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Nuts & Volts

September 2003
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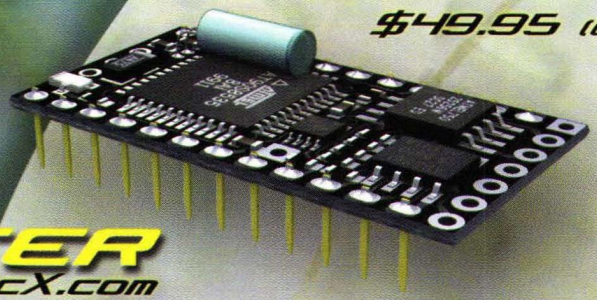

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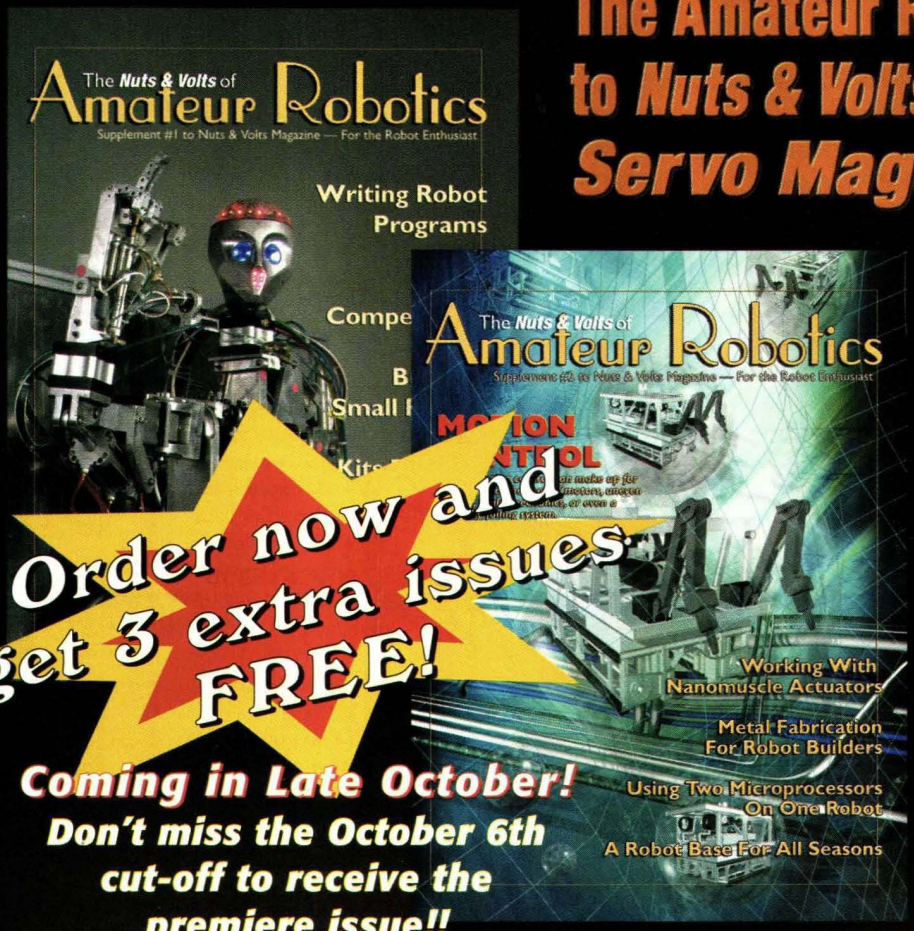
The Amateur Robotics Supplement to *Nuts & Volts* has become *Servo Magazine.*



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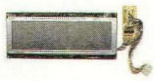

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September 2003

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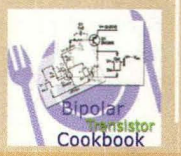

DEPARTMENTS

COLUMNS

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Reader Feedback

Dear Nuts & Volts:

I was a little confused as to why *Nuts & Volts* showed up at my doorstep a few months back, but one call to a defunct Poptronics phone number tipped me off. I'm very sad to see Gernsback Publications close its doors, having been a subscriber to *Popular Electronics* and *Radio Electronics* (a.k.a., **Electronics Now**, a.k.a., **Poptronics**) for many years. Having **Nuts & Volts** "foisted" on me with no warning, I looked through it with a suspicious eye. Boy, was I pleasantly surprised! What a great magazine!

I can remember getting a free copy of *Nuts & Volts* in the late eighties (back when it was done on newsprint!) when visiting the local electronics swap meet that met early Saturday mornings in the General Dynamics parking lot in Ontario, CA. The magazine I've been recently receiving in my mail box is sure a shined and polished version from what I remember! Let's see, what do I like, not like, and would like to see? Well, there's not too much I don't like. I think you have a pretty good mix of stuff. I'm not too crazy about the Stamp (only) section. I would like instead to see an Embedded Systems section that's more broad and could encompass more than just the BASIC Stamp every month (oops, at least I think it's the Stamp each month. If not, please excuse me!).

I know an author can't know everything about every microcontroller, so getting a variety of projects each month for various micros could be a problem. But I'd love to see a PIC one month, an AVR another, and maybe even something from the 68000 family!

I also like the articles that get 'techy' and explain concepts, device families, operating principles, etc. Not Basic Electronics 101 (although you need, and already have, that too for those folks that are looking at your magazine to get into the field), but rather articles like "Understanding and Using 'OTA' Op-Amp ICs" Parts 1 and 2 by Ray Marston. It has a good mix of theory, explanation, and application. I'll be renewing my subscription, of course, and look forward to your articles for years to come.

Joel Peavy
San Diego, CA

Dear Nuts & Volts:

I am saddened by the demise of ***Poptronics***, as well. Along with *Electronics Now*, that's two major points of view in the hobby electronics world we've lost in the US. As great as *Nuts & Volts* is, it can't hope to cover it all. As for the changes to *Nuts & Volts*, this is not a good sign. I liked the larger format. Half of the content had to be tossed out, in particular I like the text classified ads with a lot of interesing stuff. The current space ads don't compare. I am shocked to find that *Poptronics* only had a subscriber base of about 70,000. Even in just the US, this seems like an incredibly small number. Add this to the changes to *Nuts & Volts*, and it looks like the letter last year on the demise of electronics as a hobby must be true. Microcontrollers and surface mount have invaded it, but 95 percent of all of my projects are still thru hole. I only use SMD on a few because of their special use and because I simply am interested in using them. Maybe it's time to get schools to recognize the importance of electronics, science, computer, and math classes to the future of this country's engineers.

Rick Detlefsen
via Internet

I agree with Rick that our technological future lies in the minds of students and that is why I've been a FIRST robotics volunteer judge since 1999. The goal of FIRST is to inspire students to study hard sciences and the method is to pair them with adult mentors to solve problems. Nuts & Volts readers are the ideal role models! So as the next event season looms, consider visiting ***www.usfirst.org*** *to find a local team and get involved.*

Dan Danknick
NV Technical Editor

Dear Nuts & Volts:

I have enjoyed *Nuts & Volts* over the years very much. It has always seemed like a magazine more on the cutting edge than other electronics mags by presenting electronic articles that go beyond the norm of "here it is, this is how it works" to articles that describe the inner workings and ideas on how to improve/modify things.

Nuts & Volts always seemed like the kind of magazine you would find at hamfests and computer fests. Not something you'd find on a local grocery store rack. Always technically stimulating, *Nuts & Volts* always seemed to offer a look into the working electronics that a serious hobbyist could appreciate.

I've learned something from every issue that I've read. I have all my copies of *Nuts & Volts* in my bookcase for reference material. Where else can you find information on robotics, lasers, BASIC Stamp applications, theory of operation, etc., all in one magazine?

I do like the new size, it fits into my bookshelf better. Please don't start watering down the issues just to attract a wider audience. Your magazine fits a niche, and is well regarded in the electronics field. Too many magazines spread themselves thin, try to cover everything, and wind up being the same old crap every month.

A quarterly robotics issue I think will be great, but don't become just another robotics mag. Being a ham radio operator, some ham radio articles would be nice. Also home security, solar, basic electronics theory, maybe some computer articles also.

Bottom line: You have produced a GREAT magazine over the years and I guess a lot of us have put your magazine up there as a standard to judge others by. Keep it up. I look forward to opening the mailbox each month and finding *Nuts & Volts* inside.

Henry Garrett
via Internet

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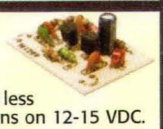

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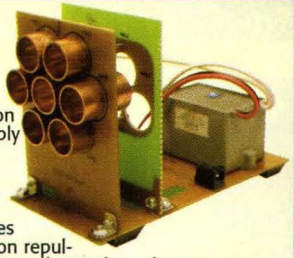
- ✔ Super Bright LED's - won't burn out!
- ✔ Audio triggered or variable flash rate!

A 3x3 array of super bright Telux™ LED's creates a brilliant sharp flash just like a Xenon flash tube. In the standard flash mode, a variable rate control varies the flash frequency from approx 1 to 220 flashes per second. In the audio sync mode, the flash is triggered by any audio input you provide into the standard RCA audio input connector. Built-in low and high pass filters allow you to select either bass or treble music triggering! An external trigger in/out connector lets you connect multiple units together for simultaneous flash. 3x3 array of LED's can be installed directly on the PC board, or on the external LEDS9 board (included) for case-top or remote locations. Optional display boards with 8 or 20 LED's are available for even more strobing power! Just imagine surrounding your room with a few of these, triggered to your stereo! Be one of the first to experience the new high output LED's of 2003!

LEDS1	**High Power LED Strobe Light Kit**	**$39.95**
CLEDS	**Matching Case & Knob Set For LEDS1**	**$14.95**
LEDS8	**Display Board, Inline with 8 LED's**	**$17.95**
LEDS20	**Display Board, 5x4 Array Of 20 LED's**	**$29.95**
AC125	**110VAC Power Supply**	**$9.95**

Ion Generator



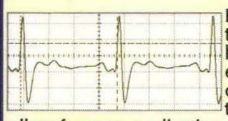
- ✔ Negative ions with a blast of fresh air!
- ✔ Generates 7.5kV DC negative at 400µA
- ✔ Steady state DC voltage, not pulsed!

This nifty kit includes a pre-made high voltage ion generator potted for your protection, and probably the best one available for the price. It also includes a neat experiment called an "ion wind generator". This generator works great for pollution removal in small areas (Imagine after Grandpa gets done in the bathroom!), and moves the air through the filter simply by the force of ion repulsion! Learn how modern spacecraft use ions to accelerate through space. Includes ion power supply, 7 ion wind tubes, and mounting hardware for the ion wind generator. Runs on 12 VDC.

IG7	**Ion Generator Kit**	**$64.95**
AC125	**110VAC Power Supply**	**$9.95**

Electrocardiogram Heart Monitor

- ✔ Visible & audible display of your heart rhythm
- ✔ Re-usable sensors included!
- ✔ Monitor output for your scope
- ✔ Simple & safe 9V battery operation



Enjoy learning about the inner workings of the heart while at the same time covering the stage-by-stage electronic circuit theory used in the kit to monitor it. The three probe wire pick-ups allow for easy application and experimentation without the cumbersome harness normally associated with ECG monitors. Operates on a standard 9VDC battery. The ECG1 has become one of our most popular kits with hundreds and hundreds of customers wanting to get "Heart Smart"!

ECG1	**Electrocardiogram Heart Monitor Kit**	**$39.95**
CECG	**Matching Case & Knob Set For ECG1**	**$14.95**
ECG1WT	**Factory Assembled & Tested ECG1**	**$89.95**
ECGP10	**Replacement Reusable Probe Patches, 10 Pack**	**$7.95**

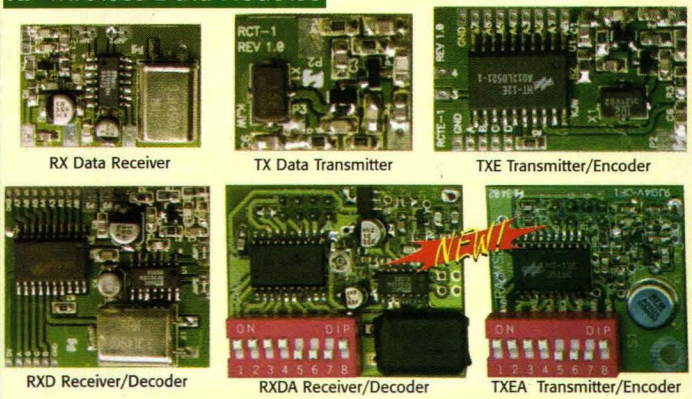
Electronic Learning Labs

- ✔ Learn and build!
- ✔ 130, 300, & 500 In One!
- ✔ Super comprehensive training manuals!

Whether you want to learn the basics of electricity, the theory of electronics, or advanced digital technology, our lab kits are for you! Starting with our PL130, we give you 130 different electronic projects, together with a comprehensive 162 page learning manual. A great start for the kids...young and old! Step up to our PL300, which gives you 300 separate electronic projects along with 165 page learning and theory manual. The PL300 walks you through the learning phase of digital electronics. If you're looking for the ultimate lab kit, check out our PL500. Includes a whopping 500 separate projects, a 152 page starter course manual, a 78 page advanced course manual, and a 140 page programming course manual! The PL500 covers everything from the basics to digital programming! Learn about electronics and digital technology the fun way...and build yourself some neat projects!

PL130	**130 In One Learning Lab Kit**	**$39.95**
PL300	**300 In One Advanced Learning Lab Kit**	**$64.95**
PL500	**500 In One Super Learning Lab Kit**	**$159.95**

RF Wireless Data Modules



- ✔ 433 MHz or 916 MHz data transmission
- ✔ Factory assembled and tested!
- ✔ Encoder/Decoder models for security issues!

Now you can build those special remote control projects in a flash, and have the ultimate in reliability...and security!

Unlike other units on the market, these units are crystal controlled for no frequency drift, yet are ultra small and very low power. These wireless RF link boards are perfect for any wireless application- sending data, car alarms, door openers, home security, electronic monitoring...you name it. All modules are pre-assembled and tested so you can start your project today! Two versions are available - 433 MHz and 916 MHz, 916 units can use shorter antennas (3 inches) and are better in high RF environments, while the 433 units have better range but need larger antennas (7 inches). NEW for 2003! A-Series modules include a programmable dip switch for encoder/decoder settings, and common dual row pin-outs for easy integration into your equipment!

RXD433A	**433 MHz Receiver/Decoder Module w/Dip Switch**	**$39.95**
TXE433A	**433 MHz Transmitter/Encoder Module w/Dip Switch**	**$37.95**
RXD433	**433 MHz Receiver/Decoder Module, Assembled**	**$34.95**
TXE433	**433 MHz Transmitter/Encoder Module, Assembled**	**$32.95**
RX433	**433 MHz Data Receiver Module, Assembled**	**$29.95**
TX433	**433 MHz Data Transmitter Module, Assembled**	**$24.95**
RXD916	**916 MHz Receiver/Decoder Module, Assembled**	**$34.95**
TXE916	**916 MHz Transmitter/Encoder Module, Assembled**	**$32.95**
RX916	**916 MHz Data Receiver Module, Assembled**	**$29.95**
TX916	**916 MHz Data Transmitter Module, Assembled**	**$24.95**

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PS-603DPI

HC-1530API

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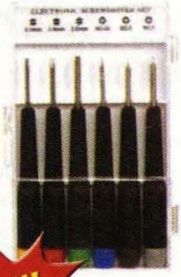
PS-355DPI	0-35V 5A	$149.95
PS-603DPI	0-60V 3A	$179.95



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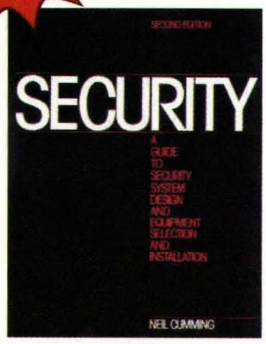

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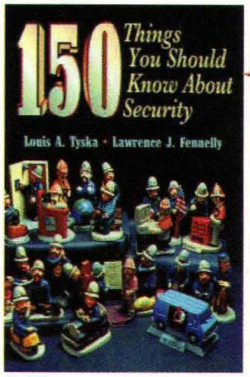

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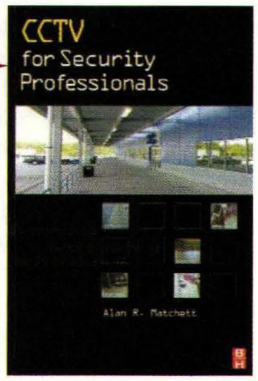

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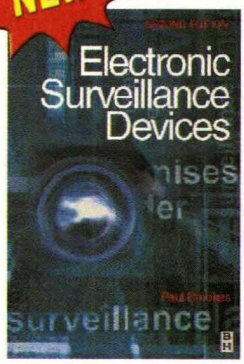

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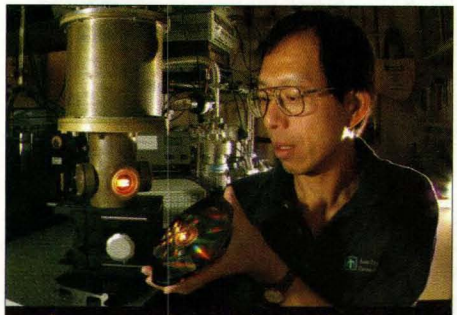
Advanced Technologies

Photonic Lattice Evades Planck's Law



A tungsten photonic lattice glows in a vacuum chamber as Sandia researcher, Shawn Lin, inspects an iridescent disk that contains approximately 1,000 tungsten photonic lattices. (Photo by Randy Montoya, courtesy of Sandia National Labs.)

Researchers at Sandia National Laboratories (**www.sandia.gov**), exceeding the predictions of a 100-year-old law of physics, recently demonstrated that filaments fabricated of tungsten lattices, when heated, emit a great deal more energy than solid tungsten filaments in certain near-infrared wavelength bands. This creates the possibility of a better energy source for supercharging hybrid electric cars, powering electric equipment on boats, and operating electrical generators that are driven by industrial waste.

The lattices' emissions put more energy into the wavelengths used by photovoltaic cells to change light into electricity. And because near-infrared is the wavelength region closest to visible light, tungsten lattice emissions soon may be achievable at visible wavelengths to provide more efficient lighting. Adding to the good news is that these sub-micron devices can be mass-produced inexpensively using existing computer-chip technologies.

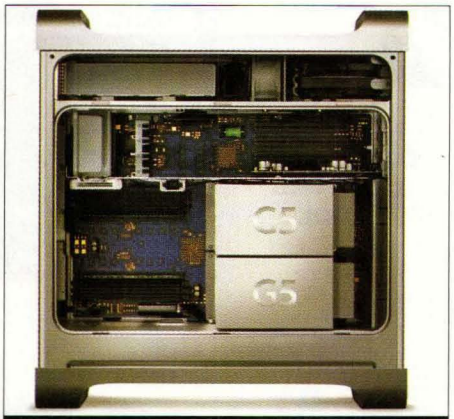
The lattice itself is constructed of a stack of rods that are 0.5 µm in diameter and separated at a distance of 1.5 µm. These are referred to as "photonic crystals" because of the crystal-like regularity of the component spacing. The channels will permit input energy to exit only within the desired frequency band. Surprisingly, when a lattice is heated in a vacuum to 1250°C, it produces an energy conversion efficiency of 34 percent — three times the theoretical performance of an ideal blackbody radiator as calculated from Planck's Law of blackbody cavity radiation. According to Sandia physicist Shawn Lin, the device does not actually break Planck's Law — it just "modifies it by demonstrating the creation of a new class of emitters."

The work has been granted two patents, and a third is pending. For those who desire more details, papers describing the advancement have been accepted by the journal *Optics Letters*. Another will be published by *Applied Physics Letters*.

Computers and Networking

New "World's Fastest PC"

The PC industry has not been a hothouse of product development lately, but this summer, Apple® Computer Corp. (**www.apple.com**) unveiled the Power Mac® G5 product line, billed as featuring the world's first 64-bit desktop processor and the industry's first 1 GHz front-side bus. Powered by the PowerPC G5 processor, designed by IBM (**www.ibm.com**) and Apple, the machine allows memory expansion up to 8 GB and 64-bit computation while running existing 32-bit applications natively.



Apple's Power Mac G5 offers the first 64-bit desktop processor, dual-processor design, and clock rates up to 2.0 GHz (courtesy of Apple Computer Corp.).

The G5 is available with dual 2.0 GHz processors, each with an independent 1 GHz front-side bus, providing 16 GBps of bandwidth. It also features expanded bandwidth memory (400 MHz 128-bit DDR SDRAM with throughput up to 6.4 GBps), a high-speed PCI interface (133 MHz PCI-X), and AGP 8X Pro graphics.

The new processor is a result of the strategic relationship between Apple and IBM, which seems to have

IBM's 64-bit PowerPC® chip is the heart of the Mac G5. Courtesy of International Business Machines Corporation. Unauthorized use not permitted. (Photo by Tom Way, IBM Corporation.)

reversed Apple's processing-power slump, which was created by Motorola's problems in manufacturing the next generation of PowerPC® chips. The processor architecture is based on a new execution core that features massively parallel computation for 215 in-flight instructions, full symmetric multiprocessing, two double-precision floating point units, and an optimized Velocity Engineô.

According to Apple, the G5 is the world's fastest personal computer, based on SPEC® CPU 2000 benchmark results and application performance tests when compared against a 3-GHz Pentium 4-based Dell Dimension 8300 and 3.06 GHz dual Xeon-based Dell Precision 650. In the SPEC CPU 2000 independent testing comparing the G5 against representative 3.0 GHz Pentium 4-based systems and 3.06 GHz Dual Xeon-based systems, the G5 won three out of four key benchmark tests.

Single-processor tests results show the G5 to be 21 percent faster than the 3.0 GHz Pentium 4-based PC on SPECfp_base2000, which measures single-processor floating point performance, and 10 percent slower on SPECint_base2000, which measures single-processor integer performance.

Dual-processor tests showed the G5 beating the 3.06 GHz dual Xeon workstations by 41 percent on SPECfp_rate_base2000, which measures the total floating point throughput of the system, and edging out the same system by three percent on SPECint_rate_base2000, which measures total integer computation throughput. Retail prices range from $2,999.00 for the 2.0 GHz dual-processor model down to $1,999.00 for a single-processor 1.6-GHz model.

Commodore Refuses to Die

Many mourned the fall of Commodore Computer Corp. nearly a decade ago, especially users of the widely-admired Amiga. But you may be surprised to learn that there are still as many as six million devoted users of the older Commodore C64 worldwide. In fact, the C64 is still the best-selling model of all time, with some 17 million of them shipped during the product's lifetime. There is a bit of good news for C64 fans.

No, Jack Trameil has not emerged from his California retirement and started building C64s again. But Tulip Computers NV (**www.tulip.com**) and Ironstone Partners Ltd. (**www.ironstonepartners.com**) recently signed a license agreement for a partnership aimed at a global re-launch of some Commodore products. Tulip is the current owner of the Commodore brand name. Under the agreement, Tulip will receive a license fee for all Commodore C64 products delivered by Ironstone, installed on all computer brands using the Microsoft or any other operating system, and all Commodore 64 branded products. In addition, Tulip will receive a license fee over the revenue from software downloads, subscriptions, and advertising.

In this partnership, Ironstone will create the official Commodore C64 games and community portal, which will be designed to address the Commodore C64 user base and to provide fee-based services to these individuals. Through its web portal, Ironstone will market the official C64 emulator in various software and hardware formats. The games offered by the Ironstone web portal will include the famous "classic" C64 games as well as new ones, and Ironstone will also sell Commodore-branded products through the site.

In a press release, Tulip offered both an invitation and a warning, saying, "Ironstone and Tulip invite the Commodore community to join the official Commodore C64 web-portal. Currently, there are about 300 commercial web sites that use the name Commodore or Commodore 64 without having a license from Tulip. Tulip will not allow unauthorized use of the Commodore brand." As to any VIC 20 users who might still be out there, it's probably time to upgrade your system.

Would You Like Internet with that Big Mac®?

In July, some selected McDonald's restaurants in San Francisco began offering high-speed wireless access ("wi-fi") to customers who come equipped with wireless-enabled notebook computers and handheld devices. When fully implemented, the program will include 75 restaurants in both urban and suburban settings in the San Francisco Bay area. The service is provided by Wayport, Inc. (**www.way**

This wireless logo will appear on the billboard of Internet-enabled McDonald's restaurants. (Courtesy of McDonald's Corp.)

port.net), a provider of Internet access to nearly 600 hotels and airports, and the two companies plan to expand the service to restaurants in New York and Chicago by the end of 2003. According to McDonald's West Division President Don Thompson, "We want the Golden Arches to be the first choice for a great meal and a place to go wireless."

Of course, it probably is also a great place to find out how your laptop works with a McFlurry® spilled on the keyboard or fries crammed into the CD slot by the creative child sitting beside you. And think how much fun it will be to send email to your friends saying things like, "Hi, there. I'm at McDonald's. Pardon me a moment while I upchuck some McNuggets®." The access charge will be $4.95 for a two-hour connection, with other unspecified options available.

Circuits and Devices

Photocells for a Variety of Sensing Applications

Selco Products Co. (**www.selcoproducts.com**) has introduced a new photocell series. These single and dual cadmium sulfide (CdS) light-dependent resistors offer high sensitivity and high stability — featuring a spectral response similar to that of the human eye. The photocells are designed to sense light in the spectral range from 515 nm to 730 nm, and have a peak wavelength of 515 nm. Performance characteristics include a wide range of resistivity values ranging from three kilohms to 240 ohms max at 10 lux, 2856 K, and an operating temperature range of -30 to approximately +75°C.

Although small in size (0.165 x 0.138 inches, or 4.2 x 3.5 mm for Model 9P Series), the output current per photoconductive surface area is large enough to drive relays directly. This allows the devices to be used in applications including photometry, light control, detection, and audio applications for sensing the presence or absence of light or measuring the intensity of light. Typical examples include camera light exposure, brightness controls, shutter controls, night lights, street light controls, low-light level detection, light dimmers, auto headlights, sun sensors for air conditioners, security systems, office machines, audio equipment noncontact volume control, and other visible light sensor applications. The new pho-

tocells are available for immediate delivery and are priced from $0.10 to $0.33 in production quantities.

Industry and the Profession

Yahoo! Profits Higher

The dot-com boom may be over for many Internet-based companies, but Yahoo!, Inc. (**www.yahoo.com**), seems to be doing just fine. For the second quarter of 2003, the company reported net revenues of $321.4 million — a 42 percent increase over the $225.8 million earned in the same quarter of 2002.

According to Terry Semel, chairman and CEO, "We're very excited about the results we have seen in the second quarter — the largest revenue producing quarter in our history. Each piece of our engine is working smoothly with the others, and the numbers show that over the last 18 months, our performance has been stronger and better. Some of the key drivers of success this quarter include more balanced growth in marketing services, from both traditional advertising and sponsored search, as well as ongoing success in converting consumers and small businesses to fee-based services. We are optimistic about the future and we remain steadfastly focused on execution against our priorities."

Spam Costs $874.00 per Employee

Confirming and expanding on other studies about the economic effects of unsolicited commercial e-mail, Nucleus Research — a research company focused on return on investment (ROI) issues — has released a study called "Spam: The Silent ROI Killer." In preparing the report, the company conducted interviews with 117 employees at 76 different US companies, along with 28 IT administrators responsible for managing email and other corporate applications. Some of the key findings in the report include the following:

- The average employee receives nearly 3,500 spam messages per year.
- Average lost productivity per year per employee is 1.4 percent.
- Company-wide spam filters only reduce employee productivity loss by 26 percent.
- One full-time IT staff person is required for every 690 employees, just to manage spam and spam-related issues.
- Given the cost of spam per employee and the limited effectiveness of anti-spam technology, large companies may want to consider legal action against spammers as another weapon against spam.

The bottom line is that the average employer cost of spam per year per employee is $874.00. For more details on this and other studies, see Nucleus at **www.nucleusresearch.com**. NV

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Simply connect ANY standard NTSC compatible VIDEO SOURCE to the completely self contained, 500mW, mini (3' x 2.5" x 0.75") transmitter. Omnidirectional patch antenna included inside transmitter housing. Now you can transmit up to several miles clear line of sight! Using the companion, external antenna receiver is simply a matter of connection the antenna to the attached 36" long cable, terminated in a male N connector. The 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)

AST-LR-YAGI.....$329 set. AST-LR-PARABOLIC.....$369 set.

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Actually a doctor would call it a anrithroscopic borescopes. Super high quality medical grade. Direct view eyepiece & standard 90 degree ext. light port. Size: 6.5"L X 7.5mm diam. SS tube with the objective end optic angled 30 degrees for easy viewing of surrounding area. This can get you in a tight spot! Reg. price: $800ea.

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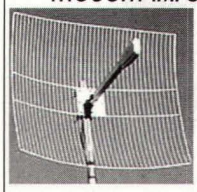

Choose from the LARGE, 24dB, 10 deg. beam width or the MEDIUM, 20dB, 13 deg. beam width PARABOLIC DISH. (shown far left) each provides an environmentally sealed "N" type male termination attached to a 30" long cable. Large size is 27" x 30" and weighs 5.3 lbs, the medium size is 20" x 24" and weighs 3.6 lbs. Can be either horizontal or vertical polarization. Quasi Log Periodic end fire array feed. Both have a commercial quality, light grey, powder coat finish. California Amplifier P/N's: 130135 & 130120. Omnidirectional types, one is a "Rubber Duck" style, the surface mount (shown near left) offers a black, 1/4 wave radiator. The overall size is 3.5"H x 2.7" diam. base. A five foot long RG58-AU cable is terminated with a gold, SMA female connector. The 9db omni, Proxim P/N 7014-05, (shown near right) is a ridgid tube, 24"L x 1.6" max. diam. Weatherproof, Std. 2" pipe mtg. hardware incl. Female TNC connector. Both omnis are black. A UV stable, polycarbonate, radome protects the 13.9dB YAGI, type PC2415N from Cushcraft. (shown far right) Max. input power is 500 Watts, the 15 element, one piece radiating design is extremely rugged. Size is 26" L, weight is 1 pound. Antenna is terminated through a pigtail connector to a "N" type female connector. **PARABOLIC 24dB..$129, PARABOLIC, 20dB..$99, DESK OMNI..$5ea, 9db OMNI..$69ea, YAGI..$89ea.**

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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 @ f0.8 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. We have the best price available for the 12V1E-EX CAMERA. VERY LIMITED QUANTITY AVAILABLE. DON'T BE FOOLED by 1/3", NON - EXVIEW, LOOK ALIKES!

GMV-EX6K...$449 Super, 6mm, f1.2 Manual Iris Lens...$69

LARGE AREA SILICON DETECTOR, MEASURES LASER POWER. A Very Handy Device.

Here's a nice little package that could n't be simpler to use. A quality, hermetically sealed detector with an active area of about 9mm square provides a proportional output voltage to a built in voltage divider with accessible trim pot. This provides a 20mV per mW output on a pair of 20", Long red and black, banana plug terminated leads. Connecting to your digital voltmeter enables you to measure mV/mW up to about 20mW. Brand new surplus from the printing industry. A threaded brass insert in the base to facilitate mounting. Overall size: 2.8"L x 1.1"W x 0.4" thick. **DETECTOR-007.....$10ea.**

BRAND NEW, SPELLMAN +25,000 VDC POWER SUPPLY SL Series, 250Watts, and it's only 1/34"HIGH !

These new, boxed units are the type: SL25P250. Utilizing resonant topology, the proprietary control system maintains high frequency over the entire operation output range. High Frequency operation allows dynamic response time of less than 5 milliseconds and one of the lowest ripple specifications available. Providing +25000VDC @ 10ma with low ripple of 0.02% rms, line and load regulation is 0.005%. Current load regulation: 0.05% of full current for voltage changes and Current line regulation ± 0.05% of full current over the specified input voltage range. 115VAC powered. Size: 1/34"H x 19"W X 19"D rack mountable. Weight is: 17 lbs. Stability of 0.01% per hour after 1/2 hour warm up. 0.02% per 8 hours typical. Temperature coefficient: 100ppm per deg C. Ambient operating temperature: -20C to +40C. Front panel on/off circuit breaker. Other features include, Internal fault protection, front panel indicators for Line power, High voltage OFF and ON, Overload, Interlock status and over temp. These supplies have no front panel controls. The I/O interface is via a 24 position terminal strip at the rear. External 20Kohm pot, not supplied can be used to remote control the current. Outputs are provided for external metering of output. Complete with original instruction manual, schematics, HV output cable and AC line cord. These units are factory set for 25KV out instant on as provided. These are hazardous and potentially deadly voltages. Do not purchase if you do not know what you are doing. Must be over 18. All sales final. **SPELLMAN, SL25KV.....$499ea.**

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A super nice, matched, 1450 RPM, 1/125HP motor & 15:1 gearbox provide 100rpm at the 0.3" diam. x 1.1"L out-put shaft. Shaft rota-tion is the same as the motor shaft. Instantly reversible capacitor start motor. (Cap. supplied) operates from 115VAC @ 0.19A. Torque is 4.4Lb in. Regular $135 each. Limited quantity. Overall size is: 2.4" X 2.4" x 4.25"Long. Weight 1.5lbs.

OM-2GN15K.....$20 or 3 for $49

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NOW, EVEN MORE, POWER to SPARE! FANTASTIC, 12 VOLT, HIGH CURRENT PANASONIC and YUASA, SEALED, RECHARGEABLE BATTERIES.

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 over $90ea.Type VA-1233P is your chance to perk up those heavy duty power projects. Perfect for powering battle bots, telescopes and as part of a solar power system. Even your fish finder, underwater camera or smaller trolling motor. The list is endless. Don't be left out of this opportunity. The size is a manageable 7.75"W x 7.25"H x 5"D, weight is 26 lbs. Heavy duty, lead post type connections with 6mm bolt holes. Use two in parallel for 66Ah! **PANA-1233P.....$39ea. 2 for $59**

ALSO AVAILABLE:

YUASA 12V@26AH, P/N NP-26-12B, 6.5"W x 6.9"H x 4.9"D, weight is 22 lbs. **$35each or 2 for $55**

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NEW, LINEAR BALL SLIDES from DCI,

Three models available: The large is 6"L x 2.6"W x 1"H with 4" of travel. The medium is 5"L x 2.6"W x 1"H with 3" of travel. The small is 1.75"W x 1.75"L x 0.75"H with 1" of travel with a removable spring return for use against a micrometer or similar. Features common to all include: Solid machined aluminum with anodized construction, hardened steel ways. Slides are usable in any position and can carry heavy loads. Over 100lbs for the large and medium and 25lbs for the small. Straight line accuracy of 0.00008"/inch of travel. All are new. Limited quantity.

DCI-LONG...$59, DCI-MED...$49, DCI-SHORT...$29

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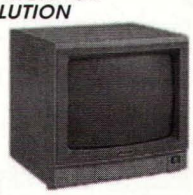
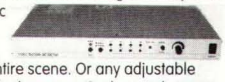


Commercial quality, Hi-resolution Black & White monitor. Brand new, 90 day warranty. BNC video in and loop through. Rugged black steel case. 1000 line resolution. You will be amazed at how much better this monitor will make your video look! There is no substitute for a real monitor. **BWMONITOR-9HR.....$79ea.**

NEW, VIDEO MOTION SENSOR.



Connect to any standard video signal and you've got an electronic "watchman" diligently watching the entire scene. Or any adjustable sized area within the scene. Such as a doorway or even a drawer or cabinet. A state of the art security aid. The unit will close a contact when it senses a change. Auto or manual reset. Internal buzzer with volume control & adj. on time. VCR record and VCR stop output. (use with time lapse VCR.) 110VAC pwr. Adjustable sensitivity. Video loop through. **VM10....$159ea.**

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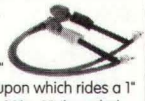

One end "Plugs" into a right angle drive which outputs the flex rotation by turning of a 1/2" diam. x 7"L, 10 TPI lead screw upon which rides a 1" x1" 2"L "nut /carriage" with two 1/4 x 20 threaded holes spaced 1" apart on the long axis. Flex shafts have a 0.14" x 0.14" square drive end. You receive two complete assemblies: one with a nylon carriage and one with a steel carriage. They were originally designed to move power seats. We do not know what car. Heavy duty construction. A very interesting device. **SALE, FLEX-PAIR...$10 / set of 2**

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NEW! Coreless DC-Micromotor with precious metal commutation with a low inductance, ironless rotor coil. Efficiency is increased by the elimination of hysteresis & core (iron) losses. Extremely light rotor & has low inertia & no cogging as with conventional DC motors. Specs: 16mm Diam. x 28.6mm L, 6mm L x 1.5mmD shaft. 16ppr, magnetic, 2 chan. encoder. Spur gearbox with metal gears and ceramic output bearing. Motor weight is 0.35oz. Gearbox weight is 0.14oz. Operating voltage: 2-6VDC, NL current: 8-14mA. Two mtg. screws. A rare find. Don't miss out.

MICRO-MO-761 $19ea. or 4 for $59

Electronic Theories and Applications From A to Z

Let's Get Technical

Why Bother with the Simple Stuff?

The Importance of Knowing the Basics

Years ago, I worked with an instructor who, right after being hired in my department, wanted to teach the senior level Electronic Communications course, and was unhappy to learn he would instead be teaching Introductory DC and AC Circuits to the freshmen. Our department chairperson believed that you must have a good grasp of the basics, especially DC and AC circuit analysis, before you can appreciate more complex circuits.

While I taught DC and AC circuits for many years, I always tried to relate to the students why they needed to understand a concept or why they would need to know this or that analysis method. For example, something as simple as the voltage divider equation for two resistors (R1 and R2) in series across a voltage source of E volts gives the students a chance to be analytical. For example, the voltage across R1 is:

$$Vr1 = E * \frac{r1}{r1 + r2}$$

The equation is not just a simple way to save time while doing calculations. Understanding how the equation works and where it came from indicates good familiarity with series analysis concepts. I show the students how to derive the equation by using variables in their equations and not numbers. When you solve for the voltage across R2, you get:

$$Vr2 = E * \frac{r2}{R1 + r2}$$

I ask my students if they see similarities between the two equations and then explain that you can also rearrange the terms and see the same equation from a different point of view:

$$Vr2 = \frac{E}{R1 + R2} * r2$$

Now, instead of Vr2 being the voltage E multiplied by the ratio of resistors, it equals the circuit current multiplied by r2 (which is just a form of Ohm's Law: E = I * R).

So, we can see that knowing algebra is an important part of being able to derive, examine, and understand the equations we have to work with.

When the students take their first electronics course (after completing DC and AC circuits), they study the common-emitter amplifier shown in Figure 1.

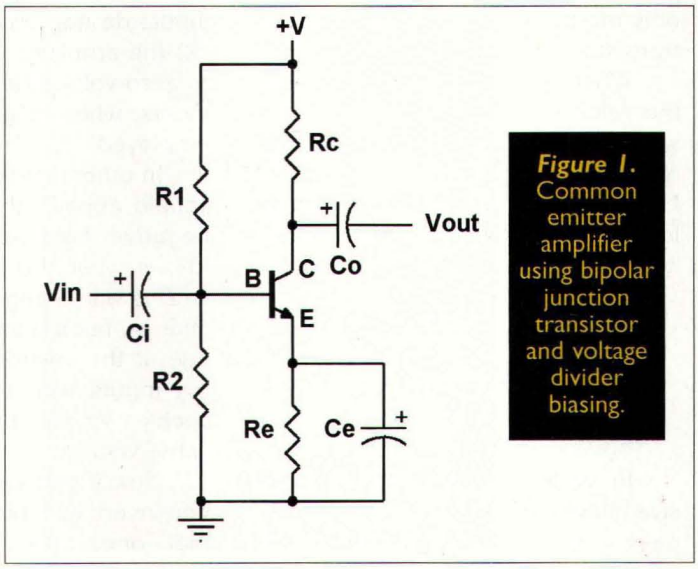

Figure 1. Common emitter amplifier using bipolar junction transistor and voltage divider biasing.

I explain to them that the circuit contains a voltage divider subcircuit at the base of the transistor that is used to create the DC bias voltage for the transistor's Q point. Thus, the voltage divider equation from DC circuits now becomes important in the electronics course while studying amplifier circuits.

When DC analysis turns into AC analysis, things can get more complex because the nature of the inductors and capacitors we use in the circuits will vary their response as the circuit frequency changes. Thus, instead of just considering a DC voltage or current, we may have to calculate and examine a range of voltages or currents. For instance, the common emitter amplifier in Figure 1 will have a frequency response dictated by the value of the coupling capacitors Ci and Co, as well as the input and output resistance of the circuit and the midrange gain.

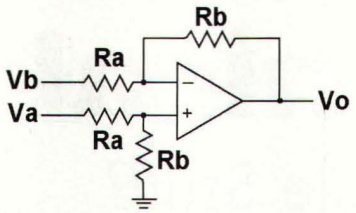

Figure 2. Operational amplifier configuration amplifies the difference of the input voltages.

