soldered. Use minimal solder to avoid bridging the pins together. The best way from our experience is to tin the chip pins and PCB pads first, and then lightly press the pins onto the pads by the solder gun tip with no extra solder. After aligning the pins to the pad, solder the two pins in opposite corners first to fix the chip in place on the board, and then solder the rest of the pins.

The second step is to solder the thru-hole component parts, including the crystal, electrolytic capacitors, push-button switches, 14-pin header, and LED. Note that the LED is mounted on the PCB's bottom side. The next step is to solder the buzzer. Because the buzzer is going to cover some other parts, make sure those components beneath the buzzer are in place before soldering the buzzer on the board. The last step is to solder the LCD display on the PCB bottom side. Note that Digi-Key carries only the high-voltage mode of VIM-503 (VIM-503-DP-RC-S-HV), which displays very low contrast in three-volt applications. You may get the low-voltage mode VIM-503-DP-RC-S from Varitronix ([www.Varitronix.com](http://www.Varitronix.com)). If the contrast is too high, you may modify the circuit to smoothen the contrast by disconnecting U1 pin 40 (R03) from ground (with R3 still connected to U1 pin 40) and re-connecting U1 pin 40 to ground through a 200K resistor.

After constructing the hardware, it is time to program the microcontroller. Connect JP1 to the FET by a 14-conductor cable as shown in Figure 7. The FET is connected to the parallel port of a host computer. Launch the IRA embedded workbench, which is included in the TI MSP430 software



**Figure 6.** The top view of the circuit board. Surface-mount components are used on the board.



**Figure 7.** The circuit board is connected to the FET by a 14-conductor cable. The FET is connected to the parallel port of a host computer.

development toolkits. Find the TI floating point package (FPP), which is in the directory "Program Files\IAR Systems\ew23\430\Fpp410\IAR" if your TI MSP430 development CD is the same version as ours. Compile the FPP source code if the FPP.r43 is not ready. A library type of FPP is required for the accelerometer software, which can be obtained either by setting the "Make a LIBRARY module" option in the FPP project assembler settings or by using the

## Parts List for Multi-Functional Accelerometer Circuit

### Semiconductors

- U1** - Texas Instruments MSP430F413 ultra-low power, 16-bit RISC microcontrollers
- U2** - Analog Devices ADXL202E low-cost  $\pm 2$  g dual-axis accelerometer
- U3** - Texas Instruments TPS77033 ultra-low power 50-mA low-dropout linear regulator
- D1** - Any standard light emitting diode

### Resistors

- R1, R4, R5, R6** - 100K, SMT 0603, 5%
- R2, R3, R7** - 1M, SMT 0603, 5%
- R8** - 1M, 3 mm square SMT trimmer potentiometer
- R9** - 10 $\Omega$ , SMT 0603, 5%
- R14** - 1K, 1/8 watt, 10%

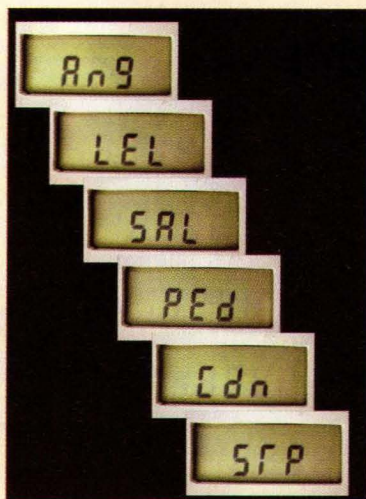
### Capacitors

- C1, C2** - 0.1 $\mu$ F, SMT 0603, 20%
- C3** - 10 $\mu$ F aluminum electrolytic capacitor, 6.3V, 10%
- C4, C5** - 0.047 $\mu$ F, SMT 0603, 10%
- C6, C7, C8, C9** - 0.22 $\mu$ F, SMT 1206, 10%
- C10** - 0.047-10 $\mu$ F, aluminum electrolytic capacitor, 25V

### Additional Parts and Materials

- Y1** - 32768 Hz Crystal (ECS-2X6)
- B1** - Piezo-electric Buzzer, 3-12V, 13.7 mm PCB mount
- JP1** - 14-pin 0.1" x 0.1" shrouded header, Digi-Key part number MHB14K-ND
- S1, S2** - Miniature 6mm x 6mm tactile switch
- LCD1** - 4-1/2 Digits 0.4" Numeric LCD display (Varitronix VIM-503-DP-RC-S)
- Case** - Serpace M-6 plastic enclosure
- Battery** - Alkaline nine-volt





**Figure 8.** The LCD displays of each operation mode. The operation modes rotate in the order shown.

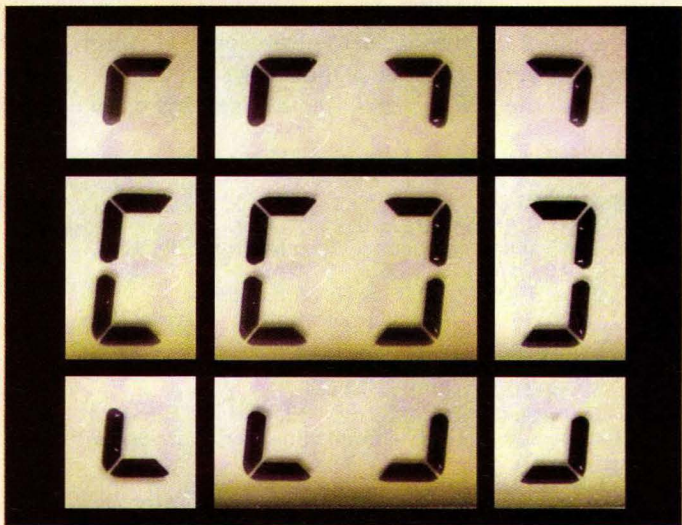


**Figure 9.** The measured angle is displayed on the LCD as degrees in tilt-angle meter mode.

"make-library" command in XLIB utility to convert the FPP.r43 from program type to library type. After the FPP is ready, compile the accelerometer assembly source code and link it with the FPP library in the development workbench (put the assembly source code and FPP.r43 in the same project). If there is no error, you can then load the executable code into MSP430F413 by selecting "Debugger" from the Project menu. After a few seconds, the loading process is finished and a CSPY debugger window is opened. Click the "Go" button in the toolbar. Voila! You have the multi-function accelerometer running on your workbench.

## Operation and Testing

Now the device is ready for you to test. There is no power switch for this device. Any button activity will turn on the device. The first step is to test the mode selection switch button S2. By pushing S2, you should see the LCD display current operation mode. If you push S2 again, within three seconds, the current operation will switch to next mode. The operation cycle is as follows: as tilt-angle meter (Ang)



**Figure 10.** The nine LCD indicators of bubble-level operation. When the device is leveled in both axes, the center indicator is displayed.

→ bubble level (LEL) → motion and shock alarm (SAL) → pedometer (PED) → countdown timer (Cnd) → Stopwatch (STP) → back to tilt-angle meter as shown in Figure 8.

A calibration procedure is needed before running all the functions accurately. Push S2 and hold it for more than three seconds (in any operation mode). The LED is blinking and the device enters the calibration mode. You can use gravity as the acceleration force to calibrate the device. Four steps in calibration need to be complete as shown in Table 1. For each step, place the device on a level surface in the described position and push the start button. The microcontroller gets 16 samples on each step for each axis, and the average value is stored in flash memory (segment A) to be used as reference. The calibration procedure can be performed repeatedly, if necessary. Note: the DCM output cycle period at U2 pin 4 is adjusted to about 5 mS by trim pot R8 (about 500K).

In the tilt-angle meter operation mode, push button S1 once the LED is lit: the current angle in degrees is continuously displayed on the LCD as shown in Figure 9. Push button S1 again; the operation is stopped and the LED is turned off. The last angle readout stays on the LCD for 20 seconds before the device automatically turns off.

For the bubble-level operation mode, lay the device face up on the surface. One of the nine directional indicators (Figure 10) is displayed on the LCD indicating the bubble position.

In motion alarm mode, when the operation is activated by pushing button S1, there is a 10-second delay before the device is armed. The LED indicates the delay period. Within these 10 seconds, the user can push the button S2 repeatedly to enter a number between 0 and 9 as a key code (the default key code is 0). Any tiny movement or shake after the device is armed will trigger the alarm. To shut down the alarm after it goes off, you must use button S2 to enter the matching number, and then push the stop button.

In pedometer and stopwatch modes, the operation is straightforward. Pushing button S1 toggles the operation on and off. On each start, the count will be reset to zero.

In countdown timer mode, pushing button S1 once enters the set-up stage (LED blinking). A time from 1 to 15 minutes can be entered by pushing button S2 repeatedly. Pushing button S1 again begins the countdown procedure. When the set time expires, the device beeps three times to alert the user.

If all operation modes tested work as expected, you can remove the FET cable from JP1. The device is ready for use. If the device cannot start after you remove the cable, you can remove the battery. Use a wire to short the power terminal to discharge the remaining charge on C10. Then reconnect the battery back, and the device should be back to functioning. **NV**

## Biography

Jingxi Zhang — Graduated from Zhongshang Medical University, Guangzhou, China. He obtained his MS in EE at UC Irvine, CA, and his PhD in Neurosciences at UCLA, CA. He is currently the Chief Technologist at JVC Laboratory of America, Santa Clara, CA. Yang Zhang — An undergraduate studying EE and CS at UC Berkeley, CA. Huifang Ni — Currently works at Elan Pharmaceuticals, South San Francisco, CA.



CALL TOLL-FREE

(800) 292-7711  
Orders Only

Se Habla Español

# C&S SALES

Secure On-line Ordering @ [cs-sales.com](http://cs-sales.com)

CALL OR WRITE  
FOR OUR  
**FREE**

64 PAGE CATALOG!  
(800) 445-3201

## Digital Multimeters

### Elenco Model M-1740



**\$19.95**

- 11 Functions:**
- Freq. to 20MHz
  - Cap. to 20µF
  - AC/DC Voltage
  - AC/DC Current
  - Beeper
  - Diode Test
  - Transistor Test
  - Meets UL-1244 safety specs.

### Elenco Model LCR-1810



**\$89.95**

- Cap. 0.1pF to 20µF
- Inductance 1µH to 20H
- Resistance 0.01Ω to 2.000MΩ
- Temperature -20°C to 750°C
- DC Volts 0 - 20V
- Freq. up to 15MHz
- Diode/Audible Continuity Test
- Signal Output Function
- 3 1/2 Digit Display

### Elenco Model LCM-1950



**\$65**

- Large 1" 3 3/4 Digit LCD
- Autoranging Freq. to 4MHz
- Cap. to 400µF
- Inductance to 40H
- Res. to 4,000MΩ
- Logic Test
- Diode & Transistor Test
- Audible Continuity Test

## Capacitance Meter

### Elenco Model CM-1555



**\$29.95**

- Measures capacitors from 0.1pF to 20,000µF
- 3 1/2 Digit LCD readout with unit indicator
- Zero control for test lead compensation
- Banana jack and special insertion jack included
- Compact size stand and holder

## Deluxe Soldering Stations

### Elenco SL-5 Series

Electronically controlled, ideal for professionals, students, and hobbyists. Available in kit form or assembled.

As Low As

**\$22.95**

Works w/ any iron! Turn any soldering iron into a variable iron.

#### Features:

- Cushion Grip Handle
- Soldering Iron (optional) with Grounded Tip for Soldering Static-Sensitive Devices. Easily Replaceable. Uses Long-Life, Plated Conical Tip.
- Heavy Steel, Non-Slip Base.
- Iron Holder Funnel - Reversible, left or right side.
- Steel Tray for Sponge Pad.
- Sponge Pad.



Quantity Discounts Available

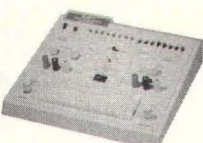
## Test Equipment

### Elenco Digital / Analog Trainer Model XK-150

**\$89.95**

#### Features:

- 830-pin Breadboard
- 8 Data Switches
- 8 LED Buffered Readouts
- Built-in Function Generator (sine & square wave)
- Built-in Clock Generator
- Variable Power Supply



### Elenco Multi-Network Cable Tester Model TCT-255

This tester is a convenient instrument for testing different RJ-11 and RJ-45 connectors and coax cables. Cables can be tested before and after they are installed.

- Mapping Function
- Tests cables before or after their installation.
- Cable Identification (straight or reverse)
- Pair Identification (straight or reverse)
- Open or Short Testing
- Low Battery Indicator
- Auto Power-Off Function (30 s.)

Soft Vinyl Zippered Case (Model C-90) Included!

TCT-255K - Multi-Network Cable Tester Kit - \$39.95



**\$75**

### 20MHz Sweep / Function Generator with Frequency Counter Model 4040A

- 0.2Hz to 20MHz
- AM & FM Modulation
- Burst Operation
- External Frequency Counter to 30MHz
- Linear and Log Sweep



- 10MHz Model 4017A \$325
- 5MHz Model 4011A \$259
- 2MHz Model 4010A \$225

**\$445**  
BK PRECISION

### Elenco Handheld Universal Counter Model F-2800

**\$99**

#### Sensitivity:

- <1.5mV @ 100MHz
- <5mV @ 250MHz
- <5mV @ 1GHz
- <100mV @ 2.4GHz

Features 10 digit display, 16 segment and RF signal strength bargraph.

Includes antenna, NiCad battery, and AC adapter.

C-2800 Case w/ Belt Clip \$14.95

Elenco RF Generator with Counter (100kHz - 150MHz) Model SG-9500

**\$235**

Features internal AM mod. of 1kHz, RF output 100MV - 35MHz. Audio output 1kHz @ 1V rms.

SG-9000 (analog, w/o counter) \$135



### Elenco Quad Power Supply Model XP-581

4 Fully Regulated Power Supplies in 1 Unit



**\$75**

4 DC Voltages: 3 fixed: +5V @ 3A, +12V @ 1A, 1 variable: 2.5 - 20V @ 2A • Fully Regulated & Short Protected • Voltage & Current Meters • All Metal Case

### Elenco Power Supply Model XP-603



**\$75**

- 0-30VDC @ 3A Output
- 3A Fused Current Protection
- Current Limiting Short Protection
- 0.025Ω Output Impedance

### Elenco 3MHz Sweep Function Generator w/ built-in 60MHz Frequency Counter Model GF-8046

Generates square, triangle, and sine waveforms, and TTL, CMOS pulse.



**\$199.95**

GF-8025 - Without Counter \$139.95

## Ordering Information:

Model SL-5 - No iron. (Kit SL-5K)

**\$22.95**

Model SL-5-40 - Includes 40W UL iron. (Kit SL-5K-40)

**\$27.95**

### Weller® Low Cost Soldering Iron Model WLC100



- Variable power control produces 5-40 watts.
- Ideal for hobbyists, DIYers and students.
- Complete with 40W iron.

**\$32.95**

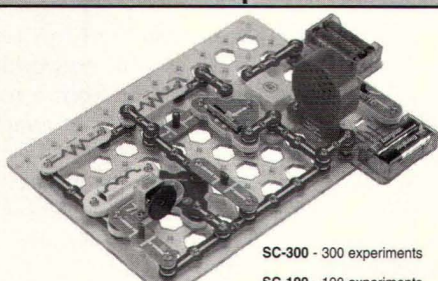
### Elenco Oscilloscopes Free Dust Cover and x1, x2 Probes



UL

2 year Warranty		
S-1330	25MHz	Delayed Sweep
S-1340	40MHz	Dual Trace
S-1345	40MHz	Delayed Sweep
S-1360	60MHz	Delayed Sweep
S-1390	100MHz	Delayed Sweep
<b>DIGITAL SCOPE SUPER SPECIALS</b>		
DS-203	20MHz/20Ms/s	Analog/Digital
DS-303	40MHz/20Ms/s	Analog/Digital
DS-603	60MHz/20Ms/s	Analog/Digital

## Elenco Snap Circuits™



SC-300 - 300 experiments \$49.95  
SC-100 - 100 experiments \$29.95

Elenco's new Snap Circuits™ make learning electronics a "snap". Just follow the colorful pictures in our manual and build over 300 projects, such as AM radios, burglar alarms, flash lights, doorbells, and much more. You can even play electronic games with your friends. All parts are mounted on plastic modules and snap together with ease. Enjoy hours of educational fun while learning about electronics. You can even create your own experiments! No tools required.

## Elenco Educational Kits

### Model MX-901SW

Short Wave Radio Kit



**\$11.95**

### Model AM-780K

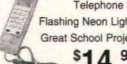
Two IC Radio Kit



**\$9.95**

### Model AK-700

Pulse/Tone Telephone Kit



**\$14.95**

### Model RCC-7K

Radio Control Car Kit



**\$27.95**

### Model M-1006K

DMM Kit



**\$18.95**

### Model K4001

7W Amplifier



**\$12.95**

## Electronic Science Lab

### Maxitronix 500-in-1 Electronic Project Lab Model MX-909

Everything you need to build 500 exciting electronic projects:

- Learn the basics of electronics. 500 different electronic experiments, special lighting effects, radio transmitter and receivers, sound effects, cool games and MORE!
- Includes built-in breadboard and an LCD.
- Explore amplifiers, analog and digital circuits plus how to read schematic diagrams.
- Includes 11 parts.
- Lab-style manual included.
- Requires 6 "AA" batteries.



- MX-908 - 300-in-1 Lab \$59.95
- MX-907 - 200-in-1 Lab \$44.95
- MX-906 - 130-in-1 Lab \$29.95
- EP-50 - 50-in-1 Lab \$18.95

**\$149**

## Guaranteed Lowest Prices

UPS SHIPPING: 48 STATES 6% (Minimum \$6.00)  
OTHERS CALL FOR DETAILS  
IL Residents add 8.5% Sales Tax

SEE US ON THE WEB

## C&S SALES, INC.

150 W. CARPENTER AVENUE  
WHEELING, IL 60090  
FAX: (847) 541-9904 (847) 541-0710  
<http://www.cs-sales.com>



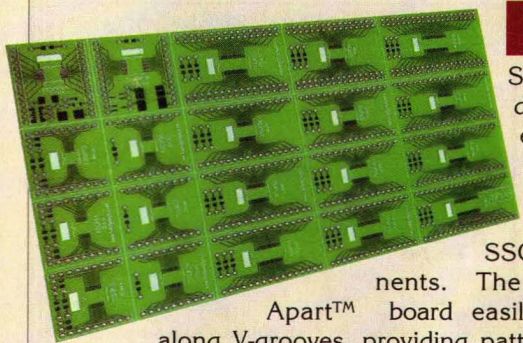
## 15 DAY MONEY BACK GUARANTEE

## 2 YEAR FACTORY WARRANTY

PRICES SUBJECT TO CHANGE WITHOUT NOTICE



## SNAP-APART™ ADAPTER BOARD MAKES SMT BREADBOARDING EASY



**B**ellin Dynamic Systems introduces an easy, economic alternative to breadboarding TSSOP and SSOP components. The P507 Snap-Apart™ board easily snaps apart along V-grooves, providing patterns with up to 40 pads on both sides of the board. Popular .65mm, .5mm, and .4mm pin pitches are available. Silk screen and solder mask provide a neat, professional look for breadboarding projects.

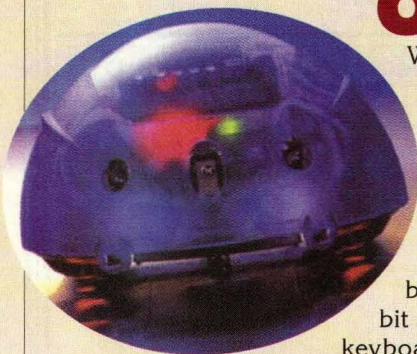
Components without DIP package equivalents may be breadboarded in minutes using only a standard soldering iron. Rapid SMT breadboarding capability provided by the P507 can often reduce circuit board revisions during project development.

The P507 is the latest in the P500 series product line, which includes Snap-Apart boards for SOIC, PLCC, QFP, SOT, SC, DPAK, and other surface-mount components.

For more information, contact:

**Bellin Dynamic Systems, Inc.**  
**714-630-8024**  
**www.beldynsys.com**

## WAO "CRANIUM" PROGRAMMABLE ROBOT KIT



**O**WI introduces the fourth generation of WAO programmable robot kits and wow is it spectacular! WAO Cranium is a two-wheeled robot that you can program without a personal computer.

The intellectual brain consists of an eight-bit microcontroller and keyboard with 33 tactile buttons. This bundle of brains can store up to 60 programming steps and 30 FOR-NEXT multiplex loops. In addition to its futuristic and powerful design, it features six vision sensors to see in front and below the robot. The "eyes" that enable it to see in front of itself have two infrared LEDs and an infrared detector IC. Four floor light sensors (CdS sensor) will enable it to distinguish the contrast of light underneath its shell.

Dr. OWIKIT says this robot is more than just fun.

Assembling, building, and following instructions help develop fine motor skills and hand-eye coordination. Because it's programmable, one has to plan ahead, think systematically and logically, develop problem-solving skills, and will challenge you to think creatively.

Easy to assemble, this OWIKIT Intermediate building level robot makes a great entrant for robotic competitions, robotic workshops, after-school programs, special events, gifts, science enrichment camps, and classroom activities.

Suggested selling price is \$119.95 USD.

For more information, contact:

### OWI, Inc.

17141 Kingsview Ave., Dept. NV  
Carson, CA 90746

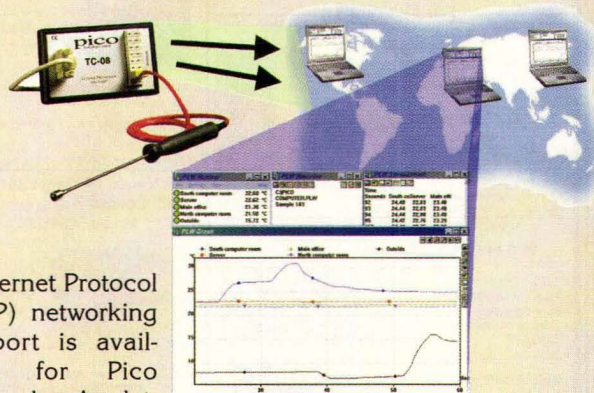
Tel: **310-515-1900**

Fax: **310-515-1606**

Email: **owikitsales@pacbell.net**

Web: **www.owirobot.com**

## INTERNET DATA ACQUISITION FOR PC-ADAPTERS



**I**nternet Protocol (IP) networking support is available for Pico Technology's data-logging scope adapters. This enables remote data collection from Pico Technology's full range of data acquisition products.

Previously, cost has been prohibitive for most remote data acquisition applications. But using IP networking, it is now possible to transfer measurements from a remote site via an existing LAN, company network, or even over the Internet at very little cost.

PicoLog software is ideal for short-term or intermittent voltage data acquisition, whereas the EnviroMon system provides reliable, continuous, long-term data acquisition for temperature and other environmental measurements.

PicoLog can also access Pico Technology's high-resolution voltage measuring devices, like the 12-bit ADC12 or 16-bit ADC16, general-purpose devices, such as the 11-channel ADC11, and high-speed conditioners like the 100Ms/S ADC200 and ADC212. Now you can run Pico Technology's economical data logging equipment locally and then remotely access these devices from another computer.



PicoLog software is available at no charge with the purchase of Pico Technology scope adapters, which are available from \$95.00 (stock).

For more information, contact:

**Saelig Co., Inc.**

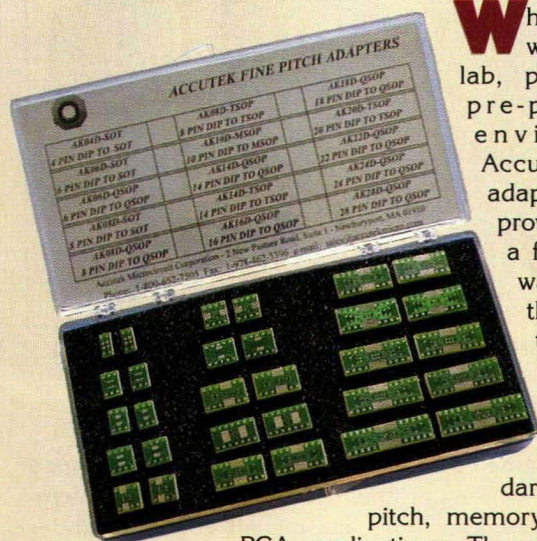
1 Cabernet Cir., Dept. NV  
Fairport, NY 14450

**716-425-3753** Fax **716-425-3835**

Email: [saelig@aol.com](mailto:saelig@aol.com)

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

## LOOKING FOR THE QUICKEST WAY TO PROTOTYPE?



**W**hether you're working in a lab, prototype, or pre-production environment, Accutek's new adapter kits can provide you with a fast and easy way to move through prototyping. We have surface-mount adapter kits for: standard pitch, fine pitch, memory, and PLCC-

PGA applications. These kits convert surface-mount components to thru-hole and are an ideal tool for developers who are looking to streamline the prototype to production process.

Potential applications include: Universities, Physics Labs, Military COTS, Medical, Aerospace, Research and Development, and Product Development.

Kits are available with gold or solder-plated machined pins or phosphor bronze solder tinned flat contact pins. The kits adapt surface-mount IC packages such as SOIC, TSOP, QSOP, MSOP, and SOJ to pin-compatible DIP modules in pin counts ranging from 4-48 pins.

The PLCC-PGA adapters work with PLCCs in 28-100 pin counts. The adapters utilize FR4 substrates and can be used to replace end-of-life thru-hole integrated circuits.

The kits are priced individually from \$45.95 to \$54.95. For more information, contact:

**Accutek Microcircuit Corporation**

Business Center at Newburyport  
2 New Pasture Rd., Ste. One  
Newburyport, MA 01950-4054  
Phone: **800-652-7505**

**978-465-6200** Fax: **978-462-3396**

Email: [sales@accutekmicro.com](mailto:sales@accutekmicro.com)

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

SEARCH & BUY ONLINE  
**WWW.MOUSER.COM**

**195,000+  
ELECTRONIC  
COMPONENTS**

Semiconductors, Optoelectronics, Lamps & Holders, LED's, Displays, Wire & Cable, Connectors, Assemblies, Sockets, Terminals, Terminal Blocks, Capacitors, Resistors, Potentiometers, Crystals, Oscillators, Inductors, Transformers, Circuit Protection, Fuses & Holders, Resettable Fuses, Breakers, Thermistors, Varistors, Industrial Automation, Switches, Relays, Speakers, Piezo Devices, Microphones, Fans, Heatsinks, Knobs, Hardware, Cabinets, Racks, Enclosures, Batteries, Battery Chargers, Battery Holders & Snaps, Power Supplies, DC-DC Converters, UPS Systems, AC Adapters, Panel Meters, Test Equipment, Tools & Equipment, Supplies & Chemicals, Prototyping Supplies ...

**MOUSER**   
ELECTRONICS

Circle #81 on the Reader Service Card.

**Need FREE PCB  
Design software?**

Perfect  
circuit  
board  
solution  
for:

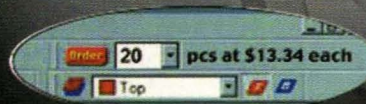
Robotics  
Hobbyists  
Students  
Engineers  
and more...

**PCB123**  
www.**PCB123**.com

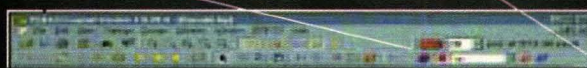
Providing the Complete Solution

**DESIGN THROUGH ORDER**

**EASY AS 1→2→3!**



PCB software that  
features real-time  
pricing as you  
design!





# LaneAlert — A Driver's Best Friend

## This Month's Projects

LaneAlert ..... 42  
Metal Detector ..... 47  
CF-MOSFET Amp ... 52



## The Fuzzball Rating System

To find out the level of difficulty for each of these projects, turn to Fuzzball for the answers.

The scale is from 1-4, with four Fuzzballs being the more difficult or advanced projects. Just look for the Fuzzballs in the opening header.

You'll also find information included with each article on any special tools or skills you'll need to complete the project.

Let the soldering begin!

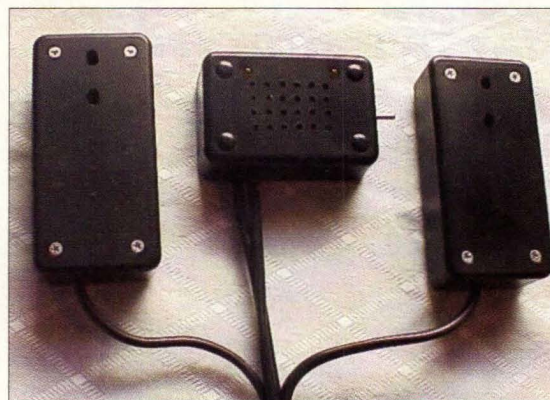
Stay "Alert" at the wheel with this effective lane detection device.

## The technology age

It happens all too often: a driver falls asleep at the wheel, veers off the road, and narrowly escapes a fatal injury. You might think in this day and age of high-tech devices and fast-paced lifestyles, that kind of scenario would be a thing of the past. After all, it's the 21st century. Cars come equipped with all kinds of gizmos: seat belts, air bags, and anti-lock brakes. And, for those like myself who can be sometimes directionally impaired, GPS navigation systems help get us from A to B.

Why shouldn't vehicles also come equipped with road-sensing devices that detect when the car is drifting out of its lane on the highway? Technological advances make this idea a definite possibility. In fact, there are several patents on the books that describe such devices. Unfortunately, they are relatively complex and expensive to implement in the average vehicle, employing digital image sensors and complex frame processing algorithms. The expense puts this type of system out of reach of the average driver, at least for now.

In the meantime, you may be surprised to discover that there's a simpler solution to the problem. Employing some readily-available and relatively-inexpensive components, you can create your own lane-detection system. I



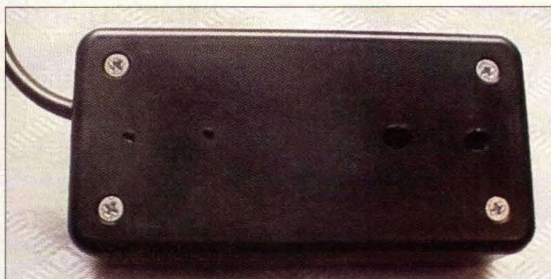
**Figure 1:** LaneAlert — lane detection system including computer module (center) and two sensor modules (left and right).

named the device "LaneAlert" and developed a working prototype including sensors, micro-controller, and alarm, all for well under \$100.00.

Let me say at the outset that LaneAlert is an experimental device meant to be a driver's aid. It is not intended to replace common-sense driving safety habits. The design was proven in daytime conditions. "But what about night driving?" you might be asking. Night testing presents some interesting challenges that we're not ready to tackle in this article. For now, we want to focus on the design and construction. We'll also do some testing, but in daytime conditions for convenience and simplicity.

## Ready to operate

The unit offers two operational modes: alarm-enabled and mute. The three-position toggle switch selects the mode. This type of switch offers two "on" positions and a center "off" position. One position activates the device and enables the piezo buzzer (the alarm). Another position also activates the device, but disables the piezo (mute). When



**Figure 2:** Sensor module — underside view showing cover and four aperture holes.



## Tools:

Parallax BASIC Stamp Development System  
Soldering iron  
Electric drill and bits  
Multimeter

## Skills:

Basic electronic assembly skills  
Beginner level programming skills

testing, it's helpful to run mute and simply view the indicator LEDs. When the unit is activated, the LEDs turn on briefly and then extinguish within a second or so. After the brief initialization sequence, the unit begins scanning. When lane markings are found, the left and/or right LED illuminates to indicate the sensor that detected them. Actually, what the device is looking for are sharp changes in contrast. If either or both sensors "see" these changes, all is well and the device continues to scan. But if neither sensor detects a contrast within a three-second period, the alarm will sound. The unit then resets itself automatically, cancels the alarm, and begins scanning once again.

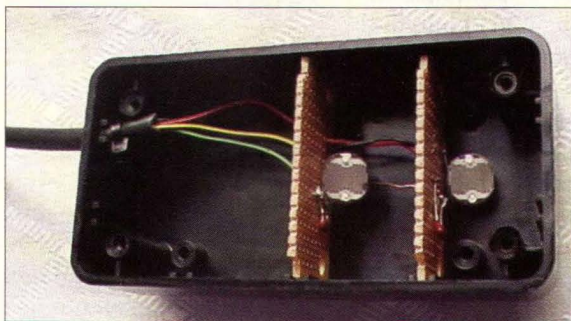
When testing in daylight, there are some variables to consider. One such variable is shadowing. When driving, shadows are detected as changes in contrast and could cause alarms. For the most part, this will not be a factor when driving at night. Another consideration is the situation that results when you're driving on a road that has dimly visible road markings such as back roads or alleys. In this instance, LaneAlert may not function properly. However, you must remember that the device's usefulness is best realized on long trips when driving state and interstate highways. In most cases, these roads should be well maintained and clearly marked.

## Construction

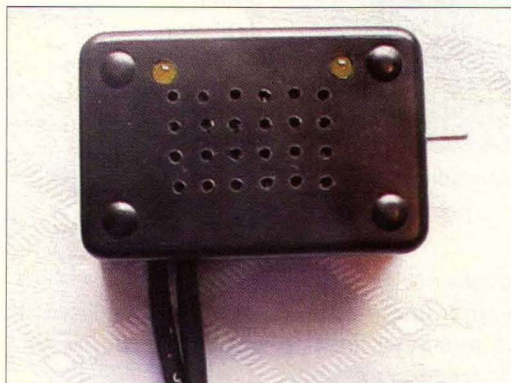
LaneAlert consists of three modules, each housed in a black plastic project box: a computer module and two sensor modules. Each sensor module is

attached to the computer module by an eight foot length of four-conductor telephone cable. These sensors are located on either side of the vehicle, mounted under the sideview mirrors, and held in place with adhesive-backed Velcro.

The sensor modules view the road for lane markings. Figure 2 shows the under-side view of a sensor module. Four screws hold the cover in place. The cover is drilled with light-entry holes, known as apertures. The amount of light entering the sensor module is important. In much the same way the pupil of the eye regulates light, we must ensure the internal photocell sensors receive the right amount of light. The diameter of the apertures greatly depends on the outdoor lighting you'll be testing under. You'll want to test the device in sunlit conditions initially. I recommend holes no



**Figure 3:** Sensor module with cover removed, exposing perf boards with photocells.



**Figure 4:** Computer module has two indicator LEDs. Small holes are drilled for the piezo alarm.

# FUN<sup>2</sup>

## JUNGLE ROBOT

### Climbing & Walking Kit

**\$19.95 USD**

**2-IN-1 KIT**

Orangutan Mode      Gorilla Mode



**"Go Ape Wild"**  
over our new "Award Winning" robotic kit. Excellent beginner series exercise. Assemble with basic hand tools. Climbing & walking actions & sound sensor activation. Pre-assembled printed circuit board. Ages 10 & up.



Intermediate Level  
(No Soldering)

## WAO "CRANIUM"

### Programmable Robot Kit

**\$119.95 USD**

**"WOW is right!"** Our 4th generation of WAO robot kits. WAO Cranium is a 2-wheeled robot that can be programmed without a separate personal computer. 4 floor light sensors and 2 infrared LEDs gives WAO the vision & can be programmed up to 60 steps & 30 FOR-NEXT multiplex loops. Ages 10 & up.

# ROBOTIKITS

## DIRECT

17141 Kingsview Ave. Carson, CA 90746 USA  
Various Skill Levels. Call Toll Free.

## 877-515-6652

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

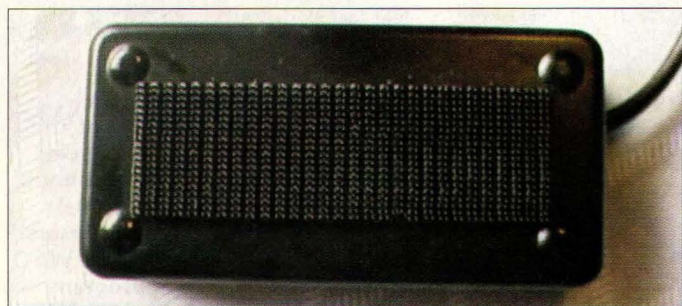




**Figure 5:** The internals of the computer module, including power switch (left), BASIC Stamp computer (top), and battery (center). Wiring is routed around the perimeter of the module.

greater than 1/16" diameter in bright light. When you're ready for low-light conditions, you will probably need to increase to about 3/16" or so. I recommend drilling two sets of holes as shown. When you want to test in low light, you can select the larger apertures. In bright light, use the smaller ones. To change the aperture configuration, simply remove the cover, rotate it 180 degrees, and re-attach.

Figure 3 shows a sensor module with the cover removed, exposing two photocells. Each photocell is mounted on a small piece of perf board, cut to fit into the slots of the project enclosure. Now is a good time to mention the importance of photocell selection. My initial experiments used a couple of different types. The type I finally decided on is made by a company called Clairex. You'll find the details including the part number and where to buy them listed at the end of the article. You



**Figure 6:** Top of sensor module containing adhesive-backed Velcro.

might be surprised to learn that all photocells are not created equal, even from the same manufacturer and model type. Use a multimeter to measure them in similar lighting conditions, noting the readings. You'll need to select a group of four photocells that are as closely matched as possible. Buy 10 or so to guarantee a good selection.

The remaining part of the system is the computer

module. It is the brain of the system, obtaining sensor readings and evaluating the results. Intended for mounting on the dashboard or resting on the passenger seat, the computer module has two visible LED indicators as shown in Figure 4. Each indicator represents the left and right sensor modules. When a sensor detects a lane marking, the indicator illuminates. The computer module is operated by a Parallax BASIC Stamp BS1-IC and a nine-volt battery. Also contained in the module is a piezo buzzer for alarm annunciation. Figure 5 shows the inside of the computer module.

Each sensor module attaches to the computer module with an eight-foot length of four-conductor telephone wire. Drill holes in each project case just large enough for cable entry. Apply a thin layer of Super Glue™ at each opening to secure the cables and to provide strain relief. Wire the system according to the schematic diagram.

To install the sensor modules, use some strips of adhesive-backed Velcro. Apply one part of the Velcro to the underside of the side-view mirror housing. Apply the other part to the top-side of the module as shown in Figure 6. Figure 7 shows the installed sensor module. Route the left sensor cable to the vehicle interior through the crevice where the door panel hinges to the body. Be careful to avoid possible pinch points. Repeat the process for the right side-view mirror. The computer module can be attached to a convenient space on the dashboard using Velcro strips or allowed to rest on the passenger seat.

## How it works

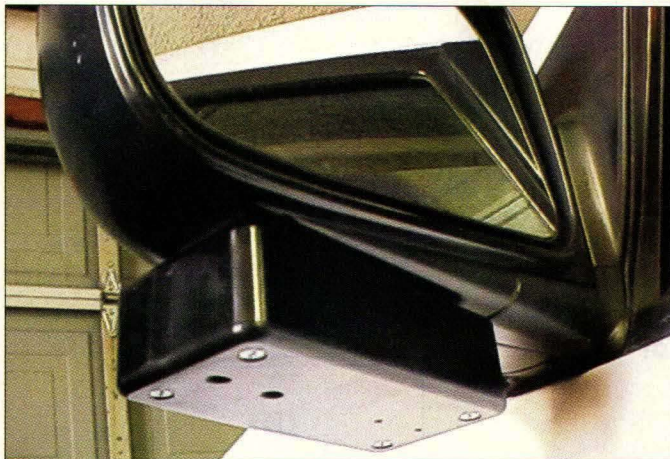
Figure 8 shows the schematic diagram of the entire system. The design is based on the concept of light reflectivity. When light hits a surface, a certain amount of it reflects away, while the remaining amount is absorbed by the surface. Different colors have varying levels of reflectivity. Light-colored surfaces have high reflectivity. White, for instance, has high reflectivity. Dark surfaces have low reflectivity. The computer continually takes light readings from each sensor module, comparing each photocell's readings. A significant difference indicates a successful detection.

The diagram in Figure 9 shows the positioning of the photocells, aperture holes, and road markings. As shown, the photocells are slightly offset from the position of the holes. This gives the device two specific fields of view in each sensor module. The computer compares the light intensity from each field. The idea is that one of the fields should "see" lane markings while the other sees the road itself. Since lane markings typically contrast the road surface, the light intensities should differ significantly, resulting in detections.

## The test drive

Now that you've constructed the prototype, it's time





**Figure 7:** Sensor modules attached to the bottom of the side-view mirror with aperture openings facing down.

for a test drive. First, you'll need to determine the time of day for the test. Generally, you have a couple of choices: low lighting and bright lighting. The selection is important since it determines which set of aperture holes you will use, as described earlier. For bright lighting (e.g., mid-day), use the smaller holes. Too much light will over-expose the sensors and you'll get improper detection. For low lighting (e.g., dawn, dusk), use the larger holes. To change the selection, simply remove the sensor module covers, rotate 180 degrees, and re-attach. Next, make sure the sensor modules have been securely affixed to each side-view mirror and that cabling does not bind or pinch in the door opening.

Now we're ready to roll. Turn the unit on at the toggle switch. Make the appropriate selection for alarm or mute.

#### Resistors:

R1 - photocell (Clairex CL5P4L, 690NM)  
R2 - 470 ohm (1/4W, 5%)

#### Capacitors:

C1 - 0.1 uF (ceramic)

#### Semiconductors:

BASIC Stamp BSI-IC  
L1 - LED (yellow)

#### Misc.:

Telephone wire, four cond., solid, black jacket (20 feet min.)  
1 project enclosure (3 x 2 x 1)  
2 project enclosures (4 x 2 x 1)  
Perf board  
S1 - DPDT switch, center off  
Piezo buzzer (3.0 - 20VDC, 2.7kHz)  
14-pin SIP IC socket  
Nine-volt battery  
Velcro strips

#### Notes:

All parts except BSI-IC, 14-pin SIP socket, and photocells available from RadioShack  
Photocells available from Mouser Electronics  
BSI-IC available from Parallax  
14-pin SIP socket (solder-tail) available from Digi-Key

## Parts List

LIMITED TIME!  
- FREE SERIAL EE  
- FREE PLCC ADAPT.  
- FREE ZIF SOCKET

## \$95 PRINTER PORT PROGRAMMER

LOWEST COST, FASTEST, EASIEST TO USE!

FLASH, EE, NVRAM, EPROM to 8meg. Adapters for micros. Super small! Stand alone or drive bay mounting kits available. WINDOWS & DOS software. Script files to simplify operation. High yield and faster program than others. 'Gang Bang' option.

## SERIAL MINI-TERMINAL

RS232 terminal for Stamp, PC, Z80, AVR etc.

