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Everything For Electronics

Nuts & Volts

October 2003
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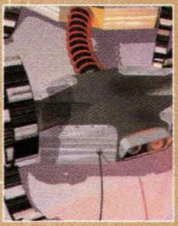
by Dennis San Vicente



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Dear Nuts & Volts:

Your "Managing People" for the "In The Trenches" June 2003 issue of *Nuts & Volts* was the best synoptic on managing people I can remember reading. Your writing style, organization and content made the article seen like a good novel that can not be put down or fascinating new bit of knowledge that is thrilling to learn.

Tonight, the past *Nuts & Volts* issues will be retrieved from archive and the "In The Trenches" will be the first section of the magazines to be read.

Vaughn
via Internet

Dear Nuts & Volts:

As a 20-year subscriber to *Poptronics*, I will subscribe to your wonderful magazine in a few days. I have one comment on the article "In The Trenches: Managing People." Very few of your readers will get much out of this article. I think your readers are after voltage type stuff. Perhaps an article on garage door openers would have more value to most of us. But I love your magazine. Thank you so very much.

Jim Easley
via Internet

Dear Nuts & Volts:

The August article on licensing and certification by Louis Frenzel was right on target! Obtaining the commercial GROL license will open many doors in the communications industry.

Your readers may be interested in knowing there is only one complete textbook in a Q&A format that contains Element 1, 3 and 8 - plus all the information about the various FCC commercial licenses. I wrote the book within weeks after the FCC changeover from a secret exam to the public disclosure of all examination questions. In fact, I helped pull together many of the test questions for all three elements!

The book is 496 pages and is entitled "GROL Plus — General Radiotelephone Operator License Plus Ship Radar Endorsement," featuring the entire question pool where each Q&A has my one or two paragraph explanation on how the answer is correct. On numerical equations, we give our readers every step in solving the math!

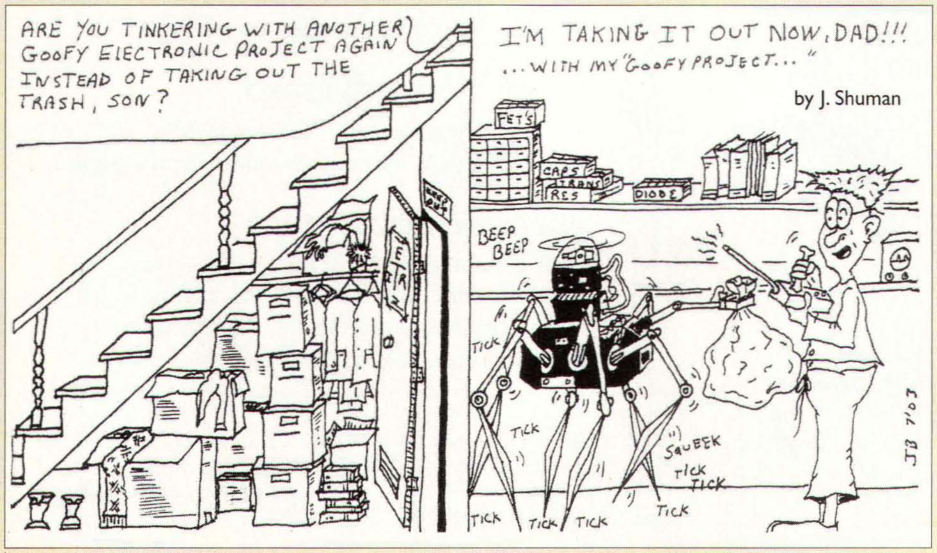
Most of the training organizations that Mr. Frenzel mentioned use my book for classroom instruction. It is also sold by the National Radio Examiners Colem at 800/669-9594, for under $50.00.

Finally, while some examination groups recommend a 30-day wait between retaking a failed exam, there is no longer any FCC rule that demands a waiting period. A second different examination might be administered the following day, or for that matter, the following hour after a failed first exam.

Louis is correct — a second exam fee will be charged for the second test. Usually, most examiners charge between $25-$35 for each exam element.

Finally, Louis is right on target when he says passing the exam is a good solid investment in your career.

Gordon West
Costa Mesa, CA



by J. Shuman

Dear Nuts & Volts:

Just gotta tell you ... I was one of the first subscribers when you guys were selling subscriptions at computer shows. I'm very pleased to now know that the mag is still okay. You keep up the good work, we'll keep buying!

Eric J. White
via Internet

Dear Nuts & Volts:

Guy Marsden's article "Leviation" (Sept. 2003) caught my eye. It reminded me of a project I did many years ago, with a similar device.

For those who build Guy's device, I would like to propose an experiment. Let the device run for 48 hours, without removing the power. I believe that the doll will turn first one way, and then the other. It will then repeat the cycle. All of this will be in very slow motion, on the order of several hours. Over a few days, the swinging arc will slowly drift as well.

Air currents (and even your cat) will affect the motion of the doll. To cut these off, one can put a clear cake dish lid over the doll, or perhaps an inverted aquarium.

Why does the doll act this way? Hint — reverse the obvious. This would make a nice science project.

Stuart B. Wahlberg
Blythe, CA

Dear Nuts & Volts:

On page 22 of the May 2003 issue of *Nuts & Volts*, George Whitaker shows in Figure 1 the traditional "phone plug" as it was indeed used on manual telephone switchboards.

However, in Figure 2, he fails to state that, historically, the association between conductors and colors was:

Green — Tip
Red — Ring
Yellow — Sleeve
Black — Ground

The use of all four wires can be seen in such places as Fonthill in Doylestown, PA, where the original wiring of the telephone system has been preserved.

Continued on Page 59

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FOUNDER/ASSOCIATE PUBLISHER
Jack Lemieux

PUBLISHER
Larry Lemieux
publisher@nutsvolts.com

ASSOCIATE PUBLISHER/ VP OF ADVERTISING SALES
Robin Lemieux
display@nutsvolts.com

MANAGING/TECHNICAL EDITOR
Dan Danknick
dan@nutsvolts.com

CONTRIBUTING EDITORS
Jon Williams
Jeff Eckert
TJ Byers
Gordon McComb
Harry Hawkins
Louis Frenzel
Gerard Fonte
George Whitaker
Al Williams
Ray Marston
Stanley York
Mike Keesling
Edwin Hawkins
Rudolf Graf
Bill Sheets
Glen Worstell

CIRCULATION DIRECTOR
Mary Gamar
subscribe@nutsvolts.com

SHOW COORDINATOR
Audrey Lemieux

WEB CONTENT/NV STORE
Michael Kaudze
michael@nutsvolts.com

PRODUCTION/GRAPHICS
Rosa Gutierrez
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DATA ENTRY
Karla Thompson
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Understanding, Designing, and Constructing Robots & Robotic Systems

Amateur Robotics

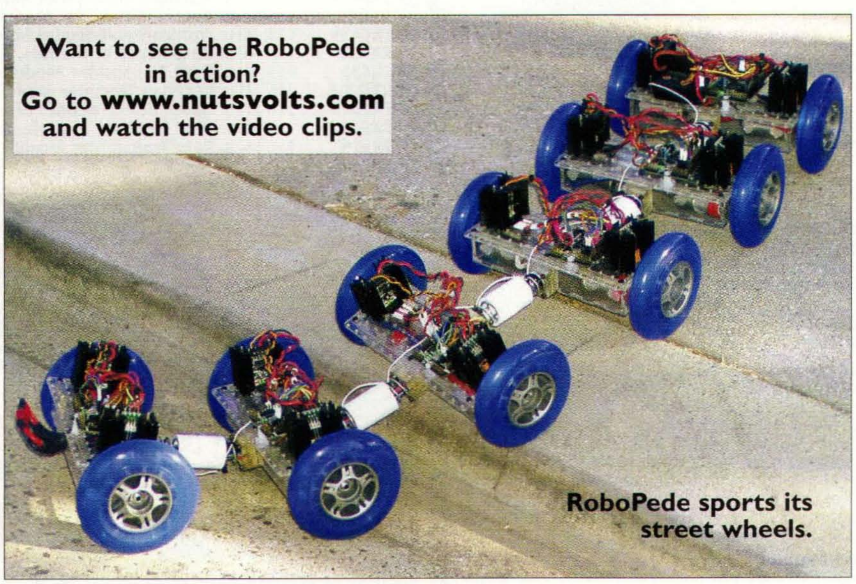
RoboPede Marches In

What do you get when you mix an over-zealous inventor, dozens of coreless motors and a microcontroller based on DSP technology? A RoboPede!

Recently, I came across the mother load of Escap coreless motors. I noodled for many long hours, wondering what I could build that was easily within my abilities, and would be truly impressive.

I looked at my inventory, and summed it up. I needed to build a multi-axis moving device that was big. I needed to build something that was different. I needed to build a robot that could conquer the world. Then, the idea came to me. I needed to build a 36-motor centipede. After some introspection, I decided to scale things down, shelve world conquest, and start off my design with only 12 wheels. This article will lead you through my design goals and how I achieved them, along with some of my failures along the way.

My primary goals for this robot were: *cheap, quick,* and *easy.* I don't have a lot of money, time, or patience for long-term projects. For the brains, I decided very early on that an IsoPod™ would be the heart of the beast. Its 12 PWM outputs, combined with 12 NMIH-0050 5 amp H-bridges were a perfect match for my centipede's 12 motors and wheels. With these components in mind, I set the goal of having 12 motors running with magnets and Hall Effect sensors for velocity control, running off one IsoPod.



RoboPede sports its street wheels.

Distributing The Chassis

Having settled on the control architecture, the chassis was next. I flailed over several designs, staying up many caffeinated nights, but the answer came to me while doing some work in my yard: sprinkler joints! I hurried up to the hardware store, motor in hand, and found that with a little machining, I could stuff the motors into opposing ends of a four-way sprinkler pipe.

The bonus of my trip was finding a spring that I could stuff into the remaining connections. The centipede's chassis was born! Two days later, all the pipe-joints were machined to allow a press fit of the motors, with holes drilled for access to the motor leads.

The next step of the process — the wheel hub — is where things got difficult. Mounting wheels to shafts is notoriously difficult and/or expensive. The solution here was to use an SAE 1/4-28 bolt, drilled hollow to 3 mm, and a 6-32 set screw tightened into one of the faces. (See photograph.) This provided a very sturdy mounting point for my wheels. SAE hardware is generally better than your typical hardware store stock, and a 28-pitch thread has a shallower root, allowing for a thicker, stronger wall.

I would like to generally discourage you from mounting wheels to the output of any gearbox that isn't specifically designed for these loads; unless you are willing to replace parts. A much better practice is to use shafts for the wheels, with appropriate linkages. Since this is a prototype and I have spares, I was willing to accept the consequences of directly loading the gearboxes.

From Wheels To Whegs

The wheels themselves also presented a design challenge. I had decided that I would keep machining to a bare minimum from the beginning of this project; to keep costs down. One wonderful resource that I know of is laser cutting of acrylic and polycarbonate, from Filener Engraving, in Oregon. Their prices are very reasonable and when provided with appropriate files, they provide quick turn-around. Rather than using regular wheels, I was inspired by an MIT website with something called "whegs." These are essentially the spokes of a wheel, without the rim.

To solve this, I designed a two-part wheg. The first part is a retainer, with a hexagonal drive hole, and 12 smaller holes for magnets. The second is a 3-1/2-inch diameter spoked body, with a 1/4-inch diameter clearance hole that was bonded to the retainer. The hexagonal hole kept the wheg assembly from rotating on the hub, and the whole thing was held in place with a retaining nut and lock washer.

As things came together, I realized I had something quite unique. So rather than wiring up everything, I decided to tape on a six-cell NiMH battery pack and parallel the motor leads to it so I could do a test run. The thing was really amazing. It took on a life of its own.

It went up and down stairs, and over concrete parking blocks. It also shook itself to pieces, literally. The gearboxes I had were pinned to the motors, and I was supporting the whole wheg and motor assembly by the back of the motor. I managed to find all of the gears that spilled out of the gearboxes, clean them up, and go back to the drawing board. I also realized that my wiring harness was going to be huge if I wanted to have feedback off each motor, power, and PWM signals running along the spine of this beast.

For the mechanical redesign, I again turned to Filener Engraving for parts. I designed the entire chassis to be built out of 1/8-inch, laser cut, polycarbonate. The motors were now properly mounted to their faces. Adequate room was provided for two internal NiMH sub-C cell batteries, and a top mounting cover was provided to affix the electronics, with a grid of holes I could mount other brackets to.

I wanted to keep the electronics exposed in this version, to facilitate debugging. If I had buried the circuit boards deep within the body of this beast, things could have been more difficult. As it turned out, everything was wired properly the first time through. All 200 or so wire connections were correct.


Anatomy of a plastic wheg.

Getting Un-Wired

The electronic design was a whole other challenge. I had envisioned one IsoPod running the whole show — which it could handle with ease. I had planned to build another 24 segments, and have three IsoPods, linked with CANBUS, controlling everything. The resulting wiring harnesses would have been bigger than my 68' Volvo's, and I would still be threading it. I changed my plans, and opted for one MiniPod™ on each segment.

The MiniPod is basically the IsoPod's little brother. With six PWM outputs, six timer inputs, eight 12-bit A/D converters, more than eight GPIO lines, SCI, SPI, and CANBUS, it's a highly capable processor. With one MiniPod per segment and two motors, it meant that I could actually gain functionality, like having position and velocity feedback for the whegs, instead of just velocity. I could also add a radio control receiver to remotely operate the beast, and save it from dangerous situations. However, all this being said, the major reason for taking a distributed approach to processing was so I could reduce the wiring harness.

Now, with distributed processing, there are only three wires that are common to the whole assembly: the two CAN signal lines, and ground. Now the power harness is the complicated part. Since I opted to use a star arrangement for all power distribution — with twisted pairs to keep radiated noise down — I even spent the big bucks, and used silicone insulated wire throughout the entire assembly.

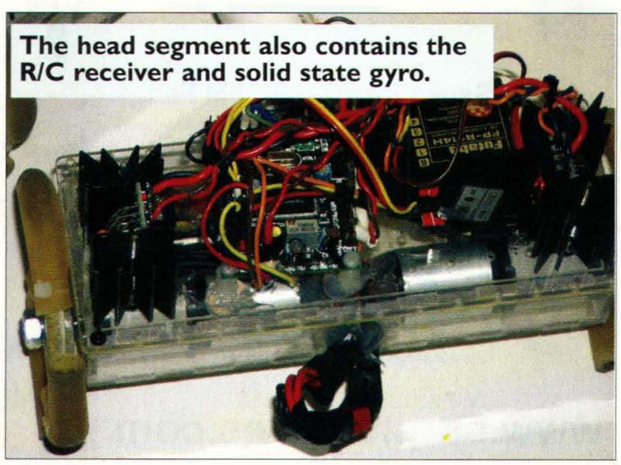
Operational Dynamics

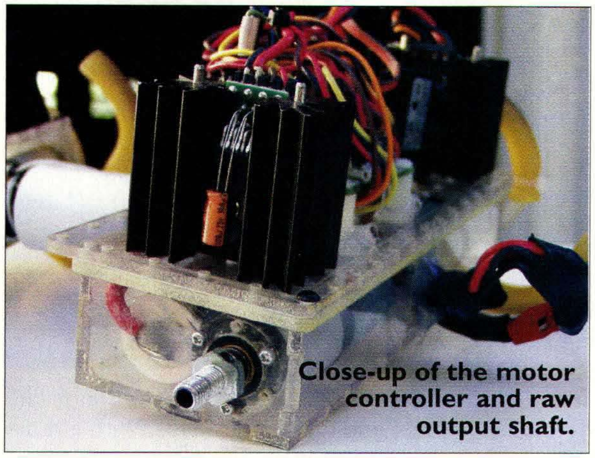
I learned from experience that catching this thing running at full throttle was no easy feat. For one thing, if you block it, it climbs over things like feet and hands with ease. With a radio control unit on board, and with software programmed to always allow me to override the system at all times, I could let it roam free, but also save it from harm if needed. I also wanted to characterize its behavior before I even attempted to program autonomous behavior. For instance, I have learned a lot about climbing up and down objects, and how to modulate the individual wheel's velocities to maintain control on different types of terrain.

So, here I am, with what must be the coolest R/C vehicle I have ever had. It's better than my plane, helicopter, and cars. Better than any toy I have ever owned. I had been getting requests at work to bring it in, so I started doing demos during break time.

"Demos" is the operative word here, as it frequently "demolishes" itself. Wires break off at the batteries, motors, screws, and hubs come loose. Plus it's noisy, *really* noisy. Like a fleet of angry giant cockroaches.

In my defense, it has tumbled down a half flight of stairs on more


The head segment also contains the R/C receiver and solid state gyro.



Close-up of the motor controller and raw output shaft.

RESOURCES

IsoPod, MiniPod and NMIH-0050 by New Micros, Inc.
www.newmicros.com

Laser Cutting by Filener Engraving
www.filener.com

Online Vibration Calculator
www.endevco.com/main/tools/vibration-calculator.php

than one occasion, and at this point, had seen several hours of 0.5-inch amplitude, 15 Hz bouncing on every segment (that's like 4 g's, if my math is correct). It was pure folly to keep on playing with it when I knew it had to be ruggedized.

So I replaced the motors, soldered the broken leads, and silicone glued all the batteries in place. I thread locked all of the screws, shaft locked the hubs to the motors, and replaced the wire ties holding the MiniPods with stand-offs — which I silicone glued in place. I also glued all the connectors to the boards, since my ample service-loops were pulling them loose. The only casualty the electronics suffered was when a MiniPod picked up some metal shavings and failed.

I guess this is what prototypes are all about. My error was in not paying attention to the design of MIT's chassis. While the geniuses at MIT used a rigid chassis and synchronized wheg movements, I have randomly flailing claws, hooking onto whatever they can. It's still cool though. Now that everything is either hard mounted or shock mounted, I have over two hours of run time without a failure.

Future Enhancements

When I embarked on this project, I envisioned an autonomous robot, crawling around and staying out of trouble. The problem is that it is very bouncy. The front segment not only pitches on its axle, it also bounces up-and-down, and side-to-side. If I slow down, the side-to-side motion stops, but the pitching and bouncing is still there.

The addition of a cheap gyro-scope helped control course deviations due to the side-to-side hopping, since they also have a bit of yaw to them. I am looking at mounting sensors to either an actively or passively stabilized platform, and have started characterizing the vibrations I need to correct.

The software to-date is really trivial. I had already written the CANBUS and PWM generation in preparation for testing. The only code remaining was the code to take the output of the R/C receiver and convert it into differential drive signals, so it can execute tight, accurate turns. The addition of a couple of Sharp GP2D12 infrared distance sensors added a whole lot of life to this beast, but the R/C is still there to override if trouble comes along.

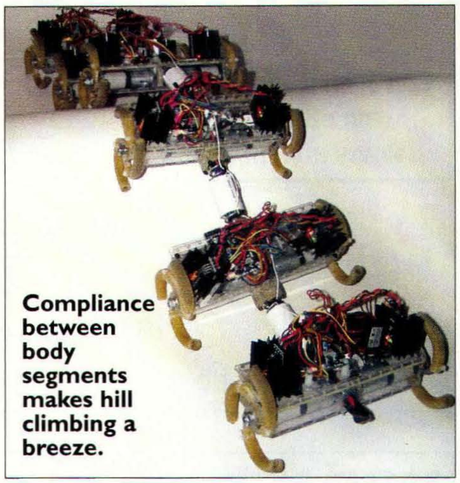
The CANBUS turned out to be ultra simple, once I had the thing figured out. Presently, I am only sending two byte packets, representing the duty cycle for each motor, but I'm also going to add wheel velocity, error bits, and possibly some cool LEDs under CANBUS control, as well.

Overall, the Forth based software was the simplest part of the entire project, taking only 10 hours or so, compared to the 40 hours of wiring. The design and construction of the chassis and the sprinkler pipe prototype amounted to another 40 hours, for a total build time of about 90 hours.

More To Come

The next generation RoboPede will see a new, enclosed chassis, spring-loaded whegs, and a bevy of sensors. Of primary interest to me is implementing my "optical mouse hack" which modifies the optics of a standard optical mouse to turn it into an actual 16x16 imager or advanced motion detector.

I will also be implementing quadrature decoding on each wheg, and hopefully an artificial neural network. A set of actual wheels for "soft testing" is also in development. In future installments, I hope to cover IsoPod programming in detail, sensors, and laser cutting design hints. **NV**



Compliance between body segments makes hill climbing a breeze.

COMMENTS/QUESTIONS?

Mike Keesling can be contacted through Email at author@bio-bot.com.

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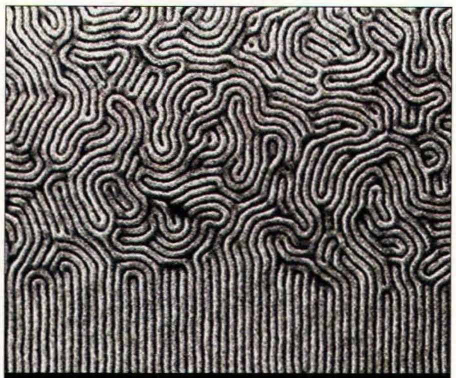
Advanced Technologies

Hybrid Manufacturing Technique for Microelectronics



A new technique of manufacturing microelectronics induces long chains of molecules (called block copolymers) to form themselves into certain patterns, in this case, parallel lines. Photo courtesy of Paul Nealey, College of Engineering, University of Wisconsin-Madison.

Back in the old days (1965), Intel's Gordon Moore projected that the number of transistors on a chip would more or less double every year for the next decade. In 1975, this was revised to every 18 months, and the concept is now known as Moore's Law. For years, it has been widely observed that standard fabrication techniques are approaching some insurmountable physical limits that will eventually cause Moore's Law to break down. So far, however, novel manufacturing techniques have extended its life beyond the expectations of many experts, and engineers at the University of Wisconsin-Madison (**www.wisc.edu**) working with the Swiss Paul Scherrer Institute, seem to have provided another extension.

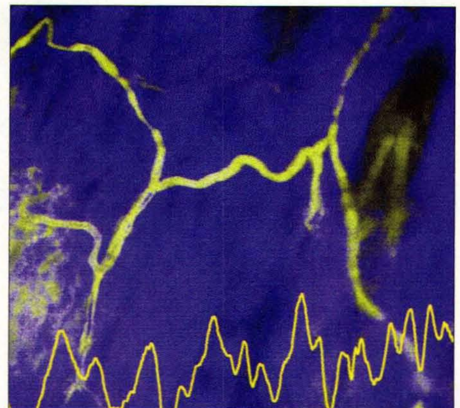
Existing photolithographic methods are incapable of generating small enough circuit traces, and the use of self-assembling molecular chains can result in an unacceptable level of defects and other challenges. However, combining the two processes into a hybrid technology seems to be a promising approach.

According to Paul Nealey, a University of Wisconsin-Madison chemical engineer, "Our emphasis is on combining the approaches, using the desirable attributes of both, to get molecular-level control in the existing manufacturing processes."

By merging the principles of both techniques, researchers developed a hybrid approach that maximizes the benefits and minimizes the limitations of each technique. Specifically, the team of researchers used lithography to create patterns in the surface chemistry of a polymeric material. Then, they deposited a film of block copolymers on the surface, where the molecules arranged themselves into the underlying pattern without imperfections. "Tremendous promise exists for the development of hybrid technologies such as this one in which self-assembling materials are integrated into existing manufacturing processes to deliver nanoscale control and meet exacting fabrication constraints," says Nealey.

The work was conducted at the Center for NanoTechnology at UW-Madison's Synchrotron Radiation Center. It was funded in part by National Science Foundation's Materials Research Science and Engineering Center and the Semiconductor Research Corporation.

3-D Imaging Technique Uses Quantum Dots



Multiphoton fluorescence microscopy with quantum dots illuminates a capillary beneath the skin of a living mouse. Courtesy of Bioimaging Resource, Cornell University. ©Cornell University

Researchers at Cornell University (**www.cornell.edu**) have developed a method of using fluorescence imaging labels, which consist of quantum dots circulating through the bloodstream to produce unusually bright, high-resolution, three-dimensional images in living tissues.

"We have demonstrated a new approach to using quantum dots for biological studies of living animals," noted Watt W. Webb, a Cornell professor, co-inventor of multiphoton microscopy (with Winfried Denk), and leader of the experimental imaging team at Cornell.

"Of course, there are easier ways to take a mouse's pulse," adds Webb's Cornell collaborator, senior research associate Warren R. Zipfel, "But this kind of resolution and high signal-to-noise illustrates how useful multiphoton microscopy with quantum dots can become, in a biological research context, for tracking cells and visualizing tissue structures deep inside living animals."

The technique relies on a novel application of multiphoton microscopy. The scanning microscope moves the laser beam across the area being imaged at a precise depth. When repeated scans at different planes of focus are "stacked," the result is a brightly-lit and vividly-detailed three-dimensional image, and a video that takes a viewer inside a living organism.

Zipfel cited the study of vascular changes in cancer tumors as one possible application, but he cautioned that the researchers are not ready to recommend human-medicine clinical applications for quantum dot imaging, in part because some of the best fluorescing nanocrystals have unknown toxicity. However, mice used in the Cornell study are still alive and apparently healthy months later. They are being monitored for long-term effects.

Computers and Networking

New Standard Defines 55 MBps Wireless Network

The top speed of wireless personal area networks (WPAN) has officially jumped from 1 to 55 Mbps under a new standard from the Institute of Electrical and Electronics Engineers (IEEE, **www.ieee.org**). This increase opens the door for the broad use of multimedia, digital imaging, high-quality audio, and other high-bandwidth WPAN applications. The new standard — IEEE 802.15.3, "Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for High Rate Wireless Personal Area Networks (WPAN)" — allows a WPAN to link as many as 245 wireless consumer devices in a home at data rates up to 55 Mbps, and distances ranging from a few centimeters to 100 meters.

The standard provides for wireless connectivity in the 2.4 GHz unlicensed frequency band among fixed and portable devices. It specifies raw data rates of 11, 22, 33, 44, and 55 Mbps, which can provide data throughputs in excess of 45 Mbps. The transmission range varies inversely with the chosen data rate. For example, you get a range of 50 meters at 55 Mbps or 100 meters at 22 Mbps. The highest rate accommodates low-latency, multimedia connections, and large file transfer, whereas 11 and 22 Mbps rates are more suitable for long-range connectivity among audio devices.

The standard uses TDMA (time division multiple access) to allocate channel time among devices to prevent conflicts, as well as to provide new allocations for an application only if enough bandwidth is available. Devices that implement 802.15.3 connect in an ad hoc manner and communicate by peer-to-peer networking, allowing them to connect without user intervention. Data in the network may be protected using AES 128 (advanced encryption standard), which was approved by the US government in 2001 to replace the older DES (data encryption standard).

Networks formed under IEEE 802.15.3 are configured to co-exist with other IEEE 802.15 WPANs, such as BlueTooth™ systems, and with IEEE 802.11™ wireless local area networks, such as Wi-Fi systems. IEEE 802.15 standards are sponsored by the IEEE Computer Society (**www.computer.org**).

QUANTUM DOT

A quantum dot is a very small particle whose properties can be modified in some significant way by adding or removing an electron. This includes individual atoms, but also certain groups of atoms, in this case, cadmium selenide-zinc sulfide. Quantum dots are also referred to as "redox groups" in biochemistry and "quantum bits" in the field of nanotechnology.

Dell Exits Eight-Processor Market, IBM Steps in

According to several reports, Dell Computer (**www.dell.com)** has now abandoned the high-end Intel-based server market, having sold only 400 eight-processor machines in the first quarter of the year. By comparison, IBM has sold more than 10,000 of its eServer x440 systems since the machine was introduced last year. Various explanations for this have been offered, including a suggestion that aiming your television marketing campaign at 18-year-old stoners does not impress the information technology professionals who buy this type of computer.

In any event, IBM has magnanimously offered Dell customers a "technology lifeline." According to an IBM press release, "To help customers constrained by Dell's decision, IBM will unleash a team of technical and sales specialists dedicated to helping Dell customers. This team will evaluate customers' existing Dell infrastructure and offer an analysis of how scalable Intel-based eServer systems can help lower costs and simplify systems management. Qualified Dell customers can select a number of pre-configured eServer systems that scale up to 16 Intel processors or scale out with blade servers. Selected eServer systems are available to Dell customers at a savings of up to 15%. IBM will also assist Dell customers to migrate workloads to the new eServer systems."

Roughly translated, this means that Dell server owners can expect a flock of sales vultures to descend upon the carcasses of their installations. The pitch will be that the average Intel-based server is actually computing only about five percent of the time, so server consolidation (getting rid of some of your smaller units and buying a few high-end multiprocessor systems, known as "scaling up") will increase your utilization rate, lower costs, and simplify system management. Dell, in contrast, will be emphasizing the opposite approach of "scaling out," which consists of spreading your workload across many low-end servers which, after all, are becoming more powerful. The best approach depends on the specific needs of the customer, so caveat emptor applies.

Circuits and Devices

Cell Phone Includes QWERTY Keyboard

If you like the concept of sending text over your cell phone, but can't quite master the art of typing messages on a numeric keypad, you may want to look at the recently introduced 6800 Messaging Phone from Nokia (**www.nokia.com**). Among its other features, the 6800 opens up to provide a QWERTY keyboard for more convenient alphanumeric input.

Cell phone with advanced messaging capabilities. Courtesy of Nokia.

Employing AT&T Wireless' GSM/GPRS network and mMode data plans, the Nokia 6800 messaging phone allows users to access services such as mobile Email, instant messaging, the sharing of digital images and sound via Multimedia Messaging Services (MMS), and over-the-air application downloads.

The phone (GSM/GPRS 850/1900 MHz) operates on packet data GPRS networks for high-speed data connectivity and delivery of Email from POP3 and IMAP4 servers. Additionally, the Nokia 6800 comes preconfigured with an Email application for access to mMode Mail, and it supports XHTML browsing for access to online mMode content, and Java™technology for downloading new applications.

Enhanced features on the Nokia 6800 phone include a full-color display, integrated speakerphone, and optional enhancements such as a desktop charger/music stand, and a stereo headset for use with the integrated FM stereo. Users can also attach the optional Nokia Camera Headset via the Pop-Port™ connector to capture, display, and send digital images to a PC or other MMS-enabled mobile device. The Nokia 6800 messaging phone is available from AT&T Wireless for $149.99.