But to someone looking at the circuit for the first time, just knowing some basics about the capacitor helps to begin the analysis. Recall that a capacitor looks like an open circuit when a DC voltage is applied. So, in terms of the DC analysis of the amplifier circuit, we can ignore the coupling capacitors and concentrate only on the four resistors biasing the transistor.

When we switch to AC analysis, the value of the coupling capacitors will help determine the minimum and maximum frequency of operation. Now we have to go back to AC circuits for the equation that predicts a capacitor's reactance at any frequency:

$$Xc = \frac{1}{2\pi FC}$$

In addition, knowledge of passive filters — both low-pass and high-pass — is also necessary, since the coupling capacitors form passive filters at the input and output of the amplifier circuit. On the input side, this will involve use of the gain equation for the high-pass filter:

$$Av(f) = \frac{1}{1 - j\left(\frac{F}{Fc}\right)}$$

Now we have ventured into the area of complex numbers, which contain both real and imaginary components. Again, we see that a good understanding of algebra is essential to electronic circuit analysis.

As the students continue with their electronics coursework, they make their way to operational amplifiers. Once again, here is a chance for the algebra-loving students to show their stuff. In Figure 2, we see the schematic for the difference amplifier. The equation that predicts the output voltage is as follows:

$$Vo = (Va - Vb) * \left(\frac{Rb}{Ra}\right)$$

Here is another chance to deepen our understanding of the circuit by deriving the Vo equation from simple things we know. For example, two important characteristics of the operational amplifier are (1) the inputs do not draw any current, and (2) the amplifier will try to maintain a zero-volt difference across its inputs when negative feedback is employed.

In other words, the same voltage should appear at both inputs when negative feedback is used. Who knows what this voltage is and, in fact, it will change when the inputs change, but it is safe to label the voltage at the inverting and non-inverting inputs with the same variable, such as Vx, since they both have the same value.

Now if you look carefully at the non-inverting input, you should see that, once again, a voltage divider configuration is present in our circuit. This allows us to write an equation for Vx at the non-inverting input that looks like this:

$$Vx = Va * \left(\frac{Rb}{Ra + Rb}\right)$$

Looking again at the schematic, do you see a voltage divider configuration involving Vb and Vo? The two resistors between Vb and Vo will obey the voltage divider principle as well, giving us this slightly more complex equation:

$$Vx = (Vb - Vo) * \left(\frac{Rb}{Ra + Rb}\right) + Vo$$

The (Vb - Vo) term tells us the voltage across the two-resistor pair. This is the voltage that divides across the two resistors. The voltage across Rb, that helps create Vx, floats above the Vo level, which is why we must add Vo to the equation. Note that if you replace Vo with zero in the equation, it reduces to the original voltage divider formula.

So, a few simple circuit techniques give us two equations. Now it is a matter of algebra to reduce them. First, we set the equation equal to each other, eliminating the Vx variable.

$$Va * \left(\frac{Rb}{Ra + Rb}\right) = (Vb - Vo) * \left(\frac{Rb}{Ra + Rb}\right) + Vo$$

Next, we multiply by the common term (Ra + Rb) to get rid of the denominators.

$$Va * Rb = (Vb - Vo) * Rb + Vo * (Ra + Rb)$$

Then, we distribute some products.

$$Va * Rb = Vb * Rb - Vo * Rb + Vo * Ra + Vo * Rb$$

The Vo * Rb terms cancel. Now we rearrange the terms a little.

$$Va * Rb - Vb * Rb = Vo * Ra$$

After factoring, we are almost there.

$$(Va - Vb) * Rb = Vo * Ra$$

Dividing both sides by Ra now gives us the final equation. Again, a

few simple DC techniques and a bit of algebra has helped us analyze a complex circuit.

Conclusion

Does the simple stuff ever go away? I'm afraid not. When studying digital-to-analog converters, the R-2R ladder circuit and its associated current division is an important part of the circuit. And the voltage divider comes back again when analyzing a DC power supply with constant output voltage. The voltage divider senses the output voltage and inputs it to an operational amplifier to adjust the output voltage accordingly.

When studying digital circuits, just knowing Ohm's Law helps to understand the operation of a pull-up resistor. Recall that a pull-up resistor is used on a digital input to make a good, logic one voltage level. How can Ohm's Law help answer the following question: Which resistor is a better choice for a pull-up, 4.7K ohms or 100K ohms? The Ohm's Law equation E = I * R becomes important in determining the answer. The input will require a small amount of current to flow through the pull-up resistor. If the resistor is too large, the voltage drop across the pull-up resistor may not leave enough voltage for the input to make a good logic one level.

Clearly, knowing the basics of DC and AC circuits leads to a better understanding of higher-level circuits and aids in their analysis, as well as exercises math skills necessary to find solutions during sign and analysis. **NV**

About the Author

James Antonakos is a Professor in the Departments of Electrical Engineering Technology and Computer Studies at Broome Community College, with over 26 years of experience designing digital and analog circuitry, and developing software. He is also the author of numerous textbooks on microprocessors, programming, and microcomputer systems. You can reach him at antonakos_j@sunyb roome.edu or visit his web site at **www.suny broome.edu/~antonakos_j**.

Tech Forum

QUESTIONS

I am trying to build handheld units that will communicate with each other using CPCA/OOK modulation. For testing I have built two PCBs, one for the transmitter and one for the receiver. I am using Linx Tech modules and their "Splatch" antenna. The boards are laid out just as their spec instructs. I am only able to send a signal about 15 feet. I read that the splatch is only about 30 percent efficient — which with their claimed maximum range of 300 feet, I should expect about 90 feet — which is fine for my purpose (15 feet is not).

I do not have the equipment to tune antennas and thought pre-engineered modules would give good results.

Does anyone know anything about these units and/or what other people are achieving using them? Are there any websites/bulletin boards that deal with this subject?

#09031 **Frank**
via Internet

I own a HP-48 calculator and the companion HP-82240B IR thermal printer (alpha numeric + graphics, 2-3/4" paper). I would like to use the printer with my Pocket PC (e740 Toshiba).

Do you know a source that defines the IR output from the HP-48 calculator?

#09032 **Wayne Boucher**
via Internet

I would like to control a process that requires a time and temperature sequence. I need a temperature span from 90° F to 170° F and time periods from 15 to 120 minutes in duration. I will be heating a circulating fluid from 90° F to 170° F in four or five steps of 15 minutes to 2 hours each (i.e., heat to 120° F and hold for 20 min., raise to 145° F and hold for 30 min., raise to 156° F and hold for 60 min., raise to 170° F and sound an alarm to signify end of process). I can do this manually by physically turning up the thermostat but would like to be able to program the whole process and walk away. Most control software is too expensive. What would be the easiest and least expensive way to accomplish this task?

#09033 **Jerome Ebel**
Mosinee, WI
via Internet

I have a situation where I needed to buy a submersible water pump. The pump runs off 120 VAC and has a line cord attached. The idea of putting a line cord in water just makes me weak at the knees. Can I use two wall-warts (both 9 VAC), one plugged into the wall with the output connected to the output of the other wall-wart? This should give me back an isolated 120 VAC at low amperage, right? The pump is rated at 120 VAC 0.09 amps.

#09034 **Matt**
via Internet

I am setting up a data acquisition system for use on a small boat and was contemplating using a mini PC like FIC's Ice Cube or Brick. I'm trying to keep the power consumption of the system down and have been looking for any "weak links in the chain." I hate the idea of using a voltage inverter to step up the 12-volt battery output to 110 VAC so I can plug my computer power supply in, which then converts back down to ±12, ±5 VDC, etc.

Does anybody make or have plans for a DC-to-DC power supply for computers that is a direct replacement ATX or mini ATX format? Are there people out there who only use computers from

Continued on Page 100

This is a READER-TO-READER Column. All questions AND answers will be provided by *Nuts & Volts* readers and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. All questions submitted are subject to editing and will be published on a space available basis if deemed suitable to the publisher. All answers are submitted by readers and NO GUARANTEES WHATSOEVER are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

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- Include the question number that appears directly below the question you are responding to.
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- 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.
- Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

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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.

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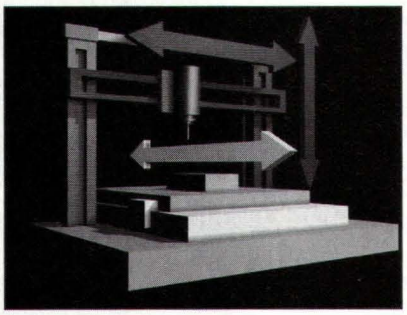

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Putting the Spotlight on BASIC Stamp Projects, Hints, and Tips

Stamp Applications

Playstation Control Redux

Most people don't realize that the BASIC Stamp II has actually been around for quite a long time. Like the BASIC Stamp I, it was designed to be a general-purpose embedded controller. And it's a darn good one — just look how many copy-cat products exist today.

I often say to friends, and in fact have stated right here in my column, that I feel like I'm one of the luckiest guys in the whole world. Now, don't worry, I won't bore you with the myriad reasons I could use to back-up that statement, but I will say that one of them is the job I get to do and all the neat people I get to meet in the course of doing that job.

A small part of my job with Parallax involves training. Back in June, I had the very good fortune to be invited to teach BASIC Stamps at IBM's EXITE (Exploring Interests in Technology and Engineering) camp for girls here in the Dallas/Fort Worth area. It was fun, if not a very tough assignment. Not the course material, mind you, I'm pretty good with BASIC Stamps. The audience ... a whole different story — twenty odd, thirteen-year-old girls who didn't have a background in electronics or computer programming.

Perhaps it's a sign that at 41 years of age, I am finally getting old, but teenagers today seem significantly more sophisticated and cynical than when I was a kid. I knew that if I was going to last all four days that I would have to start strong. So, on day one (Monday), I retrieved a Sony PlayStation® game controller from my backpack and held it in the air for the girls to see. "Does anyone know what this is?" I asked. Of course, every single one of them knew what it was and responded accordingly. Then, I planted the seed that I hoped would get and maintain their attention. "No, it isn't. This, my new friends, is a robot controller and I will prove it to you on Thursday." It seemed to work. With the minor exception of a couple of "bad attitude" girls, the rest seemed genuinely interested in how they could control a robot with a device that they all knew very well.

Thank You, Aaron

Before I go any further let me admit that I got started with the PlayStation controller because of Aaron Dahlen's neat article published in *Nuts & Volts* back in June. About a year ago, I had some interest in the controller, but never got around to doing anything with it. So my thanks go to Aaron for his work and getting me off my duff. My hope is that I can expand on Aaron's information so you can get more use from the controller.

Building an Interface

The toughest part about working with the PlayStation

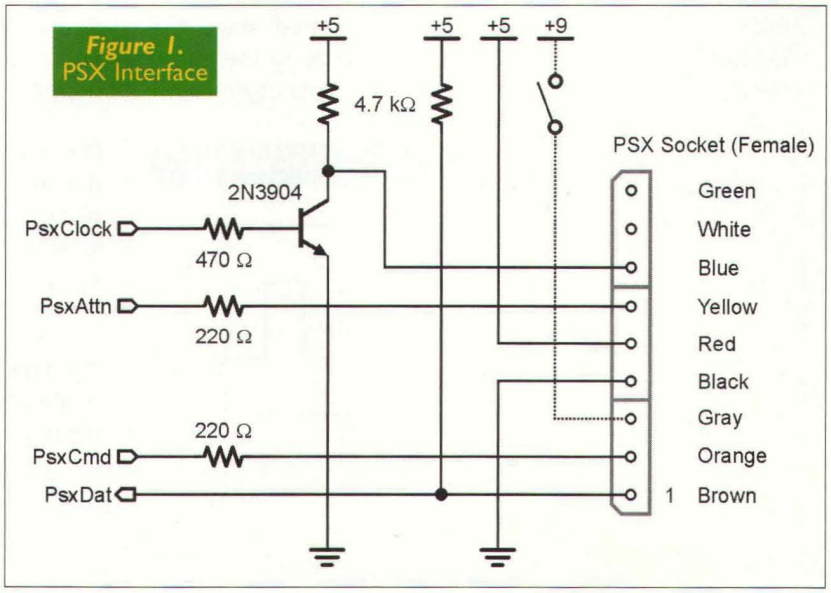

Figure 1. PSX Interface

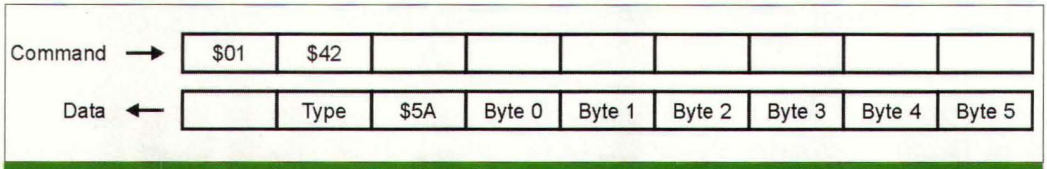

Figure 2. PSX Data Exchange

controller is building the mechanic/electrical interface, and most of that is very simple — it's the connector that is the tough part. The socket that accepts the odd nine-pin controller plug is a Sony product, and not something you can purchase readily. I did find a couple of places on the Internet that sell repair parts for games, but these were not new parts — they had been removed from damaged PlayStations, and none were cheap.

I solved this problem by purchasing a $10.00 PlayStation extension cable and carefully hacking the socket from one end of it. The socket is attached to a PCB with professional strength contact cement, and a bit of hot glue (be careful!) is used to secure the wires. Figure 1 shows the schematic for my version of Aaron's interface. This circuit varies from Aaron's only in [trivial] component values and the use of 220-ohm resistors on any BASIC Stamp pin that is used as an output - I do this for safety in case the controller fails. Also note that the nine-volt connection to pin 3 of the controller is optional (dual-shock motor power) and not required for our experiments.

Shifting Bits — Automatic and Manual Modes

Part of the reason I decided to write about the PlayStation controller after Aaron's excellent article has to do with an oddity in the values returned when using SHIFTIN (more on that in a minute), and I wanted to create code that would tell the BASIC Stamp what kind of controller is attached. Controller type detection is not possible using the SHIFTOUT/SHIFTIN method since the PlayStation controller sends its device type to the game console (or our Stamp) when the data request byte ($42) is being sent to the controller. Figure 2 shows how data is exchanged between the master and the controller, and how the overlap occurs on the second byte of the transfer.

Knowing the type (or current mode) and if the device is ready can be very useful, so how can we retrieve this data? We do it by creating a manual function to shift data to and from the controller simultaneously. While this may sound a bit complex, it really isn't. Back in the BS1 days, we had to create our own shift functions for synchronous devices — we'll just build on those strategies.

Here's a bit of code we can use to send a byte to and receive a byte from the controller.

```
PSX_TxRx:
  FOR idx = 0 TO 7
    PsxCmd = psxOut.LOWBIT(idx)
    PsxClk = ClockMode
    psxIn.LOWBIT(idx) = PsxDat
    PsxClk = ~ClockMode
  NEXT
  RETURN
```

As you can see, the code is quite straightforward. A FOR-NEXT loop accommodates eight bits. A bit from the command byte is put onto the PsxCmd pin before the controller clock line is pulled low. While the clock line is low, the PsxDat line can be scanned and the bit stored in psxIn. The clock line is returned high and the process is repeated for all bits. Notice that this routine works LSB to MSB.

Before we continue with the code, let me address an issue that occurs when using SHIFTIN to retrieve all six data bytes from the PlayStation controller. If you've run Aaron's demo program, you have probably noticed that the left joystick Y-axis (up-down) does not span the entire range — its range is 128 to 255. This seemed odd to me and after a bit of investigation, I believe I know why this is happening.

Take a look at Figure 3. This graphic shows how the PlayStation controller sampling is handled. Notice that the bit sampling — as with our code sample above — takes place while the clock line is being held low. Now take a look at Figure 4. This diagram shows how the controller is sampled when using SHIFTIN — specifically the last few bits of the last byte of the sequence.

Notice that the BASIC Stamp doesn't actually sample the data line until after the clock line is released. This normally isn't an issue, but becomes one for the PlayStation controller. What happens is that the controller can count the clock pulses, and when it detects the release of the final clock pulse it releases the data line — which is pulled up through a 4.7K resistor so the last bit (Bit7) of the final byte in the sequence is always 1. This explains why we

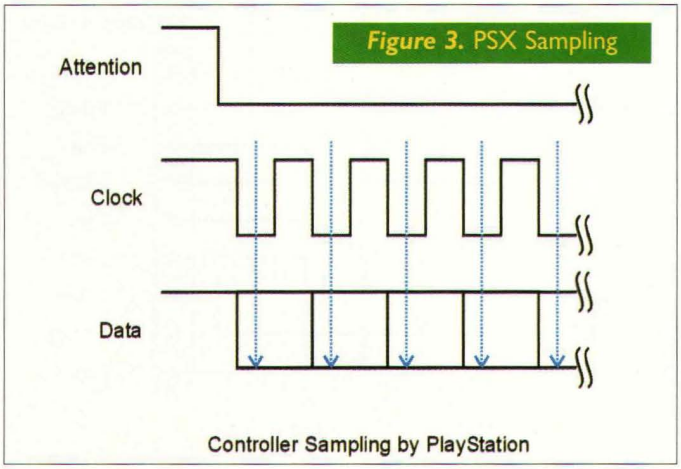

Figure 3. PSX Sampling

never see a value lower than 128 on the left joystick Y-axis. The manual code does not suffer this problem. That said, I confirmed my suspicion about SHIFTIN by structuring the manual code so that it dropped the clock line before sampling — it behaved exactly like SHIFTIN does.

The manual version is slower, however, by a significant factor so we have to make a choice between speed and accuracy. If you're using a digital controller or don't need the left joystick inputs, then you can get away with using SHIFTIN. If you need to verify the device type, or need both joysticks, then you'll need to use manual code. Let's go ahead and take a look at the routine that transfers the full controller packet.

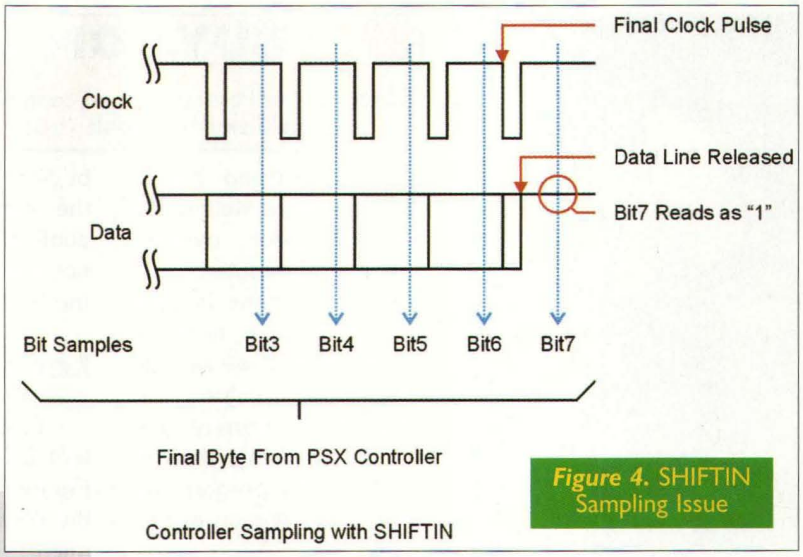

Figure 4. SHIFTIN Sampling Issue

```
Get_PSX_Packet:
  LOW PsxAtt
  psxOut = $01 : GOSUB PSX_TxRx
  psxOut = $42 : GOSUB PSX_TxRx
  psxId = psxIn
  psxOut = $00 : GOSUB PSX_TxRx
  psxStatus = psxIn
  GOSUB PSX_TxRx : psxThumbL = psxIn
  GOSUB PSX_TxRx : psxThumbR = psxIn
  GOSUB PSX_TxRx : psxJoyRX = psxIn
  GOSUB PSX_TxRx : psxJoyRY = psxIn
  GOSUB PSX_TxRx : psxJoyLX = psxIn
  GOSUB PSX_TxRx : psxJoyLY = psxIn
  HIGH PsxAtt
  RETURN
```

The routine starts, as we expect, by pulling the PsxAtt line low. This activates the controller — it works just like a chip select line (just as the controller behaves as a multi-byte shift register). The first byte out is $01 (start), followed by $42 (get data). At this point, the controller type is available in psxIn and gets transferred to psxId for later use. The next byte out is $00 — the return value at this point is the controller status which should be $5A ("ready"). We can use this byte to detect the presence of the controller. If it was unplugged, for example, the psxId and psxStatus bytes would both be $FF. The next six bytes in are the button states and joystick values. At the end of the sequence, we disconnect the controller from the buss by taking the PsxAtt line high.

Speeding It Up

I was very happy to get the manual code working and be able to detect the controller type and read all of the joystick data — until I timed it to find that it takes nearly 145 milliseconds on a stock BS2. That's just way too long. Look at Figure 2 again. The only time we really need to use the manual (slow) shifting is when something is coming back at the same time and a command byte is going out, and on the final byte so that we can read all eight bits properly. Combining techniques, we get this:

```
Get_PSX_Packet_Fast:
  IF (ClockMode = Direct) THEN Get_PSX_Packet
  LOW PsxAtt
  SHIFTOUT PsxCmd, PsxClk, LSBFIRST, [$01]
  psxOut = $42 : GOSUB PSX_TxRx
  psxId = psxIn
  SHIFTIN PsxDat, PsxClk, LSBPOST, [psxStatus]
  SHIFTIN PsxDat, PsxClk, LSBPOST, [psxThumbL]
  SHIFTIN PsxDat, PsxClk, LSBPOST, [psxThumbR]
  SHIFTIN PsxDat, PsxClk, LSBPOST, [psxJoyRX]
  SHIFTIN PsxDat, PsxClk, LSBPOST, [psxJoyRY]
  SHIFTIN PsxDat, PsxClk, LSBPOST, [psxJoyLX]
  GOSUB PSX_TxRx : psxJoyLY = psxIn
  HIGH PsxAtt
  RETURN
```

Another thing this routine does is check the interface

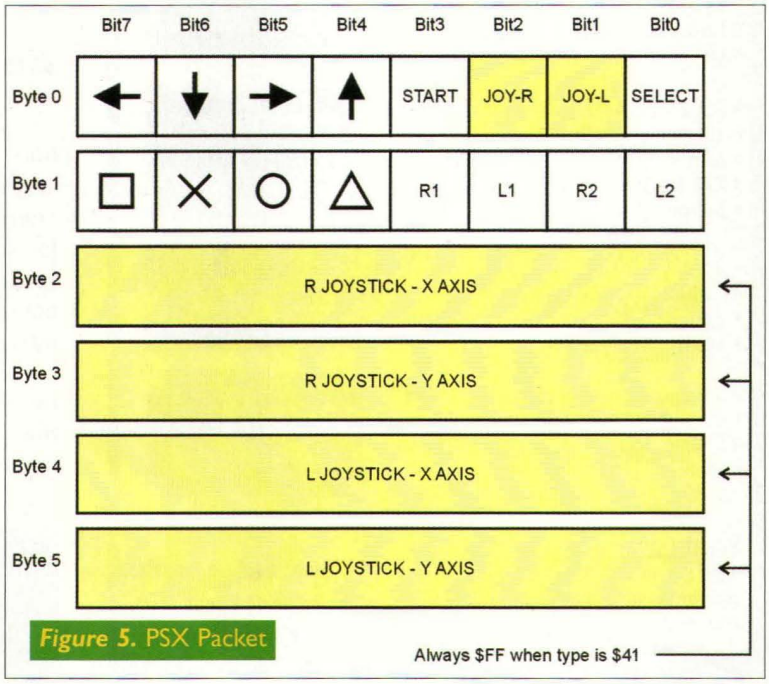

Figure 5. PSX Packet

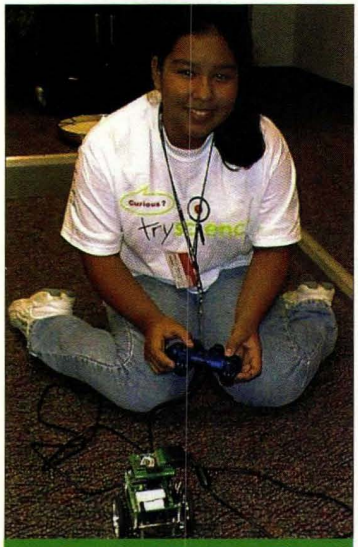

Figure 6. Dianna with BOE-Bot

BUY.COM ...

... sells various Playstation hand controllers, as well as a hackable extension cable (stock GW2J4T).

type we're using based on a constant definition. The transistor inverter can be eliminated, but what this means is that we must use manual shifting only. If we set the ClockMode value for direct (just a current limiter, no inverter), then it will force the program to the *slow* version of the code.

By combining techniques, over 100 milliseconds in execution can be shaved off the routine — this is valuable time when controlling a robot. The rest of the demo program (please download from the *Nuts & Volts* site) displays the controller type and values from it. Figure 5 shows the breakdown of the data packet. Note that the shaded areas are only applicable when the controller type is $73 (analog). My experience is that the Sony analog controller — when running in digital mode — will disable the analog joysticks. However, a clone controller made by Pelican Accessories simulates the button presses with the analog joysticks when running in digital mode. I did confirm Aaron's observation that the clone controller does not have the same resolution on the analog joysticks as the Sony, so be wary of that.

Let the Robot Roll

Finally, what about the robot I promised the girls at the IBM EXITE camp? Well, as you can see by the photo in Figure 6, I kept my promise and brought a robot that uses the PlayStation controller. The young lady in the photo is one of the stars of the BASIC Stamp class — her name is Dianna and she did a great job with the BASIC Stamp despite never working with electronics or computer programming. She also had no trouble driving the BOE-Bot with the PlayStation controller — just as we would expect.

Let this be a lesson to all of us: It's often a good idea to design toward customer expectations — in fact, it is usually the best idea. I've worked with a lot of young engineers who, in an effort to make their mark on the world, design things differently just for the sake of being different. I'm going to suggest you be careful to avoid this [ego-driven] trap, as it often leads to customer frustration and disappointment for you, the hard-working engineer. Remember that being original doesn't mean you have to be "different."

Okay, now you have a "standardized" interface device that is well known to a wide range of customers and several options for using it. How might you use this standard interface to create something original?

Another Contest

Would you like to have a spare Stamp for your collection? Perhaps try one that you don't currently own? Okay, let me tell you how you can get a brand-new Stamp at no charge — you simply need to send me working BS2 code for the Sony Dual-Shock controller that selectively activates the motors (the nine-volt connection to pin 3 of the controller is for the motors). I am actively pursuing this myself, but publishing deadlines for the article prevented me from getting it working. Once I do — or someone shows me how — I will make that code available to everyone, and the person who sends me the code will get his or her choice of a new BASIC or Javelin Stamp. Any takers?

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

Jon Williams
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Resources

Understanding, Designing, and Constructing Robots & Robotic Systems

Amateur Robotics

Several different designs for software interval timers are presented and some of the pitfalls to avoid in writing these important elements of robot code are discussed.

Almost all robot code needs some way to measure time in the range of milliseconds to several seconds. Tasks such as timing the rate of a blinking LED or measuring timeout delays for sensor loops don't need to be terribly accurate, but you still need to design the code. This article will cover several ways of timing such intervals.

Quick and dirty

The simplest interval timer you can create is a counting loop. Here is what it looks like in C:

```
for (n=0; n<TIMEOUT; n++)   ;
       // a simple counting loop
```

The CPU will hit this loop and essentially freeze while it increments N from 0 to whatever you've defined TIMEOUT to be. From the larger view, this is usually a pretty poor choice for timing intervals.

First off, it wastes CPU cycles — normally a precious commodity in embedded firmware. Cycles spent counting to TIMEOUT are not available for other tasks, such as checking for intruders or tracking motor motion.

Another problem with this technique concerns the timing resolution. Each time through the loop represents a very small number of machine cycles. For example, the C compiler might translate this loop into three or four lines of assembly language — on a 16 MHz 68hc12 system, this loop would execute in about 10 machine cycles. At 125 nanoseconds per machine cycle, each loop provides 1.25 microseconds of delay. This is fine for small delays, but it gets unwieldy for larger values. For example, you would need a TIMEOUT value of 800,000 just to get a one-second delay.

You must always view interval timers from the system level. While your robot is running, your program will likely be servicing interrupts from various sources, such as motor encoders, serial ports, or sound generators. Each of these interrupts is processed in the background, while the timing loop above runs in the foreground.

This means that each time an interrupt fires, the CPU stops counting momentarily and services the interrupt. If enough interrupts happen throughout the course of the timing interval, the final delay can be larger than the expected value. This isn't too critical if you're trying to time an LED, but other tasks may need greater accuracy.

Does all this mean you should never use the counting timer? Of course not. Despite its problems, it can prove useful. For example, consider the following code fragment:

```
for (n=0; n<TIMEOUT; n++)
{
     if (SC0SR1 & 0x20)   break;
}
```

Here, I've used a variant of the counting timer to check for an incoming character on a serial port. Control is guaranteed to reach the end of the loop. If N equals TIMEOUT at the end of the loop, you are almost positive that a character did not arrive before the TIMEOUT interval.

Of course, a character could have arrived an instant after the last count in the loop, so you may want your code to test SC0SR1 one last time at the end of the loop. But this loop will terminate early should a character arrive.

Note that this loop assumes a fairly small value for TIMEOUT, say a few milliseconds. It isn't bothered by delays from servicing other system interrupts, since waiting a little longer isn't normally a problem in such a polling loop. This type of counting timer can be used to poll for other events, such as EEPROM write completion or SPI transfers.

Down-counting timers

My tiny4th compiler uses down-counting timers. These are variables that automatically decrement to zero at some fixed rate. Once a down-counting timer reaches zero, it stays there until loaded with a new value.

The code behind a down-counting timer is pretty simple. It can be expressed in C as:

```
if (Timer)   Timer--;
```

In actual practice, you will usually need several of these down-counting timers, so you can assign a separate timer for each of several tasks. Therefore, you would need code such as:

```
for (n=0; n<NUM_OF_TIMERS; n++)
{
     if (Timer[n])   Timer[n]--;
}
```

The above code will handle an array of timers, where the value NUM_OF_TIMERS is chosen at compile time and represents the number of timers.

To make this work, your code must execute the above loop at a fixed rate, called the tick rate. Most modern MCUs have a real-time inter-

rupt sub-system (RTI) that can be set up to generate an interrupt at fixed intervals.

This means that the loop must happen in the background, as part of the RTI interrupt service routine (ISR). For example, my 68hc12 systems set the RTI interval at 8.192 milliseconds, or slightly more than 122 tics per second. Using the above loop, my code will process the timer array once every 8.192 milliseconds. At that time, every timer is tested and, if not zero, decremented.

To use a down-counting timer, my mainline (foreground) code writes a value to a timer, then occasionally checks that timer to see if it has hit zero. At zero, my code can assume that the timeout occured and can continue processing. This looks something like:

```
Timer[0] = TIMEOUT;
// start with the timeout value
while (Timer[0])
        // while not timed out...
{
        //
        //  Insert your code here
        //
}
```

This technique has several advantages over the simple counting loop we looked at earlier. For one thing, the timing takes place in the background, and CPU cycles are only used for timing when the RTI fires. This lets your code do useful work during the timing interval.

Note also that the accuracy of the timed interval is shielded from the effects of other interrupts. So long as the total delay caused by other interrupts within a single timing interval does not exceed the tick rate, the timed interval will be accurate.

Another advantage with this system is the adjustable granularity of the tick rate. Your code can set the tick rate to any value supported by the MCU's RTI sub-system. As I mentioned above, my 68hc12 programs use a tick rate of 122 tics per second. A 16-bit variable can nominally span from 8.192 milliseconds to over 537 seconds.

In practice, you will not get reliable timing in the very short intervals. Writing a 1 to a timer, for example, will not get you an 8.192 millisecond delay. This is because your foreground code cannot know when the current tick ends as it writes a value to a timer. For best results, plan on writing timer values no less than 10.

This timing system, while very useful, does have one small problem. While it frees up most of the CPU cycles between timing intervals, it does do a lot of processing at each interval. Granted, it doesn't take much time to run through the array of timers, testing and decrementing as needed. Still, those are cycles your foreground program doesn't get to use. And the larger the array of timers, the more cycles are spent in timer servicing.

The system timer

There are cases when the down-counting timers aren't the best

choice. Perhaps your program would require so many timers that the ISR for checking the timers would consume too many CPU cycles. Or you might find keeping track of the different timer array entries too cumbersome or error-prone.

Another option is the concept of a system timer. This software device is a single, large variable that starts at zero when the MCU comes out of reset and increments at a fixed tick rate. To time an event, your code must first record the value of this system timer at the start of the event, then periodically compare the current system timer value to the recorded value. The code to implement a system timer couldn't be simpler. In C, it looks like:

```
Timer++;        // add one to the timer value
```

This code is executed within the system's RTI ISR. For my 68hc12 systems described above, this means the system timer increments 122 times per second. Notice that this method generates a tiny ISR module, which means very few cycles spent servicing the tick interrupt.

You will want to use a very large variable (at least 32 bits) for Timer. Remember that in my case, each count means 8.192 milliseconds. Thus, a 32-bit timer will roll over (wrap around to zero) after 4,294,967,295 tics, or almost 408 days.

Implementing this system timer is pretty easy. However, using it isn't as simple. The obvious attempt, as shown here, will fail:

```
end = Timer + TIMEOUT;        // compute final time
while (Timer < end)           // this will fail!
{
        //
        //   Insert your code here
        //
}
```

The problem lies in the behavior and timing of the ISR. It is easy to read the above code and assume that each line of code will be executed as a single, uninterruptible chunk, known as atomic. In reality, the C compiler will turn each line into one or more lines of assembly code. For the most part, each line of assembly code is atomic, but the C code lines certainly are not.

For example, it is virtually certain that, given enough time, the RTI ISR reponsible for updating the system timer will execute during the while statement, at the exact instant that the CPU is fetching the 32-bit Timer variable. The 68hc12 does not have a single instruction for fetching a 32-bit value from memory, nor does it have a single instruction for incrementing a 32-bit value. This means the C compiler must generate a sequence of assembly language instructions for each such operation. For example, the C compiler might read the current value of the Timer variable by first reading the high 16 bits and saving them, then reading and saving the low 16 bits.

If the RTI ISR fires between these two reads, the value in Timer will have changed during the execution of that line of C code. The change can cause the comparison within the while statement to fail, throwing control out of the loop too soon. Interestingly, the obvious attempt to fix

this problem, shown below, will also fail, but for a different reason:

```
end = Timer + TIMEOUT;        // compute final time
while (1)                     // do forever...
{
       disable_interrupts();  // no interrupts
                              // allowed
       t = Timer;             // save a copy of
                              // Timer
       enable_interrupts();   // interrupts are OK
       if (t > end)  break;   // if timeout, leave
                              // loop

       //
       //  Insert your code here
       //
}
```

This attempt uses a brute-force method to prevent the RTI interrupts from affecting the Timer value as it is being read. Here, interrupts are disabled during the brief moment when the Timer value is accessed at the top of the loop.

Unfortunately, this approach shuts off *all* interrupts, so other important events, such as motor encoder updates or incoming serial characters, are also locked out until interrupts are re-enabled.

The problem comes because, quite often, the code within the loop deteriorates into a polling loop, similar to the loop above that polled the SC0SR1 register. In such cases, this loop seriously degrades system performance, since interrupts are disabled for a high percentage of the time.

A simpler approach is to accept the fact that occasionally the RTI will fire in the middle of a read or write to the Timer variable, and design your code to deal with this. Here is one way to access this system timer variable without fear of ISR corruption:

```
unsigned int  GetTimer(void)
{
       unsigned int t;
       t = Timer;             // get a copy of
                              // Timer

       if (t != Timer)        // if not the same
                              // twice...
              t = Timer;      // this one must be
                              // right
       return  t;
}

end = GetTimer() + TIMEOUT; // compute final time
while (GetTimer() < end)    // this will work!
{
       //
       //  Insert your code here
       //
}
```

Here, I've included a dedicated routine, called GetTimer(), that reads Timer twice and compares the two values. If they are different, the RTI fired in the middle of one of the accesses, so a third read is done and this value is returned.

Note that there is still a very remote chance that this routine could fail. If the RTI fired in one of the first two accesses, then interrupts were somehow disabled or starved for *exactly* one tick interval, the third access of Timer could also get corrupted. This isn't likely to happen, but you need to be aware of the weakness.

Incidently, using GetTimer() to compute the value for END before entering the loop also side-steps the possibility of corrupting the initial value, a flaw that the first two versions of this code share.

Time to go

This article has examined several different methods of generating timing intervals in software. I haven't gone into the details of the ISRs — they will vary based on the MCU you use.

But the concepts here can be applied on nearly any MCU, and should help you avoid some of the subtle problems associated with software timers. NV

Karl Lunt is a long-time author of articles for the beginning and intermediate robot builder. His book, *Build Your Own Robot!*, contains over 50 of his past *Nuts & Volts* articles, taken from his popular Amateur Robotics column. His website, **www.seanet.com/~karllunt**, contains a wealth of hobby robotics information and tools.

Circle #42 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:

Lots of little circuits, along with some more serious designs. TVI filter for taxi noise and a sub-woofer filter. Video fade to black control and three-lead fan explained. Reader fixes flaw in June's gameshow buzzer.

A Color By Any Other Name

Q. In your June '03 column, the reader said the C in Y/Cb/Cr stood for Component. I always thought that when color video was coded with a separate luminance part (component?), the color portion was called Chrominance and was determined using two other signals. This was more useful than RGB because the luminance was available directly as a B/W signal, while for three phosphors, the green could be derived by subtracting red and blue from luminance (Y). I don't know where the Y comes from, but I suspect the C stands for Chrominance.

Jim
via Internet

A. Depending on who you talk to, the C in Y/Cb/Cr can stand for Chrominance (CIE), Chroma (broadcast industry), or Component (manufacturer) — hence, the reason for the Y/Pb/Pr (Progressive Component) used in manufacturing circles. Y/Cb/Cr Color Space, where lower case b means blue and r means red, was developed as part of the Recommendation ITU-R BT.601 for worldwide digital component video standard and is used in television transmissions.

Y/Cb/Cr is a scaled and offset version of the YUV color space where Y represents luminance (or brightness), U represents color, and V represents the saturation value. Here, the RGB color space is separated into a luminance part (Y) and two chrominance parts (Cb and Cr).

The historical reasons for this choice over RGB were to reduce storage and bandwidth. Since the eye is more sensitive to change in brightness than change in color, the reduction in bandwidth requirement seemed a valid trade for little or no visual difference.

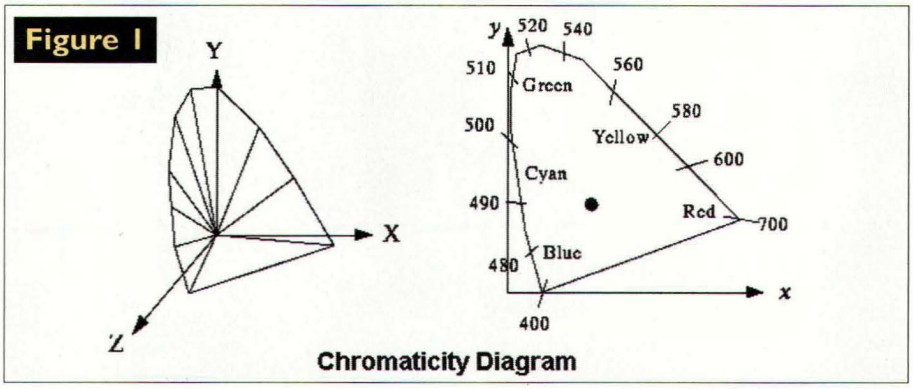
As for the origin of Y, in 1931 the CIE defined three standard primaries: X, Y, and Z. The Y primary was intentionally chosen to be identical to the luminous-efficiency function of the human eye.

All the visible colors are then represented in a horseshoe-shaped cone in the X-Y-Z space. If we assume that the plane X+Y+Z=1 and project it onto the X-Y plane, then we get the CIE chromaticity diagram shown in Figure 1.

At A Crossing

Q. My application is for a model railroad crossing signal. I want to have two LEDs flash alternately, but slow enough to look realistic (about one second apart). I plan on using a 12-volt SPST miniature relay, but how

Figure 1



Chromaticity Diagram

do I connect it to provide an alternating signal?

Ted Asousa
via Internet

A. Why use a relay when a much smaller, less power-hungry 555 chip can do the same thing? What you need is a simple astable multivibrator with the LEDs connected to the output (pin 3), as shown in Figure 2. When the output goes high, the bottom LED lights; when it goes low, the top LED lights. Want the ding-dong, too?

This flasher can also be used as an attention-getter for advertising displays and toys. The flashing rate can be adjusted by the 1uF capacitor. The larger the capacitance, the slower the rate. Moreover, the flasher rate is not voltage sensitive — any voltage between 5 and 15 volts will work.