- super low-current, powers from serial line
- LED backlit LCD, visible in all conditions
- 115.2kbps, DB9 conn, simple commands
- specify 20 customizable or 16 tactile keys

eval(1) \$75,oem(1k) \$21.30,w/BASIC cpu \$27



## LO COST MINI-PC

with DOS, NV mem, ADC, RAM, RTC, ISA/104 bus

Built-in serial, parallel, LCD, keyboard ports

Program in Turbo C, BASIC, MASM, etc.

Complete! no costly development kits required

Lowest power lowest cost pc compatible available

XT:oem(1k)\$27 eval(1)\$95 AT:oem \$55 eval \$195

WWW.STAR.NET/PEOPLE/~MVS

MVS Box 803  
Nashua,NH 03060  
(508) 792 9507



5yr Limited Warranty  
Free Shipping  
Mon-Fri 10-6 EST

Circle #49 on the Reader Service Card.

For your prototype circuit board needs, try  
[www.pcbexpress.com](http://www.pcbexpress.com)

2 layers  
\$11 each  
(see Website for details)

4 layers  
\$19 each  
(see Website for details)

6 layers  
\$25 each  
(see Website for details)

PCBexpress- the leading Internet supplier of circuit boards since 1997

**PCBexpress.com**

#1 #2 #3 #4 F.A.Q. TECHNICAL ABOUT US LINKS PROJECTS CONTACT

**PRODUCTS**

Fast! Proto-types up to 20pc Low Cost! Quality

Prototypes up to 20-pcs  
Fast deliveries  
No tooling charges!

TWO SIDED	TWO SIDED+	MULTILAYER	MULTILAYER+
<b>Express #1</b> Ships Next Day 2-Sided PTH No Mask No Legend ReflowedT/L Routed Edges 	<b>Express #2</b> 3 Day Lead 2-Sided PTH 2-Mask Legend SMOBC Routed Edges 	<b>Express #3</b> 3 Day Lead 4-Layer PTH No Mask No Legend ReflowedT/L Routed Edges 	<b>Express #4</b> 4 Day Lead 4-Layer PTH 2-Mask Legend SMOBC Routed Edges 
ORDER	ORDER	ORDER	ORDER

ECU ECU, Inc. Home of PCBexpress Copyright 2002 All Rights Reserved



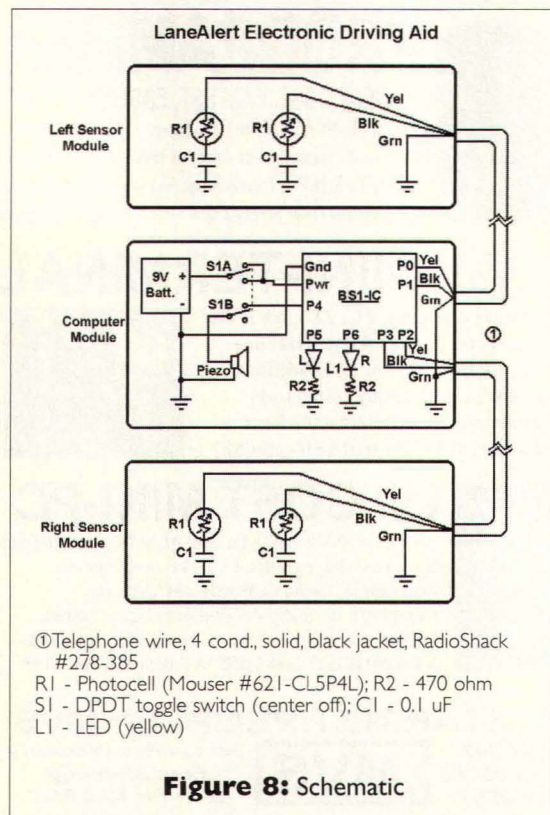


Figure 8: Schematic

You might want to start out with the alarm enabled. After a while, you should probably mute it to minimize distraction. Instead, just glance at the LEDs from time to time. As each sensor makes a detection, its associated indicator will activate. Remember to keep safety at the forefront of the experiment. Do not take your eyes off the road in a potentially dangerous situation. You don't want to become another statistic. For initial tests, I recommend less-travelled boulevards where speeds are not too great. Try to choose roads with good contrast between the road surface and markings.

A couple of things will trigger sensor detections besides road markings. One of these is shadows, as caused by buildings, power poles, trees, and other vehicles. The other source of detections is road discolorations. During daytime driving, these false triggers are to be expected. If you get good activity from both LEDs, the experiment is a success. If one or both indicators fail to activate, you'll need to return home and do some troubleshooting. The first thing to examine is the sensor module apertures. Make sure they're unobstructed and properly aligned. Next, remove the sensor cover and examine the photocells. They should be slightly tilted in the direction of the aperture. Finally, use a multimeter to ensure you have continuity between sensor and computer modules and that the cables are not damaged.

## Code listing

Listing 1 (which is available for download at [www.nutsvolts.com](http://www.nutsvolts.com))

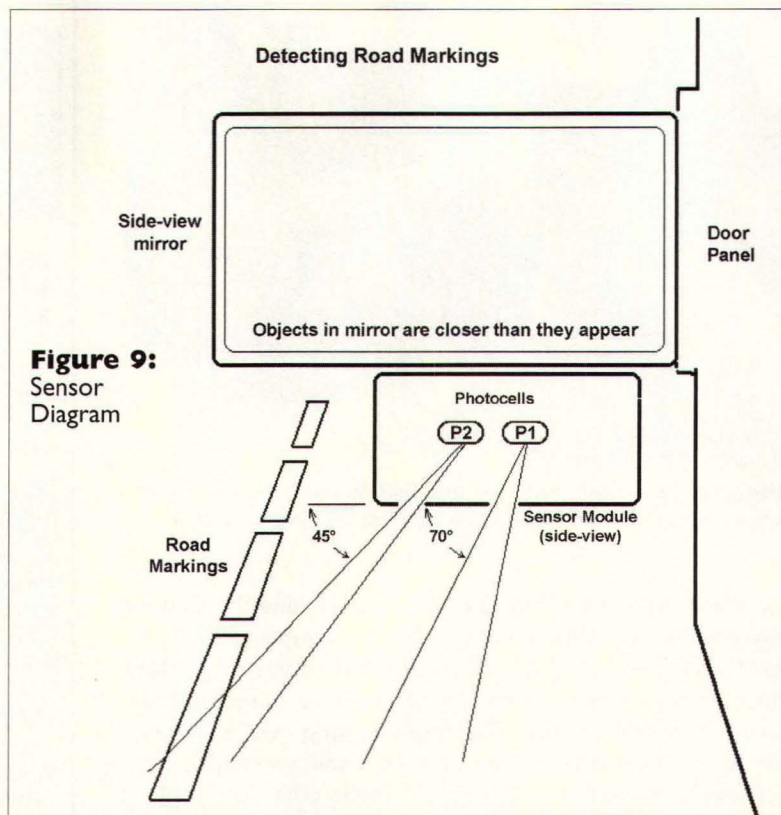


Figure 9: Sensor Diagram

[nutsvolts.com](http://nutsvolts.com)) shows the BASIC Stamp source code. The code is structured in a continuous loop that runs indefinitely (or until the unit is powered off). Each pass through the loop "reads" each of the two photocells in each sensor module. The values correspond to the amount of light detected by each photocell. The greater the amount of light, the higher the value. The values are compared to determine if a detection has occurred. If the difference is greater than CONTRAST, a detection has occurred. An alarm condition results when no detection has occurred in 50 loop passes (tracked by TCounter). This translates to about three seconds. When this occurs, the piezo buzzer sounds a series of beeps and then silences.

## Taking the next step

Remember that LaneAlert is a prototype, a work in progress. It effectively proves the concept of lane detection in sunlit conditions. The obvious next step is to make the appropriate modifications for night driving. Since there is not sufficient lighting, it will need to be improvised somehow, possibly with an onboard illuminator contained in each sensor module.

If you'd like updates on my progress, drop me a note at: [kdelahou@worldnet.att.net](mailto:kdelahou@worldnet.att.net). **NV**

Ken Delahoussaye is a software engineer/consultant with 18-years experience in real-time and embedded applications. He enjoys working with electronic and mechanical devices, prompting him to spend countless hours building all sorts of gadgets. He runs Kadtronix, a small robotics and programming services company in Melbourne, FL.



# Build a Poor Man's Metal Detector

This easy-to-build, low-cost circuit is lots of fun for young and old treasure-hunters alike ...

**M**any of us have seen metal detectors, which are portable electronic devices that contain a search coil that is passed over the ground at an area of interest. When a metallic object is detected, a tone from a speaker or headphones changes pitch, indicating a "find." These sophisticated instruments are used by enthusiasts who like to search for hidden coins and metal objects at the beach and everywhere else. But as you may know, commercially-available metal detectors are not cheap and can cost hundreds of dollars.

You can enjoy the pleasure of hunting for hidden treasures without breaking your budget, simply by constructing the metal detector described here. It's called a "Poor Man's Metal Detector" simply because it can be built for just a few dollars, far less than you might spend on a commercial unit. It employs a very simple beat-frequency circuit that is sensitive enough to locate a coin buried under one inch of

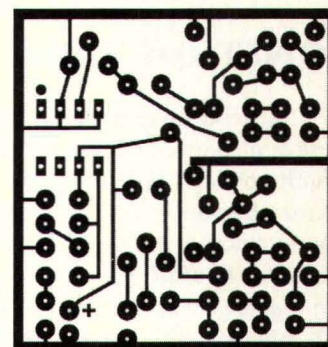
earth. This detector is powered by a common nine-volt transistor radio battery, and can be used with a loud-speaker or headphones, as desired.

## ABOUT THE CIRCUIT

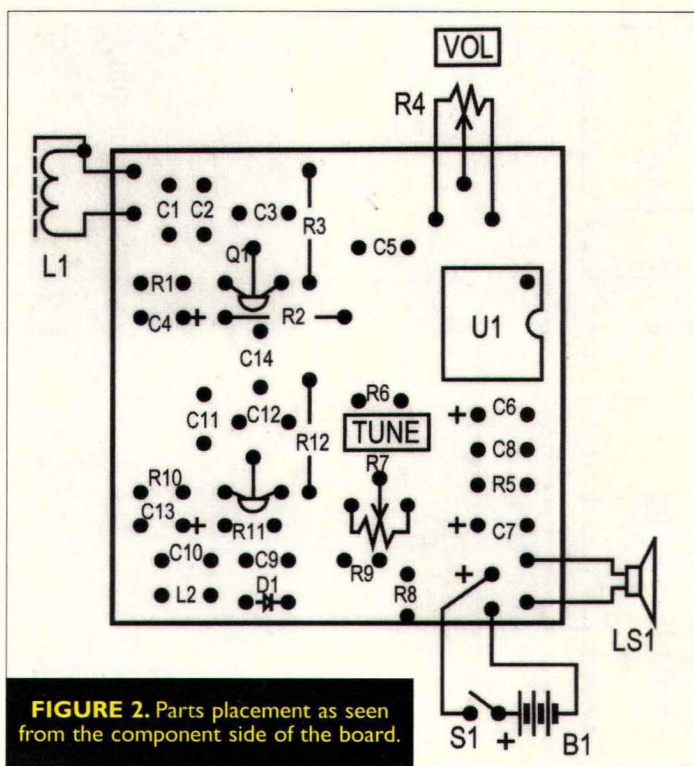
Refer to the schematic diagram. This is a "beat-frequency" circuit in which two oscillators are operating at almost the same frequency, so that an audio signal (difference frequency) can be recovered. A slight variation in the frequency of one oscillator — as the search coil comes within close proximity to a metal object — causes a relatively large change in audio frequency. The circuit contains two almost identical Colpitts oscillator circuits, and an audio power amplifier chip that drives the speaker. The circuit operates by manually adjusting one of the oscillators (Q2) to a frequency that is perhaps 100 or 200 Hz away from that of the other. In this way, the beat frequency can be used to locate metallic objects.

The tuning components of the first oscillator (Q1) are the search coil L1, plus C2 and C3 connected in series. Forward bias to Q1 is provided by R1. This is a classic Colpitts oscillator where the junction of the two capacitors — C2 and C3 — is connected to the emitter. The base and collector of the transistor are returned to the hot and cold side of L1. The circuit thus oscillates at a frequency of about 400 KHz. The circuit of Q2 is similar. In this case, L2 is a fixed inductor of 82 microHenrys, while a varactor (D1) is connected across the tank circuit. Potentiometer R7 is used to provide a variable bias to D1, so that the frequency of the oscillator can be varied both below and above the operating frequency of Q1.

Coupling capacitors C5 and C14 allow a small portion of the energy developed at the emitters of Q1 and Q2 to be

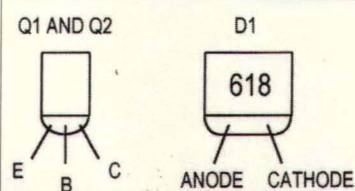


**FIGURE 1.** Layout of the printed circuit board shown full size as seen from the copper side.



**FIGURE 2.** Parts placement as seen from the component side of the board.





**FIGURE 3.** Terminal identification of Q1, Q2, and D1.

audio range, it can be heard in the speaker.

During operation of the instrument, the beat frequency is set to a low tone, and the search coil passed over an area of interest. When there is a metallic object within the periphery of the coil, the tone changes frequency. This alerts the user that a metal object has been found.

## CONSTRUCTION

Construction of the Poor Man's Metal Detector consists of several parts, which include the printed circuit board, search coil, and final assembly. The printed circuit assembly may be performed first. Refer to Figure 1, which is a full-size rendition of the printed wiring as seen from the copper side of the board. If you do not wish to etch your own board, one may be obtained from the source indicated in the Parts List. Alternatively, the circuit is not critical and may be wired on a perfboard if good construction techniques are employed. Refer to Figure 2 for the location of all parts of the board. It is important that the integrated circuit, transistors, electrolytic capacitors, and diode be placed correctly into the circuit as shown. Any polarized component placed backwards will result in an inoperative circuit, and may cause damage to itself or other parts. Figure 3 illustrates the connections to Q1, Q2, and D1. These parts are polarized and must be properly inserted into the PC board. Be sure to double-check before soldering.

If the 2.2 pF capacitors — C5 and C14 — are difficult to obtain, you can easily fabricate them by taking two 1-1/4 inch long pieces of insulated solid #24

simultaneously applied to volume control R4. The input circuit of U1 processes the two frequencies to generate a difference, or beat frequency. Since the user sets the difference frequency to within the

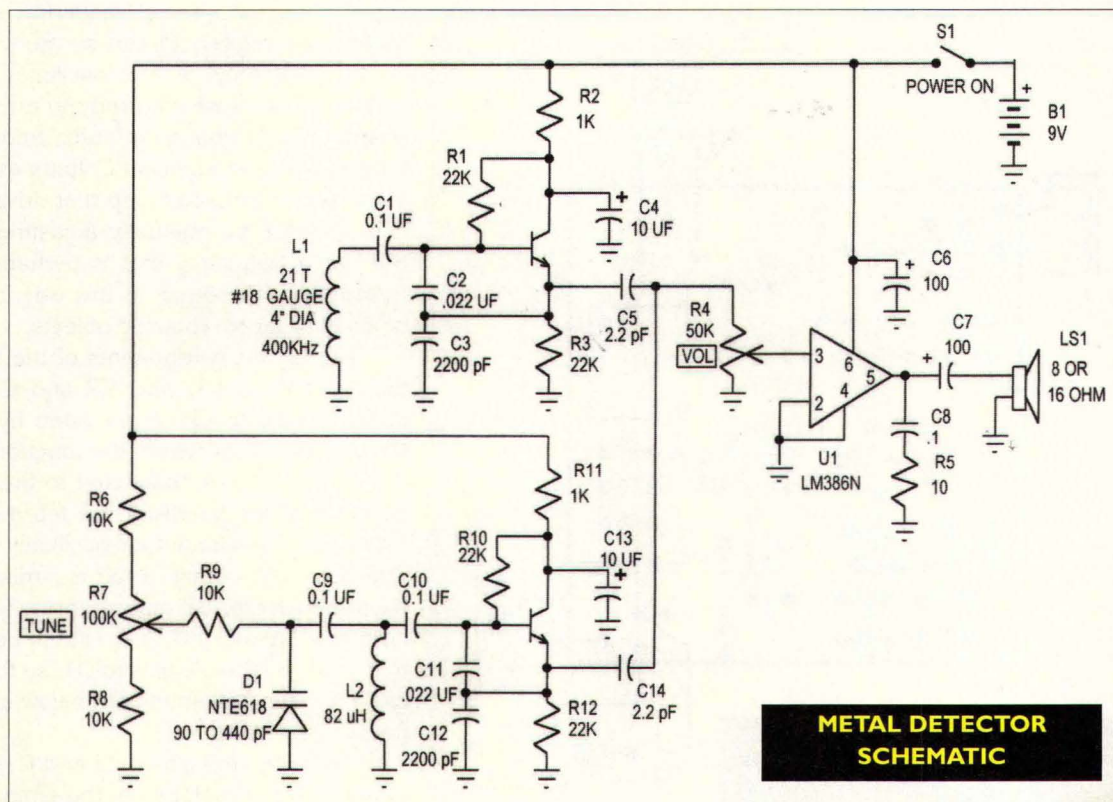
gauge wire and twisting them tightly together. Strip off 1/4 inch of insulation at one end of each wire, and solder into the proper pads of the PC board. Be sure the two wires do not short to each other. Figure 2 also illustrates the connections to L1, S1, battery, tuning control potentiometer, and speaker or headphones. R7 is a panel-mount potentiometer that allows convenience of frequency adjustment during operation of the unit. R4, the volume control, may optionally be placed externally from the board. Use flexible #22 gauge insulated wire for these connections. Using different colors will help avoid miswiring.

When the board has been completed, examine it very carefully for proper component placement. Be sure all solder joints are shiny and smooth, and there are no opens or shorts between closely spaced conductors. It is far easier to correct problems at this stage, rather than later on if you discover that your metal detector does not work. Place the completed board aside while constructing the search coil.

## SEARCH COIL

L1, the search coil, consists of several turns of insulated wire wound on a round form. Use 21 turns of #18 gauge enamel wire wound on a four-inch round form such as a plastic container. Hold the turns in place with paper or plastic tape so that the coil remains rigid after it is removed from the form. This will produce a sturdy coil that is easy to handle.

A Faraday shield will be added to the search coil after the preliminary test, which verifies that the inductance of





L1 is correct. The purpose of the shield is to eliminate capacitive effects as the coil is held close to the ground at the area of interest. Such effects could produce false indication of buried metallic objects. When the coil is finished (less the shield), connect it to the printed circuit board as depicted in Figure 2. Use two short pieces of #22 insulated stranded wire to make the connections.

## PRELIMINARY TEST

The circuit board must be tested prior to the final assembly of the search coil to ensure that the frequency of operation of each oscillator is correct and the board is totally operational. A nine-volt, well-filtered DC power supply may be used for this test, if desired. Keep the search coil away from all metallic objects when making this test. Set R4 to mid-position. Apply power to the circuit, observing correct polarity. Rotate R7 over its complete range. Normal indication is to be able to hear a varying frequency emanating from the speaker. Adjust R4 for low-volume intensity.

If no zero-beat is obtained, the fixed-frequency oscillator (Q1) may be 10 KHz or more away from the frequency adjustment range of R7. If necessary, refer to the troubleshooting section to verify that both oscillators and the audio amplifier are operating. L1 may require one turn to be removed (or added) to set the fixed frequency oscillator higher or lower.

Check the voltage at the wiper of R7 for which the varying tone goes through zero-beat. Normal indication is between one and five volts. Record this value. Record also the voltages at the wiper that produce a very high-audio fre-

quency on each side of zero beat.

For best resolution of R7, the values of R6 and R8 can optionally be increased to limit the frequency adjustment range. By using the voltages previously recorded that produce a very high-audio frequency on each side of zero-beat, calculate new values for R6 and R8 using Ohm's Law. When new resistor values are installed, the adjustment range of R7



## GET THE NEW CATALOG TODAY!

Neat New Kits, And A Lot Of Cool Stuff!

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

### 35 WATT LPFM STEREO TRANSMITTER



- ✓ 35W RF output, VSWR protected
- ✓ Automatic audio & power controls
- ✓ Digital synthesized PLL
- ✓ Full front panel control
- ✓ 110/220VAC, 12VDC operation

Whether your application is export or LPFM, the PX1 has you covered. From the over-rated continuous duty power supply & power amplifier to the 2 line vacuum fluorescent display, your station will be the easiest to setup and the most reliable for continuous operation. Full microprocessor controls provide a "virtual engineer". Check out [www.highpowerfm](http://www.highpowerfm) for full details.

PX1 35W Professional FM Stereo Transmitter \$1,795.00

---

### ELECTROCARDIOGRAM HEART MONITOR



- ✓ Visible and audible display of your heart rhythm
- ✓ Re-usable sensors included; just like visiting the hospital!
- ✓ Bright LED "beat" indicator
- ✓ Monitor output for oscilloscope display

Enjoy learning about the inner workings of the heart while covering the stage by stage electronic circuit theory of ECG/EKG systems. Be heart smart and learn at the same time! Simple and safe 9V Battery operation.

ECG1	Electrocardiogram Heart Monitor Kit	\$39.95
CECG	Matching Case & Knob Set	\$14.95
ECGP10	Replacement Reusable Probe Patches (10-Pack)	\$7.95

---

### PLASMA GENERATOR



- ✓ Generate 2" sparks to a hand held screwdriver!
- ✓ Build your own plasma balls!
- ✓ 25KV at 20 KHz from a solid state source!

Generate really impressive sparks, build your own plasma ball, light fluorescent tubes without wires! From a solid state source, generate over 25KV at 20KHz for the most dazzling displays!

PG13	Plasma Generator Kit	\$64.95
PS12	14VAC Output Power Supply	\$19.95

---

### ION GENERATOR



- ✓ Generates negative ions with a blast of fresh air!
- ✓ 7.5KV DC negative, 400uA - that's a lot of ions!
- ✓ Steady state DC voltage, constant current, not pulsed!

Learn the basics of ion repulsion by building this ion generator! Creates a continuous blast of fresh air charged with a ton of ions. Perfect for pollution and air freshening; just smell those ions! Solid state wind generation; you'll be amazed!

IG7	Ion Generator Kit	\$64.95
AC125	110 VAC Power Adapter	\$9.95

---

### HAND HELD SPEED RADAR GUN



- ✓ Measures speed from 10 to 110 MPH!
- ✓ Switchable US or Metric!

Now YOU can clock that cop car! Uses the same doppler radar technology as their radar guns use. We took it out on the road and set off a LOT of radar detectors and the traffic slowed right down! Requires six AAA batteries not included.

SRG20 Hand Held Speed Radar Gun, Assembled! \$89.95

---

### AND...OUR FAMOUS MINI-KITS!

These are easy to build kits that can be used either stand-alone or as building blocks for more complex projects.

TT7	Tickle-Stick Shocker	\$12.95
BN9	Super Snoop Amplifier Kit	\$9.95
BL1	LED Blinky Kit	\$7.95
TD1	Tone Encoder/Decoder Kit	\$9.95
TT7	Touch Tone Decoder Kit	\$24.95
CP03	Code Practice Oscillator Kit	\$14.95
UT5	Universal Timer Kit	\$9.95

### EASY-LEARN HOBBY KITS



Learn how AM, FM, and Shortwave radios work! Go back in time, and learn the theory how to use a crystal diode to convert AM radio to audio you can hear! Learn the basics of bells and motors, and actually watch them work! Start a great hobby in electronics with our 130 in 1 Electronic Lab, and build a radio, radio broadcaster, electronic organ, kitchen timer, logic circuits, and much, much more! All kits are solderless, using spring-coil connections, making it safe and easy for anyone to build. Detailed step-by-step instructions are included to guide you through the entire project. Learn about electronics and study the wonders of science today!

AM2	AM Radio Kit	\$14.95
AMFM7	AM/FM Radio Kit	\$19.95
SR3	Shortwave AM Radio Kit	\$19.95
CS2	Crystal Radio Kit	\$9.95
BA1	Bell Action Kit	\$8.95
MA1	Motor Action Kit	\$8.95
PL130	130 In One Electronic Lab Kit	\$39.95

---

### PROFESSIONAL FM STEREO RADIO STATION



- ✓ Synthesized 88 to 108 MHz with no drift!
- ✓ Built-in mixer - 2 line inputs, one microphone input, line level monitor output!
- ✓ High power module available for export use
- ✓ All new design for 2002!

Introducing the FM100B, the all new design of our very popular FM100! Designed new from the ground up, including SMT technology for the best performance ever! Frequency synthesized PLL assures drift-free operation with simple front panel frequency selection. Built-in audio mixer features LED bargraph meters to make setting audio a breeze. The kit includes metal case, whip antenna and built-in 110 volt AC power supply.

FM100B	Super-Pro FM Stereo Radio Station Kit	\$269.95
FM100BEX	1 Watt, Export Version, Kit	\$349.95
FM100BWT	1 Watt, Export Version, Wired & Tested	\$429.95

---

### SYNTHESIZED FM STEREO TRANSMITTER



- ✓ All new design & features for 2002!
- ✓ Fully adjustable RF output

Our #1 kit for years has just gotten better for 2002! Totally redesigned, the FM25B has all the features you've asked for. From variable RF output, F connector RF output jack, line input, loop output, and more. Includes case, power supply, whip antenna, audio cables.

FM25B Synthesized FM Stereo Transmitter Kit \$139.95

---

### FM RADIO STATION BROADCASTER



- ✓ Get on the air for less than \$40!
- ✓ Operates on 5 to 15 VDC

You'll be amazed at the exceptional audio quality of the FM10A! Tunable from 88MHz to 108 MHz, the FM10A features line level stereo inputs with RCA phono jacks for easy operation. Order yours today, and get on the air!

FM10A	Tunable FM Stereo Transmitter Kit	\$39.95
CFM	Matching Case & Knob Set for FM10A	\$14.95



**RAMSEY ELECTRONICS, INC.**  
 793 Canning Parkway  
 Victor, NY 14564  
 585-924-4560  
[sales@ramseykits.com](mailto:sales@ramseykits.com)



## Order Today! 800-446-2295

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



will closely reflect the previously recorded voltages.

## TROUBLESHOOTING

If there is no audio response from the speaker, the circuit must be checked to verify that both oscillators are operating close to the correct frequency. An oscilloscope, if available, will be handy.

The best way to troubleshoot a printed circuit board is to first examine it very carefully for incorrect components, solder bridges between closely-spaced conductors, and opens or bad solder joints. All polarized components must be checked for proper placement as indicated in Figures 2 and 3. This procedure will more often than not reveal a defect in the assembly.

Be sure the circuit is powered by at least +8 volts. With component placement verified, check the voltage at the emitter of Q1 and Q2 with a DC voltmeter. Normal indication is about six or seven volts DC. An oscilloscope should indicate a two-volt peak-to-peak AC voltage at the emitter of each transistor. Using the calibrated sweep speed of the scope to check the waveform, the period of each sinewave should be about 2-1/2 microseconds for a frequency of 400 KHz. If the circuit is oscillating, but the frequency is wrong, check L1, C2, and C3 for oscillator Q1. Check L2, C11, and C12 for oscillator Q2.

If the variable frequency of Q2 cannot be set both above and below the frequency of Q1, L1 must have one turn removed or added as necessary. Removing or adding a turn will cause the frequency of Q1 to go higher or lower, respectively. Measure the voltage at the wiper of R7 as it is varied over its range. Normal indication is about 0.75 to 8.75 volts with nine volts powering the circuit. If not, check R6, R7, and R8. If everything looks normal up to this point, but the speaker is silent, check the orientation of U1 and C7. Check C5, C14, and R4. Measure the voltage at pin 6 of U1 to be sure it is at least +8 volts. Check speaker wiring. If necessary, try a new chip and substitute a different speaker.

## FINAL ASSEMBLY

A Faraday shield must be placed over the search coil to avoid capacitive effects, which would alter the fixed-oscillator frequency and make it difficult to locate metal objects. This is easily accomplished as follows.

Cut several pieces of household aluminum foil about 1-1/2 inches by six inches long.

Take one piece of the foil. Starting at the point where the pair of leads of L1 come out, wrap it around the coil wires to totally enclose about three or four inches of the periphery. Squeeze the foil tight around the coil.

Take a second piece of foil and wrap it around the coil wires to continue the shield around the periphery of the coil.

Continue with additional pieces of foil as necessary to

complete the circle around the coil. There must not be any gaps in the foil covering. When done, there should be a 1/4 inch space between the beginning of the shield and the end. Otherwise, a shorted turn will result.

Take a 30-inch piece of solid bare #24 gauge bus wire, and wrap about two or three turns closely spaced around the shield at one end. Allow at least two inches lead length for connection later.

Carefully solder the turns together to secure the wire.

Wrap the remaining wire around the shield in a spiral manner so that the aluminum foil is held tight around the coil wires. When finished, wrap about two or three turns around the shield, and solder them together as before. Cut off any excess wire.

The bare wire pigtail of the shield should be soldered to the ground side of L1. Connect L1 to the PC board, using two short pieces of insulated flexible wire. Be sure the wire containing the Faraday shield connection goes to circuit common. Check operation of the circuit to verify that it will produce a zero-beat as before.

## ENCLOSURE

The PC board, battery, and loudspeaker may be placed in a small enclosure that can be located near the search coil. R7 — the tuning control — should be located where it can easily be adjusted as the metal detector is in use. If

B1 — nine-volt alkaline transistor radio battery  
C1, C8, C9, C10 — 0.1 uFd 50-volt ceramic disc or monolithic capacitor  
C2, C11 — .022 uFd 50-volt polyester or mylar capacitor  
C3, C12 — 2,200 pF 50-volt polyester or mylar capacitor  
C4, C14 — 10 uFd 25-volt radial electrolytic capacitor  
C5, C14 — 2.2 pF 50-volt disc capacitor (see text)  
C6, C7 — 100 uFd 25-volt radial electrolytic capacitor  
D1 — NTE618 varactor diode  
LS1 — 8- or 16-ohm speaker  
Q1, Q2 — 2N3904 NPN transistor  
R1, R3, R10, R12 — 22K 1/4 watt carbon resistor  
R2, R11 — 1K 1/4 watt carbon resistor  
R4 — 50K potentiometer, PC or panel mount  
R5 — 10 ohm 1/4 watt carbon resistor  
R6, R8 — 10K 1/4 watt carbon resistor (see text)  
R7 — 100K potentiometer, panel mount  
R9 — 10K 1/4 watt carbon resistor  
S1 — SPST slide or toggle switch  
U1 — LM386N audio amplifier IC

## PARTS LIST

Misc: Battery clip, #18 gauge enamel wire, #24 gauge bus wire, aluminum foil, enclosure, and search handle.

## SOURCES OF SUPPLY

Mouser Electronics: [www.mouser.com](http://www.mouser.com); 800-346-6873

Digi-Key: [www.digikey.com](http://www.digikey.com); 800-344-4539

Note: An etched and drilled printed circuit board is available from A. Caristi, 69 White Pond Road, Waldwick, NJ 07463 for \$15.00 postpaid.



desired, a connector may be installed to allow the use of headphones. Optionally, R4 may be a panel-mount control mounted to the enclosure to allow field adjustment of volume.

It is up to the builder to provide a suitable handle to which the search coil will be mounted. It is important to have a rigid assembly to avoid frequency shifts when the unit is in use. Do not use any metallic hardware for this assembly.

## USING THE DETECTOR

Use a fresh alkaline nine-volt battery. Turn power on and adjust R7 to obtain a low frequency from the speaker. When making this adjustment, be sure the search coil is located away from any metal object. Use as little volume as possible to conserve battery power.

Hold the search coil parallel to the ground at an area of interest. Best results will be obtained if the coil is about 1/2 inch away. Slowly make a sweep motion to cover as much area as desired.

As the coil passes over a buried metal object, the frequency heard in the speaker will either go higher or lower depending upon which side of zero-beat R7 has been adjusted. While moving the coil around the area of the find, you will then be able to determine its exact location.

The detector is capable of finding small objects, such as a dime, that are within one inch of the coil. Larger objects can be found at greater distances.

If the sound emanating from the speaker becomes erratic or weak, replace the battery. **NV**

Visit Our Website At  
<http://www.elexp.com>

## ELECTRONIX EXPRESS

<b>SOLDER / DE-SOLDER STATION</b> <b>MODEL XY988ESD</b> No external air needed, ESD safe, lots of free accessories, electronic temp control <b>\$390<sup>00</sup></b>	<b>BENCH DMM</b> WITH RS232 INTERFACE <b>MODEL DM9803R</b> True RMS, digital and bar graph display, AC/DC Cap, Res, frequency functions. Includes software, AC or DC operation. <b>\$99<sup>00</sup></b>	<b>ULTRA-MICRO COLOR CAMERA</b> <b>MODEL 29ECMP02</b> Low cost, color pinhole lens camera. Only 5/8" x 5/8" x 5/8". 1.5 lux, 380 lines. <b>\$49<sup>00</sup></b>
<b>INSTEK OSCILLOSCOPE</b> <b>MODEL GOS-620</b> Dual Channel - 20MHZ (INCLUDES PROBES) <b>\$299<sup>00</sup></b>	<b>RSR 3MHZ SWEEP FUNCTION GENERATORS</b> 6 Waveform Functions, Int/Ext Counter, lin/log sweep <b>MODEL FG-30 (No Digital Display) \$120<sup>00</sup></b> <b>MODEL FG-32 (5 Digit Display) \$185<sup>00</sup></b>	<b>SOLDERLESS BREADBOARD</b> 830 tie points. MB102PLT model features 3 binding posts and aluminum backplate. Part No. 1-9 10+ MB102 4.50 4.25 MB102PLT 7.50 6.50
<b>SCOPE PROBE 60 MHZ SWITCHABLE X1, X10</b> <b>\$12<sup>95</sup></b>	<b>ALLIGATOR LEADS SET OF 10</b> <b>\$2<sup>10</sup></b>	<b>PRESS-N-PEEL</b> PC Board Transfer Film PNP Blue 5 Sheet ..... \$9.90 PNP Wet 5 Sheet ..... 9.90 PNP Blue 20 Sheet ..... 28.95 PNP Wet 20 Sheet ..... 28.95
<b>DIGITAL MULTIMETER</b> 32 Ranges - 3 1/2 Digit <b>MODEL MY-64 \$27<sup>95</sup></b> AC/DC Volt/Current, Res. Cap., Frequency. Rubber Holster Included	<b>SWITCHES</b> Mini Toggle SPDT .. 50¢ ea. <b>SOLDERING IRON 3-WIRE HIGH PERFORMANCE #060501 \$5<sup>25</sup></b>	<b>ROTARY TOOL KIT</b> <b>29DR101 \$33<sup>95</sup></b> Variable speed tool (37,000 RPM) with accessory kit in a hard plastic carry case.
<b>PAD-234 DIGITAL/ANALOG TRAINER</b> Complete portable workstation. Variable and fixed power supplies, function generator, digital I/O, rugged design, high impact case. Assembled <b>\$150<sup>00</sup></b> Kit <b>\$110<sup>00</sup></b>	<b>HIGH QUALITY TOOLS</b> With Cushion Grips and Return Spring Needle Nose Pliers ..... \$2 <sup>95</sup> Wire Stripper ..... \$1 <sup>50</sup> Diagonal Cutter ..... \$2 <sup>95</sup>	<b>FREE CATALOG</b> MORE Low-Priced Items In Our <b>FREE</b> 300+ Page Catalog
<b>DC POWER SUPPLIES</b> <b>MODEL HY3003 - DIGITAL DISPLAY</b> Variable output, 0-30 VDC, 0-3 Amp ..... \$88 <sup>00</sup> <b>MODEL HY3003-3 - TRIPLE OUTPUT</b> Two 0-30 VDC, 0-3 Amp variable outputs plus 5V 3A fixed. Digital Display. ..... \$215 <sup>00</sup>	LM555 10 Min. .... 22¢ ea. LM741 10 Min. .... 27¢ ea. 74LS00 10 Min. .... 18¢ ea. 7805 Regulator 10 Min. .... 30¢ ea. 2N3904 10 Min. .... 6¢ ea. PN2222 10 Min. .... 6¢ ea. Red LED T 1 1/4 10 Min. .... 6¢ ea. Green LED T 1 1/4 10 Min. .... 7¢ ea. Yellow LED T 1 1/4 10 Min. .... 8¢ ea. Photo Cell 10 Min. .... 65¢ ea. 100K Pot., 1" Shaft PC Mt. 10 Min. 15¢ ea.	

TERMS: Min. \$20 + shipping. School Purchase Orders, VISA/ MC, Money Order, Prepaid. NO PERSONAL CHECKS, NO COD. NJ Residents: Add 6% Sales Tax.

In NJ: 732-381-8020  
 FAX: 732-381-1006

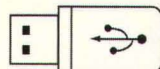
**365 Blair Road • Avenel, NJ 07001-2293**  
**800-972-2225**

<http://www.elexp.com>  
 email: electron@elexp.com

Circle #33 on the Reader Service Card.

**Let Nuts & Volts help build your electronics library!**

See our ad on Page 10. Ask about our 10% subscriber discount on selected titles!



## Roger's Systems

WE'LL GET YOU CONNECTED

© 2001



Wholesale prices to the public

\* February Specials \*



**Curtis Deluxe Monitor Riser**  
 Raises monitor up to 7.25"  
 Holds monitors up to 100lbs.  
**TM-STAND \$9.99**



**Analog Volt OHM Multimeter Economy**  
**TM-325 \$5.99**



**10 ft. USB 2.0 A to B Male/Male Cable**  
 For printer or scanner.  
**CC-USB-AB10 \$4.99**



**6 ft. 2-RCA Male Plugs to 3.5 Stereo Male Plug**  
**AC-557 \$1.00**

Audio-Video, Networking, Computer Accessories  
 ( Call, Click or Visit )

**www.RogersSystems.com**

25030 Avenue Tibbitts Unit H

Valencia, California 91355

800-366-0579 661-295-5577



**2-Way Keyboard/Video (S-VGA)/Mouse Switch Box**  
**DS-102AU \$59.00**

Circle #35 on the Reader Service Card.



# Build the CF-MOSFET **PART I** Audio Power Amplifier

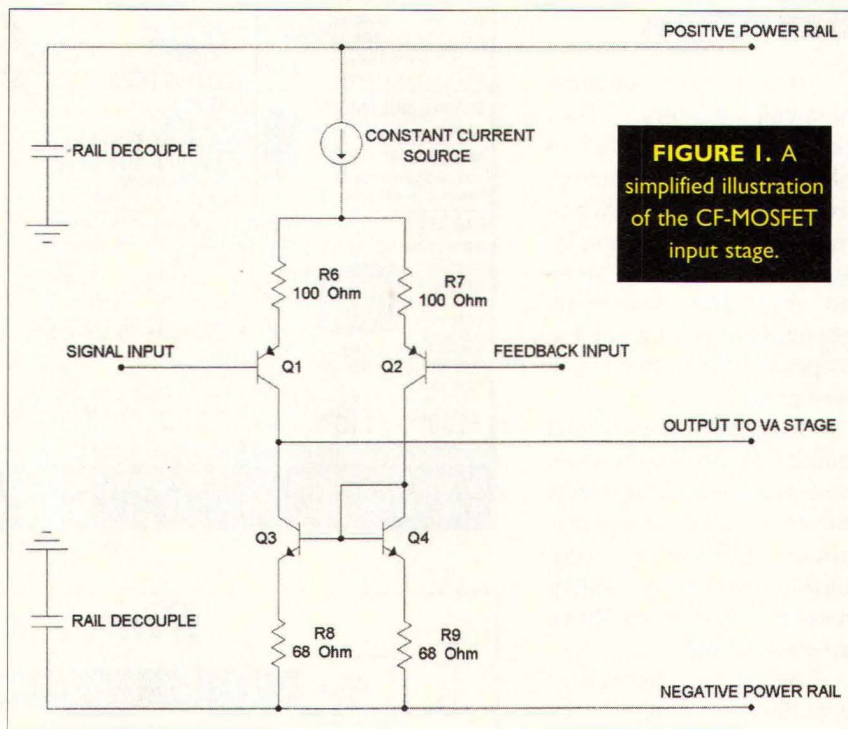
An audiophile-quality amplifier of several configurations, many applications, and surprisingly low cost.

Audiophiles have long recognized that there are significant performance shortcomings inherent to the majority of commercially-available audio power amplifiers. Although I do not have room within the constraints of a single article to adequately discuss all (or even most) critical performance parameters relative to human perception, it has been my experience that most commercially-available, moderately-priced audio power amplifiers do fall significantly short of the desirable goal of practical sonic transparency (i.e., reproduction faithful enough so that any sonic coloration being generated in the audio power amplifier is below human perception levels).

Manufacturers typically measure total harmonic distortion (THD) performance using a 1-KHz fundamental frequency at 0-dB output levels into resistive "dummy" loads. Unfortunately, "real-life" THD performance can climb to very high levels under the conditions of higher frequencies, lower volume levels, and nominally-reactive speaker loading.

Some types of very "nasty" distortion anomalies are created by inadequate slew rates, or as a result of various interactive problems transmitted through the power supply rails (due to the poor power supply rejection ratio, or PSRR, of the amplifier). And I probably don't need to mention the common problems relating to reliability — anyone even mildly involved with audio electronics already knows that audio power amplifiers have a bad reputation of "blowing up."

The quest for excellence in audio reproduction has led the audiophile community down some very exotic and expensive pathways. In today's marketplace, it is common to pay up to \$1,500.00 for a 25-watt monaural audio power amplifier, with some solid-state, 100-watt class-A versions selling for as high as \$16,000.00! Some of the exotic techniques and expensive methodologies relative to



**FIGURE 1.** A simplified illustration of the CF-MOSFET input stage.

the audiophile marketplace are pure nonsense, being somewhat analogous to the fad of placing holes in the sides of cars back in the 1950s. But a large portion of the progress made in the audio fields during the last two decades is very legitimate, and results in notable performance improvements when properly implemented. Unfortunately, many of the larger equipment manufacturers have not taken advantage of these refinements, due to the R & D costs and the simple fact that they are not targeting the "audiophile marketplace." In addition, many of the improved analog techniques are somewhat obscure, as a result of our modern preoccupation with digital equipment and the general trend away from discrete component engineering.

My goal in writing this article is to present a high-performance, no-compromise audio power amplifier design that can be constructed in the typical home-based hobbyist environment at a reasonable cost. Also, since many of



## Tools that will be helpful, but not absolutely necessary:

1. Audio Signal Generator
2. Oscilloscope
3. Good working knowledge of analog circuits

the analog techniques involved seem to be somewhat obscure these days, my intention is to customize this article to be educational, as well as practical.