CdS Cells Drive Relays Directly

Selco Products (**www.selcoproducts.com**) has expanded its range of thermal and electronic control products with a new photocell series. These single and dual CdS light-dependent resistors offer high sensitivity and high stability. Featuring a spectral response similar to that of the human eye, the devices are suited for sensor applications that model light perception of the human eye.

The photocells are designed to sense light in the spectral range from 515 nm to 730 nm, and they have a peak wavelength of 515 nm. Performance characteristics include resistivity values ranging from three kilohms to 240 ohms max at 10 Lux, 2856K, and an operating temperature range of -30 to 75° C. Other features include glass window and plastic coating construction.

Although the devices are small (0.165 x 0.138 inches [4.2 x 3.5 mm] for the Model 9P Series), the output current per photoconductive surface area is large enough to drive relays directly. For this reason, the devices can be used in photometry, light control, detection, and audio applications for sensing the presence, absence, or intensity of light. Typical examples include light camera exposure,

brightness and 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 non-contact volume control, and other visible light sensor applications.

The 9P, 8P, 7P, and 5P Series of CdS Photocells are available for immediate delivery at a cost of $0.10 to $0.33 in production quantities. Custom versions are available.

Industry and the Profession

DRAM Industry to Recover

If you have been intending to upgrade your computer's memory, but have not gotten around to it, now may be the time while supplies are still plentiful.

According to research and advisory firm Gartner, Inc. (**www.gartner.com**), after more than two years of recession and huge losses, the dynamic random-access memory (DRAM) market seems to be on the verge of recovery. Average selling prices are forecast to increase 20.5 percent during the third quarter of 2003, reaching $5.55.

Worldwide DRAM revenue is forecast to reach $5.1 billion in the third quarter of 2003 — a 37.8% increase over the third quarter of 2002. Gartner analysts project DRAM revenue to reach $18.9 billion in 2003 — a 21.8% increase from 2002.

Gartner analysts warned that the DRAM industry needs to be aware of the tentative nature of the upturn. "This recovery is going to be based on lack of supply, not increasing demand," says Andrew Norwood, principal analyst for Gartner's semiconductor research group. "We have been here before, and if the DRAM vendors become greedy and increase production, the industry will quickly swing back into oversupply and prices will crash."

Microsoft Loses Lawsuit

Back in August, a Chicago jury ordered Microsoft Corporation (**www.microsoft.com**) to pay $520.6 million to the Board of Regents of the University of California (**www.ucop.edu/regents/**) and Eolas Technologies, Inc. (**www.eolas.com**). The jury found Microsoft guilty of patent infringement when it included a technology for embedding interactive elements into its web browser. The cited patent (No. 5,838,906) covers a method of allowing "a user of a browser program ... to access and execute an embedded program object."

The suit was originally filed by Eolas in 1999, with the University of California subsequently joining in. As expected, Microsoft will appeal the decision. **NV**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PS-355DPI 0-35V 5A $149.95
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The Latest in Networking and Wireless Technologies

Open Communication

Digital Satellite Radio — Quest for a Signal

There have more than a few times in the past years that I felt manufacturers have forgotten how to make a decent AM or FM broadcast radio. This is especially true of AM radios. Did they lose the formula or something?

The AM radio portion of most car radios and stereo receivers is appallingly bad. You notice it most in the car during a long trip — just try to find a decent AM station unless you happen to be driving through a city! Lousy antennas and propagation effects contribute to the problem.

FM reception is a bit better, but the range is so short that you lose any station after an hour or so of driving. Well, the days of poor car radio reception are over thanks to a new digital satellite radio service now being offered by two new companies: SIRIUS Satellite Radio and XM Radio.

Both offer 100 channels of CD-quality digital radio distributed coast-to-coast by sophisticated satellite systems. These systems are awesome technical achievements, without doubt. And they provide continuous high-quality radio reception across the 48 contiguous states.

Recently, I had the chance to interview the SIRIUS people and test their service using one of the new Kenwood receivers. Here are my thoughts for all of you radio fans.

The Satellite System

Back in 1992, the FCC established the Digital Audio Radio Service (DARS), which authorized two companies to deliver radio service by satellite in the 2.3 GHz microwave S-band. Both SIRIUS and XM were granted licenses. It took many years to build and launch these systems. Both companies initiated their services late last year, and today they are rolling out the receivers and subscriptions. SIRIUS and XM each offer 100 channels of digital radio — mostly music, but also sports and talk radio. SIRIUS charges $12.95 per month, while XM's price is $9.95 per month. And it is worth it. If you are a serious music-listener or travel long distances by car or truck on a regular basis, you will find the quality and quantity of music well worth the price.

Figure 1

The XM system came on line first. They use two standard geosynchronous satellites to cover the US. A geosynchronous satellite is one that is in orbit around the equator 22,300 miles out. Yes, that figure is correct. The distance from earth is almost three times the diameter of the earth. That's *way out* there. Traveling at a speed of roughly 6,800 MPH, the satellite rotates in synchronization with the earth.

For that reason, the satellite has a rotational period of 24 hours, and so it stays fixed in one place over the earth. In this way, it can be used for relaying information from one point on the earth to any other point that is within view of the satellite. The satellite radio companies uplink their music and other programming to the satellites, which in turn downlink the programming back to the earth-based receivers of subscribers. See Figure 1.

If you think about it, the signal from the antenna on the satellite of a geosynchronous satellite must pass through the total thickness of the Earth's atmosphere. A receiver in the US has its antenna pointed southward at a very low angle toward the equator so it can pick up the signal from the satellite. But all of that atmosphere affects the signal, which can fade and become blocked by nearby objects such as buildings, trees, and other tall structures.

The geosynchronous system works well enough, but SIRIUS designed an even better system. They use three satellites in elliptical orbits high over the US. The apogee (highest point) is 29,200 miles, while the perigee (lowest) is 14,900 miles. Their rotational period is 24 hours like the geosynchronous satellites, but their very high angle of placement means that the satellites are more directly overhead. This eliminates a great deal of the signal loss problem due to the atmosphere and nearby obstructions. The satellites are spaced every eight hours, meaning that there are always two satellites overhead. Figure 2 shows what this arrangement looks like. All the satellites transmit the same data using quadrature phase shift keying (QPSK) — the preferred and most reliable satellite signal modulation scheme.

Figure 2

The satellites themselves were made by Space Systems/Loral. They are about the size of the trailer on an 18-wheeler and weigh about 8,300 pounds. They cost $100 million each. It costs an additional $100 million to launch each satellite into space, which does not include insurance! The SIRIUS satellites were put into orbit by a three-stage Russian Proton rocket launched from Kazakhstan.

For those of you interested in the gory technical details, read on. The SIRIUS system is assigned a total of 12.5 MHz of bandwidth in the spectrum near 2.32 GHz. This spectrum is roughly divided into thirds, with the two transmitting satellites getting 4 MHz each and a terrestrial repeater getting another 4 MHz. I will have more to say about the terrestrial repeater later.

The raw transmitting data rate is 7.5 Mb/s, which includes the actual digital music data, as well as all the overhead such as forward error correction codes, encryption, and other coding information. The audio data rate alone is roughly 4.4 Mb/s and that is divided into 100 44 Kb/s channels. The system also allows SIRIUS to change the individual channel data rates to optimize the programming. Talk shows can use less bandwidth and are transmitted at 24 Kbps. Very high quality audio might be transmitted at 64 Kbps. In any case, it is a far cry from the pitiful bandwidth offered by standard AM and FM radio.

Receiver Characteristics

The digital satellite receivers were designed primarily as car radios and that is where most of them are used. However, there are also home models available. If you are buying a new car, you will most likely be offered one of these receivers as an option. GM cars offer XM radios, while most of the other auto manufacturers offer SIRIUS radios.

The receivers are very small and not so impressive at first glance. The impression you get is that it is just another car radio. But nothing could be further from the truth. This is one of the most complex, high tech receivers I have ever seen. What makes it look so innocent is the fact that most of it is packaged into four large integrated circuits made by Agere — formerly Lucent's semiconductor division.

There is an RF IC that handles the input signal amplification and mixing. The output goes to IF filters as usual, then into an IF amplification IC. The analog output of the IF circuits is then digitized in a fast analog-to-digital converter (ADC). The digitized signals are then processed by the fourth chip which contains digital signal processing (DSP) and baseband recovery circuits. The outputs go to the speakers. Like most digital radios today — including cell phones — these are essentially software- defined radios (SDRs) that use a DSP. Except for some amplification and frequency down conversion, all radio signal processing is done digitally, including much of the filtering and all the demodulation, decoding, and signal reconstruction.

The secret to the success of receiving a miniscule radio signal from as far as 29,000 miles away is diversity. Diversity refers to signal reception techniques that take advantage of the fact that radio signals arrive in different strengths, times, and phases because of the placement of the receiver and/or the transmitter.

For example, spatial diversity refers to the fact that two satellites are transmitting from different positions above the earth. The receiver has two chances to pick up the strongest signal. And that is what it does, as it is designed to lock onto the strongest.

Another form of diversity is frequency diversity. With the satellites transmitting on different frequencies, each signal will be affected by the atmosphere and obstructions differently.

The receiver, again, goes for the stronger signal and in some cases adds the signals together. SIRIUS also implements a form of time diversity that helps overcome major obstacles, such as driving through a tunnel or a forest. The patented SIRIUS system stores four seconds of the signal in an on-chip memory before sending it on its way to the speakers. This is usually ample memory to eliminate or minimize the station loss during this time.

Despite the efforts of SIRIUS to mitigate low signal problems, their system (like XM's), comes up short in some localities. Picking up a satellite signal in a downtown area with many vertical obstructions is extremely difficult. In fact, it is basically a losing proposition.

SIRIUS overcomes this problem with a terrestrial repeater system. Their subscribers in the big cities get their signals from an Earth-bound

DIGITAL BROADCAST RADIO COMING YOUR WAY

The FCC did more than just approve digital satellite radio. They also blessed a terrestrial digital broadcast radio method that is designed to improve the overall quality of both AM and FM band transmissions. Originally known as in-band, on channel (IBOC) radio, this system in now referred to as HD Radio. This system uses the same spectrum as existing AM and FM radios along with sophisticated modulation and multiplexing techniques to add digital near-CD quality audio transmission to both the AM and FM bands.

Orthogonal Frequency Division Multiplexing (OFDM), along with multi-level Quadrature Amplitude Modulation (QAM), are used along with voice data compression and encoding to squeeze the voice and music into the narrow sidebands above and below the existing analog sidebands. The new signals coexist with the present analog AM and FM signals.

This system was developed by iBiquity Digital Corporation of Columbia, MD. The company has been testing the system for the past several years, and has now signed up 180 stations for licenses, with 50 of them already on the air with test systems. It will probably be next year before all the bugs are worked out and the new receivers become available to the general public.

It will be interesting to see how this new, free digital radio service will do. Like regular AM and FM stations, the coverage will be strictly local. In some cases, the same material will be broadcast over both the analog and digital segments of the signal. In other cases, different materials can be transmitted. The choice is left up to the stations.

The signal quality of the new digital segment will be far superior to the current AM and FM signals, but not quite up to the standards set by the satellite services. Yet, undoubtedly the two will compete in some ways. The big question is, will the car radios of the future cover this new digital service, as well as satellite? No doubt such combo radios will be available. We will have to wait for the details.

In any case, the days of digital radio are with us. Just keep in mind that if the stations transmit digitally, they are fully capable of transmitting anything else you can put into a digital format like raw data or video. What possible applications could be waiting for us?

transmitter rather than directly from the satellites. Here's how it is done: SIRIUS transmits the music and other programming up to a geosynchronous satellite operating in the Ku microwave band (12 GHz). The satellite then retransmits the signal back to the terrestrial repeaters.

These repeaters are located strategically on the top of tall buildings or towers, which then retransmit the signal on one of the three 2.3 GHz satellite channels.

These repeaters use coded orthogonal frequency division multiplexing (COFDM), a complex form of modulation/multiplexing that spreads the signal over a wide frequency range. This method has proven itself in environments where lots of multipath signals from reflections befuddle the receivers. SIRIUS has over 100 such repeaters in 50 US cities. And they fully overcome the harsh city environment to deliver a good signal to subscribers.

A Whole New Level

SIRIUS sent me one of their Kenwood Here2Anywhere receivers (see Figure 3) that can be used in the car and at home. It's a tiny thing that can be accessorized with either a car or home docking kit. These kits come with an appropriate antenna, cables, and mounting hardware.

I first tried the radio in my Miata. The radio connects to the in-car sound system through the cassette tape slot. The antenna must be mounted where it can have a good view of the satellites. It works best on the roof or trunk since the antenna is a magnetic mount unit.

Lacking a real metal roof on my Miata, I put the antenna on the trunk and it worked just fine. It is recommended that you experiment with the antenna placement to find what works best in your car.

As for reception — it was great! It is an unusual experience having so many radio stations available. The remote control lets you scan through the options until you get what you want. If you are not careful, this feature can be as distracting as a cell phone while you are driving. My charming wife did the channel selecting while we drove.

I also tried the receiver at home. The antenna is designed to mount on a nearby window, but it must be facing the right direction given what part of the US you are in. The documentation with the receiver clearly explains this.

For me, the antenna had to be moved around a bit to find the optimum reception spot. I have lots of trees in the yard and the big oaks did mess up the signal a bit. But I found a clear spot that delivered strong reception. The receiver played through our regular stereo system. As in the car, the music was superb with many choices. We listen to country, oldies, and some of the lighter rock, and we found plenty of choices in all of those genres.

With 100 channels, it's easy to find something you like. And believe me, there was never a day when you could get 100 total channels of anything on both the AM and FM bands combined at home or in the car before this. This is radio at a whole new level. If you are into music, you will get your money's worth.

As for what receiver to get and where, the Kenwood I tested worked very well. But there are many of manufacturers offering products including Alpine, Clarion, Jensen, Panasonic, Pioneer, Sony, and others. You can buy a receiver at most of the large electronic stores like Circuit City and Best Buy. And next time you buy a new car or truck, you will probably have the option of a satellite receiver. It is a feature you won't regret adding.

One final reminder: It is the antenna that makes the difference in these radios. You must have a good one and you need to play around a bit with its placement to get optimum results. In a new car installation, the antenna is buried in the roof in an optimum location and you don't have to worry about it. And if you are in the city with lots of buildings, chances are that you can get the signal from a local repeater. **NV**

RESOURCES

iBiquity Digital Corp.
www.ibiquity.com

Kenwood USA Corp.
www.kenwoodusa.com

SIRIUS Satellite Radio Inc.
www.sirius.com

XM Satellite Radio
www.xmradio.com

Basics For Beginners

Just For Starters

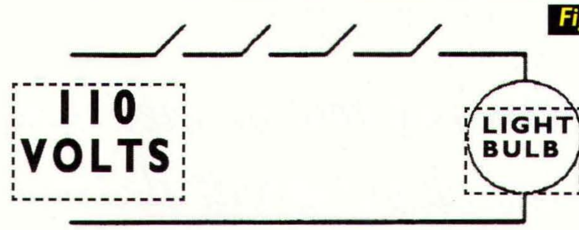
Schematics and Symbols

This month, we want to take a look at some schematic symbols and how to read them. Figure 1 (see next page) is a section of schematic for a 1,000-watt radio transmitter. It represents a fairly simple schematic that looks somewhat complicated. We want to look at the symbols and also discuss some of the nomenclature used to describe different parts.

I used this particular schematic for two reasons. First, it is a good example of flow. We are dealing with a single voltage that either goes, or does not go. Second, I have permission from Harris-Gates to use their copyrighted schematic in my teaching.

This particular schematic is a control and interlock circuit. It keeps the transmitter from being activated until all safety devices are in place. The basic circuit is the equivalent of a digital "and" gate. (It takes this "and" this "and" this to make something happen.) Figure 2 is the simplified form of this circuit. On one side, we have the 110 volts coming in, and on the other side, we have a light bulb representing the transmitter circuits. As you can see, it requires that every switch be closed before the light bulb will light.

Figure 2



The circuit we will be studying is this basic circuit with a few options thrown in. The idea here is to learn how to follow a schematic. What we study will be applicable to many, many other situations. The object is to learn the symbols and to visualize the actions within a schematic. That is, to look at an open switch and visualize what will happen when this switch is closed.

The black arrows at the top of the schematic mean that those points tie to power. In this case, each of the two arrows represent one side of the 240-volt incoming AC line. In another case, it might be a 24-volt DC power supply. The arrow tells us, however, that it does connect to incoming power and it will either be marked on the schematic at that point (as this one is) or there will be a legend somewhere that tells about the power source represented by that particular symbol.

Sometimes there will be solid arrows, non-filled arrows, and different shaped arrows that represent different voltages.

In some cases, circles are used. But, arrows are more common. There will be a legend to show what symbol represents what particular voltage. In this particular schematic, we will be dealing with a single 240-volt AC source.

If you want to follow through this discussion and study, you should keep a copy of the schematic printed this month, as we will not be repeating it.

Next month, we will begin to go through the schematic piece by piece, and see how it fits into the overall picture. NV

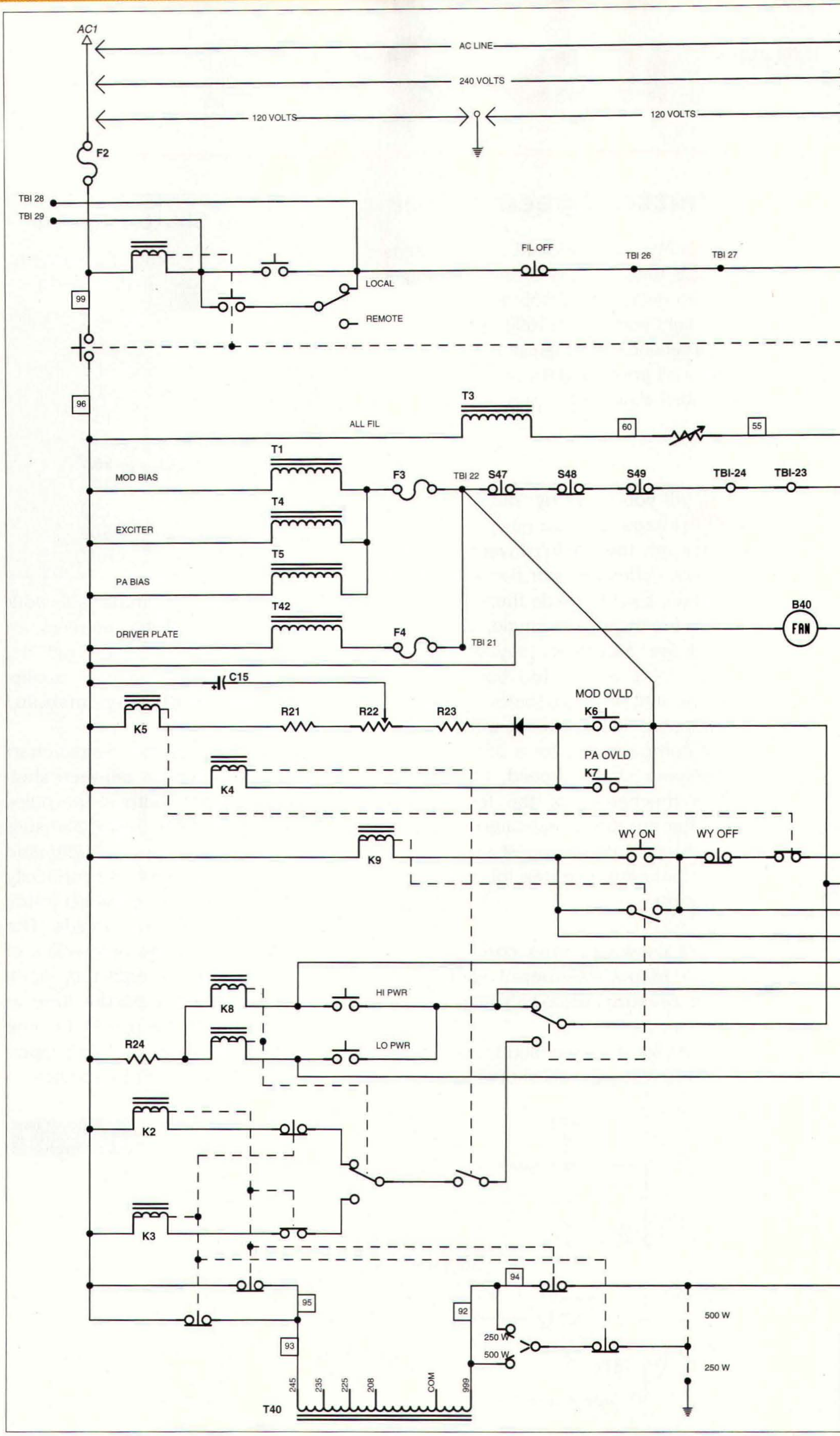


Figure 1. Schematic capture courtesy of IVEX, Inc. **www.ivex.com** See their ad on Page 25.

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:

Something for you shutter bugs. A new zero-crossing circuit and solar panel voltage upverter. All about switching regulators, and three cool websites to improve your PC's performance.

Shutter Speed Tester

Q. My old Exakta SRL camera needs a tune-up. Any ideas on using a photo detector and 555 timer to measure light pulses at 1/1000 down to 1/25 of a second? Commercial shutter testers are a bit pricey and my monetary budget won't allow such a purchase.

Stephen
via Internet

A. If you mean by "old" in that it's vintage '50, you have a treasure. Although they didn't invent the SRL (single reflex lens) or the focal place shutter, Exakta made these technologies practical in a single, affordable package. Moreover, they often used Carl Zeiss optics! Too bad they are now out of business (before you write, the name still exists but with a different company). As for a 555 circuit to test your shutter speed, no can do. The mechanics of the focal plane shutter are too complicated for a simple "light" test. I suggest you look at the following websites for a low-cost solution.

- **www.skgrimes.com/idcc/**
- **http://members.tripod.com/rick_oleson/index-135.html**

As for you other shutter bugs who wish to test your iris shutter exposure time, the following circuit will work (Figure 1). This tester requires an oscilloscope — any scope will do, even a modified sound card oscilloscope (**http://polly.phys.msu.su/~zeld/oscill.html**).

Camera Shutter Speed

Shutter Speed (seconds)	Scope Pulse Width (milliseconds)
1/1000	1.0
1/500	2.0
1/250	4.0
1/125	8.0
1/60	16.7
1/30	33.3
1/15	66.7
1/8	125
1/4	250
1/2	500
1	1000

The Camera Shutter Speed chart shows the relationship between shutter speed and the width of the pulse on the scope screen. Just make sure your light source is very bright and that the sensitivity control is critically adjusted, otherwise you will get a timing error at the highest speeds. The error is caused by the mechanics of the shutter, which is only fully open for about half the exposure time at the higher speeds; the rest of the time it is opening or closing with a proportional reduction in light brightness.

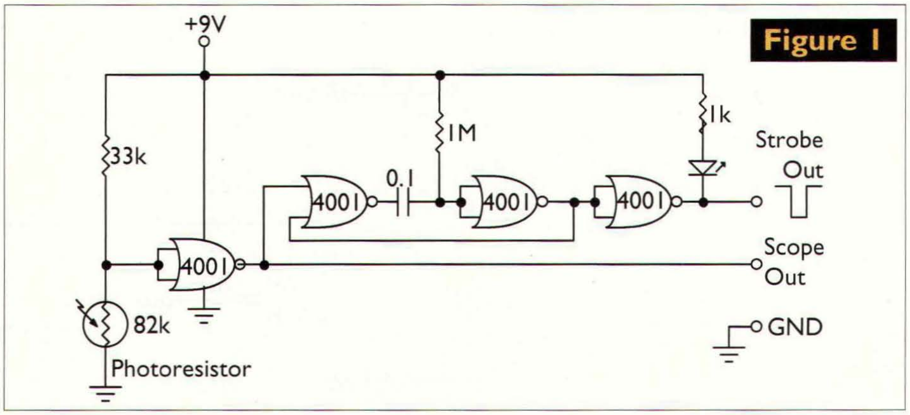


Figure 1

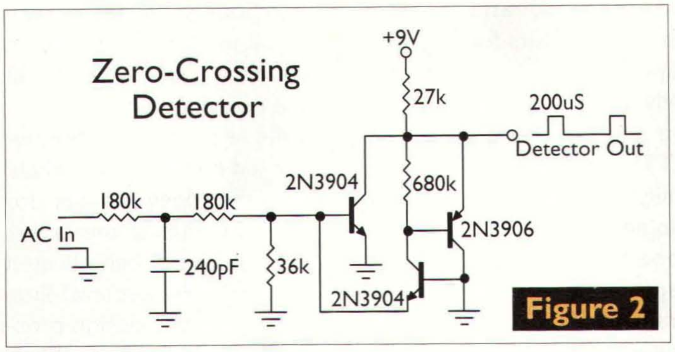


Figure 2

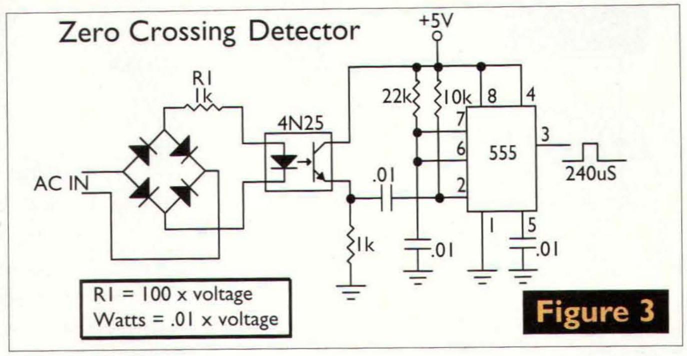


Figure 3

Another Zero-Crossing Detector

Q. I built the circuit you described in the Aug. '03 issue (Zero-Crossing Detector), but can't get it to produce a 200 uS pulse. It's more of a square wave. Any suggestions?

Neil Curry
N. Hollywood, CA

A. Grounding the collector of the 2N3906 transistor will solve this problem (Figure 2). As I explained, this circuit isn't of my design, but one you'll find in more than one switching power supply for zero-cross switching of the SCRs. What I forgot to mention (aside from the missing ground) is that the input is voltage sensitive and must fall in the range of 5 to 10 volts. You can adjust this using a potentiometer in a voltage divider configuration.

In the meanwhile, I had time to come up with the design below (Figure 3), which isn't voltage sensitive and has an adjustable pulse-width output. The AC input is full-wave rectified to produce a pulsating DC waveform that drops to zero volts each time the sine wave crosses zero. This causes the LED in the 4N25 to extinguish and turn off the coupling transistor. This generates a negative-going pulse at each zero crossing.

While you can use this pulse as it stands, I decided to sharpen it up and make the pulse width adjustable by running it through a one-shot 555 multivibrator. With the values shown (100K and .01µF), the pulse width is about 240 uS. Increasing the value of either increases the pulse width.

A word of caution: There is a forward voltage drop across the LED of about 1.2 volts. Consequently, at low input voltages of 10 volts and less, the LED will turn off before zero crossing is reached. In this case, the 555 pulse width can be adjusted so that the falling edge falls on the zero crossing point. The exact delay time is, of course, voltage dependent.

Bell/Ringer LED Alert

Q. I have a 120 VAC wireless doorbell that I want to modify so that I know if someone rang the bell while not at home. Is there an LED circuit I can install that would turn on when someone rings the bell (yes, it uses a speaker announcer), which I could clear with a simple press button to arm it for the next caller?

D. Zillbermann
via Internet

A. There are several sensor options that can be used for this design, including tapping into the speaker wires. But I decided that a sound-activated switch (Figure 4) would better serve our readers because it could be used with chimes and all sorts of bell announcers (even a telephone ringer). The pick-up is an electret microphone that is mounted inside the announcer case close to the speaker. This isolates the mic from outside noise and prevents false triggering. The vibrations it picks up are amplified by the op-amp (any garden-variety op-amp will work) and coupled to a driver transistor through a 10µF cap. At rest, no sound comes from the op-amp and the transistor is turned off.

At the first hint of sound, the transistor turns on and triggers the SCR, which remains latched — lighting the LED — until you press the Reset button. The sensitivity of the switch is adjusted by the value of the Rf resistor; increasing its resistance increases the sensitivity of the alarm.

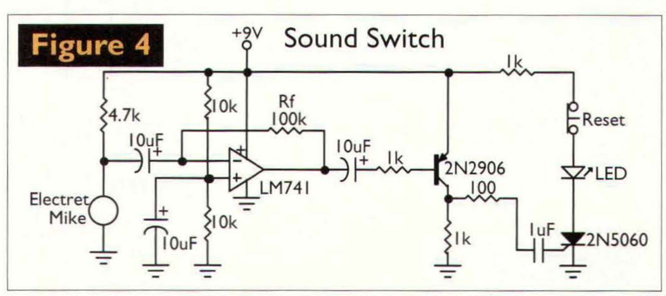


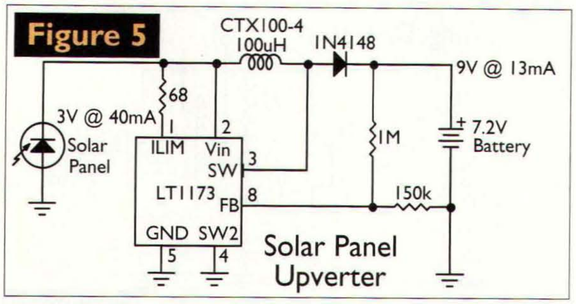
Figure 4

Solar Panel Match-Up Revisited

Q. In the Jul. '03 issue, you answered a question about matching the voltage of a solar panel to that of a rechargeable battery ("Solar Panel Match-Up"). I have a similar problem where the output voltage is less than the battery, but I can't install a bigger panel because of space limitations. Is it possible to increase the voltage of the solar panel using a DC/DC converter or something similar?

P. Fleming
via Internet

A. Yes, but with limitations. You must remember that the power output of the solar panel is a constant. Which means that when you increase the output voltage, you proportionally decrease the output cur-



rent. The circuit in Figure 5 is a high-efficiency voltage booster that will convert three volts to nine volts at output currents up to 100 mA. Using the SPL-60 solar panel (three volts at 40 mA) from All Electronics (mentioned in the Jul. '03 column), the resulting output current at 9 volts is limited to a 13 mA trickle — which is probably enough for the original application of a mailbox alarm.