Simple DC Motor Driver

Q. I have a small DC motor that I'm trying to turn on and off at measured intervals to turn a small, gear-driven device (the rest of the details I won't bore you with). I have found a circuit that uses a 555 timer to turn an LED on and off repeatedly, and have played with the capacitor to time things about right, but do I use the voltage that is turning the LED on and off to:

1) Drive the motor (it won't).
2) Use a transistor to switch the motor on.
3) Use a relay to switch the motor on.
4) Let the 555 drive a servo.

Scott Vore
via Internet

A. The 555 is able to provide up to 200 mA of drive current, so either your motor demands more current than the chip can supply, or the Vcc voltage doesn't match the motor's voltage. As to which driver to use for your "toy," it depends. Probably the most universal would be a relay. This configuration (Figure 3) completely isolates the integrated circuit from the motor, which gives you the widest range of voltage and current options. In this configuration, the relay coil voltage must equal +V.

Your other option is a transistor driver. By their very nature, transistors are voltage, current, and polarity sensitive — but they are still well-suited for small DC motor control. When the motor voltage isn't within the 5- to 15-volt range of the 555 timer, the NPN circuit on the left is the one to use. In this configuration, the transistor behaves like a solid-state relay — as long as the breakdown voltage and collector current meet or exceed the demands put on it by the motor. When the motor voltage is in the range of 5 to 15 volts, but the current draw is in excess of 200 mA, the PNP circuit on the right is preferred. Why? Simply because it's better to break the positive line rather than the ground line when turning off power to the motor.

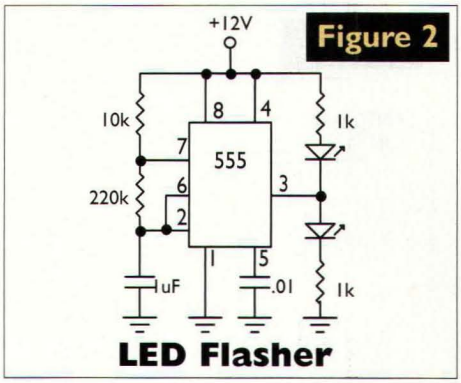
555 Schmitt Trigger

Q. I have a small 0-20 hour kitchen timer, and I want to install a louder alarm that will latch on until I manually reset it. I've removed the piezo noise maker (which sounded for 60 seconds) and checked the waveform (ugly) of the piezo driver. I cleaned up the waveform using a 555 Schmitt trigger and now have a nice, pulsating DC signal that I want to use to trigger and latch a relay. The new alarm will connect to the contacts of the relay. Any help you can provide would be greatly appreciated.

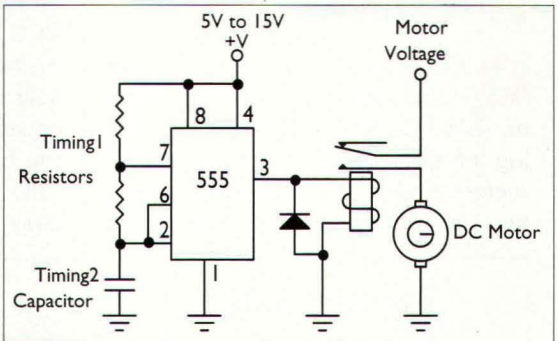
Jerry B.
via Internet

A. It's easy to add a latch to a 555 Schmitt trigger, as shown in Figure 4. In this configuration, the output (pin 3) goes high when the trigger input (pin 2) is grounded, and goes low when the ground is removed. With that in mind, it's easy to see how the addition of a transistor

Figure 2

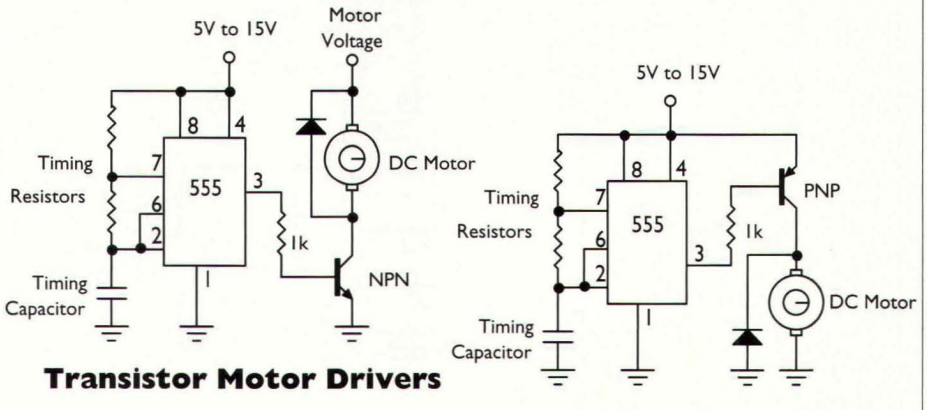


LED Flasher



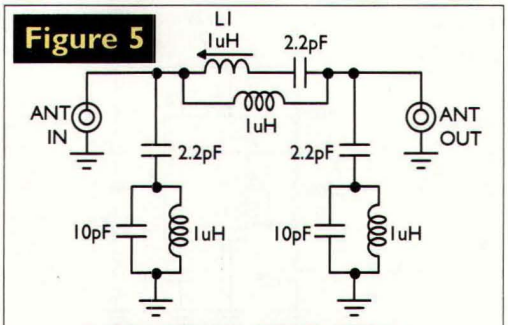
Relay Motor Driver

Figure 3



Transistor Motor Drivers

Figure 5



162-MHz TVI Filter

from the output to the trigger input can cause the circuit to latch. When pin 3 goes high, base current flows through the transistor and turns it on, which, in turn, grounds pin 2. This condition will remain until the base current is removed (pin 3 low) by grounding the reset input (pin 4).

An AC voltage with a swing of three volts or better is all that's needed to trigger the circuit. If your piezo driver's output voltage isn't up to the task, add the small-signal amplifier shown in the box to the lower left.

New Crop Of Cheap EDA Software

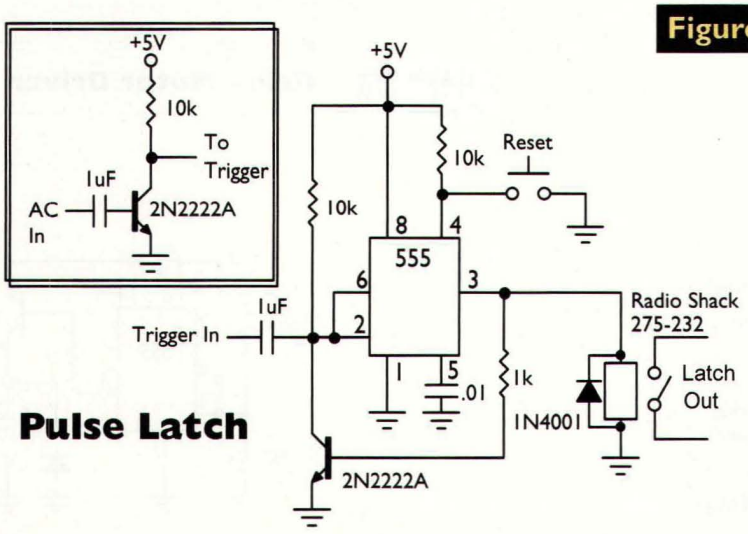
Q. Could you recommend a circuit design software program for use on IBM PCs. The software I'm thinking of allows you to simulate ICs, meters, and so on. Ease of use would be a primary consideration. Moderate cost ($200.00 or so) would be okay.

Tony Serra
via Internet

A. Up until a week ago, I would have said to download a *free* copy of CircuitMaker — the Student version — at **www.microcode.com**. It lets you draw schematics and simulate your design. But thanks to email messages from readers Dennis McMillan and Brian Roth, you now have a second option — AutoTRAX EDA (**www.autotraxeda.com**). Like CircuitMaker, it lets you draw schematics and simulate designs — plus, it lets you make a printed circuit board (PCB) of your circuit. Best of all is the price. The Lite version sells for just $45.00, with the full version tipping the scales at a mere $95.00 (at the time of this writing). A demo version is free.

If you don't mind working with just passive components (resistors, capacitors, inductors) with or without an ideal op-amp — no transistors, no VCO, no ADC — Schematica Software (**www.schematica.com**) sells a dynamite shareware program called eSketch — priced at $29.00 for the Light Edition and $69.00 for the PRO version. The schematics are easy to draw, but aren't magazine quality. Instead, eSketch has an excellent Spice simulator that creates performance curves for everything from simple voltage magnitude to Monte Carlo analysis. In fact, I used it to design the filter for the following question "Taxi TVI Blues."

Figure 4



Pulse Latch

Taxi TVI Blues

Q. I hope you can help me with a problem with a serious TV interference problem. My friend's elderly parents live in an urban area where they have to use an outside antenna for TV reception because they can't afford the luxury of cable. He asked me to look at their antenna system to see if I could improve the reception. After inspection, I decided to upgrade the antenna and install coax cable for the downlead.

The new reception proved quite good, except that at times a dark interference pattern runs up and down the screen. I have had some experience with TVI and recognized this as such. Up on the roof again and what do I see about 100 yards away? A single rod antenna on the building next door! It turns out to be a taxi company broadcasting on 162.110 MHz.

I've tried various methods to get rid of this interference, but all have proved to be fruitless. Even an FM trap didn't work (I think it's the wrong frequency). So, my question then, is it possible to build or buy such a filter?

Bob Drought
via Internet

A. What you need is a TV notch filter tuned to a frequency that resides between cable channels 20 and 21. You could buy a channel 21 filter from the local cable company and hope it does the trick, or build one yourself using the circuit in Figure 5. Just be aware that this is no easy chore because any stray wire will detune your circuit.

Basically, the design is a three-pole pi-filter tuned to 162 MHz. I have selected the capacitors and inductors

to be the same value to reduce inventory, with the exception of L1, which has to be a variable inductor.

Construct the filter using the shortest leads possible, preferably on a printed circuit board, and use quality RG/59 connectors for the ANT IN and ANT OUT (they, too, have to be very close to the filter components). Simply adjust L1 until the interference disappears. Be aware, sloppy construction can make or break this filter.

If you don't feel up to the task, Rainbow Electronics (**www.rainbowkits.com**) provides a TV Notch Filter kit (DF-222) of similar design that can be adjusted to filter out this frequency. One last thing — because of the close proximity to the taxi company's transmitter and your TV antenna, you may never be able to remove 100 percent of this interference.

Keep The Cool

Q. I like to keep my projects cool using a small fan. I recently purchased a fan for a project and noticed a third (yellow) lead in addition to the normal red and black wires. Doing some testing, I discovered that there was a 12-volt squarewave between the red and yellow leads, whose frequency varied with the fan speed. By connecting an LED and dropping resistor between the yellow and red leads, this seems to work very well as a power-on indicator. However, I don't know how the squarewave is generated and what would be the best method of utilizing this for power-on indication.

Ray Heller
Manassas, VA

A. The yellow wire is connected to an open-collector transistor that produces a pulse train in proportion to the fan's speed. Typically, this wire is used as a tachometer output to control fan speed under varying voltage and load conditions. By connecting an LED between the 12-volt line (red wire) and the tachometer output, you inadvertently created a "fan-spinning," a.k.a. power-on, indicator. At stall, though, the LED may not light — even with the power on.

A big problem in fan control is the nonlinear behavior of the fan with respect to input voltage. The typical fan does not even begin to rotate until about three to eight volts is applied. And this voltage is subject to variations with temperature and age. By building a tachometer inside the fan, full voltage can be applied for a high-torque, fast start, then feathered back to maintain the desired speed.

Figure 6 shows how to adjust and maintain the speed of the fan using a control voltage and tachometer feedback. The control voltage is applied to the non-inverting input and the feedback is applied to the inverting input.

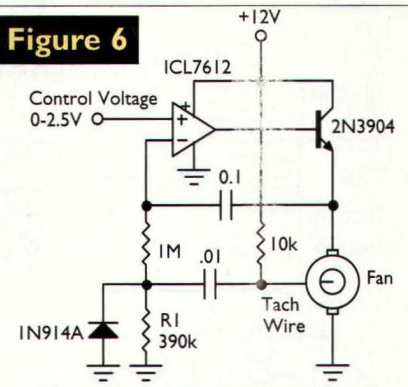
The feedback loop contains both differentiation and integration — the time constants of which have to be found empirically for a given make and model of fan (once found, they can be fixed for the same model). The values shown work for the majority of fans of this genre; resistor R1 determines the range of the control voltage: 390k = 0 - 2.5V, 180k = 0 - 1.25V.

Woof Woof, No Bow Wow

Q. I am thinking of building a subwoofer using the signals from my stereo speakers. I want to combine the signals and feed them through a low frequency filter into a high-impedance amplifier. Can you give me some ideas?

Stan
Port St. Lucie, FL

Figure 6



Fan Speed Controller

Cool Web Sites!

Remove all SMDs safely with Chip Quik and a solder iron. I've tested it and it lives up to its braggin'. Free samples from:
www.chipquik.com

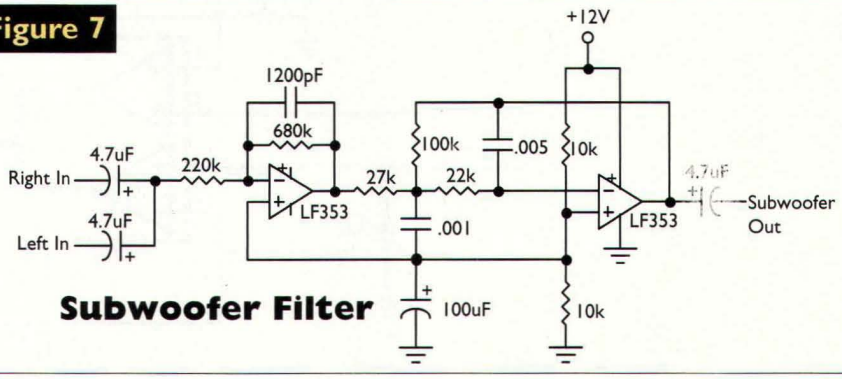
Twist Your Noodle Brain Teasers
http://chipcenter.com/eexpert/dashby/archive_tyn.html

Ohm's Law Calculator. Three calculators to determine the missing value in an electronic circuit.
www.eworld.contactbox.co.uk/calc/calcohms.htm

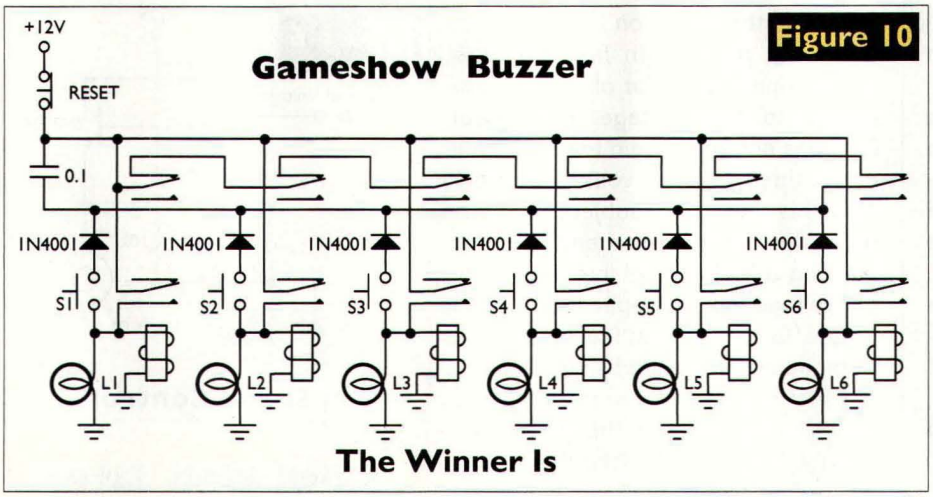
Find your birthday in the numerical sequence of Pi.
www.angio.net/pi/piquery

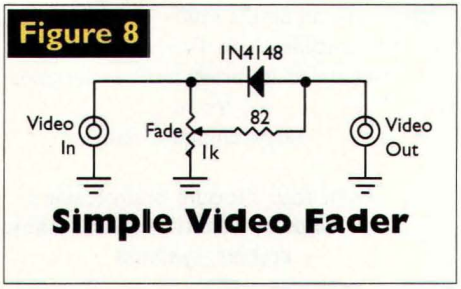
A. Sure, and here it is (Figure 7). This circuit uses two op-amps to accomplish the task. The first is a low-pass filter with a cut-off frequency of about 150 Hz. The second filter sharpens up the roll-off frequencies so that you don't get a hard boom below 10

Figure 7



Subwoofer Filter





Hz or above 200 Hz. Realize that this circuit is designed for use with 15- to 18-inch woofers in a good reflex baffle or horn enclosure. Anything smaller would be speaker suicide.

Fade To Black

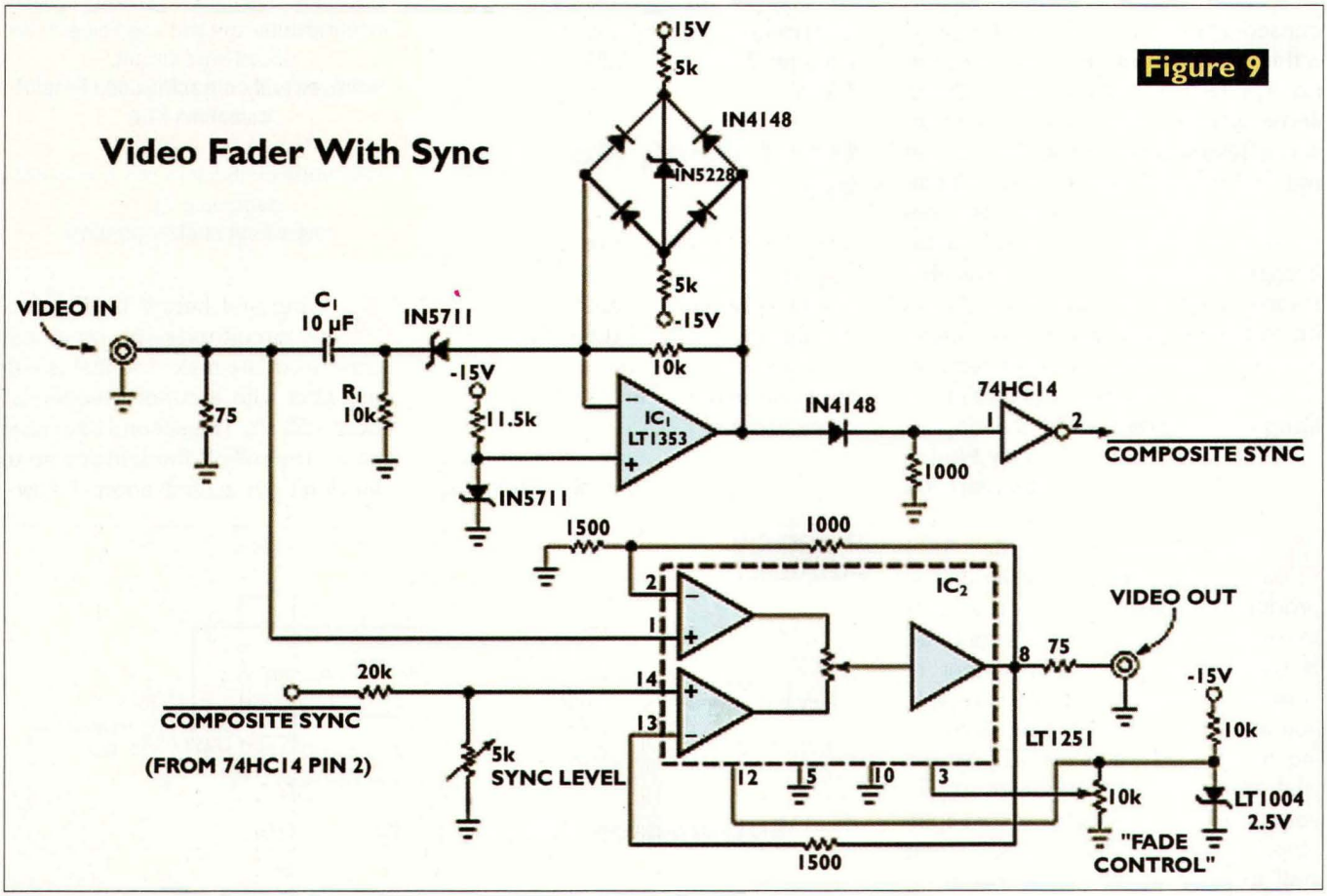
Q I'm helping my church make a video fader simply because we can't afford the $100.00 that a commercial unit costs. If you know any video fader circuits, I would like to know of them.

Unsigned
via Internet

A If I read your question right, you want to dub video from one VCR to another to make a presentation "movie" and would like to fade to black between clips. The simplest circuit uses a variable resistor with an isolation diode, as shown in Figure 8.

However, the impedance matching and amplitude levels aren't correct for all situations, and I can't guarantee it will work reliably. But given its simplicity, it doesn't hurt to try.

One of the problems you may encounter with the above circuit is the loss of sync as you advance the fade control, which will cause the picture to roll and tear. To keep this



from happening, you have to separate the sync signal from the video signal using a sync separator, then recombine them at the video output. Linear Technology has simplified this process with the LT1251 video fader and voltage controlled amplifier (Figure 9).

This chip contains two current-feedback op-amps that feed a common output. The gain of the op-amps is individually controlled to adjust the amount of signal each contributes to the output. IC1 separates the sync from the composite signal, buffers it via the 74HC14, and passes along the signal to the lower amp of the LT1251. The 5k Sync Level pot adjusts the amount of voltage it takes to keep the picture faithful as you fade to black.

MAILBAG

Dear TJ:

If you build the "And The Winner Is!" project in the June '03 column, make sure to note that is uses momentary push-button switches. Having built a very similar circuit years ago, I ran into a problem with multiple lights coming on.

This was due to the fact that I used regular push-button switches, not momentary ones. If you use regular push buttons with the circuit shown, multiple lights will light if the first player holds their button down.

Ted Gerutta
via Internet

Dear TJ:

In reference to the circuit design for the "And The Winner Is!" in the June '03 issue, if the first contestant holds down the switch, the latched relay will send power back through the switch, keeping everyone else's switch enabled and resulting in multiple lights. The simple answer is a diode in series with each switch to block power feedback (Figure 10).

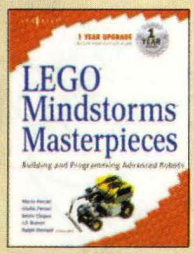
Brad Lieffring
via Internet

Selected Titles for the Electronics Hobbyist and Technician—

The Nuts & Volts Hobbyist Bookstore

Robotics

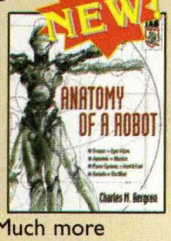
LEGO Mindstorms Masterpieces: Building and Programming Advanced Robots



While many LEGO books exist that show step-by-step instructions, they lack substantially detailed explanations about the building techniques used by the builders and the general concepts that are fundamental to the projects. These reflections are the foundation of LEGO MINDSTORMS Masterpieces. The goal of this book is to present very sophisticated projects with the maximum level of detail. In the book, you will find not only high-quality step-by-step instructions for building all of the robots, but also a complete description for each of them, including goals, building techniques, programming techniques, and the theory supporting the designer's choices. ***$49.95***

Anatomy of a Robot

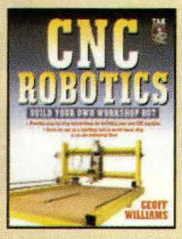
by Charles Bergren



Discover how robots articulate movements, how they see and hear, what gives them their power, and, at times, their gentleness. Delve into the robot's "brains," and learn how experienced robot designers use control systems to make their machines think. Much more than an enumeration of parts, Anatomy of a Robot exposes the life and human creativity behind today's robot. Always entertaining, this exceptional book takes you deep inside the theory and craft, philosophy, and science of robotics. **$29.95**

CNC Robotics

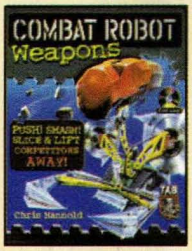
by Geoff Williams



CNC Robotics gives you step-by-step illustrated directions for designing, constructing, and testing a fully functional CNC robot that saves you 80 percent of the price of an off-the-shelf bot — and that can be customized to suit your purposes exactly, because you designed it. Written by an accomplished workshop bot designer/builder. **$34.95**

Combat Robot Weapons

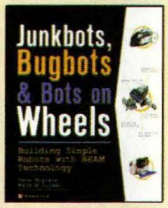
by Chris Hannold



Build combat robots that smash, slash, and pummel their way to victory with McGraw-Hill's Combat Robot Weapons. Including detailed information on weapon construction, fight strategy, and tips from combat robot guru Chris Hannold, this practical guide delivers everything you need to know to add a wide variety of weapons to your robots. **$24.95**

JunkBots, Bugbots, and Bots on Wheels: Building Simple Robots With BEAM Technology

by David Hrynkiw / Mark Tilden



Ever wonder what to do with those discarded items in your junk drawer? Now you can use electronic parts from old Walkmans, spare remote controls, even paper clips to build your very own autonomous robots and gizmos. Get step-by-step instructions from the Junkbot masters for creating simple and fun self-guiding robots safely and easily using common and not-so-common objects from around the house. Using BEAM technology, ordinary tools, salvaged electronic bits, and the occasional dead toy, construct a solar-powered obstacle-avoiding device, a mini-sumo-wrestling robot, a motorized walking robot bug, and more. Grab your screwdriver and join the robot-building revolution! **$24.99**

Building Robot Drive Trains

by Dennis Clark / Michael Owing

This essential title is just what robotics hobbyists need to build an effective drive train using inexpensive, off-the-shelf parts. Leaving heavy-duty "tech speak" behind, the authors focus on the actual concepts and applications necessary to build — and understand — these critical force-conveying systems. **$24.95**

Everything you need to build your own robot drive train:

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* Motor Types: An Overview
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* Using RC Servo Motors
* Using Stepper Motors
* Motor Mounting
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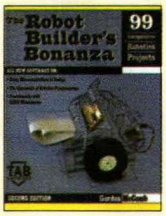
* Electronics Interfacing
* Wheels and Treads
* Locomotion for Multipods
* Glossary of Terms/Tables, Formulas

The Robot Builder's Bonanza

by Gordon McComb

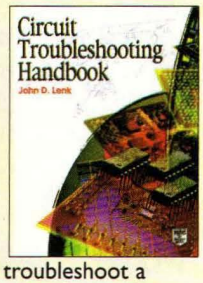


A major revision of the bestselling "bible" of amateur robotics building — packed with the latest in servo motor technology, microcontrolled robots, remote control, Lego Mindstorms Kits, and other commercial kits. **$24.95**

Troubleshooting

Circuit Troubleshooting Handbook

by John D. Lenk

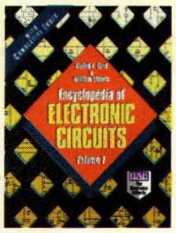


When it comes to troubleshooting, no other book even comes close — hundreds of circuits are covered in this exhaustive handbook. Heavily illustrated with diagrams and schematics, it uses an easy-to-follow format to help readers understand and troubleshoot a wide range of circuit types, and provides proven circuit testing techniques for all levels of instrumentation. **$39.95**

Electronics

Encyclopedia of Electronic Circuits Vol. 7

by Rudy Graf



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 *Sixth Edition*

by William B. Ribbens

This new edition explains electronically controlled (EC) vehicle motion control systems including advanced suspension, electric power steering, 4-wheel steering and electric brakes. The braking systems are part of an integrated motion control system that couples ABS brakes, traction control, and variable vehicle dynamics for enhanced stability. Also covers the development of hybrid/electric vehicles. **$39.99**

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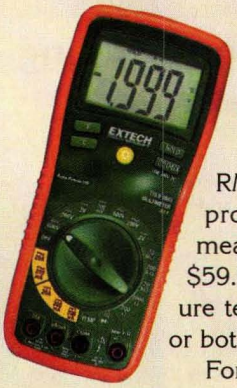

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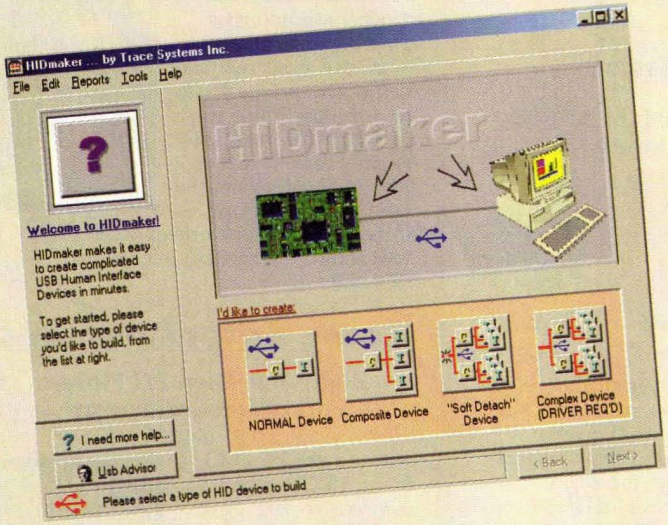

Trace Systems' new HIDmaker software completely automates the complex task of designing USB peripherals. Use HIDmaker's Visual Data Designer to define the data to be sent over the USB. Then, HIDmaker writes two kinds of programs: one kind for the PC (in Visual Basic, Delphi, and C++ Builder), and one kind for a PIC-based peripheral (in PicBasic Pro, MPASM, Hi-Tech C, and CCS C).

These two kinds of programs already know how to talk to each other over the USB, using the Human Interface Device (HID) class. No device drivers to write or distribute. No "descriptors" to write. No need to spend weeks learning arcane USB rules: HIDmaker does the job in minutes.

HIDmaker Test Suite contains two programs. The USBwatch program lets you see the USB traffic going to and from your USB device, even during "enumeration," when the PC decides whether or not to accept your device. The AnyHID program can test any USB HID device, even if you didn't design it yourself. AnyHID comes with source code, in multiple programming languages.

Prices: HIDmaker $399.00, HIDmaker Test Suite $149.00, and HIDmaker Combo (HIDmaker + HIDmaker Test Suite) $499.00.

For more information, contact:

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Circle #144 on the Reader Service Card.

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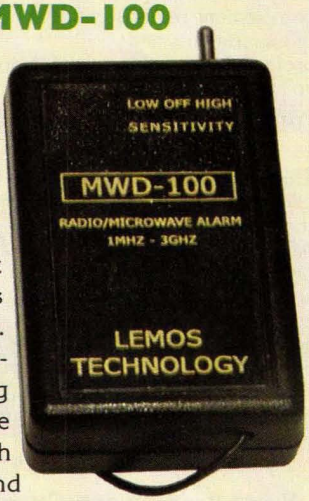

This device uses state-of-the-art technology. The mobile "video/audio detector" offers a frequency range of 1MHz-3GHz. It is the only unit that will reliably detect even 2.4GHz wireless video/audio transmitters. Even the new spread-spectrum transmitting devices will be detected. The MWD-100 is supplied with internal patch-antenna and external whip for body worn applications. The price is approximately $149.00.

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- Frequency Range: 1-3,000MHz
- RF Sensitivity: 40dbm@1GHz
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- Alert Indicator Vibrating Motor
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- Dimensions: 45mm x 40mm x 15mm

The MWD-100 is best used by women or men who think they are being illegally watched — whether in their rented homes, apartments, hotel rooms, etc. It is also good for the business person who is concerned about industrial espionage.

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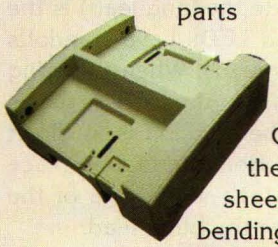

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Circle #146 on the Reader Service Card.

by John Carter

Ben Clock — Part 2

Put the finishing touches on your "Ben Clock."

This month's article will give all the details you need to complete construction of the Ben clock.

CONSTRUCTION

Printed Circuit Board

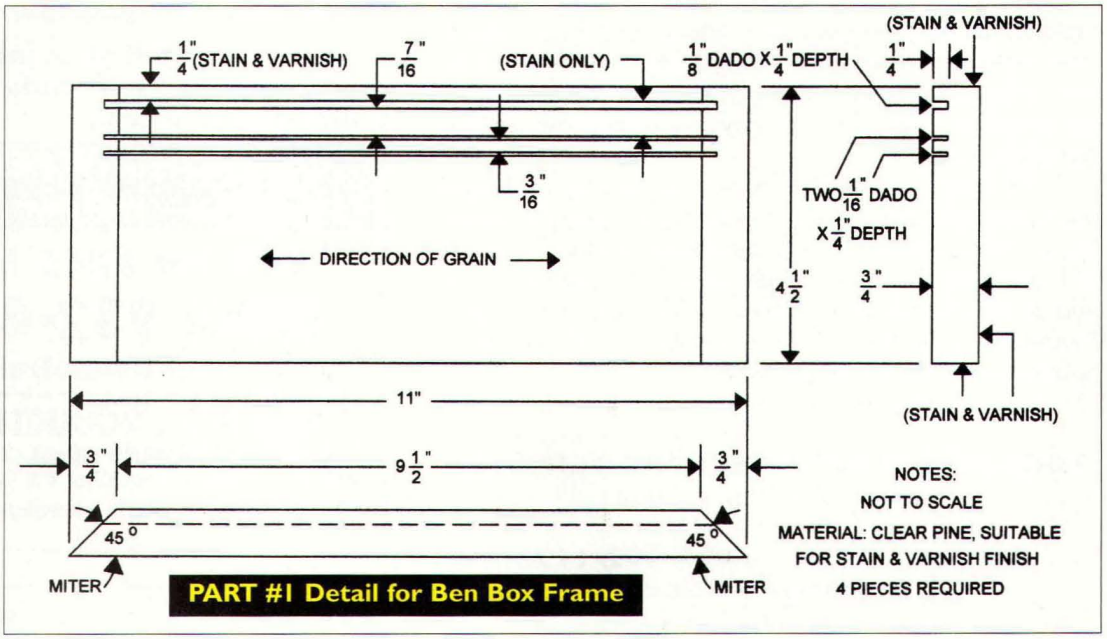
To conclude PCB assembly, solder the remaining non-LED components onto the PCB. If you wish, you may socket the ICs for easier repair and debugging. I highly recommend using a socket for the microcontroller. Pay careful attention to the orientation of the ICs. Note that the ICs are mounted on the PCB in every conceivable direction. (This is done to allow use of a two-sided PCB for layout considerations.) Also, pay careful attention to the orientation of the components.

The only components which may be inserted in either direction are the resistors and disc capacitors. You should also solder in the battery connector at this stage, but do not connect the battery until later.

Note that variable capacitors C4 and C5 are optional. The variable capacitors are used to adjust the timebase of the clock for super-accurate timekeeping. This adjustment is described in the "testing" section of the article below. I have found that the clock keeps very good time without using these optional components. If you do decide to use C4 and C5, then do not use C1 and C2. Conversely, if you do use C1 and C2, then do not use C4 and C5.

Finally, you may solder in the LEDs. You should solder in one LED at a time. If you use the LEDs called for in the parts list, the longer lead is the anode. The flat portion of the LED base (opposite the long lead) is the cathode. The specified LEDs have standoffs incorporated into their leads. When soldering the LEDs, press them into the PCB as far as they will go so that the standoff is in direct contact with the PCB. Hold the LED in place with your finger and tack-solder one of the leads. Then fully solder the other lead.

Once the second lead's solder has solidified, re-solder the tacked lead correctly. This will guarantee that the LED is correctly positioned on the board. Make sure you use the right color of LED in the right hole. The outermost ring should be yellow LEDs. Green



PART #1 Detail for Ben Box Frame

This Month's Projects

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!

LEDs are used for the innermost ring. The bars in the center of the unit are red LEDs. Be very careful when inserting the LEDs into the board to get them oriented correctly.

Unsoldering the LEDs is particularly difficult since the holes are intentionally made small to facilitate holding the LEDs in place during soldering. When handling the circuit board, be careful not to scratch the LED lenses. I recommend using a piece of felt or velvet when placing the board with the LEDs face down on a table during construction.

Once fully assembled, the PCB should be checked before putting it into the case. Connect the transformer and rear panel connector into the board.

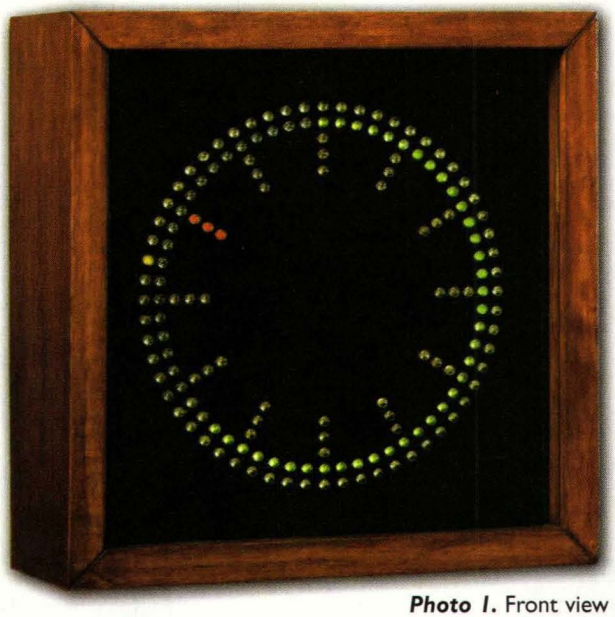


Photo 1. Front view of prototype lit at 10:37.

Casing

I have included diagrams of the wooden pieces comprising the unit's casing. The prototype was finished using a cherry stain with a spray glossy varnish finish. Of course, you can use any color finish or glossiness you desire. When staining, you will want to get stain into the slots. This is because the inside of the slots will be visible through the glass plate. After the stain dries, you may proceed with varnishing. Be careful not to get varnish into the dado slots of the frame pieces.

A good way to avoid this problem is to place a piece of cardboard into the slots before varnishing. If you get varnish into the dado slots, it will make the slots too small to accommodate the glass, Plexiglas faceplate, and PCB. Also, avoid varnishing the angled (mitered) areas of the case since the angles will join together later to provide a tight frame around the unit.

Once the finish on the wooden pieces has dried, you may assemble a portion of the case. The frame pieces should be held together with a corner vise or U-clamps to facilitate assembly. The angled (mitered) corners should be lined up precisely as like a picture frame. The small blocks are then screwed into the inside of the frame pieces. You may pre-screw all eight of the small blocks to hold the case together. You can then unscrew two of the blocks to remove one side of the frame. This will leave you with a U-shaped frame. The glass, Plexiglas, and PCB are later slid into the slots.

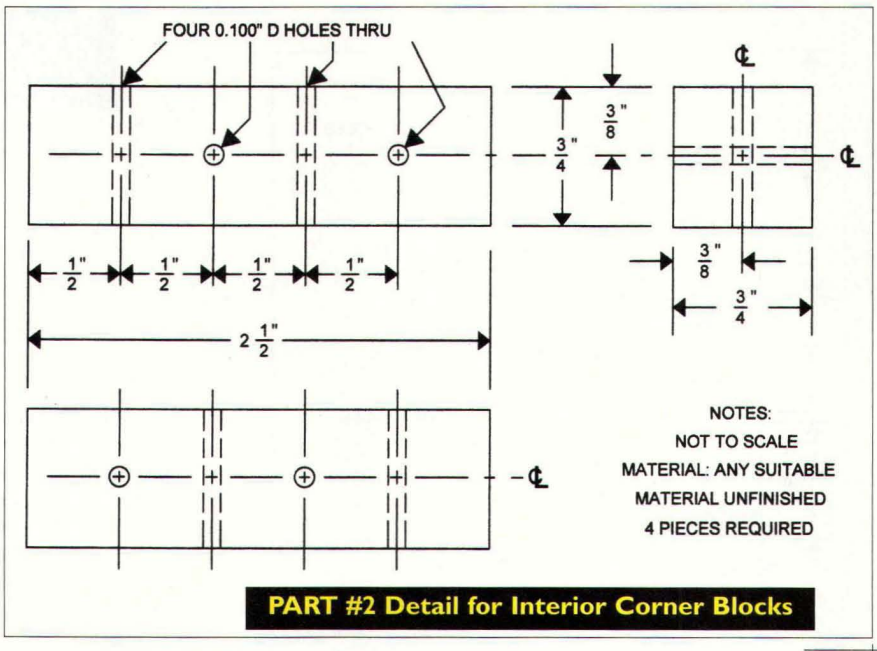
I did not finish the rear panel of the unit since I intended to place the back of my clock against a wall. If you intend on placing the clock in an area where the back would normally be visible (such as on a desk), you will probably want to finish the back of the unit, as well.