I am calling this design the "CF-MOSFET amplifier," because it is based on a complementary-feedback output stage design utilizing lateral MOSFETs for output devices (not very original, but I'm an engineer, not a poet). If properly constructed and implemented, the sonic performance of this amplifier will be quite extraordinary, with a reliability factor at least 10 times better than comparable amplifiers incorporating bipolar transistors as output devices.

The applications are many, including any domestic Hi-Fi application, musical instrument amplifiers, medium-power PA systems, multimedia, and commercial audio applications.

Each CF-MOSFET module is capable of providing up to 100-watts RMS or 160-watts RMS (depending on configuration, which is explained later) into typical audio loads, with only 0.004% THD at 1 KHz at maximum output, and only 0.03% THD under worst-case conditions (i.e., about 250 milliwatts at 20 KHz). Roughly speaking, this means that distortion components will always be at least one magnitude below human perception levels regardless of frequency or volume levels, even when driving highly reactive speaker loading. The signal-to-noise ratio (SNR) is better than -100 dB, with noise concerns dwindling into a literal "non-issue" if appropriate construction techniques are used. The bandwidth is from 3 Hz to better than 100 KHz, so transient-related distortion mechanisms can be summarily disregarded. Since L-MOSFETs are absent any secondary-breakdown, thermal runaway, or junction capacitance characteristics (in contrast to bipolar output devices), the amplifier's reliability is increased dramatically.

It was also my goal to remove much of the construction expense, hassle, and complexity from this project. Consequently, I have provided a few options from the typical hobbyist junk box, and I have tried to incorporate components that are inexpensive and readily available. I believe I have accomplished these goals for the most part, the exception being the scarcity and cost of lateral MOSFETs in today's marketplace. However, I have included a good variety of suppliers that

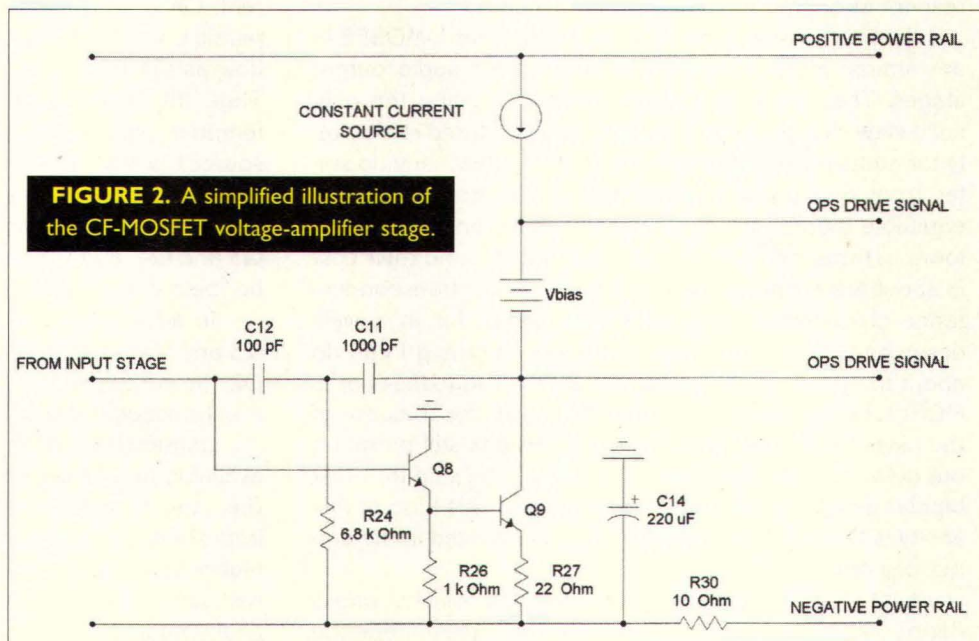
carry L-MOSFETs, so there shouldn't be any great difficulties in this regard.

## Why Lateral MOSFETs Instead of Bipolar Devices?

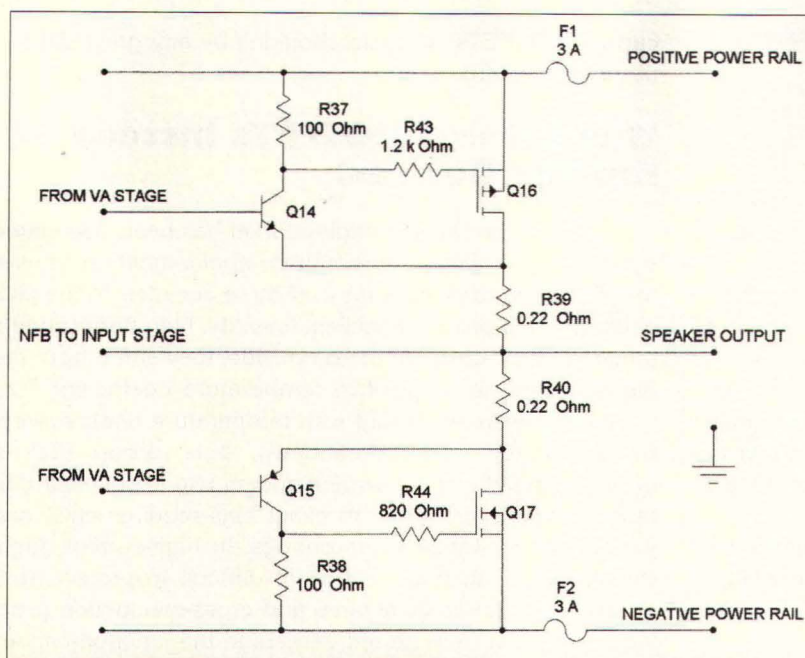
The US commercial audio market has been dominated by power amplifiers incorporating bipolar-junction transistor (BJT) output devices for over three decades. In the plus column, BJTs provide excellent linearity, high transconductance, and low cost. On the down side, they suffer from the disadvantages of a positive temperature coefficient (i.e., increasing leakage current with temperature rise), susceptibility to secondary breakdown, beta droop (i.e., a decrease in beta with a corresponding rise in collector current), extreme sensitivity to exact bias requirements, and junction capacitance shortcomings. In high-current, high-frequency applications, BJTs are difficult to protect from secondary-breakdown failures and cross-conduction problems (resulting from stored carriers in the junction capacitances).

Some BJT designs are more susceptible to destruction than others, but even extensive protective circuitry is not always successful in preventing BJT failure under every possible resistive/reactive loading condition. Almost all protection circuits are impotent during power-up and power-down transient conditions, and this situation adds to the overall risk factor. To make matters worse, most protection circuits can produce false-limiting distortion if the speaker load is more than moderately reactive, and this type of distortion is readily perceived and very discordant.

In contrast to BJTs, the high-current temperature coefficient of lateral MOSFETs (L-MOSFETs) is negative, meaning reverse leakage currents decrease with rising temperature. This characteristic automatically eliminates any possi-







**FIGURE 3.** A simplified illustration of the CF-MOSFET output stage.

bility of thermal runaway problems. Since enhancement-type L-MOSFETs do not contain any junctions in the high-current channel region, problems relating to secondary breakdown and junction capacitance (resulting in sluggish transition and cross-conduction problems) do not exist. The phenomenon of beta droop is also related to the physics of junction operation, so there is no corresponding "gain droop" mechanism inherent to L-MOSFETs. This characteristic greatly reduces large-signal non-linearities associated with drooping speaker impedances. And finally, when incorporated into class-B complementary output pairs, L-MOSFETs are less sensitive to bias levels in respect to optimum distortion performance.

At first consideration, it would seem that L-MOSFETs are almost ideal devices to implement for audio output stages. They boast the distinctiveness of being the only solid-state devices developed and manufactured exclusively for audio-power applications. Unfortunately, they do suffer from two primary disadvantages in comparison to equitable bipolar devices: they are about one magnitude lower in transconductance (i.e., gain factor) and their cost is about two to three times higher. The lower transconductance characteristic can be compensated for in a well-designed amplifier topology, but there's nothing I can do about the price tag. However, the overall ruggedness of L-MOSFETs is a well-documented fact, with the majority of the classic 70's vintage L-MOSFET designs still pumping out great sound today! The same cannot be said for most bipolar designs. It would seem to me that this kind of reliability is worth the extra \$20.00 (or so) invested in the output devices.

L-MOSFETs have been well-received as the prima donna choice for audio output devices throughout the

United Kingdom and most of Europe. US manufacturers have, in general, refused to use them because of the cost factor. The advantages of enhancement-type MOSFETs for audio power applications have enticed some manufacturers to incorporate the less-expensive D-MOS families (V-MOS and HEXFET devices) for audio output devices, but this technique represents a poor compromise. The higher  $V_{gs}$  parameters of D-MOS automatically force much higher distortion levels in the final amplifier design when compared to equivalent L-MOSFET or bipolar designs.

The CF-MOSFET amplifier design incorporates an L-MOSFET output stage in conjunction with numerous improvements to the conventional Lin three-stage topology. Collectively, these improvements effectively solve the lower-transconductance compromise associated with L-MOSFETs and provide tangible improvements in several other areas of performance.

## Input Stage Fundamentals

Figure 1 illustrates a simplified diagram of the input stage design incorporated into the CF-MOSFET amplifier. A differential input stage (Q1 and Q2) is incorporated. It is not commonly known that optimum linearity in a differential stage is accomplished "only" when the quiescent current levels through the differential transistors are closely balanced. To accomplish such an automatic current balance, transistors Q3 and Q4 are used in a configuration that is commonly called a current mirror. Since the collector-to-base junction of Q4 is shorted, its base-to-emitter voltage ( $V_{be}$ ) will be representative of Q2's collector current. Q4's  $V_{be}$  is imposed upon Q3, because they are in parallel, which will force Q3 to promote the same current flow as Q4 (assuming Q3 and Q4 are closely matched). Thus, the "total" quiescent current flow through both differential legs (originating from the constant current source) will be evenly split between the two differential legs, and optimum linearity will be achieved. Resistors R8 and R9 help to minimize small  $V_{be}$  differences between Q3 and Q4, and for best performance, Q3 and Q4 should be "beta matched" to within 10% of each other.

In addition to providing quiescent current balancing, Q3 and Q4 also serve as active collector loads for Q1 and Q2. In comparison to the more common technique of resistor-loading the differential input pair, the active loading characteristic of the current mirror provides twice the available output current to the next stage of the amplifier (i.e., the voltage-amplifier, or VA, stage). This is very important, because one of the more common origins of high-frequency distortion in conventional amplifiers is current-starving of the input stage. Resistors R6 and R7 are degeneration resistors for the differential transistors (Q1



and Q2), providing a significant improvement in overall linearity and temperature stability.

The constant current source of Figure 1 is an active method of supplying a regulated and constant level of operational current to the differential amplifier (Q1 and Q2). In contrast to the common techniques of using a high-value resistor for this purpose, or a zener/resistor combination, a well-designed constant current source provides improved linearity from the differential stage, as well as providing almost total isolation of the differential stage from any variations occurring on the positive power supply rail (an important consideration in establishing the PSRR of the amplifier). Along this same line of thought, the current mirror circuit (Q3 and Q4) also provides some isolation of the differential stage from the negative power supply rail, although it is not as effective at this function as the constant current source.

The input stage's output signal is taken from the collector of Q1 in the form of a current signal, meaning that the input stage is fundamentally a transconductance amplifier. A transconductance amplifier exhibits several advantages over more conventional voltage amplifiers for input stage applications. For one, it relies on the operational physics of transistor operation, rather than the ill-defined value of beta. The input stage transconductance ( $g_m$ ) will be a function of the value of the quiescent current (controlled by the constant current source) and the accuracy of the current balance between the two differential transistors. Transconductance amplifiers also provide improved noise characteristics, and they are less affected by loading variations. As a final note to Figure 1, note that rail decoupling capacitors are installed on both power supply rails. These capacitor networks should be physically located in close proximity to the input stage components for optimum noise and hum reduction.

## The Voltage Amplifier Stage

Figure 2 illustrates a simplified form of the voltage amplifier (VA) stage, as incorporated into the CF-MOSFET amplifier design. To take full advantage of the conventional Lin three-stage topology, all of the amplifier's voltage gain should occur in the VA stage. Consequently, a high-gain VA stage will incorporate beta enhancement (i.e., a modified Darlington pair) as provided by Q8 and Q9, in conjunction with active loading, which is provided by the constant current source in the collector leg of Q9. The resulting high beta value working together with the extremely high impedance of the constant current source

will result in very high-voltage gain factors.

The current signal input (originating from the input stage) "sees" a moderately low impedance on the base of Q8. Even though a significant impedance exists, this point is commonly referred to as virtual ground, because the important variable is the current signal. R26 and R27 are incorporated to provide temperature stability and degeneration (R27 is also used as a current-sensing resistor for protection purposes, but this will be discussed later). Since the VA stage accepts a current signal input and converts it to a voltage signal output, it is considered a transimpedance amplifier.

The combined gain of the input stage transconductance amplifier together with the VA stage transimpedance amplifier is the product of the input stage transconductance ( $g_m$ ) multiplied by the equivalent beta (of Q8 and Q9) multiplied by the impedance of the VA stage constant current source. Several of these variables are ill-defined, such as the beta of Q8 and Q9, and an accurate impedance evaluation of the constant current source. Fortunately, the exact value of this maximum gain factor — usually referred to as the open-loop gain — is not of great importance. It is only important to insure that the open-loop gain is very high (typically in the realm of 90 to 110 dB) so that high levels of negative feedback can be applied for optimum linearization purposes.

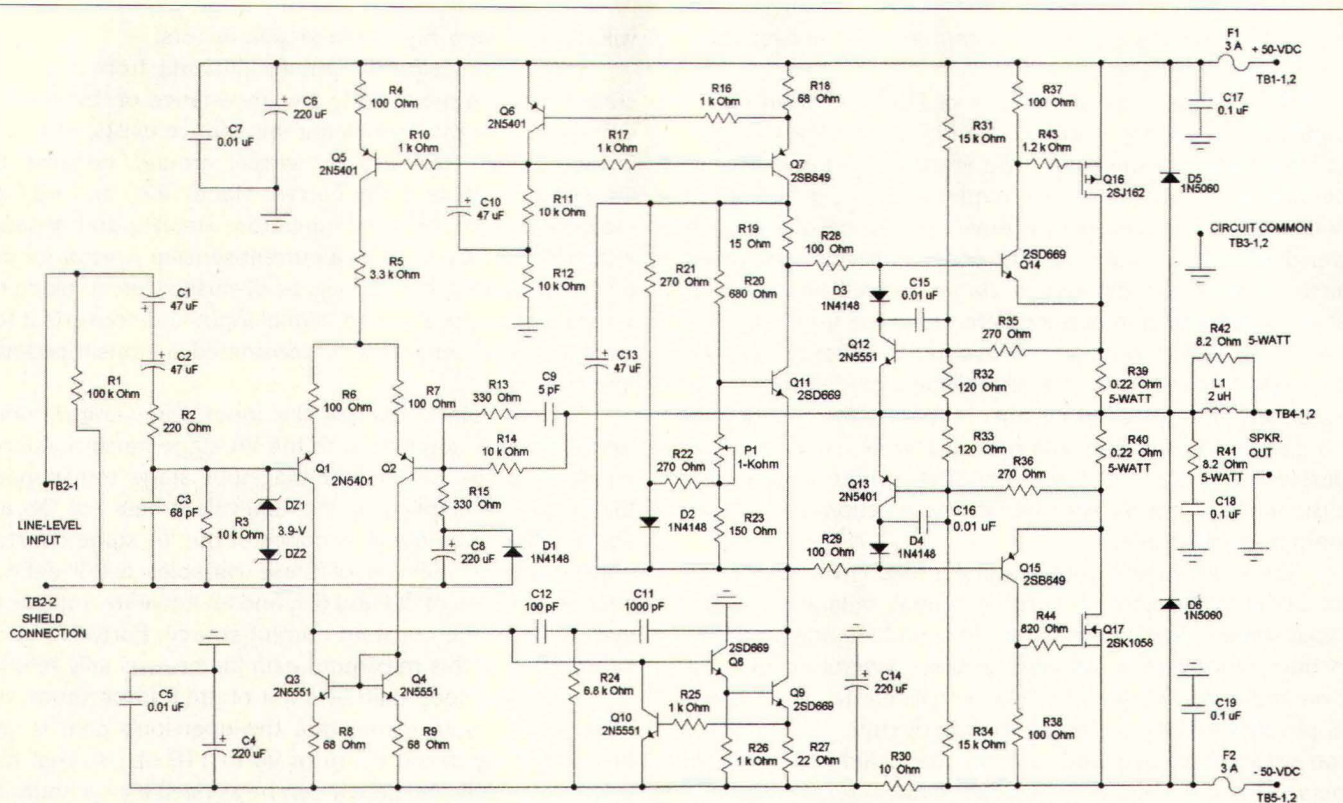
In almost all cases of high-gain, wide bandwidth amplifiers, some form of compensation is necessary. The purpose of compensation in audio power amplifiers is to force the voltage gain to drop with increasing signal frequency, so that unity gain is reached "before" the typical circuitry capacitances cause an output signal phase lag of more than -180 degrees. This is critical for good stability, because excessive phase shifts at the amplifier's output will cause the negative feedback signal to turn into "positive feedback," converting the audio power amplifier into a high-power, high-frequency phase-shift oscillator!

Referring again to Figure 2, the compensation network consists of C11, C12, and R24. In the low-frequency realm of operation, the capacitive reactance of C11 and C12 will cause them to appear to be open, and the voltage gain factor of the VA stage will be at maximum. However, as the signal frequency rises, a significant level of Q9's collector signal will be coupled back to the base of Q8. Since Q9's collector signal is inverted relative to the signal input at the base of Q8, the signal through C11 and C12 is "negative feedback," causing a reduction in voltage gain as frequency is increased. In addition, the operation of the VA stage becomes more "linear" as frequency increases (because increasing negative feedback improves linearity), and the input impedance of the VA stage drops with increasing frequency (which explains one reason that we want the input stage to be a transconductance amplifier, since a current signal is relatively immune to such frequency-dependent impedance variations).

The compensation technique of Figure 2 is commonly

G. Randy Slone is an electronics engineer, a consultant, and author of six books for the McGraw-Hill Publishing Companies, including the *High-Power Audio Amplifier Construction Manual*, *The Audiophile's Project Sourcebook*, and *The TAB Guide to Understanding Electricity and Electronics*. Mr. Slone is the owner/operator of SEAL Electronics, and the current senior design engineer for ZUS Audio Products.





**FIGURE 4.** Complete schematic of the CF-MOSFET (complementary-feedback L-MOSFET) amplifier.

called two-pole compensation, because it effectively creates two "breakpoints" of the gain rolloff slope. At lower frequencies, the compensation network will promote a -12 dB/octave rolloff of open-loop gain, but as the frequency increases to the unity-gain point, the gain rolloff slope changes to -6 dB/octave. The advantage of two-pole compensation is that it allows a steeper rolloff of the open-loop gain, meaning that the frequency at which the gain rolloff begins can be set higher while still maintaining the same stability factor. Thus, a greater degree of negative feedback (at higher frequencies) can be utilized, improving overall linearity without compromising stability factors.

The battery symbol labeled "Vbias" in Figure 2 is representative of the low-level forward bias network required to bias the class-B output stage into optimum linear operation and reduce crossover distortion. This bias circuit is a simple resistor-diode-transistor network providing an adjustable bias voltage (typically about 1.6-volts DC) from the operational current provided by the constant current source. [The VA stage constant current source is set to provide about 10 milliamps of VA stage quiescent current.] Briefly referring back to Figures 1 and 2, note that a constant current source is utilized to provide "tail current" for the input stage, while another constant current source provides active loading for the VA stage. In both cases, the constant current sources provide almost total isolation from any interference signals that could be superimposed on the positive power supply rail (i.e., signals such as

power supply ripple, rectification spikes, crosstalk signals from adjacent amplifier channels, etc.). Unfortunately, the negative power supply rail is not isolated nearly as well.

In the case of the input stage, the current-mirror circuit provides some isolation (as previously stated), and the inherent power supply noise rejection characteristic of the differential stage (Q1 and Q2) adds additional immunity to noise signals. But the VA stage is totally susceptible to undesirable signal injection problems through R27. Thus, it is desirable to improve the power supply rejection ratio (PSRR) with the filter circuit of R30 and C14. These components make up a simple low-pass filter that provides effective filtering of any interference signals riding on the negative power supply rail.

## A Hybrid Complementary-Feedback Output Stage

Figure 3 illustrates a simplified version of the CF-MOSFET output stage design. The configuration of pre-driver transistor Q14 and L-MOSFET Q16 forms a complementary-feedback pair (sometimes called a Sziklai pair, after the inventor). Since the pair is made up of two distinct semiconductor families (i.e., BJTs and L-MOSFETs), it is often referred to as a hybrid output design. Likewise, Q15 and Q17 make up an identical, but complementary, output pair.

Q14 is connected in a simple common-emitter configuration, with the input signal voltage applied to the base,



and the output signal voltage taken from the collector. The resistance ratio of the collector resistor (R37) to the emitter resistor (R39) establishes the voltage gain at a high value. However, the associated P-channel L-MOSFET (Q16) is configured so that 100% of its amplified drain signal is fed back to the emitter of Q14 as negative feedback, thus reducing the overall voltage gain of the complementary-feedback pair to unity (technically speaking, it will be a little less than unity due to slight efficiency losses of the circuitry). The advantage of such a circuit is that the "local" negative feedback loop inherent to the complementary-feedback pair dramatically improves the overall linearity of the circuit. This technique essentially compensates for the inherent low transconductance value of L-MOSFETs. Of course, the complementary-feedback pair of Q15 and Q17 functions in the identical, but complementary, manner.

The small forward DC bias provided by the Vbias network (in the VA stage) is applied between the bases of Q14 and Q15. The Vbias voltage is adjusted so that a quiescent voltage of approximately 20 millivolts is established between the drain leads of Q16 and Q17 (i.e., the sum of the voltage drops across R39 and R40). This equates to a quiescent bias current of about 40 milliamps through the L-MOSFET output devices, which is an optimum bias level for low-distortion performance. R43 and R44 are "gate resistors," incorporated to suppress parasitic gate oscillations that can occur in L-MOSFETs. The resistance values are different for the P-channel and N-channel devices because the specified gate capacitance differs between the two device polarities (i.e., the 2SJ162 devices are specified at 900 pF, while the 2SK1058 devices are specified at 600 pF).


Finally, note that the speaker output signal is also fed back to the input stage, via the negative feedback (NFB) line. This particular type of NFB is referred to as global negative feedback, because the feedback signal pertains to the functioning of the entire amplifier, rather than being representative of a single, or "local," stage.

## Putting It All Together

The complete schematic of the CF-MOSFET amplifier is illustrated in Figure 4. Now that the individual stage functions have been described in some detail, the overall functional description of the amplifier

should be a little easier to understand. Beginning at the line-level input, R1 is a type of bleeder resistor, used to provide a discharge path for any external devices that could be providing a signal output through an "open-ended" coupling capacitor. C1 and C2 are tantalum capacitors, configured as a non-polarized coupling capacitor — they should be rated for at least 25 volts.

R2 and C3 form a first-order high-frequency filter for the purpose of attenuating any ultrasonic or RF frequencies that could find their way to the input. R3 sets the input impedance of the power amplifier at 10-Kohm. The back-to-back zener diodes, DZ1 and DZ2, provide over-voltage protection for the differential input transistors (Q1 and Q2).



**SUPPORTS  
DEVICES TO  
32 MEG**

## EPROM+

A device programming system  
complete info at [www.arlabs.com](http://www.arlabs.com)

♦ EXCEPTIONAL POWER FOR THE PRO  
♦ EASY-TO-USE FOR THE NOVICE

**Here's what you get:** A rugged, portable programming unit including the power pack and printer port cable both of which store inside the case. A real printed user and technical manual which includes schematic diagrams for the programming unit plus diagrams for all technology family adapters\*. Comprehensive, easy-to-use software which is specifically designed to run under Windows 95, 98, ME and DOS on any speed machine. The software has features which let you READ, PROGRAM, COPY and COMPARE plus much more. You have full access to your system's disk including LOADING and SAVING chip data plus automatic processing of INTEL HEX, MOTOROLA S-RECORD and BINARY files. For detailed work the system software provides a full screen buffer editor including a comprehensive bit and byte tool kit with more than 20 functions.

**Broad device support:** Including FIRST GENERATION EPROMS (2708, TMS2716\*, 25XX etc.) SECOND GENERATION EPROMS (2716-27C080/8 MEG, 40 and 42 PIN EPROMS\* (27C1024-27C322/32 MEG) EPROMS (2816-28C010) PLUS ER5901, FLASH EPROMS (28F, 29C, 29EE, 29F/32 MEG), NVRAMS (12,20,X2210/12) 8 PIN SERIAL EPROMS\* (24, 25, 85, 93, 95, 8001A) PLUS ERI400/MS865\* BIPOLAR PROMS\* (74S/82S), SERIAL FPGA CONFIGURATORS (17CXXX) MICROS\* (874X, 875X, 87C5X, 87C75X, 89C) ATMEL MICROS\* (89S, 90S) (AVR) PIC MICROS\* 8, 18, 28, 40 PIN (12CXXX, 16C5X, 6X, 7X, 8X PLUS FLASH & 17C) MOTOROLA MICROS\* (68705P3/U3/R3, 68HC705C8/C9/J2/P9, 68HC11 all families)

**\$289**

**\$7.00 SHIPPING • \$6.00 C.O.D.**

Includes step-by-step tutorial plus explanation of EPROM fundamentals  
1 YR. AR WARRANTY - 30 DAY MONEY BACK GUARANTEE  
\*REQUIRES SNAP-IN ADAPTER (ORDER FACTORY DIRECT OR BUILD YOURSELF)

**ANDROMEDA RESEARCH, P.O. BOX 222, MILFORD, OHIO 45150**

(513) 831-9708 FAX (513) 831-7562

website - [www.arlabs.com](http://www.arlabs.com) email - [arlabs@worldnet.att.net](mailto:arlabs@worldnet.att.net) MADE IN THE U.S.A.

## Use your PC as a scope and datalogger!

**Parallel Port Scope**  
spectrum analyzer, and digital multimeter



**ADC Virtual Instruments** turn your PC or laptop into a sophisticated storage scope AND spectrum analyzer AND multimeter. Display simultaneously on large screen! 100MS/s 8-bit or 1.2MS/s 12-bit or 333kS/s versions. Great for schools, test depts, etc. Input to Excell LabView/NT drivers included.

**Environmental Logging**  
record temperature, humidity, etc.



**ENVIROMON** - temperature (thermistor), humidity & light sensors, door position, etc. Record for 365/24 without a PC even if power fails. Monitor 30 sensors 400 yds away. With cables and easy software. Remote audio alarm. Use TC-08 for most thermocouples.

**osziFOX**  
20MS/s handheld scope



**osziFOX** - handheld storage scope and DVM - stand-alone or plugs into your PC for display, store-to-disk, printing in color. Inputs to 100V, trigger, backlit LCD.

**Download FREE demo software. Sales only: 1-888-7SAELIG**

[www.saelig.com](http://www.saelig.com) 716-425-3753 • 3835 (fax) [saelig@aol.com](mailto:saelig@aol.com)

**pico**  
Technology Limited

**Stocked in NY by Saelig Company:** Virtual Instruments, I2C and embedded controllers, BITlink 2-wire networks, RS232/422/485, frame grabbers, etc. See [www.saelig.com](http://www.saelig.com) for Product of the Month!



Capacitors C4, C5, C6, and C7 are power supply decoupling capacitors; the larger aluminum electrolytics (C4 and C6) are not very effective at filtering high frequencies, so ceramic capacitors (C5 and C7) are placed in parallel with them for this purpose.

As previously discussed, Q3, Q4, R8, and R9 comprise the current-mirror circuit. Q1 and Q2 make up the differential input stage, with their associated degeneration resistors, R6 and R7. R5 is installed to drop a portion of the positive power supply voltage that would normally be dropped across Q5, thereby reducing the power dissipation of Q5.

Q5, Q6, Q7, and their associated components make up the two constant current sources required for the input stage and VA stage. Q6, Q7, R18, R11, and R12 form a very conventional constant current source, with the voltage drop across R18 being clamped by the  $V_{be}$  drop of Q6, and the base reference voltage of Q7 being provided by the collector voltage of Q6. The collector current of Q7 is the constant current source for the VA stage. Note that Q5 simply uses the same reference voltage provided by Q6, which is a technique that eliminates the need for an additional transistor. The collector current of Q5 is the constant current source for the input stage. The decoupling network of R12, R11, and C10 provides very effective ground noise/power supply noise immunity for the reference voltage used by the two constant current sources. Resistors R10, R17, and R16 provide some resistive isolation between the constant current sources, which helps to reduce collateral damage in the event of a component failure.

The Vbias network, which serves to reduce crossover distortion in the output stage, consists of C13, R21, R22, D2, R20, P1, R23, R19, and Q11. If you are familiar with audio circuitry, you will probably recognize this circuit as a variation of the well-known amplified diode circuit. R20, P1, R23, and Q11 are configured so that a failure of P1 will "reduce" the forward bias to the output stage, thus preventing output stage damage if P1 "opens" (a relatively common failure with trim pots). R19 compensates for Vbias voltage variations due to the internal  $r_{e'}$  resistance of Q11. C13 smoothes out any AC components existing in the Vbias network. The circuitry of R21, R22, and D2 acts to modify the temperature coefficient response of the Vbias network, causing its corrective action to be more applicable to the complementary-feedback output stage design.

In the case of most L-MOSFET amplifier designs, the Vbias network consists of a simple potentiometer (without any temperature coefficient action), due to the negative temperature coefficient of L-MOSFET devices. Unfortunately, in this design, bipolar transistors are utilized in the complementary-feedback pairs, requiring the need to "track" the temperature of the predriver transistors for an accurate maintenance of the optimum quiescent bias levels. This is the price that must be paid for overcoming the low transconductance characteristic of L-MOSFETs.

Therefore, Q11 is physically mounted to the "face" of predriver transistor Q14, and serves to monitor the temperature of Q14 for accurate tracking purposes.

Q8, Q9, R26, and R27 make up the beta-enhanced transistor stage for the VA stage, and compensation is provided by the two-pole compensation network of C11, C12, and R24, as detailed previously. Q10 and R25 form an over-current protection circuit for transistor Q9, which protects Q9 under the following set of circumstances. In the event of a short-circuit condition at the output of the amplifier, Q13 will effectively short the VA output voltage to the output rail. [The connection path running from the common connection point of the emitters of Q12 and Q13, to the output coil, L1, is typically referred to as the output rail.]

The "turning on" of Q13 could draw excessive current through the negative power supply rail (via R27 and Q9), resulting in the destruction of Q9, D4 and Q13. To prevent such circumstances, the emitter current of Q9 is "sensed" by the voltage drop across R27. If this voltage drop exceeds about 0.67 volt (equating to about 30 milliamps), Q10 will turn on and short the drive signal from the input stage to the negative rail, thus limiting the maximum VA current flow to about 30 milliamps. As discussed earlier, C14 and R30 make up a low-pass filter to attenuate any AC interference signals that could be riding on the negative power supply rail.

The output overload and short-circuit protection circuitry is "complementary," just like the output devices. R28, D3, Q12, C15, R31, R32, and R35 make up the single-slope protection circuit that monitors the positive half-cycle outputs applied to the speaker load. Basically, this circuit monitors the voltage drop across R39, and if this voltage level (proportional to the output current) exceeds the safe operating limits of the output devices, transistor Q12 will turn on, and short the drive signal from the VA stage to the output rail. If Q12 turns on, R28 acts as a dropping resistor to improve the signal reduction action of Q12. D3 keeps Q12 from turning on during negative half-cycles (a situation that can happen under rare circumstances). C15 keeps instability (i.e., oscillation) problems from occurring during the activation periods of the protection circuitry. The resistor network of R31, R32, and R35 causes the protection locus (the protection activation area) to have a sloped response, which is more beneficial to the "real-world" needs of the power amplifier than a simple maximum current clamp circuit.

For example, under normal operation, as the instantaneous voltage level of the output rail rises, the protection circuitry allows a higher maximum value of output current, and vice versa. Such a protection response will limit short-circuit currents to relatively low levels (i.e., about three amps), while allowing high peak current values (i.e., over 12 amps) during normal dynamic operation. The protection circuit of R29, D4, C16, Q13, R34, R33, and R36 functions in an identical manner to the aforementioned



tioned protection circuit, except that it is incorporated to provide overload and short-circuit protection for the negative half-cycle outputs.

Diodes D5 and D6 are called by a variety of names, such as freewheeling diodes, catching diodes, or transient suppression diodes. Their function is to protect the amplifier's output stage from damage resulting from inductive kickback spikes that can be generated in highly inductive speaker loads. C17 and C19 are decoupling capacitors, physically located close to the rail fuses. They help to attenuate any AC components (i.e., interference signals) originating in the power supply. F1 and F2 are incorporated to protect the amplifier, as well as the speaker load in the event of a component failure. They are GMA-type, three-amp, fast-acting units.

Note that a portion of the output rail signal is fed back to the base of Q2 (i.e., the inverting input of the differential input stage) through the R13, C9, R14, R15, C8, and D1 network. This is the global negative feedback loop. R14 must be the same resistance value as R3 to minimize DC offset errors at the amplifier's output. The resistance ratio of R14 and R15 determines the voltage gain of the overall amplifier (commonly called the closed-loop gain). In this case, the sum of the two resistors (R14 + R15) divided by R15, comes out to a closed-loop voltage gain of 31.3 (+29.9-dB).

Thus, a one-volt RMS input signal would be amplified to an output RMS voltage level of 31.3 volts, which equates to an "ideal" RMS output power level of 122 watts into a typical eight-ohm load. Of course, there will be some minor losses due to power supply droop and output stage inefficiencies, so the "actual" output power delivered to the speaker load would be a little less than the calculated 122-watt level. The resistance value of R15 can be modified for more or less gain (which determines the input sensitivity of the amplifier) according to your needs and applications.

Continuing to refer to the global negative feedback loop, there are actually "three" gain mechanisms involved with the complete loop operation. The first of these is the low-frequency signal-voltage gain, as detailed in the previ-

ous paragraph. The second is the R13/C9 phase advance network. This is a type of high-pass filter, which allows very high frequencies to pass through C9, with these high-frequencies affected by the modified gain-determining ratio of R13 and R15 ( $A_e = 0.5$ ). The phase advance network provides some stability improvement (since high-frequency, phase-lagging gains are reduced), and also helps to linearize high-frequency signals in the audio bandwidth by increasing their negative feedback level.

The third gain mechanism relates to the "DC gain" of the loop, and functions to decrease any undesirable DC voltage offsets. Capacitor C8 presents a very high impedance to any DC levels, so it essentially provides a 100% negative feedback factor to any DC offsets appearing at the amplifier's output. The typical output offset errors of this amplifier design is approximately 20 millivolts. In the event of an output stage component error, diode D1 protects any high levels of reverse-polarity voltage that could build up and destroy capacitor C8.

The functions of the global negative feedback loop are very critical to the linear operation and stability of the overall amplifier design. However, it is obvious by examining the Figure 4 schematic that the external speaker load will have a profound effect on the loop operation, since the speaker load is almost directly connected to the loop signal, which originates from the output rail. Consequently, it is desirable to provide some signal conditioning and isolation between the output rail and the external speaker load. C18 and R41 make up a Zobel network, which primarily minimizes the effects of whatever inductive characteristics may exist in speaker load. L1 provides a counter-effect action to any capacitive effects that may exist in the speaker load, with R42 serving as its associated damping resistor (i.e., to dampen out high-frequency resonant oscillations that could occur between the output coil and the unknown value of speaker load capacitance).

In Part 2 of this article, the physical construction of the CF-MOSFET amplifiers will be detailed, along with construction options, PC board artwork, suitable power supplies, adjustment procedures, and junkbox options. **NV**



**Mr. NiCd**

**WINTER SPECIALS!**



**THE BEST BATTERIES IN AMERICA!**

**Packs & Charger for YAESU FT-50R / 40R / 10R:**

FNB-40xh Slim-NMH	7.2v	650mAh	\$41.95
FNB-47xh (NMH)	7.2v	1800mAh	\$49.95
FNB-41xh (5w NMH)	9.6v	1000mAh	\$49.95

**For YAESU FT-51R / 41R / 11R:**

FNB-38 pack (5V)	9.6v	700mAh	\$39.95
------------------	------	--------	---------

**For YAESU FT-530 / 416 / 816 / 76 / 26:**

FNB-26 pack (NMH)	7.2v	1500mAh	\$32.95
FNB-27S (5w NMH)	12.0v	1000mAh	\$45.95

**For YAESU FT-411 / 470 / 73 / 33 / 23:**

FNB-11 pack (5v)	12.0v	600mAh	\$24.95
FBA-10 6-Cell AA case			\$14.95

**Packs for ALINCO DJ-580 / 582 / 180 radios:**

EBP-20ns pack	7.2v	1500mAh	\$29.95
EBP-22nh pk (5v)	12.0v	1000mAh	\$36.95
EDH-11 6-Cell AA case			\$14.95

**For ICOM IC-21A / T22-42A / W31-32A / T7A:**

BP-180xh pk (NMH)	7.2v	1000mAh	\$39.95
BP-173 pack (5v)	9.6v	700mAh	\$49.95

**For ICOM IC-W21A / 2GXA / V21AT (Black or Gray):**

BP-132S (5w NMH)	12.0v	1500mAh	\$49.95
------------------	-------	---------	---------

**For ICOM IC-2SAT / W2A / 3SAT / 4SAT etc:**

BP-83 pack	7.2v	600mAh	\$23.95
------------	------	--------	---------

**For ICOM 02AT etc & Radio Shack HTX-202 / 404:**

BP-8h pack	8.4v	1400mAh	\$32.95
BP-202S pack (HTX-202)	7.2v	1400mAh	\$29.95

**For KENWOOD TH-79A / 42A / 22A:**

PB-32xh pack (NMH)	6.0v	1000mAh	\$29.95
PB-34xh pack (NMH)	9.6v	1000mAh	\$39.95

**For KENWOOD TH-78 / 48 / 28 / 27:**

PB-13 (original size)	7.2v	700mAh	\$26.95
-----------------------	------	--------	---------

**For KENWOOD TH-77, 75, 55, 46, 45, 26, 25:**

PB-6x (NMH, w/ plug)	7.2v	1200mAh	\$34.95
----------------------	------	---------	---------

Mail, phone, & Fax orders welcome! Pay with Mastercard / VISA / DISCOVER / American Express

**Call 608-831-3443 / Fax 608-831-1082**

**Mr. NiCd - E. H. Yost & Company**  
2211-D Parview Road, Middleton, WI 53562

**CALL OR WRITE FOR OUR FREE CATALOG!**  
Cellular / Laptop / Videocam / Commercial & Aviation packs too!  
E-mail: ehyst@midplains.net

**EZ-EP DEVICE PROGRAMMER - \$169.95**

**Check Web!! -- www.m2i.com**

**Fast** - Programs 27C010 in 23 seconds

**Portable** - Connects to PC Parallel Port

**Versatile** - Programs 2716-080 plus EE and flash (28, 29) to 32 pins

**Inexpensive** - Best for less than \$200


- Correct implementation of manufacturer specified algorithms for fast, reliable programming.
- Easy to use menu based software has binary editor, read, verify, copy, etc. Free updates via bbs or web.
- Full over current detection on all device power supplies protects against bad chips and reverse insertion.
- Broad support for additional devices using adapters listed below.

**Available Adapters**

EP-PIC (16C5x, 61, 62x, 71, 84)	\$49.95
EP-PIC64 (16C62-5, 72-4)	\$39.95
EP-PIC12 (17C50x)	\$39.95
EP-PIC17 (17C4x)	\$49.95
EP-51 (8751, C51)	\$39.95
EP-11E (88HC11 E/A)	\$59.95
EP-11D (88HC71103)	\$39.95
EP-16 (16A1 EPROMs)	\$49.95
EP-28 (28A62, 3.4, 6, 7, 8)	\$39.95
EP-SEE2 (93x24x, 25x, 85x)	\$39.95
EP-750 (87C750, 1, 2)	\$59.95
EP-PEEL (IC22x10, 18x4)	\$59.95
EP-1051 (80C1051, 2051)	\$39.95
EP-PLCC (PLCC EPROMs)	\$49.95
EP-SOIC (SOIC EPROMs)	\$49.95
EP-TSOP (TSOP EPROMs)	\$59.95

Many Other Adapters Available

**M<sup>2</sup>L Electronics**  
970/259-0555  
Fax: 970/259-0777  
250 CR 218  
Durango, CO 81301  
CO orders please add 7% sales tax  
<http://www.m2i.com>





# Electronics Showcase

Special products and services for the electronics enthusiast.

## Pain-Free Oscilloscope Training

- OPERATE BASIC SCOPE CONTROLS
- TAKE ACCURATE MEASUREMENTS
- SET TRIGGER LEVEL
- ANALYZE WAVEFORMS
- READ THE GRATICULE
- SELECT THE CORRECT PROBE ... AND MORE!



Learn the fundamentals fast! Our one-hour video and 70 - page reference manual were designed by a college professor. Includes certification exam!

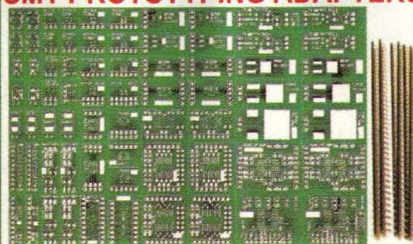
VHS tape and manual just \$34.95 + \$5.00 S/H

(U.S. addresses only) NY residents add 7% sales tax

To order send check or money order to:  
SYSPEC Inc / PO Box 2546 / Syracuse, NY / 13220  
1.877.SYSPEC1 (1.877.797.7321)

**SYSPEC**  
www.syspec.com

## SMT PROTOTYPING ADAPTERS



Snap-Apart® PCB's with .100" pin strips.  
Dozens of assorted adapters on each PCB.

A variety of PCB's with patterns front & back.

SOIC PLCC SSOP QFP DPAK SOT23 MSOP QSOP SC90 D2PAK  
TSSOP SOT89 D3PAK SOT143 TSOP SC70 SOT88 and many more.

(714) 630-8024 [www.beldynsys.com](http://www.beldynsys.com)

BELLY DYNAMIC SYSTEMS INC.  
- Rapid Development Solutions for the Technical Professional -

## ElectronicKits.Com

THE NAME SAYS IT ALL!