Power Supply Switch Box

Q. I have a bank of small router boxes that operate from three voltages: +5, +12, and -12. I use these routers for testing and need a way to selectively switch the power on and off to each using a TTL logic signal. I can easily provide the control logic, but I'm at a loss as how to manipulate the voltages. I am leaning towards using a transistor that will switch on or off, depending on the logic provided, but I just don't know how to put together my circuit. Could you please help?

Khalid Sabzwari
via Internet

A. This is a common request in the industrial community where very often power is switched between controller and testing devices. Unfortunately, their solutions are expensive and mostly overkill for your small needs. So here's what I've come up with. Of course, you'll need a separate switching box for each device you which to control.

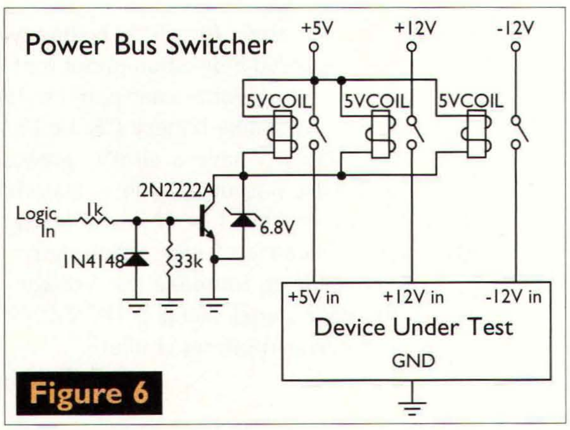


Figure 6

The first (Figure 6) uses relays to do the switching. It's the simplest and the most versatile because the voltages and currents are limited only by the relay contacts. Its shortcoming is that relay contacts bounce in the same way mechanical switches have contact bounce. This may be a problem if the bounce causes uneven current flow within the device, which can lead to erratic behavior or, in extreme cases, device failure.

Hence, the second circuit (Figure 7) which is based on transistor switches. However, the design calls for switching the high side of the power source, which is more complicated than switching the low (ground) line. My solution to this tricky design problem was to use optoisolators. When the control logic is low, the LEDs in the two leftmost 4N25 chips light. This, in turn, grounds the base of the PNP transistor via the internal 4N25 transistor and places +5 and +12 volts on the device under test.

The -5 volt line, though, requires an NPN transistor for switching. Consequently, I couldn't use the 4N25's NPN transistor to turn it on using the same method as before. Instead, I used the 4N25 transistor to short the 2N4400 transistor's base to the emitter, forcing the transistor off. To keep in step with the other switches, the control signal has to be inverted. The disadvantage of this design is the switched currents are limited to about 500 mA. Higher currents can be obtained by substituting Darlington transistors — such as the TIP120 and TIP125 — but the design is still more limiting than the relay version.

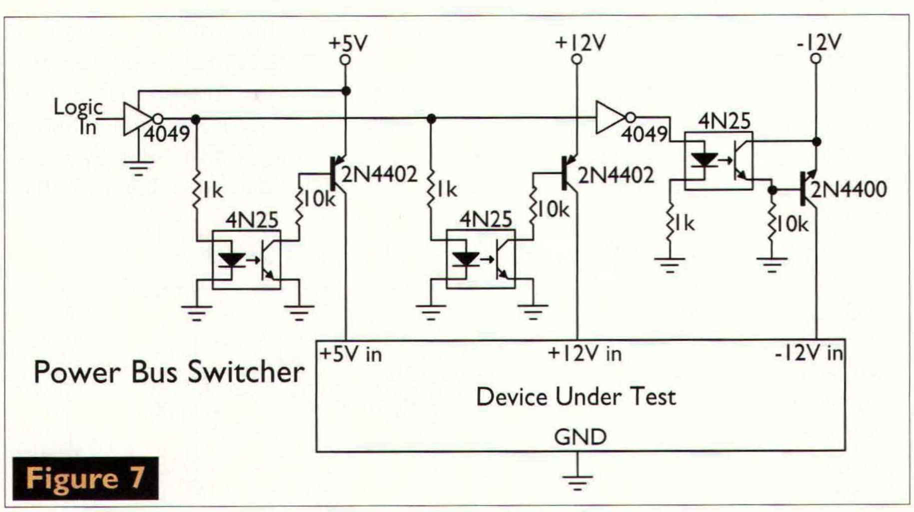


Figure 7

An Excellent Source For Disk Drive Software

Q. I belong to a club that has a fair number of its records from the 1995-1997 era on 250MB mini data tape cartridges. The computer used to create the tapes was disposed of in 1999 — along with the software to operate the Colorado Memory Systems model DJ20C87 tape backup drive (which was retained). The tape drive connects in parallel with the "A" floppy drive much as if it were a "B" floppy drive. We now need to recover some of these records. I tried to install the old drive on a computer running WIN98, only to discover it's an "unsupported device."

I did an Internet search for the

company, and discovered they no longer exist and HP bought their product line. A search of the HP website did not show any driver software or any documentation for this unit. Any idea where I can find either DOS or WIN98 driver software for this tape drive?

Robert Bennett
Las Cruces, NM

A. Yep, at StorageDrivers.com (**www.storagedrivers.com**). They also have drivers for such obscure drives as Aceex and Jet-Way — and welcome any contributions for drivers that you may have laying around that's not already posted. They also post user's comments who have downloaded the software so you kinda have a track record of the software's performance.

While they require you to register for access to the website, it's just a formality (accounting, I'm sure ... they sell ad space) and your email address won't be sold (so they say). BTW, I have the software for the Jumbo 250 series (as it was called back then; yes, I still have mine ... somewhere) on my hard disk and will post it on the *Nuts & Volts* website (**www.nutsvolts.com**) if the demand is high enough.

All About Switching Voltage Regulators

Q. Some years ago, *Nuts & Volts* published an article about a special type of voltage regulator. One that would continue to output a constant voltage even when the input voltage dropped below the output voltage, rather than shut down like linear regulators do.

For example,

12 volts in = 9 volts out
9 volts in = 9 volts out
6 volts in = 9 volts out

I don't know where my back issues are right now, and was hoping you might comment on the practicality of this regulator before I go "In Search Of."

CousinGrace
via Internet

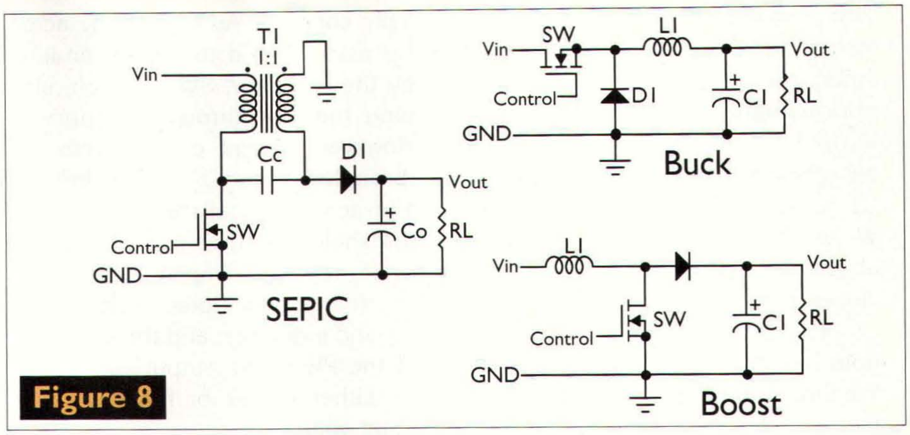


Figure 8

A. While there a few different topologies that can be used for a step-up/step-down converter, notably the flyback configuration, I think you're referring to the single-ended primary inductance converter, or SEPIC. Let's compare buck and boost and SEPIC in the following drawing (Figure 8).

The buck, or step-down, switching regulator converts an input voltage to a lower output voltage. When SW is closed (conducting), current builds up in L1 at a rate approximately equal to (Vin - Vout)/L1. The inductor current flows into the load (RL) and the output capacitor (C1). As the voltage across C1 rises to an upper threshold set by the regulator, SW opens and stops the input of power. However, the current in L1 still continues to flow through the rectifier diode D1, decreasing at a rate approximately equal to Vout/L1.

When the voltage across capacitor C1 falls below the lower limit set by the regulator, SW closes and the cycle repeats. The most voltage this regulator can output is equal to Vin, and that's with SW constantly closed.

The boost, or step-up, switching regulator converts an input voltage into a higher output voltage. When SW closes, current flows through L1 to ground (at a rate approximately equal to Vin/L1) and builds up a magnetic field. During this time, load current through RL is drawn from output capacitor C1. When the voltage across C1 drops below the limit set by the regulator, SW opens and stops shunting input current through L1.

The current in L1 now passes through D1 and charges C1. The inductor current decreases at a rate approximately equal to (Vout - Vin)/L1, where the collapsing magnetic field causes the voltage across C1 to increase beyond that of Vin. When the voltage across C1 rises above the regulator's upper limit, SW closes and the cycle repeats.

The SEPIC regulator permits both higher and lower voltages than Vin through a unique arrangement of two coupled inductors. When SW turns on, the left plate of Cc is grounded (zero volts) and current flows through the primary of T1. This induces a voltage in the secondary, which charges Cc and provides power to the load (RL).

Each winding attempts to induce the same voltage into the other. During the off time of SW, D1 conducts, applying the output voltage to the primary winding through the secondary. This voltage induced across the primary winding happens to be the same voltage applied to it by the algebraic addition of the Vin and VCc in series with Vout + VD1.

Note that capacitor C1 provides an important function in this circuit as the chief means of energy transfer from the input to the output. The value of C1 is chosen such that the voltage across it in the steady state is essentially constant. As the voltage across Co rises beyond the upper limit set by the regulator, SW turns off, stopping the flow through T1 primary. However, current continues to flow through Cc and D1. When the voltage across Co falls below the lower threshold, SW turns on again and the cycle repeats. Depending on how much energy is stored in the capacitor and inductors, and the duty cycle of the PWM, the output voltage can be either higher or lower than the input voltage.

Figure 9 shows a practical application of a SEPIC circuit. This circuit will output a constant five volts at about two amps through a range of four volts to nine volts input. You can change the output voltage by adjusting the values of R1 and R2. Linear Technology recommends R2 be less than 7K, with 6.19K the preferred value.

Replacing Sony VDRs

Q. I am trying to repair a Sony TV (Model KV27TS32) that got zapped in an electrical storm. I have a schematic for the set and they suggest several components that could be at fault in a dead set including several transistors, capacitors, a fusible resistor, and three varistors. I have verified the fusible resistor is open and two transistors appear to be bad, but I'm not familiar with varistors and would like to know of a way to check if they are bad. Also, if they are bad, how do I get replacements; my MCM Electronics catalog does not have a listing for varistors.

A. These varistors are labeled as VDR (Voltage Dependent Resistor) and are zinc-oxide devices commonly called MOVs. When the threshold voltage is exceeded, the varistor will conduct. The theory is that the surge current is bypassed to ground, thus protecting the electronics. Well, it works most of the time, but a lightning surge is more than most varistors can handle — the response time is slower than the strike and the currents are way beyond what the varistor is rated for.

Varistors can fail to either an open or shorted circuit — mostly open. A healthy varistor will have infinite resistance in both directions. Unfortunately, so will a failed varistor. Fortunately, varistors are relatively cheap and readily available (Sony part# 1-807-288-11) and I'd replace them just out of habit. Better safe than sorry. I've heard of people using the cheaper RadioShack 276-568 with success, but I can't say for myself.

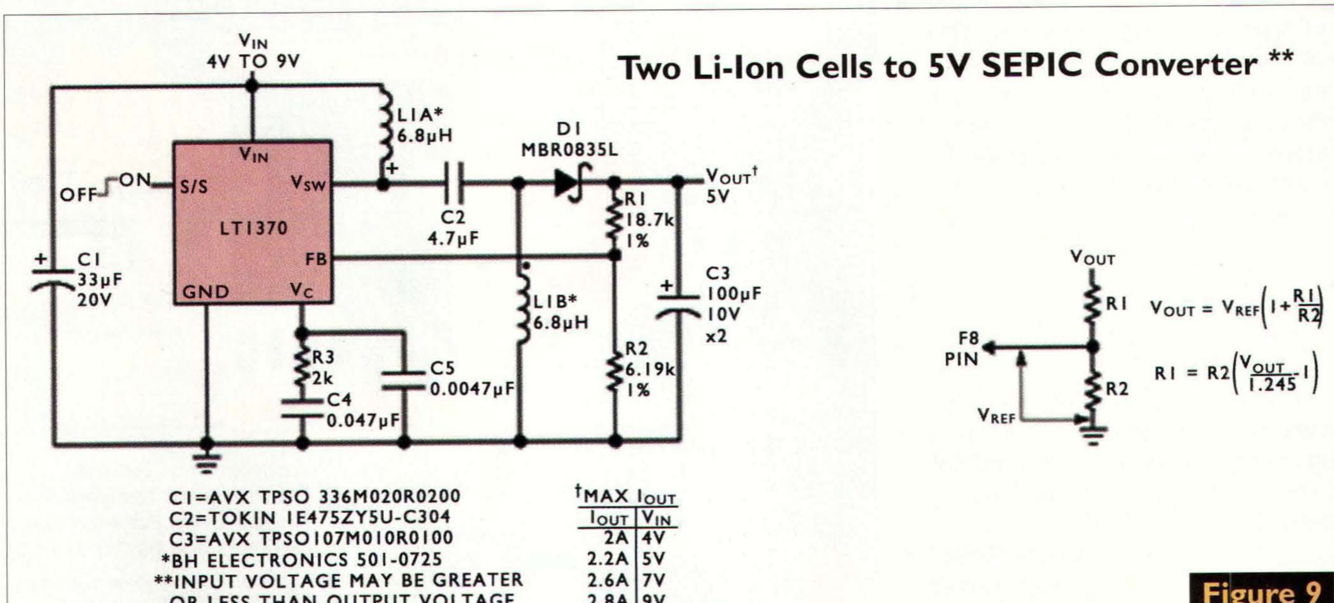


Figure 9

PCB Middleman Needed

Q. I am looking for someone to do PCB layout patterns from a schematic that I supply. I will then submit the artwork to a PCB fab house to receive a finished printed circuit board. Can you recommend a source?

Craig Kendrick Sellen
Simpson, PA

A. I have used such persons in the past with varying results. I suggest you get a copy of AutoTRAX EDA (**www.autotraxeda.com**) and try it yourself. It isn't hard: Draw the schematic, export it to the included PCB layout software, run the autoplace feature to logically position the parts for you, then start autoroute and let the software draw the traces for you. You can edit the position of the parts and trace runs as you please.

Thanks to the autoplace and autoroute features, the learning curve isn't steep and if your circuit is simple, you'll achieve amazing results on your first attempt. If your schematics are more complex than that, you'll need to consult a professional, which will cost you. If any of our readers know of a service that does this kind of work for hobbyist at a reasonable price, please let me know.

In Search Of: Melody Generator Chips

Q. I have been trying to find a source for the UM66 and M3481 melody generator chips; I want to use them in a Christmas project. However, I believe these parts have become obsolete. Can you recommend a replacement chip? I have found some programmable musical chips, but I want something with the tunes already installed.

Tim Burks
via Internet

A. As best as I can tell, these chips are still available — but only as part of a kit. And as you pointed out, nearly all the replacement chips require some form of programming (mask ROM or burn-in programmer). Here is a short list of the kits that contain these chips; most sell for $10.00 or less.

CK208 (M3481)
- **www.canakit.com**
- **www.gibsonteched.com/CK208.html**
- **www.montek.com/catalog/item501.htm**

DIY Kit 104 (M3481 and M3485)
- **www.kitsrus.com/pdf/k104.pdf**

CK303 (UM66)
- **www.canakit.com**
- **www.gibsonteched.com/CK303.html**

SG14
- **www.circuitspecialists.com/**

level.itml/icOid/458
- **www.web-tronics.com/soungenkit.html**

MAILBAG

Dear TJ,

I enjoy reading your column, and your idea (in response to Mikael K. Lenihan) to use super capacitors to increase the short-term current capacity of "AA" size dry cells is a good one. I didn't perform a rigorous analysis, but I disagree with some of your conclusions. The clock requires 200 mA for 20 seconds 24 times a day. That's about 9.73 ampere-hours per year. The capacity of the AA cells is only about 2.5 ampere-hours, and that's only by using a terminal voltage of 0.9 volt. It's doubtful the clock will wind at 1.8 volts (2 x 0.9 v), meaning the AA battery's effective rating would be less than 2.5 ampere-hours. While your circuit satisfies the voltage and current requirements for the clock, the tiny AA batteries don't store enough energy for a year's operation.

Dave Toalson
Bellville, TX

Dear TJ,

Here is a site that's an excellent source for obsolete ICs that I didn't see in your PARTFIND.DOC list:

- Rochester Electronics
  www.rocelec.com

Brad Hitch
Wheat Ridge, CO

It is now.

TJ Byers
Q & A Editor

Dear TJ,

In the June issue you talked about Heathkit. An excellent web site is: **www.heathkit-museum.com**.

Dick Blosser, Professor,
Orange Coast College

Dear TJ,

You mentioned a site for Heathkit schematics at **www.circuitarchive.co.uk/heath.htm**. Just thought you should know the link doesn't work; in fact the entire site seems to be down.

Joseph Wilson
via Internet

Cool Web Sites!

Clean Installation of Windows: A simple guide that walks the user through a clean install or upgrade of Windows.
www.usbman.com/Guides/Clean%20Install%20of%20Windows.htm

The average PC user doesn't think much about problems that can occur with a computer until the problem actually occurs. Here are some tips for keeping your computer happy and healthy.
www.webopedia.com/quick_ref/PreventiveMaintenancePC.asp

This DLL help database by Microsoft contains information about DLL files that ship with selected Microsoft products.
http://support.microsoft.com/default.aspx?scid=/servicedesks/fileversion/dllinfo.asp

Circle #75 on the Reader Service Card.

LOW-COST 9S12 EMBEDDABLE MCU MODULES DOUBLE AS EVALUATION/TRAINING PLATFORMS

Technological Arts has launched two new MCU modules, broadening its highly popular line of modular microcontroller boards. Offering engineers and educators a versatile and economical platform for evaluating and applying Motorola's latest HCS12 microcontroller offering, Adapt9S12E128 and Adapt9S12EQ128 smooth the migration path from development to product implementation/production. Because the same core module used in the evaluation phase is economical enough to be incorporated into the end product, time to market for commercial applications is shortened considerably.

Leveraging its popular HCS12 technology, Motorola has endowed the new MC9S12E64/128 MCUs with a high-speed, low-voltage core of up to 8K RAM and 128K sector-erasable Flash, along with an impressive array of hardware subsystems — all into low-cost surface-mount packages. The 9S12E128 boasts I2C, three enhanced SCIs, SPI, 10-bit sixteen-channel analog-to-digital converter subsystem, 12 PWM channels (six with hardware fault protection), dual eight-bit DACs, triple four-channel, 16-bit enhanced capture timer subsystem, and much more. The full complement of subsystems provided, together with the powerful single-wire Background Debug Mode (BDM), make this chip ideal for use in the evaluation and development of all "E"-series derivatives of the 9S12 family.

Both the 80-pin and 112-pin MCU are implemented as Adapt9S12 modules, offered as Adapt9S12EQ128 and Adapt9S12E128, respectively. Combining all the essential MCU support circuitry with a small-footprint monitor/loader program in Flash, these modules come ready-to-use "out of the box" with little added hardware required in many applications. The on-board regulator is user-selectable for 3V or 5V operation, and the basic board configuration includes dual RS232 transceivers. The fully-populated configuration adds RS485 and IrDA physical layer transceivers, as well as a buffer amp for the DAC channels. The user would only need to add application- specific interface hardware and software to implement any given design. Measuring 3.25" x 2.3" x 0.75", both modules provide access to virtually all input/output lines via a pair of standard 0.1" pitch 50-pin connectors, compatible with most application boards and accessories in the company's established Adapt12/9S12 product families. Unlike most traditional evaluation boards, the user prototyping area is implemented via separate, pluggable boards. This approach results in maximum versatility and reusability of the module, permitting easy evaluation of alternative designs or user applications, followed by effortless migration through prototyping to full production. Several interchangeable plug-on modules are available, with more under development. These include a low-cost hardware Demo Board, a 100Base-T ethernet board, a RAM expansion card, and a servo/sensor interface card ideal for small robot implementations.

To facilitate evaluation of the 9S12E128 MCU, several product bundles are being offered. A Demo Package — including MCU module, plug-on Demo Board, Prototyping Card, Serial Cable, and DC power supply — is available for $119.00 USD. Full evaluation packages, with dual prototyping cards, serial cable, DC power supply, manual, and CD-ROM are available for both the 80-pin and 112-pin versions of the MCU (#AD9S12EQ128EVP and #AD9S12E128EVP, respectively) at $139.00 USD each. A 30-day fully-functional version of ImageCraft's ICC12 C cross-compiler with integrated development environment for Windows is included. For OEMs, basic modules are offered without IrDA and RS485 transceiver at $54.00 USD, and fully populated modules for $68.00 USD, in 100s.

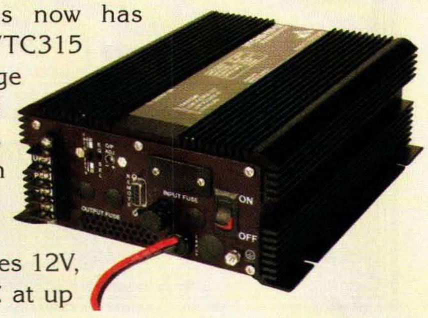
Technological Arts, founded in 1994, specializes in the design and manufacture of modular evaluation/OEM products based on Motorola's 8- and 16-bit product families. Technological Arts offers the broadest range of product configurations featuring 68HC11, 68HC12, and HC9S12.

For more information, contact:

TECHNOLOGICAL ARTS
877-963-8996 Fax: **416-963-9179**
Email: **sales@technologicalarts.ca**
Web: **www.technologicalarts.com**

Circle #117 on the Reader Service Card.

NEW ISOLATED DC/DC VOLTAGE CONVERTER PROVIDES 12V, 24V, OR 48V FROM A 24V, 32V, OR 48V POWER SOURCE!



Analytic Systems now has available VTC315 DC/DC Voltage Converter to the Marine Trade. This fully isolated precision converter accepts input voltages of 24V, 32V, or 48V, and creates 12V, 24V, 32V, or 48V VDC at up to 300 watts of continuous power.

Thane Lanz, Director of Sales and Marketing for Analytic Systems, states that the key benefit to the state-of-the-art VTC315 is “to provide precision-regulated power for running communications equipment and other sensitive electronics in marine environments.”

The units feature lightweight but rugged construction using an anodized aluminum chassis and stainless steel fasteners. Excellent filtering reduces the possibility of EMI being generated to interfere with communications systems. Audible and visual indicators, including optional bright red LED voltage and current meters that can be read from across a room, provide indication of proper operation or any problems the unit may be experiencing. A dry contact relay to interface to alarm monitoring systems is standard.

Options include one or two bank battery charging (2 or 3 Stage) with equalize and temperature compensation function and a full ruggedization package for harsh environments. The VTC315 is backed by a three-year warranty. Models are also available to convert 110V, 250V, or 300V systems to 12V, 24V, 32V, or 48 volts DC.

The manufacturer’s suggested retail price for the VTC315 series ranges from $530.00 to $620.00 USD. Units are available for immediate shipment.

For more information, contact:

ANALYTIC SYSTEMS
#207 - 12448 82nd Ave.
Surrey, BC V3W 3E9 Canada
800-668-3884 Fax: **604-543-7354**
Email: **info@analyticsystems.com**
Web: **www.analyticsystems.com**

Circle #118 on the Reader Service Card.

MODEL ST2020 DIGITAL CLAMP METER

Elenco Electronics introduces a new digital clamp meter — the Model ST2020. The ST2020 Clamp Meter is an auto/manual ranging, professional meter with digital analog display (3,260 count) and 33-segment bar graph with backlit display.

Its advanced design makes it a unique meter in the troubleshooting of electrical, heating, and air conditioning systems. The bar graph is used when quickly-changing signals in a circuit are too rapid for the numerical display to indicate. The design is rugged and safe for non-invasive current measurements of up to 1,000 amps.

It is also able to measure AC voltages, DC voltages, resistance, frequency, diode check, audible continuity, data hold, peak hold, and comes with a deluxe molded carrying case.

It has the following features: Auto/manual ranging, AC current to 1,000A, DC voltage to 1,000V, AC voltage to 750V, DC current to 600A, resistance to 30M ohm, frequency to 30 KHz, diode test, and audible continuity test.

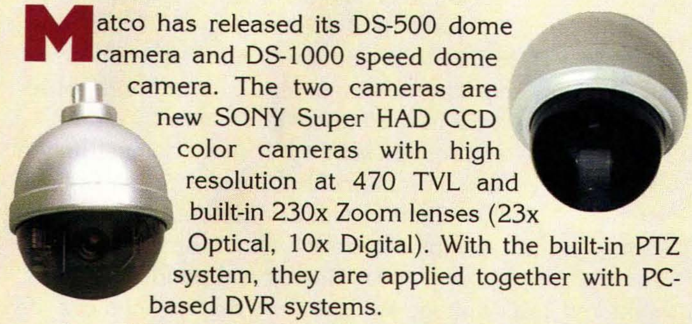
The ST2020 Clamp Meter is for someone who wants the latest features in clamp meters, and meets the rigid CE, CS, and UL standards. The cost of $66.50 is the lowest ever for a meter of this caliber. It is available for immediate delivery.

For additional information, contact:

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

Circle #119 on the Reader Service Card.

NEW DOME CAMERAS



Matco has released its DS-500 dome camera and DS-1000 speed dome camera. The two cameras are new SONY Super HAD CCD color cameras with high resolution at 470 TVL and built-in 230x Zoom lenses (23x Optical, 10x Digital). With the built-in PTZ system, they are applied together with PC-based DVR systems.

In addition, the DS-1000 Speed Dome offers 64 individually programmable preset camera positions with extremely fast speed at pan 360 degree/sec, and tilt 180 degree/sec.

For more information, contact:

MATCO, INC.
2246 N. Palmer Dr. Suite 103
Schaumburg, IL 60173
847-303-9700; 800-719-9605
Fax: **847-303-0660**
Web: **www.matco.com**

Circle #120 on the Reader Service Card.

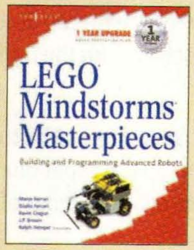
Circle #127 on the Reader Service Card.

Selected Titles for the Electronics Hobbyist and Technician—

The Nuts & Volts Hobbyist Bookstore

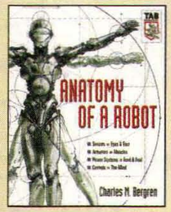
Robotics

LEGO Mindstorms Masterpieces: Building and Programming Advanced Robots



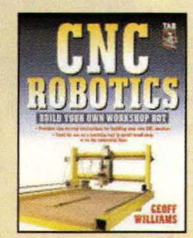
While many LEGO books exist that show step-by-step instructions, they lack substantially detailed explanations about the building techniques used by the builders and the general concepts that are fundamental to the projects. These reflections are the foundation of *LEGO Mindstorms Masterpieces*. The 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



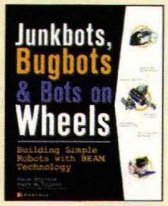
CNC Robotics gives you step-by-step illustrated directions for designing, constructing, and testing a fully functional CNC robot that saves you 80 percent of the price of an off-the-shelf bot — and that can be customized to suit your purposes exactly, because you designed it. Written by an accomplished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

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

Applied Robotics II
by Edwin Wise

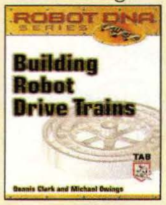
Instructive illustrations, schematics, part numbers, and sources are also provided, making this book a "must" for advanced builders with a keen interest in moving from simple reflexes to autonomous, AI-based robots. Create larger and more useful mobile robots! Ideal for serious hobbyists, *Applied Robotics II* begins by discussing PMDC motor operation and criteria for selecting drive, arm, hand and neck motors **$41.95**

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

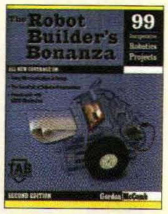


This essential title is just what robotics hobbyists need to build an effective drive train using inexpensive, off-the-shelf parts. Leaving heavy-duty "tech speak" behind, the authors focus on the actual concepts and applications necessary to build — and understand — these critical force-conveying systems.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

Everything you need to build your own robot drive train:

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

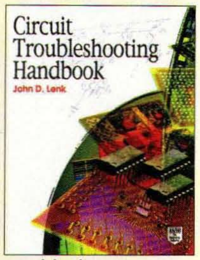
The Robot Builder's Bonanza
by Gordon McComb



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

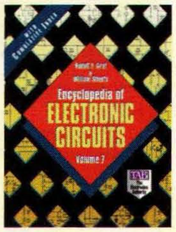
Circuit Troubleshooting Handbook
by John D. Lenk



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**

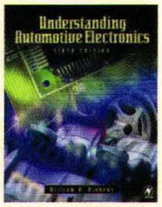
Electronics

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**

Call 1-800-783-4624 today! or
order online at www.nutsvolts.com

Guide to Electronic Surveillance Devices
by Carl Bergquist

Enjoy the peace of mind that comes from knowing how to set up and maintain an effective surveillance system! Perfect for do-it-yourselfers, *Electronic Surveillance Devices* contains all of the information needed to enhance the safety and security of a home or office, from safeguarding against theft to monitoring employee performance and preventing illegal activities from occurring on site. **$35.95**

Digital Electronics
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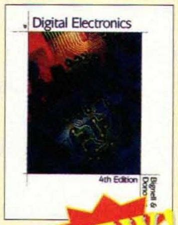

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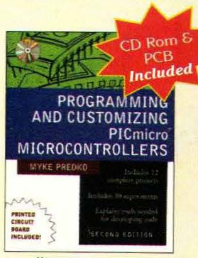

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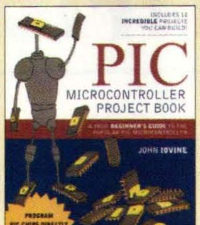

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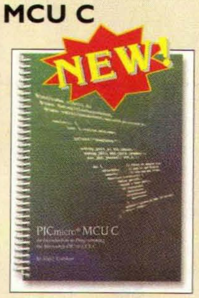

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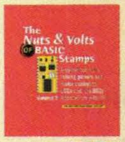

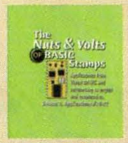

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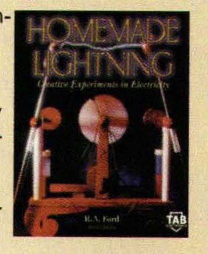

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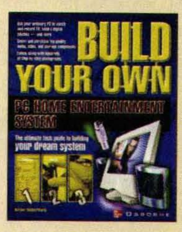

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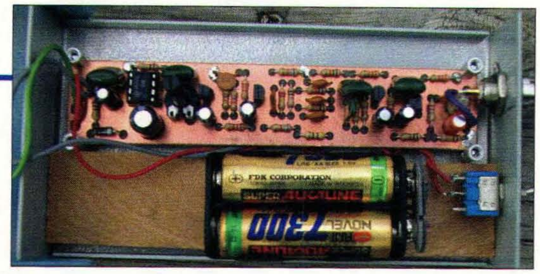


Listen to the Sounds of Mother Earth With this Easy-to-Build ELF Receiver

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 in each article on any special tools or skills you'll need to complete the project.