Rear Panel Assembly

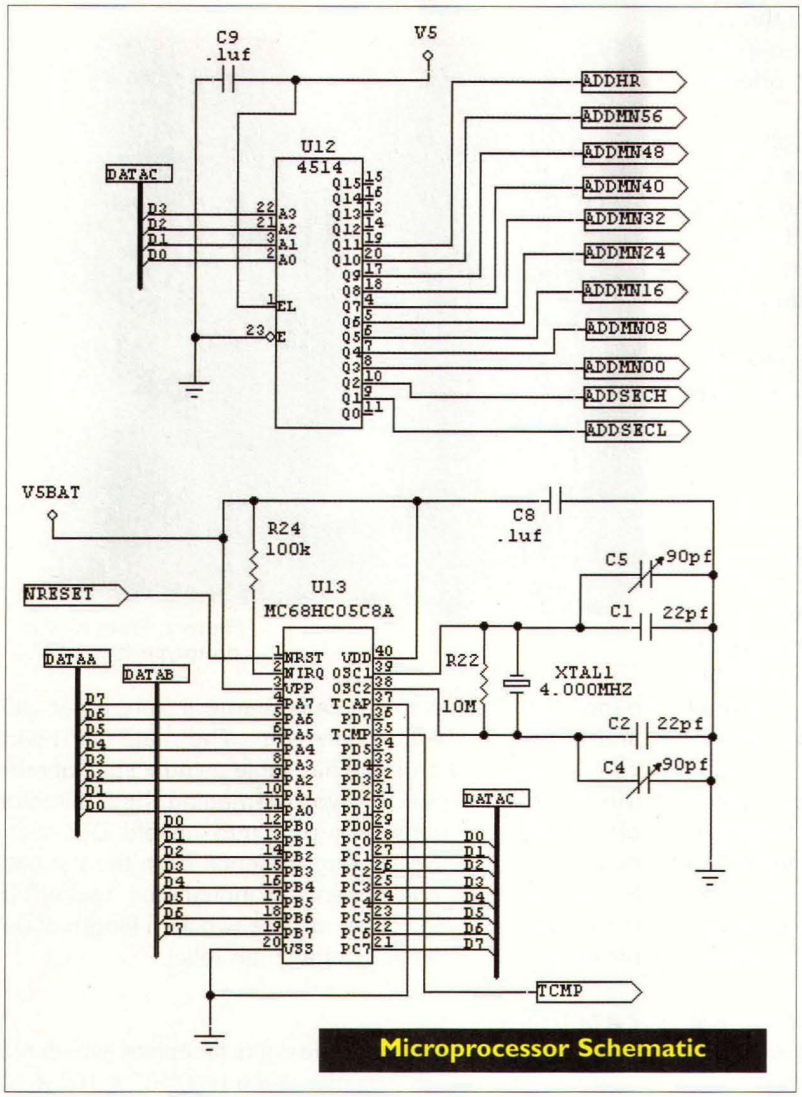
The volume control, push buttons, and speaker are mounted on the rear panel. You must create a cable harness from a flat cable and male DIP header connector. The male DIP header can be squeezed onto the flat cable using a special crimp tool or ordinary vise. To avoid damaging the connector's pins, place the connector pins into an old DIP socket before crimping. Solder the wire ends from the flat cable to the rear panel components as indicated. I "tacked" the flat cable to the rear panel using a two-inch length of double-faced tape. This acts as a strain relief.

Faceplate

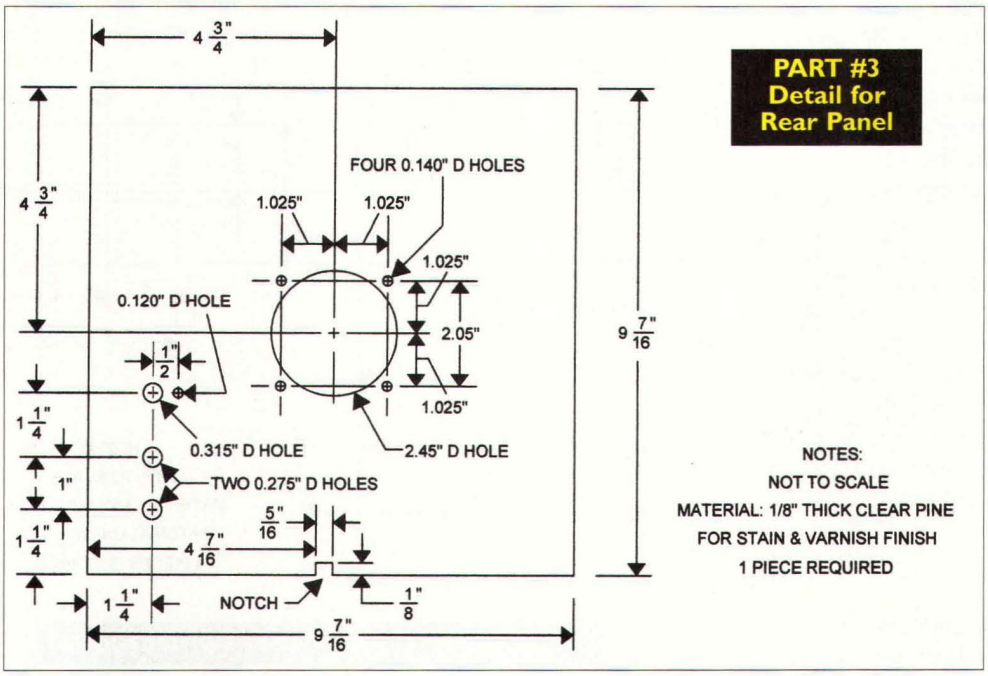
The clock has a black Plexiglas faceplate, which rests over the LEDs. The Plexiglas plate is 1/16" x 10" x 10". I used a black colored material, but you might wish to



PART #2 Detail for Interior Corner Blocks



Microprocessor Schematic



experiment with different colors. A drilling template is provided to allow precise drilling of the faceplate. ***Warning***: Do not use a normal drill bit to drill Plexiglas. Any attempt to do so will cause shattering and staring of the Plexiglas material. To avoid these problems, use a specially-machined Plexiglas drill bit. I purchased such a bit from W. L. Fuller, Inc., in Warwick RI (phone: 401-467-2900). I believe a cheaper alternative might be G.E. Polymershapes in Farmingdale, NY (phone: 631-293-9090). I originally used a 5.5 mm bit. Since the lights are 5 mm, this allows a bit of play. Do not remove the protective covering on the Plexiglas until the final assembly stage.

Since Plexiglas scratches very easily, I decided to put a glass plate into the casing, as well. The glass plate is easier to clean, and is much more resistant to scratching. I purchased a 1/8" x 10" x 10" glass plate from my local hardware store.

Testing the PCB

Connect the transformer wiring harness to the PCB and plug in the unit. The LEDs should immediately begin flashing in a particular pattern. Specifically, the right yellow LED (second 15), top green LED (minute 00), and bottom red bar of LEDs (hour 6) should be lit followed by the left yellow LED (second 45), all the green LEDs (minute 59), and the top red bar (hour 12). The pattern will repeat every 1/2 second.

When you get this far, most of the circuitry is being exercised. I have also added a more comprehensive test mode into the unit. By shorting out pins 1 and 2 of the test connector J2, a test pattern will emerge on the display. Specifically, the yellow seconds LEDs will race around the face in a clockwise pattern. The green arc of LEDs will "grow" around the face. The red hours LEDs will also race around the face. In addition, the test mode should cause the speaker to generate a precise 2 KHz tone. You may also check the volume control at this point. While in test mode, adjust resistors R3 and R4 to make the brightness of the yellow and red LEDs match the green LEDs.

Although the unit provides excellent accuracy in its timekeeping function, the test mode jumper can be used to precisely trim the internal crystal oscillator. If you wish to trim the oscillator, connect a frequency counter or oscilloscope to the Frequency Adjust Output (pin 5) of connector J2. Then trim the optional variable capacitors C4 and C5, to attain an exact 2 KHz output. (If you are using variable capacitors C4 and C5, then you should leave out fixed capacitors C1 and C2.) Note that since the Frequency Adjust Output is digital and buffered, the scope or frequency counter's test lead load characteristics are inconsequential. Once you finish this optional trimming, remove the test mode jumper.

Now, check the time-setting buttons. The top button on the rear panel will cause the time to increase. The bottom button causes the time to decrease.

At this point, you may temporarily connect the battery. Set the display to the correct time using the time-setting buttons. Unplug the unit and wait one minute. Then, plug the line-cord back in. The display should refresh within one second and indicate the correct time. Unplug the unit and remove the battery. At this point, the electrical checkout is completed.

Final Assembly

Disconnect the transformer and rear panel connectors from the PCB. Also make sure the battery is disconnected. Using 90° angle brackets, mount the transformer into the bottom of the wooden frame. Tie a knot into the line cord to act as a strain relief. The knot should be

BEN KIT OPTIONS

The following kits are available from Carter Electronics at our eBay store. Please visit **http://stores.ebay.com/CarterElectronics**. For technical information, contact the author via e-mail at **jtc0000@optonline.net** All kits (and the pre-assembled unit) are subject to availability. US, PayPal orders only. Allow 6-8 weeks for delivery. (Add 8.75% sales tax for NY orders). Pricing information is available at the eBay store.

BEN KIT 1. Includes:

- Double sided, plated-through PCB fully drilled with solder mask and silk screening for easy part placement
- M68HC05C8ACP Microcontroller (OTP plastic package), preprogrammed

BEN ASSEMBLED. Includes:

- Fully Assembled and tested unit

OTHER COMPONENTS

- Face plate variations are available. Check the eBay store for options.

PLEASE NOTE

Schematics and other files relating to building this project can be downloaded from the *Nuts & Volts* web site.

www.nutsvolts.com

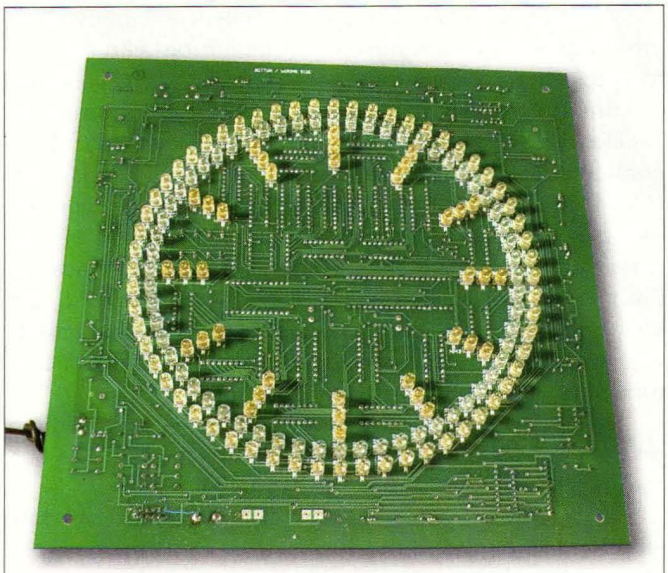


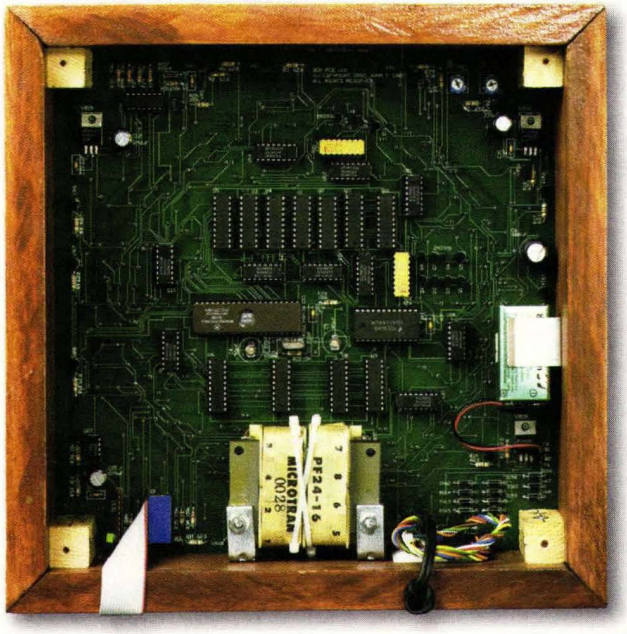
Photo 2. PC Board assembled — wiring side (LEDs).

about five inches from the PCB.

For these next steps, I recommend you use a pair of gloves to avoid cuts and fingerprints. First comes the glass. Be careful handling glass as the sharp edges can easily cut you. You should clean your glass plate first. The best way to clean glass is by using Windex and old newspaper. Newspaper is much more lint free than paper towels. Slide the glass into the outermost slot of the wooden frame.

Next comes the Plexiglas. Do not handle the Plexiglas face-plate with your bare hands. Peal the protective plas-

Photo 3. PC Board assembled — component side (chips).



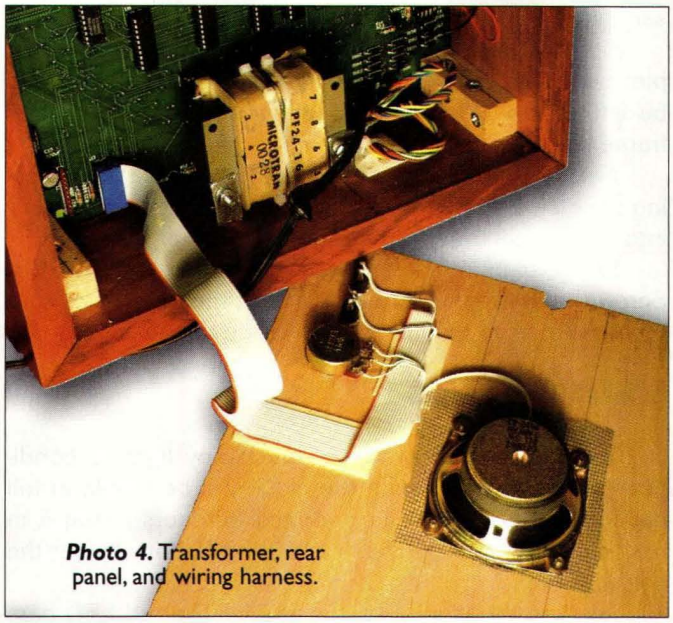


Photo 4. Transformer, rear panel, and wiring harness.

tic film off the Plexiglas plate. If you do get fingerprints on the plate, remove them with an eyeglass cleaning cloth (available at Sunglass Hut). Do not use Windex to clean the Plexiglas. If you use Windex, the finish on the Plexiglas will become foggy. I have noticed that even plastic cleaners leave scratches and fogginess.

Since the Plexiglas plate is symmetrical, it does not matter how you orient it on the LEDs. Align the Plexiglas plate over the LEDs with the black, glossy side facing outward. Press the Plexiglas onto the LEDs as far as it will go. The Plexiglas should rest on the base of the LEDs approximately 1/8 inch away from the PCB.

Now slide the PCB and Plexiglas faceplate into the slots of the two innermost slots of the U-shaped wooden frame simultaneously. You may have to pull the Plexiglas

Photo 5. Casing with top removed (U shape containing PCB, Plexiglass faceplate, and glass).

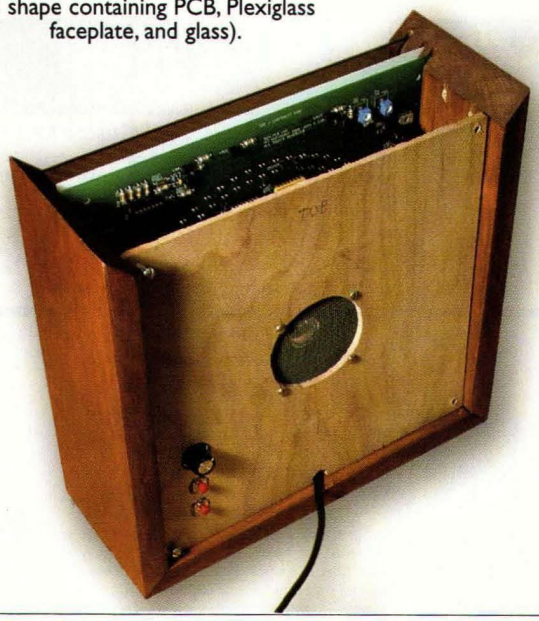


plate slightly away from the LEDs to line up the faceplate with the slots.

Now slide the glass into the outermost slot of the U-shaped wooden frame. The glass, Plexiglas, and PCB should all "fall" into the bottom slot of the frame. If necessary, jiggle the plates to make this happen.

Complete the frame assembly by screwing in the last piece of the frame into the open part of the U. You should be left with a closed frame similar to a picture or box frame.

Next, screw the battery holder into the side of the casing near the battery connector. You may snap the battery into the connector and the battery holder at this point.

Lastly, plug in the rear panel connector into the PCB. Screw the rear panel into the back of the unit. Make sure that the knot on the line cord is inside the casing.

USING THE CLOCK

The clock may be placed under any lighting conditions you wish. (Although the clock will be visible in full daylight, it should not be operated outdoors.) Plug it in and set the time. Use the time-setting buttons to set the correct time.

Reading the clock is quite simple. The red LED bars indicate the current hour. The green arc of LEDs grow from the 12 o'clock position. The longer the arc, the deeper you are into the hour. For example, at 12:00 the top green LED is lit (indicate minute 00). At a quarter after the hour, 16 green LEDs will be lit (indicating minute 15). At 59 minutes past the hour, all 60 of the green LEDs will be lit. One of the seconds LEDs will always be lit to indicate the current second.

You may wish to adjust the volume control for the desired sound level. The clock chimes at the top of the hour, and every 15 minutes thereafter. Enjoy!!! NV

You can contact me via e-mail at **jtc0000@optonline.net**. I will be happy to answer any questions you might have.

by William Sheets and Rudolf Graf

Lamp Controllers for Special Effects

Add a little something to everyday lights around your house with these evening projects.

This article describes two simple AC lamp or load controllers. One controller is activated by audible sounds, such as a conversation, a door opening or closing, dog barking, or any other random sound. The other is a controller for simulating the flickering light from a candle or a fire. This is useful for holiday effect lighting, such as Christmas tree lights, or for example, replacing the candle in a Halloween jack-o-lantern with a somewhat safer light source. They are completely electronic and use ordinary incandescent lamps of up to several hundred watts total load. This allows a much brighter light than expensive and delicate flicker flame bulbs.

Unlike a device that is frequently advertised on TV, the sound-activated controller is not for turning appliances on and off. It is for the purpose of special lighting effects, such as flashing holiday decorations with music, speech, or any other such noise. It can handle up to several amperes AC load at 12 to 120 volts, such as low voltage outdoor lighting, holiday lighting and decorations, or any other resistive load.

The electronics of this device can be configured to operate from a small DC or AC power source or battery, or to derive its power from the AC line, as the load switching can handle up to 120 volts (up to 250V AC can be handled by using higher voltage semiconductors and changing the value of one resistor) and can be AC and DC isolated from the rest of the circuitry. Low voltage operation is a safety advantage and may be used for hobby and experimental applications in which it is preferable to eliminate the possibility of accidental contact with the AC mains.

Referring to the wiring and application diagram in Figure 1, these controllers can be wired to control a lamp or other fairly resistive load from 12 to 240 volts. The sound-activated controller operates from a sound such as speech, music, or even naturally occuring sounds such as a dog barking, thunderstorms, auto horns, traffic, etc. The flicker controller is very simple with regard to circuitry, and nicely imitates fire or candlelight.

Both controllers are externally connected in exactly the same manner. Each controller has four wires — two of which are used for supplying the device electronics. One of these wires is connected to the ground foil trace on the PC board. The other two wires are connected to a solid state AC switch circuit using an optoisolator and a triac. These are electrically isolated from the ground foil and PC board electronics, and may safely be connected to the "hot" side of the AC line exactly as a conventional AC switch is wired.

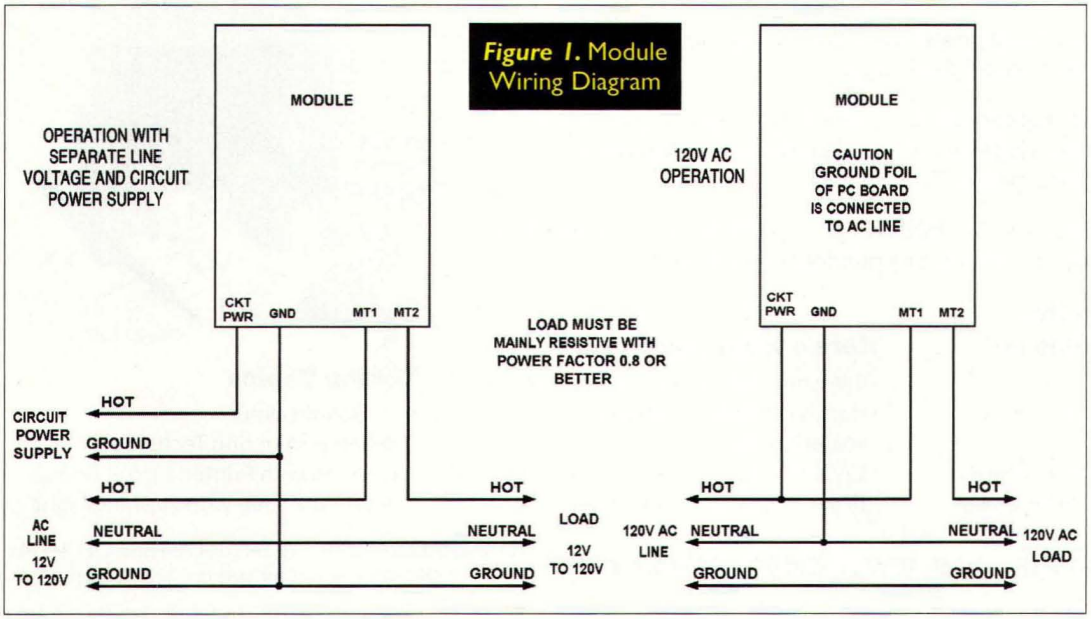


Figure 1. Module Wiring Diagram

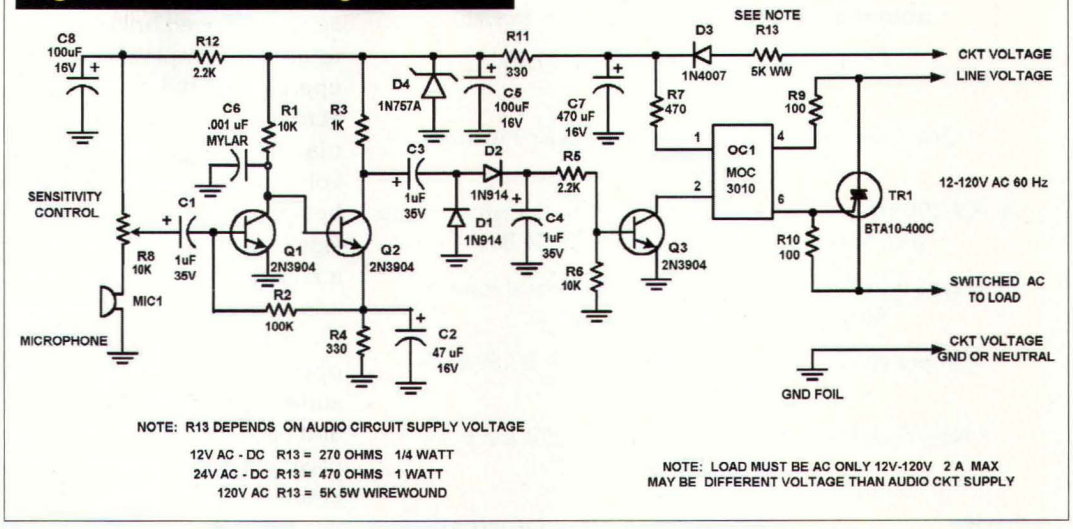
This avoids unsafe switching of the neutral AC lead, which leaves a turned off lamp (or other load) still "hot" and connected to the hot side of

the AC mains. Electrical codes generally forbid a switch in the neutral wire for this reason. While the optoisolator adds a little to component costs, it is the safest and best way to deal with a potentially unsafe situation.

Referring to the schematic of the sound activated controller in Figure 2, a triac TR1 is wired as a series switch. The AC line is connected to main terminal MT1. The triac receives its gate triggering current from the AC line through isolator OC1 via resistor R9. OC1 consists of an integrated bilateral phototransistor and an infrared LED. When the LED is activated, the phototransistor conducts and passes AC to the gate of the triac, causing it to turn on. R9 limits surges that could damage OC1, and R10 ties the gate of the triac to the mains terminal MT2, reducing the chances of stray triggering when OC1 is off. Since the internal LED is electrically isolated from the internal phototransistor and only optically coupled, there is no electrical contact between the AC load circuit and the control circuitry. This allows for a much safer design without line isolation problems.

The LED in the optoisolator is turned on by a DC current of 15 mA switched by transistor Q3. Q1 and Q2 are set up as a high gain audio amplifier. Sounds picked up by electret microphone MIC1 are fed to the base of Q1 through sensitivity control R8 and C1. R12 and C8 provide filtered DC bias to the mike through R8. Q1, Q2, with resistors R1, R2, R3, and R4 and capacitors C2, C3, and C6 make up an audio amplifier with a voltage gain of over 500. Audio signal from C3 is rectified via D1 and D2, and filtered by C4. DC across C4 of a volt or more will cause Q3 to conduct, turning on the LED in the optoisolator. R7 limits this current to 15 mA. Zener diode D4, along with C5, R11, C7, and D3 make up a simple half-wave rectifier supplying the +8 volts at 20 mA needed for the audio amplifier and optoisolator.

Figure 2. Sound Activated Light Controller



The candle flicker circuit is somewhat simpler. Referring to Figure 3, a PIC microprocessor IC1 is used to generate a random waveform. The time constant of (R1+R2) and C2 determines the waveform pulse rate. R1 and R2 produce a 15-to-1 variation in resistance. This is necessary for setting the desired flicker rate, and also depends on the lamp filament thermal time constants. Smaller lamps (10 watts or less) with thin filaments heat and cool faster than large

PRICES

- **Sound-activated Controller Kit:** $24.95
- **Flicker Module kit:** One: $19.95 Two: $39.50
- **One Sound-activated & one Flicker Module kit:** $39.50
- A 14V 200 mA AC output wall transformer suitable for use with these modules is available for $9.85.
- Please include $6.00 + $1.00 each additional item for Postage and handling (US orders).
- Orders outside US, please add $10.50 + $3.50 each additional item.
- New York state residents must add 8.25% sales tax on all orders.

Visit www.northcountryradio.com for information.

lamps (200 watts or more). Zener diode D1, C1, D2, and R6 make up a +5 volt supply of about 15-20 mA capacity for the optoisolator. R3 limits the current through the LED to 15 mA. The output pin of the chip switches to ground or five volts, turning on and off the optoisolator OC1. R4, R5, and the triac TR1 operate in the same way as in the previous circuit.

In this case, in our opinion, a better effect is obtained using a diode D3 across the triac. This allows the lamp to light at reduced brilliance when the triac is off, rather than to go out completely. When the triac conducts, the lamp operates at full brilliance. D3 could have been placed across pins 4 and 6 of the optoisolator as well, using the triac exclusively to conduct the lamp current, but a 250-volt diode would still be needed anyway, and with diodes being so cheap, the smaller diode did not really allow any significant cost savings. If desired, D3 can be omitted for a stronger flicker effect. This is a matter of personal taste and esthetics, and either way will work equally well.

Again, R6 generates significant heat with 120 volt operation and should be kept away from the PC board surface for air circulation. The flicker effect is very nice and allows use of ordinary clear, frosted, or colored bulbs of your own preference. An advantage of this is that an entire string of holiday lights can be driven at once. Use two or more of these circuits to drive several bulbs or light sets for a scintillating effect.

The triac used in these circuits is a 10 amp, 400 volt unit. A two or three amp device would do, but triacs are relatively cheap, and the 10 amp devices will handle a surge better than a three-amp device. (A 600 or 1,000 volt rating would be recommended for 208-240V operation). Incandescent lamps can draw a large current spike on powering up, and often internally arc over when they burn out, causing a large current spike before their internal fuse goes. Many times fuses and breakers are blown by an incandescent lamp undergoing its death throes, and this current surge can easily destroy a triac, diode, or other solid state device. We do not recommend using a load of more than two to three amperes with just the PC board as a heatsink, as shown in Figures 4 and 5, unless the triacs are heatsinked to a larger metal mass. Up to 10 amps is possible with adequate heatsinking, and a small finned heatsink should get you five to six amps.

The case of these triacs is electrically isolated from the device terminals, but it would be wise to mount them to any heatsink using insulating hardware and mica insulators

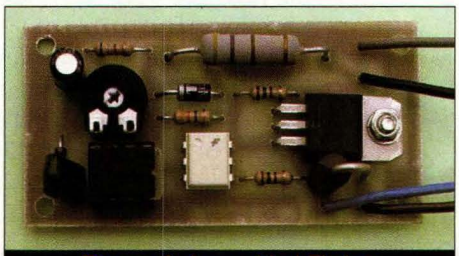


Figure 4. Assembled Flicker Controller Board

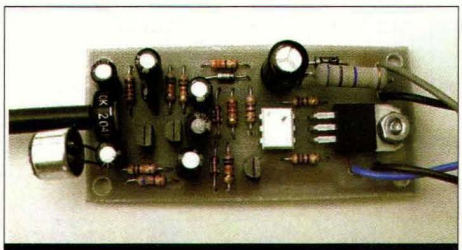


Figure 5. Assembled Sound-Light Board

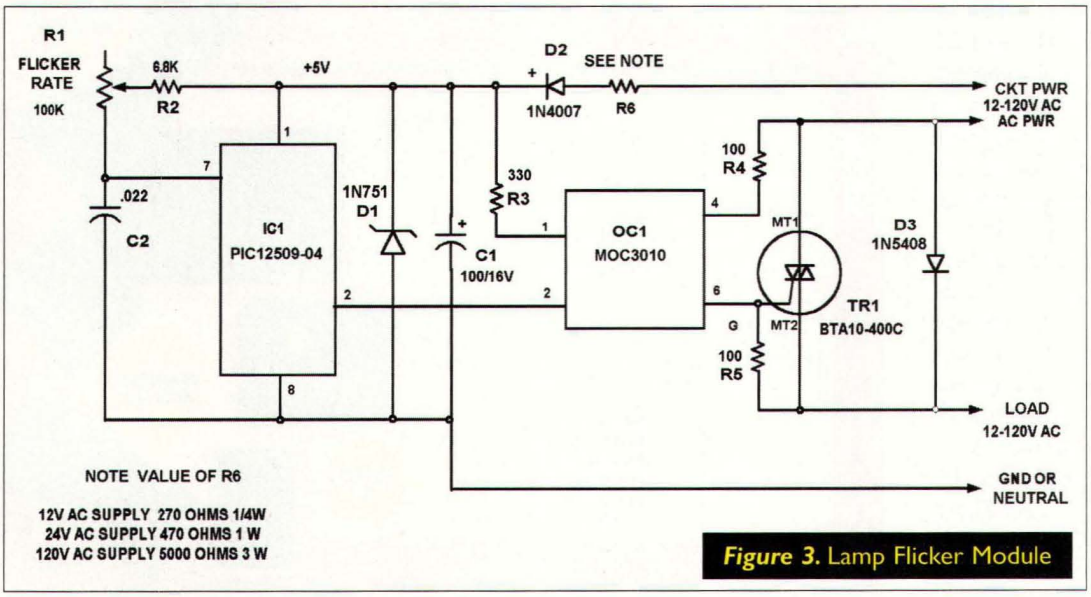


Figure 3. Lamp Flicker Module

between the device and heatsink surface. This will be much safer in case a device failure causes the device terminals (MT1 and MT2) connected to the AC line to internally short to the case of the triac. Surprisingly, no RFI supression was found necessary, as little electrical noise is generated since the triac is operated mainly in the zero voltage switching mode. It is perfectly possible to listen to an AM radio only one foot from the circuitry.

Testing should be done using a 12- to 24-volt AC source, with the appropriate dropping resistor (R13 or R6, respectively) and a small lamp (a small 12V automobile bulb #67, 1004, 1893, 89, etc.) will work well. While the electronics will work okay on DC, *note that the load must be AC-powered. DC loads will not work*, as reversal of the load current must occur to turn off the triac again once it is triggered. If 120V line voltage operation is required, you can just change R13 or R6 after testing.

Testing is quite simple ... just hook up the module as in Figure 1 and see if it works. If it does, then you are done. There is little to go wrong, except for bad solder joints or incorrectly placed or installed components. In the case of the sound activated switch, set R8 in the middle of its range. Speaking at a normal voice anywhere in the room should cause the light to flash. Adjust R8 for desired effect. In the case of the flicker module, the lamp should start to flicker almost immediately on power up. R1 varies the flickering rate. Adjust for desired effect. C2 can be changed for faster or slower rates, if desired.

These circuit boards can be wired to take their operating power from the 120V AC line, as long as the boards and their wiring are mounted in an electrically non-conducting waterproof housing, using plastic or other non-conductive hardware. This must be done in such a way so that accidental personal electrical contact with the circuitry is impossible. If this is done, use only approved listed hardware and wire in accordance with the local electrical codes; 120V AC, and especially 208-240V AC, can be very dangerous and is responsible for more serious electrical shocks than any other voltage sources. Also, do not use these circuits with anything having a significant reactive component or a built-in transformer, as there is a DC line component produced in some instances. This includes both compact and standard flourescent lamps, as well as gas discharge lamps. Only incandescent lamps should be used.

Lamp dimmer switches (depending on make and type) may sometimes work with these circuits, although often erratically and a little differently than normal.

Direct 208-240V 50 or 60 Hz AC operation is possible by doubling the value of R6 or R13 specified for 120V, and using a 600 to 800V triac in place of the 400V device specified. A 10-watt resistor will be required, as there is double the power dissipation. This may be too large to fit the board and should be mounted separately. In fact, you might want to consider powering the electronics from a small wall transformer or other source. As mentioned previously, the modules should be mounted with insulated hardware so that contact with the AC line is impossible. *Do not* use metallic hardware for mounting these boards to anything, as the hardware could concievably contact a component on the PC board, causing a shock hazard.

There are many applications of these modules. While the triac circuits should have a resistive load (which rules out standard and compact flourescents, gas discharge mercury, and sodium lamps), most holiday and party decorations and special-effect lighting is implemented with incandescent or LED lamps. (LED lamps are okay with these modules, as they are mainly a resistive load). The only limitation that may be a disadvantage is when the use of UV lamps with flourescent decorations, such as flourescent wall murals, and for Halloween (ghosts, haunted hous-

PARTS LIST
Sound-Activated Light Controller

Resistors 1/4 W 5% Unless Noted	
R1, R6	10 KΩ
R2	100 KΩ
R3	1 KΩ
R4, R11	330Ω
R5, R12	2.2 KΩ
R7	470Ω
R8	10 K potentiometer, PT10YH style
R9, R10	100Ω
R13	5000Ω 3W to 5W WW (for 120V use)
R13 alternate value	270Ω (for 12V use)
Capacitors	
C1, C3, C4	1 uF 35 or 50V elec
C2	47 uF 16V elec
C5, C8	100 uF 16V elec
C6	.001 uF ±10% Mylar 50 or 100V
C7	470 uF 16V elec
Diodes and Semiconductors	
D1, D2	1N914B or 1N4148
D3	1N4007
D4	1N757A
Q1, Q2, Q3	2N3904
OC1	MOC3010 Optocoupler
TR1	BTA10-400 Triac
Miscellaneous Items	
MIC1	Electret Microphone
1 ea	Shaft for R8
1 ea	PC Board p/n 050503B
4 ea	4-40 Nylon Hdwe. for mtg.
1 ea (for low voltage operation)	Wall Transformer 12-16V AC, current to suit lamp(s) used

Figure 6. A) Front view of the pumpkin. B) Inside view of the pumpkin.

es, etc.) is desired. In addition, the dimming of flourescents is not simply a matter of reducing the supply voltage.

Many flourescent fixtures will quit at a little less than 100 volts. (Some of the bargain flourescent fixtures sold in homeowner megastores just barely will light at 90-105 volts.) A small DC current component will be present in the AC output waveform of these controllers that could overheat the ballasts, creating a possible fire hazard. Small neon and cold cathode lamps of the glow lamp variety (without reactive ballasts) are somewhat better, but still do not dim very well. For these reasons, we do not recommend using anything except incandescent lamps.

It is probably best to put up with the rotten efficiency of incandescent UV sources if dimming and flickering UV flourescent displays are required. Use of 120-volt light strings and sets is pretty straightforward. Twelve-volt operation should be considered, using automotive or low voltage garden bulbs, especially where children may have access to the circuit, or where the possibility of water infiltration exists. These bulbs and suitable fixtures are sold by larger garden supply stores and home centers for low voltage outdoor use. They are available in clear or in several colors.

As a demo, our prototypes were mounted in plastic Halloween pumpkins and run from a 14V AC wall transformer. One pumpkin flickers to sounds, the other looks as though a flickering candle was inside it. Type 89 automotive bulbs rated six candlepower were used (about 0.5 amps current draw). Excellent results were obtained, without high voltage AC or flames — a definite safety advantage. Figure 6 shows photos of one of these pumpkins. Many other applications and configurations are possible, such as using two red or amber bulbs for eyes in this pumpkin, or in a doll, toy robot, etc.

Model railroad hobbyists can use these modules to simulate gaslight lamps, firelight effects, lightning, welding, and other similar effects where flickering light is needed, as they will work well on 12-16V AC supplies commonly used to run accessories. Two or three of these flickering light modules can be used to drive colored 120 volt bulbs to simulate a real fire in a fireplace. The modules and bulbs can be hidden behind some real or plastic dummy logs. The use of these modules, as you might see, is only limited by your imagination and creativity. **NV**

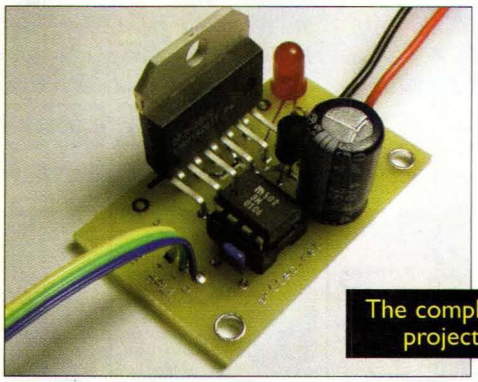
PARTS LIST
Flicker Module

Resistors 1/4 W 5% Unless Noted	
R1	100 KΩ Pot style PT10
R2	6.8 KΩ
R3	330Ω
R4, R5	100Ω
R6	5000Ω 3W TO 5W WW (120V operation)
R6 alternate value	270Ω for 12V operation
Capacitors	
C1	100 uF / 16V elec
C2	.022 uF Mylar, 50 or 100V
Diodes and Semiconductors	
D1	1N751A
D2	1N4007
D3 (optional)	1N5408
OC1	MOC3010 Optoisolator
TR1	BTA10-400 Triac
IC1	PIC12C509-04 (from author only)
Miscellaneous Items	
1 ea	PC Board p/n 060603A
4 ea	Nylon 4-40 Hdwe for mounting
1 ea	Shaft for PT10 pot 1/8" dia
1 ea (for low voltage operation)	Wall Transformer 12-16V AC, current to suit lamp(s) used

by Guy Marsden

Levitation!

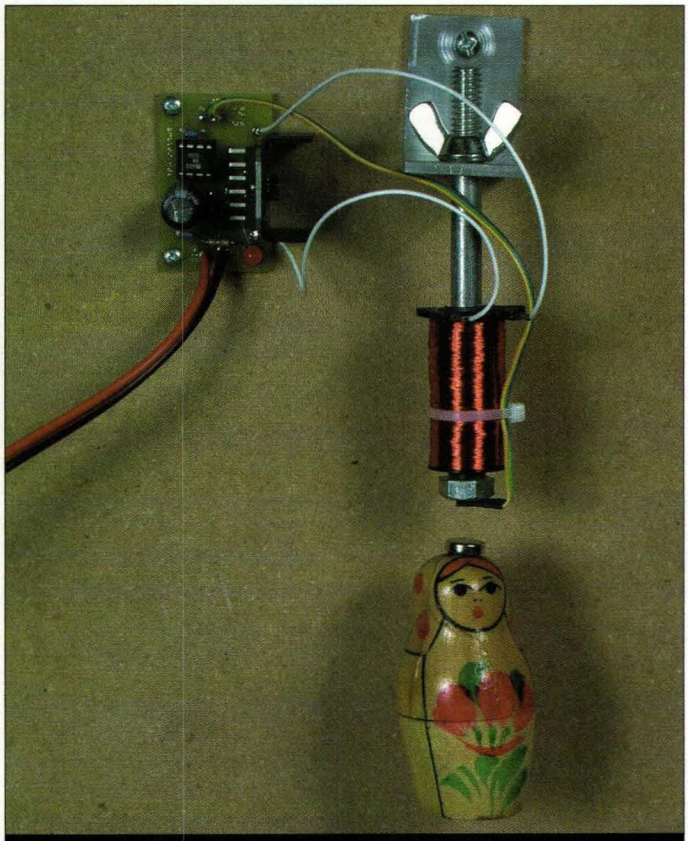
Float objects in a servo-controlled magnetic field.