- |                     |                      |
|---------------------|----------------------|
| Robot Kits          | Surveillance Kits    |
| Motor Control Kits  | Camera Kits          |
| RF Remote Kits      | Timer Kits           |
| IR Remote Kits      | Amplifier Kits       |
| FM Transmitter Kits | Solar Kits           |
| Radio Kits          | Learn to Solder Kits |
| Multimeter Kits     | Microcontroller Kits |

New Power Player Video Game System  
128 Classic Arcade Games on your TV!!!

Carl's Electronics Inc, 17 Laurelwood Road, Sterling MA 01564  
sales@electronickits.com - www.electronickits.com

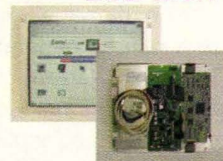
## SERIAL GRAPHIC LCD



PICL-2464 \$99.00

Sharp LM24014 240 x 64 LCD  
E.L. Backlight  
5" x 1 5/16" Viewable Area  
PIC 16F877 Re-Programmable  
Switches, A/D & I/O Bits

## LCD MONITOR KIT



A Complete 12.1  
TFT LCD Kit With  
Controller and 180  
Nit 16.7M Color  
XGA Panel- Just  
Plug Into VGA port and  
add 12 volts  
D.C.!

SK-2005R \$299

## 12.1" LCD MONITOR



Rugged Metal Case  
On Screen Display  
Free Z-Mount  
Resistive & Capacitive  
Touch Screen Options  
Available. 1024 x 768  
16.7 Million Colors  
VGA and SVGA

MTR-EVUE-12 \$399.00

**EARTHLCD.COM**

"The World Wide LCD Source"

32701 Calle Perfecto - San Juan Capistrano, CA 92675  
Ph: (949) 248-2333 Fax: (949) 248-2392

See the World's Largest Collection of LCD's and LCD  
Products at <http://www.EarthLCD.com>

Enter option code  
**NVM-M133B** when  
ordering and receive  
a 5% Discount.\*

**Stamp Stacks**

Lots of Micros!  
Basic Atom,  
BASIC Stamp,  
DOPic, PIC, HC11...

**ATOM MODULES**

**RF MODULES**

Go Wireless!

**ROBOTICS**

Kits, motors, controls,  
sensors, parts...

**Bits, Pieces,  
Sensors & parts!**

See our website!

HVW Technologies Inc.  
Tel: (403) 730-8603  
Fax: (403) 730-8903

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

\*Does not apply to shipping charges. Expires Jan. 31, 2003.

**ActiveWire® USB**  
Simple USB Interface!

- Works with MacOS 8/9, Win98/2K/ME
- FreeBSD and Linux!
- 24MHz CPU core with USB
- Firmware downloadable via USB
- 16 bit parallel Input/Output
- See web-site for add-on boards
- All drivers, manuals, demos are on our web-site for immediate download!

**\$59**  
plus shipping

**ActiveWire, Inc.**  
[www.activewireinc.com](http://www.activewireinc.com)  
ph +1.650.493.8700 x203 fax +1.650.493.2200

**BiM2** 433 MHz

900 MHz Available January 2002

**High Speed Wireless Data Transceiver**  
Physical Dimensions: 33 mm x 23 mm x 4 mm

- Data rates up to 160 kbps
- RX sensitivity -100dBm
- Usable range up to 200m
- SAW controlled FM transmitter
- 3V and 5V versions
- Low power requirements
- TX power 10mW @ 5V
- Fully screened
- Double conversion Superhet receiver
- Plug in replacement for BiM-433-F

**Radlometrix**

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

**LEMO INTERNATIONAL**  
Microwave and RF Specialists

48 Sword Street  
Auburn, MA 01501  
Tel: (508) 798-5004  
Fax: (508) 798-4792  
Email: [Sales@lemosint.com](mailto:Sales@lemosint.com)

**QKITS.COM**

PC Function Generator Kits •  
PC Oscilloscope Kits • Amplifier Kits •  
VU Meter Kits • FM Transmitter Kits •  
Programmer Kits • Intelligent Multimeters •  
Mechanical Motorized Wooden Kits •  
Xmas Kits • Mini Robot Kits • 433MHz Trx  
& Rx Modules • PIR Sensors

**GREAT PRICES, GREAT SHIPPING RATES**  
**1-888-GO 4 KITS**  
**49 McMichael St., Kingston, ON**  
**K7M 1M8, CANADA**  
**Free Catalog Available**

Synthesizer Modules, Guitar Effects, Mixers, EQs,  
Tube PreAmps, and dozens of other kits for

**ELECTRONIC MUSICIANS**

**Theremin**  
The PAIA Theremin uses the same heterodyne principles as the original turn of the century instrument for classic tone and adds features made possible by modern ICs. Shown with optional lectern case.

9308K Kit \$154.00

**9505K Kit \$89.75**

**FatMan Analog MIDI Synth**  
A complete music synthesizer with all the big bottom and phat sound that makes analog famous. 20 knobs and controls for real-time sound sculpting. Compatible with standard MIDI sources like keyboards or computers. Desktop case or rack panel available.

Check out <http://Paia.com> for schematics, tech details, firmware source files and more...

PAIA Electronics • 3200 Teakwood Lane • Edmond, OK 73013  
405.340.6300 • fax: 405.340.6378 • email: [info@paia.com](mailto:info@paia.com)



## PRINTED CIRCUIT BOARDS

### QUALITY PRODUCT FAST DELIVERY COMPETITIVE PRICING

- \* UL approved
- \* Single & Double sided
- \* Multilayers to 8 layer
- \* SMOBC, LPI mask
- \* Reverse Engineering
- \* Through hole or SMT
- \* Nickel & Gold Plating
- \* Routing or scoring
- \* Electrical Testing
- \* Artwork or CAD data
- \* Fast quotes

We will beat any  
competitor's prices!!!

yogii@flash.net • flash.net/~yogii

10 pcs (3 days)  
1 or 2 layers \$249  
10 pcs (5 days)  
4 layers \$695

(up to 30 sq. in. ea.)  
includes tooling, artwork,  
LPI mask & legend

PROTOTYPE THROUGH  
PRODUCTION  
**PULSAR, INC**

9901 W. Pacific Ave.  
Franklin Park, IL 60131

Phone 847.233.0012

Fax 847.233.0013

Modem 847.233.0014

# MATCO

## EverSecure™

www.matco.com

**Volume Pricing Available!**

**BX-123-AU \$69**  
**BX-123-CAU (color) \$149**

**PC-103 \$99**

**ES-8960 \$329**

**KX-880 \$89**  
**KX-880-C (color) \$129**

**LCD-5.5 \$129, LCD-7 \$259**

- Compact footprint, ultra-bright display, RCA inputs NTSC or PAL
- 960 x 240 pixels w/brightness & tilt controls
- Attractive enclosure w/built-in speaker

**ASK-7003-TR \$169**

**WR-700 Weather Resistant \$99**

**Sales: 847-303-9700**  
**Toll Free: 800-719-9605**

For a list of retailers that  
carry Nuts & Volts in  
their store, go to  
[www.nutsvolts.com](http://www.nutsvolts.com)

## The Fighting Robots Are Back!

The fighting robot craze is returning to Southern California on **February 8th, 2003** when Steel Conflict — robots with attitude — presents the Robot Fighting League's South West Championship!

The sport of robotic combat is growing exponentially nationwide and the Robot Fighting League is where they compete. According to event promoter Steve Brown — founder of Steel Conflict and himself a builder of three successful combat robots — "This is an exciting time in the sport. There are over 160 robots converging on the Fairplex for the division championship and they all have the same objective, destroy the opponent and win the division title!"

The Robot Fighting League (RFL) is a conglomerate of fighting robot organizations from all over the US. Combined, they hold over 50 tournaments a year. The RFL South West Division is represented by Robojoust in Las Vegas, NV, BotBash in Tempe, AZ, and Steel Conflict in Southern California. The best robots from these three regional tournaments will be fighting it out in a steel arena for their shot at the division title and a trip to the RFL Triangle Series National Championship at the Minnesota State Fair.

The RFL South West Championship — hosted by Steel Conflict — will be held February 8th and 9th at the Fairplex in Pomona, CA. Steel Conflict is expecting over 6,000 spectators. Tickets are on sale now and can be purchased from the Steel Conflict website: [www.steelconflict.com](http://www.steelconflict.com). For more information on the Robot Fighting League, visit [www.botleague.com](http://www.botleague.com). "The world will never be the same after this one," Brown says.

**Steel Conflict, LLC**  
Email: [sfb403@yahoo.com](mailto:sfb403@yahoo.com)  
Web: [www.steelconflict.com](http://www.steelconflict.com)

# ProtoLab 4.0

Easy-to-use circuit simulation package from the leader in electronic prototyping.

Works with Windows®95 and above

Low Cost - \$49.95

Design circuits instantly while choosing from a complete list of active and passive components

Analyze circuits using built-in test instruments

Create and Analyze Circuits INSTANTLY for only \$49.95!

**GLOBAL SPECIALTIES SOFTWARE**

1-800-572-1028 • For more information, please visit:  
[www.globalspecialties.com](http://www.globalspecialties.com)

Windows®95 is a U.S. registered trademark of Microsoft Corporation.

Circle #47 on the Reader Service Card.

WWW.CONITEC.NET

## GALEP-4

UNIVERSAL PROGRAMMER

**\$333**

COMPLETE KIT

### Introducing a pocket programmer with true Universal Output

Latest generation Galep-4 uses ASIC universal pin technology for each pin of 40 pin ZIF-socket. 1300+ device library / lifetime free updates. Programs 8/16-bit EPROM's, EEPROM's, 0-Power RAM, FLASH, Serial EEPROM's, GAL, PALCE,

microcontrollers such as 87/89xxx, PIC, AVR, ST62, etc. Low voltage devices down to 1.3V. No adapter required for DIL devices. 8 Hrs. operation on battery (AC charger included). Runs WIN 98, NT, ME, 2000, XP with Hex/Fuse Editor.

Remote control from other apps, (e.g. VisualBasic). Substitutes high priced universal programmers e.g. ALL-11 (HILO) or LAB-TOOL-48 (ADVANTECH). Providing virtually matching performance at only 1/3-1/5 the price. Info, orders, softwr : 619-702-4420

info, downloads: [www.conitec.net](http://www.conitec.net)

CONITEC DATASYSTEMS - 1951 4TH AVE, SUITE 301 - SAN DIEGO, CA 92101 - TEL: 619-702-4420 FAX: 619-702-4419

Circle #48 on the Reader Service Card.



## Save up to 90% on Inkjet Inks for HP Canon Epson Lexmark Apple Compaq Xerox

Printer (Call for others not listed)	Refill kits Black 8oz / Color (4 oz C, Y, M)	Cost/Fill	Kit Price
HP500 Series, 400, Officejet 300, 350, Fax		4.71	2.85
HP600 Series, Officejet 500, 570, 600, 610 630, 700		4.71	3.21
HP820C, 855C, 870C, 1000C, 1150C, Copier 120, 210		6.67	3.33
HP720C, 722C, 712C, 880C, 890C, 895C, 1120C, 1170C		6.67	3.75
HP900C Series, P1000 Series, Officejet G55, G85, G95		6.67	3.75
HP2000C Pro Color Printer, 2200, 2500		6.67	3.75
Canon BJ-10, 200, 210, 240, 250 Apple StyleWriter 1200, 1500		2.15	2.00
Canon BJC-4000 Series, 2000, 5000 Series, Multipass Series		0.50	0.67
Canon BJC-6000, 3000, S400, S450, S600, Multipass 755		2.85	1.67
Epson Stylus Color 400, 600, 800, 850, 1520, Photo		1.50	2.65
Epson Stylus Color 440, 660, 670, 740, 760, 860		1.50	2.65
Epson Stylus Color 480, 580, 880		1.50	2.65
Epson Stylus Color 777, C60, C50 (Requires Resetter) <b>NEW</b>		1.66	2.22
Lexmark 3200, 5700, Z11, Z12, Z31, Z32		2.67	2.35
Compaq IJ300, IJ600, IJ700, IJ750, IJ900 Xerox XK Series		2.67	2.65
Lexmark Z42, Z51, Z52, Z83, Compaq IJ1200, A1000		2.67	2.65
<b>Combination Kits</b> Black dye 4 oz / Color 2 oz each			44.95
<b>Combination Kits</b> Black pigmented 4 oz / Color 2 oz each			49.95

## Save 40 - 70% on New Compatible Cartridges Quantity Discounts for 3 or 6+ cartridges Mix & Match



Call Toll Free  
today or  
See us online

- ✱ Inkjet Cartridges
- ✱ Refill Kits
- ✱ Laser Cartridges
- ✱ Thermal Fax Rolls
- ✱ Copier Supplies

Cartridges now available for:

Black	1 / 3+	Color 1 / 3+
Epson C42	12.95 / 11.01	15.95 / 13.56
Epson C62	10.95 / 9.31	14.95 / 12.71
Epson C80	17.95 / 15.26	8.95 / 7.61ea

Cartridges for popular Epson / Canon / Brother  
HP / Lexmark / Xerox printers

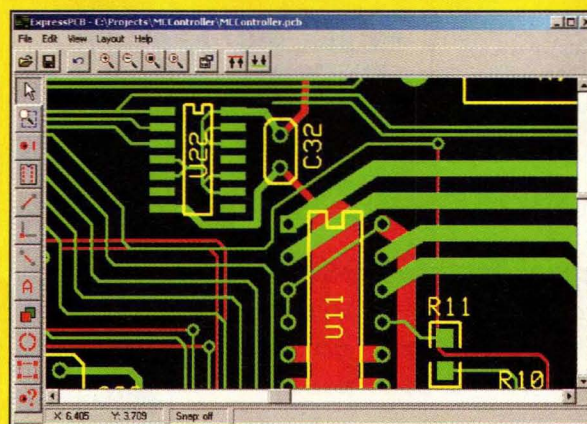


**www.inkjet.com 1-800-447-3469**

Circle #50 on the Reader Service Card.

# \$62 PCBs

And our layout software is **FREE!**



Download our **FREE** layout software  
Design your two-sided plated-through PCB  
Send us your design with just a click  
Receive your boards in a few business days

Select our MiniBoard service and get three top quality  
2.5" x 3.8" PCBs for \$62 - shipping included!

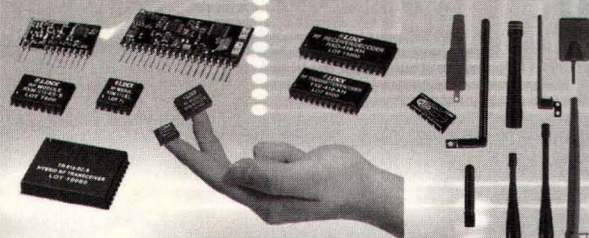


**expresspcb.com**



Remote Control/Command • MIDI • RS-232 •

## WIRELESS MADE SIMPLE™



RF MODULES • PRECERTIFIED PRODUCTS • ANTENNAS



**EASILY MAKE YOUR  
NEXT PROJECT WIRELESS!**

**RF DIGITAL**  
**www.rfdigital.com**  
**(818) 541-7622**

Call Systems • Robotics • Telemetry •

## Turn Your Multimedia PC into a Powerful Real-Time Audio Spectrum Analyzer

### Features

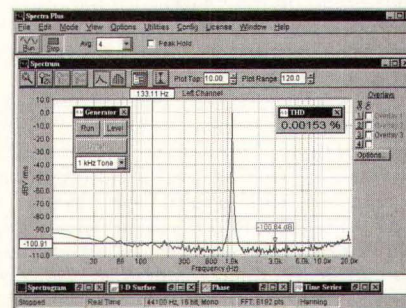
- 20 kHz real-time bandwidth
- Fast 32 bit executable
- Dual channel analysis
- High Resolution FFT
- Octave Analysis
- THD, THD+N, SNR measurements
- Signal Generation
- Triggering, Decimation
- Transfer Functions, Coherence
- Time Series, Spectrum Phase, and 3-D Surface plots
- Real-Time Recording and Post-Processing modes

### Applications

- Distortion Analysis
- Frequency Response Testing
- Vibration Measurements
- Acoustic Research

### System Requirements

- 486 CPU or greater
- 8 MB RAM minimum
- Win. 95, NT, or Win. 3.1 + Win.32s
- Mouse and Math coprocessor
- 16 bit sound card



**Priced from \$299**

(U.S. sales only - not for export/resale)

**DOWNLOAD FREE 30 DAY  
TRIAL!**

**www.spectraplus.com**

**PHS** Pioneer Hill Software  
24460 Mason Rd.  
Poulsbo, WA 98370  
a subsidiary of Sound Technology, Inc.

**Spectra Plus**  
FFT Spectral Analysis System

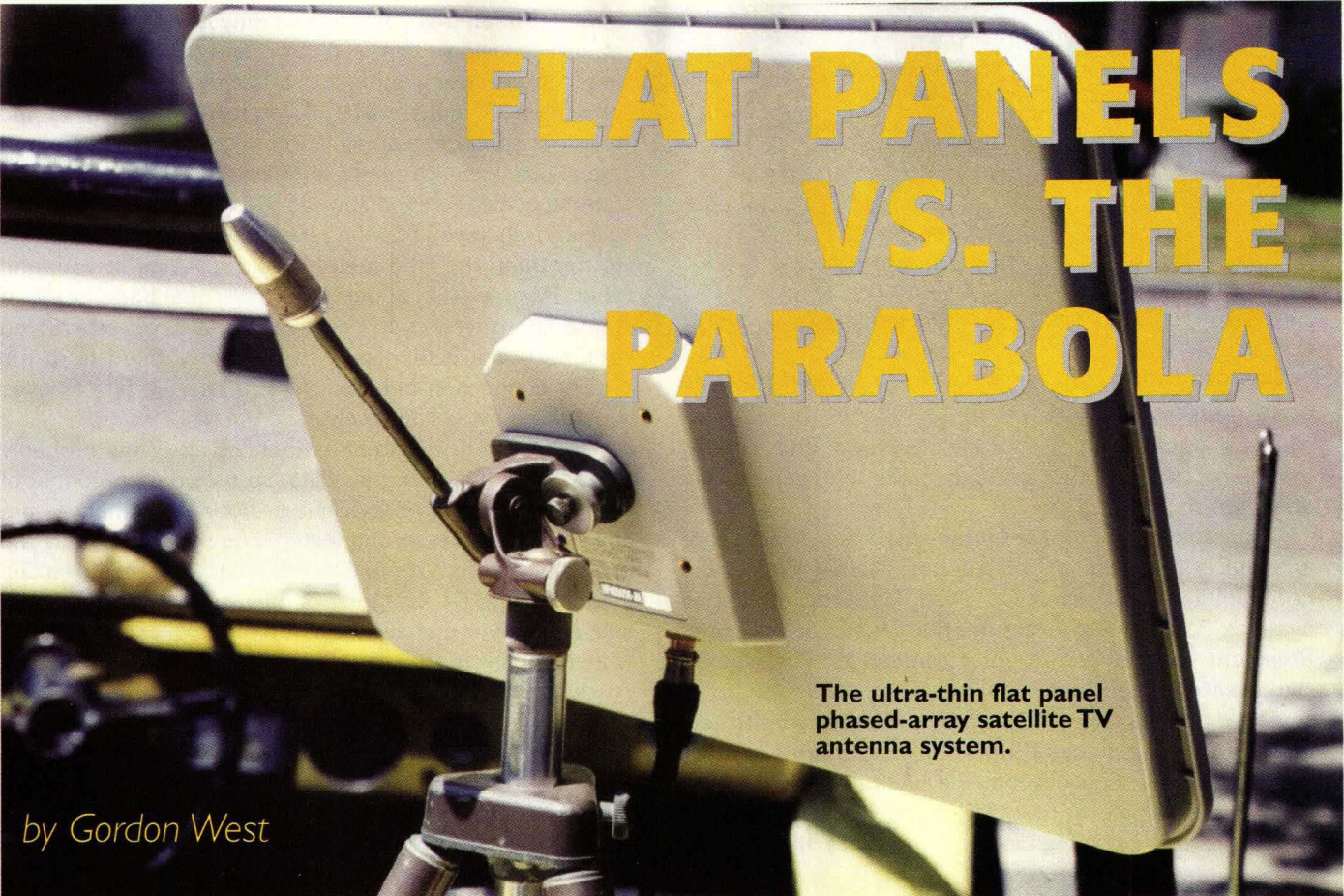
Sales: (360) 697-3472

Fax: (360) 697-7717

e-mail: pioneer@telebyte.com

Circle #51 on the Reader Service Card.





# FLAT PANELS VS. THE PARABOLA

The ultra-thin flat panel  
phased-array satellite TV  
antenna system.

by Gordon West

**P**ulling in 12 GHz signals from Direct Broadcast Satellite (DBS) television satellites out 22,500 miles is best accomplished with the traditional 18-inch parabolic reflector and its associated LNB (low noise block) down converter.

The geostationary satellites broadcasting Dish™ and DirecTV™ programming offer a good balance of power output to the modest gain of an 18-inch dish for nearly 100 percent signal reliability during good weather conditions. But during periods of intense rain activity or wet snow conditions, 12 GHz signals may be dramatically attenuated by the suspended water molecules, and freeze-frame or picture blackout occurs. But just sit tight — generally, the localized storm cell will pass through, and magically direct broadcast satellite television reception resumes.

Nothing beats a good dish.

In the recreational vehicle (RV) industry, the white dome you see for direct broadcast satellite reception covers up a modified form of a parabolic reflector that stays locked onto the selected satellite even with the RV in motion.

The KVH ([www.kvh.com](http://www.kvh.com)) TrackVision LM — plus oth-

ers — is a good example of parabola antenna efficiency inside a relatively low-profile, 18-inch high dome. It will track the satellite better than 30 degrees per second, operating off of 12-volts DC at three amps. It has an elevation range of 15 degrees to 75 degrees; and as you are RVing down the road, the antenna control unit from KVH generates a conical scanning function to maintain peak signal strength to the receiver and to update the satellite's position. When conical scan tracking is active, the antenna moves continually with a circular motion to sweep across the satellite's peak signal. The signal strength is then fed back to the control circuits to keep coming back to the direction of the strongest signal. With the KVH antenna — once you park — you can turn off the motorized tracking to avoid unnecessary current consumption. The antenna will continue to receive the satellite TV signals, and relay them to the receiver.

But not everyone in smaller RVs needs an antenna that is actively tracking the incoming microwave TV signals. The smaller RV may opt for a portable dish that gets deployed on a tripod when they get to their favorite campsite, or maybe a dish on the roof that will "nest" as they travel down the road. While the dish is the unqualified winner of best incoming signal strength capabilities, direct broadcast signals from the geostationary television satellites have enough "headroom" that an antenna design with slightly less gain than the 18-inch dish will still achieve rock-solid reception with a clear shot at the sky, and reasonably good reception during inclement weather.

Enter phased-array technology — microwave receiving

*Flat-panel technology is becoming an important factor as we go higher up the microwave spectrum to pull in satellite signals.*





**SatCom motorized antenna in the stowed position.**

elements etched on a flat circuit board and phased to obtain close to the same approximate gain as an 18-inch dish.

"Our flat-panel, phased-array, kU band, microwave antenna is revolutionary because of its thin profile and compatibility with DirecTV, Dish Network, and Bell Express Vu System," comments Dr. H. H. Chung, President of SatComm Electronics in Poway, CA ([www.satcomweb.com](http://www.satcomweb.com)).

"Our panel is circular polarized and is etched with several hundred individual microwave elements," adds Chung, also pointing out that the back of the flat panel also contains single- or twin-LNB outputs, getting their DC power via the coax feed coming up from the satellite receiver.

The flat panel we tested measured only 16 inches wide, 12 inches high, and catch this — only two inches deep. It weighed in under five pounds, and was thin enough to store under an RV mattress when not in use.

During our tests, we compared the SatComm flat panel to a traditional 18-inch dish from as far south as the Mexican border and north to Yellowstone, WY. The flat panel took the same kind of precise aiming as the 18-inch dish. While compasses are good, we found the easiest way to aim the dish was looking for a peak in signal strength with the coax cable series signal strength meter in line. These analog meters sell for around \$40.00 and anyone who regularly moves their satellite antenna system around and in an RV uses one.

Start by setting up the dish or flat panel to the approx-

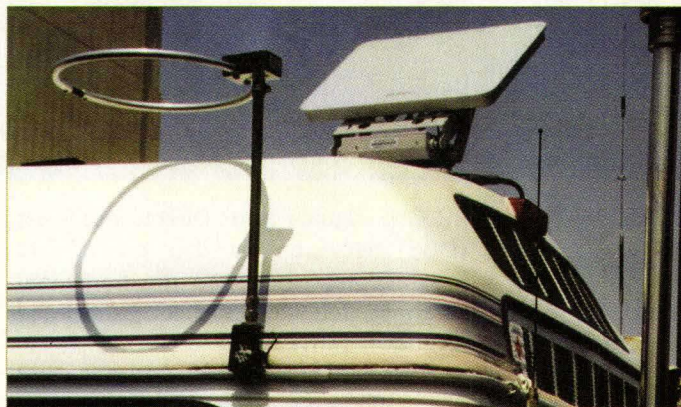


**The active tracking KVH antenna is small, portable, and easy to install.**

imate position that you see everyone around you looking at, give it a wiggle here and there, and see if you can pop-in reception strong enough to refine the pointing with the on-screen TV signal meter. If you just can't seem to find the right spot, get a small 75-ohm jumper cable, and put the signal strength meter in line and twist the knob for quarter-scale reading. Now, do the dish or flat panel wiggle; and when you find the "sweet spot," the needle jumps to the right, the little meter mail also sings at you, and your TV may or may not show the signal bars. Some of these little meters you can leave in line, yet others you optimize your setting, and then remove them from the series connection because they rob a little bit of power going to the satellite receiver.

Still no TV reception? Chances are you probably locked onto the wrong satellite, so try again a couple of degrees to the left of your initial "hot spot." Chances are you'll spot another strong signal, and this is probably the one you want! SatComm even manufactures their own digital meter that Dr. Chung says may many times be left in line, and they even have a step-up model that will positively identify which TV satellite you have locked into.

When we tested the flat panel versus the dish with



**The SatCom satellite TV antenna during our testing.**

trees all around us, we found that both the panel and the dish needed an unobstructed view of the sky through heavy foliage. But just a few tree branches or leaves generally did not create problems except for a few freeze-ups.

But when the heavy clouds and approaching rain squall began to form in between our RV and the distant TV satellites, the dish would hold on longer before freeze-frame. The dish had more gain to overcome the path loss due to heavy moisture. But as soon as the heavy squall passed overhead, both the dish and the flat panel would almost simultaneously regain enough signal strength to provide reception to the satellite receiver.

But probably the biggest advantage of the flat panel over the dish was when we were ready to move on and store the equipment. The panel slides out of the way. The bulky dish with its pivoting LNB arm always seems too big to go completely out of the way. It's just a little too large to store in one locker, and a little too deep to put in another. If you have a small mobile home or you plan to go tent camping, the flat panel is a delight!

"Believe it or not, there is an advantage to slightly less



gain with our flat panel," comments Dr. Chung. "Alignment to the satellite is not as critical as with the dish, and if the flat panel is temporarily installed on, let's say, an RV bicycle rack, movement within the RV won't unlock the picture that may sometimes occur with the conventional dish."

Our next test was to take the flat panel and work it with the SatComm automatic acquisition, motorized, mobile antenna base. The flat panel mounts quickly to the motorized base unit, and now stands only 5.6 inches tall in the stowed position. The motorized mobile base unit is indeed a heavyweight — 14 pounds — but a lot of this weight is designed for safety as the unit on a motor home will be exposed to high winds and an occasional brush with tree branches.

"Our flat panel motorized, automatic acquisition, satellite antenna system does more than just pull in direct broadcast television reception," comments Dr. Chung. "For RVers on the move, our antenna and accessories are designed with broadband satellite communications in mind, taking advantage of high-speed Internet downloading," he adds, speaking of the possibilities with the Canadian satellite system.

This capability could allow you to electronically steer the antenna motor system to an alternate satellite to access your mobile Internet account, and let a Canadian or US geostationary satellite beam down mountains of email in a fraction of the time it takes to collect it via terrestrial wires or wireless connections. The SatComm automatic acquisition, motorized antenna unit will commence a sky search and lock into as many as 12 different satellites for instant recall with the small controller inside your motor home.

"Emerging technologies will bring unprecedented efficiency to broadband data compression for audio, video, and multimedia, and our flat panels will facilitate wireless satellite communications to and from even micro devices," adds Dr. Chung, giving us a sneak preview of what lies ahead beyond simple TV viewing from an ostensibly TV satellite antenna.

In the generic search mode — a default setting — our test unit took less than 60 seconds to acquire the first TV satellite, and then a few seconds later picked up other satellites with sufficient incoming signal strengths. It was easy to choose which satellite we wanted to lock onto by just pushing one of the six buttons. A secondary button brings in six additional satellite position selections.

The face of the remote controller has red light-emitting diodes to con-



The small control panel mounts by the TV set.

stantly show you the status of the system. Once the status shows "locked" and you are beginning to pull in great television satellite reception, you can shut down the controller to conserve current that would otherwise be going into the motor drive system. Now the automatic acquisition drive assembly becomes passive, and you receive the incoming signals from the poised flat panel array just like you did with the flat panel all by itself on a little tripod outside your coach.

But what happens if you forget that



Tripod mounting of the flat panel SatCom TV antenna.

## Smart Choice! Smartuner!

Do **YOU** want to be heard? *OF COURSE!* Then use the SGC Smartuner™ - the *Essential* link between your **HF transceiver** and **antenna**. Matching at the transceiver is good, but matching at the antenna is better. SGC Smartuners are designed to do just that. They operate completely independently to provide the best match between the feed line and the antenna, eliminating SWR problems completely.

SGC Smartuners are designed to work with *any* transceiver (including the ICOM 802) and *any* antenna. They are fully automated, intelligent enough to select the best match between feed line and antenna in seconds and remember it so it can recall that match in milliseconds. The Smartuner sets the standard. It is the original and still the best.



Once you've learned how the Smartuner works, you won't want anything else!



SG-230



**No Compromise Communications**

Visit [www.sgcworld.com](http://www.sgcworld.com) for more information on the entire line of Smartuners



SG-231

SGC Inc. 13737 SE 26th St. Bellevue, WA 98005 USA Tel: 425-746-6310 Fax: 425-746-6384  
[sgc@sgcworld.com](mailto:sgc@sgcworld.com) [www.sgcworld.com](http://www.sgcworld.com)



you have left your antenna system "up" and drive away? As soon as it detects a loss of signal, it immediately drives the antenna down into the stowed position to minimize any chance of the deployed system getting hung up on a tree branch.

This is a safety feature which we tested several times, and it works absolutely as advertised. Only once during a big cloud burst did it become a problem — it went into an emergency nest even though we knew it was just a passing rain shower that would soon go away. I suppose for

long-term use at an always fixed location, you could wire around the automatic acquisition feature and run your cable directly to the flat panel, keeping the motorized assembly frozen at a specific position. But this does away with the safety feature of automatic nesting, so we didn't try this trick.

So what does all this stuff cost? If you get just a simple dish and LNB, along with a tripod, probably under a couple hundred bucks. Compare this to the flat panel with single LNB at \$249.00, with a tripod mount screw receiver already in place. The

flat panel with twin LNB is \$299.00, and the digital satellite seeker meter around \$70.00. The satellite specific meter is \$120.00.

For a full-blown, automatic-acquisition KVH or other large dome system, expect to spend \$3,000.00 (as a minimum) on up. But for the SatComm automatic-acquisition including the phased-array, flat-panel antenna, including twin LNB output, you pay a little over \$1,200.00.

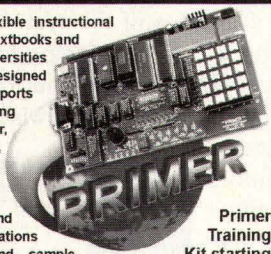
The motorized unit comes all cabled up for "plug and play" and all you need to do is just add 12 volts and mount the unit up on the roof, or plan to set it up on a nearby bench. It is a fine piece of motorized electronics, so I wouldn't necessarily leave it on the bench overnight.

As more and more services become geostationary satellites born to match up with your computer, I see flat-panel technology becoming an important factor to minimize space and to facilitate your own satellite system that can actually fit in a backpack.

As we go higher up the microwave spectrum, be assured that phased-array technology with flat panels may be the chosen way to pull in these incoming satellite signals. **NV**

## Microprocessor Hands-On Training

The PRIMER Trainer is a flexible instructional tool featured in Prentice Hall textbooks and used by colleges and universities around the world. Ruggedly designed to resist wear, the PRIMER supports several different programming languages including Assembler, Machine Language, C, BASIC, and FORTH. A comprehensive instruction manual contains over 25 lessons with several examples of program design and hardware control. The Applications Manual provides theory and sample code for a number of hands-on lab projects.



Primer Training Kit starting at \$120.00 USD

- Scan Keypad Input & Write to a Display
- Detect Light Levels with a Photocell
- Control Motor Speed using Back EMF
- Design a Waveform Generator
- Measure Temperature
- Program EPROMs
- Bus Interface an 8255 PPI
- Construct a Capacitance Meter
- Interface and Control Stepper Motors
- Design a DTMF Autodialer / Remote Controller

### Application Projects Include:

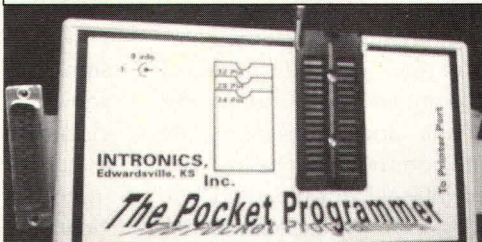
New! - Programming a Reaction Time Tester

Since 1985  
OVER  
17  
YEARS OF  
SINGLE BOARD  
SOLUTIONS

**EMAC, inc.**  
Phone 618-529-4525 Fax 618-457-0110  
2390 EMAC Way, Carbondale, Illinois 62901  
World Wide Web: <http://www.emacinc.com>

Circle #41 on the Reader Service Card.

## The Pocket Programmer



The portable programmer that uses the printer port instead of an internal card. Now with easy to use Windows software that programs E(E)prom, Flash & Dallas Ram. 25/27/28 & 29 series from 16K to 8 Megabit with a 32 pin socket. Adapters available for MCU's 874X, 875X, Pic, Atmel, 40-Pin X16, Serial Eprom's, PLCC, Bi-Prom's, Eprom Emulator to 32K X 8 and More....

**Only \$149.95**

Same Name, Address & Phone # for 20 Years....  
Isn't it Amazing?

### Intronics, Inc.

Box 12723 / 612 Newton St.

Tel. (913) 422-2094

Fax (913) 441-1623

Add \$7.00 COD

Add \$6.00 Shipping

**WWW.IN-KS.COM**

Visa/MC/Amex/Disc



## REFILL INKS FOR INKJET PRINTERS

Refill your old cartridge and save. All refill kits come with instructions and needed materials for refilling inkjet cartridges. Available

for Canon, Epson, Hewlett Packard, Apple, Compaq, and Lexmark printers.

## HARD-TO-GET PRINTER RIBBONS



Gorilla Banana, Commodore, Texas Instruments, Centronics, Riteman, Apple, Printronix, Star

Over 300 different ribbons in stock.  
All ribbons new, not re-inked.

Check our web page or write for complete price list.

## H.T. ORR Computer Supplies

249 Juanita Way, Placentia, CA 92870-2216

714-528-9822 • FAX 714-993-6216

Toll Free 1-800-377-2023

e-mail: [Htorr@aol.com](mailto:Htorr@aol.com)

<http://home.adelphia.net/~htorr>



## PRIMECELL.com

IF YOU NEED NEW BATTERIES FOR YOUR ELECTRONIC EQUIPMENT  
DON'T PITCH EM - SEND THEM FOR REBUILDING! - SAVE \$ \$

- WE INSTALL NEW NI-CAD OR NI-MH BATTERIES INTO YOUR CASE.
- WE IMPROVE PERFORMANCE TO BETTER THAN ORIGINAL.
- WE FIX WHAT CAN'T BE FOUND. (OR AFFORDED)
- WE PROVIDE QUICK SERVICE. / EXTEND LIFE OF OLDER EQUIPMENT
- WE OFFER FREE QUOTES. / FREE RETURN IF QUOTE IS REFUSED.
- WE PROPERLY DISPOSE OF YOUR OLD CELLS BY RECYCLING.
- WE GIVE YOU A 12 MONTH WARRANTY.
- WE WILL BE HERE WHEN YOU NEED US / EST. 1986
- WE SAVE YOU \*\*\*\* MONEY \*\*\*\* \$ \$ \$



WE SERVICE RECHARGEABLE BATTERY ASSEMBLIES FOR ALL TYPES OF ELECTRONICS.  
RADIOS, SCANNERS, CORDLESS TOOLS, BAR CODE READERS, GPS, SCIENTIFIC, SURVEILLANCE

GENERAL ELECTRIC	UNIDEN	RADIO SHACK
MPD PLS MPA 4850P \$ 34.50	APX850 1050 1105 \$ 32.50	HTX 202/404 \$ 22.50
MPD PLS MPA 4860P \$ 39.50	1010 1070 1100 \$ 32.50	NEW NiMH HTX pack \$ 39.50
MPR MPS MPX 763/777 \$ 39.50	1120 1200 Series \$ 32.50	8.4V 1650mAh \$ 39.50
MONOGRAM 4506P/13 \$ 37.50	BP2500 650mAh \$ 19.50	K E N W O O D
	BP205 1600mAh \$ 22.50	PB2/6/33/34 \$ 28.50
M AXON SA-1155 1160 \$ 39.95	I C O M	PB7/8/9/13/14/18 \$ 34.50
	BP2 / BP3 / BP22 \$ 19.50	KNB6/7/12/14/15 \$ 34.50
MOTOROLA	BP5 / BP23 / 24 \$ 27.50	PB10/25/26/32 \$ 24.50
MX300 HT600 MT1000 STX	BP7 / CM7/ BP8 \$ 34.50	C O R D L E S S D R I L L S
NTN 4886 4824 6414 \$ 37.50	BP167/174/180 \$ 34.50	50% MORE CAPACITY.
NTN 5447 5621 5546 \$ 37.50	CM140/141/166 \$ 41.50	Any brand 7.2V \$ 21.50
NLN 5860 NTN 4327 \$ 39.50	Y A E S U	Any brand 9.6V \$ 29.50
	FNB 3 4 12 14 16 \$ 32.95	Any brand 12.0V \$ 36.50
	FNB19 21 26 27 38 \$ 32.95	Any brand 14.4V \$ 39.50
	FNB 10 1117 26 36 \$ 23.95	Any brand 18.0V \$ 44.50

See our web pages about rebuilding battery packs used for Land Surveying.

## BATTERY REBUILD SERVICE

FOR INFORMATION ABOUT YOUR REQUIREMENTS ... CONTACT US:  
USE THE EASY INFO. REQUEST PAGE AT <http://www.primecell.com>  
PHONE OR FAX: (814) 623-7000 E-MAIL TO: [sales@primecell.com](mailto:sales@primecell.com)  
SEND PACKS FOR FREE QUOTATION BY: UPS, FEDEX, OR US MAIL

CUNARD ASSOCIATES INC., 9343 US RT 220, Bedford, PA 15522

Circle #42 on the Reader Service Card.

Circle #43 on the Reader Service Card.



# Home Automation Via the Web

by Michael Gardi

## Add a web interface to your X10-based home control system.

In this article, I will describe how I added a web interface to my X10-based home control system. I'd like to say that this project arose out of a pressing need to provide external control for some critical operational aspect of my home, but I'd be lying. Truth of the matter is, I undertook this project because I thought it would be fun to do. It also brought together in a very nice way some of my recent interests: PIC programming, home automation, and web interfacing.

### Talking to Your Home

Home automation hardware has been around for years. X10-based systems are by far the most popular today. The term X10 refers to a communications protocol that allows devices to talk to each other via the existing 110V electrical wiring in the home. No costly rewiring is necessary. In addition to this, wireless radio frequency transceiver units are available to extend the reach of X10 beyond the "outlet." Each device that participates in an X10 "network" is assigned an address



**Photo 1** — SitePlayer from NetMedia, Inc. A complete web server in a very small package.

(usually via external switches on the device itself). Up to 256 different addresses are available by combining "house codes" (the letters A-P) with "device codes" (the numbers 1-16). If you want more than one device to respond to the same signal, simply set them to the same addresses. One of the beauties of this system is that all X10 compatible products can be freely mixed and matched. Quite a number of vendors offer home control products based on the X10 protocol. A list of X10 manufacturers can be found in the "More Information" sidebar.

### More Control With the CM11A

A powerful recent addition to the X10 arsenal is the home automation controller: a software programmable X10 transmitter device (some have the ability to receive status information from X10 devices, as well). Typically, these units connect to a PC via the serial or parallel port, and come with Windows-based software that enables you to control your home with the click of a mouse. There are a number of controllers available, but the one that I used for this project is the CM11A from X10 ([www.x10.com](http://www.x10.com)).

A CM11A plugs into any outlet (preferably one close to your PC) and comes with a cable that connects the CM11A to a serial port on your PC. The PC communicates to the CM11A using an RS-232 based protocol at 4800 baud (eight bits, no parity, one stop bit). The CM11A handles the X10 protocol to your devices. We'll explore this in more detail a bit later.

### Introducing a Web Interface

The ActiveHome software that ships with the CM11A is very good. It provides a clean visual interface to the devices under control.

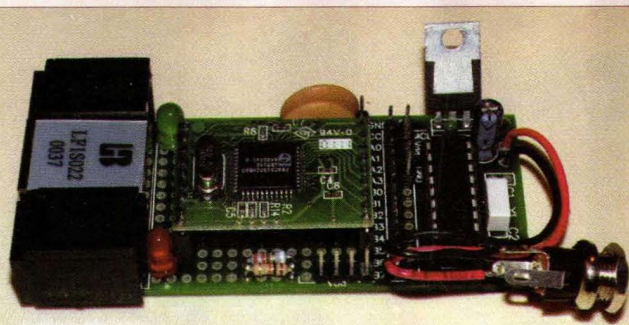
**Table 1**

House Code	Device Code	Binary Value
A	1	0110
B	2	1110
C	3	0010
D	4	1010
E	5	0001
F	6	1001
G	7	0101
H	8	1101
I	9	0111
J	10	1111
K	11	0011
L	12	1011
M	13	0000
N	14	1000
O	15	0100
P	16	1100

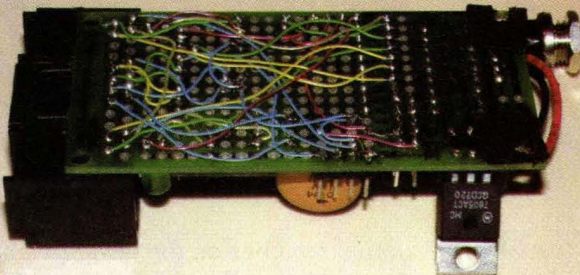
**Table 2**

Function	Binary Value
All Units Off	0000
All Lights On	0001
On	0010
Off	0011
Dim	0100
Bright	0101
All Lights Off	0110
Extended Code	0111
Hail Request	1000
Hail Acknowledge	1001
Pre-set Dim (1)	1010
Pre-set Dim (2)	1011
Extended Data Transfer	1100
Status On	1101
Status Off	1110
Status Request	1111





**Photo 2** — Top view. All components fit nicely onto the PICProto18 board.



**Photo 3** — Bottom view. Point-to-point wiring is a bit tight, but not too bad.

The only problem is that you have to physically be at the PC to which the CM11A is attached in order to use it. If you could somehow connect the CM11A to a web server, then you could control your household devices from any browser that has access to that server.