Let the soldering begin!

If you are interested in radio, astronomy, space science, weather, or geology, then you will surely want to be able to listen to the VLF and ELF radio spectrum to observe naturally-occurring radio phenomena. And it is quite easy to build a receiver to listen in on this part of the radio spectrum. This article will discuss such a receiver.

A receiver for the extra-low frequency range may be made very simply, consisting of a high-gain, high-impedance audio amplifier. Since the frequencies are in the audible range, the receiver needs no detector circuit if only audible listening is desired. While the receiver can be quite simple, some design and operational factors must be considered.

First, you have to do your listening in an area as free as possible from man-made noise. You cannot listen inside your house, unless it has no electricity and is well away from other houses. Natural radio is not for "couch potatoes." In order to do this, you have be able to get away from AC power lines, so battery operation is essential.

Most people living in suburban and city dwellings, from an electrical noise standpoint, are literally living in a refuse heap. There is so much emitted garbage from everyday household devices, and power and telephone lines, that all but the most powerful signals will drown in the noise. Even in our rural New York State location, with a very low man-made noise level, it is still necessary to operate the receiver outdoors and at least 200 feet from the 4,800-volt AC feeder and transformer serving the house. In city and suburban areas, you may have to do your listening in a park, a large open field, or at the beach. The idea is to get as far away as possible from power and other utility lines.

One might think a huge antenna is needed at these low frequencies, but in practice, a six-inch whip antenna will allow atmospherics to be heard, and a 24-inch whip antenna (67 cm) is adequate for most uses. The antenna acts as an E-field probe. By virtue of its high input impedance, this receiver works well with short antennas. Larger antennas than one meter (39 inches) can overload the receiver by delivering excessive amounts of man-made VLF radio signals and 60 Hz hum.

An active antenna is used for reception, with a receiver input impedance of more than 10 megohms. While no ground is needed, a short earth spike (a 6 to 12 inch nail or a knitting needle works well) connected to the metal case of the receiver with a three to five-foot length of wire greatly improves reception

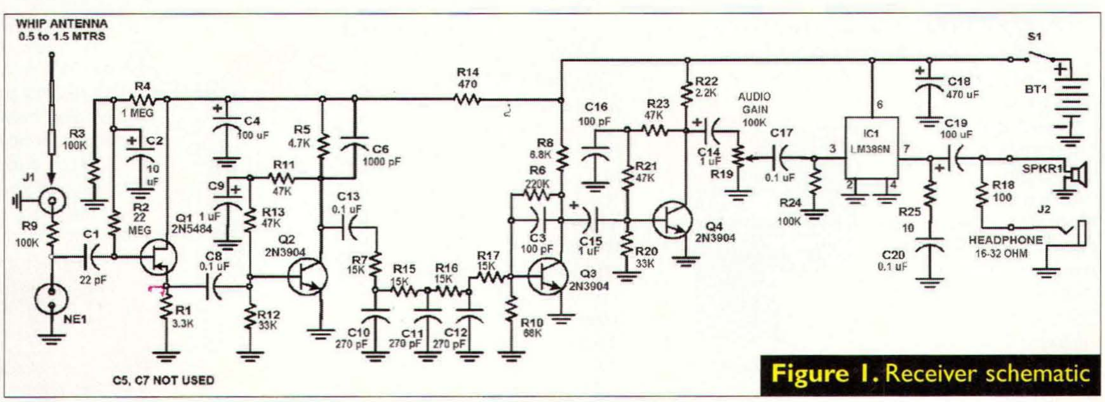


Figure 1. Receiver schematic

and eliminates instability occasionally noted due to capacitive coupling of the headphone cable to the antenna. Even in rocky soil areas, it should be no trick to stick a short spike into the topsoil. Since the antenna impedance is so high, several thousand ohms of ground resistance is acceptable.

ELF to Audio

Referring to Figure 1, you can see that signals picked up by the antenna are fed through R9 and static drain tube NE1, and coupling capacitor C1 to the gate of FET Q1. R9 helps suppress stray AM broadcast pick-up. R1-R4 bias FET Q1 which acts as a source follower and matches the very high impedance of the antenna connected to J1 to the lower input impedance input of pre-amp Q2. Q2 is biased by R6 and R11-R13. C9 prevents AC feedback in Q2 and C6 limits high frequency response. Signal from the collector of Q2 is coupled via C13 to a low pass filter network and fed through R17 to amplifier Q3. Q3 is biased by R6, R8, and R10. C3 reduces high-frequency response and C15 couples signal-to-amplifier Q4. R20-R23 bias Q4.

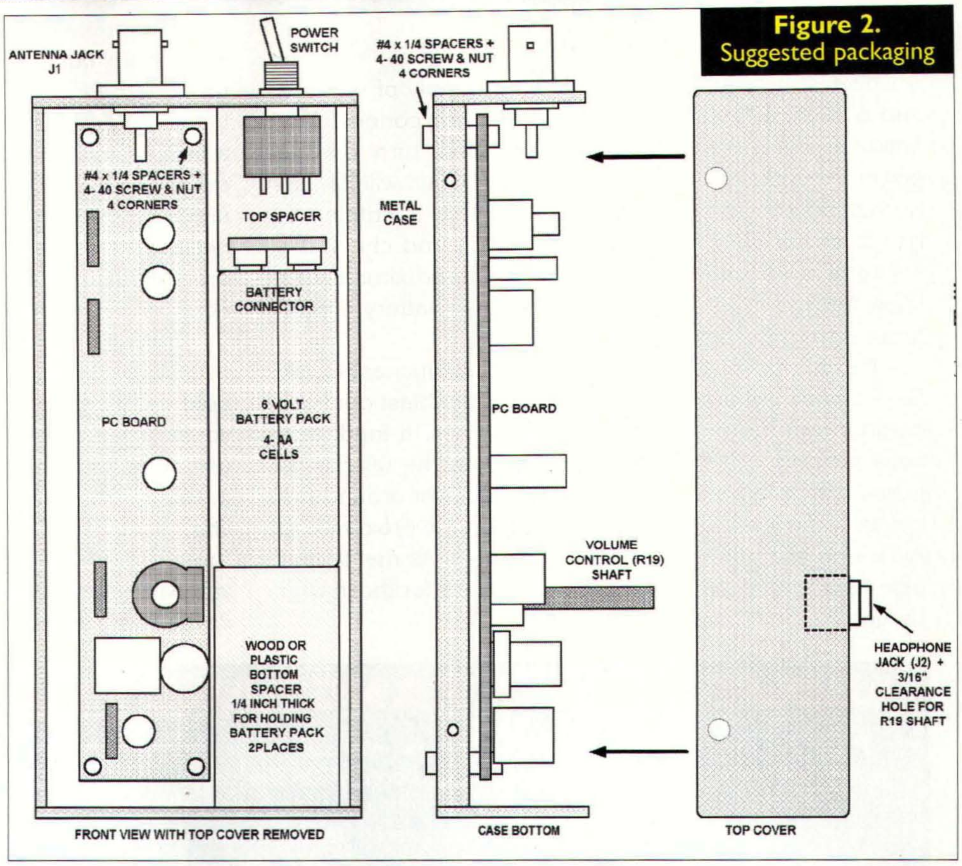


Figure 2. Suggested packaging

Amplified signal at the collector of Q4 is fed to volume control R19 and then through R17 to audio output amplifier IC1. R24 provides bias for pin 3 of IC1 and audio output of IC1 at pin 7 is fed to an optional speaker or through limiting resistor to headphone jack J1. R25 and C20 are a compensation network for stabilizing IC1 against possible high-frequency oscillation.

A pair of common 32-ohm pocket stereo headphones is recommended for use with this receiver. C18 is a supply bypass capacitor, and R14 and C4 decouple the low-level stages from the power supply rail to ensure against stray feedback.

The overall 3 dB bandwidth of this receiver is approximately 800 Hz to 11 kHz, with 40 dB or better suppression at 60 Hz and 100 kHz. Sensitivity at 3,000 Hz is about one microvolt for an audible signal. Overall voltage gain is approximately 83 dB from antenna to audio IC input pin 3.

The receiver *must* be mounted in a conductive housing or it will suffer from instability. A metal case is necessary, and a battery supply of four AA cells for DC power (nominally +6 volts) with a plastic four-cell battery holder. Four AA cells will last a long time, as the current drain is very small. The antenna jack should be mounted well away from the headphone jack and optional speaker wiring (if used).

KIT ORDERING INFO

A complete kit of parts including a drilled, etched, and screened PC board, all parts that mount on it (resistors, capacitors, diodes, transistors, and integrated circuits), jacks, switch, suitable metal case, and hardware to build one complete receiver may be obtained from the following source:

North Country Radio
PO Box 53
Wykagyl Station, NY 10804-0053
www.northcountryradio.com

Price $44.95 USD plus $5.00 for P/H in the US

The whip antenna is sold separately. A collapsible eight-section whip antenna with BNC connector is $14.00 plus $1.00 for P/H if ordered with the parts kit, or $14.00 plus $5.00 for P/H if ordered separately.

Headphones, batteries, hook-up wire, and battery holder are not included as these items are at the discretion of the builder. The earth spike assembly is made from a short (three to six foot) piece of wire and 6 to 12 inch rod or nail, obtained locally at your variety or hardware store, and is not part of the kit.

PLEASE NOTE:

For shipment outside the US, P/H is $10.50 for the first item plus $3.50 for each additional item ordered. NY residents must add 8% sales tax to the price of any of the above items.

Tuning In

To test the unit, connect a battery supply of six volts and a pair of headphones to J2. Do not connect any antenna yet. Keeping R19 at minimum, turn on the power. A smooth hiss should be heard, which will be fairly loud at the maximum setting of R19. If nothing is heard, check your assembly and wiring, and check the voltages in the circuit. They should be approximately as shown in Table 1. Use a DVM and six volt battery supply to perform these tests.

Next, connect a short antenna (6 to 24 inches) to J1. Set R19 near minimum — you don't want to blast out your eardrums in the next step. In most homes, a loud, raucous buzzing will be heard, coming from the 60 Hz AC power wiring in the house. Carry the receiver around the house — the level will vary depending on the proximity to AC wiring and other RF producing devices. As mentioned before, listening "live" to natural radio is not for those who do not like being outdoors.

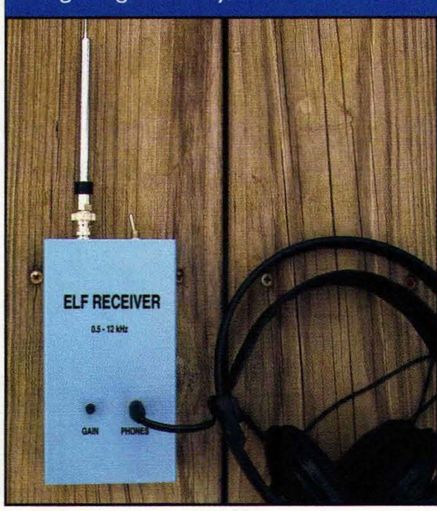
Next, take the completed receiver outdoors to a spot away from buildings, power lines, and other sources of unwanted RFI. A large parking lot, picnic area, field, beach, or any other such place can be tried. If you live in a large city or a suburb, you might have to take a drive out to the country to find a suitable location. Set the volume control R19 about a quarter of full rotation. As you get away from buildings and power lines, the hum will drop and you should hear the crackling and crashing noise of atmospheric activity in the earphones.

Hold the receiver high with the antenna away from you. If feedback is experienced (squeals and whistles), hold the antenna well away from the earphone cord and your body. You can also try shortening the antenna. If you use a short earth spike and connect the receiver case to it, this will help a lot (see Figure 3). You will hear crackling, swishing sounds, some crashing, and occasional "tweaks" and, if you are patient, eventually a whistler. What you will hear, of course, depends on the weather, time of day, and whatever is happening in nature at the time.

ABOUT THE ELF RANGE AND "NATURAL" RADIO

The ELF (Extremely Low Frequency) range is taken as the 300 to 3 KHz range, although the portion used for natural radio is generally this range plus the lower half of the VLF range — about 500 Hz to 10 KHz. This frequency range is not used for routine radio communications, due to the giant antennas and high-power levels needed to generate a useful signal, and the competition from natural static sources.

There are many interesting naturally-occurring radio signals generated by electrical activity in the earth's atmosphere. These include sferics, chirps, whistlers, and the "dawn chorus." The Earth and surrounding space produce a variety of naturally-occurring radio phenomena from lightning storms, solar events, auroras, geologic activity, and other related natural events. A number of radio hobbyists, bored with shortwave listening or just looking for something different, have discovered this and have built or purchased ready-made receivers for this purpose. They have been called "Natural Radio Enthusiasts," and there are a few groups on the Internet that deal with this field. You can visit the website of the Long Wave Club of America at **www.lwca.org** for information about these natural phenomena and natural radio, in general. This website has links to many other such sites.



The most common generator of natural radio signals are the ever-present thunderstorms on our planet. Other sources are various electrical phenomena in our atmosphere and space. These effects were first noticed by the early radio experimenters and operators. In the early days of radio, low and very low frequency transmission was used for the bulk of long distance communications, and this frequency range is very productive of many of these strange sounds. There are several hundred to more than 1,000 thunderstorms occurring on Earth at any one time. The tremendous energy and the dimensions of this activity all allow significant RF energy to be generated in the audio frequency range (30-15,000 Hz, or 0.03 to 15 KHz), but since this energy is electromagnetic, we cannot directly hear it.

If you could measure the current that flows between the Earth and its atmosphere, it would total about 1,000 to 1,500 amperes, or about 2-3 µA per square km. This current is related to the large number of electrical discharges that are always occurring somewhere on Earth. A lightning bolt can consist of thousands of amperes of current, and a voltage in the millions is necessary to produce lightning bolts that may be several kilometers in length. Since a lightning bolt occurs in a relatively good conductor of electricity (ionized atmospheric gases), this bolt acts as an antenna long enough and high enough to radiate appreciable electromagnetic energy in the VLF and ELF regions of the radio spectrum. These frequencies propagate very well in the space between the Earth's ionosphere and the ground.

The noise bursts produced by lightning are called "sferics," which is short for atmospherics. These are generally worse at AM radio frequencies in the summer season when more thunderstorms are taking place, and tend to be more intense at low latitudes, where more thunderstorms generally occur. Anyone who has listened to an AM radio during the summer, when thunderstorms are common, will have probably noticed this. However, at VLF, these distinctions are blurred, and due to the long distance propagation that occurs at very low frequencies, sferics can almost always be heard anywhere on Earth.

Late evenings through dawn to about two to three hours after sunrise are usually the best times to listen. In the background, you may hear products resulting from the mixing of a few strong VLF signals and the rattling noise of the powerful LORAN-C navigation system operating on 100 kHz. Advancing the volume control may, in some cases, cause the receiver volume to quiet down. This may be due to overload from these strong VLF signals. These signals themselves will be in the ultrasonic range and inaudible (unless you are a cat or a dog).

However, mixing of these signals in non-linear media, both in and around the receiver, often produces products in the audio range which you might be able to hear. They sound like faint RTTY (radioteletype) signals in the background at our location. If removing the antenna causes this effect to disappear, this will confirm that overload is present. Shorten the antenna or keep R19 below the overload level. If AM broadcasts are picked up, increase the value of R9 as much as needed or use a shorter antenna.

The receiver can be equipped with sharper cut-off filters made from L-C components. Active filters were tried in our prototype, but were found to be too much circuitry for a simple project as this, and were also prone to overload, which defeated their purpose. L-C filters would be the best approach, but need costly inductors and plenty of PC board real estate, so they were not considered. The overload from VLF signals should not be a problem if the antenna is kept no longer than needed.

Go to the *Nuts&Volts* website (**www.nutsvolts.com**) to download figures that show the PC board mounted in a case with a battery pack and headphone jacks. No speaker was used, as earphone listening is better anyway, though if desired, one can be installed in the case.

And finally, for safety reasons, do not operate this receiver outdoors near utility lines or during an electrical storm. **NV**

Figure 3. Use of ground wire to improve reception

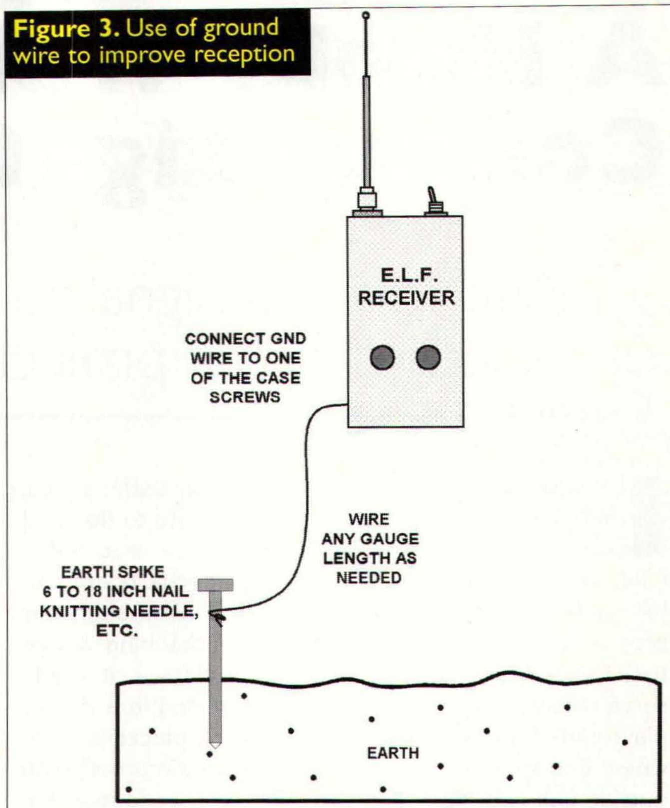


TABLE I
ELF Receiver Voltage Chart

Battery voltage = six volts nominal
Actual test voltage = 5.35 V actual expected from used (mid-life point) cells, 1.34 V average voltage per AA cell. Readings shown are for a supply voltage of 5.35V

Source Q1	+ 1.00 V	May vary ± 40% depending on device
Drain Q1	+ 4.35 V	± 15% OK
Collector Q2	+ 2.65 V	± 15% OK
Collector Q3	+ 3.10 V	± 15% OK
Collector Q4	+ 3.00 V	± 15% OK
Pin 6 IC1	+ 4.68 V	Will be 0.7 volts less than battery voltage
Pin 7 IC1	+ 2.34 V	Should be half of that on pin 6 IC1

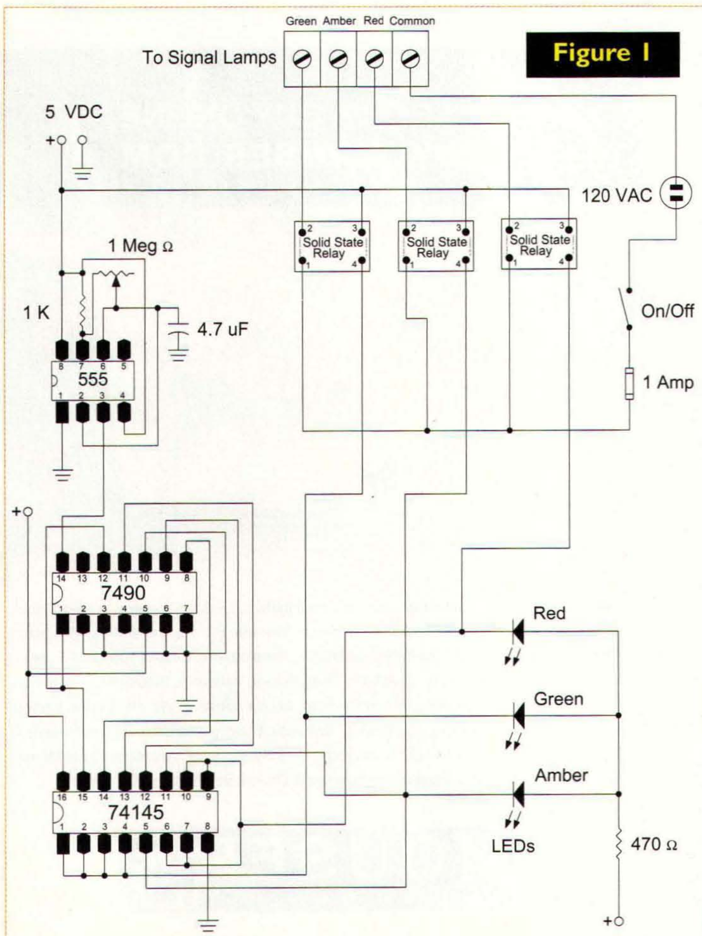
by Harry Hawkins and Edwin Hawkins

A Hobby Traffic Control Light

Add this light signal to your collection of projects!

If you've ever wanted to build a cycling traffic signal, then this article gives you the green light to do so! If you are lucky enough to already own a used traffic light, the controller circuit and printed circuit board can be used to sequence its 120 VAC lamps. Although this project was constructed primarily as a teaching device that is used in technology education classes, it would serve nicely as a conversation piece located in a den or playroom. This unit is not designed to be placed outside where it is subject to weather — it's not waterproof! If an outside unit is desired, it would be necessary to redesign the unit and use appropriate materials for that purpose.

Figure 1



A Simple Control Circuit

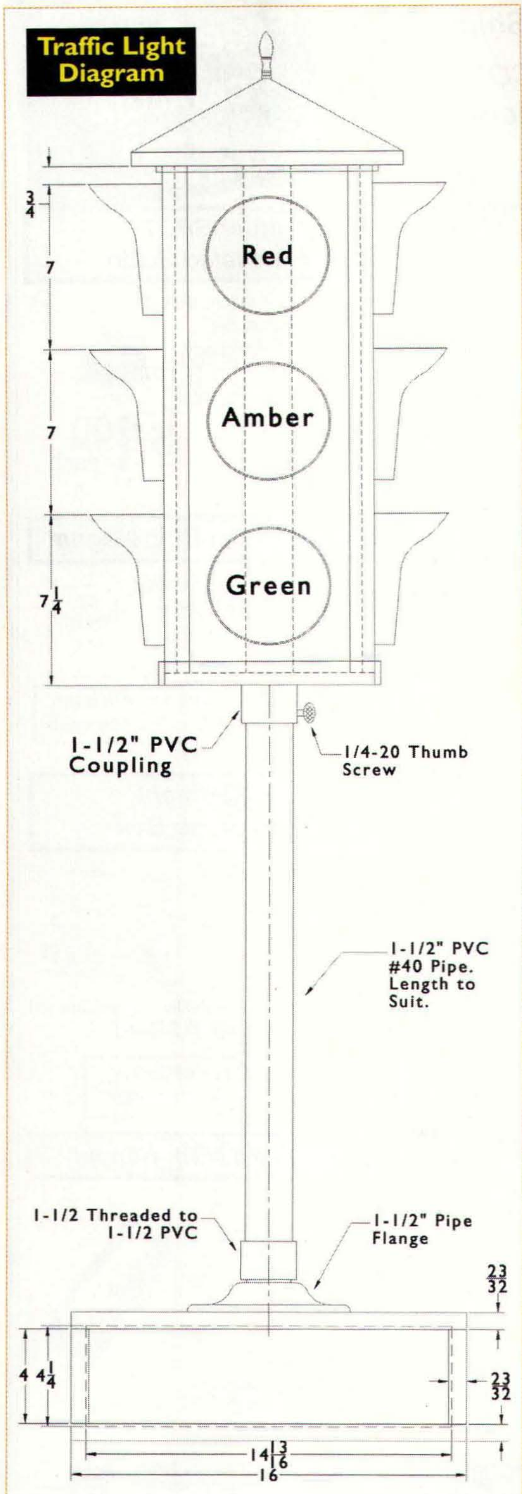
The control circuits for commercial traffic lights are more sophisticated than this circuit. Modern units employ dedicated computers so that any combination of on-off times to any individual lamp can be programmed. Use of a computer also permits easy time changes by simply changing the program parameters. In this project, a dedicated logic circuit is used, as shown in Figure 1.

A 555 timer I/C is used to create a square wave signal that is delivered to a 7490 BCD (binary coded decimal) counter. The 7490 creates a BCD output — ABCD — that is delivered to the BCD input lines of the 74145. The 74145 converts the BCD data into a sequential 1 of 10 output. The output pins from the 74145 are normally high, and only one pin at a time is driven low in sequence. The first four outputs are tied together to give a long count (1, 2, 3, and 4) to the green light output. The next pulse, 5, drives the amber light. The next four pulses (6, 7, 8, and 9) provide another long count to the red output. Finally, the 10th count is also tied to amber. This wiring provides for the red and green to be on four times longer than the amber. This is appropriate since the amber is only on between changes from red to green or green to red, and is only on for a minimal amount of time.

LEDs are also installed at the three outputs from the 74145 in order to monitor the circuit and verify that it is working correctly. This aids in troubleshooting. Optionally, another LED can be installed to monitor the output of the 555 for the same reason.

The red, green, and amber logic outputs are used to activate 120 VAC solid-state relays (SSR). The outputs from the relays are, in turn, tied to a terminal strip to which the signal lamps are wired. The prototype unit used Crydom S312 solid-state relays that are available from many online sources, but are rather expensive. Hoffman Industries (**www.hoffind.com**) has a limited supply of Crydom #OAC-5A, three-amp SSRs for $3.95

A Hobby Traffic Control Light



each, which can be substituted.

In this design, 12 signal lamps are used. These are common 25 watt, 120 VAC incandescent lamps. The selection of these lamps rather than colored lamps — such as those found on theater marquees — is strictly due to cost. The signal colors were created by painting acrylic plastic and using colored plastic film, which will be discussed in the construction section. The signal lamps are wired so that the north and south red are wired to the east and west green. This "cross wiring" allows for only three outputs to control the entire lamp display correctly. Note that the red, green, amber, and common 120 VAC lines are wired to the terminal strip on the printed circuit board.

The Printed Circuit Board

A simple PCB was designed to support the electronics. If components used are not the same as listed in the bill of materials, it will need to be redesigned. This is especially true if a substitute is used for the solid-state relays. The remaining logic parts are relatively inexpensive and can be purchased at RadioShack or other suppliers as listed in the bill of materials.

Introduction to Construction

The traffic light consists of the lamp housing and the base. The base holds the electrical wiring connections to the lamps, as well as the 5 VDC power for the PCB and the 120 VAC power for the entire unit. A 1-1/2 inch PVC schedule 40 pipe is used to support the lamp housing, as well as serve as a conduit for the AC wiring to the lamps.

Plans to construct the base and the more complex lamp housing are available, but were too lengthy to print here. Please visit the *Nuts & Volts* website (**www.nutsvolts.com**) to download the bill of materials, detailed mechanical plans, PCB artwork, and step-by-step instructions required to finish off this fun project. **NV**

by Glen Worstell

LCD Fluid Level Monitor

When your finger won't reach, use this capacitance-based meter.

In preparation for retirement from my job as an engineering manager for a Fortune 500 company, I purchased a 37-foot sailboat and got ready to cruise into the sunset. The boat had three water tanks and no way to measure the water levels in them, short of upending mattresses and opening inspection ports. As I needed something to ease my withdrawal from the working world, the LCD Fluid Level Monitor project was born.

The LCD Fluid Level Monitor uses a capacitive probe in the tank to be monitored. The capacitance of the probe varies with the fluid level. A Texas Instruments MSP430F1121 microcontroller measures the capacitance value, calculates the level as a percent of full, and displays the result on a single-digit LCD display, showing "E" for empty, "F" for full, or a single digit representing 10% to 90% full.

By using the MSP430 low power mode and a reflective seven-segment LCD that does not require power-consuming back lighting, the monitor will run for years on a pair of AA batteries. Thus, there is no requirement for external power, and the monitor can be placed in any convenient location — perhaps far from power lines.

A low-cost development board with breadboard space is used for the circuitry. The microcomputer board must be located close to the probe, and is connected to the display with a 10-wire ribbon cable.

The analog comparator in the MSP430 is wired as an oscillator with a period that is proportional to the capacitance of the probe. The MSP430 Timer_A module is used to measure the frequency of the oscillator, with a time base derived from a low-cost and low-power 32,768 Hz watch crystal.

The watchdog timer circuit in the MSP430 is programmed to generate interrupts every 31.25 mS to control the drive to the LCD display (the LCD drive must be a symmetrical AC signal) and to provide a "heartbeat" controlling the various software routines.

A SPST switch is used to select the calibration mode, which gives a direct read-out of frequency. This is required for programming the display set points, especially important when tanks of non-uniform cross section are used.

THE CAPACITANCE CONTROLLED OSCILLATOR

A capacitor consists of two conductors separated by an insulator. The capacitance depends on the area of the conductors, the distance between them, and the dielectric constant of the insulation between the conductors.