The completed project.

Levitation! The word inspires images of stage magicians and lovely ladies. For me, it became a challenge to create a simple workable design to make an object hover in space. The trick obviously is to use magnets. The design problem has to do with overcoming Earnshaw's Theorem that explicitly states that it is impossible to achieve stable magnetic levitation using exclusively permanent magnets in a gravity system.

Implied in that theorem is the need for some kind of electromagnetic servo that can respond to the position of a permanent magnet and stabilize it in position. My design places a variable strength electromagnet above a suspended permanent magnet — the electromagnet is servo-controlled to hold the permanent magnet in place beneath it.



The author's test set-up, levitating a doll. Note the heatsink on the LM18201 and the placement of the Hall Effect sensor on the bolt head.

POSITION SENSOR

A servo system requires feedback from some kind of positional sensor. A simple way to sense the position of a magnet that is suspended below an electromagnet uses a light beam with LEDs on one side and a photo cell on the other. As the object moves, a shadow from its upper or lower edge partially blocks the light, and changes the corresponding resistance of a photocell so that a proportional signal is generated. The drawback to me is the visual "give away" of the light beam's components. We're going for magic here — right?

My approach is to use a Hall Effect sensor with an output that is proportional to magnetic flux. This means that the closer to a magnet it gets, the greater the signal that it produces. My sensor of choice is a Honeywell SS490 high performance miniature ratiometric linear sensor (U2). The output of this simple three-leaded device is at 50 percent of a single 5VDC supply in the absence of a nearby magnet. The output can go rail to rail depending on the polarity of the nearby magnet. A magnet with a north pole facing the sensor will drive the output in one direction while a south pole will drive it the other way. This provides an ideal servo proportional control signal.

PWM CONTROL

To make use of this signal, I wanted to drive an electromagnet with a PWM (Pulse Width Modulated) signal. This is a scheme most often used to control the brightness of DC lamps and the speed of DC motors. A repeating pulse changes its width to apply more or less power to the device over time. PWM circuits can be constructed from op-amps or timer circuits, but I wanted to keep my design very simple with a really low parts count.

In my research, I came across a chip that is used to modulate the speed of CPU cooler fans based on the resistance of a thermistor. The chip provides only as much fan speed as is needed to cool the computer, with the side benefit of a quieter running fan. I realized that the

thermistor could be replaced with any proportional signal, such as that provided by the Hall sensor. The chip is made by Micrel — part number MIC502 (U3). The pulse frequency can be set by a capacitor. A 0.1uF cap will give approximately a 100Hz signal and a 0.01uF cap will yield about 10kHz. I opted for the higher frequency as it provides a more rapid response dynamic.

ELECTROMAGNETIC DRIVER

Since an electromagnet (or solenoid coil) has a ferrous core, the suspended permanent magnet will be attracted to it. My theory for the control is that if the suspended magnet gets too close to the electromagnet above it, the electromagnet should push it away. Conversely, if it falls too low the electromagnet should work at pulling it back up, eventually reaching a balance of push-and-pull. This theory requires that the electromagnet can change polarity from attraction to repulsion in a proportional manner. I decided to use a motor driver chip that has a built-in H-bridge switch that can reverse the polarity of its output. I used a LM18201(U4) motor control chip that is well known to robotics hobbyists. It can control up to three amps (six amp peak) with the appropriate heatsink.

By wiring the PWM signal to the U4's DIR (pin 3) input and connecting the PWM input (pin 5), to 5V the electromagnet can be proportionately controlled from full reverse to full forward current. If the input signal is at 50 percent, then the net effect is equal attraction and repulsion of the suspended permanent magnet. As the permanent magnet moves further away from the Hall sensor, the duty cycle changes to a higher ratio that attracts the magnet, and the reverse.

CONSTRUCTION

Construction is fairly simple — there are no significant part placement issues. The only annoyance is the lead spacing of the LMD18201 which won't fit into 0.1-inch perfboard without a lot of bending. Be very careful to observe the pin numbering that goes left to right (long leads are odd numbered) and keep the leads apart. C2 and C3 should be as close as possible to U4 for good filtering of the motor switching spikes. I designed a small circuit board to simplify construction (see parts list).

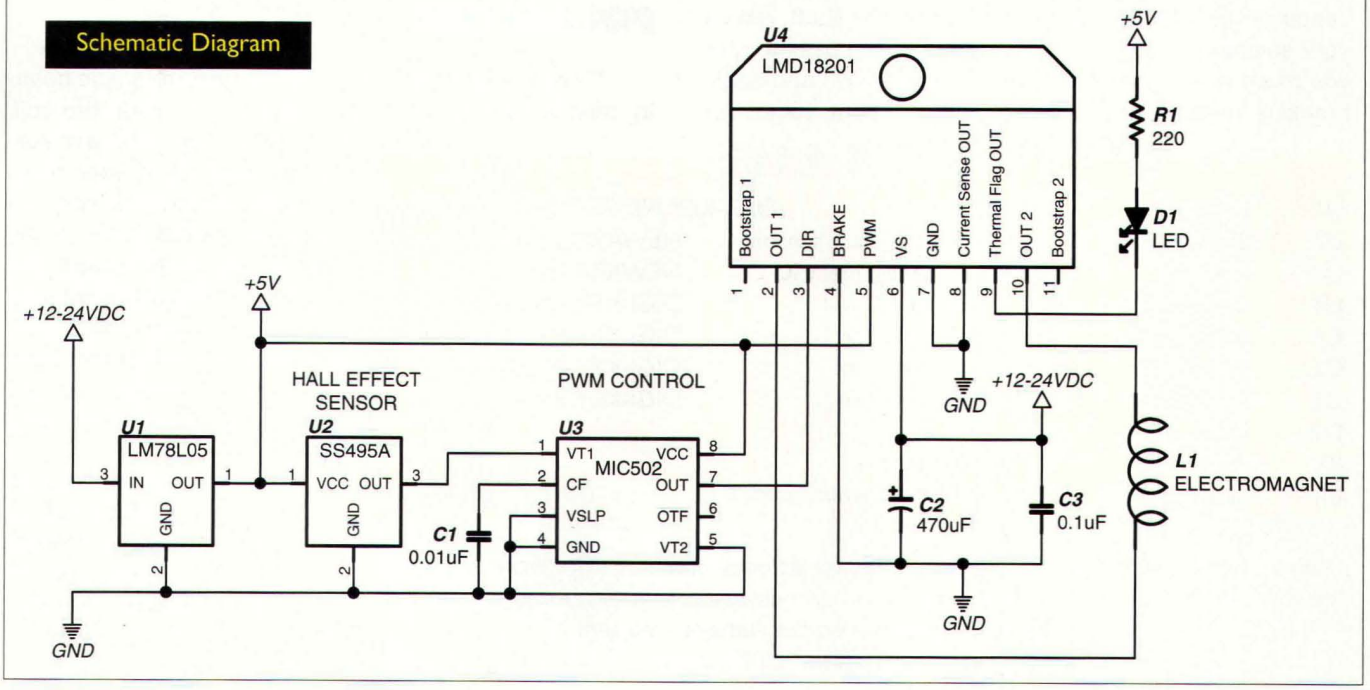
An optional LED and 220-ohm resistor can be connected to pin 9 of U4. This will give you early warning that the chip is overheating. I used a solenoid that draws less than half an amp, so I didn't bother with a heatsink. However, your electromagnet may draw more and need it. For that reason, be sure to place U4 with its tab at the edge of your board to make it easier to attach it to a large heatsink.

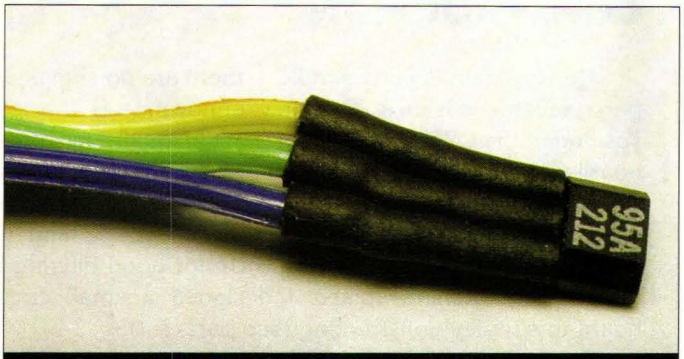
The Hall sensor (U2) should be connected with three wires — I used ribbon cable. Make sure to carefully insulate the leads at the chip with shrink tubing or tape. It's almost certain that those wires will get smashed between the magnet and solenoid as you fool around with the set-up. A bit of tape or heat shrink tubing around the body of the sensor will also help protect it from physical shock. Leave two wires with stripped ends connected to pins 2 and 10 of U4 (or use screw terminals) so that you can readily reverse the wires or swap out different coils for testing.

MAKING THE ELECTROMAGNET

The electromagnet can be any substantial solenoid.

Schematic Diagram





Suggested Hall Effect sensor wiring to prevent shorted leads during testing.

Look for something rated around 12VDC with a lot of pulling force — at least 12 oz. pull at 1/4 inch, preferably much more than that. You can wind your own from magnet wire, but be sure to calculate your current consumption before hooking it to the circuit so you don't exceed three amps or so. Anything below about eight ohms will cook U4! I made my (32 ohm) electromagnet from a spare solenoid by hacking off the end of the plunger so it sits flush with the end of the coil. Glue the shaft into the solenoid (or wrap a turn or two of tape around it and force it in). I also have used a small DC clutch as a magnet with a steel shaft inside it. An actual commercial lifting type electromagnet will work fine, too.

BUILDING A SUPPORT

It is very important that the axis of the electromagnet be perfectly vertical for this design to work. So give some thought to mounting so that it can be adjusted and leveled. The sensor should be securely taped or glued to the center of the bottom of the coil, right on the shaft. Mount your solenoid at least eight inches above the base to give you room to work. I used particle board (MDF) and angle brackets (image), and my solenoid is about 18 inches above the base, which puts the magnet above eye level when I'm sitting at my workbench.

TESTING

The circuit requires at least 12VDC from a regulated power supply — this is the minimum voltage requirement for U4. It will not work at all below about 11 volts. U4 can handle up to 60 volts, but the circuit is limited by the 78L05's max of 30 volts and the voltage tolerance of C2 and C3. This gives you the opportunity to "overdrive" 12V solenoids up to 24 volts or so to enhance the performance.

Take a small Neodymium magnet and tape it to the end of a plastic pen for testing. The magnets I used are 3/8 inch in diameter and 1/8 inch to 1/4 inch thick. They are available from many of the surplus stores advertising in *Nuts & Volts*. Don't glue it, as you may need to flip it over to get all the polarities correct. Connect your solenoid and connect power to the circuit. Power consumption should be very low — under 50mA for a 30-ohm coil like I used.

Now hold the pen in your hand and slowly move it up towards the electromagnet, keeping it directly in line below the center of the coil. As it approaches the coil within about 1/2 inch, you should begin to feel a slight push or pull. If you have a 'scope, you should see a 50 percent duty-cycle waveform at pin 7 of U3 when no magnet is present. The pulse width and frequency will change as a magnet approaches, and you will also see a lot of "hash" on the waveform as the circuit engages and switches the coil. You may also hear a squeal from your coil, depending on its construction, and you will feel the coil switching as a vibration as you move the magnet around near it.

POLARITIES

Three things need to be in the correct magnetic polarity relative to each other in order for it to work: the coil, the Hall sensor, and the suspended magnet. If your magnet pulls toward the coil, try reversing the coil wires. If the magnet still pulls toward the coil, try reversing the orientation of the magnet. Eventually, you will know which combination works when you feel the pen pushed away as it gets close to the coil.

Of course, if your magnet gets too close, it will be attracted to the core of the electromagnet and smack into it, potentially crushing the Hall Effect sensor, so take care. If you have a current meter on

PARTS LIST

U1	LM78L05	5-volt regulator	DIGI-KEY NJM78L05A-ND
U2	SS495A	Honeywell Hall Effect sensor	NEWARK 52F1662
U3	MIC502	Micrel Fan Management IC	NEWARK 05C4623
U4	LMD18201	Motor control IC	DIGI-KEY LMD18201T-ND
C1	0.01uF 50V	monolithic capacitor	DIGI-KEY P4963-ND
C2	470uF 35V	electrolytic capacitor	DIGI-KEY P5168-ND
C3	0.1uF 50V	monolithic capacitor	DIGI-KEY P4923-ND
D1	LED	LED	
R1	470 ohm	1/4 watt resistor	
L1	electromagnet	solenoid or hand wound coil (8 ohm min. 16+ ohm good)	

Kit of parts available from the author for $40.00 includes circuit board, electronic parts, and two magnets. You will need to supply your own electromagnet. Suggested sources for electromagnets and kits are on the author's web site:
www.arttec.net/Levitation/Kit.html

your power supply, it will go up as the pen approaches from over 1/2 inch away, then go down as you hit the ideal levitation position, then go up again as you move it closer to the coil. Once you have the design tweaked, the power consumption will stay relatively low during stable levitation.

CALIBRATION

Once the polarities are right, you will feel the magnet "grab" as it enters the "sweet spot" under the coil. At this point, you should try to let the pen go very gently so you don't bump it up, down, or sideways.

If it pulls up and sticks to the coil, you will need to add more weight — try sticking another magnet to the top. If it falls away, your pen is too heavy, or your electromagnet is not strong enough. It will take some time to find the right weight that your combination of electromagnet and permanent magnet will lift. The range of viable weights is fairly small, so be prepared to do a lot of testing and changing of weights. Small plastic models like Harry Potter toys will be sure to delight the kids!

PATIENCE IS REWARDED

My design is very simple and does not use any dynamic damping as some other designs I have seen do, but those designs are very complex. You can expect the levitated object to bobble up and down a bit until it stabilizes. Adding a small amount of ferrous metal to the suspended magnet will dampen the vertical oscillations and stabilize the levitation — try small washers or nuts.

It takes some patience to learn how to carefully get the magnet into position and release it so it stays stable. It is a very spooky feeling when it all works right and the magnet pulls into place. If you start a levitated object spinning it will continue for a long time — it's a frictionless bearing!

This is the type of simple magic that evokes my favorite quote from science fiction writer Arthur C. Clarke: "Any sufficiently advanced technology is indistinguishable from magic." People young and old will marvel at your mastery of the "magic" of electronics! NV

ABOUT THE AUTHOR

Guy Marsden designs custom prototypes for inventors and controls for kinetic artworks. He also makes electronic and wood sculptures and furniture. See his extensive web site at **www.arttec.net** or email him at guy@arttec.net.

Patents 101

The US Government has a vested interest in promoting innovation — use it to your advantage!

by Danny Graves

When you have a great product idea that you want to protect and guard, the biggest and baddest guard dog in the world won't do you any good. What you need is legal protection that establishes you were the first to hatch the idea. You need the US government (the biggest and baddest guard dog?) to back you up. You need a US patent.

A patent can be used defensively to prevent others from claiming the same idea. A patent can also be used offensively to attack infringers and get them to pay you a royalty for using your idea. This article will explain where you obtain a patent, what types of patents are available, what determines patentability, costs of getting a patent, subject matter that gets special treatment, patent application requirements, acting as your own patent attorney/agent, and the difference between a patent agent and an attorney. In most cases, I will not give you the specific, lengthy, detailed information, but simply an overview and tell you where you can find more information if you need it.

Where do you get a patent?

The United States Patent and Trademark Office (USPTO) is in charge of issuing patents in the US. The USPTO has been around for over 200 years. They are headquartered in Arlington, VA. Their web site — **www.uspto.gov** — is a wealth of information including the ability to electronically search patents and pending patent applications. In addition, the Manual of Patent Examining Procedure (MPEP) is available on the USPTO web site. The MPEP is a huge document, with many chapters, that has the answer to just about every question you could have about completing a patent application. The trick is being able to ferret out the specific data you need in the massive amount of information. Having the MPEP on computer so that you can use the "find" feature of a word processor or Acrobat Reader is very handy.

The USPTO web site also includes United States Code (USC) Title 35, which contains the patent laws. In addition, the USPTO web site includes the Code of Federal Regulations (CFR) Title 37, which contains the patent rules.

These two documents, along with the MPEP, will tell you everything you ever wanted to know (and more) about patents. Of the three documents, the MPEP is the most practical since it sort of sums up the contents of 35 USC and 37 CFR. The USPTO Web site patent page is shown in Figure 1.

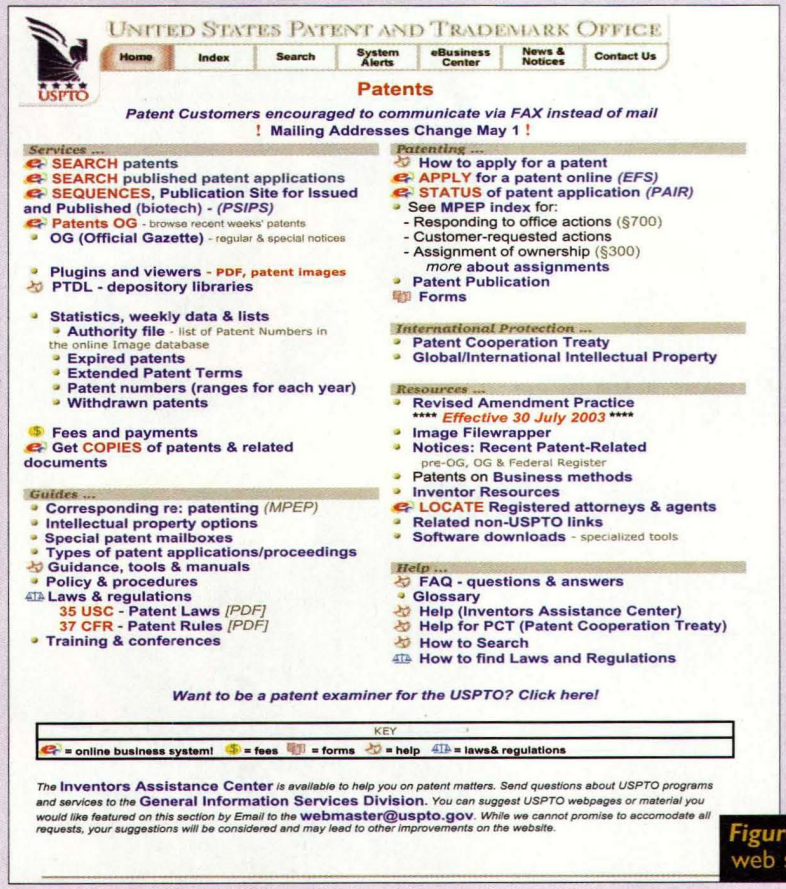


Figure 1. The USPTO web site patent page.

What type of idea do you need protected? Is it a unique shape for a cell phone, a better mousetrap, or a new variety of petunia? There are three types of patents to choose from: design, utility, and plant.

Design patents protect the way a product looks, but not the way it functions. MPEP Chapter

1500 defines the design of an article as the visual characteristics embodied in or applied to an article. It is not the article itself that is the subject of a design patent, but instead, the *ornamental design*. A unique shape for a cell phone or a novel computer icon would qualify for a design patent. Design patents are less expensive to get and maintain than a utility patent. They are also easier to get approved or "allowed" by the USPTO. It is fairly easy to have a unique design. Design patents expire 14 years from the date the patent is granted.

Utility patents are typically what people think of when they hear the term "patent." A utility patent protects the way an article *is used and works*. A utility patent is the most difficult to get approved and costs the most money to obtain and maintain. If you designed a mousetrap that works better, you would need to get a utility patent (note that if you wanted to also protect the way your mousetrap looks, you could get a design patent in addition to the utility patent). Utility patents require well-written claims (defined in the next section) in order to be effectively used as an offensive weapon (prevent others from infringing upon) in the future. The specification must also be well written — fully describing the invention — in order to be used defensively (keep others from patenting the idea). Currently, utility patents expire 20 years after the filing of the application.

MPEP Chapter 1600 covers the details concerning plant patents. Since most of you are not into gene splicing as a hobby, I will simply mention that they only cover asexually reproduced plant varieties (clones) to prove genetic stability, exclude tubers, and require that the plant is an unobvious invention. Currently, a plant patent will expire 20 years after the filing date of the application.

Parts of a utility patent application

MPEP Chapter 600 defines the parts, form, and content of a utility patent application. The main parts of the utility patent application are the specification, oath/declaration, drawings, and filing fee. The appropriate transmittal forms must also accompany the application. Figure 2 shows an example of the first page of a utility patent showing the inventor information, title, abstract, etc.

The specification is where the invention is completely described in a manner which would enable a person — skilled in the subject — to make the invention. The specification also includes the claims of the patent. A claim is a statement, of specified construction, that points out a specific, special feature(s) that you want patented. The claims portion of the specification usually begins with "We claim:" or a similar statement. Figure 3 shows the claims section of an issued utility patent. The feature that is claimed must be adequately described elsewhere in the specification. A utility patent application may have more than one claim. In fact, utility patents usually contain many claims. If there are more than three independent claims (claims that don't reference another claim), there is an additional fee ($84.00 per claim in 2003). If a claim references more than one other claim, it is termed a multiple dependent claim and there is an additional fee ($280.00 per multiple dependent claim in 2003). For any type of claims in excess of 20, there is a fee of $18.00 per claim in 2003.

If drawings are necessary to understand the invention, they must be included with the patent application. The drawings initially submitted with the patent application need not be formal. The formal drawings can be submitted later. MPEP Chapter 600 details the drawing requirements. Note that even

Figure 2. An example of the first page of an issued utility patent.

United States Patent [19]
Graves et al.

[11] **Patent Number: 6,031,451**
[45] **Date of Patent: Feb. 29, 2000**

[54] **ELECTRICAL CIRCUITS FOR TURN SIGNAL, HAZARD SIGNAL AND BRAKE SIGNAL LIGHTS**

[75] Inventors: **Danny R. Graves**, Springfield; **Timothy W. Brooks**, Cedar Hill, both of Tenn.

[73] Assignee: **ACD Tridon Inc.**, Burlington, Canada

[21] Appl. No.: **09/030,897**

[22] Filed: **Feb. 26, 1998**

[51] **Int. Cl.**[7] **B40Q 1/26**

[52] **U.S. Cl.** **340/468**; 340/458; 340/641; 340/642; 340/475; 340/479; 340/477; 307/10.8

[58] **Field of Search** ..... 340/468 OR, 458, 340/641, 642, 475, 479, 477; 307/10.8

[56] **References Cited**

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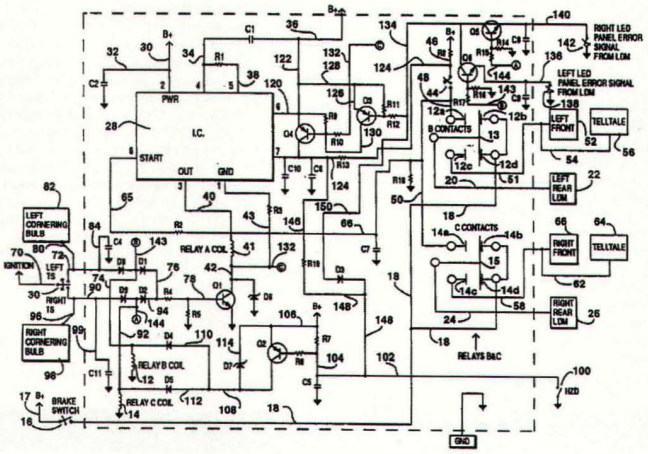
5,828,139	10/1998	Slater	307/10.8

Primary Examiner—Jeffery A. Hofsass
Assistant Examiner—Tai T. Nguyen
Attorney, Agent, or Firm—Robert F. Delbridge

[57] **ABSTRACT**

An electrical circuit for turn signal, hazard signal, and brake signal lights of an automotive vehicle has first and second relays each having an energizable coil and contacts which are in a first configuration when the coil is not energized and a second configuration when the coil is energized. A brake signal switch is operable to supply relative high steady electrical current to the first and second relay contacts, the contacts of the first relay when in the first configuration conducting the relative high steady electrical current to left rear light and the contacts of the second relay when in the first configuration conducting the relative high steady electrical current to a right rear light. The turn signal switch, when operated, also causes relative high electrical current to be supplied intermittently to the first and second relay contacts, the contacts of the first relay presenting an open circuit to the intermittent relative high current when in the first configuration and supplying the relative high intermittent current to a left front and the left rear lights, when in the second configuration to cause the left front and the left rear lights to be illuminated intermittently in a flashing manner, and the contacts of the second relay presenting an open circuit to the relatively high intermittent current when in the first configuration and supplying the relatively high intermittent current to a right front light and the right rear light, when in the second configuration to cause the right front and right rear lights to be illuminated in flashing manner. A hazard signal switch is operable to energize the coils of the first and second relays with relatively low steady electrical current to cause the contacts thereof to move to the second configuration, the hazard switch when operated also causing relatively high electrical current to be supplied intermittently to the first and second relay contacts to cause the left and right front lights and the left and right rear lights to be illuminated in a flashing manner.

7 Claims, 2 Drawing Sheets



software patents frequently include drawings.

An oath or declaration is where the inventors list their full name, citizenship, address, etc., and sign to certify the information. The oath or declaration must identify the application to which it is directed.

Parts of a design patent application

MPEP Chapter 1500 defines the required contents and order of a design patent application. A design patent essentially has the same elements as a utility patent application. Good quality drawings or photographs are obviously an essential part of a design patent application. A design patent application is required to have only a single claim which is directed at the ornamental design of the article.

Parts of a plant patent application

MPEP Chapter 1600 details the required content and order of a plant patent application. A plant patent application is required to have the appropriate transmittal forms along with the specification, drawings, oath/declaration, and appropriate fees. Like a design patent, only a single claim is permitted in a plant patent.

Is the invention patentable?

In order to get your patent allowed, you must convince the patent examiner that your invention fulfills the requirements of patentability as described in MPEP Chapter 2100. These are simply that the invention must be useful, non-obvious, and novel.

Usefulness is fairly easy to establish. Something can be useful for a variety of reasons including the fact that it provides amusement to the user. If a use has not been established for your invention, your patent may get rejected. Also, if the use is illegal, you are out of luck as far as getting a patent.

Non-obviousness is a little tricky to establish. The standard for measurement of non-obviousness is that a person working in the field of the invention must find the invention unexpected and surprising rather than apparent and expected. There is a lot of room for opinion when it comes to an invention being non-obvious. Items that seem obvious today (paper clip, safety pin, ironing board, etc.) were not obvious when they were invented.

In order for your invention to be novel, it must differ from the status quo in the field of your work. The existing subject matter in the area of your invention is termed "prior art." If the invention is already patented or described in a printed publication, you can forget getting a patent.

What will get you in trouble?

If you publicly expose your idea more than a year before you submit your patent application, you are out of luck as far as getting a patent. That means you can't write a magazine article about it, you can't sell it, you can't show it at a trade show, etc. This is true even if your idea or product is contained inside a larger machine and is not readily visible.

Be wary of invention promotion companies. They offer to represent the inventor for a hefty sum of money and then may

of transistor Q4. It will be noted that resistor R10 is connected to line 132. Enabling transistor Q4 causes the voltage across terminals 6 and 7 of flasher IC 28 to be reduced to the saturation voltage of transistor Q4, it being arranged that the saturation voltage is below the predetermined voltage, such as 85 mV required by the flasher IC 28 to induce the previously described voltage mode.

It is necessary that the above described outage mode of the flasher IC 28 be disabled when the hazard signal switch 100 is actuated. Thus, when hazard signal switch 100 is closed, lines 102, 148 resistor R19 and lines 146, 142 are grounded, thereby grounding terminal 7 of flasher IC 28. This maintains the voltage dropped across terminals 6 and 7 of flasher IC 28 above the pre-determined value, such as 85 mV, required to keep the flasher IC 28 in the normal flash mode. Also, closure of the hazard signal 100 grounds resistor R12 through lines 100, 148, diode D3 and line 150, thereby preventing left and right error switches 138, 142 from initiating an outage mode.

The function of various components of the circuit not specifically described, such as various resistors, capacitors and diodes, will also be readily apparent to a person skilled in the art. For example, the decoupling capacitors are included to minimize the effects of EMI.

FIG. 2 shows a similar circuit diagram to FIG. 1, but without the error sensing function and with the capacitors omitted for clarity. Also for clarity, the same reference numerals have been used to identify the components shown in FIG. 2 which are also shown in FIG. 1. It is therefore believed that further description of the circuit of FIG. 2 is unnecessary. Some minor changes have been made, the nature of which will be readily apparent to a person skilled in the art from the comparison of FIGS. 1 and 2. It should however be mentioned that, in this embodiment, the low current flasher IC 28 is a Telefuken U6438.

Other embodiments of the invention will be readily apparent to a person skilled in the art, the scope of the invention being defined in the appended claims.

We claim:

1. An electrical circuit for turn signal, hazard signal and brake signal lights of an automotive vehicle, said electrical circuit having:

first and second relays each having an energizable coil and contacts which are in a first configuration when the coil is not energized and a second configuration when the coil is energized,

a brake signal switch operable to supply relatively high steady electrical current to the first and second relay contacts, the contacts of the first relay when in the first configuration conducting the relatively high steady electrical current to a left rear light and the contacts of the second relay when in the first configuration conducting the relatively high steady electrical current to a right rear light, whereby operation of the brake switch, when the coils of the first and second relays are not energized, cause the left and right rear brake lights to be illuminated in a steady manner,

a turn signal switch operable to energize the coil of the first relay or the coil of the second relay by relatively low steady electrical current depending on the direction of turn to cause the contacts of the relay concerned to move to the second configuration,

said turn signal switch when operated also causing relatively high electrical current to be supplied intermittently to the first and second relay contacts, the contacts of the first relay presenting an open circuit to the intermittent relatively high current when in the first configuration and supplying the relatively high intermittent current to a left front light and the left rear light when in the second configuration to cause the left front and rear lights to be illuminated intermittently in a flashing manner, and the contacts of the second relay presenting an open circuit to the relatively high intermittent current when in the first configuration and supplying the relatively high intermittent current to a right front light and the right rear light when in the second configuration to cause the right front and rear lights to be illuminated in a flashing manner, and

a hazard signal switch operable to energize the coils of the first and second relays with relatively low steady electrical current to cause the contacts thereof to move to the second configuration, the hazard switch when operated also causing relatively high electrical current to be supplied intermittently to the first and second relay contacts to cause the left and right front lights and the left and right rear lights to be illuminated in a flashing manner.

2. An electrical circuit according to claim 1 also including a flasher relay having an energizable coil and a contact operable by energization and de-energization of the flasher relay coil by relatively low steady electrical current or absence thereof respectively to cause said relatively high intermittent current to be supplied to the first and second relay contacts, and an IC flasher unit operable to effect said energization and de-energization of the flasher relay coil.

3. An electrical circuit according to claim 2 including a flasher transistor switch in series with the flasher relay coil providing an open circuit therefor when neither the turn signal switch nor the hazard signal switch is actuated, the actuation of the turn signal switch or the hazard signal switch causing a signal to be sent to the base of the flasher transistor switch to cause the flasher transistor switch to become conducting and enable the flasher relay coil to be energized and de-energized by the IC flasher unit.

4. An electrical circuit according to claim 3 wherein the IC flasher unit has a ground connection in series with the flasher transistor switch whereby the ground connection of the IC flasher unit is broken when neither the turn signal switch nor the hazard signal switch is actuated, with current flow in the IC flasher unit thereby being discontinued.

5. An electrical circuit accordingly to claim 2 including a voltage sensing device for sensing voltage change caused by failure of any one of the front and rear lights, when selected for flashing operation, said voltage sensing device causing the IC flasher unit to effect flashing of another light selected for flashing operation at a frequency different from normal.

6. An electrical circuit according to claim 2 including a left error sensing device and a right error sensing device for sensing an error in the left or right load (?) respectively, said left or right sensing device being operable, when a left or right light respectively has been selected for flashing operation, to cause the IC flasher unit to effect flashing at a frequency different from normal.

7. An electrical circuit according to claim 6 including a means for disabling operation of the left and right error sensing devices when the hazard switch is operated.

* * * * *

Figure 3. An example of the claims section of an issued utility patent.

do nothing. Make sure you deal with a registered patent agent or an attorney. The USPTO web site has a list of the registered patent practitioners.

Is there any subject matter that gets special treatment?

Applications can be moved up ahead of others in the examining order if a petition to make the application special is granted. MPEP Chapter 700 lists the reasons that an application might be made special. These reasons include the applicant's health, applicant's age, and topics related to energy resources. In fact, these three reasons result in the application being made special without filing the petition fee. Other reasons, such as someone infringing on your patentable idea, require the petition fee to be submitted. The 2003 filing fee for the petition to make special is $130.00.

Patent it yourself?

Just like you can represent yourself in court, you have the right to patent your ideas yourself. Patent agent and/or attorney fees could be thousands of dollars. Therefore, if you have the capability and fortitude, you can save a lot of money by patenting it yourself.

The process of completing the patent application, communicating with the USPTO patent examiner (the person that determines whether or not you get a patent), submitting the drawings, revising the claims, etc., from the initial application submittal until the patent is allowed (approved by the examiner) and granted is called prosecuting the patent application. You have the right to do all of this yourself.

There are many self-help books available on the subject of "patenting it yourself." These books detail the items that are needed for a complete patent application. Of course, you can get the information for free from the USPTO via the MPEP. MPEP Chapter 600, 1500, and 1600 cover the parts, form, and content of the utility, design, and plant patent application, respectively.

The form and structure of the patent is very specific. There is no room for creativity when it comes to the form and structure of a patent application. For example, there is a rule for the maximum number of characters (500) in the patent title and the maximum number of words (150) in the patent abstract. These rules must be adhered to or you will get a chance to repeat your work and probably pay fees for the mistake. Writing the abstract, technical specification, claims, etc., is well within the capability of most astute people. However, the offensive use of a patent is directly tied to the claims.

Therefore, it is critical that quality claims be written in order to make the patent worth its money and effort. The USPTO patent examiner will actually write the claims for you if you request it. Since the value of a patent is contained in its claims, you will want to thoroughly inspect the claims for value to you, not just allowability, if the examiner writes them for you. Writing effective patent claims is an art form!

While an intelligent person can certainly handle prosecuting a patent application when everything goes right, it is when something goes wrong that a patent agent or attorney is most needed. For instance, if it turns out that your application will interfere with another pending application, an "interference" (see MPEP Chapter 2300) may be declared by the USPTO Director. An interference is a complicated, expensive procedure which would be difficult for the uninitiated to handle.

It is not my intention to scare you away from patenting your inventions yourself, however, you should be informed of what you are getting into. I am a firm believer that people should handle their own legal affairs as much as possible if they can do a competent job. One way to gauge the potential difficulty of prosecuting a patent is to look at the results of the Patent Practice Exam given by the USPTO twice a year to potential patent agents and attorneys. This exam covers the rules and procedures of patent practice and at least a 70 out of 100 is required to pass the exam. The pass rate usually hovers in the 35 to 50 percent range. In other words, 50 to 65 percent of educated people, that have presumably studied the MPEP, fail the exam.

Patent agent or patent attorney?

If you decide to hire a professional to prosecute the patent, you will either hire a patent agent or a patent attorney. These two types of professionals can both successfully get you a patent. However, it is important to understand

www.uspto.gov — Web site for United States Patent and Trademark Office and your online resource for:

- **Manual of Patent Examining Procedure (MPEP)**
- **United States Code (USC) Title 35 — Patent Laws**
- **Code of Federal Regulations (CFR) Title 37 — Patent Rules**

- **Nolo Press — Tons of good, legal self-help books — available at www.nolopress.com**

the differences between the two types of professionals.

A patent agent is a person who does not have a law degree, but is authorized to practice a specialized law — patent law — before the USPTO. Patent agents are individuals with technical backgrounds that have passed the Patent Practice Exam that is administered by the USPTO. Patent agents may have their own patents, as well as experience prosecuting patent applications for others. They may also have many years of technical experience. However, if litigation becomes necessary, a patent agent can't represent you in court.

A patent attorney is just that — an attorney who has passed the Patent Practice Exam that is administered by the USPTO. Patent attorneys typically will not have as much technical experience as a patent agent. Patent attorneys can not only prosecute your patent application, but can also represent you in court in the event litigation becomes necessary.

Either a patent agent or attorney can be equally effective in successfully getting you a patent. The typical patent agent may have a technical edge over the typical patent attorney. This may allow the patent agent to see technical features that would be unapparent to a patent attorney. However, if litigation becomes necessary, only a patent attorney can help you in court.

How much will it cost?

If you prosecute your own patent application, you will only have to contend with the fees that the USPTO imposes. These fees can be substantial. For instance, the 2003 application fee for a utility, design, and plant patent is $750.00, $330.00, and $520.00, respectively. If your utility, design, or plant patent is allowed, you will be required to pay an issue fee of $1,300.00, $470.00, or $630.00, respectively. In addition, utility patents have maintenance fees of $890.00, $2,050.00, and $3,150.00 that are due at 3.5, 7.5, and 11.5 years after issue, respectively. There are various other fees for such things as claims in excess of 20, multiple dependent claims, etc. The full listing of fees is available on the USPTO web site.

If you utilize a patent agent or attorney, you will also be responsible for paying their fee for prosecuting your patent application. You can find plenty of patent agents on the Internet by searching for "patent agent." Depending on the complexity of the invention, a patent agent may charge $1,000.00 to $3,000.00 for a utility patent application. A

design or plant patent application may result in a charge of only around $500.00 from a patent agent. Generally, patent searches are an extra charge of around $500.00. Some patent agents will exchange their services for a percentage licensing agreement. They will do this only if they think your invention has the potential to generate royalties.

A patent attorney will generally end up being more expensive than a patent agent since they customarily charge by the hour. A patent attorney may also require a retainer to be paid initially.

The USPTO maintains a list of registered patent agents and attorneys. This list is available on their web site. However, the USPTO will not recommend a specific agent or attorney.

Do I have to pay the same fees as big corporations?

If you qualify as a "small entity," you get to pay half the rate on certain USPTO fees. The definition of small entities includes individuals, small business concerns as defined by the Small Business Administration (SBA), and nonprofit organizations. Small entities do not get all fees reduced, but most of the big fees such as the application fee, issue fee, and maintenance fees are reduced by 50 percent. Therefore, it pays to be a small entity! However, if you license or assign your invention to a company that does not qualify as a small entity, the small entity status may be revoked.

Conclusion

Hopefully, this article has cleared up the patenting process a bit for you by explaining the types of patents that are available, what determines patentability, costs of getting a patent, subject matter that gets special treatment, patent drawing requirements, acting as your own patent attorney/agent, and the difference between a patent agent and an attorney.

Getting a patent can often be costly, time consuming, and difficult whether you complete the process yourself or hire a professional.

However, a patent will protect your unique idea and keep others from cashing in on it. It is a process that has had 200 years to become complicated and convoluted. However, it has also proven itself to be a very effective way to protect intellectual property while encouraging innovation.

Of course, do not totally rely on the information in this article for your patent activities. It should be used as a general guide only. You should always consult the latest USPTO requirements or a registered patent agent or attorney.

Finally, a US patent protects your invention in the United States only. If you want to protect your invention in foreign countries, you must file a patent application in each country that you desire protection. Search for information on the Patent Cooperation Treaty (PCT) on the USPTO web site for useful information on filing a patent application in other countries. **NV**

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BIPOLAR TRANSISTOR COOKBOOK — PART 3

Ray describes a variety of practical common-emitter and common-base amplifier circuits in this month's episode of this eight-part series.

by Ray Marston

Last month's edition of this *Transistor Cookbook* series described practical ways of using bipolar transistors in useful common-collector (voltage follower) circuit applications, including those of relay drivers, constant-current generators, linear amplifiers, and complementary emitter followers. This month's article moves on and shows various ways of using bipolar transistors in simple, but useful common-emitter and common-base configurations.

COMMON-EMITTER AMPLIFIER CIRCUITS

The common-emitter amplifier (also known as the common-earth or grounded-emitter circuit) has a medium value of input impedance and provides substantial voltage gain between input and output. The circuit's input is applied to the transistor's base, and the output is taken from its collector — the circuit's basic operating principles were briefly described in the opening installment of this eight-part series. The common-emitter amplifier can be used in a wide variety of digital and analog voltage amplifier applications. This section of the *Cookbook* series starts off by looking at "digital" application circuits.

DIGITAL CIRCUITS

Figure 1 shows a simple npn common-emitter digital amplifier, inverter, or switch, in which the input signal is at either zero volts or a substantial positive value, and is applied to the transistor's base via series resistor R_b, and the output signal is taken from the transistor's collector. When the input is zero, the transistor is cut off and the output is at full positive supply rail value. When the input is high, the transistor is biased on and a collector current flows via R_L, thus pulling the output low. If the input voltage is large enough, Q1 is driven fully on and the output drops to a "saturation" value of a few hundred mV. Thus, the output signal is an amplified and inverted version of the input signal.