While your favorite web site is probably running on expensive high-end hardware for light use, web server software will run comfortably on a low-end PC. So one way to add a web interface to the CM11A would be to run a web server package on the PC that it is attached to. This can be made to work, but you would have to leave your PC on all the time in order to access the CM11A.

## How Small Can You Go

Enter the SitePlayer by NetMedia, "the world's

smallest Ethernet web server." This one-inch square device is a complete web server solution, and forms the heart of this project. (See Photo 1.)

SitePlayer handles all of the web protocols required to deliver web pages over the Internet. SitePlayer has about 48K of flash memory available for your web pages. Standard web authoring tools can be used to make the pages. Web pages are downloaded to the SitePlayer through the Ethernet connection. You can obtain the PC-based software necessary to bundle and download your pages from the SitePlayer web site ([www.siteplayer.com](http://www.siteplayer.com)).

SitePlayer has a powerful object system called SiteObjects.<sup>TM</sup> This feature maps special fields on stored web pages to internal SitePlayer variables or to external events. The key SiteObjects feature used in this project is the ability to map a link on a web page to the built-in serial communications port. In other words, when you click on this special link, a sequence of characters (of your choosing) will be transmitted from SitePlayer's serial port.

## Composing a Command

So, given that the CM11A can receive commands via RS-232 and the SitePlayer can be set up to serially transmit command strings at the click of a mouse button, what has to be sent? A "standard" transmission to the CM11A refers to the communication of a house code and device code combination, or the transmission of a function code. The binary format for house and device codes can be seen in Table 1. Function codes are listed in Table 2.

A standard command consists of two bytes, a "header" and a "code" byte. The header byte is composed as follows:

### Header:

Bit-7	Bit-6	Bit-5	Bit-4	Bit-3	Bit-2	Bit-1	Bit-0
Number of Dims (values 0 to 22) Dim/Brighten by $((\text{Dims} / 22) * 100)\%$					Always 1	0=Address 1=Function	Always 0

If Bit-1 of the header is set to 0, the address code byte that follows will look like:

## More Information

This article covers quite a number of diverse topics: X10 home automation, PIC programming, web protocols, etc. I have tried to touch on enough of the key parts of each topic in order to describe how my web-based X10 device works. For a better understanding of the topics covered, please check out the following links.

### X-10 Home Automation

#### A couple of good general sites:

[www.homeautomationforum.com/](http://www.homeautomationforum.com/)  
[www.geocities.com/ido\\_bartana/](http://www.geocities.com/ido_bartana/)

#### Vendors:

[www.x10.com/](http://www.x10.com/)  
[www.marrickltd.com/](http://www.marrickltd.com/)

[www.leviton.com/](http://www.leviton.com/)  
[www.act-solutions.com/](http://www.act-solutions.com/)

### CM11A Communications Protocol Documentation:

[http://software.x10.com/pub/manuals/cm11a\\_protocol.txt](http://software.x10.com/pub/manuals/cm11a_protocol.txt)

### SitePlayer

[www.siteplayer.com](http://www.siteplayer.com)  
<http://fargo.itp.tsoa.nyu.edu/~tigoe/pcomp/siteplayer.shtml>  
<http://mypage.bluewin.ch/a-z/laforge.brenles/SitePlayer/index.html>

### PIC Microcontroller

[www.microchip.com](http://www.microchip.com)  
[www.piclist.com/techref/microchip/davidtait/picprog.html](http://www.piclist.com/techref/microchip/davidtait/picprog.html)



## Address:

Bit-7	Bit-6	Bit-5	Bit-4	Bit-3	Bit-2	Bit-1	Bit-0
House Code				Device Code			

If Bit-1 of the headers is set to 1, then a function code will follow with the format:

## Function:

Bit-7	Bit-6	Bit-5	Bit-4	Bit-3	Bit-2	Bit-1	Bit-0
House Code				Function			

You not only have to know what to send to the CM11A, but you have to know how to send it. The CM11A uses an asynchronous handshaking protocol. A typical command sequence might look something like Table 3. This sequence will address lamp modules A1 and A2, then dim them by 72%. The checksum is simply the sum of the command bytes send to the CM11A module 256. The CM11A also supports an "extended" command similar to what has been described here, but four bytes in length. A link to the complete CM11A Interface Communication Protocol can be found in the "More Information" sidebar.

## Sending a Command

You will have to read the full SitePlayer documentation for details on configuring the SitePlayer to work on your network, and on bundling your web pages up in a binary image and downloading them to the SitePlayer itself. Having said that, setting up the web page to deliver a command string to the serial port at the click of a link is relatively straightforward. In order to do so, we take advantage of the predefined Serial Port Output object (referred to as the COM object in the SitePlayer documentation).

A simple web page with a link to turn on the device at address A1 might look like:

```
<html>
<body>
  <a href="SPtoX10.spi?com=%04%FB%04%66%06%62">
    Turn On A1
  </a><br>
</body>
</html>
```

Let's break this down a bit. The link "Turn on A1" is enclosed in an HTML anchor tag. The "href" parameter of the anchor tag is the address to go to when the link is clicked. In this case, the href refers to SPtoX10.spi, a SitePlayer Interface file. This is a special file used when sending data to the SitePlayer from a web browser (see the SitePlayer documentation for more details). The data is being sent to the COM object (indicated by the "com=") and is formatted according to the protocol defined in the previous section with a two-byte header pre-pended (see the next section). The bytes of data are

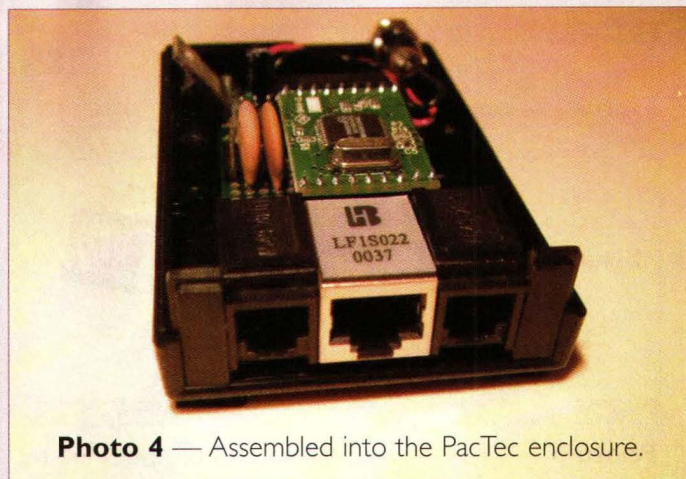


Photo 4 — Assembled into the PacTec enclosure.

Table 3

Transmission to CM11A	CM11A Response	Description
0x04, 0x66		Address A1
	0x6a	Checksum
0x00		OK for transmission to X10
	0x55	CM11A ready
0x04, 0x6e		Address A2
	0x72	Checksum
0x00		OK for transmission to X10
	0x55	CM11A ready
0x86, 0x64		Function A Dim 16/22*100%
	0xe0	Incorrect checksum
0x86, 0x64		Function re-transmission
	0xea	Checksum
0x00		OK for transmission to X10
	0x55	CM11A ready

in hex notation with each byte being preceded by a "%" symbol.

When the link is clicked, the data will be sent out the SitePlayer's serial port's TX line using eight bits, no parity, one stop bit, at the current baud rate (which defaults to 9600 baud). There is no handshaking. This presents a slight problem since we have already seen that the CM11A requires a handshaking protocol.

## PIC Protocol Conversion

A PIC 16F84 processor was used to solve this pro-

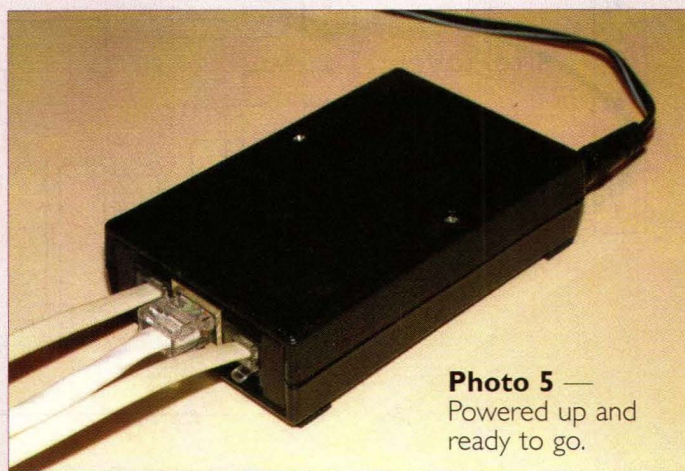
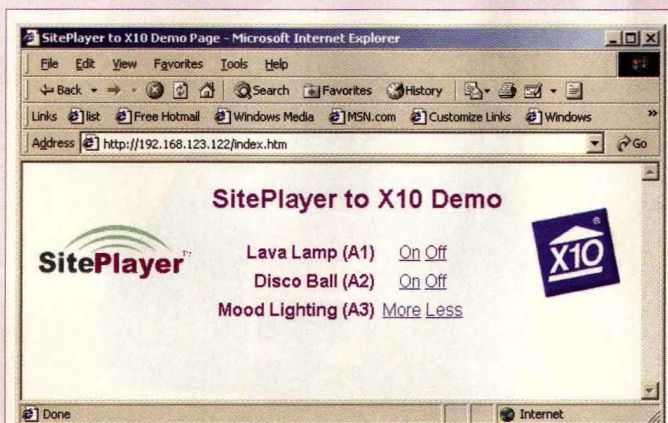


Photo 5 — Powered up and ready to go.





**Photo 6** — Browser view of the web page defined by Listing 6.

toocol conversion issue. The PIC waits for command strings to arrive from the SitePlayer. A full command string consists of a small two-byte header followed by any number of standard two-byte and extended four-byte CM11A command sequences.

The first byte of the header contains the total number of bytes in the command string (minus the header itself) and the second byte in the header is the inverse of the first (as an integrity check). The total command string must be less than 64 bytes.

Once the full command string has been received, the PIC will transmit the individual standard and extended command sequences to the CM11A with the appropriate handshaking.

While it is waiting for a command string to arrive from the SitePlayer, the PIC will "pass through" any serial traffic between the CM11A and your PC. This allows you to use the ActiveHome software to access

the CM11A to handle tasks not covered by the device described here (like downloading macros or setting the time on the CM11A).

Full PIC assembler code can be seen in Listings 1-3 which are available for download at **www.nutsvolts.com**. See Listings 4-6 (printed here and also downloadable) and Screen Shot 1 (shown in Photo 6) for a sample web page with embedded commands.

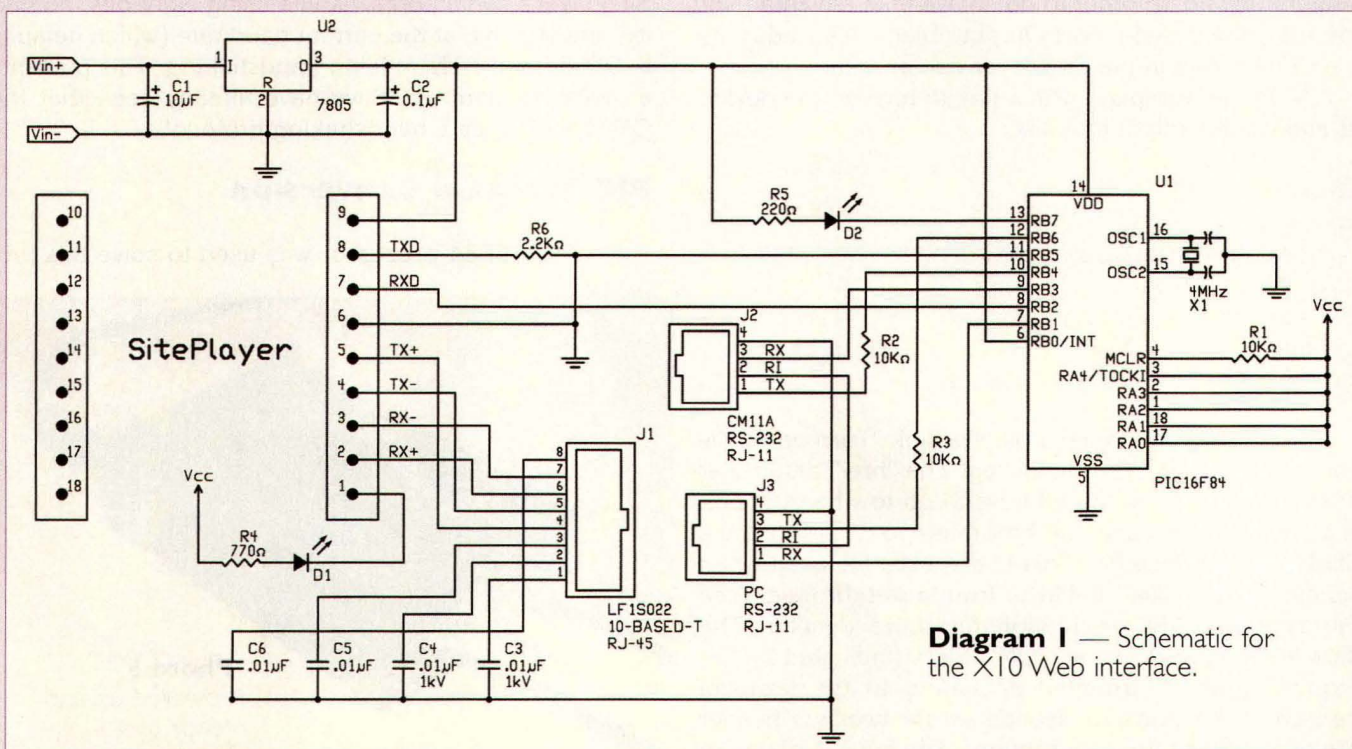
## The Hardware

A schematic for the device appears in Diagram 1. The whole project was constructed on a PIC Proto-18 board (see the Parts List for details). This readily-available PCB works well for a number of reasons:

- The prototyping area was large enough for the SitePlayer module and the few additional parts required.
- The power supply was sufficient for both the PIC and the SitePlayer. Total current draw is about 100 mA.
- The area at the bottom of the board normally set up for a DB-25 connector was perfect for mounting the RJ-45 Ethernet jack and two RJ-11 jacks (although the mounting lugs at the bottom of the jacks needed to be removed for this set-up to work).

The Ethernet line connection requires both a 10BaseT transformer and an RJ-45 socket. I have used the LF1S022 Lan-Mate combined unit available from a number of sources including NetMedia (makers of the SitePlayer).

The whole project fit nicely into a PacTec HM model 2.4" x 3.8" x 0.9" enclosure. This particular



**Diagram 1** — Schematic for the X10 Web interface.



model has a panel opening at one end to allow access to the various connectors (see Photo 5).

To connect the device to your network via a hub or router, you would use a standard Cat-5 cable. You can also connect it directly to a PC with a "crossover" cable.

The CM11A uses a modular headset connector (sometimes referred to as RJ-22). I used RJ-11 connectors on the device (since I could not find modular phone jacks at the time).

As a result, I had to build a four-wire "crossed over" cable to connect the device to the CM11A, and a similar RJ-11 to DB9 cable to connect to the PC. If I had it to do again, I would have used RJ-22 modular jacks on the device, which would have allowed me to use a standard four-wire modular telephone cable and the serial cable that ships with the CM11A instead.

## Wrap-Up and Futures

This project leaves lots of room for future "tinkering." For instance, the CM11A is a two-way interface that not only accepts commands, but returns status information from the devices it controls. The PIC firmware could be extended to monitor this information and update internal SitePlayer variables.

A transmit line from the PIC to the SitePlayer is enabled, but unused at this point, for this very purpose. These internal variables can then be used to dynamically update your web pages.

Another improvement might be to have the PIC periodically check to make sure that the SitePlayer is operating normally. There is a status command that can be sent via the serial port for this very purpose.

If there is any problem, the PIC could restart the SitePlayer via its reset line.

I'm happy to report that I was right when I started

### Listing 4 — SPtoX10.spd. SitePlayer definition file.

```
;
; These are initial variables that you can
; place in your system
;
; $Devicename sets the name or description
; of the device
; $Devicename "SitePlayer(tm) to X10 Demo
; Web Page"
;
; $DHCP on sets SitePlayer to find its IP
; address from a DHCP server
; $DHCP on
;
; $DownloadPassword sets password for
; downloading web pages and firmware
; $DownloadPassword ""
;
; $SitePassword sets password for browsing
; web pages
; $SitePassword ""
```

```
; $InitialIP sets SitePlayer's IP address to use
; if no DHCP server is available
; $InitialIP "192.168.123.250"
;
; $PostIRQ on sets SitePlayer to generate a
; low level IRQ on pin 11
; $PostIRQ off
;
; $Sitefile sets the binary image filename
; that will be created
; $Sitefile "C:\Program
; Files\SitePlayer\SPtoX10\SPtoX10.spb"
;
; $Sitepath sets the root path of the web
; pages for this project
; $Sitepath "C:\Program
; Files\SitePlayer\SPtoX10"
;
; $Include sets the name of a file to include
; during make process
; $Include "C:\Program
; Files\SitePlayer\pcadef.inc"
; $Include "C:\Program
; Files\SitePlayer\udpsend_def.inc"
```

### Listing 5 — SPtoX10.spi. SitePlayer interface file.

HTTP/1.0 302 Found  
Location: /index.htm

### Listing 6 — index.htm. NetMedia's SiteLinker software uses these files (Listings 4-6) to create a binary image to download to the SitePlayer.

```
<html>
<head>
<title>SitePlayer to X10 Demo Page</title>
<meta http-equiv="Content-Type" con-
tent="text/html; charset=iso-8859-1">
</head>
<body text="#8c007b">
<font face="arial">
<table width="100%"><tr><td align="left"
valign="center">

</td><td>
<h2>SitePlayer to X10 Demo</h2>
<table border="0" cellspacing="5"><tr>
<td align="right"><b>Lava Lamp
(A1)</b></td>
<td align="center">
<a
href="SPtoX10 spi?com=%04%FB%04%66%
06%62">On</a>
<a
```

```
href="SPtoX10 spi?com=%04%FB%04%66%
06%63">Off</a>
</td></tr><tr>
<td align="right"><b>Disco Ball
(A2)</b></td>
<td align="center">
<a
href="SPtoX10 spi?com=%04%FB%04%6E
%06%62">On</a>
<a
href="SPtoX10 spi?com=%04%FB%04%6E
%06%63">Off</a>
</td></tr><tr>
<td align="right"><b>Mood Lighting
(A3)</b></td>
<td align="center">
<a
href="SPtoX10 spi?com=%04%FB%04%62%
36%65">More</a>
<a
href="SPtoX10 spi?com=%04%FB%04%62%
36%64">Less</a>
</td></tr>
</table>
</td><td align="left" valign="center">

</td></tr></table>
</font>
</body>
</html>
```

this project; it was a lot fun. I learned a great deal along the way, and hope that my work will inspire others to embark on their own journeys of discovery. **NV**

**C1** 10 uF 16V electrolytic capacitor  
**C2** .1 uF tantalum capacitor  
**C3,C4** .01 uF 1kV ceramic capacitor  
**C5,C6** .01 uF ceramic capacitor  
**R1-R3** 10K 5% 1/4W resistor  
**R4** 770 ohm 5% 1/4W resistor  
**R5** 220 ohm 5% 1/4W resistor  
**R6** 2.2K 5% 1/4W resistor  
**U1** PIC16F84 Microcontroller  
**U2** 7805 Voltage Regulator  
**D1** Red LED  
**D2** Green LED  
**J1** RJ-45 PCB mount jack with 10BaseT

**J2,J3** transformer (LFIS022 Lan-Mate)  
RJ-11 PCB mount jacks (or modular headset jacks)  
**X1** 4.00 MHz ceramic resonator with capacitors  
**SPI** SitePlayer SPI Module  
([www.siteplayer.com](http://www.siteplayer.com))  
**PCB** PICProto18 Prototyping Board  
([www.melabs.com](http://www.melabs.com))  
**Enclosure** PacTec HM model 2.4" x 3.8" x 0.9"  
([www.pactecenclosures.com](http://www.pactecenclosures.com))  
**Misc.** 0.1" Male headers, wire-wrap wire, power jack and matching 9V "wall-wart" transformer power supply, RJ-11 and CAT5 cables

## Parts List



# A Radio-Controlled Airborne-Video System

by Phil Blake

*SuperCircuits' VideoBug System makes it simple to get live video while flying your R/C airplane.*

## Introduction

It seems us down-to-earth folks have always had a fascination with flight. To soar with the eagles and to be free is part of what the enjoyment of flight has to offer. My fascination with flight started at an early age with the local Civil Air Patrol. Cadets wishing to learn about flight could rent the Patrol's Cessna 150 with an instructor for only \$8.00 an hour. That seemed like a lot of money, back then! I continued to learn as much about flight as I could.

When "ground-based," I would head up to the local soaring slope and toss my radio-controlled (RC) glider into the thermal breeze. Now flying a Cessna 150 compared to flying an RC thermal glider shouldn't be that much different, but it is. Both are exciting, but it sure would be nice to be "up there" with the RC glider.

So way back in 1993, my fellow soaring friends and I got together to see if we could equip a glider test bed with airborne video. To help us get started with this great ambition, we turned to SuperCircuits, and their plethora of video equipment. From them, we purchased a miniature color camera, and transmitter and receiver kits. It took a few pleasurable days of work soldering together the transmitter and receiver kits, and then electrically tuning both for proper operation and range. Using a large, hand-held UHF television antenna, we pointed the antenna at the glider for best reception.

Although expensive and bulky in size, the airborne system worked to our complete delight. The received and recorded video provided hours of fascinating enjoyment. Seeing a flight video from above — where you are the pilot — is as fun and as close to being "up-there" as possible.

We could finally see and feel the freedom of flight.

Back in 2000, SuperCircuits began offering a truly turnkey, miniature airborne-video system that's 100-percent plug and play. The transmitter and receiver are ready-built and tested. The color camera is mounted in a rugged plastic case. The camera readily plugs into the transmitter using the supplied RCA cables. The transmitter/receiver pair operate at 900 MHz, which is a relatively quiet, ham-radio licensed frequency band.

Improvements in technology have lead SuperCircuits to offer an even lower cost, lighter, and smaller system called the AVX-900-S2-V, 900-MHz FM Wireless High Power VideoBug System (Figure 1). This is also a complete plug-and-play video system to be used in various real-world applications. We'll be using it in a unique radio-controlled airborne-video application. Radio-controlled airborne video combines a number of skills that most of us already have. These skills include piloting RC aircraft, ham radio and, of course, basic tinkering, if you are inclined to do so.

## System Specifications

Three components comprise the airborne section. They include the transmitter, the camera, and the battery pack (Figure 2). Each component is plug and play, with color-coded video and power cables. This makes set up and testing a brisk event. On the ground is the receiver, which receives the transmitted video from the airborne transmitter. For field use, a battery-powered television, together with an inverter-powered camcorder or video tape recorder, simply plugs into the video output jack of the receiver. This is almost all it takes to obtain first-rate, live video from your radio-controlled airplane, helicopter, car, or boat.

Inspecting the individual components that make up the wireless video system — first and foremost — is the transmitter. It is encased in a metal, radio-frequency shielded housing. The transmitter measures a diminutive 2" x 1" x 1/4". The transmitter is pre-wired with two RCA-type input jacks — one for video and the other for sound — and a power jack for battery power. A matching 900-MHz whip antenna screws onto the mounting ear of the transmitter. The antenna measures approximately 5-3/4" long. The combined transmitter/antenna and cabling weigh 2.1 ounces. Power requirement is 12-volts DC at 280 milliamps. RF output power is approximately 250 mil-



Figure 1



liwatts, operating on the ham-band frequency of 910.1 MHz.

Next is the color camera. The camera is housed in a rugged plastic case. The video and power cable routes out from the back of the case. The case measures approximately 2" x 2" x 1". The video lens protrudes another 3/8" out from the front of the case. The camera/case and

cabling weigh 2.4 ounces. The camera is a SuperCircuits PC169XS with a 4mm, medium/wide-angle, 70-degree field-of-view lens. The PC169XS delivers an impressive 460 lines of resolution, which is sharper than standard VHS or 8-mm recorders. Low-light performance goes all the way down to one lux — not night vision, but this specification is impressive for a camera this economical. The camera is fully automatic in its operation of gain, white balance, back light compensation, and stepless shutter. Power requirement is 12-volts DC at 120 milliamps. The camera's video output jack easily mates to the transmitter's matching video input plug.

The airborne transmitter and camera share an eight-cell, 12-volt DC battery pack. The battery pack includes a Y-harness to provide simultaneous power to the transmitter and camera. The battery pack and Y-harness with eight AA alkaline cells tops in at 8.5 ounces. The entire airborne system, including transmitter, camera, and batteries, will add an additional 13 ounces to your application. At 12-volts DC, the transmitter and camera together consume approximately 425 milliamps.

The last component of the AVX-900-S2-V system is the ground-based receiver (Figures 3 and 4). The receiver measures 7-1/2" x 5-1/4" x 1-1/4". On the back of the case are the color-coded, plug-and-play connections that output video and sound to your supplied television and/or video tape recorder. A matching 900-MHz whip antenna screws onto the receiver's antenna mounting jack. A supplied wall-mounted transformer attaches to the receiver's power jack. At the field, most of us will not be using the wall transformer, but rather the 12/13.5-volt DC power furnished from your automobile battery using the included cigarette lighter plug adapter. Power consumption of the receiver is 12-volts DC at 350 milliamps.

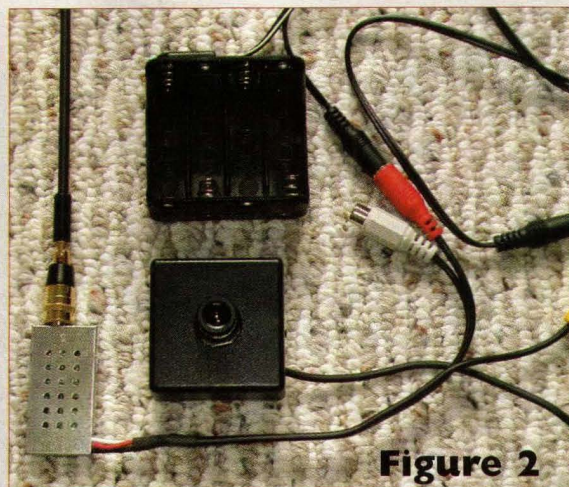
## Ham Radio Licensing

The AVX-900-S2-V falls under the category of FCC licensing known to amateur radio operators as ATV, or Amateur Television. Thus, the FCC requires the operator of these components to hold as a minimum, a no-code Technician class license. I do not feel that this is a major hindrance, as the Technician class license is relatively easy to obtain; there is no code to learn and, due in part to the

**Figure 3**



**Figure 4**



**Figure 2**

Internet, many testing sites are available to study for the exam and to even take randomly sampled tests on-line. Local amateur radio clubs are also of great help, and can provide you with study guides and licensing information. With a few weeks of study, I foresee that most of you will be able to pass the 35-question exam.

While making the licensing easier for most to obtain, the FCC has also raised the bar for violators. If caught using ATV without the proper licensing, the FCC can fine the operator up to \$10,000.00 per day of unlicensed operation and up to six months in jail! The remedy here is to have the proper license. Again, all that is required is a Technician — no code — license.

As an added benefit, once you have obtained the license, a whole new world of communications can open up for you. Ham radio is fun and provides a helpful communication service for our local communities in the event of an emergency.

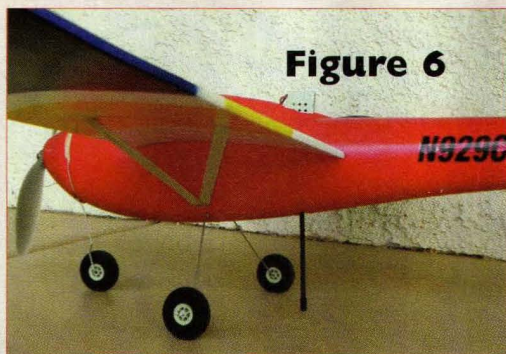
## ATV Installation

Due to the lightness of the airborne components, the camera and transmitter can be mounted just about anywhere in the intended application, provided the cabling can reach between the two. It is important to place the heavy airborne battery at or near the center of gravity (CG) of the airplane. The camera and transmitter should be mounted in a foam bed to isolate them from engine vibration. Keep the video transmitter away from your airplane's radio equipment as much as possible to lessen the likelihood of radio interference, although I could find no interference, on even

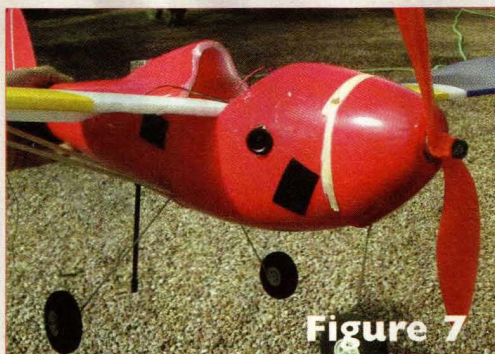


**Figure 5**





**Figure 6**



**Figure 7**

my single-conversion 72-MHz radio-controlled receiver.

For most of you, the installation will be quick and easy, as I previously mentioned the plug-and-play nature of the components. With this said, I preferred an alternative route! My radio-controlled activities — for the past several years — have been electric, slow-flight airplanes. Imagine no more messy fuels and oils. No more loud and powerful gas engines. This is not to say I still don't fly gas, it's just that I would rather not. For me, after a long day of work, little is more pleasurable, simple, and convenient than tossing my 11-ounce slow/park flyer from the front yard for a 30-minute ride to relaxation. What if I could reduce the 13-ounce weight of the airborne-video system to make it light enough to accompany a ride on one of my slow/park flyers? The size of the airborne system will fit, but something will have to be done to minimize the weight.

## Cut and Chop Time

I would like to mention that SuperCircuits has recently introduced an ultra-lightweight camera/transmitter pair, more suited for slow flyer applications. I intend to report on this new system in a future article. But for now, my technique will focus on tinkering to see how much I can reduce the weight of this airborne-video system. I would like to stress that this is not the preferred technique, as the AVX-900-S2-V is a wonderful plug-and-play system for most gas-powered airplanes, electric-powered cars, or even two-meter gliders!

My Great Planes Escapade park flyer has seen sever-

al dozens of flights around my neighborhood (Figure 5). Each has been hand-launched from my front yard. On a good day, I can average a 30-minute flight with the help of some late afternoon warm, rising air.

The AVX-900-S2-V will provide an excellent opportunity to take an airborne peek around the neighborhood. My foam-constructed Escapade, with its 40-inch wingspan, has an advertised weight of 13 ounces. I use NiMH batteries as the power source for the airplane, therefore my Escapade only weighs 10.8 ounces with the flight battery.

Here is how I lowered the weight of the airborne-video equipment. First, I removed the camera from its plastic case. From the camera and transmitter, I cut off and removed their RCA and power plugs. I then hard-wired the two together, splicing in a miniature plastic power plug to the camera and transmitter power lines for their separate battery power source. I had a surplus seven-cell, 110-mAhr NiCd, which will be used to power the camera and transmitter for this application. Note that it is not advisable to power the transmitter/camera from the airplane's radio control/motor drive source, as glitches in the servos can and will occur.

Through experimentation, I found that the transmitter could operate as low as 6.5 volts before dropping its signal. The camera is good all the way down to five volts. In testing, the surplus 110-mAhr, 8.4-volt pack provided about 15 minutes of video "down-link" power, which will be adequate for this application. The all-up weight for my "cut and chop" airborne-video system went from 13 ounces all the way down to 4.2 ounces, including the NiCd pack.

To maintain the center of gravity, I fooled around a bit and found a good CG with the transmitter installed mid-fuselage (Figure 6). I poked a hole through the foam fuselage up front for the tiny camera (Figure 7). The additional video battery pack rested securely in the lower section of the front fuselage. Once installed, the Escapade's flight weight went up to 15 ounces, or two ounces heavier than advertised. In spite of the additional weight, I feel the Escapade will be able to sustain flight.

## Flight Video

I set up the ground-based video receiver with stock antenna to have full coverage of my flight radius. The video out of the receiver went to a VCR. The VCR's video out connected to a portable TV. Whoops! Before taking off, don't forget to press the Record button on the VCR!

Out in the front yard, I turned on the airborne video and the airplane's radio. I performed a range check and could detect no interference. My assistants relayed they were receiving the live video — ready to launch! I applied motor power and hand-tossed the Escapade upward. The additional weight did not adversely affect flight perform-



**Figure 8**

10/27/02 16:10:56





**Figure 10**



**Figure 9**

ance, nor were any radio glitches detected.

I wondered what the airborne video was sending. I flew around the neighborhood, gaining altitude along the way. Total flight time was right at 15 minutes, and it was time to touch down on the street; I could hardly wait to see the video! I was not disappointed, either.

The tiny PC169XS color camera produced some of the best visuals I have ever seen. The views were terrific, with only an occasional amount of video noise. In reviewing the video, I even saw several birds flying nearby, which I also spotted during the flight! The landing on the street looked pretty good, too!

Please note that the captured images, (Figures 8, 9, and 10) do not serve justice to the actual video. The video capture card on my computer could only capture the images in 320 x 200 format; thus, the pictures shown are distorted and considerably grainy in appearance. For the best visuals, place the camera with the lens pointed below the horizon. This will allow the camera's automatic gain setting to be relatively low, thereby allowing better exposure of the ground below.

If the camera is aimed so that most of the sky is visi-

ble, then the ground will appear quite dark, again due to the automatic gain setting of the camera. Another item worth noting is that the smoother the airplane is flown, the better the video looks. Calm air or an airplane flying near the limits of its power curve, produces the smoothest, most realistic video. Needless to say, it's a really "neat" experience to see a flight of the neighborhood taken from an eagle's perspective.

## Conclusion

The AVX-900-S2-V opens up a whole new world for the modeler/experimenter enthusiast. Best of all, this system is remarkably user-friendly, thanks to its plug-and-play colored connections.

There are many avenues to pursue using live video. Imagine using a wrap-around, head-mounted goggle to display real-time video! What a visual treat this would be!

I hope that you have enjoyed this article on airborne video. I look forward to presenting you with additional products and articles that are both high tech, yet simple to use, and reasonably priced. **NV**

## Stepper Motor Book

### Easy Step'n

- For the experimenter.
- Determine surplus stepper motor specs using simple easy to build test equipment.
- Design and build microcontroller-based control systems (flow charts and code examples included).
- Design and build stepper motor driver circuits.
- Analyze the mechanical characteristics of stepper motor-driven devices.
- The book is full of experiments, circuits and code. \$34.95

Table Of Contents And Ordering Information On Web Site

<http://www.stepperstuff.com>

## SQUARE 1 ELECTRONICS

P.O. Box 501, Kelseyville, CA 95451  
Voice (707) 279-8881 Fax (707) 279-8883

We have been selling on the Internet since 1996. We ship the day we receive your order or the next business day.

## PIC® Microcontroller Books



### New Titles

### Same Useful Books

Table Of Contents And Ordering Information On Web Site.

Not Distributed Via Book Sellers

We accept VISA, MC, AM, DS, MO. Check CA residents please add 7.25% CA sales tax. See our web sites for s/h rates.

PIC, PICmicro and MPLAB are trademarks of Microchip Technology Inc.

### Easy Microcontrol'n - Beginner \$29.95

- Programming Techniques
  - Instruction set, addressing modes, bit manipulation, subroutines, loops, lookup tables, interrupts
- Using a text editor, using an assembler, using MPLAB
- Timing and counting (timer 0), interfacing, I/O conversion

### Microcontrol'n Apps - Intermediate \$44.95

- Serial communication - PICmicro to peripheral chips
- Serial EEPROMS
- LCD interface and scanning keypads
- D/A and A/D conversion - several methods
- Math routines
- 8-pin PICmicros
- Talking to a PICmicro with a PC using a terminal program
- Test equipment and data logger experiments

### Time'n and Count'n - Intermediate \$34.95

- 16-bit timing and counting applications
- Timer 1, timer 2 and the capture/compare/PWM (CCP) module

### Serial Communications - Advanced \$49.95

- Synchronous - bit-bang, on-chip UART, RS-232
- Asynchronous - I2C (Philips Semiconductors) SPI (Motorola), Microwire (National Semiconductor)
- Dallas Semiconductor 1-Wire bus

<http://www.sq-1.com>



# CLASSIFIEDS

## CLASSIFIED ADVERTISING

\$50 Per Inch — No extra charge for color. (Limited time offer)

Classified ads must be paid in full prior to the closing date. Visa/MC/Amex accepted. Payment for ads received after the closing date will be placed in the following issue at our discretion. Minimum charge is one inch with half-inch increments. No proofs will be sent.

Ads to be typeset by Nuts & Volts must be received by the closing date. Supplied ads must be received by the artwork due date. Call the office at 909-371-8497 or email [classes@nutsvolts.com](mailto:classes@nutsvolts.com) for closing dates, available sizes, and special prepay discount offers.

*Classified ads work! Call today!*

### ANTIQUE ELECTRONICS

#### WANTED:

FOR HISTORICAL MUSEUM  
pre-1980 microcomputers,  
magazines, and sales literature.  
Floyd, VA 24091-0341.  
540-763-3311 • 540-745-2322

### BATTERIES

#### POWERING YOUR PORTABLE WORLD

All batteries for  
all types of equipment.

Tel: 603-548-0125  
Web: [www.criticalbattery.com](http://www.criticalbattery.com)

### COMPUTER EQUIPMENT WANTED

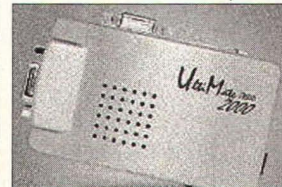
#### WANTED:

FOR HISTORICAL MUSEUM  
pre-1980 microcomputers,  
magazines, and sales literature.  
Floyd, VA 24091-0341.  
540-763-3311 • 540-745-2322

### COMPUTER HARDWARE

#### VGA TO COMPOSITE (NTSC) VIDEO CONVERTER — ULT-2000

Handheld. Powered from keyboard



with S-video and RGB outputs, too.  
3:1 zoom control with many extras.

**\$99 EA**

Matco, Inc., Schaumburg, IL  
1-800-719-9605  
[sales@matco.com](mailto:sales@matco.com) or order  
on-line at [www.matco.com](http://www.matco.com)

### AUDIO/VIDEO

#### VISIT [WWW.BIBBTEK.COM](http://WWW.BIBBTEK.COM)

Wide selection of:

- Audio recording
- Video production equipment
- Musical instruments
- Tubes and components
- 1950s tape archive

#### CONTACT

Tom@mrbbbs@snip.net  
or 856-222-0636 for a list.  
Credit Cards accepted



#### Button Batteries Cheap!

\$1.00 for a card  
of 10 pcs.

Laser pointers  
and watches.  
More variety  
coming soon!

AG 1, AG 3, and  
AG 13 (#44)

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

### CNC

#### CNC & COMPONENTS ROBOTIC

For build-it-yourself CNC projects,  
PC boards, kits, machined parts,  
motors, lead screws, hardware,  
surplus electronics, routers,  
and drummels.

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

### PROGRAMMERS

#### SERIAL TTL 24 X 8 LCD MODULE

An Intel 8032 based 24 x 8 Serial  
Input LCD Module. With  
documentation and C source code.  
Run 8052 Basic. Use 7 I/O pins to  
control other instruments.  
Email [rfequip@att.net](mailto:rfequip@att.net)  
for complete details.

### TEST EQUIPMENT

#### USBee Digital Pod



[EE101.com](http://EE101.com)

PC based Logic Analyzer  
Signal Generator  
Frequency Counter  
Source Code/API  
USB Device Builder  
Expert Design Help

Connect, Control and Debug  
your embedded project  
from your PC over USB  
(909) 693-3065

#### RF TRANSISTORS, TUBES, SILVER MICA & METAL MICA CAPS, DOOR KNOB CAPS

2SC2879	2SC2290	SD1446
MRF454	2SC1969	2SC2166
2SB754	TA7222AP	78L05
78L08	TA7222AP	MRF247
MRF317	SAV7, etc.	3-500ZG
4CX250B	4CX1000A	4CX1500B
3CX3000	A7572B	811A,

SEE OUR CATALOG  
FOR OTHER PRODUCTS  
Westgate 1-800-213-4563.

### COMPUTER SOFTWARE

#### SWIZ BASIC COMPILER

for the Uicom SX28  
microprocessor

Extreme speed from a basic  
program, using a \$4 micro.  
Up to 75 million instructions/sec.  
<http://www.sxwiz.com>

### COMPUTER HARDWARE WANTED

#### DEC EQUIPMENT WANTED!!!

Digital Equipment Corp.  
and compatibles.  
Buy - Sell - Trade

CALL KEYWAYS 937-847-2300  
or email [buyer@keyways.com](mailto:buyer@keyways.com)

#### WANTED MICROSOFT:

WINDOWS, OFFICE,  
SERVER SOFTWARE.  
COMPLETE SEALED PACKAGES, OR  
MANUALS, OR CDs ONLY.  
**914-738-6830**

#### FEITEK PROVIDES

Repair, calibration and traceable  
certifications of test equipment.