Tools required: Soldering iron, oscilloscope (optional), software development tools (free from www.ti.com/dev), PC with parallel port for software development and JTAG download, and JTAG parallel port interface.

Skills: Basic electronic assembly, beginner level programming (only a table of constants must be changed).

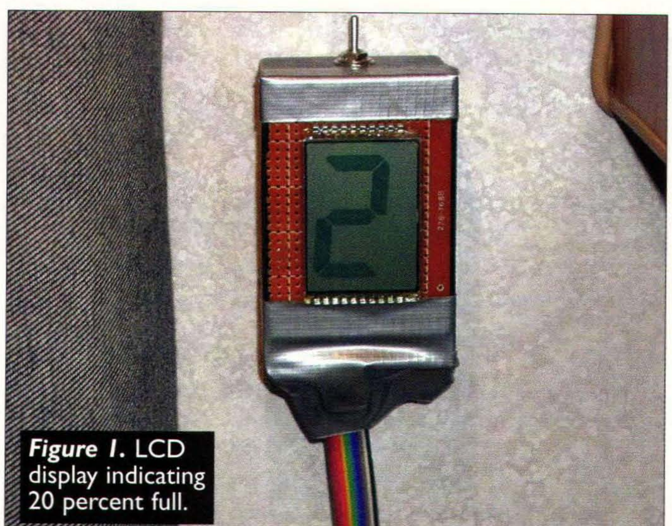


Figure 1. LCD display indicating 20 percent full.

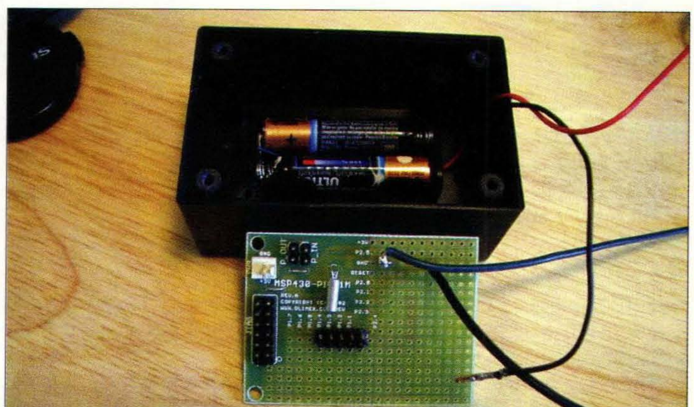


Figure 2. The Olimex breadboard fits into a plastic box with batteries in the bottom. The 10-pin ribbon cable connector connects to the remote LCD display. The black and blue wires connect to the probe.

By using a probe consisting of two conductors immersed in the tank from top to bottom, with air or fluid as the insulating material (fluid when the tank is full, air when it is empty, or something in between), the capacitance will depend on the fluid level, as long as the fluid has a different dielectric constant than air.

Air has a constant of about 1.0, while water has a constant of about 80, resulting in a large change in capacitance between full and empty. Gasoline or diesel fuel has a constant of only about 2.0, which is still enough to make this technique practical, although an uninsulated probe will give better results than the probe described here.

For use in water, one of the conductors must be insulated to prevent current flow between the conductors. This will result in a capacitive change of less than 80, as the dielectric constant of the insulation will affect the capacitance. Insulation is not required for fuel, which has a very low conductance.

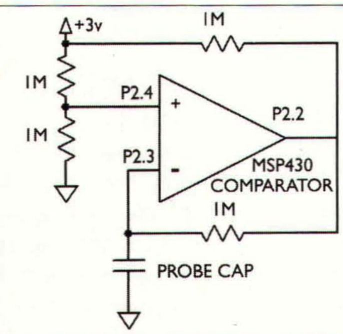


Figure 3. The comparator in the microcontroller is used as a capacitance-controlled oscillator.

OSCILLATOR FREQUENCY

The period of oscillation is governed by the time constant of R*C. The formula for the capacitor voltage during charge or discharge is given by Vc = Vs + (Vco - Vs) exp [-t/(R*C)], where:

Vc = voltage across capacitor
Vco = voltage across capacitor at time 0, when the discharge or charge begins
Vs = the charging voltage, in this case either Vcc or zero
t = the time since the beginning of the charge or discharge
R = the resistance
C = the capacitance

To determine the time required to charge from Vc = (1/3)Vcc to Vc = (2/3)Vcc, we can set the following values, and solve for t, which will be one half of the total period:

Vco = (1/3)Vcc
Vs = Vcc
Vc = (2/3)Vcc

A little algebra gives a very nice result: Vcc falls out of the equation, and the half-period is given by:
P/2 = -RC ln(1/2), where ln is the natural logarithm. The total period is then approximately:
P = 1.386 RC

For one of the probes I constructed, the empty frequency was about 10 kHz. As the resistor, R, used in my circuit is 1M, the capacitance is about 72 pF.
Since Vcc does not appear in the equation for the period, it is not necessary to use a regulated voltage for the microcomputer supply. A pair of AA batteries in series gives about 3.2 volts, well within the maximum value of 3.6 volts specified for the MSP430. The circuit will continue to operate as the battery discharges well below three volts.

MEASURING PROBE CAPACITANCE

A comparator is used as an oscillator with a frequency that depends on the capacitance. Referring to Figure 3, the comparator output toggles between ground and Vcc. When the output is high, the voltage at the comparator positive input is (2/3)Vcc, and the capacitor charges toward Vcc through the 1M feedback resistor. When the capacitor voltage at the negative input of the comparator reaches the value at the positive input, the output switches to ground. This then gives a voltage at the positive input of (1/3)Vcc, and the capacitor starts discharging towards ground. When the capacitor voltage discharges to (1/3)Vcc, the output then switches to Vcc and the process repeats.

MSP MODULE CONSTRUCTION

The recommended Olimex breadboard includes most of the parts needed for the LCD fluid level monitor — the MSP430F1121A microcomputer, JTAG and power connectors, bypass capacitors, and a 32 KHz watch crystal. There is a breadboard area with holes on 0.1-inch centers. Hardware construction consists of adding six resistors

RESOURCES

www.ti.com/sc/msp430
Hardware: Evaluation boards for the various MSP430 family devices, including a JTAG parallel port interface, priced from $49.00 to $99.00.
Software: Compiler (limited), assembler, JTAG programming and debug, and a software simulator. Free.

www.olimex.com/dev
Hardware: MSP430F1121A breadboard, JTAG programming interface (both under $10.00).

www.sparkfun.com/shop **1-866-212-4061**
Hardware: US distributor for Olimex breadboards and JTAG interface.

www.digikey.com **1-800-344-4539**
Hardware: Resistors, connectors, MSP430 parts (if you prefer to develop your own board instead of using the Olimex board), single digit LCD display.

www.mouser.com **1-800-346-6873**
Hardware: Resistors, connectors, etc.

and a connector to connect the single digit LCD display to the board. The display cable could be hard-wired to the board to eliminate the connector. The LCD board has just the LCD and a switch to select normal operation or calibration.

I like to work with surface mount components; 0803 size resistors were used. There is plenty of room on the breadboard to use through-hole resistors, and there is no disadvantage in doing so with this simple circuit. I expect most folks will prefer to use ordinary through-hole resistors.

It is necessary to add only six resistors to the Olimex breadboard, as shown in Figure 5.

The display module is connected to the processor board with a 10 conductor ribbon cable. The schematic for the display module is shown in Figure 6.

CIRCUIT DESCRIPTION

The circuit is so simple that little explanation is required. P2.5 is pulled up to Vcc during normal operation. For calibration, a switch on the display module grounds P2.5, and the software switches modes when a poll of the P2.5 input shows a change.

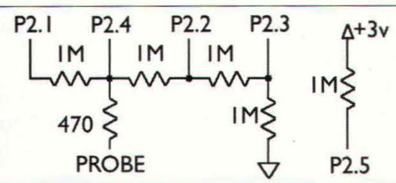


Figure 5. Add these parts to the board.

LCD DISPLAY FUNDAMENTALS

Unlike an LED display, a seven-segment LCD display must be run from an AC voltage. There is a common terminal in addition to one terminal for each segment. For a segment to be on, the voltage on the segment must be high (or low) while the common terminal is low (or high). The terminals must be switched between low and high at the refresh rate (31.25 mS in this application). If the refresh rate is too low, there will be a noticeable flicker, and if it is higher than necessary, the power required will be higher.

In order to ensure that there is no DC component between a segment and common, the period should be symmetrical. Other members of the MSP family have hardware to handle the refresh (and the multiplexing required when displays of several digits are used). As the MSP430F1121 has no LCD drive hardware, the job is done in software. By using no other interrupts and by doing the refresh at the beginning of each 31.25 mS interrupt, there is no DC component on the segments.

LCD displays are optimized for viewing either slightly below or slightly above the plane of the LCD. This is described as "6 o'clock" or "12 o'clock." Since the decimal point is not used, the display can be turned upside down if necessary to optimize the viewing given the location of the display in your particular application. Of course, the table driving the display must be changed unless you want to stand on your head to check fluid levels!

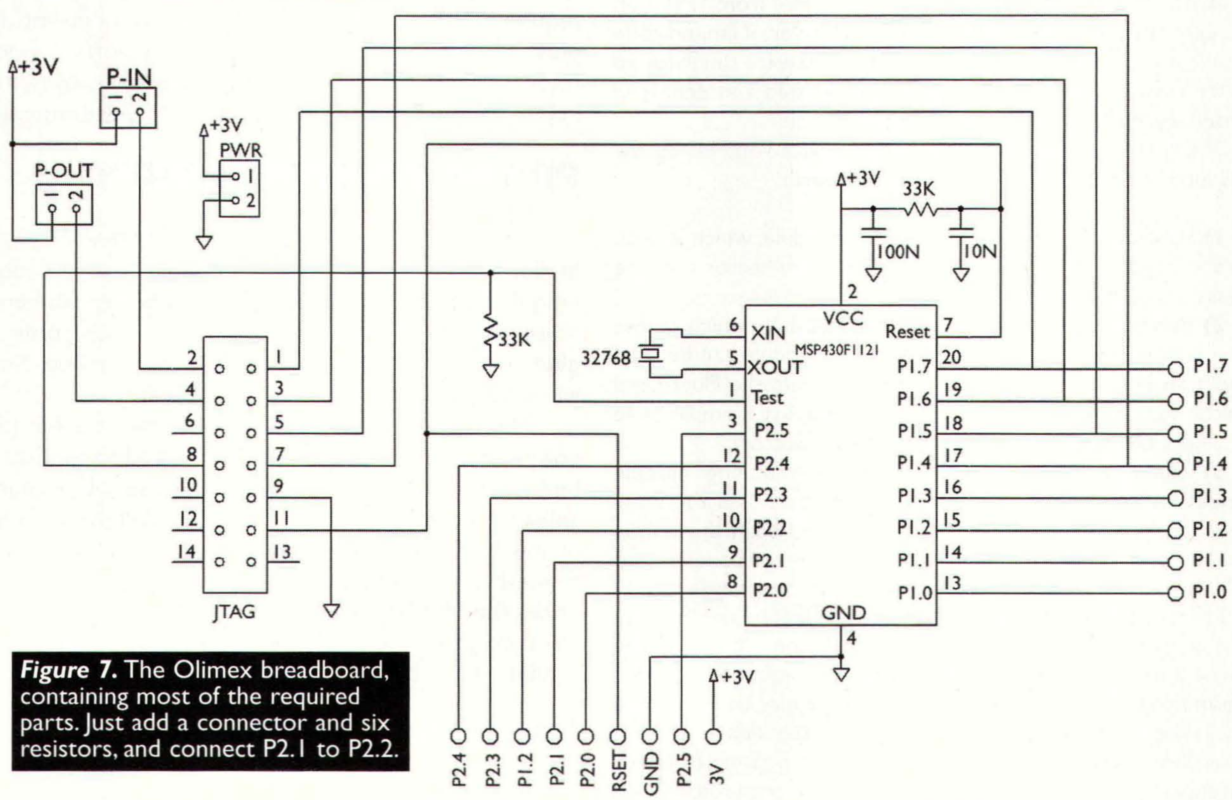


Figure 7. The Olimex breadboard, containing most of the required parts. Just add a connector and six resistors, and connect P2.1 to P2.2.

PARTS LIST

Breadboard - Olimex MSP430-P-1121M
R1-R5 - 1 M resistor
R6 - 470 ohm resistor
Capacitive probe - See text
LCD display - Lumex Opto/Components, Inc., P/N LCD-S101D14TR, Digikey P/N 67-1506-ND
10 conductor ribbon cable - Length 10 feet or as needed
Connector for ribbon cable (optional) - I used a 2x5 pin header on the processor board

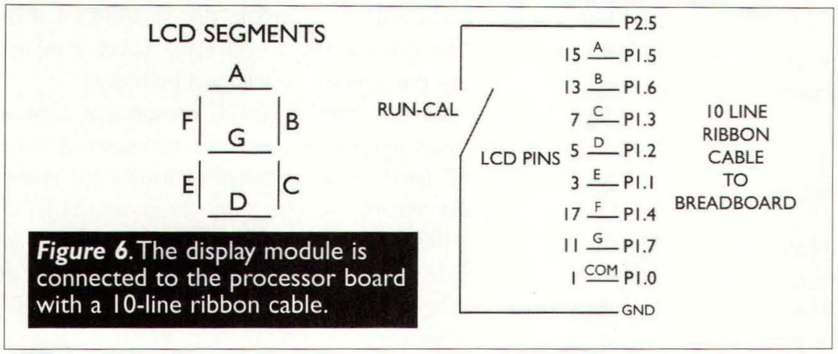


Figure 6. The display module is connected to the processor board with a 10-line ribbon cable.

MSP430 JTAG PROGRAMMING

The TI MSP430 series microcomputers are programmed and debugged using a JTAG interface. This is a very nice system for simple projects, as it gives much of the capability of a full bond-out emulator at a fraction of the cost. The program and debug software (which runs on a PC) is available for free from TI as is an assembler and a software simulator. A C compiler of limited code length is also available for free. I found the software simulator to be very useful — much of the code was written and debugged without any MSP430 hardware connection at all.

There are (at least) three ways to connect your PC to the JTAG interface pins on the MSP430 breadboard:

1) Purchase the $99.00 TI evaluation module, which is used with the larger MSP430 parts. It has a 14-pin connector with the necessary signals to program any of the MSP series parts.

2) Purchase the $49.00 TI evaluation module, which comes with a couple of MSP430F1121 devices. The module can be used without an MSP device in the socket to program the Fluid Level Monitor module (it will be necessary to construct a simple cable to connect the board to the 14-pin JTAG connector).

3) Purchase the Olimex $10.00 programming module (sources for parts are given below). This module uses the same 14-pin connector as the $99.00 TI module, although the ribbon cable comes out of the other side of the connector compared to the TI module — be careful not to hook it up backwards.

I have used all three methods with satisfactory results. I use a 5 x 2 ribbon cable header for the interface to the LCD. The Olimex breadboard includes the connector required for JTAG programming. During debug, the LCD module may be connected or not, depending on the requirements of the debug session. During debug, the power to run the system can come from the parallel port JTAG module, so batteries are not required.

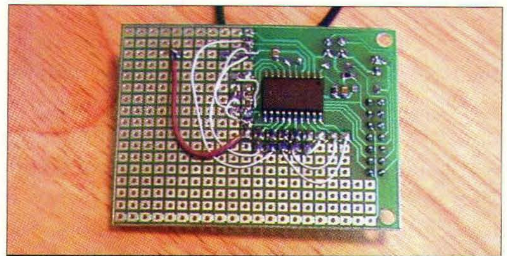


Figure 4. The six SMD resistors (nearly invisible) are soldered between pads on the bottom of the breadboard. Most readers will probably use ordinary through-hole resistors.

Resistors of 33K are used for test pull-down and reset pull-up — values in that ballpark are recommended in TI application notes. The 1M resistors used in the oscillator circuit are not critical, however they should have low temperature coefficients. The 470 ohm resistor connected in series with the probe capacitor is used to limit the current in case the probe is shorted to ground.

The comparator output at P2.2 — a square wave in the range of a few hundred Hertz to perhaps 20 KHz — is connected to the Timer_A input on P2.1.

P2.0 is set high to enable the bias needed for oscillator operation. It would be possible to just connect the line to Vcc, but there would then be a small power drain through the resistor network at all times. As the oscillator is enabled for one-half second every minute, the power required is lower with this approach. The current drain is only two or three microamps during normal operation (only the display and the 32 KHz clock are active), increasing to about 40 microamps during the measurement cycle.

PROBE CONSTRUCTION

The probe consists of a copper tube about 1/4-inch in diameter, with a loosely twisted insulated wire loop running through the length of the tube. The two wire ends are stripped a few inches above the tube, with some epoxy glue at the top of the tube to hold them in place. Keep the wires above the tube as short as possible.

The tube is inserted through a hole in a flat plate of copper or brass, which is then mounted to the top of the tank with screws, bolts, or silicone sealer. Use plumber's solder to solder the tube to the plate. Drill a hole in the top of the tank, just large enough to insert the tube. When mounting the plate to the tank, use some silicone seal under the plate to prevent leaks. Drill some small holes in the tube just below the plate — without a way for air to escape, the tube will not fill with water.

SOFTWARE DESCRIPTION

The software, written in assembly language, is avail-

ALTERNATE DISPLAY HARDWARE

If it is not necessary to run on battery power, or if an on-off switch is provided and the circuit is activated only on occasion, it is possible to use a single digit LED display instead of the LCD version. No circuit changes are necessary in the measurement module. The display module will have a series resistor of perhaps 200 ohms in series with each segment to limit the segment current to about 5 mA. The common pin of the LED display is connected to Vcc if a common anode LED is used, or to ground if a common cathode one is used.

Pin P1.0 is not used for the display, and can be used for some other purpose, if desired.

The software is essentially the same, except that it is not necessary to refresh the display — just write the desired segment values to the P1 output port at any time.

I built this display and found that it is very nice to look at when the lights are low. However, as I wanted to use battery power and wanted the display to be on all the time, the "production" system uses the LCD display.

able from the *Nuts & Volts* web site. A complete description of the software operation is included as comments in the source file.

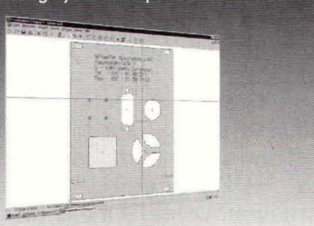
SUMMARY

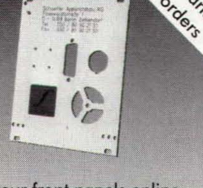
The low-power fluid level measuring system has been built and tested with satisfactory results. The single digit display gives a resolution of 11 values, sufficient for the accuracy needed to monitor non-critical tank levels.

Developing the hardware and software was actually a lot of fun. Now I can go sail off into the sunset without worrying about the holding tank overflowing, which would be totally yucky! **NV**

ABOUT THE AUTHOR

Glen Worstell is a consultant specializing in embedded systems hardware and software development. He can be reached at worstell@copper.net





FIRST Nationals Announced

The largest robotics competition in the world – FIRST – has announced Atlanta, GA as the site for the 2004, 2005, and 2006 Robotics Competition Championships. The competitions will take place in the Georgia Dome – one of the premiere sporting venues in the world. Nearby Centennial Olympic Park will provide open space for outdoor activities. FIRST is the brainchild of inventor Dean Kamen, best known for developing the Segway and iBot through his engineering company, DEKA. The dates for the 2004 FIRST Robotics Competition Championship are April 15-17. To learn more about the mission of FIRST, or to get yourself hooked up with a regional team, visit **www.usfirst.org**

World's Largest Battery Goes Live

What happens if you take 13,760 NiCad cells and tie them together in a temperature-stabilized underground facility larger than a soccer field? You get the BESS project in Alaska, designed to power the city of Fairbanks for up to 15 minutes should main generation facilities or the local intertie fail. The $35 million system, designed by the Swiss based ABB Group, automatically switches onto the main power grid and can provide up to 40 MW while secondary diesel-electric generators come online. The scope of this project is truly staggering – each battery weighs 165 pounds, is the size of a large PC computer, and contributes to the overall array weight of 1,500 tons. The battery cells have an estimated life of 20-30 years after which they will be recycled by the manufacturer, Saft. For more information, visit **www.gvea.com/projects/bess.php**

Futuristic Air Force Robots Demonstrated

Lackland AFB in Texas saw the arrival of a dozen experimental robots on August 6th as part of an advanced force-protection development project. New technologies in mobility were the stars, which included vacuum-based machines that could drive up walls and across ceilings, compliant "legs" for clambering over rocks and "snake-bots" that could wriggle through pipes. "Why put a person in harm's way if you can use a machine and new technology to go ahead and take a first look?" asked Col. Tommy Dillard, a Lackland Force Protection Battlelab commander. Dillard's lab is tasked to investigate future force-protection concepts.

Continued on Page 58

Electronics Showcase

Continued from Page 56

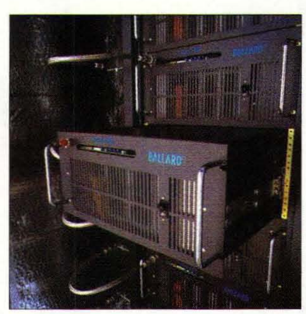
RSA Robot Games A Huge Attendance Draw, Tech Showcase

The Robot Society of America's recent Summer Games and Expo was a "roaring success," according to event organizer Dave Calkins. "Every room was filled to capacity with every type of robot fan — from people who had played with 'bots for years to people who had never seen a robot. But it was the robots that made the show." Groups attended from Singapore, Japan and all over the United States, showing off their various creations.

When pressed to name one that truly stood out, Calkins explained, "There were so many cool 'bots, it's hard to describe them all, but I think one of the best was Ted Larson and Bob Allen's balancing two-wheeled 'bot, Bender. Dean Kamen better watch out, because this is going to give Segway a run for its money!" Bender used a high speed digital control system fed by digital accelerometers to dynamically balance on its two wheels. A radio interface even let the operator drive it around while in balance mode.

The RSA is planning many more events over the next year in the San Francisco Bay area, so those interested in attending should stay current by vising the RSA website, **www.robotics-society.org/**

Stationary Fuel Cell In Field Trials



Ditch that 19-inch rack mount power inverter in your server room and trade up to a hydrogen powered fuel cell from Ballard Power Systems! Well, you should be able to in early 2004 if everything goes as planned in the current telecom and data center trials of their new Nexa RM™ power module. The Nexa is available in 1 KW power increments, making it scalable to the task at hand. It provides extended run capability during lengthy blackout periods while happily moving electrons with a zero emission environmental footprint. Fuel cells are on the horizon! More information is available at **www.ballard.com**

Continued from Page 6

It was shortly discovered that it was possible to rely on earth ground, so the black wire was no longer needed. In the days of party lines, however, the "side" of the party line was distinguished by whether ringing was applied between Tip and Sleeve (a "tip" party) or between Ring and Sleeve (a "ring" party). Single-party lines had ringing applied between Tip and Ring.

It was not until the demise of the ubiquitous two-party line that Black and Yellow began to be commonly used for the second pair, as described in Figure 2. Also, multipair cable is thought of in terms of bundles of five pairs. A complete listing can be found at **www.ptialaska.net/˜jsteven2/tel/color.ht**

But in brief, the Ring colors are in sequence: Blue, Orange, Green, Brown, and Slate; and the Tip colors are White, Red, Black, Yellow, and Violet. So, the first six pairs are White/Blue, White/Orange, White/Green, White/Brown, White/Slate, and Red/Blue.

Peter Zilahy Ingerman, PhD
via Internet

Response:

I have to admit this goes back farther in history than I do. Thanks to Peter for the additional information. I have learned something new that's "old."

George Whitaker

BIPOLAR TRANSISTOR COOKBOOK — PART 4

by Ray Marston

Ray Marston describes a variety of practical small-signal audio amplifier circuits in this month's edition of an eight-part series.

> ***A Quick Key to Euro Coding of Resistors***
> The tens multiplier replaces the decimal point — 2R2 = 2.2Ω, 4k7 = 4.7K, 1M2 = 1.2M, etc.

Last month's edition of this *Transistor Cookbook* series described practical ways of using bipolar transistors in simple, but useful common-emitter and common-base configurations. This month's article shows various ways of using bipolars in practical small-signal audio amplifier applications.

AUDIO AMPLIFIER BASICS

Transistor amplifiers have many useful applications in mono and stereo audio systems. For most practical purposes, each channel of a stereo system can be broken down into three distinct circuit sections, or blocks, as shown in Figure 1. The first section is the selector/pre-amplifier block. It lets the user select the desired type of input signal source and applies an appropriate amount of amplification and frequency correction to the signal so that the resulting output signal is suitable for use by the second circuit block.

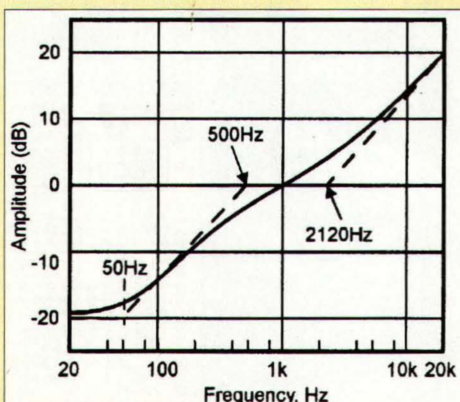


Figure 5. Typical phonograph disk frequency response playback curve.

The second section is the tone-/volume-control block, which lets the user adjust the system's frequency characteristics and output signal amplitude to suit personal tastes. This section may contain additional filter circuits and gadgets, such as scratch and rumble filters, and audio mixer circuitry, etc. Its output is fed to the system's final section — the audio power amplifier — which drives the loudspeakers.

A variety of practical pre-amplifier, tone-control, and associated circuits are described here. Audio power amplifier circuits will be dealt with in a future episode of the series.

SIMPLE PRE-AMPS

The basic function of an audio pre-amplifier is that of modifying the input signal characteristics so that they give the level frequency response and nominal 100mV mean output amplitude needed to drive the amplifier's tone-control system. If the input comes from a radio tuner, CD player, etc., the signal characteristics are usually such that they can be fed directly to the tone-control sections, by-passing the pre-amplifier circuit. If they are derived from a microphone or an old-style record (disk) pick-up, they usually need modification via a pre-amp stage.

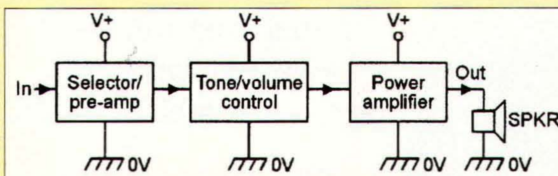


Figure 1. Basic elements of one channel of an audio amplifier system.

Microphones and pick-ups are usually either magnetic or ceramic/crystal devices.

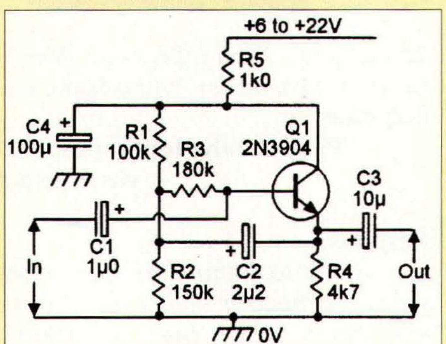


Figure 2. High-impedance pre-amp for use with ceramic/crystal microphones.

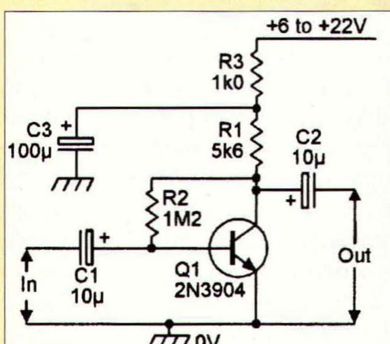


Figure 3. Magnetic microphone pre-amp, giving 46dB of gain.

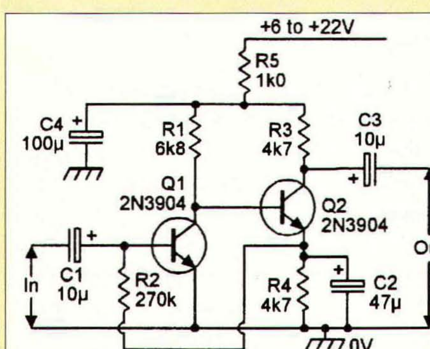


Figure 4. Magnetic microphone pre-amp, giving 76dB of gain.

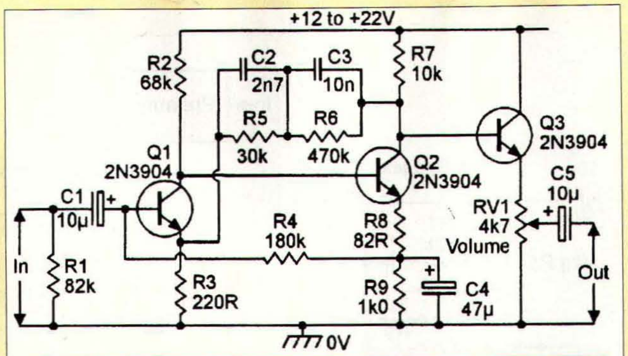


Figure 7. RIAA equalization pre-amp, for use with magnetic pick-up cartridges.

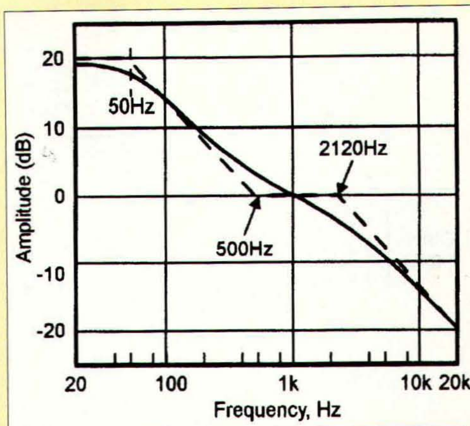


Figure 6. RIAA playback equalization curve.

Magnetic types usually have a low output impedance and a low signal sensitivity or mean output amplitude (about 2mV nominal). Their outputs thus need to be fed to high-gain pre-amplifier stages. Ceramic/crystal types usually have a high output impedance and a high sensitivity (about 100mV nominal). Their outputs thus need to be fed to a high-impedance pre-amp stage with near-unity voltage gain.