In Figure 1, resistor R_b limits the input base-drive current to a safe value. The circuit's input impedance is slightly greater than the R_b value, which also influences the rise and fall times of the output signal — the greater the R_b value, the worse these become. This snag can be overcome by shunting R_b with a "speed-up" capacitor (typically about 1n0), as shown dotted in the diagram. In practice, R_b should be as small as possible, consistent with safety and input-impedance requirements, and must not exceed $R_L \times h_{fe}$.

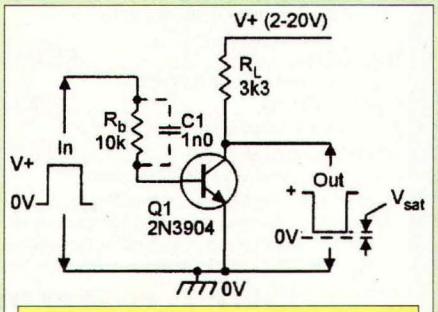

Figure 1. Digital inverter/switch (npn).

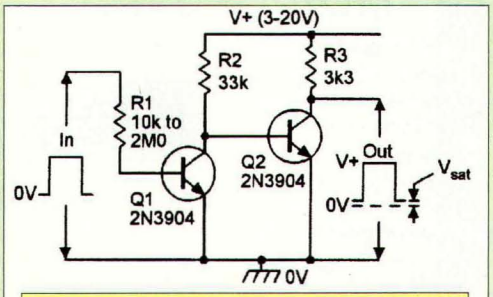

Figure 3. Very-high-gain non-inverting digital amplifier/switch using npn transistors.

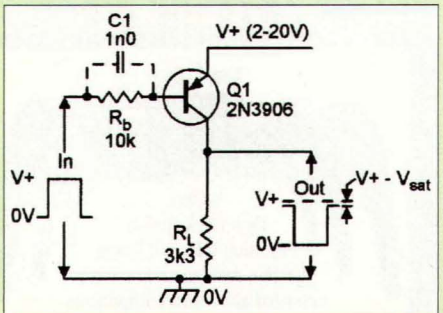

Figure 2. Digital inverter/switch (pnp).

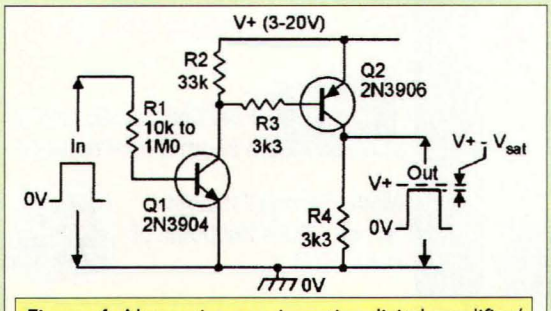

Figure 4. Alternative non-inverting digital amplifier/switch using an npn-pnp pair of transistors.

Figure 2 shows a pnp version of the digital inverter/switch circuit. Q1 switches fully on, with its output a few hundred mV below the positive supply value, when the input is at zero volts, and turns off (with its output at zero volts) when the input rises to within less than 600mV of the positive supply rail value.

The sensitivity of the Figure 1 and 2 circuits can be increased by replacing Q1 with a pair of Darlington- or Super-Alpha-connected transistors. Alternatively, a very-high-gain non-inverting digital amplifier/switch can be made by using a pair of transistors wired in either of the ways shown in Figures 3 or 4.

The Figure 3 circuit uses two npn transistors. When the input is at zero volts, Q1 is

cut off, so Q2 is driven fully on via R2, and the output is low (saturated). When the input is "high," Q1 is driven to saturation and pulls Q2 base to less than 600mV, so Q2 is cut off and the output is high (at V+).

The Figure 4 circuit uses one npn and one pnp transistor. When the input is at zero volts, Q1 is cut off, so Q2 is also cut off (via R2-R3) and the output is at zero volts. When the input is "high," Q1 is driven on and pulls Q2 into saturation via R3. Under this condition, the output takes up a value a few hundred mV below the positive supply rail value.

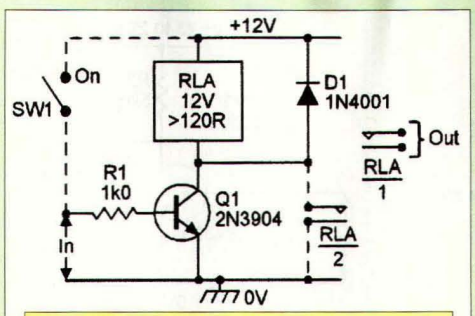

Figure 6. Simple relay-driving circuit.

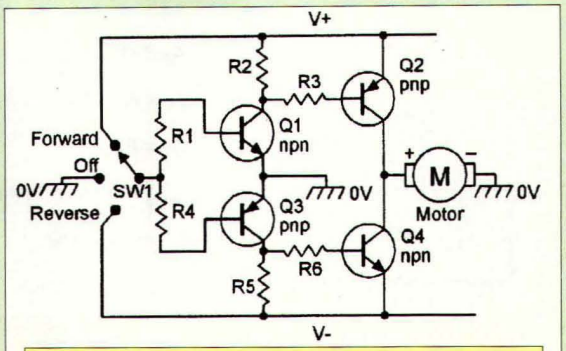

Figure 5. DC-motor direction-control circuit.

Figure 5 shows (in basic form) how a complementary pair of the Figure 4 circuits can be used to make a DC-motor direction-control network, using a dual power supply. The circuit operates as follows.

When SW1 is set to "Forward," Q1 is driven on via R1, and pulls Q2 on via R3, but Q3 and Q4 are cut off. The "live" side of the motor is thus connected (via Q2) to the positive supply rail under this condition, and the motor runs in the forward direction.

When SW1 is set to "Off," all four transistors are cut off, and the motor is inoperative.

When SW1 is set to "Reverse," Q3 is biased on via R4, and pulls Q4 on via R6, but Q1 and Q2 are cut off. The "live" side of the motor is thus connected (via Q4) to the negative supply rail under this condition, and the motor runs in the reverse direction.

RELAY DRIVERS

The basic digital circuits of Figures 1 through 4 can be used as efficient relay drivers if fitted with suitable diode protection networks. Figures 6 through 8 show examples of such circuits.

The Figure 6 circuit raises a relay's current sensitivity by a factor of about 200 (= the current gain of transistor Q1), and greatly increases its voltage sensitivity. R1 gives base drive protection, and can be larger than 1k0, if desired. The relay is turned on by a positive input voltage.

The current sensitivity of the relay can be raised by a factor of about 20,000 by replacing Q1 with a Darlington-connected pair of transistors. Figure 7 shows this technique used to make a circuit that can be activated by placing a resistance of less than 2M0 across a pair of stainless metal probes. Water, steam, and skin contacts have resistances below this value, so this simple little circuit can be used as a water, steam, or touch-activated relay switch.

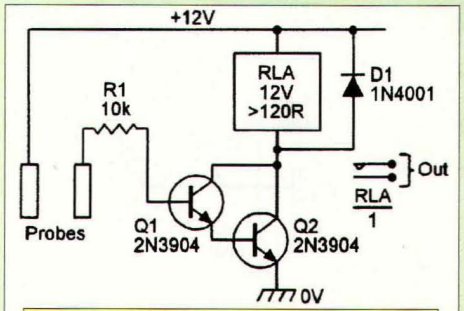

Figure 7. Touch, water, or steam-activated relay switch.

Figure 8 shows another ultra-sensitive relay driver, based on the Figure 4 circuit, that needs an input of only 700mV at 40µA to activate the relay. R2 ensures that Q1 and Q2 turn completely off when the input terminals are open circuit.

LINEAR BIASING CIRCUITS

A common-emitter circuit can be used as a linear AC amplifier by applying a DC bias current to its base so that its collector takes up a quiescent half-supply voltage value (to accommodate maximal undistorted output signal swings), and by then feeding the AC input signal to its base and taking the AC output from its collector (as shown in Figure 9).

The first step in designing a circuit of the basic Figure 9 type is to select the value of load resistor R2. The lower this is, the higher the amplifier's upper cut-off frequency will be (due to the smaller shunting effects of stray capacitance on the effective impedance of the load), but the higher Q1's quiescent operating current will be. In the diagram, R2 has a compromise value of 5k6, which gives an upper "3dB down" frequency of about 120kHz and a quiescent current consumption of 1mA from a 12V supply.

To bias the Figure 9 circuit's output to half-supply volts, R1 needs a value of R2 x $2h_{fe}$, and (assuming a nominal h_{fe} of 200) this works out at about 2M2 in the example shown. The formula for the circuit's input impedance (looking into Q1 base) and voltage gain are both given in the diagram. In the example shown, the input impedance is roughly 5k0, and is shunted by R1 — the voltage gain works out at about x200, or 46dB.

The quiescent biasing point of the Figure 9 circuit depends on Q1's h_{fe} value. This weakness can be over-

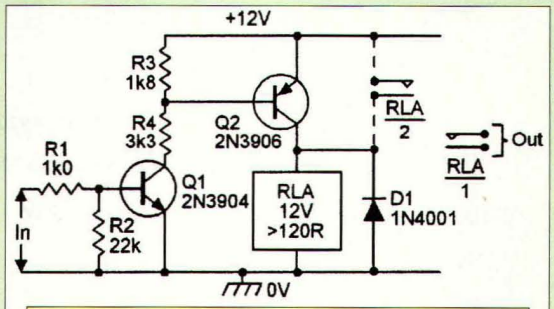

Figure 8. Ultra-sensitive relay driver (needs an input of 700mV at 40µA).

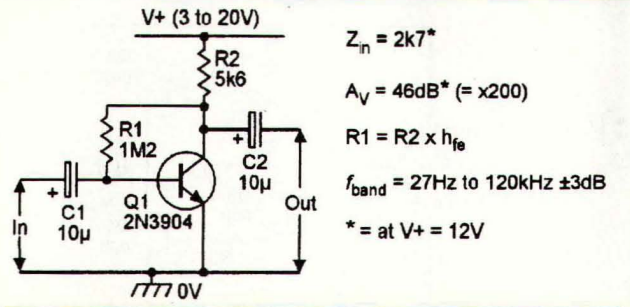

Figure 10. Common-emitter amplifier with feedback biasing.

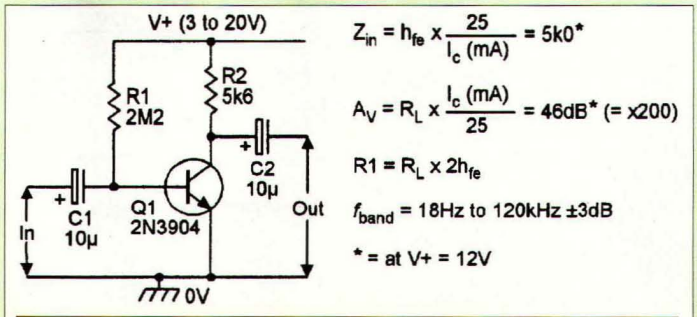

Figure 9. Simple npn common-emitter amplifier.

come by modifying the circuit as shown in Figure 10, where biasing resistor R1 is wired in a DC feedback mode between Q1's collector and base, and has a value of R2 x h_{fe}. The feedback action is such that any shift in the output level (due to variations in h_{fe}, temperature, or component values) causes a counter-change in the base-current biasing level, thus tending to cancel the original shift.

The Figure 10 circuit has the same values of bandwidth and voltage gain as the Figure 9 design, but has a lower total value of input impedance. This is because the AC feedback action reduces the apparent impedance of R1 (which shunts the 5k0 base impedance of Q1) by a factor of 200 (= A_V), thus giving a total input impedance of 2k7. If desired, the shunting effects of the biasing network can be eliminated by using two feedback resistors and AC-decoupling them as shown in Figure 11.

Finally, the ultimate in biasing stability is given by the "potential-divider biasing" circuit of Figure 12. Here, potential divider R1-R2 sets a quiescent voltage slightly greater than V+/3 on Q1 base, and voltage follower action causes 600mV less than this to appear on Q1 emitter. V+/3 is thus developed across 5k6 emitter resistor R3, and (since Q1's emitter and collector currents are almost identical) a similar voltage is dropped across R4, which also has a value of 5k6, thus setting the collector at a quiescent value of 2V+/3. R3 is AC-decoupled via C2, and the circuit gives an AC voltage gain of 46dB.

CIRCUIT VARIATIONS

Figures 13 to 16 show some useful common-emitter amplifier variations. Figure 13 shows the basic Figure 12 design modified to give an AC voltage gain of x10 — the gain actually equals the R4 collector load value divided by the effective "emitter" impedance value, which in this case (since R3 is decoupled by series-connected C2-R5) equals the value of the base-emitter junction impedance in series with the paralleled values of R3 and R5, and works out at roughly 560R, thus giving a voltage gain of x10. Alternative gain values can be obtained by altering the R5 value.

Figure 14 shows a useful variation of the above design. In this case, R3 equals R4, and is not decoupled, so the circuit gives unity voltage gain. Note, however, that this circuit gives two unity-gain output signals, with the emitter output in phase with the input and the collector signal in anti-phase. This circuit thus acts as a unity-gain phase splitter.

Figure 15 shows another way of varying circuit gain. This design gives high voltage gain between Q1 collector and base, but R2 gives AC feedback to the base, and R1 is wired in series between the input signal and Q1 base — the net effect is that the circuit's voltage gain (between input and output) equals R2/R1, and works out at x10 in this particular case. Finally, Figure 16 shows how the Figure

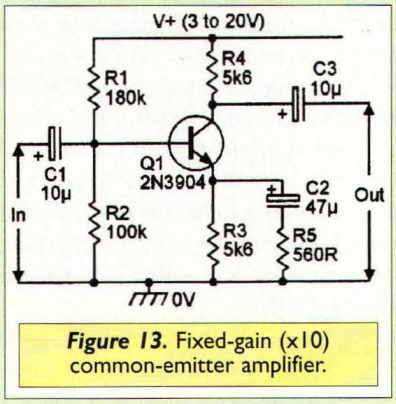

Figure 13. Fixed-gain (x10) common-emitter amplifier.

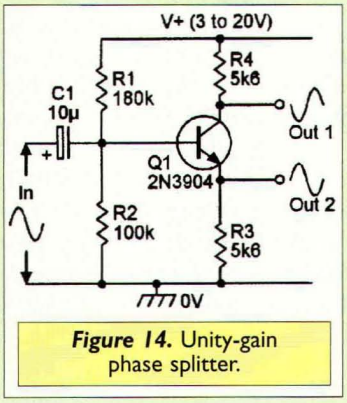

Figure 14. Unity-gain phase splitter.

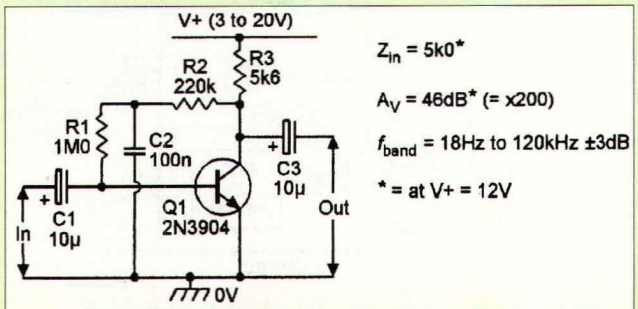

Figure 11. Amplifier with AC-decoupled feedback biasing.

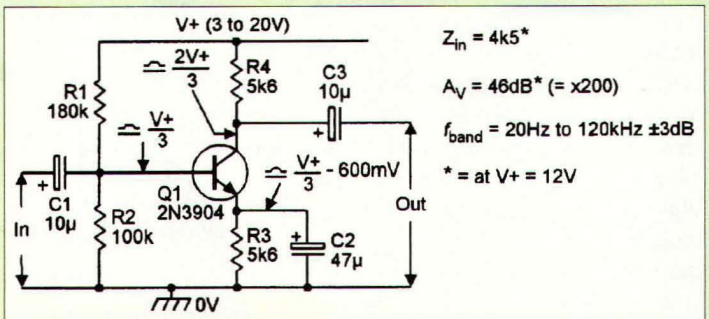

Figure 12. Amplifier with voltage-divider biasing.

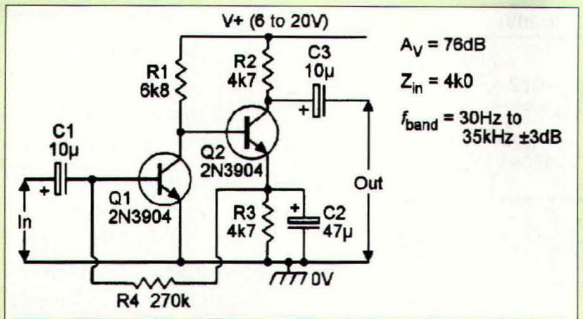

Figure 17. High-gain two-stage amplifier.

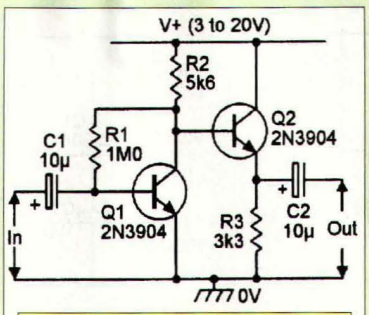

Figure 16. Wide-band amplifier.

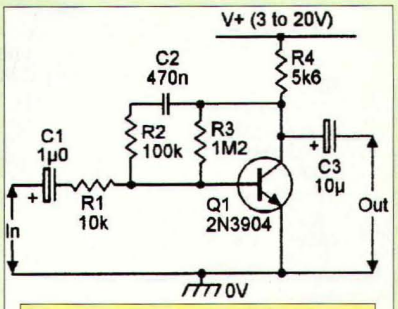

Figure 15. Alternative fixed-gain (x10) amplifier.

10 design can be modified to give a wide-band performance by wiring DC-coupled emitter follower buffer Q2 between Q1 collector and the output terminal, to minimize the shunting effects of stray capacitance on R2, and thus extending the upper bandwidth to several hundred kHz.

HIGH-GAIN CIRCUITS

A single-stage common-emitter amplifier circuit cannot give a voltage gain much greater that 46dB when using a resistive collector load — a multi-stage circuit must be used if higher gain is needed. Figures 17 to 19 show three useful high-gain, two-transistor voltage amplifier designs.

The Figure 17 circuit acts like a direct-coupled pair of common-emitter amplifiers, with Q1's output feeding directly into Q2 base, and gives an overall voltage gain of 76dB (about x6150) and an upper -3dB frequency of 35kHz. Note that feedback biasing resistor R4 is fed from Q2's AC-decoupled emitter (which "follows" the quiescent collector voltage of Q1), rather than directly from Q1 collector, and that the bias circuit is thus effectively AC-decoupled. Figure 18 shows an alternative version of the above design, using a pnp output stage — its performance is the same as that of Figure 17.

The Figure 19 circuit gives a voltage gain of about 66dB. Q1 is a common-emitter amplifier with a split collector load (R2-R3), and Q2 is an emitter follower and feeds its AC output signal back to the R2-R3 junction via C3, thus "bootstrapping" the R3 value (as described in last month's installment) so that it acts as a high AC impedance. Q1 thus gives a very high voltage gain. This circuit's bandwidth extends up to about 32kHz, but its input impedance is only 330R.

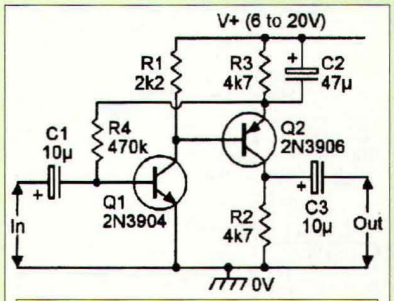

Figure 18. Alternative high-gain two-stage amplifier.

COMMON-BASE AMPLIFIER CIRCUITS

In a so-called "common-base" transistor amplifier, the input signal is applied to the transistor's emitter, and the output is taken from the transistor's collector. The common-base amplifier has a very low input impedance, gives near-unity current gain and a high voltage gain, and is used mainly in wide-band or high-frequency voltage amplifier applications. Figure 20 shows an example of a common-base amplifier that gives a good wide-band response.

The Figure 20 circuit is biased in the same way as Figure 12. Note, however, that the base is AC-decoupled via C1, and the input signal is applied to the emitter via C3. The circuit has a very low input impedance (equal to that of Q1's forward-biased base-emitter junction), gives the same voltage gain as the common-emitter amplifier (about 46dB), gives zero phase shift between input and output, and has a -3dB bandwidth extending to a few MHz.

Figure 21 shows an excellent wideband amplifier — the "cascode" circuit — which gives the wide bandwidth benefit of the common-base amplifier, together with the medium input impedance of the common-emitter amplifier. This is achieved by wiring Q1 and Q2 in series, with Q1 connected in the common-base mode and Q2 in the common-emitter mode.

The input signal is applied to the base of Q2, which uses Q1 emitter as its collector load and thus gives unity voltage gain and a very wide bandwidth, and Q1 gives a voltage gain of about 46dB. Thus, the complete circuit has an input impedance of about 1k8, a voltage gain of 46dB, and a -3dB bandwidth that extends to a few MHz.

Figure 22 shows a close relative of the common-base amplifier — the "long-tailed pair" phase splitter — which

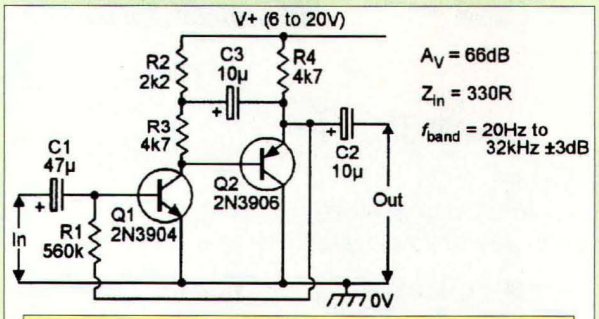

Figure 19. Bootstrapped high-gain amplifier.

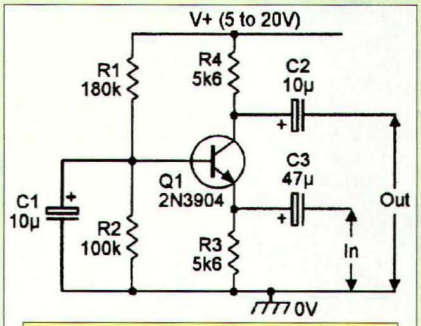

Figure 20. Common-base amplifier.

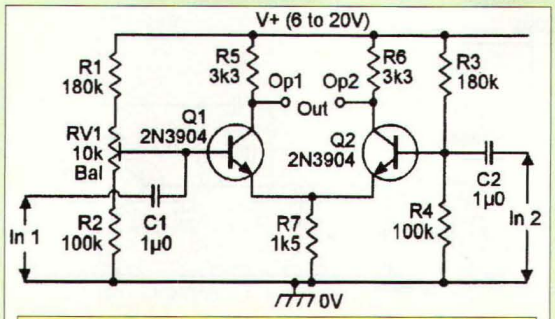

Figure 23. Simple differential amplifier or long-tailed pair.

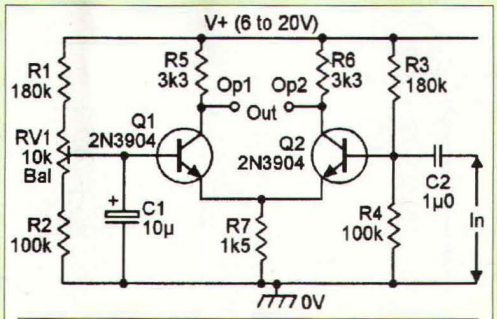

Figure 22. "Long-tailed pair" phase splitter.

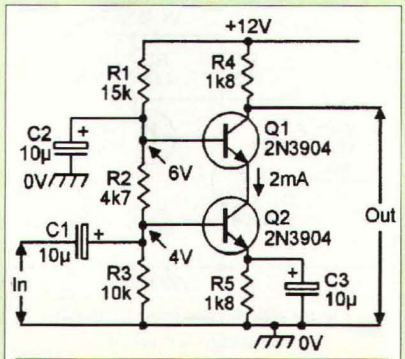

Figure 21. Wide-band cascode amplifier.

gives a pair of anti-phase outputs when driven from a single-ended input signal. Q1 and Q2 share a common emitter resistor (the "tail"), and the circuit bias point is set via RV1 so that the two transistors pass near-identical collector currents (giving zero difference between the two collector voltages) under quiescent conditions.

Q1 base is AC-grounded via C1, and AC-input signals are applied to Q2 base via C2. The circuit acts as follows.

Suppose that a sinewave input signal is fed to Q2 base. Q2 acts as an inverting common-emitter amplifier, and when the signal drives its base upward, its collector inevitably swings downward, and vice versa. Simultaneously, Q2's emitter "follows" the input signal, and as its emitter voltage rises, it inevitably reduces the base-emitter bias of Q1, thus making Q1's collector voltage rise, etc.

Q1 thus operates in the common-base mode and gives the same voltage gain as Q2, but gives a non-inverting amplifier action. This "phase-splitter" circuit thus generates a pair of balanced anti-phase output signals from a single-ended input.

Finally, Figure 23 shows how the above circuit can be made to act as a differential amplifier that gives a pair of anti-phase outputs that are proportional to the difference between the two input signals — if identical signals are applied to both inputs, the circuit will (ideally) give zero output. The second input signal is fed to Q1 base via C1, and the R7 "tail" provides the coupling between the two transistors. **NV**

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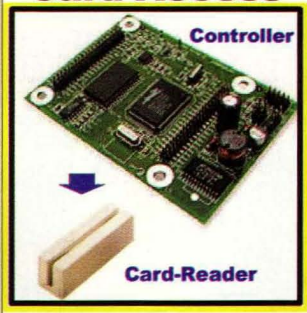

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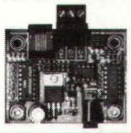

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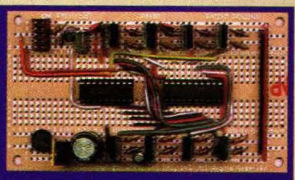

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Micro Memories

How The DVD Was Won

The laser disc was first demonstrated to the public in the early 1970s by MCA and Phillips, and first went on sale in 1978. Thoroughly beaten in sales by the VCR — which had a far inferior picture, but could record — by the mid-1980s it was looking doomed, likely to only be remembered as the stepping-stone to the compact disc.

Then something quietly happened to help turn around its fortunes. In 1984, a man named Bob Stein bought the laser disc rights to two venerable, but classic films ("*Citizen Kane*" and "*King Kong*"). Then he hooked up with Jonathan Turrell and Bill Becker, the two men who founded Janus Films (a distributor of classic and offbeat films to art houses and revival theaters) with the hope of releasing their content on laser disc. But not the same kind of featureless laser discs the big studios were then churning out for the tiny laser disc market.

A sampling of Criterion laser discs from the mid-1980s to the early 1990s. The heavy clear plastic sleeves were sold by numerous laser disc retailers, to help their customers protect their expensive discs.

Stein, described by *Wired's* Amy Virshup as a sort of techno-Maoist, said in 1980, while he was supporting himself as a waiter, "I realized that fundamental change — as in revolution — was a long way off, and I couldn't wait that long."

Visits to the public library turned up articles about the media lab at MIT, which was experimenting with additional capabilities of laser discs beyond simply displaying pre-recorded images. "I read until I got interested in something. And I got interested in this."

Naming themselves after the NASA probe, Stein and the Janus partners formed The Voyager Company to distribute interactive laser discs (and later CD-ROMs), and labeled their classic films division The Criterion Collection.

Putting The Disc To Work

What interested Stein was that the laser disc had several things going for it that were rarely taken advantage of by mainstream Hollywood studios. Its original CAV format could display 24 frames a second, meaning that a film could be stopped and each frame individually examined.

Also, because laser discs originally had a stereo analog audio track, and later, a stereo digital audio track in addition to the analog track, there were multiple audio tracks available on the disc. The theory was that while most new laser disc players could play digital and analog tracks, the discs would have both sets of tracks, in case it was purchased by someone who had an older player.

But there was nothing that said they had to. Those analog tracks could hold an optional audio commentary — heck, they could hold two audio commentaries, as there's little need for stereo when the track consists of one voice talking about a movie.

And finally, the discs could be chapter encoded, meaning that it would be possible to click to certain spots on the disc, either during the movie, or in the ancillary material after the film.

Ironically, many, if not most mainstream films on laser disc didn't even bother with chapter encoding. Their makers assumed the viewers would watch these discs like they would a video tape — pop it in, press play, veg out.

But thanks to Stein's efforts, suddenly the laser disc had a new lease on life as a vehicle for film buffs and scholars to study a film that was as close as television could get to celluloid in a projector. In a way, it was even better. Taking advantage of a far more flexible medium, Criterion discs started having all sorts of ancillary features, including trailers, documentaries, still photos, audio commentary, photos from a film's marketing campaign, and seemingly anything else Criterion could find about a movie.

Douglas Pratt, who began writing *The Laser Disc Newsletter* (now the *DVD-Laser Disc Newsletter*,

www.dvdlaser.com) in the mid-1980s, told me, "What you really saw with Criterion's "*Citizen Kane*" and "*King Kong*" were people who loved movies and who understood the potential of the laser disc medium, seizing it as soon as they could get their hands on it and exploring what the interactive potentials could be. The "*Citizen Kane*" laser disc was the 'Citizen Kane' of laser discs. It had this boyish sense of innovation and enthusiasm for pushing the limits of its medium, and it pretty much defined what a 'collector's edition' of a motion picture could provide to enhance a collector's appreciation of a film."

By creating a laser disc with both a movie and many of the same elements that a film historian's "making of" book would have, but in an interactive, audio/video format, Criterion had just answered the question, "Why should I buy a laser disc player? It can't record!" Oh yeah — well, it can do this.

Assembling The Elements

Susan Arosteguy, a producer at Criterion (**www.criterionco.com**) told me that while Criterion and Voyager used Apple and Photoshop from the get-go, getting the image into the actual laser disc didn't always use bleeding edge technology. "A lot of that stuff — the really early video graphic design was actually printed out and photographed in 35mm and telecined back to video. We had these crazy Nikon cameras that loaded 35mm movie film, and a lot of the still frame supplements that we had back then we would actually put on a copy stand and photograph them individually frame by frame, develop it, telecine it, and lay it back to video, and then we would use that video in our master. Obviously, now it's really easy — that stuff doesn't happen too much anymore."

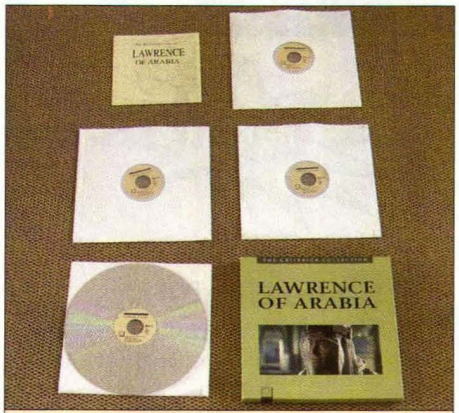
Part of the challenge for Criterion was that unlike today's DVDs, with their seamless branching from chapter to chapter, "The laser disc was linear," Arosteguy says, "So you had to be a little bit more creative, if you were presenting a multimedia essay. You didn't have as many programming options, as you obviously do now with DVD."

Because all of Criterion's design work was done in-house, their premium laser discs carried a premium price — $99.95 and even $124.95 price tags were common on many of their titles, whereas most other laser discs were in the $39.95 ballpark.

Today, a Criterion DVD is about $10.00 to $15.00 more than a typical studio DVD. It's still premium, but obviously much more affordable.

Letterboxing Comes To Lasers

Also unlike today's DVDs (and the 16 x 9 TVs to support them), in the mid-1980s, letterboxed films were a rare commodity. One of the very first was Woody Allen's "*Manhattan*" — the only film Allen has shot to date in a very widescreen Panavision format, and he insisted (probably contractually) that MGM release the film on laser disc with a letterboxed picture. Soon after, Arosteguy says, Criterion's "first letterboxed feature was "*Invasion of the Body Snatchers*," and we were the first company to commit to presenting



The four disc *Lawrence of Arabia* set from 1989, complete with a booklet on the film's restoration process. Releasing this title in laser disc's original CAV format allowed for 30 minutes per side, hence the number of discs necessary to hold such a long movie.

films letterboxed and in their original aspect ratios."

Peter Becker, the current director of the Criterion Collection (and the son of Bill Becker, the co-founder of Janus Films), told Todd Doogan of The Digital Bits web site (**www.digitalbits.com**) that when Criterion released "*Body Snatchers*," "letters poured in from people saying, 'I think my disc is defective, I can only see a third of the picture.' It's amusing now, but letterboxing was something that people said the public will never ever buy — they don't want the picture smaller on their television set, they wanted the picture bigger. They want to see the faces. And there are still people who feel that way."

In contrast, Becker adds, Criterion felt that it was important "right from the beginning, to make a commitment to presenting films as filmmakers wanted them seen, and that meant respecting their framing. And it meant respecting the composition that they had established in the first place."

Doug Pratt says that in 1997, "when DVDs enabled interactive home video to reach the mass market, all of the home video companies were able to hit the ground running, using what they had initially learned from Criterion.

The home video companies themselves are filled with people who like movies and are attracted to collectors' editions, and there is a certain amount of vanity appeal for the filmmakers themselves that encourages them to participate in creating the programming. And when aspects of these expanded features caught on with the mass market — particularly the inclusion of deleted scenes — it helped to define home video as being the true end product of the production of a motion picture." The movie companies themselves also took advantage of this change, shooting behind-the-scenes footage specifically for inclusion — first in laser discs and later in DVDs — something that would have been unheard of for a simple re-heated VHS leftover of a movie.

The employees of the Criterion liked what they saw when their original laser disc of "*Citizen Kane*" was completed in 1984, but they obviously had no idea they had just invented the basic format for how movies would be presented on DVD — a format which wouldn't be born until 13 years later.

Today, we expect that when we buy a $24.95 DVD, it will have a variety of bonus and documentary materials on it. But in the mid-1980s, this was new and revolutionary stuff. Stein, the techno-Maoist, had just spearheaded his techno-revolution, and unlike the real Mao, it was a bloodless one at that. **NV**

Exploring and Experimenting With Lasers and Their Properties

Laser Insight

Construction of the Cr:Ruby laser continues ...

Last month, I started to describe the water cooling system for the Cr:Ruby laser project. In this issue, we will look at the control electronics for the water system and start to work on the laser power supply.

Again, I must emphasize that without water cooling, the laser will have serious drawbacks. It can still do useful work, but less of it, and at a slower rate.

I must repeat the warning I gave earlier about this laser:

Warning Warning Warning

The laser to be described is dangerous. The power supply is capable of producing ***lethal voltages****, and at very high pulsed-current capacity. This is a serious laser and should only be undertaken by those persons who will take it seriously. The capacitors used in the supply will retain a high voltage charge for a long time, and must be completely discharged before any work is done inside the unit. If a short circuit occurs during the charge or discharge of the high voltage capacitors, then serious damage to the supply will result, as well as anything else that may be attached to the supply. It is a very powerful supply, and should be built carefully, with regard for safety being the top priority. There will be a number of safety interlocks built into the power supply and laser rail, and these devices must be incorporated to ensure safe operation of the laser.* ***DO NOT OMIT OR BYPASS ANY OF THESE INTERLOCKS!!*** *Neither the author nor this magazine can be held responsible for your actions, so please be careful and act responsibly.*

Water control and interlock circuit

The main power supply schematic includes the water monitoring, safety interlocks and power distribution, and is shown in Figure 28-1. The start-up sequence for the laser is as follows:

Turning on the main circuit breaker CB1 supplies power to transformer T1. T1 provides 18VAC for the low voltage side of the power distribution/interlock monitoring section. The power ON indicator D1 will illuminate, showing the presence of AC power. The 18VAC power is rectified by the diode bridge BR1, and filtered by capacitor C1 to give a rough 24VDC. Since there is nothing critical about the voltage in this part of the circuit, regulation of the raw 24VDC is not required.

In this circuit, the status of the safety interlocks is checked, and indicator LEDs on the front panel show the state of readiness of the system. At this point, with the keyswitch in the OFF position as shown, the water flow switch will be open, Q1 will have no base drive, and its collector will be up around 24V, so the flow indicator lamp D5 will be illuminated, indicating a lack of water flow.

If any panels are removed from the power supply cabinet, switches Sw5-Sw7 will open, and another indicator lamp D7, will illuminate showing this fault. In this schematic, an illuminated LED indicates a fault in the particular area indicated. Presumably, at this stage the water over temperature indicator D6, will be off since the system is starting from cold. If the water were hot enough to trip the over temperature switch, then Sw8 would be open, allowing D6 to illuminate.

Resistors R8 and R9 are chosen so that in the event of an open switch in the Sw5-Sw8 string, the bias voltage on transistor Q2 is too low to allow collector/emitter conduction, and therefore K2 will not be energized, shutting off the high voltage supply. If the power supply drops out due to an over temperature water condition, the pump should remain

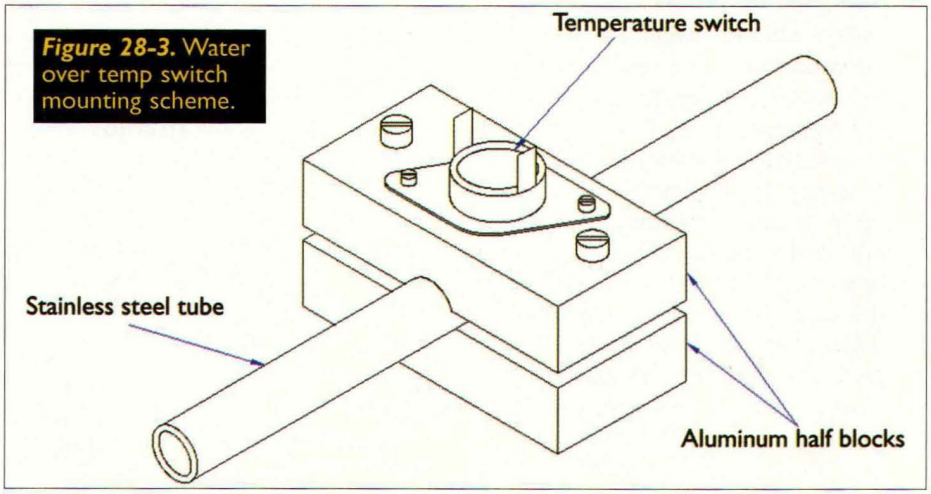


Figure 28-3. Water over temp switch mounting scheme.

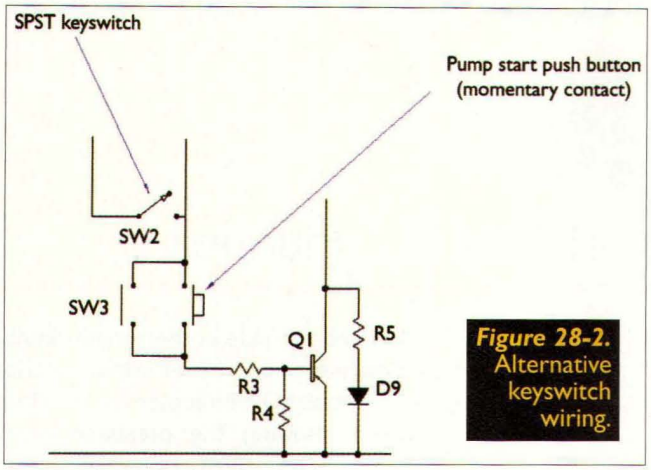


Figure 28-2. Alternative keyswitch wiring.

running in an effort to reduce the temperature of the laser head components. Diode D9 provides additional bias to the base/emitter junction of Q2, ensuring that this transistor turns fully off in the event of a fault condition.

With the keyswitch in the OFF position, power is only supplied to the unregulated 24VDC supply, used in the interlock circuit as described above. The power supply control electronics are fed from a section of the keyswitch, through an on-board regulator on the control board, and not shown here.

Turning the keyswitch to the center position (ON) applies power to the laser power supply control electronics. At this point, the pump is still not running and the high voltage charging circuit is not under power. The center position of the switch thus allows checking the control circuit without turning on the high voltage.

A word now on the keyswitch. This switch is chosen for a spring return in the START/RUN position, like an automobile ignition switch. When water is flowing, the flow switch closes and effectively provides a parallel current path to hold the start relay (K1) in when the keyswitch is released back to the center position. If the spring-loaded keyswitch cannot be found, then a single-pole keyswitch may be substituted for the Off/On position, and a momentary pushbutton used for the pump start.

Use of a keyswitch is recommended in any event, as removal of the key rules out any possibility of unauthorized use of the laser. (Remember, kids are very inquisitive, and these days, very smart too!) If the alternative approach is used, then diode D3 may be eliminated, as shown in Figure 28-2. The remainder of the circuit is unchanged. Note the position of the flow switch is always across the momentary start switch.

Turning the keyswitch now to the PUMP START position (or pressing the pump start button) will start the water pump. If we assume this is the first start-up sequence, and there is water in the tank, water will be pushed through the laser head, heat exchanger, and DI filter and return to the tank.