#### Free estimates

We buy, sell and trade all makes of  
test equipment

Visa and Mastercard accepted  
Check out our inventory and specials  
at [WWW.FEITEK.COM](http://WWW.FEITEK.COM)

2752 Walton Road,  
St. Louis, MO 63114  
314-423-1770

HP 8920A/B service monitors  
from \$2,900 Spectrum analyzers;  
signal generators; cellular test  
sets for CDMA, TDMA & GSM  
and more  
Ph 716-763-9104;  
[www.amtronix.com](http://www.amtronix.com)

Subscribe today!  
[www.nutsvolts.com](http://www.nutsvolts.com)



# CLASSIFIEDS

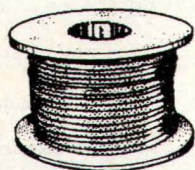
## CONNECTORS WIRE/CABLE

**The RF Connection**  
213 N. Frederick Ave., Ste. 11N  
Gaithersburg, MD USA 20877  
<http://www.therfc.com/>

Complete Selection of MIL-Spec Coax,  
RF Connectors and Relays  
UG-21B/U N Male for RG-213/214 \$.50  
UG-21D/U N Male for RG-213/214 \$.325  
N Connectors for 9913/Flexi4XL/9096  
UG-21B/9913 .....\$6.00 / Pins Only.....\$1.50  
UG-21D/9913 .....\$4.00 / Extra Gasket\$.075  
Amphenol 83-1SP-1050 PL-259 \$.090  
UG-176/U Reducer RG-59/8X, \$.025  
or 5/\$1.00  
UG-175/U Reducer RG-58/58A, \$.025  
or 5/\$1.00  
Silver Teflon PL-259/Gold Pin, \$1.00  
or 10/\$9.00

MIL-Spec Coax Available (Teflon, PVC IIA)  
New Product: Belden 9913F, 9913 with  
High Density PE Foam dielectric,  
stranded center cond. and Duobond  
III Jacket \$.80/ft or \$.76/100ft  
Also New: 9092, RG8X with Type II Jacket.  
Intro Price .....\$23.00/100ft  
Call for Specials of the Month  
Full Line of Audio Connectors for Icom,  
Kenwood, and Yaesu  
8 Pin Mike Female \$2.50  
8 Pin Mike Male Panel \$2.50  
13 Pin DIN for Kenwood \$2.75  
8 Pin DIN for Icom \$1.00  
8 Pin DIN for Kenwood \$1.50  
Prices Do Not Include Shipping  
Orders **800-783-2666**  
Info **301-840-5477**  
FAX **301-869-3680**

## ANAHEIM WIRE PRODUCTS

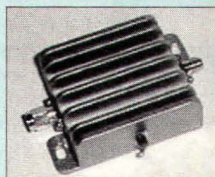


Manufacturer and distributor of  
electrical and electronic wire  
and cable since 1973.

### ITEMS AVAILABLE FROM OUR STOCK:

Hook up wire, Shrink tubing,  
Cable ties, Connectors,  
Wire cut & strip to specs.  
If interested, please call  
**1-800-626-7540**  
**FAX: 714-563-8309**  
See us on the Internet:  
[www.anaheimwire.com](http://www.anaheimwire.com) or  
email: [info@anaheimwire.com](mailto:info@anaheimwire.com)  
Visa/MC/Amex.

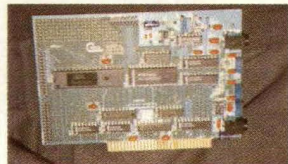
## HAM GEAR



**2.4GHz POWER** amplifier with  
power supply. 10-40 mW input,  
1 (one) watt output with in-line SMA  
connectors and built-in heat sink.  
Approx. 2" x 2" x 5/8" size.  
Frequency range 2.3GHz-2.5GHz.  
\$189/each. Compatible with all  
ATV product lines.  
See our website for more info  
on accessories and transmitter  
and receiver modules.  
**EzATV. Visit our web-site for dealers  
or order on-line at [www.4atv.com](http://www.4atv.com)**

## EDUCATION

### ISA DIGITAL/ANALOG BOARD



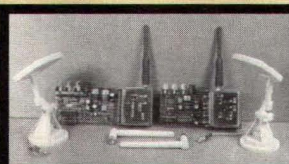
Great for experimenters, designers  
& students. 27 digital I/O lines.  
Eight 8-bit AD inputs, one w/mike  
preamp. Two 8-bit DA outputs, one  
w/audio power amp. Buffered data,  
address & control lines, plus  
3 spare selects for expansion.  
Bare board only \$20, kits &  
assembled available.  
More info, free tutorial & source  
code at [www.learn-c.com](http://www.learn-c.com).

### WANTED: ROCKWELL

Collins HF-80, KVM2A, and  
S-Line equipment.  
Also Collins literature.  
Jim Stitzinger  
**661-259-2011 • Fax 661-259-3830**  
[jstitz@pacbell.net](mailto:jstitz@pacbell.net)



**SUPER HIGH GAIN** 14 dbi  
flat antenna with N or SMA  
connector tuned for 2.3-2.5 GHz.  
Use with 2.4GHz ATV 8 channel  
transmitter or receiver: **\$179/ea**  
— **SPECIAL PRICE! EzATV.**  
Visit our web-site for dealers  
or order on-line at  
[www.4atv.com](http://www.4atv.com).



**2.4GHz & 1.2GHz ATV**  
8 channel transmitters & 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](http://www.4atv.com).

**WIRELESS COMPUTER  
INSTALLATION METER**

**100 TIMES MORE SENSITIVE**  
Than A Field Strength Meter

- Optimizes hub sites for network coverage.
- Detects "hot" and "dead" spots.
- Determines baseline RF levels before installations.
- Detects RF leakage and localizes RF problems.
- Determines antenna/transmitter radiation patterns.

Also useful for:

- Detecting and correcting grounding & shielding problems
- Detecting instrumentation crosstalk and interference from microwave ovens, wireless phones, cell phones, etc.
- Detects surveillance devices and wireless cameras.
- Determines RF levels at desks and working sites.

Features: Bandwidth: 10 MHz. to 4.5 GHz; Sensitivity: 100uV; Linear & Logarithmic Detection (Log detection for plotting and localization); Sensitivity control; 2 fixed internal antennas; Analog Meter & LED displays (for viewing at a distance & at night); Silent Vibrate Mode for in-pocket detection and hands-free operation.

Alan Broadband Co., Inc.  
83 Arch Street  
Redwood City, CA 94062

[www.ZAPCHECKER.com](http://www.ZAPCHECKER.com)  
ABCom@prodigy.net

(650) 369-9627  
(888) 369-9627  
Fax: (650) 369-3788

## MISCELLANEOUS ELECTRONICS FOR SALE

White  
LED  
Keychain  
Flashlights!

**\$1.00 ea.**

**Super  
Blowout  
Deal!**

**Regular White LED  
Flashlights Too!**

Other colors available.

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

Large PC board plant closed.  
Must sell over million dollars of  
all types of equipment.

**Call ISE**  
**956-350-5555**

[www.ISESURPLUS.COM](http://www.ISESURPLUS.COM)

## Rare Earth Magnets

Super powerful. All shapes  
and sizes. Great prices!  
Order 150 pcs and qualify  
for wholesale prices.

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

## SURPLUS & REFURBISHED ELECTRONIC EQUIPMENT

Over 3,600 items in stock.

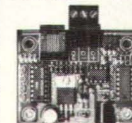
**SMC ELECTRONICS**

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

## RS485/422/232/TTL

**ASC24T \$45**

- Converters
- Repeaters
- Fiber Optics
- Digital I/O
- Multidrop RS232
- Custom Units
- Auto TX Enable



### Extensive Interface Product Line

RS232 "Extension Cords"  
Up to 115.2 Kbps, 4000 ft. ++  
Large Multidrop Networks.  
Isolated Units. Smart Units  
Remote Relay "Extension Cords"

Call the RS485 Wizards at  
**(513) 874-4796**

**RES** **R.E. Smith**  
[www.rs485.com](http://www.rs485.com)

## CABLE

### DIGITAL CABLE TV FILTER

Just now available! Latest 2003  
model technology, no leakage.  
Wholesale prices.

Call for info or flyer.

412-833-0773

### CABLE TV CONVERTERS

Wholesale pricing, full warranties  
SA 8580 \$15 • SA 8590 \$19  
SA 8600 \$20 • Jerrold DPV7 \$18  
BB/CFT \$20 • CFT 2254 \$25  
CODs welcome. Converters, parts, &  
accessories. Toll free 877-915-3727.

## SAMSUNG

**Universal boxes as  
low as \$60.**

Call us first **1-866-798-8182**

or visit:

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



# CLASSIFIEDS

## SATELLITE

 **Skyvision**  
**FREE SATELLITE**  
**TV Buyer's Guide.**  
**BIG Dishes—BIG**  
**Deals!** Get the MOST free and  
 subscription channels with C-  
 band digital upgrade! Get high  
 speed Internet on your big dish!  
**SKYVISION 800-334-6455.**  
 Int'l 218-739-523  
**www.skyvision.com**

## MILITARY SURPLUS

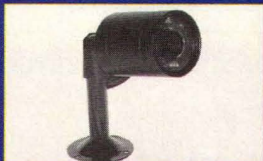
**GRAPHITE-HIGH** density,  
 slabs, blocks, plates, pieces.  
 Used for fuel cells, motor  
 bushings, melting metals,  
 crucibles, rocketry, science  
 projects, electronics.  
 Big 15 pound box assorted,  
**ONLY \$99 SHIPPED.**  
 Jim Sciuto, Box 128,  
 Methuen, MA 01844 or  
 603-645-4772 or see photo at  
**USMintquarters.com**

## NEED TO READ?

Check out the latest titles  
 available at the  
**Nuts & Volts Bookstore**  
 on Page 10

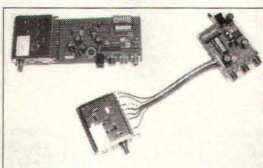
## SECURITY

### INFRARED CAMERA



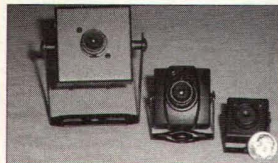
For underwater or all-weather use,  
 AX-808 (B/W) or AX-808-C (color).  
 Designed for lake water to  
 depths of 85 feet. Enclosed LEDs  
 illuminates up to a distance of 20 feet.  
 12 volt operation.  
**COLOR \$149 • B/W \$99**  
**Matco, Inc., Schaumburg, IL**  
**1-800-719-9605**  
**sales@matco.com** or  
 visit/order on-line at  
**www.matco.com**

### 2.4GHz WIRELESS



transmitter/receiver kit. ASK-  
 2008-TR, 8 frequencies uP  
 controlled 2.300 to 2.481 MHz,  
 video NTSC/PAL with 2 channels  
 of audio for development testing.  
 12 VDC/100 mA for both  
 transmitter and receiver. Includes  
 2 rubber duck antennas. **\$125.**  
**Matco, Inc., Schaumburg, IL**  
**1-800-719-9605**  
**sales@matco.com** or  
 visit/order on-line at  
**www.matco.com**

### COLOR & B/W BOARD CAMERAS



•W/cases, BX-120-LC  
 (350 lines color) **\$89**  
 •BX-125-LC (380 lines color) **\$99**  
 •Sub-miniature BX-123-AU  
 (420 lines B/W with audio) **\$69**  
**Matco, Inc., Schaumburg, IL**  
**1-800-719-9605**  
**sales@matco.com** or  
 visit/order on-line at  
**www.matco.com**

### WIRELESS COLOR



rechargeable 2.4GHz system,  
 ASK-7003-TR. 150 foot range.  
 Includes camera/transmitter,  
 receiver and built-in battery pack  
 with charging systems. Range 150  
 feet. High volume seller! **\$159**  
**Matco, Inc., Schaumburg, IL**  
**1-800-719-9605,**  
**sales@matco.com** or  
 visit/order on-line at  
**www.matco.com.**

### WEATHER RESISTANT OUTDOOR CAMERAS

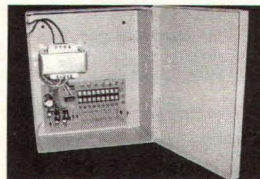


WR-700 type,  
 high impact  
 tempered glass  
 with stand.  
 Black & white  
 (430 lines), or  
 color (420+  
 lines) available. Standard 3.6mm  
 lenses with optional lenses of 6,  
 8, and 12 mm at \$20 extra.

**B/W ..... \$119/each.**  
**Color ..... \$179/each.**  
 Small compact size with sun shield.

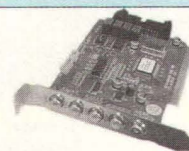
**Matco, Inc., Schaumburg, IL**  
**1-800-719-9605,**  
**sales@matco.com** or  
 visit/order on-line at  
**www.matco.com**

### CAMERA DISTRIBUTION Box, XF-250-DC/XF-250-AC.



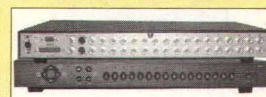
Connect your cameras directly  
 to power source with screw  
 terminals or plug in using a 2.1  
 mm connector.

**Special price: \$59 (DC  
 version) and \$49 (AC version)**  
 Can use pre-molded 50 foot  
 video/power cable A-402-CA \$15.  
**Matco, Inc., Schaumburg, IL**  
**1-800-719-9605,**  
**sales@matco.com** or  
 visit/order on-line at  
**www.matco.com**



**4 PORT video capture card**  
 with remote internet access,  
**DVRC-4; \$339.** Remotely view  
 any 4 NTSC video cameras over  
 your internet connection.  
 Sophisticated motion sensing  
 option allows camera to be  
 activated by motion or time.  
 500 MHz or higher; 98/2000/XP,  
 NT compatible. Installation time  
 under 10 minutes.  
 16 channel unit is also available,  
 bundled with PC.  
**Matco, Inc., Schaumburg, IL**  
**1-800-719-9605,**  
**sales@matco.com** or  
 visit/order on-line at  
**www.matco.com**

### 16 CHANNEL MULTIPLEXER MUX-1600



Display 4, 8, and 16 video outputs  
 directly on a TV or security  
 monitor. This is the only device  
 which allows full screen display of  
 video on VCR playback (see 40 days  
 and 40 nights recorder). Plenty of  
 options including tilting, zoom,  
 individual gain adjustments, etc.  
**Reduced price! \$799/ each.**  
**Special 4 channel version,**  
**MUX-400, \$429/each.**  
**Matco, Inc., Schaumburg, IL**  
**1-800-719-9605,**  
**sales@matco.com** or  
 visit/order on-line at  
**www.matco.com.**

### 40 DAYS and 40 NIGHTS RECORDER



Time lapse, with remote, can be  
 activated by either contact  
 closure or continuous duty  
 operation with standard T-120  
 tape. ES-8960 at **\$339.**  
**Matco, Inc., Schaumburg, IL**  
**1-800-719-9605**  
**sales@matco.com** or visit/order  
 on-line at **www.matco.com.**

**www.nutsvolts.com**



# CLASSIFIEDS

## Low-Cost Video Cameras

- Home •
- Hobby •
- Robotics •
- Nanny Monitoring •

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

**ARobot Kit** from Arrick Robotics uses the Basic Stamp II. Quality metal construction. Easy to assemble and very expandable.

**\$235.00**  
[www.robotics.com/arobot](http://www.robotics.com/arobot)

## Water your yard, not the sidewalk.

AccuRain introduces a revolutionary new

**ROBOTIC** way to water your yard.

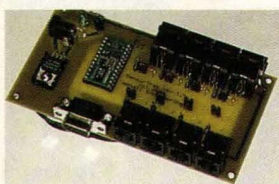
[www.AccuRain.com](http://www.AccuRain.com)

## ROBOT BOOKS.COM

Visit our web site for reviews of robotics books, plus robot kits, toys, movies, & magazines!

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

## ROBOTICS



### SONAR COPROCESSOR

Add SONAR to your project with this easy to use eight channel microcontroller.

**SensorTrak™** connects to your serial port and supports up to eight high-performance range finders, namely the Devantech SRF04 ultrasonic and Sharp GP2D02 infrared sensors. Available as a board or as a complete kit with eight SRF04 transducers.

Visit us at [www.wehali.com](http://www.wehali.com) or email [davee@wehali.com](mailto:davee@wehali.com)

## The Standard for checking Capacitors in-circuit



Good enough to be the choice of Panasonic, Pioneer, NBC, ABC, Ford, JVC, NASA and thousands of independent service technicians.

Inexpensive enough to pay for itself in just one day's repairs. At \$179, it's affordable.

And with a 60 day trial period, satisfaction guaranteed or money-back policy, the only thing you can lose is all the time you're currently spending on trying to repair all those dogs you've given up on.

### CapAnalyzer 88A

Available at your distributor, or call 561-487-6103

**Electronic Design Specialists**

## Locate shorted or leaky components or conditions to the exact spot in-circuit

Still cutting up the pcb, and unsoldering every part trying to guess at where the short is?

\$179



Your DVM shows the same shorted reading all along the pcb trace. LeakSeeker 82B has the resolution to find the defective component. Touch pads along the trace, and LeakSeeker beeps highest in pitch at the defect's pad. Now you can locate a shorted part only a quarter of an inch away from a good part. Short can be from 0 to 150 ohms

### LeakSeeker 82B

[www.eds-inc.com](http://www.eds-inc.com)

**TEK-BIDZ**

Buy / sell  
**Robotics & Industrial Automation!**

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

**DC MOTOR CONTROLLERS:**  
12V-48V, 50A & 100A versions, PWM controllers in either unidirectional or H-bridge designs. Microcontroller based inputs accept pot, R/C servo, or computer signals for 0-100% speed control of DC motors.

**Kwan Motorsystems**  
408-929-2777.  
[info@kwanms.com](mailto:info@kwanms.com)  
[www.kwanms.com](http://www.kwanms.com)

## AMAZING DEVICES

See in Action video on our web site at [www.amazing1.com](http://www.amazing1.com)

### Tesla Lightning Machine

Variable 20,000 volt pulser used for laser flash tube, spark gap and pyro ignitor, garden pest shocker, electric fence, snake venom removal etc. 12 volt battery operation.

TLTE10-Assembled and Tested.....\$54.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

TLTE10-Kit/Plans.....\$29.95

### Shocker Trigger Ignitor

Variable 20,000 volt pulser used for laser flash tube, spark gap and pyro ignitor, garden pest shocker, electric fence, snake venom removal etc. 12 volt battery operation.

TRIG1K - Kit/Plans.....\$29.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

TRIG1K - Lab Assembled.....\$49.95

### Body Heat Telescope

Detects living bodies over 300' Heat leaks etc. Built in chopper and sens control

BHT6 Plans.....\$10.00 BHT6K Kit.....\$99.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

BHT60 Ready to use.....\$149.95

### Explore a Wire, Vaporize a Target, Crush a Can Generate EMP etc.

As seen in video on our web site All using electric and magnetic forces. Uses high energy pulses and trigger switches. We supply all the parts necessary to build these fascinating and action packed projects

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

HEP9 Plans and data all the above.....\$20.00

### Ion Ray Guns

Star Wars Technology Directs Energy

Star Wars Technology Demonstrates Weapons Potential, Force Fields, IonMotors, Antigravity etc.

Projects electric shocks without contact!!

Conduct many weird and bizarre experiments.

Handheld battery operated and easy to operate.

IOG9 Plans.....\$10.00

IOG9K Kit/Plans.....\$129.95

IOG90 Assembled/Testing.....\$199.95

IOG90 Assembled/Testing.....\$199.95

IOG90 Assembled/Testing.....\$199.95

IOG90 Assembled/Testing.....\$199.95

IOG90 Assembled/Testing.....\$199.95

IOG90 Assembled/Testing.....\$199.95

IOG90 Assembled/Testing.....\$199.95

IOG90 Assembled/Testing.....\$199.95

IOG90 Assembled/Testing.....\$199.95

IOG90 Assembled/Testing.....\$199.95

IOG90 Assembled/Testing.....\$199.95

IOG90 Assembled/Testing.....\$199.95

IOG90 Assembled/Testing.....\$199.95

IOG90 Assembled/Testing.....\$199.95

IOG90 Assembled/Testing.....\$199.95

IOG90 Assembled/Testing.....\$199.95

IOG90 Assembled/Testing.....\$199.95

IOG90 Assembled/Testing.....\$199.95

IOG90 Assembled/Testing.....\$199.95

IOG90 Assembled/Testing.....\$199.95

IOG90 Assembled/Testing.....\$199.95

IOG90 Assembled/Testing.....\$199.95

### New Health Concept

Pulsed magnetic breakthrough provides miraculous healing and rejuvenating properties.

THMAG10 Magnetic Pulser.....\$24.95

THMAG10 Magnetic Pulser.....\$24.95

THMAG10 Magnetic Pulser.....\$24.95

THMAG10 Magnetic Pulser.....\$24.95

THMAG10 Magnetic Pulser.....\$24.95

THMAG10 Magnetic Pulser.....\$24.95

THMAG10 Magnetic Pulser.....\$24.95

THMAG10 Magnetic Pulser.....\$24.95

THMAG10 Magnetic Pulser.....\$24.95

THMAG10 Magnetic Pulser.....\$24.95

THMAG10 Magnetic Pulser.....\$24.95

THMAG10 Magnetic Pulser.....\$24.95

THMAG10 Magnetic Pulser.....\$24.95

THMAG10 Magnetic Pulser.....\$24.95

THMAG10 Magnetic Pulser.....\$24.95

THMAG10 Magnetic Pulser.....\$24.95

THMAG10 Magnetic Pulser.....\$24.95

THMAG10 Magnetic Pulser.....\$24.95

THMAG10 Magnetic Pulser.....\$24.95

THMAG10 Magnetic Pulser.....\$24.95

THMAG10 Magnetic Pulser.....\$24.95

THMAG10 Magnetic Pulser.....\$24.95

THMAG10 Magnetic Pulser.....\$24.95



*"Where It Is and How to Get It"*

# Robotics Resources

## Roundup of Serial Servo Controllers

**R**adio control (R/C) servos have become a mainstay in amateur robotics. In one small and relatively-affordable package, you get a gear motor, H-bridge, and control electronics. They're easy to interface to most any microcontroller, requiring no additional circuitry. R/C servos can even be controlled using a simple 555-based circuit.

For robotics, servos can be employed as they come from the factory, for example, with walking robots. In this application, the servos provide precise positional control over an arc of 90 to 180 degrees. With this set-up, it's possible to engineer specific "walking gaits" for legged robots, and experiment with different movements. Most R/C servos can also be modified to allow for continuous rotation. They lose the ability to be precisely positioned when modified, but they're great as the drive motors for wheeled and tracked robots.

In either application, the servo must be commanded using a series of pulses; they can't simply be turned on and off, like an ordinary DC motor. The pulses repeat about 50 times each second (50 Hz or every 20 milliseconds). The duration of the pulses — nominally from 1.0 to 2.0 milliseconds — determines the position of the servo wheel. A signal of 1.5 milliseconds positions the servo in its center. For a servo modified for continuous rotation, 1.5 milliseconds stops the servo; shorter or longer pulses cause the servo to rotate in one direction or the other.

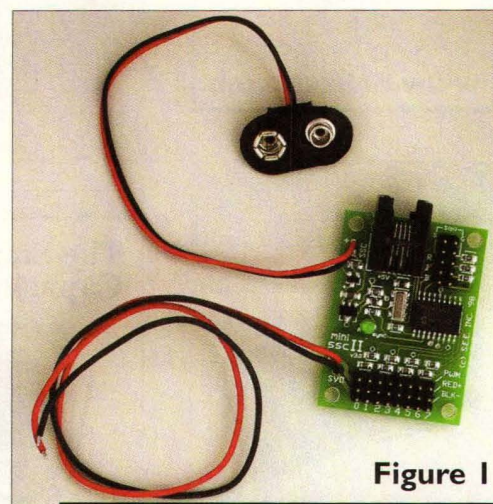
Because of variations in servo design, the precise timing of the pulses must be determined empirically. For example, on some servos modified for continuous rotation, a pulse of 1.64 milliseconds might stop it. It's up to the robot builder to determine the proper timing requirements. Fortunately, this isn't as hard as it sounds when you're using a microcontroller. Timings can be quickly changed in software.

Most robots — wheeled, tracked, or legged — have at least two servos, and some have as many as 18 or 20! Controlling multiple servos can be taxing on a microcontroller because of the timing requirements. Recall that the pulses must be repeatedly sent to the servo. If you're using just one microcontroller, it must continually "refresh" its servos, as well as perform any other tasks you want your robot to do.

Some microcontrollers are better than others at running multiple servos. Both the IsoPod (New Micros, [www.newmicros.com](http://www.newmicros.com)), and the OOPic II (Savage Innovations, [www.oopic.com](http://www.oopic.com)) are designed to run multiple servos and still leave room for other tasks.

Fortunately, even if you're not using one of these micros, you can still command multiple servos by using a serial servo controller. These controllers accept simple serial data input, and then — completely separate from your microcontroller — operate all your servos.

While servo controllers sound like a panacea, they aren't without



**Figure 1**

The Mini-SSC II servo controller from Scott Edwards Electronics.

their shortcomings. The most serious is that there is a limit to the number of servos they can operate. Most all servo boards command each servo one at a time. Assuming a 50 Hz refresh rate, the servos need a new signal every 20 milliseconds. Worst case, each servo needs the maximum 2.0 millisecond pulse, and there must be some time left over to process the incoming serial signal. As a result of this data bottleneck that must be repeated each second, most serial controller boards are limited to eight servos. If you need to control more servos, most designs allow you to daisy-chain additional boards.

## How They Work

Servo controllers operate multiple radio control servos from a single RS-232 or TTL-level serial line. The benefit of servo controllers in robotics is obvious: rather than devote the majority (or all) of a robot's controller to servo functions, this task is handed off to a "co-processor" that does all the work.

In operation, the robot's computer or microcontroller sends a short set of instructions to the serial controller, telling it which servos to oper-



ate, and where to move them to. In the most basic serial data scheme, these instructions are sent through a simple one- or two-wire serial connection. In the typical two-wire connection, one line is used for the actual data, and the other line is used as a synchronizing clock. Even those microcontrollers that lack true serial communications capability can use the two-wire approach by applying what's known as "bit banging" — sending data to a pin one bit at a time.

There are a number of serial servo controllers on the market. Here are over a half dozen that you may want to investigate further.

### Mini-SSC II (Scott Edwards Electronics)

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

The Mini-SSC II set the stage for the other servo controllers that followed and, as a result, many products are functional duplicates of this one. The Mini-SSC II (\$44.00) connects to a serial communications port at 9,600 bps or 2,400 bps, and controls up to eight standard hobby servos at one time. It's possible to link several Mini-SSC II boards in parallel, and therefore, control even more servos.

The data format used by the Mini-SSC II has also become something of

a standard. Each command from your microcontroller is composed of three bytes: a "preamble," a servo board/servo address, and servo position. The preamble is hex FF (decimal 255); when the servo board receives this byte, it knows to look for the second two bytes. The board/servo address tells the controller which board (if using more than one) and which servo is to be commanded.

Finally, the position byte tells the servo where you want it to go, in 256 discrete steps. Assuming an unmodified servo with a full rotation of 180 degrees, the rotational resolution is 0.7 degrees. For example, if 128 centers the servo, 129 positions it to the right by 0.7 degrees, and so forth.

### SV203 (Pontech)

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

The Pontech SV203 series of serial servo controllers operate up to eight standard servos, at serial speeds of 2,400, 4,800, 9,600, or 19,200 bps. Like the Mini-SSC II, each board can be assigned a different address, and therefore, you can control multiple banks of eight servos.

The basic SV203 retails for \$59.00. The upgraded SV203B/C boards (\$79.00 and \$85.00, respectively) also feature infrared, digital

I/O, and on-board program memory, allowing them to be used in stand-alone mode, without a controller or computer.

### Servo 8T (BasicX/NetMedia)

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

The Servo 8T (\$39.00) controls up to eight servos, and eight units can be daisy-chained to control up to 256 servos. The Servo 8T supports serial speeds up to 19,200 bps. What sets this controller apart from the others is that it incorporates force feedback for each servo. This information is communicated back to the computer or microcontroller, and can be used to moderate the position of the servo.

The Servo 8T requires a different command string than the Mini-SSC II, though it's just as easy to use. The preamble character is >, followed by two bytes — one for the board, one for the servo. The last two bytes indicate the command you're sending (e.g., goto position, get position, goto home, etc.), and the position of the servo. The 8T has a handy "turn off" feature whereby no control signal is sent to the servo. This has the effect of de-powering the servo. (To be clear, the servo still receives operating voltage, but because it's not get-

# Budget Robotics

*All the fun, half the price.*



Affordable and durable robot kits, built for easy expansion  
 BYOB (build your own 'bot) with precision CNC-cut bases!  
 Quality servos, standard and modified  
 Parts and supplies below hobby store prices  
 Exclusive servo brackets - mount servos anywhere!  
 Fast-and-easy wheel mount solutions  
 Unusual sensors, encoders, specialty fasteners, lots more!



[WWW.BUDGETROBOTICS.COM](http://WWW.BUDGETROBOTICS.COM)



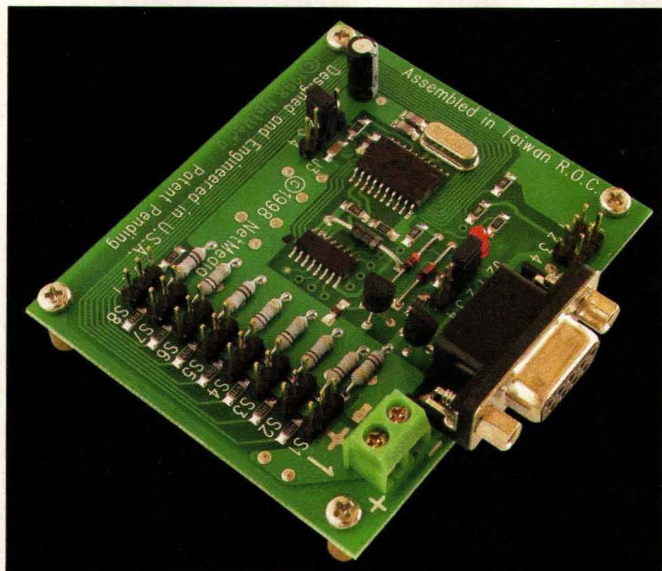


Figure 2. The 8T servo controller from BasicX (NetMedia).

ting any control signals, it doesn't attempt to move anywhere.)

## FT639 (FerretTronics)

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

The FT639 is the smallest servo controller of the lot discussed here; everything is contained in an eight-pin integrated circuit. The chip can control up to five servos, and supports 2,400 bps communications. The FT639 cannot be paralleled to control additional servos; however, the company offers another product — the FT649 — that can control five FT639 servo controllers (for a total of 25 servos, which is usually more than enough for anybody).

The FT639 by itself is \$14.99. You need to mount it on a circuit board and provide headers for signal lines and power. Or, you can purchase the chip with a custom circuit board for \$20.99. The circuit board is also available separately for \$6.99, and the board comes with a five-volt regulator.

## ASC16 (Medonis Engineering)

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

The ASC16 operates up to 16 R/C servos. To help separate it from

the rest of the pack, the product also sports eight high-current digital outputs (up to 250 mA each), and eight inputs configurable as either analog or digital inputs.

The ability to control more than just servos can be a great feature. For example, you could operate a small solenoid, or light a bank of

LEDs. If your robot's main microcontroller lacks analog inputs (like the BASIC Stamp 2), you can use the ASC16 as a kind of data acquisition co-processor. The ASC16 is one of the more expensive serial servo controllers (\$119.00), but if you need the extra I/O, you could actually save money by combining it all in one board.

## Pololu Servo Controller (Pololu)

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

Provided in kit form (you must solder it together), this controller operates up to 16 servos, at data rates from 1,200 and 19,200 bps. Price is \$47.00.

## Ohmark Digital Servo Controller (Ohmark)

[www.ohmark.co.nz/](http://www.ohmark.co.nz/)

The Ohmark DSC (about \$30.55 in US dollars) controls up to eight servos, and can be daisy-chained to operate up to 32 servos. In addition to being able to set the position of the servo, the DSC can control the "rate" or speed of the servo movement — this is a unique and great feature! And like the BasicX Servo 8T, the DSC can dis-

able individual servos so that they do not consume power.

Note that Ohmark is based in New Zealand, but they will ship most anywhere. As of this writing, they lack a distributor for the US.

## And One in Development

As I was finishing this column, a friend told me privately of a new serial servo controller he's developing that can operate up to 32 servos on a single board. The controller board uses a fast PICmicro and a unique programming scheme whereby it commands the servos in parallel, rather than one at a time. This allows it to control 32 servos (expandable by adding more boards), without sacrificing the 50 Hz refresh rate.

If you're interested in this product, drop me a line at the email address listed in this column, and I'll pass on your name to the developer when he's ready to announce his new product.

## Roll Your Own Serial Servo Controller

In addition to commercial serial servo control products, a number of websites demonstrate how to make your own, typically with a PICmicro controller and assembly language or Basic programming. Here are two:

16-Channel Serial Servo Controller  
[www.seattlerobotics.org/encoder/200106/16csscnt.htm](http://www.seattlerobotics.org/encoder/200106/16csscnt.htm)

5-Channel Serial Servo Controller  
[www.frii.com/~dlc/robotics/projects/botproj.htm](http://www.frii.com/~dlc/robotics/projects/botproj.htm) **NV**

**Make Contact.** Got a great source for a nifty robot, kit, or component? Feel free to pass it along to me at: [robots@robotoid.com](mailto:robots@robotoid.com).



The Business of Electronics Through Practical Design and Lessons Learned

# In The Trenches

## Why Good Ideas Aren't Good Enough

**T**here is the urban legend about this smart young engineer who came up with a good idea and sold it to a big company for enough money to retire. Like any good legend, there is some small truth to this ... very small. The truth is that this can happen if you or your parents happen to know a prominent businessman or politician. Unfortunately, if you are reading this, then you probably don't have those types of connections to easy millions.

The sad truth is that good ideas are not rare. Every reader is certain to have had an idea that is potentially profitable. Everyone — at one time or another — has said: "Gee! I could make a lot of money selling these." Therein lies the problem. Everyone has good ideas. You have to compete with everyone else!

How can you sell your idea to your boss, when your boss is trying to sell his idea to *his* boss? How can you get an outside company interested in your idea when hordes of its own employees are clamoring for research funds to develop *their* own ideas? The short answer is that you aren't likely to. But, hope is eternal.

This month's column will show you how to approach companies properly, why companies are reluctant to accept outside ideas, the costs required to develop an idea, and the most likely way to make money from your idea. Also, this is just an overview to point you in the right direction. Books could be written on this subject (and probably are).

### It's a Risky Business

First of all, it takes lots of time and money to develop an idea into a product and market it successfully. As an example, let's use a simple test instrument that consists of a single PCB with

a few switches and a microcomputer. How much do you think it will take to develop it into a product from just an idea? Let's work out a rough estimate.

We'll need a design engineer for the hardware, a software engineer for the programming, someone to lay out the PCB, as well as overhead in the form of engineering and support staff. Let's assume it takes three weeks to design and test the hardware and four weeks to write and debug the software, with one week for PCB layout and miscellaneous odds and ends. This is about eight weeks or about 320 hours (and this is a very fast turn-around).

The loaded labor cost (includes salary, benefits, overhead, and everything else) is about \$75.00 per hour for a development cost of \$24,000.00. Remember, this is for a small, simple idea with an efficient development cycle. It can often cost two to four times this much. This is especially true for new products that require learning new techniques or procedures.

Next, as we go into production, we'll need to train people to test, assemble, inspect, troubleshoot, and package the product. In addition, we'll have to market the product. This means advertising, training salespeople, getting feedback from customers, and so forth. All of this requires time and money. It is not at all unusual for a company to spend about \$100,000.00 of up-front money and up to six months of time to converting a simple idea into a product.

Now we add a very practical consideration. How many instruments must be sold to recover the development and marketing costs? How long will that take? Typically, if a company can't recover those costs within a year, they probably won't pursue the idea. Now, if you were running a company, would you spend \$100,000.00 on

some stranger's idea? And, remember too, many new products fail. Now, you can start to see why trying to sell an idea is difficult, but we will later see ways to improve the odds.

Note, small companies are generally more efficient, but limited in their resources. They are more receptive to small product ideas. Large companies, with a lot of bureaucracy are less efficient, but have larger resources. They are more receptive to bigger product ideas.

### Be Brutal, Stubborn, and Patient

First of all, is your idea good? In order to determine this, talk to others who are in the field. You shouldn't have any problem because your idea should be in your field and those "others" should be your co-workers, friends, boss, teachers, etc. (If your idea is not in your field, don't waste your time.) Be objective and ask your reviewers to be, too. Be brutally honest in your evaluation (a hard thing to do). Identify and examine all the weak points. What makes your idea good? It must clearly, repeat *clearly*, show a significant, repeat *significant*, technical or financial advantage over all existing ideas. If it can't show this, either abandon it or improve it. It won't succeed as it is.

It is important to realize that probably very few people will love your idea. Everyone will have something to say, suggest some way to improve it, find something wrong with it, etc. Use this information to make your idea better. Don't fall in love with it! No idea is perfect. Criticism of your idea is not criticism of you. If you invest feelings in your idea, you almost certainly will make bad decisions.

However, sometimes you have to be stubborn. There are many cases



where experts have panned an idea only to have the future prove them wrong. But, if the reviewers don't like your idea, it makes it much more difficult to sell the idea as an idea. You'll have to invest a lot of time, effort, and money before you are likely to get anyone else to seriously consider it. (More on this later.)

Remember, good ideas are not rare. Successful good ideas are rare. This means that you shouldn't be afraid to defer a good idea. Often, time causes circumstances to change and that can make your idea more attractive and more likely to succeed. The best chance for an idea to blossom is to present it when the need arises.

So keep a list. Whenever you get a good idea, write it down. Every year or so, re-examine the list. Remove ideas that are no longer viable. (I've got a list that I limit to 50.) Be patient.

### Formal or Informal Approach

There are two basic ways to present your idea: formally and informally. The informal way is just talking about it. (Hopefully to someone who is interested.) You can *never* expect anything to come of this. Simply, people forget, get confused, get busy, or just don't know what to do with it. The most you can expect from an informal approach is the expression of interest. If you find someone who is interested, then ask to formally present the idea. Please note, if the person is not interested, don't waste his/her time and good will by pushing. It will only annoy them and make it much less likely that they will give you any future consideration.

The formal approach typically starts with a "White Paper Proposal." This is a document that provides an overview of what the idea is and does. It does not say how the idea operates. Nor does it include any sensitive or proprietary information. This is a teaser. It sells your idea technically and financially in general terms. It compares your idea with others and identifies why your idea is better. Typically, it's a couple of pages long. Its sole purpose is for you to be granted an in-person presentation.

This is a meeting with business and technical decision makers where you present your idea in all its detail and answer all questions. Here is where your idea flies or dies. If you think this sounds like a resume/interview, you're right. The only difference is that you are selling your idea instead of yourself. (Note, on some occasions, your proposal may be the only contact you will have. In this case, the proposal must be detailed, complete, and probably fairly lengthy.)

### Get an Inside Contact

Suppose you have an idea for a new test instrument. You write a formal proposal to Agilent (ex-Hewlett Packard) trying to sell the idea. First of all, who do you send the letter to? If you address it to the company, it will probably end up in the Public Relations Department. Then you'll probably get a polite thank you note and that's it. Don't think that they'll route it to the right person. They're not engineers and it's not their job. Their job is to send out polite thank you notes, not bother high-level engineers who have better things to do. You must have the proper company contact before even considering sending a proposal!

### How to Make Contacts

There are a number of ways to find a contact. The best is to attend a seminar or trade show. Here, you meet field engineers and application engineers. Talk to them and find out if your idea interests them. If so, they will give you a name to contact. When you contact that person be sure to say who and where you got their name from. This is important because it gives you credibility in the form of a reference.

You can also talk to a salesperson from the company of interest. They may be able to provide a name. However, they are somewhat removed from the engineering department. Likewise, you can view the company's website and try to figure out the best person to contact. This approach is

somewhat hit or miss.

If you have your own company, there are other options. If your target is a small local company, you can sometimes aim high. With small companies, "the principals" (owner, president, etc.) are often quite accessible by telephone (but you must know their name). They may be willing to talk. Especially to someone who knows about the company and is friendly, professional, and confident. Always do your homework!

Know about the target company's products and philosophies. Know your idea completely. There is nothing worse than being unable to answer a simple question about it. (One method of getting a small company's principal's name is to call that company and ask the receptionist who the "principal design engineer" is because you want to know how to address a letter. Then wait two weeks and call back asking for that person. Be prepared to answer "What is this in regards to?" )

### How to Improve Your Likelihood of Success

The most important aspect of selling anything is communication. If you can't express yourself in a way that clearly describes your idea, no one will be interested. No one will work at trying to understand you. They'll just look at each other, shake their heads, and say "this doesn't make sense."

Your proposal must be aimed at the specific company you are targeting. You must show how the company can make money with your idea. Always remember, companies are in business to make money! That is their only purpose. Your proposal must quickly and clearly show them this. You must demonstrate to them why their particular company is most suited for developing and marketing your idea. Be technical enough to be clear, but don't use technical jargon if you can avoid it. Don't use a writing style that is forced because it often sounds pompous or condescending or just plain odd. Be simple and clear and professional. Write so you can't be misunderstood.



Your personal presentation is just like an interview. Wear a suit. Be confident and friendly and professional. Be prepared for any questions ranging from conceptual, technical, financial, and maybe even legal issues. Be able to address development, production, and testing concerns. Have a feel for marketing. You certainly may not be able to answer every question on every topic. However, you must appear competent. (Don't ever fake an answer ... say "I don't know, but I'll find out.") Yes, this takes work. But, as Edison said, success is 90% perspiration and 10% inspiration. Just remember to reverse the roles. Would you spend money on someone who waved their arms and make vague statements?

## More Work Means Better Odds

You can make a huge improvement in your chances for success by making a model or prototype of your idea. A model is a non-functional object or device that illustrates the important aspects of your idea. Sometimes, a computer model is sufficient. It's much easier to sell an idea if someone can see how it works. It also provides you with some credibility. It shows that you've worked at your idea and put effort behind it. Obviously, the better the model, the better the odds that there will be interest.

If a model is good, then a working prototype is even better! This proves that the concept is sound and removes a significant amount of risk in the development cycle. It provides answers to technical problems and clearly shows how the idea functions. It reduces time and money needed to develop the idea.

However, the best prototype is a "Production Prototype." This is not just a working model. It is a true product sample. It is functionally identical to the expected product. The only difference between this and a true product is that the "tooling" (case, cover markings, and other custom non-recurring costs) is simplified. (Note, a real printed circuit board is required. No perf board or point-to-point wiring should be used.) A production prototype should also include an operator's man-

ual, testing procedures, parts list, assembly procedures, software listings, and so forth. Of course, this is a lot of work. But, this work provides you with credibility and it eliminates risk from the company. Remember, a company exists to make money. By providing them with a product, rather than an idea, they are much more likely to accept it. All that they will have to do is market it. There is essentially no risk or cost for the development process. You've already done that. And, if your idea clearly provides a technical or financial incentive, they will see how to market it. It becomes an easy decision for them.