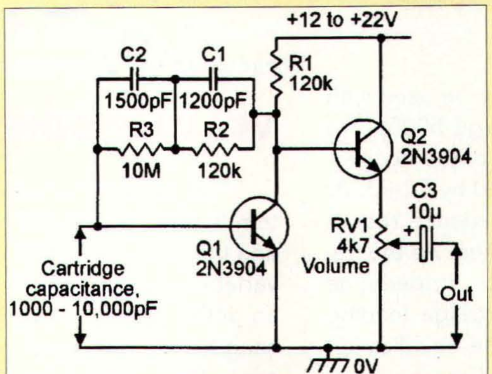


Figure 8. RIAA phonograph equalizer for ceramic pick-up cartridges.

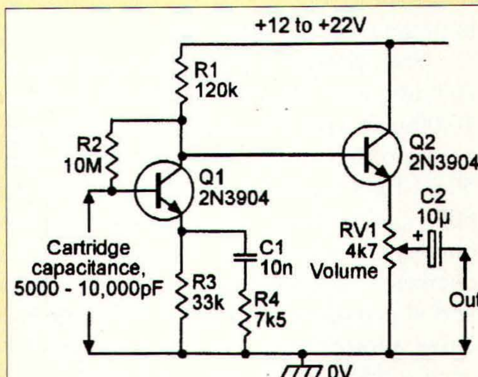


Figure 9. Alternative RIAA phonograph equalizer for ceramic cartridges.

Most microphones have a flat frequency response and can be used with simple pre-amp stages. Figure 2 shows a unity-gain pre-amp that can be used with most high-impedance ceramic/crystal microphones. It is an emitter follower circuit with a bootstrapped (via C2-R3) input network, and has an input impedance of about two megohms — its supply is decoupled via C4-R5.

Figures 3 and 4 show pre-amp circuits that can be used with magnetic microphones. The single-stage circuit in Figure 3 gives 46dB (x200) of voltage gain, and can be used with most magnetic microphones. The two-stage circuit in Figure 4 gives 76dB of voltage gain, and is meant for use with magnetic microphones with very low sensitivity.

RIAA PRE-AMP CIRCUITS

If a constant-amplitude 20 Hz to 20 KHz variable-frequency signal is recorded on a standard 33.3 RPM phonograph disk (record) using conventional stereo recording equipment, and the record is then replayed, it generates the highly non-linear frequency response curve, shown in Figure 5 — the dotted line shows the idealized shape of this curve, and the solid line shows its practical form. The idealized response is flat between 500 Hz and 2120 Hz, but rises at a rate of 6dB/octave (20dB/decade) above 2120 Hz, and falls at a 6dB/octave rate between 500Hz and 50 Hz. The response is flat to frequencies below 50 Hz.

These responses enable disk recordings to be made with good signal-to-noise ratios and wide dynamic ranges, and are used on all normal records. Consequently, when a disk is replayed, its output must be passed to the power amplifier via a pre-amp with an equalization curve that is the exact inverse of that used to make the original disk recording, so that a linear overall record-to-replay response is obtained.

Figure 6 shows the shape of the necessary RIAA (Record Industry Association of America) equalization curve. A practical RIAA equalization circuit can be made by wiring a pair of C-R feedback networks into a standard pre-amp (so that the gain falls as the frequency rises), with one network controlling the 50 Hz to 500 Hz response, and the other the 2120 Hz to 20 KHz response. Figure 7 shows such an amplifier.

The Figure 7 circuit can be used with any magnetic pick-up cartridge. It gives a 1V output from a 6mV input at 1 KHz, and provides equalization that is within 1dB of the RIAA standard between 40 Hz and 12 KHz. The actual pre-amp is designed around Q1 and Q2, with C2-R5 and C3-R6 forming the feedback equalization network. Q3 is an emitter follower buffer stage, and drives optional volume control RV1.

Ceramic/crystal pick-ups usually give a poorer reproduction quality than magnetic types, but give output signals of far greater amplitude. They can thus be used with a very simple type of equalization pre-amp, and are consequently found in many popular record player systems. Figures 8 and 9 show alternative phonograph pre-amplifier circuits that can be used with ceramic or crystal pick-up cartridges. In each case, the pre-amp/equalizer circuit is designed around Q1, and Q2 is an emitter follower output stage that drives optional volume control RV1.

The Figure 8 circuit can be used with any pick-up cartridge that has a capacitance in the 1000pF to 10,000pF range. Two-stage equalization is provided via C1-R2 and C2-R3, and is typically within 1.6dB of the RIAA standard

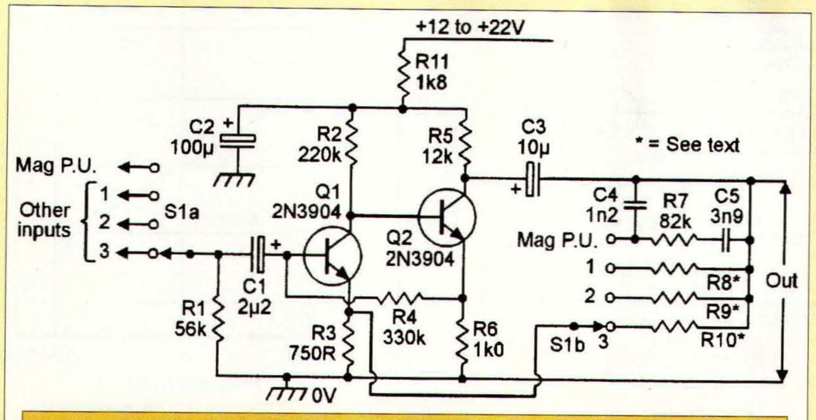


Figure 10. Universal pre-amplifier circuit.

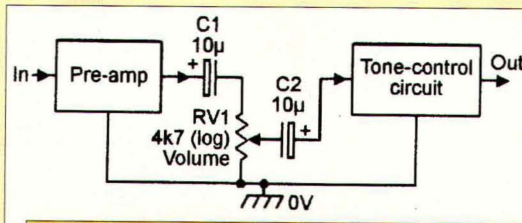


Figure 11. Ideal form and location of the volume control.

between 40 Hz and 12 KHz.

The alternative Figure 9 circuit can only be used with pick-ups with capacitance values in the range 5000pF to 10,000pF, since this capacitance forms part of the frequency response network The other part is formed by C1-R3. At 50-60 Hz, this circuit has a high input impedance (about 600K), and causes only slight cartridge loading. As the frequency is increased, however, the input impedance decreases sharply, thus increasing the cartridge loading and effectively reducing the circuit gain. The equalization curve approximates the RIAA standard, and the performance is adequate for many practical applications.

A UNIVERSAL PRE-AMP

Most audio amplifiers use pre-amps with variable characteristics, such as a high-gain linear response for use with magnetic microphones, low-gain linear response for use with a radio tuner, and high-gain RIAA equalization for use with a magnetic pick-up cartridge, etc.

To meet this requirement, it is normal to fit the system with a single universal pre-amp circuit of the type shown in Figure 10. This is basically a high-gain linear amplifier that can have its characteristics altered by switching alternative types of resistor/filter networks into its feedback loops.

Thus, when the selector switch is set to the "MAG P.U." position, S1a connects the input to the magnetic pick-up cartridge, and S1b connects the C4-R7-C5 RIAA equalization network into the feedback loop. In the remaining switch positions, alternative input sources are selected via S1a, and appropriate linear-response gain-controlling feedback resistors (R8, R9 and R10) are selected via S1b. The values of these feedback resistors should be selected (between 10K and 10M) to suit individual requirements — the circuit gain is proportional to the feedback resistor value.

VOLUME CONTROL

The volume control circuitry of an audio amplifier system is normally placed between the output of the pre-amp and the input of the tone-control circuitry, and consists of a variable potential divider or pot. This pot can form part of an active circuit, as shown in Figures 7 through 9, but a snag here is that rapid variations of the control can briefly apply DC potentials to the next circuit, possibly upsetting its bias and generating severe signal distortion.

Figure 11 shows the ideal form and location of the volume control. It is fully DC-isolated from the pre-amp's output via C1, and from the input of the tone-control circuitry via C2. Variation of the RV1 slider thus has no effect on the DC bias levels of either circuit. RV1 should be a log-type of pot.

TONE CONTROL CIRCUITS

A tone control network lets the user alter the frequency response of the amplifier system to suit a personal mood or requirement. Simple tone control networks consist of collections of C-R filters, through which the audio signals are passed — these networks are passive, and cause some degree of signal attenuation. Figure 12 shows the practical circuit of a passive tone control network that gives about 20dB of signal attenuation when the bass and treble controls are in the flat position, and gives maximum bass and

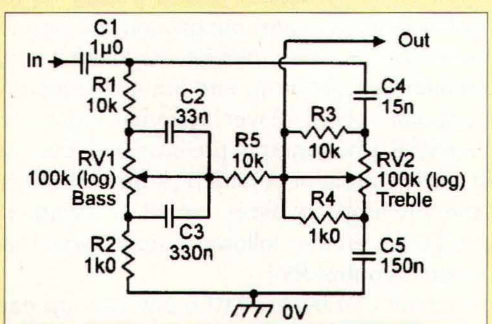


Figure 12. Passive bass and treble tone control networks.

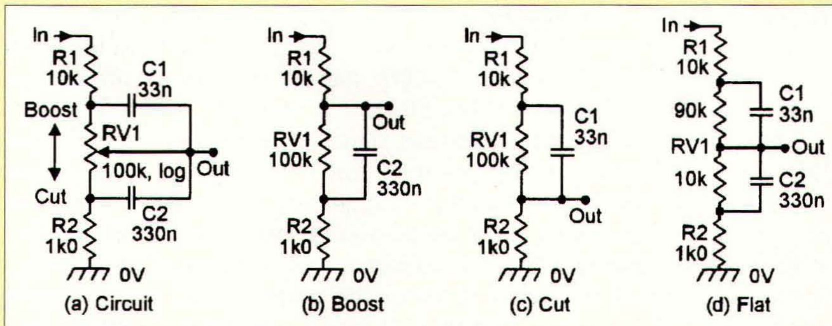


Figure 13. Circuit and equivalents of bass tone control network.

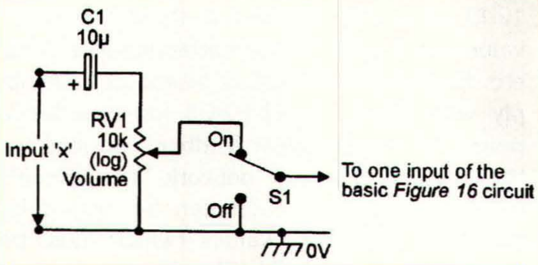


Figure 17. Way of adding independent volume and on/off control to each input channel of the basic Figure 16 audio mixer circuit.

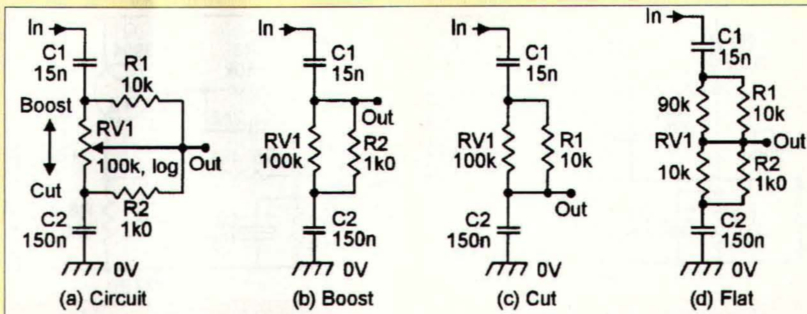


Figure 14. Circuit and equivalents of treble tone control network.

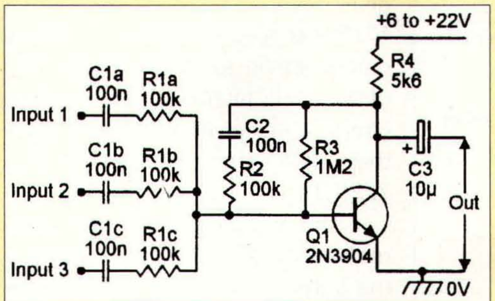


Figure 16. Simple three-channel audio mixer.

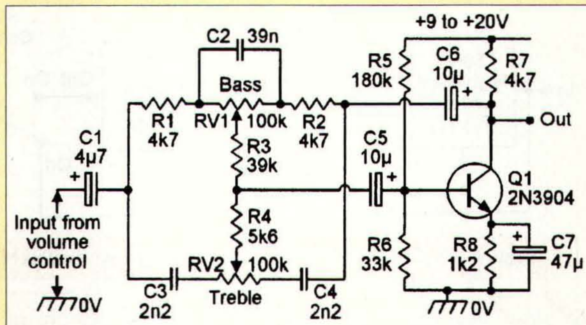


Figure 15. Active bass and treble tone control circuit.

treble boost and cut values of about 20dB relative to the flat performance. The input to this circuit can be taken from the circuit's volume control, and the output can be fed to the input of the main power amplifier.

The basic action of the Figure 12 tone control network can be understood with the help of Figures 13 and 14, which show (a) the basic circuit and its equivalents under (b) boost, (c) cut, and (d) flat conditions of the bass and treble tone control networks, respectively. Brief explanations of these two diagrams are as follows.

In the Figure 13 bass control diagram, C1 is shorted out via RV1 when RV1 is in the maximum boost position, to give the equivalent circuit of (b), which gives only slight bass attenuation. When RV1 is in the maximum cut position, it shorts out C2, to give the equivalent circuit of (c), which gives roughly 40dB of bass attenuation. Finally, when RV1 is in the flat position, it gives the equivalent circuit of (d), which gives about 20dB of signal attenuation at all frequencies. Thus, this bass control circuit gives a maximum of about 20dB of bass boost or cut relative to the flat signals.

In the Figure 14 treble control diagram, R1 is shorted out when RV1 is in the maximum boost position, to give the equivalent circuit of (b), and R2 is shorted out when RV1 is in the maximum cut position, to give the equivalent circuit of (c). When RV1 is set to the flat position, the circuit equivalent is that of (d), which gives about 20dB of signal attenuation at all frequencies. The net result is that this treble control circuit gives a maximum of about 20dB of treble boost or cut relative to the flat signals.

A passive tone control network of the basic type described above can easily be wired into the feedback path of a transistor amplifier so that the system gives an overall signal gain (rather than attenuation) when its controls are in the flat position. Figure 15 shows a practical example of an active tone control circuit of this type. In this particular example, the design uses a modified version of the basic Figure 12 tone control circuit, which enables the tone-control circuit to use three (rather than four) tone-control capacitors.

AUDIO MIXER CIRCUITS

One useful gadget that can be fitted in the area of the volume/tone-control section of an audio amplifier is a multichannel audio mixer, which enables several different audio signals to be mixed together to form a single composite output signal. This can be useful in, for example, enabling the user to hear the emergency sounds of a front-door or babyroom microphone, etc., while listening to normal entertainment sources.

Figure 16 shows an example of a simple three-channel audio mixer that gives unity gain between the output and each input. Each input channel comprises a single 100nF capacitor (C1) and 100K resistor (R1), and presents an input impedance of 100K. The circuit can be given any desired number of input channels by simply adding more C1 and R1 components. In use, the mixer should be placed between the output of the tone-control circuitry and the input of the main power amplifier, with one input taken from the tone-control output and the others taken from the desired signal sources.

Figure 17 shows a simple way of adding independent volume and on/off control to any desired number of input channels of the basic Figure 16 audio mixer circuit – RV1 controls the volume, and S1 provides the on/off function.

SCRATCH/RUMBLE FILTERS

A common annoyance when playing old records/disks is that of scratch and/or rumble sounds. The scratch noises are mainly high-frequency (greater than 10 KHz) sounds picked up from the disk surface, and the rumbles are low-frequency (less than 50 Hz) sounds that are mostly caused

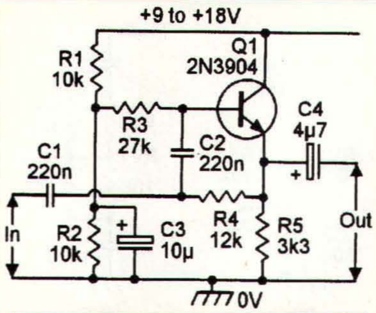


Figure 18. 50 Hz rumble or high-pass filter.

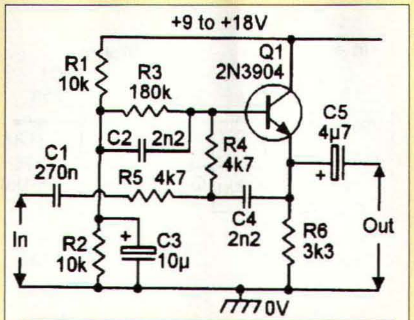


Figure 19. 10 KHz scratch or low-pass filter.

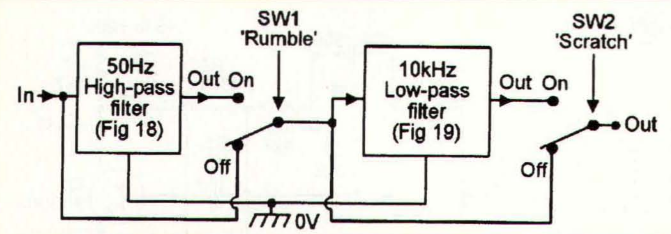


Figure 20. Complete scratch/rumble filter, with switching.

by slow variations in motor-drive speed. Each of these noises can be greatly reduced or eliminated by passing the player's audio signals through a filter that rejects troublesome parts of the audio spectrum. Figures 18 and 19 show suitable circuits.

The high-pass rumble filter in Figure 18 gives unity voltage gain to signals above 50 Hz, but gives 12dB per octave rejection to those below this value, i.e., it gives 40dB of attenuation at 5 Hz, etc. Emitter-follower Q1 is biased at half-supply volts from the R1-R2-C3 low-impedance point, but has negative feedback applied via the R3-C2-C1-R4 filter network. The circuit's frequency turnover point can be altered by changing the C1-C2 values (which must be equal). Thus, if the C1-C2 values are halved (to 110nF), the turn-over frequency doubles (to 100 Hz), etc.

The low-pass scratch filter in Figure 19 gives unity voltage gain to signals below 10 KHz, but gives 12dB per octave rejection to those above this value. This circuit is similar to that in Figure 18, except that the positions of the main filter network components are transposed. The circuit's turn-over frequency can be altered by changing the C2-R4 values; e.g., values of 3.3nF give a frequency of 7.5 KHz.

The Figure 18 and 19 circuits can be combined, to make a composite scratch and rumble filter, by connecting the output of the high-pass filter to the input of the low-pass filter. If desired, the filters can be provided with bypass switches, enabling them to be easily switched in and out of circuit, by using the connections shown in Figure 20.

Note that if the Figure 18 and 19 designs are built as a single unit, a few components can be saved by making the R1-R2-C3 biasing network common to both circuits. **NV**

Customize YOUR Processor!

by Al Williams

Everyone wants something custom. Custom vans, custom pools — even cell phones have personalized face plates so you can have a unique phone. Not surprisingly, the latest trend in microprocessors is to let you customize your own CPU.

Consider this scenario: You set out to design a circuit with a traditional single-chip microcontroller family (for example, a PIC or a 6805). You pick a processor that works at the speed you require and has sufficient memory and I/O. You also have to pick the peripheral devices you need. For example, many PICs have a hardware UART (but some don't). Many have A/D converters with varying specifications.

Somewhere down the road, your requirements change (as shocking as that may seem). Now instead of 8-bit A/D converters, you need 12 bits. What can you do? You have to select another processor. However, with the new "system on a chip" or SOC processors, you simply reconfigure the existing chip to have the features you need.

IN PRACTICE

Probably the most sophisticated of the SOC processors available today are the Cypress PSoC family of parts. These processors contain a standard 24 MHz 8051-style processor, some sophisticated clock hardware, and a number of programmable digital and analog blocks. Read that again— the processor has analog circuitry onboard!

Suppose you are working on a controller for a vending machine. You need to read two voltages (perhaps measuring temperature, input voltages, and other real-world quantities). You also need to talk to a serial printer and a coin accepter. Very few CPUs have more than one hardware UART onboard, so a traditional design would "bit bang" one of the serial ports. With a PSoC, you could configure the analog blocks to form the A/D converters (and also add amplification and filtering all on the chip) and then use the digital blocks to create two UARTs.

Resources used for a typical small program.

Resource Meter

	Total	Used
Digital Blocks	8	2
Analog Blocks	12	0
RAM	256	0
ROM	16384	
Decimator	1	0

As another example, consider a mobile robot. You want a timer to generate infrared modulation, a few pulse capture registers, and an A/D to monitor battery voltage. When the battery is low, you guide the robot to a charging base. While charging, you could use a UART to hook up to the Internet for more instructions. However, suppose that after you put in the timers, pulse capture registers, and the A/D, you are out of programmable blocks. No problem! You can actually reconfigure the chip at run time! So while the robot is roaming, you have one set of peripherals. When the robot is charging, the CPU has a different set of I/O devices.

The PSoC chips are available in several packages including 28- and 8-pin DIP packaging, so they are easy to use for development. They have a host of features that all work to slash the number of external parts required for many applications. Oh, and one more thing. These chips are fairly inexpensive, ranging from $4.00 to under $8.00 each in single quantities. If you are buying them by the hundreds, the price drops even further.

DETAILS

Even without the programmable analog and digital blocks, the PSoC is a powerful chip with an impressive list of features:

- A 24 MHz clock generated by a 32 KHz source
- An internal 32 KHz source that provides ±2.5% accuracy at 24 MHz
- An 8x8 hardware multiply
- A 32-bit hardware accumulator
- Up to 16K of flash program memory, and 256 bytes of RAM
- The I/O pins with Schmitt trigger inputs and 25 mA drive
- Interrupt on pin change
- Watchdog timer
- Low voltage detection
- Operates at 3 to 5.25V
- Can operate at 1V using an onboard voltage pump

The chip doesn't have EEPROM per se, but you can use over 2K of the flash as EEPROM if you need it. Of course, the real star of the show is the programmable analog and digital blocks. You can configure these blocks for a myriad of functions including:

- A/D converters (up to 14 bits)
- Amplifiers
- Counters and timers (up to 32 bits)
- D/A converters (up to 9 bits with or without multiplication)
- RS232, I2C, and SPI communications
- Low pass and bandpass filters
- PWM output (up to 32 bits)
- Digital inverter

Blinker	
User Module Parameters	
Clock	CPU_32_KHz
Enable	High
Output	Global_OUT_5
Period	65535
CompareValue	32767
CompareType	Less Than Or Equal
InterruptType	Terminal Count

The counter properties.

This sounds great (and it is). However, there are a few caveats. First, some functions consume multiple blocks. For example, a 14-bit A/D converter requires four digital blocks and one analog block. Also, not all blocks are equal. So, for example, amplifiers require special analog blocks — not just any will do. That means you may have analog blocks available, but not the correct kind to do what you want to do.

Another problem is routing. You may have enough blocks to do what you want, but there may be no way to get the output of one block to the input of another (although you might be able to use an external connection). The problem is that the blocks connect in specific ways, and you can't always make the connections you would like to make.

Transforming the generic blocks into specialized I/O devices can be a tricky business. Not only do you have to set the options correctly, but some functions require some support code in the processor to handle interrupts and perform other tasks. Luckily, Cypress makes this easy with their PSoC Designer software.

Designer is a fairly straightforward IDE — it allows you to write assembly language programs, compile them, and send them to the chip (using programming hardware attached to your PC's printer port). If you buy the optional C compiler (which is not free), you can use that too.

However, the Designer has another mode that is unlike what you see in most IDEs — the device editor mode. In this mode, you can design your custom PSoC processor while the Designer does all the actual work. In a traditional project, you start by selecting a processor from a catalog or a data book. With PSoC, you start by designing the processor you want to use. If you change your mind later, it is easy to modify the chip's functions.

DEVELOPMENT TOOLS

One thing Designer does not do is simulate your program in software. With all the I/O devices virtual, that would be a big task. If you are on a budget, there are several ways to make a cheap programmer that Designer can use (the protocol is documented), and there are even a few inexpensive commercial options. However, if you can afford it, the PSoC ICE-4000 is highly recommended. This is a real in-circuit emulator and allows you to debug your programs directly in Designer in real time. This isn't a fancy bootloader with a single breakpoint. It has multiple breakpoints, tracing, and a very sophisticated event system (for example, you can set a breakpoint when a certain byte appears in a range of addresses).

The ICE is really worth the $250. unless your time is absolutely wor less. It comes with several device sa ples, a 28-pin pod (you have to b other pods separately), a demonst tion board, and a special board used program parts using the ICE (in ot words, the ICE is also a device progra mer).

The C compiler is an extra you c probably do without. However, it is good compiler and the architecture well-suited for C. If you plan to do a serious development, the $145.00 for the compiler is mor well spent.

A VOLTAGE TO PWM CONVERTER

For a practical project, I decided to tackle a pecu form of A/D converter. What I wanted was an A/D conve that could output to an RS232 port (a PC, for example) a also output PWM. That means you could use a voltage control a lamp's brightness or a motor's speed. With a li change in the logic, it would be easy to convert the volta into a signal for an R/C servo. For testing, I used a pot tiometer to generate the input voltage, but an LM34 temp ature sensor also works well.

Figure 1 shows the layout for the chip. The external cuitry was just a potentiometer connected to the ampli input, an LED (with a dropping resistor) connected to PWM output, and a MAX232 (actually, an RS-I adap board) connected to the serial output. The RS-I provide MAX232, a DB9, and all the external components requi by the MAX232. There are several blocks in this design:

- lamp — The input amplifier for the voltage. For the p the gain is set to 1. However, for the LM34, you can crank gain up to get a wider range on the readings.
- A2D — The 8-bit A/D. This is a delta-sigma conve that requires both an analog and digital block.
- PWM — An 8-bit PWM block to generate the outp You set a total period, and how much time the output sho be high.
- BRG — This is a counter used to generate the baud r clock for the UART transmitter. The block is set to out with a period of eight times 9,600 baud.
- TX — Although the PSoC has a complete UART blo this project only needs a transmitter. The block require clock equal to eight times the required baud rate.

The design uses five digital blocks and two ana blocks. The actual code is written in C (listings availa online). Since the program doesn't have anything to do u the A/D is ready to go, it does not use the A/D block's int rupt capabilities. Instead, it polls the block to see when d is ready (this requires you to enable the "Enable interrupt g eration control" option in the project settings). The progr also polls the UART instead of implementing a buffer, althou it is certainly possible to deal with the UART via interrupts.

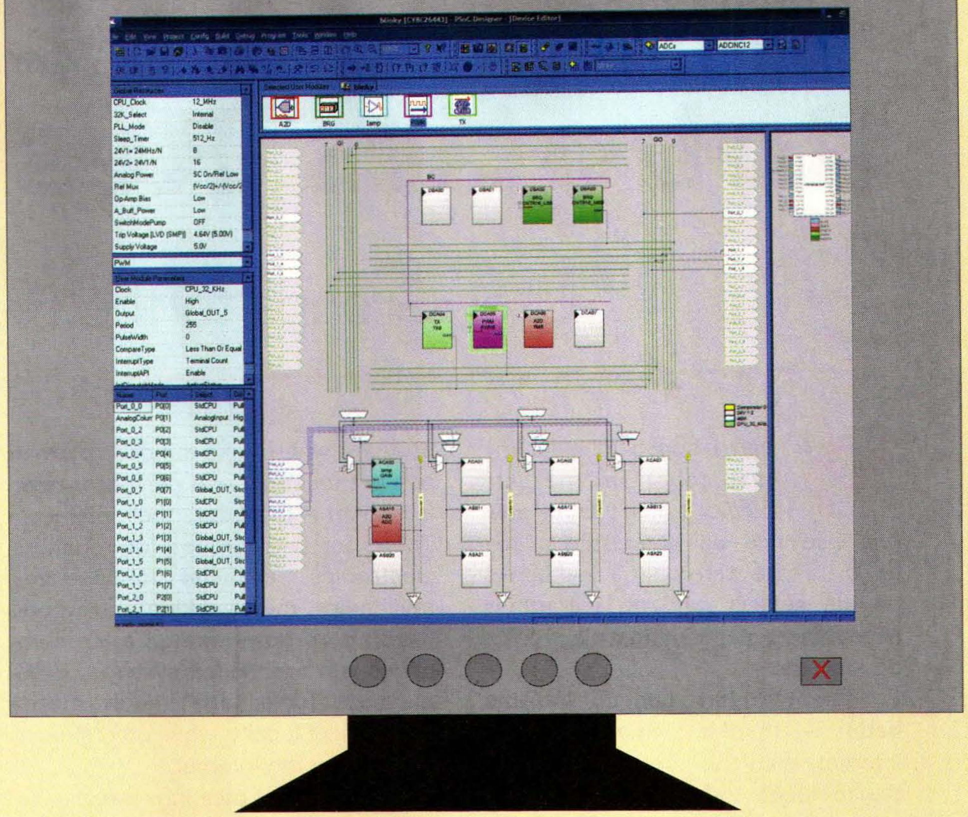
However, the program does use the PWM interrupt. The PWM output uses a period of the clock divided by 255. Therefore, by setting the pulse width to a number from 0 to 255, the program obtains a square wave with a proportional duty cycle. That is, setting the pulse width to 0 produces a (nearly) 0% duty cycle, 255 produces a 100% duty cycle, and setting the width to 128 creates a 50% duty cycle.

So why bother with interrupts? The pulse width register in the PWM block is in use by the block all the time. If you change it at some arbitrary time, you may interrupt a pulse that is already in progress which causes the PWM to be inaccurate. To prevent this, the program only changes the PWM when a cycle has completed. The block generates an interrupt which I handle with a C-language handler:

```
#pragma interrupt_handler pwm
change

void pwmchange()
{
  PWM_WritePulseWidth(brate);
}
```

Figure 1. The Design View's interconnect mode is very busy and hard to read even on a large screen.



You also have to add one line to the PWMINT.ASM file that the Designer automatically creates:

```
ljmp _pwmchange
```

Notice that in assembly you must add an underscore to all C symbols.