Initially, there will be a lot of air in the system, and it will be heard bubbling in the tank. Note that the water flow switch is wired parallel to the start switch. When the pump is first started, there is too much air in the system to maintain closure of the water flow switch. If the keyswitch is allowed to return to the center position, the flow switch may not yet be making reliable contact, and so it may not latch Q1 properly.

When all the air is out of the hoses and laser head, then the flow switch should maintain the pump operation when the key is returned to the center position (or the start button released). Thus, if flow is reduced by an obstruction in the water line or a kinked hose, the flow switch will open, shutting off the power supply and water pump. Also, if a water hose bursts or detaches itself from the laser head (don't laugh, it happens!), then the flow switch will open again, shutting off the pump. If the pump power is removed, then so is the laser HV supply power.

The level switch (Sw1 Digi-Key #376-1008-ND) and LED (D2) are merely an indicator that the water level is above or below a predetermined point. The kind of switch to use is one that is reversible. That is to say, the sense of the switch may be changed so that the switch makes (or breaks) as the level falls. In our schematic, we need the switch to make when the water gets too low. This switch will not cause any interruption of power supply operation. I may have mentioned before that a top mounting, float-type level sensor is preferred over a side mounting device, simply because it eliminates any sources of water leakage.

The series of switches labeled Sw5-Sw7 are cabinet interlocks, and are fixed to the frame of the power supply cabinet to prevent operation of the supply with the covers removed. Three switches are shown to cover the two side panels and the top cover. These switches can be overridden for setting up purposes only, but must always be operated normally when the laser is on and the covers attached.

If any of the side panels or covers of the power supply are opened during operation, you must shut down the supply. The Center for Devices and Radiological Health (CDRH) has some very stringent rules regarding the use of laser equipment, and particularly in regard to safety. If you intend to use this laser for anything other than pure hobbyist or research activities, you would be well advised to read through the CDRH literature. You can get a copy of the relevant material through Kentek, or from the CDRH website at **www.fda.gov/cdrh/comp/index.html**. Look for compliance and safety information.

A pair of connections has been brought out to an external connector (J1) in series with the safety shutter, and mounted on the rear of the power supply cabinet. This connector is used as an external door interlock to close the laser safety shutter to prevent the laser from firing if anyone enters the room without proper

authorization.

If the external door is left open, the laser will not fire. If not used, a shorting plug may be inserted into the connector with a jumper wire across the two pins. This interlock only acts on the shutter, and does not cause any part of the supply to shut down. This is obviously a dangerous power supply, requiring an equally obvious approach to maintaining safety.

Notes on some of the components

There are some special components used in this project, and there are some parts you probably have not had call to use before. The keyswitch is one item likely to give you a headache trying to find. The reason this may be difficult is because of the spring return from the third position back to the second position — like an auto ignition switch. I found some at a local surplus store here in Orlando, FL, but you should be able to get them at Digi-Key or other outlets. Alternatively, you can use the optional scheme mentioned elsewhere in this article, and shown in Figure 28-2.

The relay used to turn on the water pump can be fairly small, depending on your pump. Just make sure the contacts are rated for at least the current draw of your motor, and preferably double that value. As I mentioned before, we don't need a whole lot of water flow, and a small/medium aquarium pump should be able to handle this task. About one gallon per minute should be enough for this laser.

The relay used for the power supply should be somewhat bigger as the charging current will be quite high at the start of charge. The relay shown in the schematic (Figure 28-1) is a slave relay used to pull in a larger contactor. This larger relay is not shown in this schematic, and will be included in the power supply section.

The water flow switch should be selected to normally be open, and to close when water flow is greater than about 1/2 gal/min. These flow switches are directional and usually have the flow direction indicated on the body, so take care to insert it properly in the circuit. These are available from Digi-Key — the one gallon/min part number is 376-1106-ND.

The water over temperature switch is a surface-mounting type, and should be mounted to a solid block or plate for best heat transfer. Get a switch that resets itself after cooling down. Use heatsink compound between the switch and plate. See Figure 28-3 for the mounting method I have used successfully many times. In this assembly, the

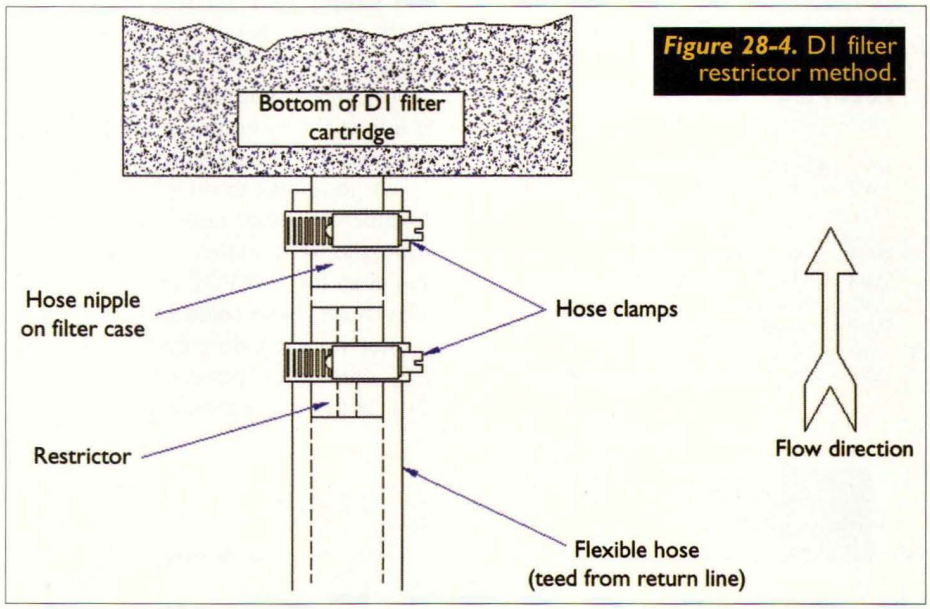


Figure 28-4. D1 filter restrictor method.

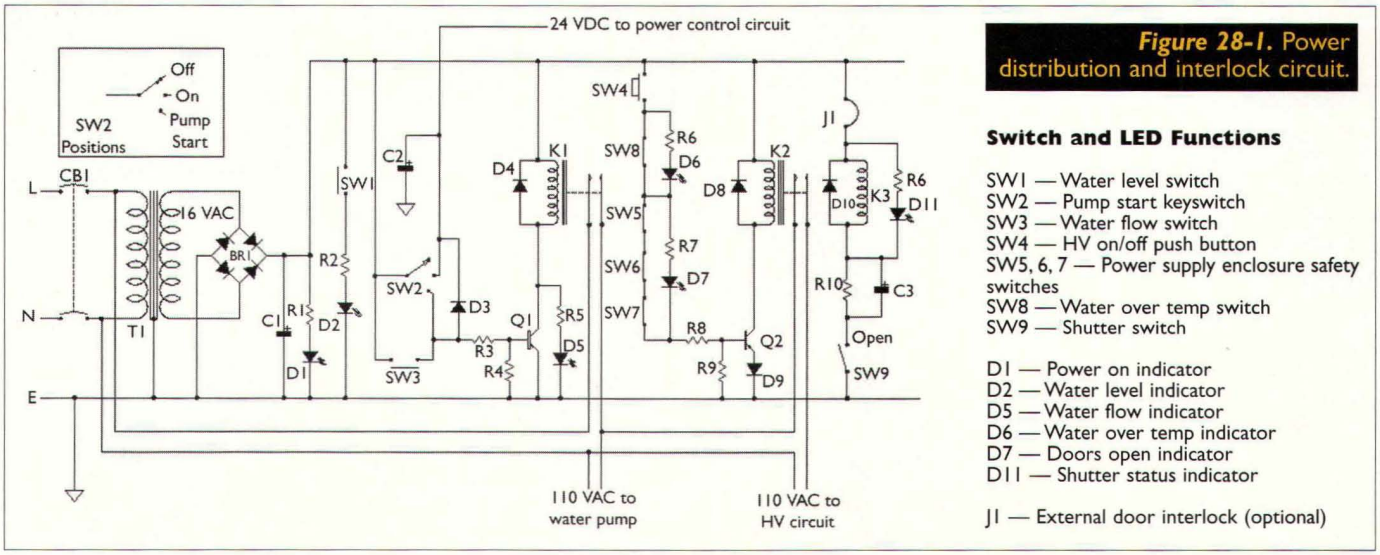


Figure 28-1. Power distribution and interlock circuit.

Switch and LED Functions

SW1 — Water level switch
SW2 — Pump start keyswitch
SW3 — Water flow switch
SW4 — HV on/off push button
SW5, 6, 7 — Power supply enclosure safety switches
SW8 — Water over temp switch
SW9 — Shutter switch

D1 — Power on indicator
D2 — Water level indicator
D5 — Water flow indicator
D6 — Water over temp indicator
D7 — Doors open indicator
D11 — Shutter status indicator

J1 — External door interlock (optional)

PARTS LIST

Power distribution and interlock circuit

R1, 2, 3 — 2.2k
R4 — 120
R5, 6, 7 — 2.2k
R8 — 1k
R9 — 120
R10 — See text
R11 — 2.2k

C1 — 1,000uF/ 50V
C2 — 1,000uF/50V
C3 — See text

D1 — Red LED
D2 — Yellow LED
D3 — 1N4001
D4, 8, 10 — 1N4007
D5, 6, 7 — Yellow LED
D9 — 1N4001
D11 — Red LED

BR1 — Diode bridge 100PIV/1A

T1 — 120/18VAC 1A
K1, 2 — 24VDC relay DPDT contacts rated 120VAC/5A
K3 — Shutter solenoid (Ledex rotary solenoid, 12-24VDC)

CB1 — Circuit breaker 120VAC/20A front panel mounting

SW1 — Water level switch
SW2 — Three-position rotary switch, spring biased (or optional switch scheme, see text)
SW3 — Water flow switch
SW4 — HV on/off toggle push button
SW5, 6, 7 — Frame interlock switches
SW8 — Water over temperature switch (100°-110°F max)
SW9 — Shutter control toggle switch

tube is stainless steel and the half blocks aluminum. Drill a hole through the half blocks as shown, making the hole the same diameter as the tube. Clamp the half blocks together with a thin spacer between them as you drill. This way, you'll be sure the two halves align properly and the spacer ensures that the blocks can be clamped tightly around the stainless tube for good heat conduction.

The safety shutter can be a bought item or a homemade device. For my unit, I had an old rotary solenoid (Lucas Ledex device, from the same surplus store in Orlando, FL) and I made a light aluminum flag and simply epoxied the flag to the shaft. I have shown it connected to the raw 24VDC line, which was fine for my power supply, but you'll have to adjust the operating point for your solenoid if it is different.

A good way to do it is to insert a resistor/capacitor network as shown in the diagram. In fact, you should do this even for a 24VDC solenoid. This is because these solenoids are usually rated for a low-duty cycle, meaning they cannot be powered for a long time without overheating. This is a waste of energy, and could shorten the lifetime of the solenoid. The resistor/capacitor combination allows the solenoid to draw a large initial current (through the capacitor) and drop to a holding current (limited by the resistor).

You'll need to figure out what you need as a limiting resistor by using a 24-volt DC supply and some resistors. Apply Ohm's Law to get your values. Allow the solenoid to pull in normally and increase the resistor value until the solenoid does not quite drop out. This will represent the lowest holding current for your solenoid. The value of capacitance will also depend on how much current is required to pull the solenoid in, and again, must be determined by experiment.

Placement of components

When you are ready to start mounting things in the power supply cabinet, think carefully about servicing. Many times I have opened cabinets built by even reputable dealers and found it almost impossible to service the system. For example,

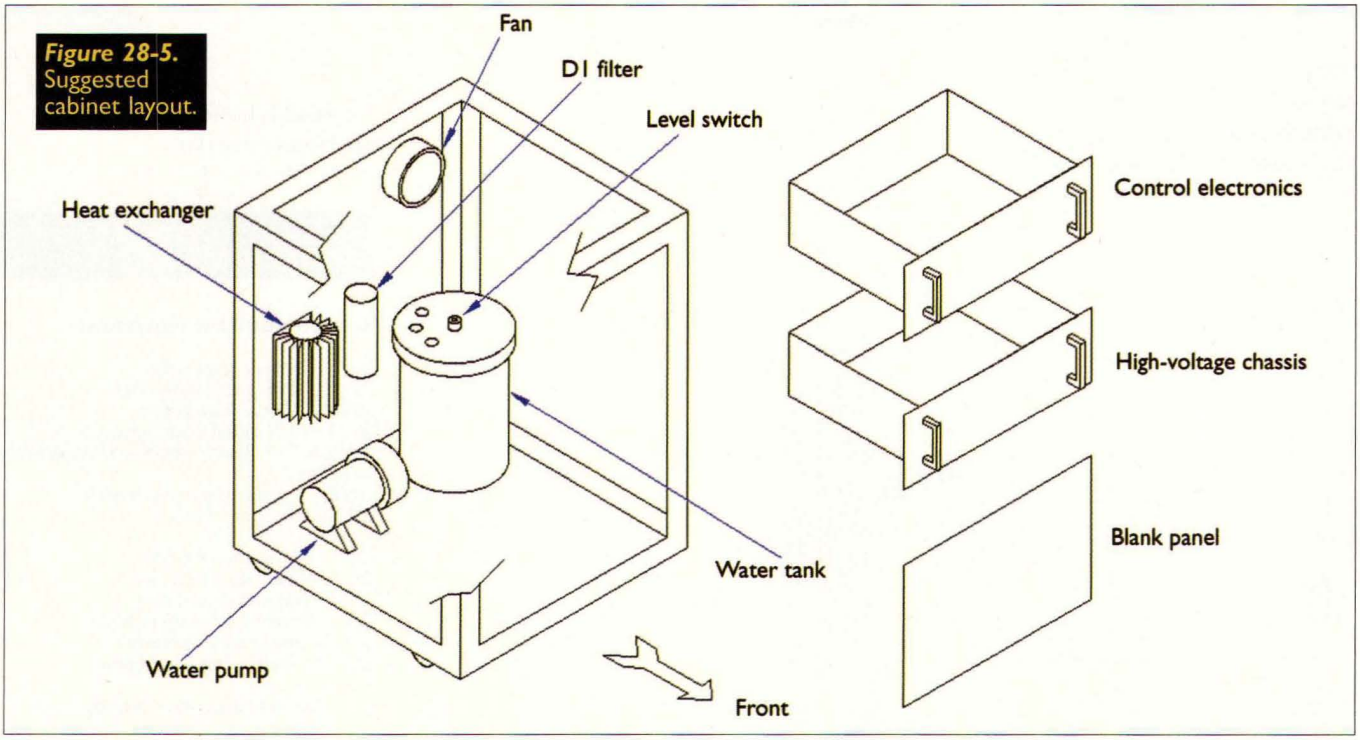


Figure 28-5. Suggested cabinet layout.

you'll need to periodically refill the water tank with fresh water, and perhaps once every year or so replace the DI filter cartridge. You should make sure, in this case, that you can remove the top cover of the tank without disassembling the supply. (I mention this specifically because I did service a laser a few years ago that required the high voltage supply to be removed from the cabinet before access to the water tank was possible!)

Also, keep in mind that you will be dealing with some high voltages ... make sure to give yourself enough clearance for installing and removing HV connectors. Remember, too, that there will be a huge current surge through the lamp cables when the lamp fires. Give plenty of clearance for these cables, too. They will be fairly big wires with a strong magnetic field. Also, there will be a high voltage pulse to trigger the lamp discharge conducted down this wire.

When you select a cabinet, find one that allows easy access to the inside. This will make the installation of components and future servicing much easier. Commercial cabinets are widely available from many industrial sources, and some surplus houses. Standard 19-inch rack cabinets cost between $400.00 and $600.00 for this size, if bought new. For this project, a 19-inch cabinet, 24-30 inches deep and about 30 inches high, will give plenty of space for the high voltage components, control unit, water tank, pump, filter, and heat exchanger. A suggested layout for this type of cabinet can be seen in Figure 28-5.

Get the large items close to the rear of the cabinet to give yourself as much room as possible up front. The items drawn may not look like the ones you get, but the general layout is what I'm trying to impress here. The drawer sections off to the side of the mainframe slide in and out on drawer slides made to fit the cabinet. These are usually heavy-duty types made specifically for these frames, not the type you find at home centers. The upper unit will be the low voltage control and power distribution chassis, while the lower one will be reserved for the high voltage stuff. The lowest panel shown is just a blank panel used to close up the front and hide the plumbing.

As a reference, I always place the water tank close to the rear of the cabinet, and the water pump could then sit on the base next to it. Water hoses can be put through holes in the rear panel close to the bottom. You should keep all water fittings and hoses as low as you can. This minimizes any chance that a water leak (or spray from a pinhole) will drip onto the HV cables, or perhaps splash the control electronics (disaster!!).

If you have room inside the cabinet, the DI filter could be mounted next to the tank. DI filters are normally mounted vertically, and have a preferred flow direction. Refer to the instructions that come with your unit. Don't forget to install a restrictor in the input line to the filter though, or you'll have a real bad, real smelly mess to clean up if the case ruptures (I speak from experience here). Details about the restrictor placement are shown in Figure 28-4.

When plumbing the water system, allow hoses to loop naturally — don't force them into sharp bends because they will kink after a while (again, I learned this from experience!). If you use a heat exchanger with an integral fan for cooling, make sure you allow room for air circulation. Some heat exchangers may also require a second fan to exchange air within the enclosed cabinet. If this is so, make sure you have room on the rear panel to mount the additional fan (as shown in Figure 28-5) and orient it so the air blows out from the cabinet. This being the case, you'll need to have some kind of hole or opening in the bottom of the cabinet to let fresh air in.

The door interlock switches can be mounted to the framework of the cabinet, and wired in series, terminating in a simple connector that can be plugged into the main power distribution and interlock circuit. Next issue, we'll look at the high voltage section, the control section, and try to finish up this project.

If you have questions about this column, or ideas for future columns, you may contact me as always at: **stanley.york@att.net**, or through this magazine. It sometimes takes a while to answer all my emails, but bear with me, I will reply. **NV**

by Gordon McComb

"Where It Is and How to Get It"

Robotics Resources

Batteries for Your 'Bot

Mobile robots require a self-contained power source, and most robots use a battery or battery pack for this purpose. As common as batteries are, Alkaline batteries available at the local supermarket are not ideal for use in robotics. Your robot will drain its batteries in short order, and you'll have to frequently replace them — a costly proposition.

For this reason, the ideal robot power source is the rechargeable battery. Two rechargeable battery technologies stand out as being easy to get, and relatively inexpensive. The older nickel-cadmium (ni-cad) batteries, as well as the newer nickel metal hydride (NiMH) batteries, are available at hobby stores, home improvement outlets, and even some discount stores like Target and Wal-Mart.

Chemical Make-up of Batteries

While there are hundreds of battery compositions, only a small handful of them are regularly used in amateur robots.

• Carbon-zinc batteries are also known as garden-variety "flashlight" cells, because that's the best application for them — operating a flashlight. They're a simple battery with relatively low current capacities. While they can be "rejuvenated" to bring back some power, they are not rechargeable, and they end up being expensive for any high-current application (like running a robot).

• Alkaline batteries offer several times the current capacity of carbon-zinc, and are the most popular non-rechargeable battery used today. They cost several times more than carbon-zinc. Robotics applications tend to discharge even alkaline batteries rather quickly, so a 'bot that gets played with a lot will run through its fair share of cells. Good performance, but at a price.

• Rechargeable alkaline batteries are the mass-merchandising answer to the high cost of regular alkaline batteries used in high-demand applications — robotics is certainly one such application, though battery makers had things like portable CD players in mind when they designed rechargeable alkalines. These cells require a recharger designed for them, and can be recharged dozens or hundreds of times before discarding.

All things considered, rechargeable alkalines are probably the best choice as direct replacements for regular alkaline cells.

• Nickel-cadmium (or ni-cad) rechargeable batteries are an old technology, and unfortunately, one that has caused considerable poisoning of the environment — cadmium is extremely toxic. So, battery makers have been weaning consumers off ni-cads, favoring, instead, the battery formulation that follows. While you can still get ni-cads, there's little reason to, so we'll ignore them as a choice.

• Nickel-metal hydride (NiMH) rechargeable batteries not only offer better performance than ni-cads, they don't make fish, animals, and people (as) sick when they are discarded into landfills. They are the primary choice in rechargeable batteries today, but they're not cheap. Like rechargeable alkalines, they require a recharger made for them. (Many of the latest rechargers will work with rechargeable alkalines, ni-cads, and NiMH — just don't use a ni-cad recharger with NiMH.)

• Lithium-ion (Li-Ion) cells are frequently used in the rechargeable battery packs for laptop computers and high-end camcorders. They are the Mercedes-Benz of batteries, and are surprisingly lightweight for the current output they provide. However, Li-Ion cells require specialized rechargers, and are frightfully expensive.

• Lithium (without the -Ion) batteries are also available. These are non-rechargeable, and are used for long-life applications, such as smoke detector batteries. They are also used as memory back-ups, and are commonly available in three-, six-, and nine-volt cells.

• Sealed lead-acid (SLA) batteries are similar in make-up to the battery in your car, except that the electrolyte is in gel form, rather than a sloshy liquid. SLAs are "sealed" to prevent most leaks, but in reality, the battery contains pores to allow oxy-

ELECTRON CHEMISTRY

$$Cd + NiO_2 + 2H_2O \rightarrow Cd(OH)_2 + Ni(OH)_2$$

Reversible chemistry is the backbone of every battery design, but a pretty gory subject to cover here. Fortunately, the people at PowerStream did all the legwork and published it on their web site for you to enjoy. So, break out that high school chemistry book and start counting up electrons at:

http://www.powerstream.com/BatteryFAQ.html

gen into the cells. SLA batteries, which are rechargeable using simple circuits, are the ideal choice for very high-current demands, such as battle 'bots or very large robots.

• Polymer batteries are among the latest in rechargeable technology. They are used for medium- to high-current electronics applications, like cellular phones. These batteries use lithium as a component, but they are not quite the same as the lithium and Li-ion cells mentioned above. Polymer batteries can be manufactured with thicknesses as small as one-millimeter wafers. Table 1 shows these different batteries.

Battery Voltage and Current

The two most critical aspects of batteries are their voltage and their current. The importance of voltage is obvious — the battery must deliver enough electrical juice to operate whatever circuit it's connected to. A 12-volt system is best powered by a 12-volt battery. Lower voltages won't adequately power the circuit, and higher voltages may require voltage reduction or regulation, either of which entails some loss of efficiency.

If voltage is akin to the amount of water going through a pipe, then current is the pressure of that water. The higher the pressure, the more forceful the water is when it comes out. Similarly, current in a battery determines the ability of the circuit it's connected with to do heavy work. Higher currents can light bigger lamps or move bigger motors.

Because batteries cannot hold an infinite amount of energy, the current capacity of a battery is often referred to as an energy store, and is referred to simply as C — for capacity.

Battery current is rated in amp-hours, or roughly the amount of amperage (a measure of current) that can be delivered by the battery in a one-hour period. In actuality, the amp-hour rating is an idealized specification. It's really determined by discharging the battery over a 5 to 20 hour period. Few batteries can actually deliver their rated amp-hour currents throughout that stated hour.

Smaller batteries are not capable of producing high currents, and their specifications are listed in milliamp-hours. There are 1,000 milliamps in an amp. Therefore, a battery that delivers half an amp is listed with a capacity of 500 milliamp-hours (abbreviated mAh).

Common Battery Sizes

If you've ever changed the batteries in an electronic device, you already know there are different sizes available. There's no point in telling you batteries are available in N, AAA, AA, C, D, and nine-volt ("transistor") size.

But with the notion of different sizes fresh in our minds, it's worth noting that the size of the battery directly affects its capacity. For comparison purposes, Table 2 shows the typical capacity ratings for rechargeable ni-cad or NiMH batteries.

Battery	Volts/cell*	Application	Recharge**	Notes
Carbon-zinc	1.5	Low demand, flashlights	No	Cheap, but not suitable for robotics or other high current applications.
Alkaline	1.5	Small appliance motors and electric circuits	No	Available everywhere; can get expensive when used in a high current application like robotics.
Rechargeable alkaline	1.5	Substitute for non-rechargeable variety	Yes	Good alternative to non-rechargeable alkalines.
Ni-cad	1.2	Medium and high current demand, including motors	Yes	Being phased out because of their toxicity.
NiMH	1.2	High current demand, including motors	Yes	High capacity; still a bit pricey.
Li-Ion	—	High current demand, including motors	Yes	Expensive, but lightweight for their current capacity.
Lithium	3	Long life, very low current demand	No	Best used as battery backup for memory circuits.
SLA	2.0	Very high current demand	Yes	Heavy for their size, but very high capacities available.
Polymer	3.8	Long life, medium current demand for electronics	Yes	Cells can be made to most any size and shape; very high price; voltage varies widely over discharge.

*Nominal volts per cell for typical batteries of that group. Higher voltages can be obtained by combining cells.

**Many non-rechargeable batteries can be "revitalized" by zapping them with volts for a few hours. However, such batteries are not fully recharged with this method, and are re-discharged very quickly.

Table 1. Batteries at a Glance

Cell Size	Diameter (mm)	Height (mm)	Weight (g)	Capacity in mAh
N	12.0	30.0	5	150
AAA	10.5	44.5	12	650
1/3 AA*	14.0	14.0	7	50
1/2 AA *	14.0	17.0	14	110
2/3 AA*	14.0	28.3	14	600
4/5 AA*	14.0	42.2	23	1,200
AA	14.0	50.0	25	1,500
A*	17.0	50.0	35	2,200
1/2 C	23.0	26.0	23	2,100
C	25.2	49.2	80	3,500
D	32.2	60.0	150	7,000
9-volt	25.7x17.4	48.2	45	160-200

*Typically used in specialty battery packs, and not available in traditional consumer packaging. They are available from battery specialty retailers as replacement cells, however.

Table 2

The Right Voltages for Your Robot

Standards are a wonderful thing. You can buy a TV at your local electronics boutique and know that it'll work when you plug it into the socket at home. Don't count on electronics for robots to be as accommodating. There is no standard for operating electronic equipment — some require five volts, others need 3.3 volts, and yet still others need 12, 15, 24, or 48 volts, and everything in-between.

Providing the proper voltages to the various sub-systems in your robot requires careful planning. Obviously, the easiest way to manage the power requirements of your robot is to choose components that operate at a single voltage — say five volts. That's not always possible, especially for a mechanical device like a robot, which uses a wide variety of systems.

There are three basic approaches to powering the various components in your robot. Each one is discussed below.

Single Battery; Multiple Voltages

Most of the electrical equipment in your home or office is operated from a single power supply (such as wall current). Each piece of equipment, in turn, uses this voltage as-is (as in the case of an electrically-powered fan), or it converts the incoming current via a transformer or other device to the voltage required. This is the natural approach because each piece of equipment is a stand-alone unit, and doesn't depend on any other to operate.

This same approach can be used in your robot. A single battery — delivering say, 12 volts — powers different sub-systems. A voltage regulator or DC-DC converter is used to provide each subsystem with the precise voltage it requires.

While this approach sounds good in theory, in practice it can be expensive and/or difficult to implement properly.

- Linear voltage regulators — the most common variety — are cheap, but relatively inefficient. In effect, they "step down" voltage from one level to another — the difference in voltage is dissipated as heat. The heat can be dealt with, but the real problem is the unnecessary drain on the battery. It's better to conserve battery power for productive tasks, like running the robot's motors.
- Switching voltage regulators are more efficient — some offer efficiencies of up to 80 percent — but they are more expensive to implement, and many require additional components and design consideration. Like linear voltage regulators, switching regulators "step down" one voltage to provide another.
- DC-DC converters are self-contained voltage changers. They are the most expensive of the lot, but they require no additional components. DC-DC converters can step down or step up voltages, and can provide negative voltages. The disadvantage of many DC-DC converters (besides cost) is that they require high-input voltages in order to supply adequate current at the output. For instance, the input voltage may be on the order of 24 to 48 volts, in order to provide reasonable current at 5 or 12 volts.

Multiple Batteries; Multiple Voltages

A potential alternative to voltage regulation or conversion is to add separate battery packs to your robot. One battery pack may power the main electronics of the robot, while another may power the motors. This

...and the Usual Suspects

A number of robotics-centric and general surplus mail order companies also offer rechargeable batteries as part of their line-up. Many of these are regular *Nuts & Volts* advertisers, so be sure to keep them in mind in your hunts for the best 'bot battery.

All Electronics
www.allelectronics.com

Circuit Specialists
www.web-tronics.com

Gateway Electronics
www.gatewayelex.com

Fair Radio Sales
www.fairradio.com

HSC Electronic Supply
www.halted.com

HVW Technologies
www.hvwtech.com

Lynxmotion
www.lynxmotion.com

often works out well because the electronics probably need regulation, and the motors do not. The pack for the electronics can be 6 or 7.2 volts (regulated to five volts), and the pack for the motors can deliver 12 volts.

The trick to making this work is to tie all the ground (negative terminal) wires of the battery packs together. Each sub-system receives the proper voltage from its battery pack, but the shared grounds ensure that the various parts of your robot work together.

The exception to tied grounds is if you use opto-isolators. A typical application of opto-isolators in robotics is to control the drive motors. The electronics and the motors are on completely separate circuits, and their grounds are not tied.

Rather than connect wires directly from the electronics to the motor control circuitry, the electronics instead power opto-isolators, which contain a light emitting diode (LED) and a photo-transistor. The link between electronics and motor control is therefore made of light, not wire.

Single Battery; Single Voltage

Depending on the sub-systems of your robot, you may be able to use a single battery and single voltage for everything.

For example, if your electronics do not contain any five-volt TTL parts, you might be able to run all circuitry at 12 volts, along with the motors of your robot. Since applying excessive voltage to electronics can damage them, always check the specifications first.

This disadvantage of using a single battery for both electronics and motor is that DC motors — especially large ones — produce a lot of electrical noise that can disrupt the operation of microcontrollers and computers.

If you plan on operating your robot from a single, non-regulated battery pack, be sure to add noise suppression to the motors. One effective noise suppression technique is to solder 0.1 uF non-polarized disc capacitors across the terminals of the motor, and/or from each terminal to the ground case of the motor.

Sources

Acme Model Engineering Co.
www.acmemodel.com

Battery holders for AAA, N, AA, C, D, and nine-volts.

Advanced Battery Systems
www.advanced-battery.com

Batteries: Sealed lead acid, ni-cad, NiMH, lithium, lithium-ion, lithium polymer, alkaline; in all traditional sizes and capacities. Also rechargers and battery packs (custom and stock) for cell phones, laptops, cordless phones, and other electronic devices.

Batteries America
www.mrnicd-ehyostco.com

Batteries (including sealed lead acid, ni-cad, NiMH) and rechargers; single-cell and packs.

Batteries Plus
www.batteriesplus.com

US nationwide battery retail chain, sells product for retail and commercial applications. Check the web site for a store locator.

Battery City
www.batterycity.com

Consumer-packaged batteries: ni-cads, NiMH, camcorder, and

About the Author

Gordon McComb is the author of the best-selling *Robot Builder's Bonanza* and the *Robot Builder's Sourcebook*, both from Tab/McGraw-Hill. In addition to writing books, he operates a small manufacturing company dedicated to low-cost amateur robotics, **www.budgetrobotics.com/**. He can also be reached at robots@robotoid.com.

other needs.

Battery Mart
www.batterymart.com

Mail order batteries, large and small, all types (including sealed lead-acid, motorcycle, ni-cad, NiMH); chargers. Online sales; local stores in Winchester, VA and Martinsburg, WV.

See their section of Robot Batteries — a selection of sealed lead acid batteries in sizes from single cells to large 12-volt packs.

Battery Specialties
www.batteryspecialties.com

Resellers of alkaline, ni-cad, sealed lead acid, and lithium batteries; battery holders.

eBatts.com
www.ebatts.com

Rechargeable batteries. In single cells or packs for camcorders, laptops, cordless phones, and cellular phones.

Edmond Wheelchair Repair & Supply
www.edmond-wheelchair.com

Wheelchair and scooter parts, including motors, wheels, and batteries.

Energizer Holdings, Inc.
www.eveready.com

Energizer either makes bunny toys or batteries; it's hard to tell from the commercials.

In any case, the web site has some interesting technical information about batteries, including an overview of battery chemistry, charge and discharge curves, and other engineering data. Haven't found any technical info on rabbits yet.

Energy Sales
www.energy-sales.com

Distributors of name brand primary and rechargeable batteries. Locations in OR and WA.

EVdeals
www.evdeals.com

Electric motors for bikes and scooters; 12- to 48-volt batteries; battery chargers.

Hawker Energy Products, Inc.
www.hepi.com

Hawker claims to be the world's largest battery manufacturer. I can believe it, considering how many products they have and how many stores carry their wares. Their main product line is sealed lead-acid (SLA), which are available in single cells (usually two volts per), and in packs up to 24 and 48 volts.

The site offers no direct purchasing (reps and distributors handle that for Hawker), but there is plenty of battery spec sheets and technical papers to print out and take to bed with you. Interesting tidbit — Hawker is the battery of choice among many battling robot builders.

House of Batteries
www.houseofbatteries.com

House of Batteries is a distributor and online retailer of batteries, battery packs, and chargers. Most name brands are carried, in common consumer and industrial sizes. Not all products are available for online ordering.

Jbro Batteries / Lexstar Technologies
www.jbro.com

Manufacturer and distributor of rechargeable batteries and battery chargers. Brands include Panasonic and Hawker.

KidsWheels
www.kidswheels.com

Monster trucks for kids: Perego, Fisher-Price Power Wheels, and other makes. Can be ordered from the web page. Also offers parts, such as gear boxes, wheels, and batteries.

Only Batteries
www.onlybatteries.com

Like their name says, Only Batteries only sells batteries. All types, all sizes. Rechargeables are a specialty.

Maha Energy, Corp.
www.mahaenergy.com

Rechargeables for consumer products, as well as individual cells for R/C and other applications. PowerEx brand.

Mega Batteries
www.megabatteries.com

Superstore of rechargeable batteries. Separate cells, packs, and rechargers.

Millenium Batteries
www.millenniumbatteries.com

Rechargeable batteries and chargers. Packs for consumer products (e.g., camcorders, cell phones), as well as individual cells.

Planet Battery
www.planetbattery.com

Batteries and battery packs. Sells sealed lead acid battery packs in different voltages and capacities.

Robotics Resources

Power Sonic, Corp.
www.power-sonic.com

Rechargeable batteries and rechargers. Products include: Sealed lead-acid batteries, ranging from 0.5 to 100 Ah; nickel-cadmium and nickel-metal hydride batteries; automatic battery chargers.

The web site hosts numerous spec sheets, data sheets, and materials safety sheets on battery technologies and compositions.

Primecell
www.primecell.com

Primecell offers replacement and service of rechargeable batteries. All major brands.

Rechargeable Battery Recyling, Corp.
www.rbrc.org

Informational. RBRC is dedicated to helping you recycle (rather than throw away) your old rechargeable batteries.

Robotic Power Solutions
www.battlepack.com

Specializing in combat robot parts, the company sells ni-cad and NiMH battery packs, chargers, and cobalt AstroFlight gearmotors. Their "Battlepack Kits" include batteries, wires, support bars, heat-shrink tubing, and padding foam.

Sanyo Energy
www.sanyobatteries.net

Industrial and consumer batteries: ni-cad, NiMH, lithium, and lithium-ion. Product specifications and technical white papers are provided at the site.

Star Batteries
www.starbatteries.com

NiCad and NiMH rechargeables, and rechargers.

Tadiran US Battery Division
www.tadiranbat.com

Providers of lithium batteries. Product descriptions, spec sheets, technical briefs.

The Gillette Company
www.duracell.com

Duracell makes batteries. Billions of dollars worth every year. You'll buy them at your local store or through the mail, but the web site provides some interesting semi-technical articles in the Technical/OEM section.

The NiCd Lady Company
www.nicdlady.com

Ni-cad Lady sells ni-cad, NiMH, and sealed lead-acid batteries, in all sizes. Also carries rechargers and battery packs for cell phones and laptop computers.

Thomas Distributing
www.nimhbattery.com

Batteries (specializing in NiMH) and battery holders. Very large selection. Also provides semi-technical backgrounders on battery technologies.

TNR Technical
www.batterystore.com

Batteries of all types and sizes; major manufacturers. Alkaline, ni-cad, NiMH, sealed lead acid, lithium, and lithium-ion. In separate cells or packs (e.g., for camcorders, cordless phones, and laptops).

Many cells available in round and rectangular/prismatic packages, with size and weight specifications provided in handy cross-reference tables.

Ultralife Batteries
www.ulbi.com

Specializing in lithium batteries, rechargeable and non-rechargeable. Also offers polymer batteries in standard and custom packs.

ZapWorld.com
www.zapworld.com

Zap World sells motors, batteries, and parts for small electric vehicles, namely bikes, ground scooters, and aquatic scooters (as well as some off stuff, like personal hovercrafts). Use the stuff for your own performance robots. **NV**

FIRST Lego League Regional Announced

Since 1998, FLL International has been holding an annual task solving competition for kids age 9-14 that combines a hands-on, interactive robotics program with a sports-like atmosphere. Participation last year was 27,000 students on 3,000 teams and nearly double that is expected this September when the newest challenge "Mission Mars" is unveiled. Because of such drastic participation in her area, regional coordinator Marsha Segard has announced the first ever Lego League regional event, slated for December 6th in Phoenix, AZ. "It is a wonderful opportunity for students to grow and challenge themselves" explains Segard. More regional announcements are expected as participation swells throughout the world, from Singapore to Scandinavia. Visit their website at **www.firstlegoleague.org** for complete details.

Shiver Wins Top 'Bot Award At NCRSF

Innovation Robotics newest 220 lb. combat robot pulled in the Coolest Robot trophy at the July 5th North Carolina Robot Street Fight. Built in Lawrence Feir's subterranean robotics laboratory, *Shiver* wields a 55 lb. spinning weapon disc that rotates at frightening speed. Its single S7 steel tooth carves through aluminum and steel like butter. *Shiver* is powered by three Bodine Electric motors, two for mobility and one to power the weapon. It is constructed from high grade steel and titanium, shaped on Feir's custom built CNC plasma cutter. More information on *Shiver* and Feir's other robotic creations can be found online at **www.innovationrobotics.com.**

Worldwide Sensor Grid On The Near Horizon

The Ember Corporation recently announced the general availability of software and hardware to build extremely resilient, self-organizing and self-healing networks, with very low power requirements and immunity to single point failures. Core to their evaluation kit is the *EM1020 evaluation module,* a souped-up hockey puck containing a temperature sensor, two axis accelerometer, some LEDs, a piezo buzzer, and a programmable GPIO expansion port all connected to the "mesh" through a 915 MHz radio link. A Windows® compatible graphical management tool, *Ember Studio Lite* lets the user perform both network and node management, as well as node service data processing. Visit **www.ember.com** for product information, as well as information on their protocol stacks and custom hardware.

Single-Use Megapixel Cameras A Boon For Hobbyists?

Ritz Camera is test marketing a "refurbishable" digital camera in select US cities under the name "Dakota Digital." This $11.00

unit stores up to 25 two-megapixel images in a 12 MB onboard memory and though it lacks an LCD preview, it will let users delete those images suspected to be bad. Returning the camera to the purchase point starts processing which yields a photo CD and index print. Hardware in the camera is based on the Pure Digital™ Imaging Platform and is described as "proprietary." More info is available at **www.ritzcamera.com.**

Robots, Lost Penguins, And The Linux Revolution

At the LinuxWorld Expo in San Francisco, CA, a groundbreaking robotic vision demo took place August 6th. To a standing-room-only crowd, robots from SRI's "Centibots" project were shown a penguin doll and

instructed to find that "object of interest" within an obstacle course. Once the penguin had been hidden, a preliminary mapping robot with laser range finders identified the configuration of the maze and was then followed by a second wave of tracking robots. This second wave used machine vision to search for the penguin, while sharing information and communicating with a "command center" over a wireless data link. Discovery of the penguin was successful twice, each time taking between three and five minutes.

SRI's Centibot research is a DARPA funded project to create a system whereby a team of robots can be sent into an unknown environment, build a map in real time, and deploy itself to search that environment. The Centibots themselves are built with off-the-shelf components including the VIA EPIA x86-based mainboards executing Debian Linux and a special integrated architecture for robot perception developed at SRI's Artificial Intelligence Center. For more information on SRI's Centibot project, visit **www.ai.sri.com/centibots/** and if you want to build your own distributed AI system, read up on the VIA Robotics Initiative at **www.via.com.tw/en/robotics/robotics.jsp.**

Website Encourages "Nerds In Control"

Take a spin by **www.control.com** and you'll agree that their mantra is not only accurate but intriguing (especially if you're a control systems engineer). Warning: the wide range of free form discussions and detailed technical papers may suck you right in and burn an entire evening. Founder Tom Bull also lists numerous technical papers that he has written on control system optimization.