## Your Own Company?

If a company accepts an idea, they may pay a 1% to 2% royalty. If they accept a product, the royalty will probably be around 5% to 10%. (Also, expect some on-going paid contract work until they get into production.) This doesn't sound like a lot of money. And, it probably isn't. But, you've put in relatively little money and effort. You spent a couple of months or so building a production prototype and then you get years of royalty checks mailed to you. That's not bad.

Of course, you could sell your product yourself and make much more money. Naturally, this takes much more effort. But the likelihood of making money with your idea is much more certain and completely under your control. If your idea is good and you are dedicated to it and willing to really work long and hard, this may be the way to go. It will take a fair amount of front-end money, but this may not have to be excessive, if you do a lot of the work yourself. You market, you sell, you advertise, etc. Many small companies fail because of bad management rather than a bad product.

Look around your town or city. Look at all the small companies that grew into larger companies. These are all ideas that were good and successful. This is the most likely way to make money with your idea. You develop it. You sell it. You make all the profits from it. And, after it's successful, you sell the company and retire! Just like Bill Gates!

## Odds and Ends

Naturally, before you make any technical presentation or provide any company or individual with sensitive or proprietary information, you should have them sign a non-disclosure statement. This is just an agreement that they acknowledge that your idea is yours and that they will keep all information confidential. There are many types of non-disclosure statements. A patent attorney will probably provide a basic one for you free, if you ask nicely. In any event, it should be fairly inexpensive. A company may want you to sign their non-disclosure statement. This is normally not a problem. But, always read and understand any legal document you sign. Note, no reputable person or company will balk at signing a standard non-disclosure form. Don't get involved with any marketing or patent companies that promise to develop, patent, show, and sell your idea for just a few dollars of up-front costs. Buying lottery tickets is a better investment. True marketing is expensive because it is labor intensive.

If you own your own business, it is possible to get government funding to develop your idea. (But it's not likely. There's a lot of competition for free money.) There are a number of government agencies that fund research and development. The most likely agency is the Small Business Agency (SBA) that provides SBIR grants (Small Business Innovative Research) at [www.eng.nsf.gov/sbir/](http://www.eng.nsf.gov/sbir/). The paperwork is significant and the lead time is measured in years. If you are not a company, a local small company might be willing to partner with you. This is especially true if you do the paperwork and they get most of the money. (You would be a paid contractor.)

## Conclusion

Good ideas take a lot of work to be successful. This is because there are so many good ideas and because they need money and time to develop into real products. Companies are reluctant to risk time and money on an unknown individual. But, by developing your idea — on your own — you can greatly increase the likelihood of making money from it. **NV**



Exploring and Experimenting With Lasers and Their Properties

# Laser Insight

## Interferometers, interference fringes, and their interpretation

**T**his month, we are going to cover some more new ground. Interferometers were invented even before the laser was a remote possibility and, in themselves, are very interesting. I'm sure that most readers who have an interest in this kind of thing have heard about the famous experiments performed by Michelson and Morley in 1887, in which they tried to prove (or perhaps, disprove) the existence of a luminiferous 'ether' on which light waves were carried.

The experiments became known as the world's most important scientific failure, because it failed to prove anything. The type of interferometer that was used for these experiments became known as the Michelson interferometer, and has evolved into a number of forms since its invention. The experiments performed by Michelson and Morley relied on the interference of light waves to detect a change in the speed of light, but more on this later.

If a beam of light is considered as a wave motion — similar to water waves or sound waves — then it is acceptable that when two waves emerging from different sources pass

through or intersect each other, there will be some interference of the respective wavefronts. Some of these wavefronts will oppose others, making them reduce in amplitude, while others will reinforce, making these other wavefronts higher in amplitude. This cancelling and reinforcement of the colliding waves depends on the relative amplitudes and phases at the interfering points.

Similarly, there are now devices on the market that cancel or at least reduce sound waves by producing another sound, equal in amplitude, but opposite in phase to the offending wave. Most construction workers are supplied with these devices, if they are to work around high-noise level equipment.

This interference effect is certainly seen to be so in water and sound waves, and is easily demonstrated, so does it work the same with light? Well, the short answer is yes, it does behave the same (for our purposes, anyway). We'll not go into too much detail about the how's and why's this time. There have been many books

written on this subject, and I don't have enough space in this column to do justice to such a profound subject. It deserves much more space than I can allow here, so for now, we'll take it for granted.

When two beams of light from different sources interfere, the wavefronts add. Due to the differences

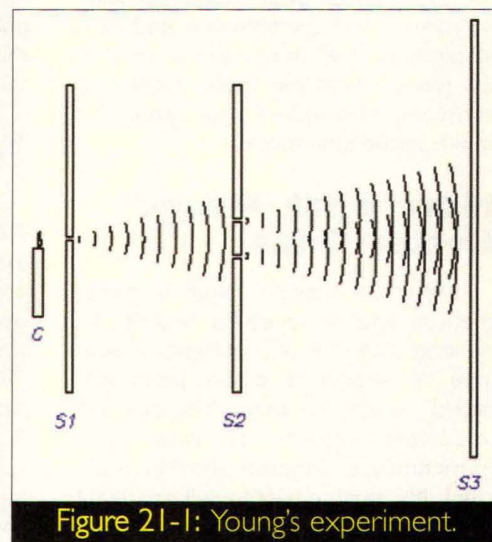
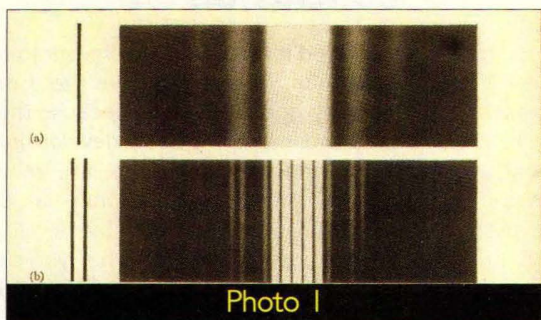


Figure 21-1: Young's experiment.

in arrival time of the wavefronts, there may be constructive interference, destructive interference, or some combination of the two. The wavefronts add positively or negatively, as it were, depending on their relative strengths and phases. The results of all this interference are a series of light and dark areas.

Do you remember Thomas Young's slit experiment? The English scientist Thomas Young had thoughts about the wave nature of light many years ago, and performed an experiment in 1800 to demonstrate this wave nature, through the interference effects of light rays. The experiment was witnessed by many important people in the scientific community, and went a long way to reinforce the belief that light was a wave motion, rather than the corpuscular motion proposed by Sir Isaac Newton, 150 years earlier.

Figure 21-1 shows the experi-





ment. The screen S1 has a narrow slit in the center. Screen S2 has two narrow slits. A light source C is placed behind S1, and the light emitted from the slit is allowed to fall across the two slits in S2. Light transmitted through the series of slits is allowed to fall onto a flat screen S3. Young found that if either of the two slits in S2 were covered, the image falling on the flat screen was a broad band of light with some slight edge diffraction, as you would expect. However, when both slits were open, S3 showed an image composed of a series of light and dark bars. A view of what Young saw is shown in Photo 1.

The corpuscular theory cannot explain why a point on the screen would be light when one slit is open, but dark when both slits are open. But the wave theory could. The experiment lent great strength to the wave theory, and it became widely accepted as the most likely explanation of the nature of light.

Before this, the scientific world was torn between this and the corpuscular theory of light. Many believed that light consisted of particles because of shadows. If light were composed of waves, why then, can we not see around corners? Sound is a wave motion, and we can hear around corners, so why not with light?

It is now commonly accepted that light actually has a dual nature; it exhibits qualities of both waves and particles. But I digress, I want to show you some examples of interference that you can see for yourself. Perhaps we can discuss the nature of light some other time.

Want to see some interference fringes? The simplest interferometer can be made by placing two plane mirrors face-to-face as shown in Figure 21-2. If you use a silvered mirror, make sure it is the lower one. (If you use a silvered mirror on top, you won't be able to see through it!) This interferometer is of the Fizeau-type and tells you — among other things — how closely those mirror surfaces are matched. Figure 21-3 shows a simple set-up using a single color light

source, and two flat mirrors placed one on top of the other, with their reflecting surfaces in contact. It is assumed here that there is either no coating, or at least a transparent coating on the mirror surfaces.

Depending on the type of coatings on the surface, many laser mirrors can be checked in this way. Most standard laser mirrors use a thin multilayer dielectric coating (usually an evaporated or sputtered metal), but because the coatings are so thin, it remains transparent to the majority of visible light.

If you look at these mirrors in white light, and gradually move them relative to your eye, you can see many different colors transmitted through them, or reflected from the coated surface, showing how some wavelengths can be transmitted (or reflected) by using either different coating thicknesses or else angle of incidence selection to filter out the different wavelengths. All mirror blanks (i.e., uncoated mirrors) are tested for flatness in this way before being coated.

The most common light source to view interference fringes is a sodium light, with its characteristic yellow coloring, but it can also be a darkroom safelight as used in photography. A darkroom light will give out a red colored light that, while not truly mono-

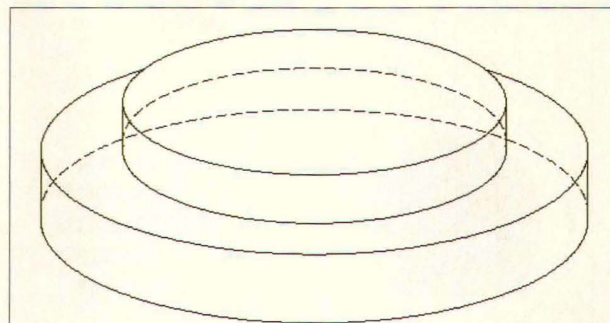


Figure 21-2: Simplest of all interferometers.

chromatic, is close enough for our purpose. If you do not have a single color light source, then viewing the interference fringes under regular white light will be made difficult, but not impossible. Try using a photographic filter or colored film in front of a lamp, if you have nothing else available.

Figure 21-4 shows what the Fizeau interferometer reveals when used in a monochromatic light field. Here, the mirrors are depicted as being between the light source and the observer. Figure 21-4a shows two perfectly flat mirrors. The dark field covering the interface between the mirror surfaces indicates that all points on the mirrors are touching. The reflected wavefronts from the two surfaces overlap perfectly, leaving no interference bands. They are in what is called the 'zero order.'

If a slight tilt is imposed on the upper mirror, so that a slim wedge of air is introduced between them, then the dark field is broken into a series of straight parallel bands as seen in

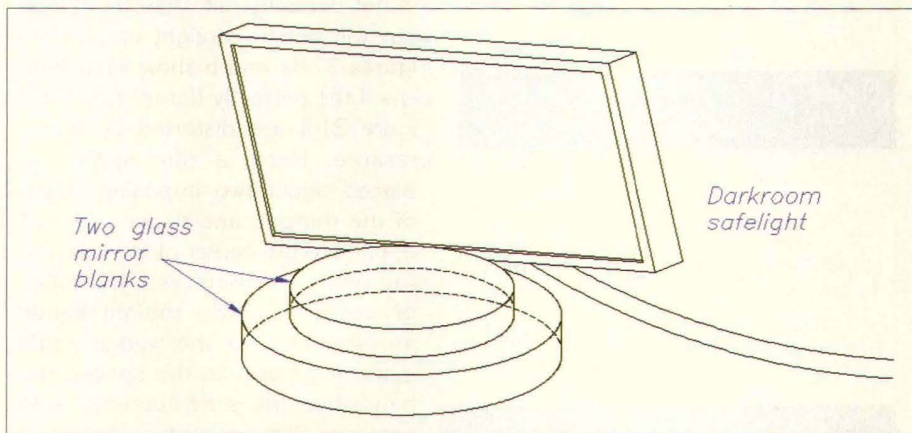
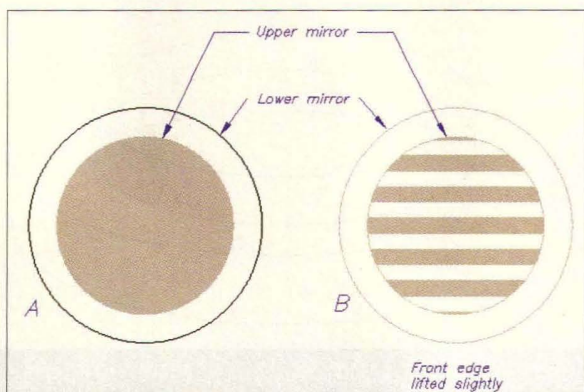


Figure 21-3: Simple set-up for viewing interference fringes.

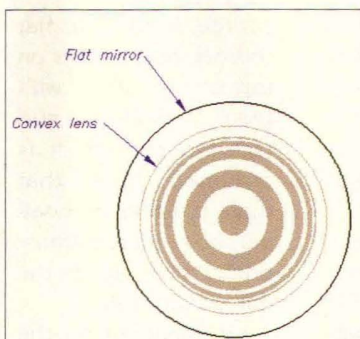




**Figure 21-4:** Two flat mirrors in a monochromatic light field.

Figure 21-4b. The alternate light and dark bands indicate that the two mirrors are flat, and that there is an airspace between them. The distance between the bands is dependent upon the thickness of the airspace, i.e., the magnitude of the tilt between the mirror faces. As the airspace angle is increased, the bands get narrower, and the separation between them becomes closer.

In a similar manner, if a convex (magnifying) lens is placed on a flat mirror, curved side down, the interference bands show a circular disposition as shown in Figure 21-5, with the bands growing wider as they get closer

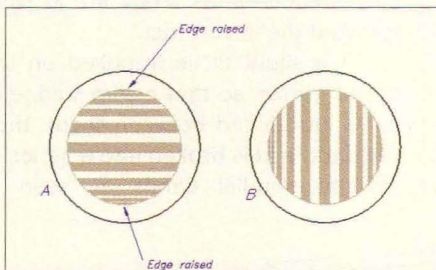


**Figure 21-5:** A spherical lens on top of a flat lower mirror.

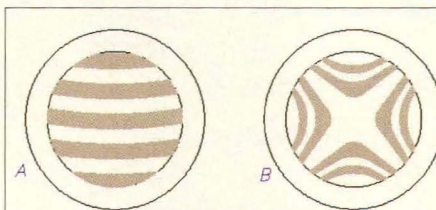
er to the center. The reason the bands get wider near the center is due to the fact that as the surfaces of the lens and mirror become more nearly parallel, interference fringes become wider, as illustrated in the case of the flat mirrors mentioned above.

A lens with a long focal length will show bands similar to those in the drawing; a shorter focal length lens will show a small center spot, with interference bands much closer to the center, and increasing very rapidly in frequency as you move away from the center. If a lens is placed on a form that has the same curvature as the lens, the reflected wavefronts will again overlap perfectly, and give a result similar to the flat mirror example shown in Figure 21-4a. Lenses for critical applications are tested this way.

If the flat mirrors in Figure 21-4 are not perfectly flat, then the bands seen will not be straight or parallel. Figures 21-6a and b show what happens if the perfectly flat mirrors from Figure 21-4 are distorted by finger pressure. Here, a thin spacer is placed under two opposing edges of the mirrors, and finger pressure applied to the center of the top mirror. Where the surfaces are parallel, or nearly so, wide straight bands are seen, but as the wedge angle increases closer to the spacer, the bands become more numerous and narrower. The curvature imposed by finger pressure produces a sur-



**Figure 21-6:** Flat mirror distorted by center pressure.



**Figure 21-7:** Example of a non-flat mirror.

face area that is closer to the lower mirror along the middle axis. As such, the mirror surface goes through a long curve that is almost parallel to the lower mirror along the middle axis. The curving sides of the upper mirror thus show a varying wedge angle, evidenced by the changing spacing of the interference bands in Figure 21-6a.

Rotating the viewing angle through 90 degrees will produce the interference pattern shown in Figure 21-6b. In raising the edges of the mirrors, it is only

necessary to raise them by a small amount, say the thickness of a playing card or so. This method of measuring the form of a mirror surface is very accurate and sensitive, as you no doubt can see.

Mirror flatness is crucial to the proper operation of a laser. You will see later in this series, that wavefront distortion introduced by a non-flat mirror will also prevent the production of good holograms. Laser mirrors — and the mirrors used for holography — are normally made with degrees of flatness that vary from 1/4 wave to 1/10th wave. The flatter the surface, the more expensive the optic.

What these numbers mean is that the surface of the mirror in question will have a peak-to-peak flatness that can only be measured in terms of fractions of a wavelength of the light used to measure them. Thus, a mirror that has a flatness of 1/10th wave, let's say, at one wavelength, may have a flatness of 1/8th wave at a different wavelength. In a similar manner, the curvature of a lens can be described in terms of fit to an ideal surface.

When mirrors and lenses are specified, the wavelength of light used to measure the flatness or form is usually given. For example, Melles Griot (Irvine, CA) usually specifies flatness of their optics in terms of light at 546nm (yellow/green region of the visible spectrum). Optics typi-



cally run from 1/4 wave to 1/10th wave flatness for standard items. Other vendors may use a red HeNe laser as their standard (694.3nm) to specify flatness. Using the Melles Griot figures, at 546nm, a 1/10th wave optic would have a peak-to-peak non-flatness (for want of a better word) of about 55nm, measured over the surface of the optic. That's pretty flat!

The above description of the surface of an optic is very important to the optical engineer, who must decide the best compromise between the surface fit and the cost of the optic for a particular application.

In Figure 21-7, we see a couple of forms of distortion that can creep into a lens or mirror surface during manufacturing. During the polishing process, the mirror or lens blanks must be held very securely in order to get the correct surface figure required of the optic. If there is any tendency for the blanks to move, then the resultant polished surface will not be flat, but will exhibit unpredictable peaks and valleys.

In Figure 21-7a, the upper mirror shows some degree of radius, evidenced here by the curved interference bands. Further testing will show whether the surface is convex or concave. For instance, if finger pressure is applied to the center of the upper mirror, the interference bands will be seen to move. If the bands get wider under the center of pressure, it means the mirror surfaces are being forced closer to parallel, so the mirror must be concave.

Figure 21-7b shows a mirror whose surface is divided into four areas, each trying to cause some distortion or lensing effect on light passing through it. In this case, the combined distortion would be called astigmatic, and the optic would have preferential focusing effects on orthogonal axes, possibly two focal planes at slightly different distances from the lens.

These are just a couple of the many types of interference fringes that can show up using this simple set-up. This

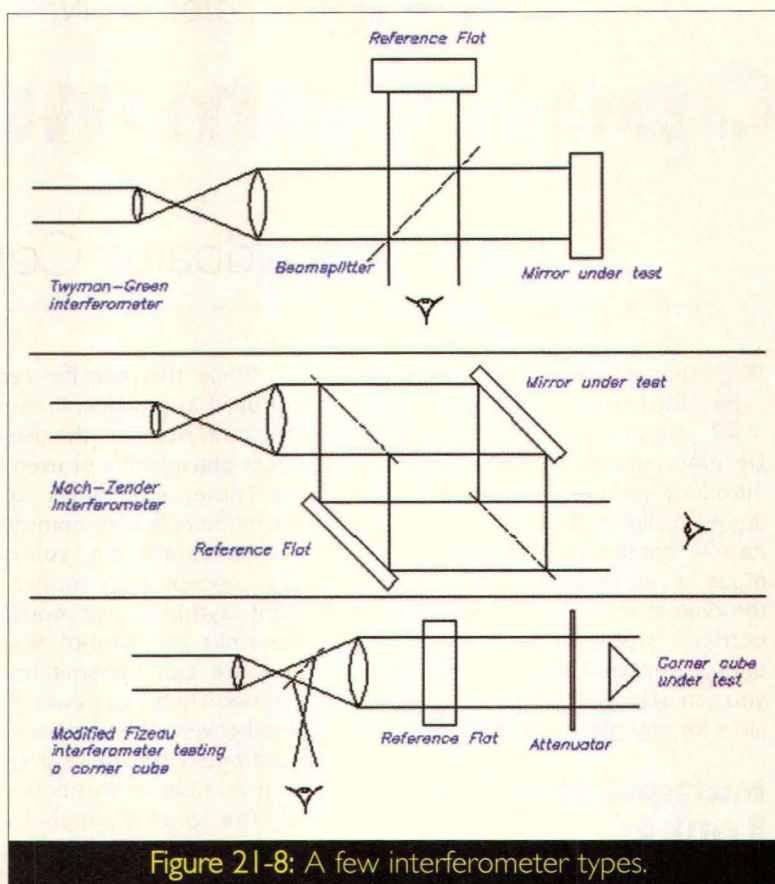


Figure 21-8: A few interferometer types.

type of interferometer has also evolved into many others, each with its own advantages and particular applications. A few interferometer types are shown in Figure 21-8. I haven't room in this column to go into details about each one, so please bear with me.

If you have any questions on these, please email me at the address given below. I always answer all my emails, even though it sometimes takes me a while. So, if you have any questions about this column, or about optics and lasers in general, please write to me in care of this magazine, or at stanley.york@att.net. **NV**

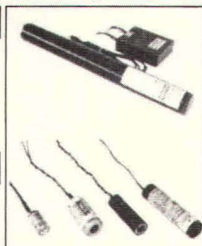
## LASERS & ACCESSORIES

### HELIUM NEON LASERS

- ☒ Complete Systems
- ☒ Plasma Tubes
- ☒ Power Supplies

### ACCESSORIES

- ☒ Optics
- ☒ Electro-Optics
- ☒ IR Viewers
- ☒ Books & More



**MEREDITH**  
INSTRUMENTS

### DIODE LASERS

- ☒ Visible / IR
- ☒ Complete Modules
- ☒ Collimating Optics
- ☒ Drive Circuits

WEBSITE:

WWW.

mi-lasers.com

Phone: 623-934-9387 • Fax: 623-934-9482

Circle #29 on the Reader Service Card.

**AUTOTIME**  
LCD FLAT SCREEN REPAIRS  
**\$79.00**  
**+ PARTS**

  
LAPTOP DISPLAYS

  
MONITOR DISPLAYS

  
KIOSK DISPLAYS

FOR DETAILS: [WWW.REPAIRLCD.COM](http://WWW.REPAIRLCD.COM)

**AUTOTIME** - 6605 SW Macadam Ave. - Portland, OR 97239  
 Phone: (503) 452-8577 Fax: (503) 452-8495 e-mail: [info@autotime.com](mailto:info@autotime.com)  
 Custom mounting and video walls at [www.slim-screen.com](http://www.slim-screen.com)

Circle #30 on the Reader Service Card.



The Latest in Networking and Wireless Technologies

# Open Communication

## Part 3: Broadband Communications

**T**his month, we continue with the broadband modulation discussion I started back in the December issue. This time, I want to introduce you to the concept of sending even higher data rates through a narrow bandwidth by using a technique of representing multiple bits in the data stream by a mix of different carrier amplitudes, frequencies, and/or phases. Using this technique, you can achieve the highest rates possible for any given bandwidth.

### Multiple Bits Per Symbol

I haven't used the term symbol yet, so let me define it. A symbol is one specific carrier state. It may be a specific frequency or phase position or even a specific amplitude. When transmitting binary data, we use one symbol per bit or one bit per symbol. In FSK, there are two symbols: a binary 0 is one frequency and a binary 1 is some other frequency. In BPSK, a binary 0 is  $0^\circ$  phase shift, while a binary 1 is  $180^\circ$  phase shift. Anyway, you get the idea.

We can expand upon that idea and say that we could use more than just two symbols to transmit more bits per symbol. For example, we could use four symbols to transmit pairs of bits (sometimes called dibits). Suppose that we used four discrete frequencies in a unique FSK scheme where one frequency or symbol represents each unique two-bit pair.

Frequency 1 = 00  
Frequency 2 = 01  
Frequency 3 = 10  
Frequency 4 = 11

While this specific technique is not used in practice, it does illustrate the point. However, the use of four different phase shifts or even four different carrier amplitudes to represent the bit pairs is very common.

As it turns out, you can extend this concept even further. By using eight symbols, we could transmit three bits per symbol. With 16 symbols, we can transmit four bits per symbol. There is a power of 2 relationship between the number of bits to be transmitted ( $N$ ) per symbol and the total number of symbols ( $S$ ) or  $S = 2^N$ . The result is simply that you are going to be able to transmit more bits/Hz than with other methods. And the number of bits/Hz can be even further increased by combining two different types of symbols.

### Popular Modulation Methods

There are several widely-used data modulation methods that transmit multiple symbols per bit time. These are QPSK, DQPSK, and QAM. Let's take a look at these methods.

**QPSK** — A very popular version of BPSK is called QPSK or quadrature phase shift keying. Figure 1 shows the modulator circuit. The serial binary data is fed into a two-bit shift register. Each bit of the pair of bits in the register modulates a separate balanced modulator. One balanced modulator receives the carrier signal represented by the mathematical expression  $V \sin \theta$  which is just the trigonometric expression for a sine wave.

This carrier is shifted in phase by  $90^\circ$  to produce another sine wave, really called a cosine wave, designated  $V \cos \theta$  which is the trig expression for a sine wave shifted in phase by  $90^\circ$ . The output of each balanced modulator is a BPSK signal, but one is shifted from the other by  $90^\circ$ .

These two signals are called the in-phase (I) and quadrature (Q) signals. The I and Q signals are then linearly added together to produce the QPSK output. What you get when you add two sine waves of the same frequency and amplitude but different phases, is another sine wave of the same frequency, but with some intermediate phase. For example, adding sine waves with phases of  $0^\circ$  and  $90^\circ$  produces a new sine wave with a  $45^\circ$  shift. Anyway, the table below shows the output phases you get with the different bit pairs.

00 =  $45^\circ$   
01 =  $135^\circ$   
11 =  $225^\circ$   
10 =  $315^\circ$

This is usually shown graphically

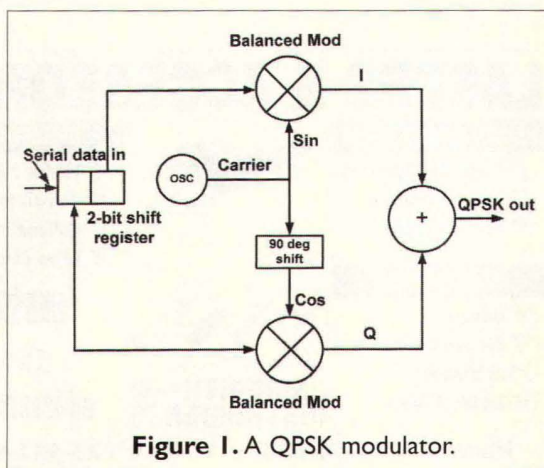


Figure 1. A QPSK modulator.



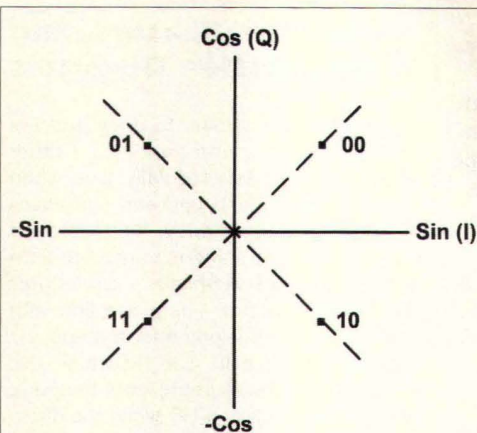


Figure 2. A constellation diagram for a QPSK modulator.

in Figure 2 in what is called a constellation diagram (see sidebar).

What you are really doing in QPSK is transmitting two separate BPSK signals simultaneously. By adding them together, you get one signal and the  $90^\circ$  shift between them allows you to separate them out at the receiver. QPSK is very spectrally-efficient. It can theoretically achieve a two bits/Hz rating.

**DQPSK** — Differential QPSK is simply a version of QPSK that uses the previously-transmitted signal phase as the reference for the current phase. As discussed in the previous installment of this article, this method does not require the complex carrier recovery needed in standard QPSK for demodulation. Also known as  $\pi/4$  - DQPSK,

This method is used in time division multiple access (TDMA) digital cell phones. It permits transmitting digital voice data at 48.6 kbps in the 30 kHz cell phone channel. This gives an amazing  $48.6/30 = 1.62$  bits/Hz rating even with the noise and signal fading associated with wireless transmissions.

**8-PSK and Beyond** — You can take the basic principle of QPSK and extend it to use even more phase increments. In 8-PSK, you use eight phase symbols equally spaced  $45^\circ$ . See the constellation diagram in Figure 3. This gives you three bits/Hz theoretical efficiency. With 16-PSK, you use 16 phase shifts spaced  $22.5^\circ$ . This gives you a maximum of four bits/Hz, in theory. All of these methods provide major increases in the

data rate for a given bandwidth. The downside is that it gets progressively more difficult to detect small phase changes at the receiver and noise introduces phase shifts that result in bit errors. The practical limit for this method is about 16-PSK.

**QAM** — QAM stands for quadrature amplitude modulation. It is a combination of both PSK and ASK. Also known as amplitude phase keying (APK), QAM uses combinations of signal amplitude and phase symbols to

represent multiple bits. For example, in 8-QAM there are eight symbols, two different amplitude levels, and four different phase positions. See the constellation diagram in Figure 4A. 16-QAM encodes four bits per symbol with four different amplitudes and four different phase positions. An alternate method uses three amplitude levels along with 12 phase positions to provide four bits per symbol. See Figure 4B that shows the constellation diagram. 8-QAM and 16-QAM give theoretical maximum efficiencies of three bits/Hz and four bits/Hz, respectively. Again, while you can achieve amazing speeds in limited bandwidths, QAM is more noise-sensitive than any of the PSK modulation methods. Greater errors are potentially possible if the signal-to-noise ratio is not large enough.

QAM is very widely used in data communications. For example, it is the modulation method used in common dial-up computer modems. How else do you think that you can transmit up to 56 kbps (actually only 53 kbps max) in a four-kHz bandwidth voice telephone line? 64-QAM is widely used in cable TV systems to transmit video digitally. Using the 6-MHz bandwidth channels on the cable, they can achieve a data rate of 27 mbps. Such a high rate is needed to transmit video that has been digitized. Some cable systems use 256-QAM to get 38

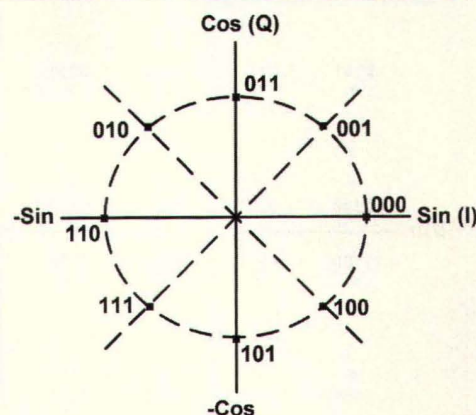


Figure 3. A constellation diagram for 8-PSK modulation.

mbps in each 6-MHz wide channel.

## What's Noise Got to Do With It?

All during this discussion, you probably noticed that I kept stating the theoretical maximum bit rate for a given bandwidth. That maximum rate is rarely achieved in practice. Why? Noise.

Speed and bandwidth are directly related and you can see how that relationship works. But what is not clear at all is that noise in the system also greatly affects the data rate. So let's look at that. But first, what is noise?

Noise is any random amplitude and/or frequency/phase variations that occur in all communications systems. These variations add to any signal being transmitted and partially obscure the data, even obliterating it on occasion. Noise comes from two

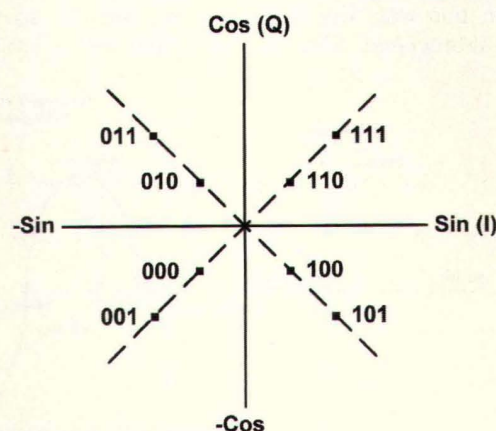
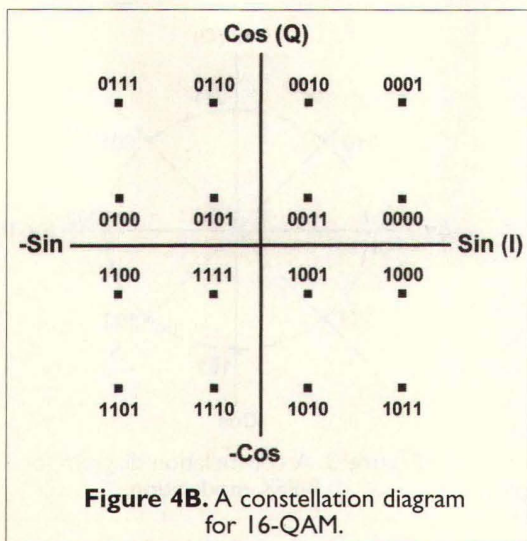


Figure 4A. A constellation diagram for 8-QAM.





sources: external and internal. External noise is produced by atmospheric effects like lightning and rays from the sun and stars. External noise is also generated by other electrical apparatus like motors and relays turning off and on, auto ignitions, fluorescent lights, and anything else that creates transients rich in harmonics that radiate.

Internal noise occurs in all resistors and transistors. It is caused by thermal agitation. The heat in any component causes random motion of the electrons that creates random noise. Such noise can be reduced by using low-noise components, but it can never be eliminated completely. So, in any communications system, we put up with the noise since we usually have little or no control over it. But what we can do is make the signal being transmitted have a much greater power than the noise power. In this way, the signal-to-noise ratio (abbreviated SNR or S/N) will be

favorable to recovering the signal.

Since noise is both random amplitude and frequency variations, it affects all types of modulation. However, since FSK and PSK have a constant amplitude and the data is contained in the frequency or phase, the receivers can clip off amplitude variations without disturbing the data content. Therefore, FSK and PSK are far more immune to noise than any type of amplitude modulation like ASK, OOK, or QAM. But while FSK and

PSK modulation is preferred, there are still many applications with amplitude modulation variants (such as QAM) used if the S/N is great enough.

The basic law relating bandwidth and noise-to-data rate is the Shannon-Hartley Law that expressed mathematically is:

$$C = 3.32B \log (1 + S/N)$$

C is the channel capacity or rather the data rate in bits per second.

B is the bandwidth in Hz.

S is the signal power.

N is the noise power.

Log is the common logarithm or base 10 log.

As you can see from this formula, the data rate is directly proportional to bandwidth and the logarithm of the S/N. Since bandwidth is usually specified by the FCC, the speed is limited by that bandwidth. Luckily,

multi-symbol modulation methods help us to overcome this limitation. And we do have control over the S/N since we can set the signal power to a level that more than adequately overcomes the noise.

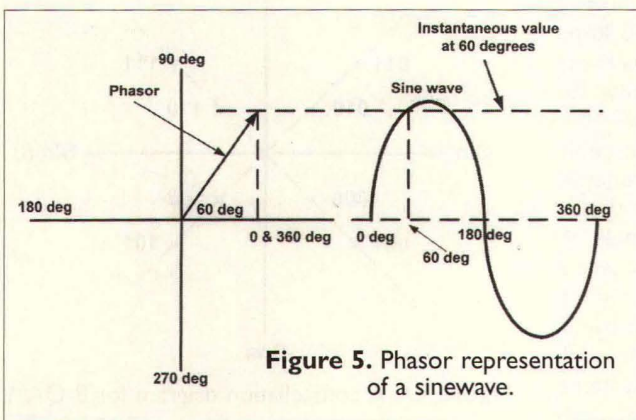
So, now you know. The speed vs. bandwidth relationship is so com-

## Sinewaves, Phasors, and Constellation Diagrams

**S**inewaves are a pain to draw and are difficult to compare to other sinewaves. This is especially true when trying to distinguish between sinewaves of the same frequency, but different phase shifts. The solution to this problem is to use phasors. A phasor — sometimes also called a vector — is just a line with an arrowhead on it pointing in a specific direction on an axis. See Figure 5. The length of the phasor represents the peak value of the sinewave (V) while the direction the phasor is pointing represents the phase position of the sinewave.

If you drop a line from the tip of the phasor perpendicular (90° angle) to the horizontal axis, you form a right triangle. The perpendicular line length represents the instantaneous voltage amplitude (v) of a sinewave at some specific phase position or angle  $\theta$  or stated mathematically,  $v = V \sin \theta$ . The phasor is assumed to be rotating in the counter-clockwise position. As it does, the perpendicular line length traces out a sinewave over the 360° rotation. One complete rotation represents one cycle of a sinewave.

The phasor is a great way to visualize sinewaves as you can tell at a glance where they are in their phase transition. This method is widely used to indicate the phase of a sinewave in various types of phase shift keying. However, only the position of the point of the phasor arrow is indicated on the axis. The actual phasor is not drawn as you can assume that a line is drawn from the point of the arrow to the center of the axis. This greatly simplifies the drawing. Multiple points or dots shown on the axis indicate that a sinewave is changing phases. Such a diagram is known as a constellation diagram and is widely used to show different types of phase and amplitude-phase modulation.



mon in electronics that it is hard to escape it. Understanding it certainly explains many things. It especially brings home the importance of radio spectrum space that is more than just a precious natural resource. Anything we can do to squeeze more speed in a given bandwidth is worthwhile. Just don't forget that the noise level also plays an important role in setting the upper speed limit for a given bandwidth. As in all electronic engineering, the design trade-offs between power, speed, bandwidth and noise are the hardest. **NV**



Basics For Beginners

# Just for Starters

## A Close-up Look at Desoldering

**L**ast month, we took a look at some soldering basics. Now, we find we have the wrong component on the board. So, let's take it off.

Desoldering is one of the more difficult arts to learn in this business. It is the area where we most often damage the item we are working on. The key to desoldering is heat control. You want to apply enough heat to get the job done. But, you must remove the heat quickly to avoid damage. Tremendous strides have been made in the manufacturing process for printed circuit boards that make them much harder to damage. In the 50s and 60s, it was extremely difficult to remove a part without damage to the board. Fortunately today, we have a lot more latitude during the learning process.

I can give you a few tips on getting started. However, "practice makes perfect" definitely applies in this area. Photo 1 shows the use of a wick-type solder remover. The wick is placed under the tip of the iron, leaving an inch or so of fresh wick sticking out and, as the solder is melted, you pull the wick back and it will absorb the excess solder.

This needs to be done very quickly because once the solder is hot enough to melt, the heat being applied is also hot enough to damage the board. You may have to do this operation in several stages, allowing the board to cool a bit (20 to 30 seconds) in between each application of heat. Experience will give you a feel for this and you will get where you can move faster and allow less cooling time. Cut off the used part of the wick when it becomes saturated and unwieldy.

Once you have removed as much of the old solder as you can, the lead will very likely slip out with no heat applied. If needed, you can apply heat

to the joint and pull the lead back through the board. If the lead is bent over, you can use desoldering tools such as the Mouser #384-1018 desoldering kit provides. For 25 years, I got by without the tool set, but they are worth having. There are differences in the efficacy of the various brands and styles of wick. The wick sold by RadioShack is a decent, garden variety wick. However, you might want to try some of the other brands and sizes.

There are differences in the chemicals applied to enhance the action of the wick. Mouser carries wick by Techspray and Soder-Wick. The Soder-Wick "no clean" series is my favorite. I generally buy the .080 in their "60 series" (Mouser #5878-60-3-5). This is a good size for general hobby work and is extremely efficient. Techspray also makes a wick similar to this (Mouser #577-1816-5F) and it is most likely comparable in action. I just got started with Soder-Wick and have stayed with them.

As with most other things in this world, you probably should try several sizes, brands, and styles to find the one that works best for your application. I drive a Dodge pickup with fuzzy dice hanging from the mirror. Some people would swear that Ford is the only way to go and that fuzzy dice only show my age. I have found that clipping a lead on the component side of the board (Photo 2) as near the component being removed as possible allows me to deal with each lead as a separate entity.

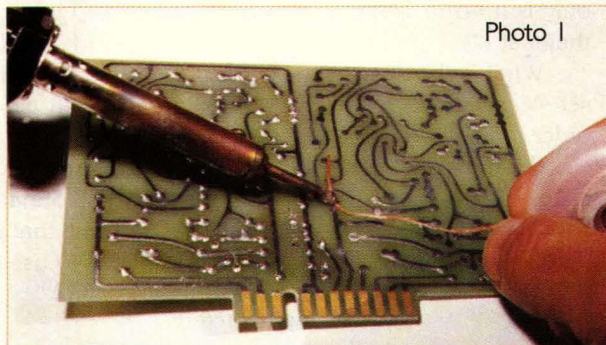


Photo 1

One of the strange things about desoldering is that, if the old solder doesn't want to melt, you can apply just a touch of new solder and it will cause the old to melt. In the event you find that some old solder doesn't want to melt, even though you are applying what appears to be adequate heat, take your roll of solder and act as if you were soldering rather than desoldering. After you get the old solder to melt, it will solidify again as soon as you remove the heat. However, you will find that it will liquefy easily with the next application of heat, at which time, you use your wick to remove it.

Remember that practice makes perfect. Just be sure to start your practice on things that don't matter.

Next month, we will have some "random thoughts." Little bits and pieces of unrelated information that might come in handy. **NV**

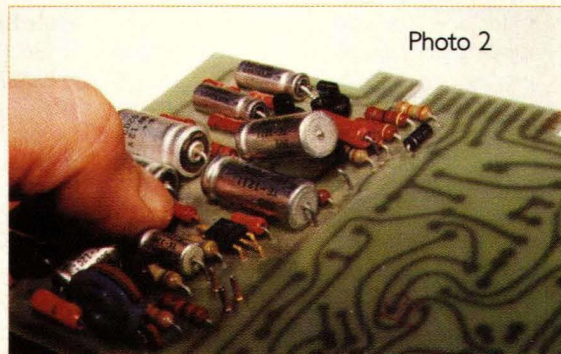


Photo 2



## QUESTIONS

I bought a system from Quantex Microsystems three years ago. The system works well or did. The company — who is now defunct — told me the system came with an NEC 19" Trinitron monitor. The monitor does not get a picture. I called NEC and they told me that not only is it not a Trinitron, but it is not theirs at all.

What is the possibility I can get a set of schematics for this thing in order to fix it? I believe it's a relay.

When I shake the mouse to wake it up, I get a click. The green power light's on, but no click. It's not the card, it tested okay.

#2031

**Stu Weinstein**  
via Internet

I have an aftermarket CD player in my car that came with an infrared (IR) remote that mounts on the steering wheel. The remote needs to mount on the right side of the steering wheel in order for the CD player to be able to receive the IR signal. However, in my car, the right side of the steering wheel has the cruise control buttons. Therefore, I need to mount it on the left side.