THE BAD NEWS

There isn't much bad news associated with the PSoC, but there are a few issues to consider. First, these parts are relatively new. Compared to a PIC or a 68HC11, there isn't much information about them. There are also very few development tools (although the Cypress tools are very nice and the software is free). There are quite a few "silicon errata" posted on the early revision chips that cause problems — particularly when running the chip at full speed (24 MHz). The tools try to help you around these problems, but they aren't always successful.

For example, there is a problem with certain instruction alignments when running at full speed. The Cypress linker can identify these problems and tries to pad your code to avoid the problem areas. This is great until you start using most of the chip's memory. Then the linker may not be able to help. Some of the block functions (notably the UART) have problems when running at full speed also. The Designer software is a marvel, but it is clunky in a few spots. In particular, some screens are hard to read. It also is annoying to have to switch away from debug mode to change files. However, these are minor gripes and overall the software is easy to use. In particular, I like the way you can easily call up the data sheets for each block type for reference while programming.

FINAL ANALYSIS

All that aside, the PSoC is a great bargain. Not only can you custom — design your CPU for the job, but you can also stock one CPU and use it for many different projects — a big savings if you are producing products commercially. The newest parts should have fewer "silicon bugs" and that will be a big help.

Because the software is unique, it is a bit difficult to learn. However, Cypress offers free training both in the form of application notes and documents, and also via "teletraining" where you actually call a toll-free number and work through examples with a live instructor.

One day, most processors will have this kind of capability. Surely we will eventually see a CPU coupled with a CPLD or FPGA in a single package. But until then, the PSoC offers real benefits for development. Customizing hardware — even at run time — to fit your problem is a tremendous benefit. The devices are inexpensive and easy to use. Although the development tools are a bit cumbersome (and the ICE is somewhat expensive for the hobbyist), they are still quite usable and improving all the time. So next time you think about picking a CPU for a project, maybe you should just design your own! **NV**

ONLINE RESOURCES

CYPRESS - www.cypress.com

RS-1 ADAPTER - www.al-williams.com/rs1.htm

"Where It Is and How to Get It"

Robotics Resources

User Groups to the Rescue!

When I began to build my first robot in the late 1970s, I didn't know anyone else who was interested in my hobby. There were only a few books on the subject, and no magazines except the general-interest electronics periodicals.

The world has changed — for the better — thanks primarily to the Internet. With the Internet, it's possible to locate others who have the same interests as you.

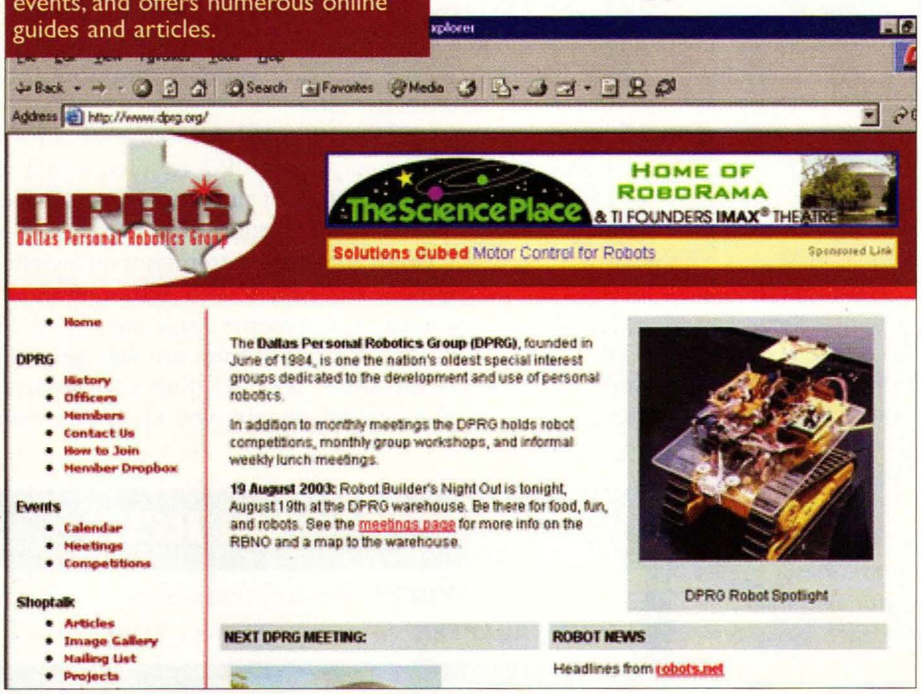
With just a modicum of effort, you can find people all over the world to exchange ideas with. You might even be able to find folks in your home town who share your interests.

Such places are called user groups, where like-minded people can get together — in person or over a modem — to discuss their interests. There are user groups for robotics, electronics, artificial intelligence, mechanics, metalworking and woodworking, programming, microcontroller and embedded systems, CNC machine tools, and much more. Some meet locally, while others meet virtually on the Internet.

The Internet meetings are usually held through an online bulletin board. An example of an all-online user group is The Robotics Club of Yahoo! — or TRCY.

Here, some 2,000 members from around the globe use the bulletin board and chat features of Yahoo! to discuss the art of robot building. Libraries filled with photos, schematics, and building plans are available.

Dallas Personal Robotics Group sponsors competitions and other events, and offers numerous online guides and articles.



Not all robotics user groups are virtual, of course. Many are held in business parks, school auditoriums, and people's homes. Most of these groups hold monthly meetings (or at other regularly scheduled times); most meetings are informal and show-and-tell — member presentations are encouraged.

If you like the idea of a robotics user group that meets regularly, but one isn't near you, consider starting it yourself! All it takes is a desire and at least one other member. Meetings can be held at local schools, in the recreation rooms of understanding companies, or even members' homes or workshops.

Here are several dozen local and Internet-based robotics user groups. Web pages or message boards for the local groups are provided, along with their general location.

Note that user group home pages change fairly frequently, especially if the group doesn't have its own unique domain name. If a group's page is no longer available, you may still be able to find it using a Google search.

Art & Robotics Group (ARG)

www.interaccess.org/arg
Toronto, Canada

User group, discussion board, and latest news on the artistic side of robotics.

Atlanta Hobby Robot Club

www.botlanta.org
Atlanta, GA

B9 Robot Builders Club

www.b9robotbuildersclub.com

Dedicated to building the Robot from the *Lost in Space* television series. Impressions of Dr. Smith ("Oh, the pain!") are optional.

Carnegie Mellon Robotics Club
www.roboticsclub.org
Carnegie Mellon University

Central Illinois Robotics Club
www.circ.mtco.com
Peoria, IL

Says the site: "The Central Illinois Robotics Club was founded ... in an effort to promote, educate, explore, and compete in the field of hobby robotics. The club is located in the greater Peoria area and meets monthly."

Central Jersey Robotics Group
dpein.home.netcom.com
New Jersey

Chicago Area Robotics Group
www.chibots.org
Chicago, IL

Computers, Robotics, and Artists Society
www.crash.org
Houston, TX

Connecticut Robotics Society
www.ctrobots.org
Hartford, CT

Says the site: "We are a unique group of friends, experimenters, and mad scientists who meet monthly in Hartford, CT ... Our interests are in electronics, mechanics, fun, and the sciences involved in automation and homebuilt robots."

Dallas Personal Robotics Group (DPRG)
www.dprg.org
Dallas, TX

Projects, tutorials, articles. The DPRG also sponsors the well-received RoboRama competitions. Events include line following, sumo, fire-fighting, and others.

See: www.dprg.org/dprg_contests.html

Denver Area Robotics Club
www.ranchbots.com
Denver, CO

East Bay Builders Group
www.buildcoolstuff.com/ebg
Berkeley, CA

EFREI Robotique
http://assos.efrei.fr/robot
France

Finnish Robotics Association
www.psavolainen.net/robotics/index.html
Tampere, Finland

Front Range Robotics
www.frontrangerobotics.com
Northern Colorado

(Note: Redirects to Yahoo! message board.)

HCC Robotica gg
http://members.tripod.com/~hccrobotica
Netherlands

(Note: Watch for pop-ups!)

HomeBrew Robotics Club
www.hbrobotics.org
San Jose, CA

KISS Institute for Practical Robotics (KIPR)
www.kipr.org

Says the site: "KISS Institute for Practical Robotics (KIPR) is a private, non-profit, community-based organization that works with all ages to provide improved learning and skills development through the application of technology — particularly robotics. We do this primarily by providing supplementary, extra-curricular and professional development classes and activities.

KISS Institute's activities began in 1993." KIPR also sponsors the annual Bot Ball tournament for middle and high school students.

Laboratory Robotics Interest Group
http://lab-robotics.org
New Jersey

Mobil Robotics Research Group
www.dai.ed.ac.uk/groups/mrg/MRG.html
University of Edinburgh, Scotland

Nashua Robot Club
http://nashuarobotbuilders.org
Nashua, NH

Northern New Mexico Robotics
www.cbc.umn.edu/~mwd/robot/NNMR.html
Los Alamos, NM

Northeastern PA Robotics Society
www.nepars.org
Northeastern Pennsylvania

Says the site: "NePARS is an informal group of hobbyists, experimenters, and robot builders who meet monthly in Wilkes-Barre, PA. Our membership is a diverse group composed of people with many different backgrounds and experience levels.

Our interests include, but are not limited to, electronics, mechanics, fun, and the science related to automation and homebuilt robotics."

Ottawa Robotics Enthusiasts (O.R.E.)
www.ottawarobotics.org
Ottawa, Ontario, Canada

Phoenix Area Robot Experimenters
www.parex.org
Phoenix, AZ

Pittsburgh Area Robotics Society
www.pittsburghrobotics.org
Pittsburgh, PA

Portland Area Robotics Society
www.portlandrobotics.org

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 bots@robotoid.com

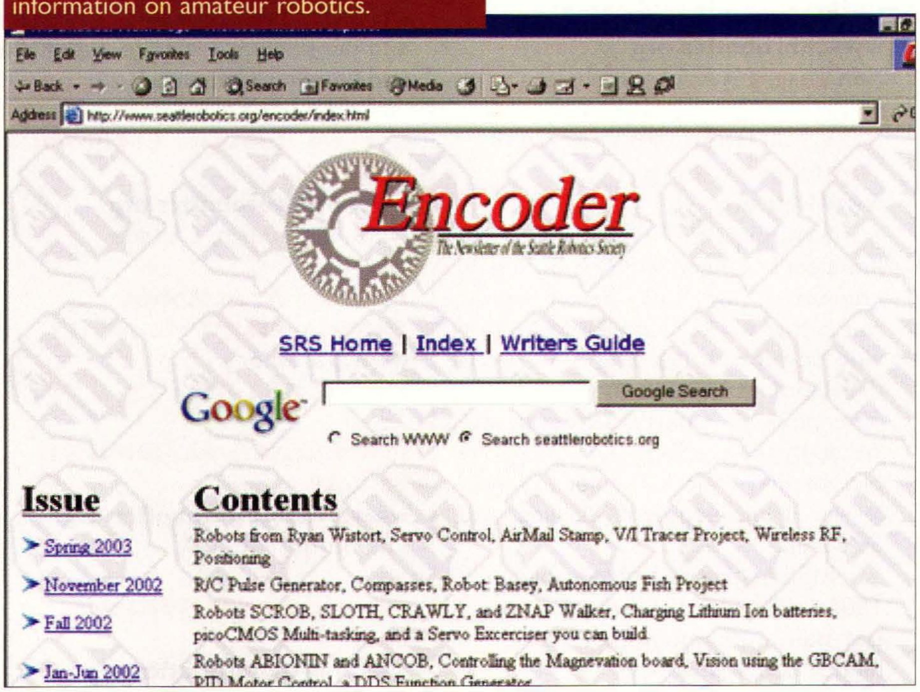
Portland, OR

Says the site: "The Portland Area Robotics Society is a club formed to help those interested in learning about and building robots.

The club involves professionals, amateurs, students, college professors, engineers, artists, hobbyists, and tinkerers.

PARTS will help explore all aspects of robotics for its members, and work toward expanding communication between robot enthusiasts. PARTS members share ideas, experience, and enthusiasm for building robots."

Seattle Robotics Society publishes the semi-monthly *Encoder*, one of the best resources on the Internet for technical information on amateur robotics.



RoboFesta-International

www.robofesta.net

RoboFesta is an international movement to promote interest throughout the world in science and technology, including robotics. Sponsors Olympics-style competition events. Web page in Japanese, English, and French. See also www.robofesta-europe.org

Robot Club of Traverse City

www.wdweb.com/robotclub

Traverse City, MI

RobotBuilders.Net

www.robotbuilders.net

Umbrella Web site for various specialty Internet-based robot building clubs.

- B-9 Club
- Robot Club
- R2-D2 Builders Club
- The Drone Room (Silent Running)

Robotics Society of Southern California

www.rssc.org

Fullerton, CA

Sacramento Area Robotics Group

www.sacrobotics.org

Sacramento, CA

San Diego Robotics Society

www.sdrobotics.org

San Diego, CA

See also: **http://groups.yahoo.com/group/sdrs-list**

San Francisco Robotics Society of America

San Francisco, CA

The San Francisco Robotics Society of America also sponsors the annual Robot Sumo conference.

Seattle Robotics Society

www.seattlerobotics.org

Seattle, WA

SRS has a major presence on the Internet and publishes *the Encoder*, an online technical journal on amateur robot building.

Southern Oregon Robotics Club

www.sorobotics.org

Southern Oregon

Sponsors RoboMaxx and other competition events.

The Robot Group

www.robotgroup.org

Austin, TX

Says the site: "The Robot Group was founded in the Spring of 1989 by a small group of artists and engineers from Austin, TX who shared a common vision — utilizing technology to provide and explore new mediums for art.

Through the synergy of fusing art and technology, The Robot Group has stimulated the public into a playful interest in high technology, and art now has new vehicles for effecting culture."

The Robotics Club of Yahoo! (TRCY)

http://groups.yahoo.com/group/theroboticsclub

Internet-based group of robotics enthusiasts.

Titan Robotics Club
www.titanrobotics.net

International School Robotics Club. For high schoolers and middle schoolers who are interested in robotics.

Triangle Amateur Robotics
http://triangleamateurrobotics.org

Raleigh, NC

Twin Cities Robotics Group
www.tcrobots.org

St. Paul, MN

Self-described as "a loose affiliation of people interested in robots, located in the Twin Cities metro area."

The site hosts a number of useful resource pages, includes articles (identified by skill level), useful links, and colorful photos of the monthly meeting — see people and robots in action.

UK Cybernetics Club
www.cybernetic.demon.co.uk

For UK-based fans of robotics, but membership is open to everyone everywhere.

Union College Robotics Club
www.vu.union.edu/˜robot

Schenectady, NY

Vancouver Island Robotics
www.vancouverislandrobotics.org

Vancouver Island, Canada

Sponsors workshops and day camps.

Wichita Robotic Club
www.robot-club.org

Wichita, KS

Sponsors several robotics contests.

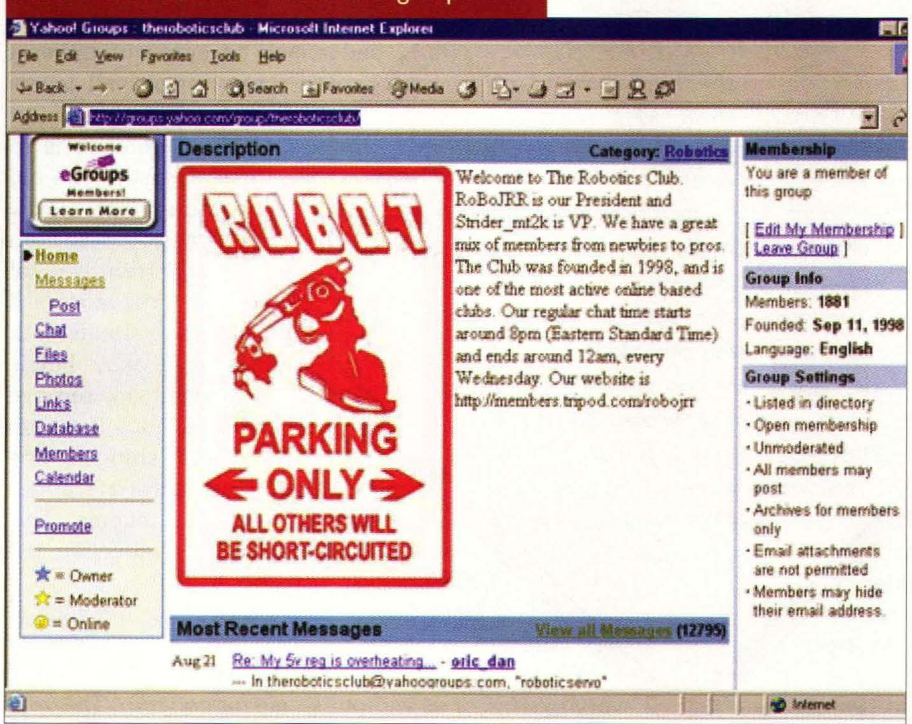
Winnipeg Area Robotics Society
www.winnipegrobotics.com

Winnipeg, Canada

Yahoo Groups: Kansas City Robotics Society
http://groups.yahoo.com/group/KCRS

Online gathering point for all hobby or professional roboticists in the Kansas City area. **NV**

The Robotics Club of Yahoo! is one of the more active Internet-based robotics user groups.



Exploring and Experimenting With Lasers and Their Properties

Laser Insight

Construction of the Cr:Ruby Laser Continues ...

The past few columns have been devoted to the building of a Cr:Ruby laser, which may be used pretty much as-is for drilling or light welding, using a lens, of course, or with a few refinements, it may be used for holography.

Last month, we looked at the water monitoring and safety interlocks that shut down the supply under various operating system fault conditions. This month, we'll be looking at the control electronics. Next month, we'll cover the high-voltage stuff.

However, because this is a serious laser, I must be sure that I cover things thoroughly, and in tune with this, I must repeat the warning I gave earlier about it, and its safe use.

CAUTION

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.

Construction notes

The schematic for the control section of this laser is given in Figure 29-1. The circuit is quite straightforward and should not present any problems either in construction or in operation. There are a few adjustments to make to calibrate things, and these will be discussed as we get to them.

Most of the components used in the circuit can be mounted on a single piece of perfboard or PCB, depending on your preference. There will be a number of wires coming off the board for control panel mounted switches, pots, indicator LEDs, etc., so you may want to consider adding a board-mounted, multi-pin connector for easy removal in case you need to troubleshoot the board later.

In fact, it may be a good idea to add two connectors — one for the front panel controls, and another for the interlock and HV monitoring inputs. If you use different types of connectors, there can be no mix-ups. I haven't given a layout for the board because it will depend on what you use, and what you decide to do regarding the water system and monitoring.

The control board may be mounted in the same chassis as the power distribution and interlock circuit described last month. The high voltage section will be kept well away from the control section, and will go into a separate chassis. This will give us more room to space things out for isolation purposes.

Notes on some of the components

There are a couple of references to special requirements in the schematic. The high voltage resistor R17, for instance, is a string of resistors connected in series, and covered with either a plastic tube or several layers of heatshrink sleeving.

My preference is to use a plastic tube big enough to allow easy insertion and removal of the resistors, if necessary. Heatshrink sleeving is okay, but is more difficult to remove later, if you have to. The total value of the R17 string is one megohm and will dissipate about four watts at maximum loading. This can be made by series connecting ten 100K one-watt resistors.

Having 10 resistors will reduce the voltage stresses on each resistor, and lower the power dissipation. The final value is not critical, and can vary by 10% or so without cause for concern. The variable resistor VR2 will be adjusted later to compensate for any discrepancy.

The dump solenoid shown in Figure 29-2 is a critical component for safety, and must be made very carefully. It is used in a couple of different ways, and these are discussed below.

Two heavily insulated wires are connected across the main contacts to discharge the main capacitor bank under different conditions.

When the system is shut down, the solenoid is de-energized and the two main contacts close, discharging the main capacitor bank. In the shut-off state, the solenoid will prevent any charge accumulating on the main capacitor through interaction with RF fields (think about a CRT!).

Another function of this component is to prevent any charge building up through leakage in the charge relay (a solid-state device) until the CHARGE button is pressed. The microswitch mounted on the solenoid backboard will change state only when the plastic block mounted on top of the moving armature actuates the operating button on the switch.

Until this happens, the solid-state relay cannot turn on because the microswitch contacts (Sw2) are wired across the control voltage input. A third function is to discharge the main capacitor if the fire button is not pressed within a given time period. This again is a safety issue.

If the capacitor is left in a charged condition, there is the potential that you may forget that it is charged (if, for instance, you find you have to make adjustments to something outside the laser, or if someone else in the room is unaware that the capacitor is charged, or perhaps something will distract you). Thus, there is the potential for an accident.

The timer circuit around U5 (LM555) will initiate when the charge button is pressed. The time period is arbitrarily set here by R31 for about 30-45 seconds. If the time period elapses before the FIRE button is pressed, then the timer will release the dump solenoid and discharge the main capacitor. This is another safety feature that is required by CDRH and OSHA, so please do not leave it out.

To make the dump solenoid assembly, I used an old 12VDC Guardian relay that I had lying around, and made an extended armature to provide clearance between the high voltage and the microswitch. The plastic block mounted to the top of the armature is about 3/16 inch thick, and is secured using Superglue™.

Mount the microswitch on a backboard (also plastic) using small screws, and allow a bit of movement in the screws so that you can adjust the position slightly for correct operation.

When assembled, the microswitch should change state when the armature is at the top of its travel. The high voltage side of the discharge path is terminated on the base of the solenoid through a brass screw that forms one of the high voltage contacts.

Be careful not to break through the plastic block when tapping for this screw. You want total isolation when you mount this assembly to the

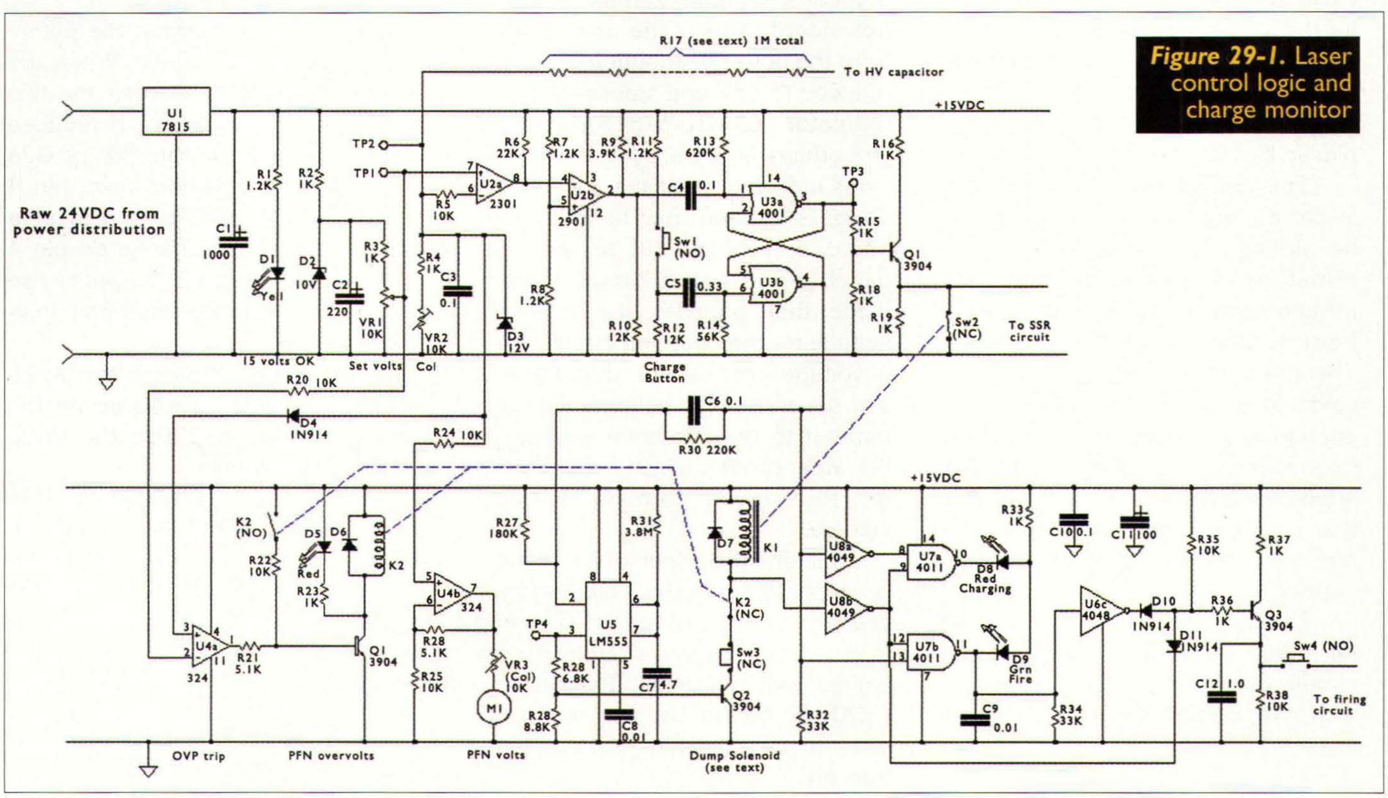


Figure 29-1. Laser control logic and charge monitor

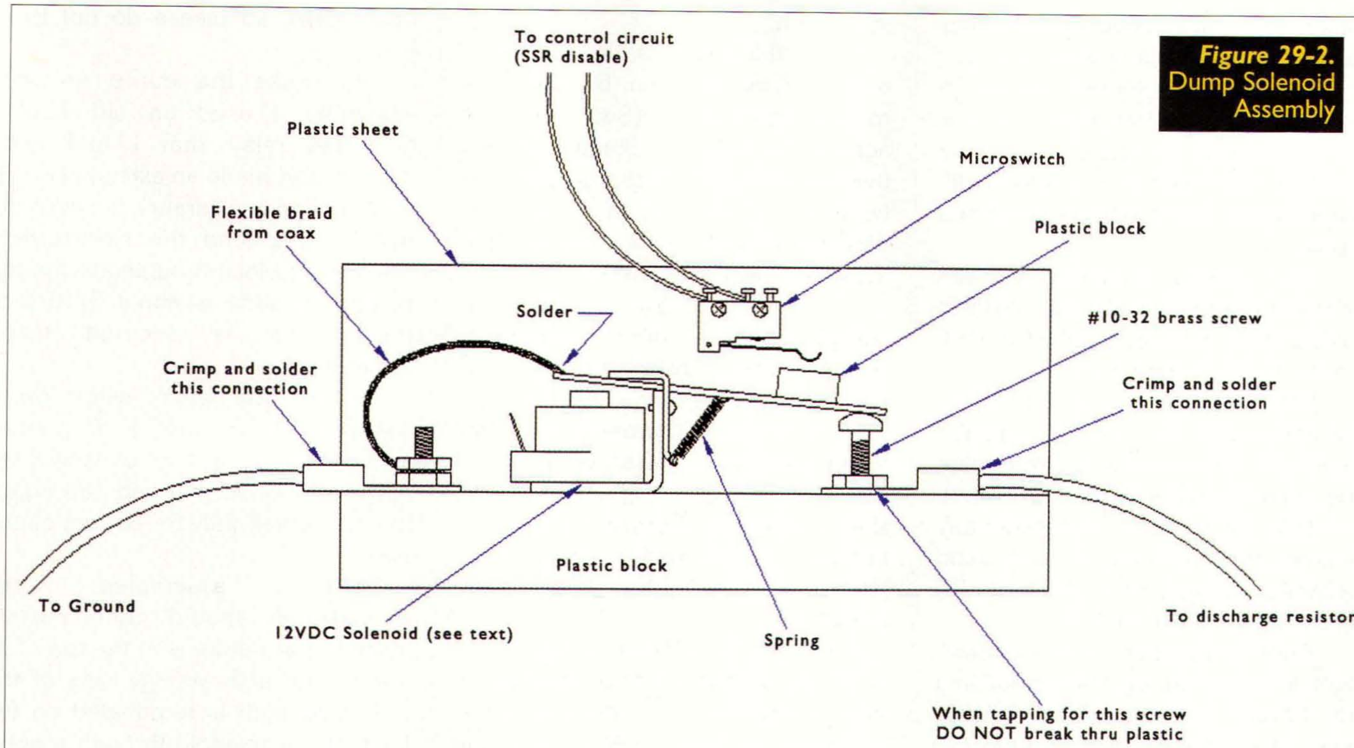


Figure 29-2. Dump Solenoid Assembly

HV chassis. The high voltage will be limited to about 2,000 volts under normal operating conditions, but there may be a situation that causes an over-voltage condition to exist, and allowances must be made for this.

Make the base about 3/4 inch to one inch thick and you should be okay. Try to leave about 1/4 inch of plastic beneath the screw.

The ground side of the solenoid is not as critical in depth, and may be drilled through. Connect the armature of the solenoid to the ground screw using a piece of braid from a short length of coax cable. The braid should be flattened and soldered to the armature, and long enough and flexible enough to allow free movement of the armature. The spring ensures a positive return to the safe position when power is removed, and minimizes any contact bounce.

Finally, the ground wire should be taken to chassis ground and circuit common. Again, take care with the construction of this sub-assembly — your life just might depend on it!!

Theory of operation

Looking a bit further at the schematic diagram in Figure 29-1, you'll see several component blocks that come together to make this control board work. The raw 24VDC from the power distribution chassis is reduced to 15V and stabilized by the regulator U1 (LM7815). Supply smoothing is done by C1. D1 provides indication that the low voltage power is on, and may be left on the board or brought out to the front panel, as you wish. D2 is a 10V zener diode that provides the reference voltage for the charging circuit. U2 is a voltage comparator that takes a sample of the high voltage and compares it to the reference voltage on the wiper of VR1, which is used to set the PFN (pulse forming network) voltage.

Initially, the wiper of VR1 (TP1) is set to, let's say five volts, and the charge button is pressed. U3a and U3b (CD4001) form a latch that initializes with pin 3 low. Pressing the CHARGE button triggers a change of state in the latch forcing Q1 to turn on.

At the same time, U5 is triggered, operating the dump solenoid, and opening the microswitch across R19. This turns on the solid-state relay and allows the main capacitor bank to charge up.

As the bank charges, the potential at TP2 begins to rise. When the voltage differential between the two inputs of the comparator is reduced to zero, then the output pin of U2a drops to ground taking down pin 4 on U2b. Pin 5 of U2b is held at a fixed level and the change on pin 4 causes the U2b (pin 2) output to rise sharply, resetting the latch and shutting off Q1.