The Business of Electronics Through Practical Design and Lessons Learned

In The Trenches

Learn How To Write — The Right Way!

Writing is something engineers do a lot, but few seem to like it. Being able to do it well is not really such a hard task. If you keep certain goals in mind as you write, you will find that the written word offers opportunities rather than misery.

Why writing is disliked

Most people regard writing as a reluctant necessity. Memories of term papers and essays are hard to forget. Writing is often associated with late-night assignments, dull documentation, tedious sales reports to management, and the occasional research proposal. Naturally, if you are forced to do something you don't really understand, you won't like it. This is especially true when you feel your reports are not read, when you have no time for documentation, or don't really care about the research proposal (because you don't believe you'll get it).

And here is the main point of this article. Most engineers don't really understand the importance of writing. Most feel that it's a nasty requirement that they wish would just go away. It's much more fun being in the lab designing something useful. However, what good is designing a perfect product if you can't tell anyone about it? As Erwin Schrodinger said, "If you cannot — in the long run — tell everyone what you have been doing, your doing has been worthless." (Schrodinger was awarded a Nobel prize for his equations describing wave mechanics.)

Writing as telepathy

Writing is a form of telepathy. It's taking an idea in your mind and passing that idea into another person's mind. This telepathy knows no physical or temporal boundaries. Something you write can be sent world-wide on the Internet. Or, it could be found in 50 years, 500 years, or even 5,000 years.

Unfortunately, expressing ideas is generally something that is learned by experience. High school and college English courses usually study other people's writing and how they expressed their ideas. Actual writing classes usually focus on grammar and composition rather than taking an idea and expressing it well. There are books that tell you how to be published, there is software that corrects spelling and grammar, and so forth, and so on. But writing is a skill. And all skills require practice. Simply, the more you write, the better writer you will become.

With that said, there are aspects to writing that can be learned quite quickly. The most important is to realize that the idea must be clear in your mind before you can try to describe it to someone else. If it is not clear, even the best writer will not be able to make another person understand it. Muddy ideas cannot be clarified with words. Although, fairly often, the process of writing exposes the confusion and allows the writer to better understand the subject.

How to start

Closely associated with the clear idea is the goal you want to achieve. What is the purpose for writing about this particular topic? Is this documentation, or a sales report, or a resume cover letter, or a product description, or a complaint? Obviously, this makes a big difference. You wouldn't write your resume cover letter as a complaint, would you? The goal sets the tone of the text.

Once your goal is defined, you should know who your audience is. It is clearly different if you are writing a product description for fellow engineers or for the vice president of consumer affairs. The level of detail, the vocabulary, the length, and the basic structure of the document will be different for different audiences.

These three requirements (clear idea, goal, and audience) may seem obvious. However, I have found that inexperienced writers neglect these concerns. Unfortunately, this means that such writing cannot possibly convey the idea that they have. It won't matter how well they construct sentences, if their grammar is perfect, or if the descriptions are graphic.

Without a clear idea, a specific goal, and a known audience, comprehension simply will not be achieved. Conversely, with these three points, many other grammatical weaknesses can be overcome.

Power in clarity

Suppose you want to suggest to upper management (non-engineers) an idea you have to save money using the Zip+4 code rather than the regular five-digit Zip code. The first example fails to have a clear idea, a specific goal, and is written for the wrong audience. The second example succeeds.

"The Zip+4 process lets mail be sorted by the post office faster. With the LPX5523 file containing 15 million records, over 17.7 GB of DASD can be saved. Port-to-port access time can be reduced by 15 percent with a corresponding user response decrease."

Versus: "I would like to suggest using the Zip+4 process for our name/address computer files. This will save 10 percent of hardware disk space while improving throughput by 15 percent. This saves us money on postage and hardware and improves

customer relations."

Hopefully, you can see a dramatic difference. Which example do you think will succeed with upper management? And, how many times have you heard someone complain that someone else got credit for their idea? Perhaps their idea simply wasn't understood and someone else had the same idea and presented it better.

Writing mechanics

There are a few points to discuss about the so-called mechanics of writing. It's usually helpful to have an outline of what you want to discuss. However, this doesn't have to be anything formal (like in high school). I use a "talking-points" type of outline. This is just a few phrases (say 10 or so) about topics I want to discuss. I don't put them in any order.

Rather, as I write the column, I choose the next topic that seems most appropriate. You may want to organize the ideas before you start writing. And you may want to have more detail. Do whatever works best for you.

Use an informal style of writing (like this) unless there is a specific reason not to. This is the easiest to read and understand. Unfortunately, many people think that it's important to try to impress the reader with fancy words and complex sentences. Yes, you got good marks for that in English class, but this is different. The goal is to clearly transmit an idea — so keep it simple. If a sentence is longer than 20 to 25 words, break it into two sentences. Use simple, direct statements.

This also means to try to avoid technical jargon. Obviously, if you are writing a technical paper, some jargon is expected. But for general readers, jargon is a turn-off.

The same is true for acronyms. There is nothing worse than trying to read an article with undefined acronyms. Sometimes the whole context of the article depends upon knowing what "CFIS" means. And, if you don't know that it stands for Computerized Flight Inspection System, the article is useless to you. The rule I learned was to define each acronym the first time it is used.

There are a few exceptions to this. I don't define units of measurement (KHz, mA). And general use of common technical acronyms, like CMOS and TTL, are assumed to be understood by the readers of *Nuts & Volts*. However, if I was discussing them in length, I would define them, as well.

The length of the text is also important. However, there are no spe-

Check Those Facts!

Use of a familiar illustration to convey an idea is a powerful writing tool. But how do you know that illustration has a basis in fact? You have to research it! A good place to start is at **www.snopes.com** where all manner of myths and legends are discounted and debunked. You might be surprised to learn that we use far more than 10% of our brain, as well!

cific rules for this. Obviously, if it's too long, the reader gets bored. If it's too short, important information may not be included. Generally, the more technical the topic, the longer it can be. For reference, a typical type-written page (not screen) on a word processor is about 500 words. My columns are typically 3,000 words and are three published pages. Your audience defines the length.

Accuracy, completeness, and clarity

There are three main attributes for any discussion: accuracy, completeness, and clarity. Obviously, you want to be correct in what you say. Believe me, I know what happens if you say something wrong in a publication. It's not pretty. But what's worse than getting deserved criticism, is that the error can never be completely erased. There will always be readers who think what you said was right. "I read it in a magazine!" At the least, they may be embarrassed when they are shown to be wrong. At the worst, their lives could be at risk. (For example, giving the wrong color for the "Hot" wire of a power cord is dangerous.)

Clearly, you want to be extra careful about anything of importance. Always check your facts. Sometimes, well-known "facts" are wrong. For example, Lemmings do *not* spontaneously leap to their death, regardless of what that old Walt Disney movie showed.

It's also important to be complete in discussing your topic. Obviously, this is a relative term. In theory, no discussion can ever be complete because there is always something new occurring. Completeness really means "no major omissions."

For example, if you are talking about resistors, you should include the color code, tolerance, types, and ratings. You may not need to discuss humidity effects, lead inductance, and manufacturing methods. How complete a paper is depends upon the length. The length depends on the goal you want to achieve and the audience.

The last attribute is clarity. This is the most important one. If something is clear and in error, the error will be noticed easily. It will also be evident if a topic is missing. The most important facet of clear writing is simple — *write so you can't be misunderstood*. I learned this a long time ago and it has helped me continuously. If you can write without any ambiguity, then you can write well.

A few tips

The first tip is well-known. Write about something you know. (This also refers to having a clear idea, as discussed above.) If you are an engineer writing documentation about a

project you just finished, there will be no problem. But suppose you're writing a user manual for a product you haven't actually seen. You're probably going to write a poor manual because you can't know about something you haven't used.

A similar problem occurs when writing a research proposal. If you don't fully understand the research topic (not always an unusual situation), you can't explain it. In cases like these, it is important to do some homework.

Another tip is to re-read the text after a day or so. This lets your brain retract from the topic and you can read it more objectively. Often, you will find dis-jointed sentences or poorly constructed paragraphs. Basically, this allows you to add "polish" to your work. Unfortunately, most people wait until the last minute and the time for this is not available.

Letting someone else read your work is also useful. But two things are important here. The first is that the reader must be honest. The second thing is that any criticism must not be taken personally. This information is important. Don't get defensive. If you do, the next time everything will be "fine" even if it isn't.

Try not to get emotional when writing (unless it's poetry or fiction). This is hard if you are talking about something important to you. But the result is usually strident and irritating. People don't like to be shouted at or lectured to.

Sometimes, if something is important, it is useful to say the same thing more than once. But use different words and say it in a different place. Repetition helps people remember. Additionally, point out important items by simply saying "this is important." Don't expect your reader to know this. You're supposed to tell him.

Stay away from cliches and overused phrases. If you're lucky, they will only make you sound pretentious. If you're unlucky, you will appear silly. Your own words are much more powerful than any trite saying.

Naturally, there are many books you can refer to in the library, bookstore, or on the Internet. They can provide more detail than I can here.

Reader response

John King, a reader from France, wrote and requested a discussion about writing user manuals and service manuals. His timing was good since I was in the process of writing this. However, since I have no information about the products (hardware, software?) or the market (commercial, industrial, military?), my comments will be fairly general.

The first point is that the person who is writing these manuals should have hands-on experience with the products. As I noted before, you can't write well about something you don't know. There are some companies where technical writers are expected to convert notes and documentation into a manual. It's very hard to do this.

User manual

The two major considerations for a user manual are the audience and the goal. Generally, the goal is to teach the user how to operate the product. Note that teaching is different from just presenting information. And how you teach depends on the audience. Obviously, you would write very differently for high school students versus experienced engineers.

Since a user manual is the company's interface to the customer, it is important that the manual be readable and understandable by all. This means that the vocabulary and style must target the lowest level user. Otherwise, that user may not be able to operate the item properly. This could cause lots of problems. In particular, a poor manual usually requires additional customer support. This is expensive. Then there are the product returns because of user frustration and the inability to follow the instructions.

A good user manual explains, rather than describes, the product. It has a logical progression of material from general to specific, and important to trivial. It has a good index and table of contents so that the reader can find specific topics and related items quickly. Remember, too, that the user may not know exactly the proper word.

For example, suppose the user wants to delete a file. He doesn't remember the word "delete" so he looks up "erase" and "remove" in the index. Help him out by adding these words to the index with pointers to "delete." When "delete" is found, don't simply say "Delete is the command for deleting files." This is obvious. What the user wants to know is *how* to delete. Is deleting a file different from deleting a directory? What if two files have the same name? How do you delete many similar files? What is the difference between "erase" and "delete?" Put yourself in the user's position when you write. What would you want to help you understand?

Walk-thru's are generally a poor choice. This is because they don't explain what is happening. The user isn't learning — he's copying. Walk-thru's also don't separate between important and trivial actions (which is clearly very important).

A good technique for measuring manual quality is to give the manual and product to a co-worker for evaluation. The co-worker should have a similar background to the expected audience, but no specific knowledge of the product. (Heath-Kit used this procedure and created outstand-

ing assembly manuals.) Take all feedback very seriously. Finally, an unconventional approach can sometimes work. This depends upon the product and audience. There is no law against a manual being entertaining. Can you add humor to the manual? What about illustrations? The military has used a comic-book format for some manuals. Be careful here, though. Don't let the format obscure the content.

Service manuals

Obviously, a service manual is generally referenced when there is a problem. (However, sometimes people read them to become familiar with the product before a problem arises.) The goal of a service manual is to allow the reader to repair the product quickly. It's also important to remember that the audience is well-educated and quite self-directed. A good service manual explains how the unit operates in general. It then goes on to explain — in detail — each sub-unit. This gives the reader an understanding of the whole system. This is important to know because it helps locate the problem. I've seen some manuals that explain the function of *every* part. This is great because you can quickly determine if a suspicious part has the potential for causing the failure.

Decision trees for fault location are generally not all that useful. This is because they don't explain anything. What's worse, it's nearly impossible to predict every failure mode. What happens when you have a fault that doesn't match a node in the tree? (Three Mile Island had a decision tree that failed.) These trees assume that the reader is dim-witted and can't think for himself. This is not true. Explain the system and let the reader make the decisions based on his own observations.

You can never have too much information in a service manual. But it is important to identify likely versus unlikely failures. Always put a tolerance for every measurement because no measurement is perfect. If the voltage is supposed to be 5.0 volts, is 4.75 volts acceptable? Saying 5.0 volts ± 5 percent indicates that 4.75 volts is suspicious. A service manual can be tested, but it requires effort. The best way is to give the manual and a deliberately failing product to a technician and measure how much time the repair takes. Feedback from the technician is important.

Once you determine you have a good manual, maintain the format for all other manuals. There are a couple of reasons for this. The first is that it makes all other manuals easier to create and more likely to succeed. The second reason is that technicians will get used to that format and find your other products easier to service. If your products are easy to repair, they are more likely to be bought.

Conclusion

Writing is a skill that improves with practice. But three factors are always necessary. You need a clear idea of what you want to say, a goal for your writing, and you must know your audience. With these factors, a grasp of basic writing mechanics, and a few tips, you can take an idea in your mind and place it in someone else's mind. And when you stop to think about it, that's pretty amazing. **NV**

Continued from Page 20

batteries? I will have this system on eight plus hours a day, so I can't use my laptop as the battery only lasts two hours at best.

If this power supply was possible, would it be more efficient?

I would like to connect my fishfinder and GPS to one of these small computers via a data acquisition box so I can do low budget seafloor mapping using the Windmill data acquisition software available on the web from **www.windmill.co.uk**.

I also have video feed from an underwater drop camera, a video monitor, a PIC-based onscreen display board from **www.icircuits.com/prod5.htm**, and a pair of fluxgate magnetometer sensors **www.speakesensors.com** to detect metal artifacts and junk. All this equipment needs a lot of juice, especially my small remotely operated vehicle thrusters, so I'm always worrying about line noise, battery life, voltage drop, and current draw. I will probably use two small gel cells of whatever size gives me satisfactory operating times, and it will be on two separate circuits to keep the motor noise away from sensitive electronics.

#09035 Michael J. Lenardi
Department of Anthropology
State University of New York at Stony Brook

ANSWERS

[5033 - MAY 2003]

I would like to feed a security camera output to a VHS VCR to prevent unauthorized persons from entering a restricted area and using equipment (by which they could be injured).

My VCR can be easily controlled by CC relays, K1 to close for 115 VAC power, K2 to simulate the RECORD PB, and K3 to simulate the PAUSE function. K2 should energize after the tape is threaded during the power on and should remain energized until the VCR power (K1) is removed (lights in room go off). The actual recording should then be controlled by K3 by using the PAUSE (PB) function for 15-30 seconds every 2-3 minutes (K2). I wish to use 555s not 4017s.

I am currently working on a project like this for a friend who has been broken into and fears the intruder may come back and strike again. He lives out in the country and frequently leaves for several days at a time, so needs a camera system that can turn on and off the recorder by itself, for a set period of time.

What I did was to remove the faceplate from an old VCR and solder wires across the connections for the N.O. micro-switches that correspond to the record and stop buttons. I used two very small five volt relays to interface the switches and provide an access point for remote control.

I have been using a very small and cheap PIR sensor package for a while now in various projects. It's a DK-76B detector kit and costs about $10.00 from MPJA **(www.mpja.com)**. All the associated PIR electronics are mounted on a small board, as well as the Fresnel lens. Powered with anything from about 5 to 12 VDC, it outputs a 1 sec. high pulse whenever it senses infrared motion.

Not being able to find a 555 timer circuit that would give me the on time that I desired of about 15 min. after motion was sensed, I went with a PIC micro (16F84) instead. The output of the PIR sensor is connected to one of the port input pins. A very short program realizes the pin is high and powers up the relay effectively "pushing" the record button on the VCR. Then, after a 15 min. wait period, the relay connected to the VCR stop button is triggered, the VCR stops recording, and the sensor resumes watching for infrared motion. It works well and was surprisingly quick to assemble.

The nice thing about going with the micro is that I am only using three input pins right now. It would be very easy to monitor other types of sensor inputs to switch the camera on or off. In your case, you might be able to sense particular machines being turned on and off, use a CdS photocell to sense the presence of light, or even a small microphone to trigger on loud noises. The microcontroller allows you to vary your timings at will and it would even be possible to add a pan and tilt mechanism to take in wider views at some later date.

The total price is under $20.00 and the minor surgery needed to "upgrade" the VCR is worth it for the flexibility. The only thing I wish to add to my system before I install it is a small LED blinking counter like you see on some answering machines. This way, my friend can tell how many recording events have occurred when he returns from his trips. To be honest, I have a feeling we are going to be watching a lot of deer, dogs, foxes, and birds (which won't be all that bad either).

Eric Daine
Macon GA

[5037 - MAY 2003]

I'm finding voltage doubling circuits that need AC input. What about DC-DC?

The idea behind a voltage doubler is that you have two capacitors in series. You charge one capacitor during each phase of the AC cycle, using diodes to distinguish between the two half-cycles.

This can't be done with DC, but you can chop DC into AC, double it, and convert it back to DC. The ICL 7660 voltage multiplier IC does this. Instead of diodes, it uses high-speed solid-state switches that are synchronized with its built-in oscillator. For more information, see: **www.maxim-ic.com/appnotes.cfm/appnote_number/725**.

Michael A. Covington
Athens, GA

[6033 - JUNE 2003]

I own a 220-volt, 250-amp shop arc welder of a simple brute force design. It consists of an AC variable-core transformer coupled to a large diode assembly.

What I need is a means of injecting a high-frequency signal into the output leads going to the handheld welding rod. The frequency and current need to be high enough to help start the arc

when the welding rod is applied to a metal surface that is not perfectly clean (rust, scale, paint, etc.). I am told this will smooth the welding process when working with hard-to-start electrodes – by acting as a pilot arc, so to speak.

Is there a schematic for a home-brew device as I have described? Perhaps with hand-wound torroids and control knobs for frequency and current?

The method for adding an HF arc involves using a high-frequency transformer and vibrator 555, and a method of coupling it to the main cable or welder stick.

Induction is always the best way to do this. It requires that you make a coil large enough to pass all the DC current of the welder through, and have a smaller high frequency inner coupling coil to induce the high frequency into that main coil.

First, wrap a 7-10 windings of 1/2 inch dia. copper bar around a 4-inch dia. air core. Then make a smaller set of windings from solid 12 ga. copper wire to slide inside the larger coil. Be sure to insulate the two with paper, cardboard, or insulation tape. The coils must not touch each other at any point.

The overall length should be about five to seven inches with an outer coil spacing of 1/4 inch per winding. The 12 ga. inner coil should fit inside and be about the same length (with a tighter winding) to induce the maximum effect in the outer coil. The entire insulated assembly should be snug and not wobble or rattle.

The high-frequency is generated by an automotive coil (or other high voltage coil) with a HEI module coupled to a 555. This should be adjustable from a low frequency of around 1 kHz to over 30 kHz via a pot to find the "best frequency" for the coil saturation and welding performance. The HEI module that comes with most modern car ignition coils will handle the heavy amperage switching to the inner coil. Use an astable 555 circuit to trigger it continuously.

This output is placed through the smaller 12 ga. inner coil and back to earth or ground while its effects are induced into the outer coil and onto the job.

An adjustable "air gap" is also needed to boost the impedance and lower the resistance in the line. This makes it an open circuit that jumps the air gap and steps up the voltage without loading the coil down.

The air gap can be made using two sharpened stainless steel screws or platinum carbide Heli-arc rods, on an insulator allowing you to adjust the gap from zero to around one inch wide. Seal them tightly in a box to muffle the sound, and keep the points clean and free from corrosion by moisture flux powder smoke. The high frequency goes through these points, onto the smaller diameter core windings and back to ground.

Low voltage switching and wiring can be made to turn this device on and off from a foot switch or hand switch on the welder handle, as most arcs once started don't need the further boost from this device.

Chris
Bieber, CA

[6032 - JUNE 2003]

I need to build a circuit that switches over to a battery when the AC power in my house fails.

The battery voltage should be adjustable from 3-12 volts, but use a power transformer to supply the voltage when the power is on. It does not need to be fancy like a battery charger.

Please keep it simple for a 16-year old to read. I understand most of the stuff, but not all yet.

The easiest way to switch from house power to battery is to use two rectifier diodes. Convert your AC to DC with a standard transformer and rectifier/capacitor circuit. The negative output is "ground" and is connected to the negative battery terminal. The positive output is connected to the anode of one of the diodes. The anode of the other diode is connected to the positive terminal of the battery. Both cathodes of the diodes are connected together and are your outputs to the load. This can then be regulated with a standard three-terminal regulator. The battery will power the load when the transformer power falls below about .7 volts lower than the battery voltage. There is no significant switching time. For adjustable voltage output, read up on the National LM317 regulator **www.national.com/ds/LM/LM117.pdf**.

Robert Zusman
Scottsdale, AZ

[6034 - JUNE 2003]

I'm looking for a circuit that will take an input from a current transformer and give a 4-20 mA output to control motor speed through a frequency drive.

This needs to be an inverse relationship: as current transformer voltage increases, the 4-20 mA output current decreases, causing the motor to run slower.

Total output of the current transformer would be about 34 VAC. The output should swing between 4 to 20 mA with a change of about 6 VAC in the current transformer. An operator control pot would be necessary to fine-tune the circuit current output.

This is a feedback control scheme where increased speed of the motor causes an increased current through the current transformer.

The best way to accomplish this is with a current transducer hooked up to a PID controller. They are available off-the-shelf with a 4-20 mA output. However, since you need to reverse the action, you need to get a PID controller involved; most have this capability by setting a bit during the set-up routine.

You need to tune the whole arrangement, and the Nichols Ziegler (Ultimate Cycle) tuning procedure has worked very well for me and is well described in the literature. If you need further information, I can recommend Robert Bateson's book *Introduction to Control System Technology*. If you decide to use a current transformer — which can be done — make sure it is properly terminated. Open current transducers can get hot and even blow up in extreme cases.

Walter Heissenberger
Hancock, NH

[6035 - JUNE 2003]

I have an old 7.2 volt Makita cordless drill that would cost more to replace the battery and charger than replace the drill.

I'd like to run it on 12 volts from my truck with a cord to the drill. How can I drop 12 volts to 7.2?

#1 I have a similar cordless drill made by Skil tools. I attached a salvaged vacuum cleaner cord (18 ga., about 20 feet long) directly to the battery contacts inside the drill handle and then two battery clips to the other end. The voltage drop over the 20 feet of cord gives the drill just about what it is happy with. I use it a lot when doing small jobs on cars out in the driveway. The battery is never dead and the cost was zippo. It's been going for a couple years already.

Lloyd Hartenberger
Chester, IL

#2 Don't bother to drop the voltage to the drill. It will run even better on 12 volts than on 7.2. Generally speaking with DC motors, volts = speed, amps = torque. With the increased voltage, the motor will run faster but won't draw appreciably more current unless you stall it. If you do hold it stalled, it is a bit more likely to burn up at 12 volts than 7.2, but no electric drill will tolerate this in any case.

D.P. Armstrong
via Internet

[6036 - JUNE 2003]

I'm building the temperature probe project that was in the April '03 issue for monitoring a saltwater tank. I'd like to be able to log the data in a semicolon separated format at five-minute intervals. Can anyone provide the code changes for this? This would make the cheapest data logger I have seen.

Here is what needs to be added to the SER2TEMP.BAS code to have it print the time in 24-hour format along with temperature readings of both probes:

```
42 OPEN "FILENAME.TXT" FOR OUTPUT AS #1
212 TM = TIMER: WHILE TIMER < TM + 300: WEND
214 PRINT #1, TIME$ "; " T1 "; " T2 ";"
```

Line 42 creates a text file named FILENAME.TXT. Line 212 waits for 300 seconds (five minutes), line 214 adds the time and temperatures separated by a semicolon.

What you can also do is generate HTML source. Change the filename to FILENAME.HTML and add the following line of code:

```
44 PRINT #1 "<HTML><H1>
SALTWATER TEMP</H1><HR>
<PRE>"
```

This file when read by your favorite web browser will show a subject title of SALTWATER TEMP in large bold letters followed by a horizontal bar (<HR>). The <PRE> tag makes it display the file in its original format to prevent the data from running together.

I use this to show me the temperature of my wine cooler anywhere in the house from my wireless Pocket PC. I will soon have it email me a message if the temperature gets too high!

Mark Roles
Seattle, WA

[6037 - JUNE 2003]

What is the best way to make a soft power switch for a microcontroller (i.e., a momentary button-press latches power to a microcontroller which can then power itself down after a predetermined time)? Is there a name for this type of functionality?

With the wake-up feature found on many modern microcontrollers (MCU), there is no need to create a hardware-only soft power switch feature.

Instead, you should use the MCU's resources. Many MCUs offer two ways to do this. You can use the (1) wake-up on pin change or (2) wake-up on timer overflow.

The pin change method is the best since it offers fast response. What you do is maintain power on the MCU and when the task is done, you set your I/O pins as required in your application then issue a "sleep" command. Usually this is a result of the user pressing the momentary "power" button that is connected to a MCU I/O pin. Your program polls the pin and when it senses the switch closure, it performs the sleep command after the switch is released.

While in the sleep state, the MCU goes into a low current mode (just a few microamps), so battery operation is supported. When the user presses the power switch again, the MCU sees a state change on the I/O pin. This commands the MCU to "wake-up" and your program can then do whatever you want (light power LED, enable I/O devices, perform tasks, etc.)

If you use the timer overflow method, then you must periodically wake-up the MCU using a timer/counter and poll the I/O pin that is connected to the switch. This method draws more average current and there might be a short delay due to the chosen polling period.

For more Microchip (PIC) technical information on this, read app note AN528 on the Microchip website at **www.microchip.com.**

Thomas B.
Folsom, CA

[7032 - JULY 2003]

I found two hybrid IC power amp modules in my electronics stash, and beyond what they are, I cannot identify them further.

One is marked "Sanyo power amplifier SS1001." The code on the back is 86AE303. The other is marked "The Fisher pa501 Hybrid IC power amplifier module." The code on the back is 50HL093.

They are in rectangular cases, a screw hole for mounting is on each end, and 10 solder terminals (for PC mount) are along one side. The case size is 3" long, 1.75" wide, and 1/4" thick.

Does anyone have a cross reference, hook-up diagrams, or specifications? Google was no help.

The power amp modules you have are older units, however there is a cross reference for them. The SS1001 amp crosses to ECG or NTE1337 and also to STK086. This is a 70-watt amp requiring a bipolar 55-volt supply. The pinouts can be found at **www.nteinc.com**. You will have to use the pdf file for the NTE1320 module. The pinouts are the same but the supply voltage for the 1320 is 37 volts versus 55 volts for the 1337.

The PA501 amp module crosses to an NTE or ECG1148 or STK-036 or SK3292. The pinouts are not at all close to the SS1001. The PA501 is a 30 watt amp that also requires a bipolar supply. I could not find a pdf file on the NTE website for this module.

My advice would be to put them back in the parts bin in the event something turns up needing one of these modules. If you are going to build a power amp, you can save a lot of headaches and money using some newer amp modules that have a full set of specifications and some application drawings.

Terry Kasie
via Internet

[7033 - JULY 2003]

I need information about Uninterrupted Power Supply maker, "Electro Vector."

My Electro Vector SRP-500A back-up power system recently conked out. Before I junk it, perhaps there is a successor company or some firm which can supply replacement components?

It has been about six years since I communicated with the company. There is no answer at the last phone number I had for them and my letter to Electro Vector in Forrestville, CA, was returned.

#1 www.apc.com Select products, scroll down to UPS Battery Replacement & Up Grade Selector. They say they will give up to a 40% discount when trading in any UPS whether it is working or not.

Edwin Spencer
Burns, TN

#2 Magnetika has posted the following information on this web page **www.magnetika.com/news.htm**, dated 03-25-2003. "Over the years Magnetika has acquired many manufacturers of Magnetic Components, such as Transformers, and we have in our possession most of their designs and we own the rights to use their names and manufacture any and all of their products.

These manufacturers are: Mercury Transformers, Inc., Servo-mechanisms, Inc., Ferrodyne Corporation, Rucker Electronics, Electro Engineering Works, Electro Vector, Torwico Electronics, OPT Industries, Nytronics, United Trans-former Company (UTC), Titan Transformers, DB Products."

As you can see, the sixth entry in the list appears to be your Electro Vector. The CONTACTS page lists a number of locations. These phone numbers are the closest locations to you. Phillipsburg, NJ T (908) 454-2600, F (908) 454-3742; Lakewood,

NJ T (732) 364-1800, F (732) 363-6234.

Tom Tillander
Bay Village, OH

[7034 - JULY 2003]

Is there such a cable with an upstream (square) USB plug at one end, and a 37-pin female (parallel) plug at the other end? If so, can someone recommend sources?

I'd like to connect my USB 2.0 printer to a parallel switch box since all my USB connections have already been taken and, so far I haven't seen a USB switch box!

What you should be looking for is a USB hub not a USB switchbox!

The great thing about USB is you can connect up to 127 devices to one USB port, provided, of course, that you have enough input jacks to plug that many devices into. The key to doing this is called a USB hub. This is a small box that plugs into ONE USB port of your computer then expands that one port into several more. You should be able to find a USB hub at any computer store for less than $20.00. Another great source is eBay. These are available with different port configurations, but four or five ports seem to be the most common.

One thing to watch out for ...

Try to get a USB v2.0 hub.

The first USB hubs ran at 12 mb/s. The newer v2.0 USB hubs run at 480 mb/s and are backward compatible with any USB port or device. Although you would notice very little difference with a printer (which is a relatively slow speed device) connected to a v1.0 USB hub as opposed to a v2.0 hub, there will be a quite noticeable difference when connecting a higher speed device such as an external hard drive, CD-ROM drive, CDRW burner, or camera. And, of course, the real beauty of the hub is there are no switches to fool around with as all devices connected to the hub are connected to the computer all the time.

John
via Internet

[70310 - JULY 2003]

I need a system that will let me combine two composite video signals into a single 'picture-in-picture' signal with one image superimposed over the other. Until recently, you could buy stand-alone units, but it seems that they are only available as built-in options now.

Are there components that can be used to build a small PIP?

In late June, there were several external PIP adapters listed on eBay for prices less than $20.00. One model is the Allegro Videa, another is Multivision model 2.1. These will probably be gone by the time you read this, but check again, you'll probably find something.

Steve Bepko
via Internet

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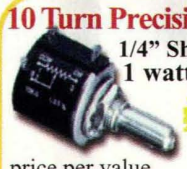

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MicroProcessor Controlled !
Includes 4 Nozzles!

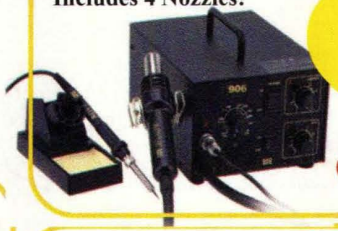
only $199.00!

SMD RE-WORK SYSTEM w Vacuum Pick-up tool. Details at web site !

SMD RE-WORK SYSTEM w Solder-iron

item# CSI906

Includes 4 Nozzles!



Incredible Deal ! only $169.00!!

Detailed Specs on the Web

Hand-Held 3.0GHz Universal Counter with Field Strength Measurement

Now only $99.00!

*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)

Includes:
*extendable/retractable whip antenna
*Internal 4AA Nicad batt pack (600mAH)
*9VDC, 500mA wall plug-in charger

item # FC1002

Extensive Details at www.web-tronics.com

Super Economy DMM

1999 counts LCD Display, 15mm digit height
H/E DATA HOLD
Audible Continuity
Rubber Boot Included
Includes test leads

1	10	50+
$9.99	$7.99	$6.99

*DC Volts: 200m/2V/20V/200V/600V
*AC Volts: 200/600
*DC Current: 200u/2m/20mA/10A
*Resistance: 200/2K/20K/200K/2M
*Size: 138 x 69 x31mm

CSI 830

Protek 60 & 100 MHzRealtimeScopes

Incredible Low Prices!

2 Channel
Dual Trace
6" Internal Grid
ALTMAG
ALTTRIG
TV Sync

AMAZING VALUE S !

Brand New Not Refurbished! includes 2 scope probes

60MHz only $469.00
100MHz only $699.00
(Limited Time Offer)

See all Details at web-tronics.com under Test Equipment

Digital Read Out 3Amp Bench Power Supplies

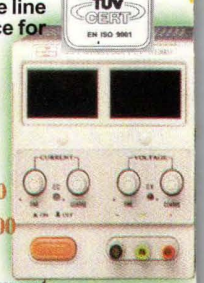
Available in 0-30 volt & 0-50 volt versions

AS LOW AS $85

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.

Line Regulation: 2x10⁻⁴ +1ma
LED Accuracy: Voltage ±1% +2 digits
Current ±1.5% +2 digits
Wave Line Noise: ≤1mvrms
Dimensions: 291mm x 158mm x 136mm

New ! Lower Prices



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

DC to AC Inverters

Modified Sine Wave
SP-150WATT...$19.95
SP-300WATT...$34.95
SP-600WATT...$64.95
SP-800WATT...$98.00

12V DC to 120VAC

item# 30S-12A 300 Watt Pure SineWave Inverter $119.00!

More Details at web site under "DC to AC Inverters"

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 at our web site under "Test Equipment"

item# 200DSO $859.00

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 5+
$59.95 $52.95 NEW!
item # CSI 1802D

Personal UV EPROM ERASER

NEW!
item# D-ERASE
$49.95
Erase Up to 4 Chips at a time
Adjustable Timer..4 to 24 minutes

5MHz Dual Channel Digital Scope Meter

*DC to 5MHz *details at web site*
*Dual Channel item# S2405
*Sampleing Time:50Ms.S
*Auto Triggering
*Auto Calibration $299.00 !
*Roll & single shot mode
*16 shot reference wave-form & set-up memory
*Built in autoranging True RMS Digital Multimeter
*Includes RS-232 I.F. software, RS232 cable & Rubber Boot

Circuit Specialists 20MHz Dual Trace Scope

*20Mhz Bandwidth Item# CSI6502
*Alt-Mag sweep
*1mV/Div vertical sensitivity
*Alternate trigger
*X5 sweep magnification
*Large 6"CRT/autofocus
*ships w 2 (x1 & x10) probes)

$269.00!!!
More Details at web site!

Innovative 5 in 1 DMM

IntegratedSOUND/LIGHT/HUMIDITY SENSORS
DCV/ACV/RES/CAP/FREQ./TEMP/RH/LIGHT/SOUND/CONT/DIODE
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More Information at www.web-tronics.com

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:Temperaturein F/C; relative quantity & error % of relative value at the same time...
MORE DATA at WEB SITE
CSI 8203.....~~$189.00~~

SALE! $129.00

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 RFtransmissions

$1699.

Extensive Tech Details & a Special Offer At Our Web Site (www.web-tronics.com)

Details & Software Download @ our web site Intelligent Multi-function Digital Counter

An intelligent multi-function counter controlledby 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

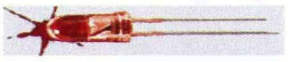
New Lower Price! $129.00!!

Circuit Specialists now carries FLUKE TEST EQUIPMENT

FLUKE

Visit our web site & view our extensive offering of new FLUKE TEST EQUIPMENT. Just go to our home page & selectTEST EQUIPMENT. We've got great deals .....
New !
FLUKE COLOR SCOPES

LED's/Megabright Blue, White, GREAT PRICES!

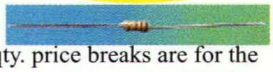


		luminous intensity @ 20mA	1	10+	100+
Megabright Blue 5mm	(L7113PBC/G)	1400	$1.95	$1.50	$1.25
Megabright Blue 3mm	(L7104PBC/G)	600	$1.95	$1.50	$1.25
Megabright White 5mm	(L7114PWC/G)	600	$2.15	$1.59	$1.35

more technical details @ our web site under SEMICONDUCTORS
FLASHING red 3mm (L36BHD).....as low as $.28 ea!

GREAT 1/4 Watt Carbon FilmResistor Deal !

1-199 $.07
200 $.01
1000 $.003
NEW LOW PRICES
as low as $3.00 per thousand



(qty. price breaks are for the same value resistor. 200 lot pricing & 1000 lot pricing based on ordering in multiples of 200 or 1000 of each value)

5% tolerance/bulk packed
All Standard Values
from 1 ohm to 10 meg ohm

PROGRAMMABLE DC POWER SUPPLY

item# CSI3645A

NEW!!
only $199.00 !!

manual pdf available at web-tronics.com

*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 at web-tronics.com (under test equipment)

BAG of LEDs DEAL 100 LEDs for $1.50 !!

Normal brightness leds now available in RED or GREEN in 3mm or 5mm size. Your choice. Each bag of 100 costs $1.50 ! (that's 1.5 cents ea.!) Each bag contains 100 of the same led.

BAG-RED 5mm.....$1.50 BAG-GREEN 5mm..$1.50
BAG-RED 3mm....$1.50 BAG-GREEN 3mm..$1.50

Visit our website for a complete listing of our offers. We have over 8,000 electronic items on line @ 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 handleing items, hand tools for electronics, breadboards, trainers, programmers & much much more ! Some Deals you won't believe !

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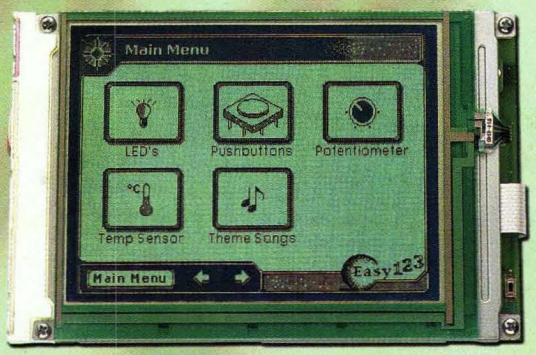
800-528-1417/480-464-2485/FAX: 480-464-5824 Circle #145 on the Reader Service Card.

Liquid Crystal Invasion!

You've got a Stamp and a programming board. What's next? Give your next BASIC Stamp or Javelin Stamp project new dimension with a GUI or LCD from Parallax. These smart screens are the best way to display your digital results and computations to the world.

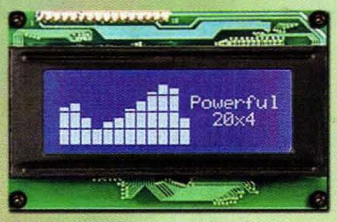


Amulet Easy GUI 5.7 Starter Kit with Bezel (bezel not shown); #30053; $399.00; For complete details, additional projects, and GUI downloads, visit the Amulet GUI page at www.parallax.com.

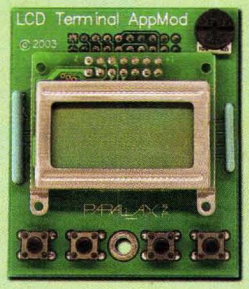
The GUI Starter Kit includes a 1/4 VGA, 5.7" monochrome display with a CCFL backlight, a fully-integrated analog touch panel, Amulet Controller Board, serial cable, development software CD, stylus touchpen, AC power adapter and is mounted in a high quality bezel (not pictured). *Note: To operate this kit with the standard GUI, you must have a BS2-IC or higher and a BASIC Stamp Activity Board (#27905).*

The Amulet GUI is fully customizable for your own projects, but Amulet has created a GUI for the following to get you started: the BASIC Stamp Activity Board (#27905), the Boe-Bot (#28132), Parallax Standard Servo (#900-00005) and the Javelin Stamp (#JS1-IC). Our favorite, the Boe-Bot GUI shows you how to remotely control a Boe-Bot via RF using icons on the Amulet display screen. In order to utilize the GUI projects, you will need to purchase additional hardware.

2x16 Serial LCD; #27910; $49.00; 2x16 Serial LCD – Backlit; #27923; $59.00; A Scott Edwards Supertwist 2x16 LCD with a factory installed LCD Serial Backpack interface. The 2x16 LCD is the right choice if you require a small footprint and low current draw (2-3 mA without backlight).



4x20 Serial LCD with Keypad Interface; #30058; $109.95; The Matrix Orbital 4x20 Serial LCD has an Inverse Blue display with a white backlight, 6 general purpose outputs, keypad interface (up to 5x5 Keypad) and can communicate over RS-232 or I²C (connect up to 16 displays over I²C). This LCD is pre-modified TTL for BASIC Stamp-compatibility.



***NEW!* LCD Terminal Application Module; #29121; $39.00;** This low-cost display is excellent for your smaller projects. The module has a 2x8 display, 4 pushbuttons, and will connect to any programming board that has a 2x10 AppMod header.

PARALLAX

www.parallax.com

Visit the "Audio/Visual" page in the PRODUCTS section of www.parallax.com to see our entire line of GUI screens and LCDs. You can order online or call the Parallax Sales Department toll-free at 888-512-1024 (M-F, 7-5, PST).

Circle #154 on the Reader Service Card.