I need a wired IR repeater in which I can mount the IR sensor on the left dash, run a wire to the center console, and have an IR LED retransmit the signal to the radio. (RadioShack has a device for use at home that does this via RF, but I need this to use a wire.)

#2032

**Adam Huber**  
via Internet

A PC motherboard comes with IrDA connection pins on it. I am looking for a general, cheap, and simple IrDA adaptor circuit (schematic) which I can connect to the PC motherboard connectors to receive remote control signals and also to communicate between the IrDA devices.

There are some circuits on the Internet for PC remote control which use the PC's serial port instead of IrDA pins. The drawback of this type of serial port circuit is on the software side, which makes a load on the CPU, due to continuous checks for an IR signal present or not.

#2033

**Kintesh Patel**  
Columbus, OH

This is a READER-TO-READER Column. All questions AND answers will be provided by *Nuts & Volts* readers and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. All questions submitted are subject to editing and will be published on a space available basis if deemed suitable to the publisher. All answers are submitted by readers and **NO GUARANTEES WHATSOEVER** are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

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

### ANSWER INFO

- Include the question number that appears directly below the question you are responding to.
- Payment of \$25.00 will be sent if your answer is printed. Be sure to include your mailing address if responding by email or we can not send payment.
- Your name, city, and state, will be printed in the magazine, unless you notify us otherwise. If you want your email address printed also, indicate to that effect.
- The question number and a short

summary of the original question will be printed above the answer.

- Unanswered questions from a past issue may still be responded to.
- Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

### QUESTION INFO To be considered

All questions should relate to one or more of the following:

- 1) Circuit Design
- 2) Electronic Theory
- 3) Problem Solving
- 4) Other Similar Topics

### Information/Restrictions

- No questions will be accepted that offer equipment for sale or equipment wanted to buy.
- Selected questions will be printed one time on a space available basis.
- Questions may be subject to editing.

### Helpful Hints

- Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
- Write legibly (or type). If we can't read it, we'll throw it away.
- Include your Name, Address, Phone Number, and Email. Only your name, city, and state will be published with the question, but we may need to contact you.

The camcorder that I have is a Sony CCD-TRV16. It is an analog unit, but does have a connector identified as "LANC" that has digital pulses coming out when in the playback mode. The mating connector is a miniature tip-ring-sleeve plug (miniature three-circuit phone plug). Is there any information on what these pulses are and how they can be used? Can pulses be sent in to perform functions?

Sony sold a piece of equipment that could be used for editing and other uses, but it costs as much as the camcorder. Any information about these pulses or equipment that can be built or purchased to work with this for editing and remote control will be most helpful.

#2034

**Dale Blackwell**  
Brazil, IN

I'm interested in producing power from a wind-driven generator. Should I use a large 32-volt DC Baldor motor that I salvaged from a golf cart? This motor is a shunt-type DC with an extra set of brushes (four brushes). The extra set must be for reverse? I have spun the motor with a belt and another motor, but it doesn't produce electricity. I have disassembled the motor and it's possible to isolate the field from the armature. Is there a circuit to excite



the field and turn this motor into a brute-force, blade-driven generator?

**#2035 Gordon McKittrick**  
Havre, MT

Is there anyone that can tell me where I can find a MM5369 60 Hz timebase chip? It seems to be obsolete and very hard to find. If this chip is unavailable is there a direct replacement for it?

**#2036 Lexpro, via Internet**

Has anyone interfaced a PIC with a standard ISA Ethernet network interface card so that no PC is involved?

I have just been given a box of assorted out-of-date PC hardware and there are a few ISA NICs. I had an idea that I could plug them into little roving gadgets. The whole thing would look something like an octopus (the body would hold the hub) on rollerskates.

**#2037 Mr. Bwtz, via Internet**

I'm looking for a device called a "Solar Dancer" — a linear motor that is used in point-of-purchase advertising.

It's plastic and approximately 1" x 2" x 3". It has a pendulum that is expended past the pivot to which a sign is affixed. The unit is self-starting when exposed to a bright light and will wave a sign with the advertiser's message. I could use a dozen(?), maybe more if my application catches on. Or they can be battery

powered? Does someone know of a source, have a schematic (for sale), or have the gizmo in a kit?

**#2038 Rick Otto, via Internet**

Can anyone think of a way to take serial data into a PIC and convert it from logic pulses to audio (serial data) tones to be transmitted via amateur radio, say using two PICs? I found a modem chip (MX614), but it is very hard to purchase. I thought with using two PICs, I could eliminate the modem, but I can't seem to think of a way.

**#2039 Chris, via Internet**

Is there a simple or cheap way to mount a PC camera to a microscope? I would like to take advantage of fine adjustments of the microscope (focus and manual stage) for the purpose of viewing watches and other small mechanical objects. Is there a way to modify the eyepiece for this purpose?

**#20310 Chuck, via Internet**

Can anyone recommend a good PCB .cad file format viewer? I tried the Unisoft View free version, but it's too limited to view the .cad file I'd like.

**#20311 Bob, via Internet**

## ANSWERS

[1 2025 - DEC. 2003]

*I fly radio-controlled model*

*gliders made from foam so we can combat them (i.e., literally try to knock each other out of the sky)! I have seen ideas that use infrared technology to have an IR "gun" on the nose of the fuselage and a sensor that counts the hits on the "enemies" rear or cockpit. Are there bits and pieces that would let me put together such a setup?*

The difficulty with most of these units is that many of the beams emitted have an extremely limited effective range. For instance, ultrasonic beams tend to spread out — a beam that starts out only as wide as two centimeters, with spread out to wider than one meter after travelling three meters (and the signal needs to travel another three meters to get back). At this rate, the signal would be too wide and too weak to do anything. Also, while a flat surface pointed directly back at the "emitter" will send its reflection back at the emitter, an angled or curved surface will deflect the emitted beam off to where you don't have a detector.


My best suggestion would be to place some "targets" in the other plane, so that when you hit it with a beam, it registers "I've been hit!" Look at [www.omega.com](http://www.omega.com) for sensors and free handbooks and see what's possible!

**Thomas Ng**  
San Jose, CA

**NEW!**  
**From AWC**

### MPU and PLD/FPGA Tools





**Prototyping Tools/Kits**

- Programmable logic prototyping kits (Xilinx and Altera)
- RS-232 prototype boards
- Power supply kits
- MPU/Internet gateway software

**PAK Coprocessors**

- 32-bit floating point math (PAK-II)
- 8 channels of PWM/Pulse I/O (PAK-V, VII, VIII)
- Read PS/2 keyboards or mice (PAK-VI)
- Floating point A/D (PAK-IX)
- Data sheets and projects online

Check out our tools and PAK coprocessors for Basic Stamp, PIC, AVR, 805x, 68HC11, or any MPU. Our prototyping tools save your time and our PAKs add powerful features to your designs. Visit our Web site now for free tutorials, tools, and projects!

**AWC**  
310 Ivy Glen  
League City, TX 77573  
(281) 334-4341  
(281) 754-4462 (fax)

[www.al-williams.com/awce](http://www.al-williams.com/awce)

### New Controller and Logger Kits Low Cost!

Both the I/O Module and the Call Logger Kit includes plastic cases and don't need to be attached to a computer during operation. Complete documentation on each kit is available from our web site. Shipping and Handling: USA \$5.95, Canada \$8.95 Other \$12.95.

**Serial Isolated I/O Module**

PC controlled 8-Relay Board with 115/250V relays. Uses serial port of PC for programming. Includes plastic case 5.5"x4.5"x1". Kit: CPS108 **\$59.95**  
Assembled: CPA108 **\$62.95**

**Telephone Call Logger Kit**

Stores over 2,800 x 10 digit DTMF numbers. Records all buttons pressed during a call. The time and date recorded also. Uses serial port of PC to download data. Includes a Plastic Case 5"x4"x1" 9-12 VDC. Order: Kit CPS164 **\$54.95** Assembled: CPA164 **\$58.95**

**Infrared Remote**

12 channel relay board. Each relay individually controlled with included infrared remote control unit. Toggle or momentary. Over 50' range. PCB size 4.8"x4.5". 12VDC Order Code: CPS142 **\$42.95**

**Rolling Code 4-Channel UHF Remote**

State of the Art, with 4 channels either momentary or latching. Range up to 100'. Up to 15 Tx's can be learnt by one Rx. (Includes 1 Tx). PCB size 3 3/8" x 3 1/16" 12VDC 6mA (at rest) Kit: CPS180 **\$42.95** Assembled: CPA180 **\$49.95**

**TOLL FREE: 1-888-549-3749 (US & CANADA)**

Tel: (330) 549-3726. Request a FREE catalog or visit us at [www.electronics123.com](http://www.electronics123.com) for more products.

Amazon Electronics, Box 21 Columbiana OH 44408 USA.

We ship world wide!



[12028 - DEC. 2003]

I have a "solid-state automatic charger for deep cycle 12-volt batteries. I do not measure any voltage at the terminals, but when connected to a battery, it turns on and charges. I noticed a small circuit board with a transistor and three diodes. What is the principle of operation of this charger?

The circuit is likely an SCR being used as a switch and a power rectifier. The SCR connects the AC power to the battery-. It is turned on with a resistor from battery+ to the SCR's gate. When the battery voltage reaches a zener's voltage, a small transistor shunts the gate current to the SCR's cathode, turning it off.

A voltmeter does not pull enough current to keep the SCR on. This circuit is often found on lawn tractor-type engines, too.

G. E. Brown, via Internet

[12027 - DEC. 2003]

I was challenged by the question of making a free-running clock using (two) 74122s and all of the necessary resistors and caps to set the timing, and LEDs to indicate the pulse at the out of each of the 122s. I have read, seen, and made the same free runner using a 555 timer and two resistors and a cap to set the pulse timing with an LED to indicate the pulse, with no problem. Any suggestions on the wire-up?

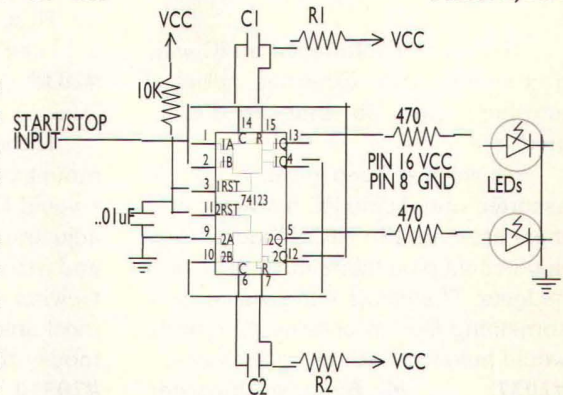
This answer uses the 74HC123, a dual of the 74122. If you have 74122s, the wiring is the same, but the pin numbers are different.

The time between pulses is set by C1 and R1. The time is given by:  $T_w = .45RC$ . The pulse width of the second one shot is set by C2 and R2 using the same formula. For

long times, I recommend low-voltage ceramic capacitors, values up to 1uF in X7R material can be found.

The period of oscillation is  $T_1 + T_2$ . The 10K resistor and .01 capacitor insure that the system starts up at power on with both LEDs not lit. The oscillator is started by bringing the start/stop input low, and it must stay low as long as the oscillator is running.

Russell Kincaid  
Milford, NH



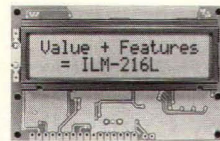
## Seetron Serial LCDs

Interface a sharp LCD display to your BASIC Stamp® or other micro-controller project with ease. No-solder wiring harnesses and easy mounting kits available too. See [www.seetron.com](http://www.seetron.com) today.

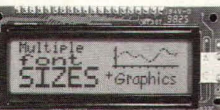
- 3.2 x 1.4 in. supertwist LCD **\$45** BPI-216N
- 2400/9600 baud serial
- Low (~2mA) current draw
- Great with BASIC Stamps®



- 3.2 x 2 in. backlit LCD **\$49** ILM-216L
- 1200-9600 baud serial
- Advanced protocol, 4 switch inputs
- EEPROM for configuration settings
- Favorite for OEM applications



- 3.2 x 1.4 in. graphics LCD **\$99** SGX-120L
- 2400/9600 baud serial
- Font and 15 screens in EEPROM
- Easily draw points, lines, screens



- 3 x 2 in. supertwist LCD **\$119** TRM-425L
- 1200-9600 baud serial
- ESD-protected, 4x4 keypad input
- Store up to 95 screens in EEPROM



Scott Edwards Electronics, Inc.

1939 S. Frontage Rd. #F, Sierra Vista, AZ 85635  
phone 520-459-4802 • fax 520-459-0623  
[www.seetron.com](http://www.seetron.com) • [sales@seetron.com](mailto:sales@seetron.com)

More displays available,  
including bright VFDs.  
See [www.seetron.com](http://www.seetron.com)

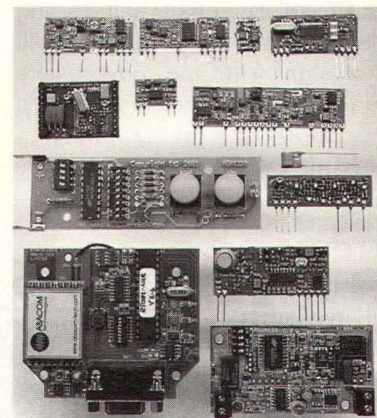
## RF MODULES

Great selection of...

- Transmitters
- Receivers
- Transceivers
- Antenna
- RF subassemblies
- Radio Modems
- Evaluation Kits
- Amplifiers
- Data encoders
- Data decoders

Typical Applications

- RF remote control
- Data communications
- Wireless Audio
- RF data acquisition
- Wireless Security
- Robotics
- Remote Sensing
- Remote Monitoring
- Wireless Networking



[www.abacom-tech.com](http://www.abacom-tech.com)



Tel: +1(416)236 3858  
Fax: +1(416)236 8866  
[abacom@abacom-tech.com](mailto:abacom@abacom-tech.com)

Same Day Shipping—Visa, MasterCard, Amex, Diners Club cards welcome



# Advertiser's Index

Abacom Technologies	96
ActiveWire, Inc.	60
All Electronics Corp.	25
Amazon Electronics	95
Andromeda Research	57
Autotime Corp.	89
AWC	95
Basic Micro, Inc.	33
Bellin Dynamic Systems, Inc.	60
Blue Bell Design, Inc.	30
Budget Robotics	81
C & S Sales, Inc.	2, 39
Carl's Electronics, Inc.	60
Circuit Specialists, Inc.	98-99
Conitec DataSystems	61

Cunard Associates	66
Earth Computer Technologies	60
E.H. Yost & Co.	59
Electro Mavin	29
Electronic Design Specialists	79
Electronix Corp.	17
Electronix Express	51
EMAC, Inc.	66
ExpressPCB	62
Front Panel Express LLC	9
Global Specialties	61
Halted Specialties Co.	3
H.T. Orr Computer Supplies	66
HVV Technologies, Inc.	58

Information Unlimited	79
Inkjet Southwest	62
Intronics, Inc.	66
LabJack	7
Lemos International	60
Linear Systems	13
Lynxmotion, Inc.	9
M2L Electronics	59
Matco, Inc.	61
Meredith Instruments	89
microEngineering Labs	13
Micromint	7
Mouser Electronics	41
Mr. NiCd	59

MVS	45
Net Media	31
PAiA Electronics	60
Parallax, Inc.	Back Cover
PCB123	41
PCBexpress	45
Pioneer Hill Software	62
Polaris Industries	11
Pulsar, Inc.	61
Quality Kits	60
R4 Systems, Inc.	23
Ramsey Electronics, Inc.	49
Resources Un-Ltd.	9
RF Digital	62

Robotikits Direct	43
Rogers Systems Specialist	51
Saelig Company	57
Scott Edwards Electronics, Inc.	96
SGC	65
Solutions Cubed	21
Square 1 Electronics	75
Steel Imperium	30
superbrightleds.com	5
Supercircuits	18-19
Syspec	60
Technological Arts	5
Weeder Technologies	17
Zagros Robotics	30

## AMATEUR RADIO & TV

Ramsey Electronics, Inc.	49
SGC	65

## BATTERIES/CHARGERS

Cunard Associates	66
E.H. Yost & Co.	59
Mr. NiCd	59

## BUYING ELECTRONIC SURPLUS

Earth Computer Technologies	60
Rogers Systems Specialist	51

## CCD CAMERAS/VIDEO

Autotime Corp.	89
Circuit Specialists, Inc.	98-99
Matco, Inc.	61
Polaris Industries	11
Ramsey Electronics, Inc.	49
Resources Un-Ltd.	9
Supercircuits	18-19

## CIRCUIT BOARDS

Cunard Associates	66
ExpressPCB	62
PCB123	41
PCBexpress	45
Pulsar, Inc.	61
R4 Systems, Inc.	23

## COMPONENTS

Bellin Dynamic Systems, Inc.	60
Electronix Express	51
Front Panel Express LLC	9
Linear Systems	13
PCBexpress	45
Pulsar, Inc.	61
Solutions Cubed	21
superbrightleds.com	5

## COMPUTER

<b>Hardware</b>	
ActiveWire, Inc.	60
Autotime Corp.	89
Earth Computer Technologies	60
Electro Mavin	29
Electronix Corp.	17
Halted Specialties Co.	3
Rogers Systems Specialist	51

<b>Software</b>	
Global Specialties	61
Pioneer Hill Software	62
R4 Systems, Inc.	23

<b>Microcontrollers / I/O Boards</b>	
Abacom Technologies	96
Amazon Electronics	95
AWC	95
Basic Micro, Inc.	33
Conitec DataSystems	61
EMAC, Inc.	66
microEngineering Labs	13

Micromint	7
MVS	45
Net Media	31
Parallax, Inc.	Back Cover
Scott Edwards Electronics, Inc.	96
Square 1 Electronics	75
Technological Arts	5
Weeder Technologies	17

## Printers/Printer Supplies

H.T. Orr Computer Supplies	66
Inkjet Southwest	62

## DESIGN/ENGINEERING SERVICES

ExpressPCB	62
Front Panel Express LLC	9
Pulsar, Inc.	61
Solutions Cubed	21
Weeder Technologies	17

## EDUCATION

EMAC, Inc.	66
R4 Systems, Inc.	23
Syspec	60

## EVENTS/SHOWS

Steel Imperium	30
----------------	----

## KITS

Amazon Electronics	95
Autotime Corp.	89
C & S Sales, Inc.	2, 39
Carl's Electronics, Inc.	60
Earth Computer Technologies	60
EMAC, Inc.	66
HVV Technologies, Inc.	60
Information Unlimited	79
Inkjet Southwest	62
PAiA Electronics	60
Quality Kits	60
Ramsey Electronics, Inc.	49
Robotikits Direct	43
Scott Edwards Electronics, Inc.	96
superbrightleds.com	5

## LASERS

Information Unlimited	79
Meredith Instruments	89
Resources Un-Ltd.	9
superbrightleds.com	5

## MISC./SURPLUS

All Electronics Corp.	25
Front Panel Express LLC	9
Halted Specialties Co.	3
Linear Systems	13
Resources Un-Ltd.	9

## PROGRAMMERS

Amazon Electronics	95
Andromeda Research	57
Basic Micro, Inc.	33
Conitec DataSystems	61
HVV Technologies, Inc.	60

Intronics, Inc.	66
M2L Electronics	59
microEngineering Labs	13

## PUBLICATIONS

Square 1 Electronics	75
Mouser Electronics	41

## RF TRANSMITTERS/RECEIVERS

Abacom Technologies	96
Lemos International Co., Inc.	60
Matco, Inc.	61

## ROBOTICS

Blue Bell Design, Inc.	30
Budget Robotics	81
HVV Technologies, Inc.	60
LabJack	7
Lemos International Co., Inc.	60
Lynxmotion, Inc.	9
Net Media	31
Robotikits Direct	43
Solutions Cubed	21
Steel Imperium	30
Zagros Robotics	30

## SECURITY

Information Unlimited	79
Lemos International Co., Inc.	60
Matco, Inc.	61
Polaris Industries	11
Supercircuits	18-19

## TEST EQUIPMENT

Bellin Dynamic Systems, Inc.	60
C & S Sales, Inc.	2, 39
Circuit Specialists, Inc.	98-99
Conitec DataSystems	61
Electronic Design Specialists	79
Electronix Corp.	17
Intronics, Inc.	66
LabJack	7
Pioneer Hill Software	62
Saelig Company	57
Syspec	60

## TOOLS

C & S Sales, Inc.	2, 39
Electronix Corp.	17

## WIRE/CABLE & CONNECTORS

Rogers Systems Specialist	51
---------------------------	----

## WIRELESS PRODUCTS

RF Digital	62
------------	----



**High Tech Video system w Audio**

Includes TWO B/W Cameras w sound & I.R. (night vision) ONE 5.5i B/W Monitor with Built-In adjustable Switching (from 2 to 20 seconds) & two 60 ft. pre-wired cables. Everything you need to set up a high tech video monitoring system at home, office, restaurant warehouse or use it as a baby monitor. Easily hooks into VCR for Video Recording also item # Dual View



**Fantastic Price!**  
\$119.00 ea  
(\$109.00 ea. qty 4)  
view extensive details @ web site



24-960 Hour Time  
Lapse VCRs  
12VDC version and  
120VAC version  
only \$319.00 !

Details @ web site under  
miniature camera section

**Removable Hard Drive Rack****BEST CHOICE!**

3 COOLING FANS!  
AUTO-CLOSE FRONT DOOR!  
OUR NEW "BEST CHOICE" Hard Drive Rack features aluminum frame & carrier for rugged performance & heat dissipation. Also, 3 internal cooling fans provide even more help with heat dissipation. Includes key lock, LED activity light, Auto-eject handle design & ground wire. Available for IDE ULTRA DMA 66/100/133 & also ultra wide SCSI version.  
AMR-3F (IDE Ultra DMA).....\$17.95  
AMR/UWSCSI (ultra wide SCSI).....\$22.95



**ONLY \$17.95**  
any qty.  
Compare with models costing twice as much!

**Auto-Temp Solder Station with Ceramic Element**

- With Ceramic Heating Element for More Accurate Temp Adjustment
- 3 Conductor Grounded Power Cord
- 250°C-480°C (470°F-900°F)
- Fast Heating Feature



**ONLY \$39**  
SR-976  
Extra Tip Options Available. See Web!

CTRL - D to bookmark this site

For More Info See [www.web-tronics.com](http://www.web-tronics.com)

**CCD B/W Board Cameras**

- ASIC CCD Area Image Sensor
- Extremely Low Power Consumption
- 0.5 Lux Min Illumination
- Built-In Electronic Auto Iris for Auto Light Compensation



VM1030PA-B 30mmx30mmx25mm, Pinhole lens, 12V \$39.00 any qty.  
VM1030A 30mmx30mmx26mm, Standard lens, 12V \$39.00 any qty.  
VM1035A 42mmx42mmx25mm, Standard lens, 12V with back light compensation \$49.00 any qty.  
VM1036A 32mmx32mmx25mm, Standard lens 12V, reverse mirror image feature \$49.00 any qty.  
VMCB21 44mmx38.5mmx28mm, with 6 infra-red LEDs, 12V \$49.00 any qty.

**B&W, Color & Powerful Night Vision Bullet CCD Cameras Model**

- Smart Rugged Metal Housing
- Extremely Low Power Consumption
- 12 Volt
- CCD Area Image Sensor for Long Camera Life
- Built-In Electronic Auto Iris for Auto Light Compensation
- No Blooming, No Burning
- 0.1 Min Lux Illumination (B&W), 1 Lux Min Lux Illumination (color)



VMBLT1020 B&W, 21mm(D)x55mm(L) \$49.00 any qty.  
VMBLT1020W B&W Weatherproof, 21mm(D)x58.5mm(L) \$69.00 any qty.  
VMBLTJC19BW COLOR! Weatherproof, 17mm(D)x88mm(L) \$109.00 any qty.  
WDB-5007S Powerful night vision camera (56 IR LEDs) \$159.00 (\$139.00/5+)

**Hand-Held 3.0GHz Universal Counter**

- \*10 digit LCD Display
- \*High speed 300MHz direct counter w 0.1Hz resolution
- \*50 ohm input for full range 1MHz to 3.0GHz coverage
- \*Ultra sensitive synchronous detector 16 segment bargraph display of RF signal strength
- \*4 selectable gate speeds
- \*hold switch locks display
- \*low power consumption (6 hr nicadoperation)

with Field Strength Measurement \$129.00

- Includes:
- \*extendable/retractable whip antenna
- \*Internal 4AA Nicad batt pack (600mAh)
- \*9VDC, 500mA wall plug-in charger



item # FC1002

**NEW!**

Extensive Details @ [www.web-tronics.com](http://www.web-tronics.com)

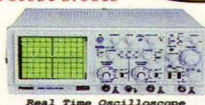
**Protek 40 MHz & 60MHz Oscilloscopes**

2 Channel  
Dual Trace  
6i Internal Grid  
ALTMAG  
ALTTRIG  
TV Sync

**AMAZING VALUE \$!**

40MHz only \$319.00 !  
60MHz only \$399.00 !

(Limited Time Offer)



Real Time Oscilloscope

See all Details @ [web-tronics.com](http://web-tronics.com) under Test Equipment

**Protek's Best DMM**

with RS-232 Interface & Software, 3-3/4 Digit, 4000 Count, Auto-Ranging with Analog Bargraph

- True RMS Mode
- 10MHz Frequency Counter
- Time Mode with Alarm, Clock, and Stop Watch
- Dual Display
- 10 Location Memory
- Min, Max, Avg and Relative Mode
- Decibel Measurement
- Cap and Ind. Measurement
- Temperature Mode (C/F)
- K Type Temperature Probe Included

- Pulse Signal for Logic & Audible Test
- Continuity/Diode Test
- Logic Test
- Auto Power OFF/"Keep ON" Mode
- Fused 20A Input with Warning Buzzer
- Back Light
- Data Hold/Run Mode
- Safety Design UL1244 & VDE-0411
- Protective Holster
- Silicon Test Leads



**NOW ONLY \$149**  
More Details on our Web Site

Item # PROTEK 506 \$129.00 ea. qty 10

Our Best SCOPE DEALS EVER!

**Digital Read Out 3Amp Bench Power Supplies**

Available in 0-30 volt & 0-50 volt versions

High stability digital read-out bench power supplies featuring constant voltage and current outputs. Short-circuit protection and current limiting protection is provided. Highly accurate LED accuracy and stable line regulation make the 3000 series the perfect choice for lab and educational use.

**New!****Lower Prices**

Line Regulation:  $2 \times 10^{-4} + 1\text{ma}$   
LED Accuracy: Voltage  $\pm 1\% + 2$  digits  
Current  $\pm 1.5\% + 2$  digits  
Wave Line Noise:  $\leq 1\text{mVrms}$   
Dimensions: 291mm x 158mm x 136mm

CSI3003: 0-30v/0-3amp 1-4 / \$89.00 5+ / \$85.00

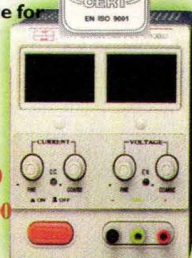
CSI5003: 0-50v/0-3amps 1-4 / \$99.00 5+ / \$95.00

Bookmark our WEB Site! Many more Power

Supplies are Available. Look Under Test Equipment



EN ISO 9001



[www.web-tronics.com](http://www.web-tronics.com)

Easy to Navigate  
Includes a Search Engine  
That Really Works  
New Items Added Constantly

Detailed Specs on the Web

**Circuit Specialists Inc.**

In Business Since 1971

**new!****Mini CCDs (B/W & Color)**

Sensational NEW Design for Small Observation Cameras. Smaller and Better!

- Ultra Miniature Design
- Black & White Versions Only 25mm x 25mm
- Color Versions Only 32mm x 32mm
- Available in Standard Lens or Pinhole Lens
- All Include Pre-Wired Cable Harness for Video & Power
- 12V Regulated Power Supply Required (120mA typical power consumption)
- 0.1 LUX Rating (B/W), 1 LUX (color)
- CCD Area Image Sensor for Long Camera Life
- Back Light Compensation Circuit
- Built-In Electronic Auto Iris Lens

Detailed Specs on the Web

VMCW-H11A 32mmx32mmx30mm, Color CCD with standard lens, wired cabling for video/audio, 12V DC Power \$109.00 / \$99.00 5 or more  
VMCW-H12A 32mmx32mmx19mm, Color CCD with pinhole lens, wired cabling for video/audio, 12V DC Power Input \$109.00 / \$99.00 5 or more  
VMPS-718A 25mmx25mmx30mm, B/W CCD with standard lens, wired cabling for video/audio, 12V DC Power Input \$49.00 / \$45.00 5 or more  
VMPS-250A 25mmx25mmx15mm, B/W CCD with pinhole lens, wired cabling for video/audio, 12V DC Power Input \$49.00 / \$45.00 5 or more

**Bench Digital Multimeter****\$99.00 !**

- \*Digital & Analog Display, 3999 counts & 42 segment bar graph
- \*Autorange & Manualrange
- \*DATA HOLD, Min/Max Relative Measurement
- \*Storage Data DISPLAY/RECALL
- \*True RMS fAC voltage & current
- \*Back Light
- \*ADP Measurement: 400mV+/-3%
- \*Continuity & Diode test
- \*Power Source: AC or DC

Item# CSI9803R

See details @ web site

**Super Economy DMM**

1999 counts LCD Display, 15mm digit height  
HFE DATA HOLD  
Audible Continuity  
Rubber Boot Included  
Includes test leads

1 10 50  
\$9.99 \$7.99 \$6.99

- \*DC Volts: 200mV/20V/200V/600V
- \*AC Volts: 200/600
- \*DC Current: 200uA/20mA/10A
- \*Resistance: 200/2K/20K/200K/2M
- \*Size: 138 x 69 x 31mm

CSI 830







### Digital Storage Oscilloscope Module

Convert any PC with USB interface to a high performing Digital Storage Oscilloscope. This is a sophisticated PC based scope adaptor providing performance compatible to mid/high level stand alone products costing much more! Ships with two probes. Complete details & software download @ our web site under test equipment.

item# 200DSO **\$869.00**



### 2 AMP 0-18V Bench Power Supply LCD Display

input voltage: 110VAC  
output: 0-18VDC  
Current: 0-2A  
Source Effect: <0.02%+1mV  
Load Effect: <0.01%+5mV  
Ripple & Noise: <1mVrms

1 \$59.95 5+ \$52.95  
item # CSI 1802D

**NEW!**



### SoftTube Heatshrink

2:1 shrink ratio  
Sold in 4 ft lengths  
Sold Bulk on Spool  
Extremely Low Prices  
Many diameters  
Many colors

**UL**

PLEASE VISIT OUR WEB SITE FOR SELECTION & PRICES  
www.WEB-TRONICS.com

### New DC Fans ! @ GREAT PRICES

UL/Ball Bearing Sleeve/3 wire

item # 1 10 25 100+

40mm 12V (PL42B12H)	\$5.95	4.25	3.95	3.28
60mm 12V (PL60B12H)	\$5.95	4.25	3.97	3.30
60mm 24V (PL60B24H)	\$5.95	4.29	4.09	3.39
80mm 12V (PL80B12H)	\$5.95	4.25	3.95	3.28
80mm 24V (PL80B24H)	\$5.95	4.25	3.95	3.28
92mm 12V (PL92B12H)	\$5.95	4.25	4.00	3.35
92mm 24V (PL92B24H)	\$5.95	4.25	4.09	3.45
120mm 12V (PL120B12H)	\$7.95	6.75	5.69	5.59
120mm 24V (PL120B24H)	\$7.95	6.75	5.69	5.59

More Information @  
www.web-tronics.com

### Intelligent DMM with PC Interface



- \*Auto-Ranging
- \*Dual Display
- \*Conforms to IEC1010
- \*3999 counts & 38segment bar graph display
- \*DC voltage (autoranging)
- \*AC voltage (auto ranging)
- \*Temperature measurement
- \*Resistance (auto ranging)
- \*capacitance
- \*diode testing
- \*transistor check
- \*audible continuity

item# CSI345  
Ships with Rubber Boot, RS-232 cable, Software & Test Leads & K-probe

**\$44.50**

### OPTAscope

Digital Real Time Oscilloscope  
An affordable USB digital oscilloscope for students & hobbyists

- \*1Ms/s Max Sample Rate
- \*8 Bit Vertical Resolution
- \*2 Channel
- \*Ext Trig

EXTENSIVE DETAILS @  
www.WEB-TRONICS.com

**\$169.00** item# SCOPE 81M

### Intelligent Auto-Ranging DMM

Our Most Sophisticated DMM Ever!



Large 4 Dig backlit 8000 count dual display & Analog Bargraph. RS232 I.R. Interface/software/cable 4 display modes, True RMS value & Freq. of Min/Max values: Temperature in F/C; relative quantity & error % of relative value at the same time...

MORE DATA @ WEB SITE

CSI 8203.....**\$189.00**

### RF Field Strength Analyzer

The 3201 is a high quality hand-held RF Field Strength Analyzer with wide band reception ranging from 100kHz to 2060MHz. The 3201 is a compact & lightweight portable analyzer & is a must for RF Technicians. Ideal for testing, installing & maintenance of Mobile Telephone Comm systems, Cellular Phones, Cordless phones, paging systems, cable & Satellite TV as well as antenna installations. May also be used to locate hidden cameras using RF transmissions

Extensive Tech Details & a Special Offer At Our Web Site (www.web-tronics.com)



**\$1699.**

### Details & Software Download @ our web site

### Intelligent Multi-function Digital Counter



An intelligent multi-function counter controlled by an 8-bit micro-controller with eight-digit high bright LED display. Four measuring functions (frequency, period, total mode & self-check). Also, a 10MHz OSC. OUT.

item# CSI 6100  
Frequency Measurements:  
CH A, Range 10 to 100Mhz  
CHB, Range 100Mhz to 1.3GHz  
DETAILS AT OUR  
WEB SITE under TEST EQUIPMENT

**\$149.00 !!**

**NEW**

**SALE!**  
**\$129.00**

### LEDs/Megabright Blue, White, GREAT PRICES!



luminous intensity @ 20mA

1 10+ 100+

Megabright Blue 5mm (L7113PBC/G)	1400	\$1.95	\$1.50	\$1.25
Megabright Blue 3mm (L7104PBC/G)	600	\$1.95	\$1.50	\$1.25
Megabright White 5mm (L7114PWC/G)	600	\$2.15	\$1.59	\$1.35

more technical details @ our web site under SEMICONDUCTORS  
FLASHING red 3mm (L36BHD).....as low as \$.28 ea!

### PROGRAMMABLE DC POWER SUPPLY



item# CSI3645A

**NEW!!**

**only \$199.00 !!**

- \*Stores up to 10 settings for fast & accurate recall
  - \*Backlit LCD display
  - \*High Resolution (1mV)
  - \*PC compatible (with optional RS-232 adaptor module)
  - \*Easy programming w numeric keypad or fast rotary code switch
  - \*Power shut down memory function
- SPECIFICATIONS @ web-tronics.com (under test equipment)

manual pdf available @  
web-tronics.com

### FLUKE

Visit our web site & view our extensive offering of new FLUKE TEST EQUIPMENT. Just go to our home page & select TEST EQUIPMENT. We've got great deals .....

**FLUKE COLOR SCOPES**



### MultiTurn Cermet Potentiometers

PRICED TO SELL!

(WIW1012series)

"V"

Single Turn 1/41 SQ. Cermet Pots (Horiz. & Vertical)

Stocking standard values from 100 ohm to 1 Meg

(WIW1036 series)

### 22 TURN RECTANGULAR

(standard values from 100 ohm to 2 meg)

10+ 100+ 500+

\$0.89 \$0.79 \$0.55 \$0.49

26 TURN 3/81 SQ Top Adjust

(standard values from 100 ohm to 1 meg)

1 10+ 100+ 500+

\$1.09 \$0.99 \$0.75 \$0.65

(WIW3296 series)

"H"

\$0.79 \$0.69 \$0.55 \$0.45

Cermet Prices shown are per value/ More Details @ www.WEB-TRONICS.com

### BAG of LED's DEAL

**100 LED's for \$1.25 !!**



Normal brightness leds now available in RED or GREEN in 3mm or 5mm size. Your choice. Each bag of 100 costs \$1.25! (that's 1.25 cents ea.!) Each bag contains 100 of the same led.

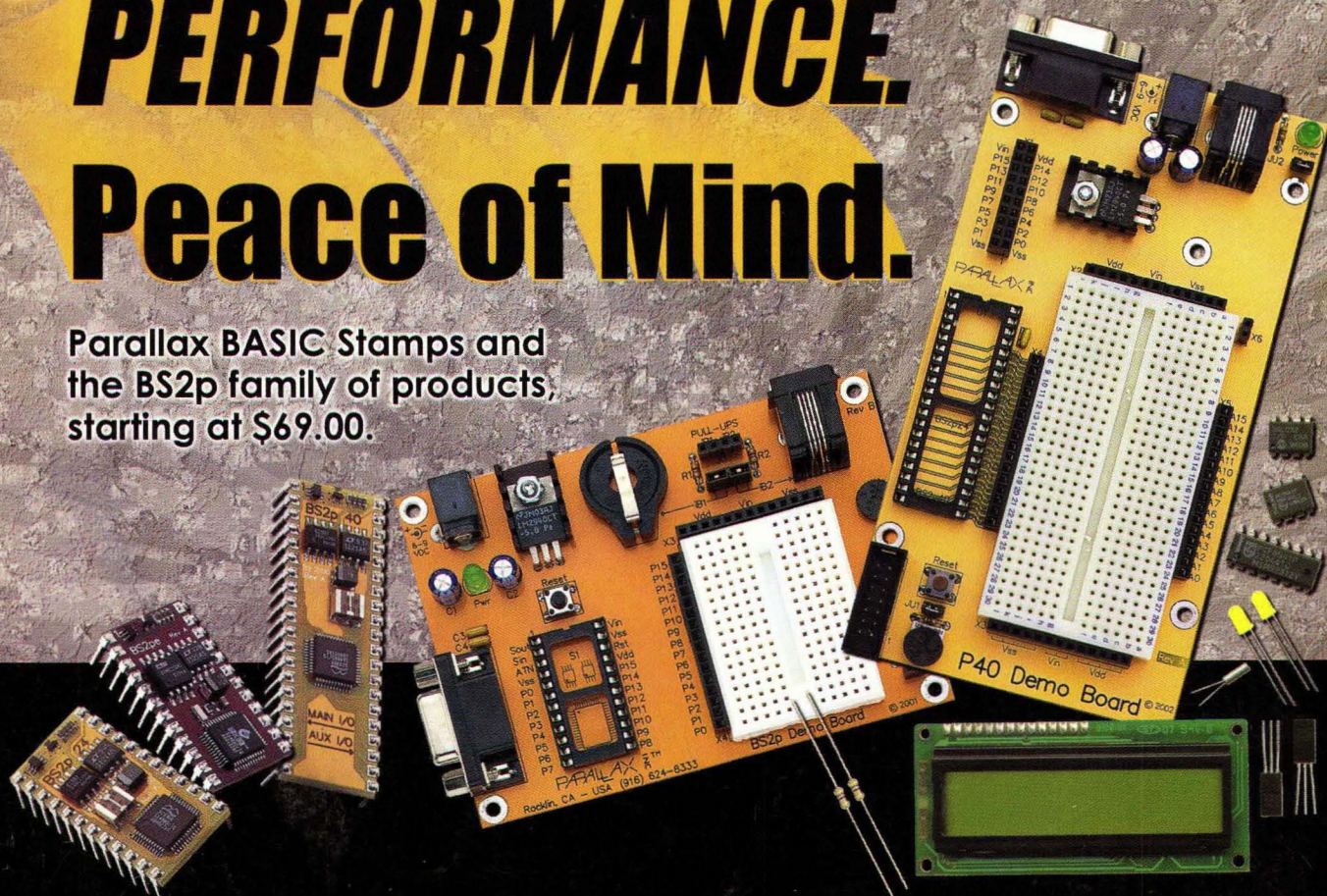
BAG-RED 5mm.....\$1.25 BAG-GREEN 5mm.....\$1.25  
BAG-RED 3mm.....\$1.25 BAG-GREEN 3mm.....\$1.25

Visit our website for a complete listing of our offers. We have over 8,000 electronic items on line @ [www.web-tronics.com](http://www.web-tronics.com). PC based data acquisition, industrial computers, loads of test equipment, optics, I.C's, transistors, diodes, resistors, potentiometers, motion control products, capacitors, miniature observation cameras, panel meters, chemicals for electronics, do it yourself printed circuit supplies for PCb fabrication, educational D.I.Y.kits, cooling fans, heat shrink, cable ties & other wire handling items, hand tools for electronics, breadboards, trainers, programmers & much much more ! Some Deals you won't believe !



# POWER. PERFORMANCE. Peace of Mind.

Parallax BASIC Stamps and the BS2p family of products, starting at \$69.00.



## Power. Performance. Peace-of-mind.

That's what you get when you use genuine Parallax microcontrollers. The power to turn your good ideas into working products. The performance you need to meet your project's unique demands. The peace-of-mind that comes from working with Parallax, the industry's most trusted name in BASIC-language microcontrollers.

We weren't the first to put BASIC on a chip, but we did it best and no company has matched what we have to offer in the way of product and support.

Like with our BS2p family of microcontrollers. We go beyond the silicon; any kid with a microcontroller programmer can hack out a knock-off. What we offer is real product, tested and ready to run. We also provide development and prototyping tools, along with non-trivial applications code. Real code you can use to speed your ideas to completion. That's why so many educational institutions, government agencies and professional engineers specify and insist on genuine Parallax BASIC Stamps.

Do you need to add an I<sup>2</sup>C<sup>®</sup> component to your project? No problem. Would you like to communicate with a number of sensors using Dallas/Maxim 1-Wire<sup>®</sup>

technology? No problem; in fact, we make it easy. How about an LCD for your cool user interface? It's okay, we've got you covered.

**Power. Performance. Peace-of-Mind.**  
**The BS2p family of microcontrollers.**  
**The original BASIC Stamp.**  
**Only from Parallax.**

**Order online at [www.parallax.com](http://www.parallax.com) or call us toll free 888-512-1024.**

Shown left to right: BASIC Stamp 2p24 module, BASIC Stamp 2pe module, BASIC Stamp 2p40 module, BASIC Stamp 2p Demo Board, BASIC Stamp 2p40 Demo Board and BS2p Plus Pack. Also available: BASIC Stamp 2p24 and BASIC Stamp 2p40 Professional Starter Kits.

© BASIC Stamp is a registered trademark of Parallax, Inc. 1-Wire is a registered trademark of Dallas Semiconductor. I<sup>2</sup>C is a registered trademark of Philips Semiconductors.

# PARALLAX

Circle #154 on the Reader Service Card.