This action turns off the solid-state relay, halts the charge on the main capacitor, and sets the stage for the fire sequence.

During the charge period, U7a turns on D8 — a red LED — indicating that the capacitor is being charged. When the charge voltage is reached D8 extinguishes and D9 — a green LED — illuminates indicating that the system is ready to fire. When D9 illuminates, the input to the inverter U6c is held low, forcing its output high and turning on Q3, which arms the FIRE stage.

Note that until this sequence of events is played out, the FIRE button will be inoperative, and so the lamp cannot be fired while still in the charging mode. If the lamp were allowed to fire during the charge period, it may try to run in a CW mode, which would result in a steady high current through the lamp, causing a rapid and enormous heat build-up, destroying the lamp and very likely melting the laser head block.

A visual indication of the state of charge on the main capacitor bank is given by the front panel meter M1. This meter is basically a 1 mA meter made into a fixed-range voltmeter, calibrated by adjusting VR3, and is set to continuously read the PFN voltage. The charge voltage level at TP2 is buffered by U4b to prevent erroneous readings.

U4a is the over-voltage monitor. In the unlikely event that the solid-state relay does not shut down, and the charge on the main bank continues to rise, there has to be a way of preventing a dangerous situation from developing.

U4a is an LM324 op-amp connected as a comparator, and monitors the potential on TP2. This comparator will allow the dump solenoid to close and discharge the main capacitor in the event that the voltage across the main bank goes higher than the level set by VR1. K2 will energize if U4a pin 3 rises above the level on pin 2, and will cause the contacts in series with the dump solenoid to open.

The second set of contacts will latch this relay, preventing any further operation until the system is shut down and re-started.

Thus, it will be impossible for the laser to run in an over-voltage condition. D5, the red LED, will illuminate under this condition and should be brought out to the front panel to indicate the fault. This fault will not shut down the entire system — only the high-voltage and firing sections. However, a system shut-down is required to reset relay K2, and allow investigation of the condition.

Initial testing and calibration

The control board should be tested before hooking it up to the rest of the circuit. We must make sure this is working properly before we even think about applying the HV. This can be done quite easily on the bench, using a separate DC source. Feed the circuit from a 24VDC source and follow the sequence outlined below.

1. Check for 15VDC at the out-

PARTS LIST

Resistors	
R1, R7, R8, R11	1.2K
R2-R4, R15, R16,	1K
R18, R19, R23, R33,	1K
R36, R37	1K
R5, R20, R22, R24,	10K
R25, R35, R38	10K
R6	22K
R9	3.9K
R10, R12	12K
R13	620K
R14	56K
R17	1M (see text)
R21	5.1K
R26, R28, R29	6.8K
R27	180K
R30	220K
R31	3.6M
R32, R34	33K
Capacitors	
C1	1000µF
C2	220µF
C3, C4, C6, C10	0.1µF
C5	0.33µF
C7	4.7µF
C8, C9	0.01µF
C11	100µF
C12	1.0µF
Transistor	
Q1, Q2, Q3	2N3904 NPN
Diodes	
D1	Yellow LED
D5, D8	Red LED
D9	Green LED
D2	10V 1/4W Zener diode
D3	12V 1/4W Zener diode
D6, D7	1N4001 or 1N4002
D10, D11	1N914 or 1N4148
Integrated Circuits	
U1	LM7815 Voltage regulator
U2	LM2901 Quad comparator
U3	CD 4001 Quad NOR gate
U4	LM324 Quad op-amp
U5	LM555 Timer
U6	CD4049 Hex inverter
U7	CD4011 Quad NAND gate
Miscellaneous	
Sw1	Pushbutton NO mom.
Sw2	Microswitch (see text)
Sw3	Pushbutton NC mom.
Sw4	Pushbutton NO mom.
K1	Dump solenoid (see text)
K2	DPDT 12VDC coil
VR1	10K 10 turn
VR2	10K trimpot
VR3	10K trimpot
M1	0-1 mA FSD
TP1, TP2, TP3	Wire loops or solder pins

All capacitors 35V except where noted
All resistors 1/4W unless otherwise noted.

put of the regulator U1.

2. Connect a voltmeter to TP1 and see that the voltage changes from zero to about 10V as the SET VOLTS control (VR1) is rotated. CW rotation should increase the voltage.

3. Adjust VR2 so that maximum resistance is seen between TP2 and ground.

4. Monitor the voltage at TP3. Turn the power supply off and on a few times to see if TP3 changes state during the power transition. If no changes are seen, then leave the power on, otherwise you should troubleshoot your wiring. TP3 should always power-up LOW.

5. If everything is okay up to this point, continue checking by pressing the CHARGE BUTTON (Sw1), and observe several more things:

- Relay K1 should immediately energize.
- TP3 should go from LOW output to HIGH.
- Sw2 contacts should open.
- U5 (LM555) should begin its timing cycle.
- D8 should illuminate.

Continue to watch the timing of U5, and see that it reverts back to its initial state after about 30-45 seconds, depending on the value of R31. This resistor may be changed to give you more or less time, as you prefer, but try to keep it to this sort of a time period. Don't go too long. When it does, then K1 should de-energize, Sw2 contacts should close, and D8 should extinguish.

Press the CHARGE BUTTON again, but this time press the DUMP button Sw3 before U5 can time out. The dump solenoid K1 should immediately drop out. The timing cycle of U5 should not be interrupted. D8 should extinguish.

For the next test, you'll need a 9V battery, a 100µF 25V capacitor, and a 100K resistor. Solder one end of the resistor to the positive side of the cap, and connect the negative side of the battery to the negative side of the capacitor. Use clip leads to connect the negative side of the capacitor to the circuit common, and connect the positive side of the cap to TP2. Monitor the voltage at TP2 using a DVM or an oscilloscope, if you have one. Leave the positive side of the battery disconnected at this time.

This circuit has about a 10 second CR period, so you may need to repeat this test a few times.

Turn everything on, and set the slider of VR1 to about five volts, press the CHARGE BUTTON, connect the positive side of the battery to the open end of the resistor, and observe a few more things:

1. The voltage at TP2 will start to rise as the capacitor charges. The needle of the analog voltmeter will begin to move, indicating the charge status.

2. As the voltage rises on the capacitor, pay attention to the sequence of events as it approaches five volts. When five volts is reached, a few things should happen:

- TP3 will transition from a HIGH state to LOW.
- D8 will extinguish, and D9 will illuminate.
- The voltmeter should read approximately mid-range — use VR3 to calibrate this meter.
- When D9 illuminates, the emitter of Q3 should go to approximately 12 volts.

• When the transitions above take place, disconnect the battery immediately.

3. Repeat the above test and let the capacitor continue to charge above five volts, and check for a few other transitions:

• As the capacitor approaches five volts, monitor the voltage at U4a pin 1. This will normally be low, and toggle high when the voltage at pin 3 rises above the voltage at pin 2.

• When the voltage changes on pin 1, see that relay K2 pulls in. This will open the contacts that hold K1 in, and cause the dump solenoid to de-energize.

• The over-voltage LED D5 will illuminate, showing the system has gone over the set voltage, indicating a problem.

• When K2 pulls in, it latches itself using its own contacts, and so cannot de-energize without turning off the power. The dump solenoid drops out, and regardless of the conditions of the rest of the circuit, the contacts across the solid-state relay will prevent this device from turning on, stopping any further operation of the system until it is reset by powering down.

Repeat these tests until you get a firm grasp on how the circuit functions, and how the various stages interact.

As I said, the circuit is not complex and it can be built and tested in stages, and should not give you any problems.

If all these tests perform correctly, then you did a good job with the wiring, and can relax until the next issue.

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. **NV**

The Business of Electronics Through Practical Design and Lessons Learned

In The Trenches

Giving Effective Presentations

Often engineers are required to present ideas or products. This can be difficult because this is not usually a task engineers have been trained for. However, by understanding what is expected and what to expect, this activity does not need to be feared.

Marketing Versus Engineering

A presentation is usually associated with marketing. Whether it's a new idea presented to upper management for development, or a new product presented at a trade show. The idea of a presentation is to sell something and to get immediate feedback about that thing. This is called marketing. Moreover, it's something many engineers dread.

This is because the marketing department always seems to be in conflict with engineering, mostly because of differing mind-sets. Marketing tends to overlook problems with a product; where engineering spends much time identifying and eliminating these problems. Marketing sometimes commits engineering to "impossible" tasks. They may define time restraints, specifications, or development costs that are not reasonable. Marketing isn't always logical.

I won't go into more detail about the marketing/engineering feud this time. I'll save it for another whole column in the future. Nevertheless, it's important to realize that marketing's point of view is just as valid as engineering's. Each department has its own goals and procedures. Each department is important to the company. So, it's not unreasonable for an engineer to have reservations about working for "the other side."

While a presentation may be associated with marketing, it's your job as an engineer to represent engineering. You can be sure that your presence is critical to the success of the presentation. So, whether or not your company has an engineering/marketing feud, your skills in presenting an idea or product are important.

Size of Audience

Probably the most important emotional aspect of any presentation is the size of the audience. Engineers are generally quiet, introverted types (of course, there are exceptions). Moreover, the idea of getting up in front of hundreds of people can be intimidating.

On the other hand, engineers must be good communicators. Think of all the documentation and interactions needed to produce a product. Problem solving requires engineers to talk with each other and exchange ideas that are both subtle and complex. Therefore, every engineer has the potential to be a good presenter, if emotions are controlled.

As with any skill, practice makes perfect. What's more, the stress of presenting is reduced if you have already done it. Ideally, you should have a practice audience similar to your real audience. But this may not be practical. However, you should have a technical or non-technical friend who is willing to listen to you. Hopefully, this person will be honest with you and you will be able to accept any criticism without getting upset. (Otherwise, this exercise loses a lot of its usefulness.)

Most engineers are comfortable talking to a small group of engineers. So, when faced with a large group, single out one audience member (or perhaps several) and speak directly to that person(s). Try to forget about the others. Just explain to your selected person about your product or idea. This will make you feel more comfortable and confident, and the audience will notice this. A comfortable and confident presenter is usually a good presenter.

If you are presenting to a small group or an individual, a demonstration should always be considered. A demonstration greatly enhances any presentation. There are a number of reasons for this. The first is that it generates more interest. People can see, touch and examine a piece of hardware. This is different from most plain presentations, so people remember it better. A demonstration can illustrate principles that are difficult to explain. A simple demonstration of the action/reaction physics principle, for example, is something that transcends numbers and diagrams. What's more, a good demonstration often cuts across technical boundaries. You don't need a physics degree to see that every action has an equal and opposite reaction.

Here is a classic example. During the government inquiry of the space shuttle Challenger's explosion on liftoff, when Dr. Richard Feynman made a simple demonstration. He had a small piece of O-ring material on a small clamp inside a glass of ice water. The ice in the water chilled the O-ring material to 32°, approximating the temperature at the time of the accident.

When the clamp was released, the O-ring material didn't return to its original shape immediately. This clear and simple demonstration showed exactly how the O-rings failed. Everyone understood this. Nearly everyone who saw this remembers it. Few remember the hours of verbal and technical explanations. A good demonstration can be extremely powerful and persuasive.

Type of Audience

The most important technical consideration is the type of audience. If they are all engineers, you will probably have little problem in communicating your ideas. But, engineers can have difficulties when talking to non-technical people about technical topics.

When this problem occurs, it is usually one of two situations. The first is when the engineer ignores the idea of the non-technical audience. The result is that the presentation fails because the engineer uses jargon and undefined technical concepts. The result is that the audience cannot follow the presentation. The engineer is speaking a different language.

The second problem is the opposite. The presenter treats the audience as intellectually challenged and "speaks down" to them. In this case, the engineer has failed to understand the significant difference between stupidity and ignorance. The result is that the audience thinks that the presenter is arrogant and contemptuous of them. The truth is that these non-technical audiences are generally composed of bright people. Why else would they be there? Stupid people usually don't come to technical presentations.

The proper approach, when presenting to a non-technical audience, is to refrain from using too much technical jargon and to clearly explain needed technical concepts in plain language. For example, suppose you need to discuss how your new product deals with aliasing. Don't get into the details about sampled systems, heterodyning, low-pass filters, and the Nyquist limit. Just say something like, "Aliasing is a significant problem that can occur whenever a signal is measured with a digital system. We have used a special filter that reduces this problem to levels well below our competitors' products."

Presenting a Product

Most product presentations are straightforward. You are there to explain how the product works, what it does, and the things that make it special. Usually, the product is available for examination or testing. Encourage the audience to handle it. Remember these people are potential customers. If you are worried about them damaging the product, then you have serious product problems.

Never, repeat *never*, get in the way of someone who wants to touch the product. This is an interested person. Therefore, this is a potential buyer. (If they are not interested, they will not buy your product.) Stand back and let that person examine your product on his own. Do not offer advice. Do not point out features. Do not say anything unless asked, or unless the person is clearly having difficulty with the product. After all, don't you hate when a salesperson keeps interrupting your train of thought when you are looking at new software or a new signal generator?

Be patient and let the person satisfy himself about what he wants to look at. Only after he has finished, should you mention features he may have overlooked, or points you want to add.

Give the product an opportunity to speak for itself. It may be very eloquent.

Presenting an Idea

Presenting an idea is different from presenting a product. A product is a real thing that can be seen and touched. It's usually available to the audience. Most product presentations discuss the features, cost, and other characteristics of the item. A demonstration of the product is normally a simple task. Such demonstrations are just a confirmation of what the presenter says.

An idea is different. Nothing can be touched or examined. Because of this, it is easy for the audience to dismiss the idea. This makes credibility the most important aspect for a presentation of an idea. This credibility comes in two forms. The first is the credibility of the presenter. The second is the credibility of the idea. If either fails, the presentation fails.

The credibility of the presenter holds the audience's attention. If a 10-year-old child was to present a new idea about a video encoding and data reduction principle, you probably wouldn't listen too closely. However, if that same child was talking about a new game or toy, you would be all ears. Your credibility as a presenter is based on what you've done and how you appear. Since you can't change the past, you're stuck with what you've done. Hopefully, your professional experience matches what you're presenting. If not, you must work harder to achieve credibility.

You can enhance your credibility with attention to your appearance and your presentation skills. You must always look believable. Dress appropriately and appear as your audience expects. If you don't know what your audience expects, you have a problem. In this case, talk to other people for advice.

A person who simply reads prepared text to a group will have difficulties. First, the presentation is boring and people will not remember what you said. Second, reading something makes it appear that you don't know the topic. This reduces your credibility. Finally, this presentation lacks confidence. If you don't have confidence in your idea or yourself, why should your audience be different?

You certainly can have notes and refer to them *occasionally*. However, a confident presenter talks to the audience. He clearly knows his subject and convinces the listeners of that. Therefore, your credibility as a presenter depends mostly on how well you present.

The credibility of the idea depends entirely upon how you present it. A great idea can die from poor presentation. Conversely, a poor idea may succeed if presented well to the proper audience. (An example of a "successful" poor idea is Coca Cola, when it changed its formula.) You must target your presentation to your audience and be able to explain your idea so that they can clearly understand it. You only get one chance, so make it your best.

A demonstration of an idea is very useful. As noted above, demonstrations can be extremely powerful. Even if your idea cannot be realized in hardware, it may be possible to demonstrate the principles. If the underlying principles are understood, and the demonstration is clear, the credibility of the idea is increased.

For example, a long time ago, I had to present an idea for a solid-state laser aircraft/runway positioning system. There was no hardware. The existing solid-state lasers were the old, pulsed, infrared type. So for my demonstration, I used a visible HeNe (Helium/Neon) laser and simple glass rods as lenses to generate visible laser "curtains" (two-dimensional sheets). Then the audience could understand how an approaching aircraft's position could be precisely measured as it flew through laser "curtains," set in particular locations with particular angles.

Questions and Feedback

It is very unusual if there are no questions or comments. How you respond is extremely important. If it is a large group, you may want to answer questions when you finish. If so, let the audience know this at the beginning. If you forget, and someone has a question, answer that person and then ask everyone to hold their questions until the end. Never put off a question. If you do, it will annoy people and create a bad impression.

You should always have a command of your subject and should be able to anticipate most questions. Be honest. Never make up an answer or try to bluff someone. You may fool one person, but you won't fool the audience. They always seem to know a phony. If you don't know an answer, say, "I don't know, but I'll get back to you." Then be sure to do exactly that. If you must, ask for the person's name and contact information. Or else, ask him to talk to you after the presentation.

Any feedback or comments are

important. It doesn't matter if they are good or bad. In truth, the bad comments are probably more helpful. They show weaknesses in your product or idea. Write all comments down. You will need to decide if you want to do this during the presentation or afterwards. It's important to show that you take the comments seriously, but you don't want to interrupt the flow of the presentation. Use your best judgment.

Feedback can be used in two ways. The first is to improve your product or idea. You can often treat presentations as being similar to a market survey. If you have good information about what potential buyers want, you can tailor your work to those wants. This makes the product or idea more attractive and easier to sell.

There is no reason why you can't ask the audience questions. Unless this is a very formal presentation in front of a large group, this is often useful. It provides you with information and involves the audience with the presentation. This involvement increases interest and will generally make the audience more receptive. However, there are considerations.

Some audiences, such as upper management, may feel uncomfortable with this. They may not expect to be questioned. Moreover, some higher-level managers feel that questions are not appropriate.

Make any questions you ask simple and general (unless you are responding to a question from the audience). For example, you might ask if the audience is familiar with your product, if they would like a particular feature added, or if they understand certain technical explanations. Don't ask for a "show of hands." This is not grammar school. You will know from the reaction if the answer is yes or no.

What should you do if you realize you've said something wrong? If you've been too offhanded and make an improper or offensive remark, apologize immediately and move on. If you don't know until later it was improper, obliquely refer to it, apologize, and move on. For example, "I now realize that I said something improper earlier today. I apologize for being inconsiderate and insensitive. It won't happen again."

If you realize that you have said something factually wrong, stop immediately and correct the error. Be sure everyone knows the error and what the correction was. If someone catches you in an error, acknowledge it. There is nothing worse than an arrogant presenter who doesn't know the error of his or her ways.

Presenting Data or Research Results

This is somewhat different from presenting an idea or a product. Here, you are presenting information. Unfortunately, this can be a most difficult thing to do in an interesting manner. Data is often boring. Research is often summarized with graphs and numbers. This is hard to present without getting sleepy.

Here are a few tricks to fight the snoozers. Be sure that there is a lot of cold water, free coffee, and caffeinated soft drinks available. Never make a presentation right after lunch. Digestion makes people sleepy. (Not to mention the beers or martinis some people may have had.) Keep the lights bright and the seats uncomfortable. Make the presentation short, if possible. If not, have frequent breaks.

You can also help by being enthusiastic about your work. (If you aren't, why should anyone else be?) Keep moving around if you are presenting in front of the audience. If you are sitting around a table, pass out materials as you need them, rather than at the beginning. Speak loud and clear (but don't shout). Make eye contact with each person on a regular basis. Don't read from a prepared script.

Try to make the information interesting. For example, explain how a particular table shows how to lower costs. If you have any hardware, bring it out. Even if it has little to do with the research, passing the hardware around will keep the audience interested and involved in what you have to say. Sometimes you can add humor. For example, customer satisfaction could be measured in happy faces instead of a plain bar graph. But, be careful here. Humor can make your work seem less serious.

Saying Thank You

Unless you are presenting at a trade show or other paid venue, it is often useful to send a thank-you note afterwards. There are a couple of reasons for this. First, it allows you to remain in contact with the potential buyers of your product or idea. It also allows you to point out features or considerations that were not in the presentation. Second, it can serve as a reminder of your presentation. It's also polite, professional, and somewhat unexpected. This makes them feel good.

The thank-you note can be sent by Email or regular mail. If you presented to a small group of close co-workers, a verbal "Thank You" is appropriate — a written note would be too formal. The thank-you should be sent to each participant. If you don't know every one, then send it to the organizer. It should be short, direct, and polite. Always include your contact information and indicate that you welcome comments *and* criticisms.

Presenting a product or an idea is an opportunity for you to do something different. It gives you a chance to be noticed. It's also useful for building your confidence. It may seem a little scary, but it doesn't have to be debilitating. **NV**

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

Stamp Applications

This is Your Brain on Stamps!

Dual Role I/O Pin Techniques, Scrolling Menus, and Some Blinkenlights!

Since you read this magazine, and you're reading my column, you're probably a lot like me — smart, good-looking, a blast to hang out with ... okay, okay, I was kidding — except for the smart part. The fact that you read *Nuts & Volts* makes you very smart. What I should have said is that, like me, you're probably a gadget freak. Am I right?

The scariest element of this single-guy's home is not the rabid dust-bunnies living under my bed, but rather the growing collection of "Wow, that looks neat ..." gadgets that are now occupying that space. I guess if I just went to sleep at a decent hour and stopped watching late-night infomercials, I'd have a smaller collection of junk. Oh well ...

While cruising the web a couple weeks ago, I came across an ad for something I'd seen before and considered buying — a brain-wave synchronizer. This is, essentially, a set of goggles that holds lights (LEDs) that can be flashed at controlled rates and patterns. My first acting coach taught me relaxation and self-hypnosis techniques, and I thought it would be fun to add a little electronic assistance. But after thinking about it for a few minutes, I concluded that I could build my own with a BASIC Stamp. And that's what I did.

Now, even if you're not interested in brain-wave synchronizing, this project may still interest you in that it's a pretty good example of a simple menu system. And, as long-time readers know, one of my favorite topics with Stamps is lighting controllers. This project is, in effect, a mini light show for the eyes and brain. I could just as easily hook it up to a set of opto-relays and control holiday lights. Okay, let's jump into this dude.

Menus Made Small

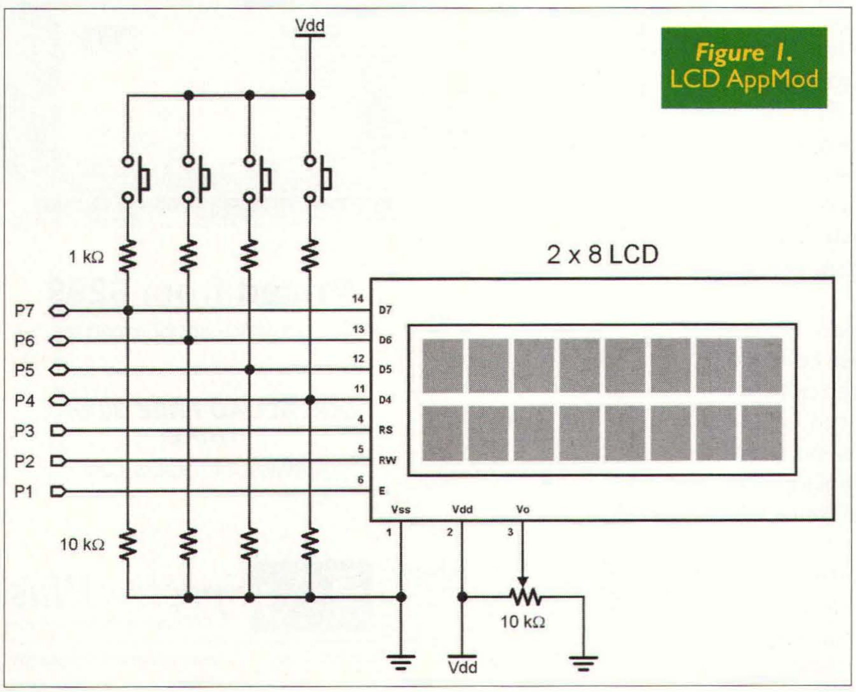


Figure 1. LCD AppMod

Since I wanted to test my project for a month or so before committing to a permanent enclosure, I built it on a Parallax Board of Education (BOE) — actually, there is nothing connected to the BOE breadboard. What I did use is the new LCD AppMod from Parallax. It plugs into the BOE AppMod connector and gives me a nice little two-line by eight-character display and four button inputs. Now, the LCD AppMod is very straightforward (see Figure 1) and you can certainly assemble your own with a standard LCD, a few resistors, and some normally-open push-buttons.

The clever design of this LCD/button circuit was done by our old pal (and very smart guy) Scott Edwards. What's great about it is that a button press will not interfere with data being sent to the LCD. With a button open, the signal from the Stamp to LCD will be felt across the 10K resistor on that line. So, what happens when a button is pressed? Well, if the signal from the Stamp is high (five volts), there is no conflict, since both the Stamp and the push-button are sourcing 5V to the bus line. When the output from the Stamp pin is low and a button is pressed, there will be a small amount of current (about 5 mA) through the 1K resistor, but the LCD will still see a low since it's connected directly to the Stamp.

When do we use the bus pins as inputs to read the switches? With the button open, the 10K resistor pulls the pin to Vss (ground), so we get a low (0). When the button is pressed, the 1K and 10K form a voltage divider and the Stamp will see about 4.5 volts on the input — this is well above the high threshold for a Stamp pin.

A Program For All Seasons

Not long after the security gate controller project, I got a nice Email from a reader who was having problems with the code running on a BS2sx (my code was tested on a BS2) because the BS2sx is faster than the BS2. Then, there was the issue with the BS2p family since they have built-in LCD commands.

While writing the LCD AppMod documentation, I decided to take full advantage of the conditional compilation feature of the new PBASIC compiler. I've covered it a bit before, but not as extensively as I will here. By using this technique, we can be sure that the program will work for anyone — no matter what their favorite flavor of BASIC Stamp may be.

Since we're using the LCD AppMod for my project, I'm able to take advantage of that code, and add a few tweaks to give it a bit more flexibility.

Let's start from the top. While most programs set pins to be inputs or outputs, this one requires the LCD bus and button input pins to change on-the-fly, so we're going to create a set of definitions that make the program easy to read and maintain.

```
E           PIN    1
RW          PIN    2
RS          PIN    3
BusDirs     VAR    DIRB
BusOuts     VAR    OUTB
BusIns      VAR    INB
LEDs        VAR    OUTH
```

The first three definitions are LCD control pins, and as you can see, we've used the PIN type definition where we used to use CON. Remember that PIN helps us when we have I/O pins that can be inputs or outputs, depending on what's happening with the program. Using PIN prevents duplicate definitions for the input and output register bits.

But PIN only works on single pins, not on groups. So, to keep things as clean as possible, we've aligned the LCD bus with one of the Stamp's standard I/O groups (P4-P7). By using aliasing, we're able to rename the various elements of I/O group B for use in the program. Finally, we do the same with the OUTH group (P8-P15) for the LEDs. Figure 2 shows our LED circuit mounted inside the goggles, and Figure 3 shows how the LEDs are physically positioned.

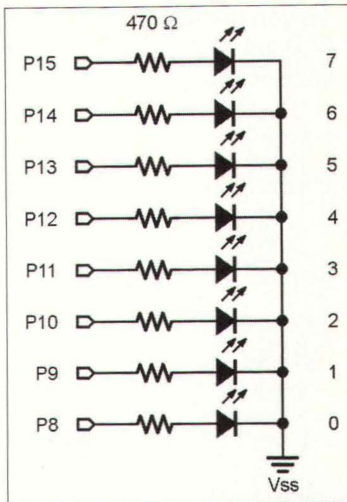


Figure 2. Stimulus LEDs

Please allow me to stress that taking the time to do this kind of programming will save you from a lot of trouble later. Give your pins and pin groups names that are meaningful — not just for you, but for others who may come in contact with your program. I promise that this will save you more time than you might think you're wasting by being "fancy." Trust me, I know from experience.

Conditional Love

As I've told you before, the newest PBASIC compiler can — if we direct it — conditionally compile portions of code to be downloaded to our Stamp. The trigger for the conditional compilation can be automated or manual — it just depends on what we're trying to accomplish. For this program, we'd like the compiler to make things work no matter what BASIC Stamp we have plugged in. Let's see how.

In the Constants section, we have this line:

```
#DEFINE _LcdReady = ($STAMP = BS2P) OR ($STAMP = BS2PE)
```

By using #DEFINE, we've created a compiler symbol. Compiler symbols are generally defined as True or False. If a symbol is not defined, but appears in program code, the compiler will assume it's False. In our case, _LcdReady will be True if we're using a BS2p or BS2pe, otherwise it will be False. Keep in mind that the compiler actually *polls* the connected Stamp for its type before compiling and downloading the program. This keeps us from having a problem if our $STAMP definition is not matched to what we're actually connected to. The compiler will alert us and fix the $STAMP definition.

As a matter of style, I like to preface compiler symbols with an underscore character so that I know it's a compiler symbol and not a program constant. This keeps me from attempting to use them in normal program logic where an error would be generated. Where we can use them is in conditional compilation structures: #IF-#THEN and #SELECT-#CASE.

Okay, let's put the symbol to use. In the Initialization section of the program, we go through the steps to get the LCD up and running with a four-bit bus and using two lines of characters. Here's the code:

```
LCD_Init:
  PAUSE 500
  #IF (_LcdReady) #THEN
    LCDCMD E, %00110000 : PAUSE 5
    LCDCMD E, %00110000 : PAUSE 0
    LCDCMD E, %00110000 : PAUSE 0
    LCDCMD E, %00100000 : PAUSE 0
    LCDCMD E, %00101000 : PAUSE 0
    LCDCMD E, %00001100 : PAUSE 0
    LCDCMD E, %00000110
  #ELSE
    BusOuts = %0011
    PULSOUT E, 3 : PAUSE 5
    PULSOUT E, 3 : PAUSE 0
    PULSOUT E, 3 : PAUSE 0
    BusOuts = %0010
    PULSOUT E, 3
    char = %00101000
    GOSUB LCD_Command
    char = %00001100
    GOSUB LCD_Command
    char = %00000110
    GOSUB LCD_Command
  #ENDIF
```

What's important to understand here is that only a portion of this code will be compiled and downloaded to the Stamp — what portion depends on the installed Stamp. If we're using a BS2p or BS2pe, the first section (#THEN) will be compiled and downloaded, allowing us to take advantage of the built-in LCD commands. If we're using any other BASIC Stamp, then the #ELSE section will be compiled and downloaded.

You can see this in action by using the Memory Map feature of the compiler and comparing the EEPROM use with one Stamp model versus another. Not surprisingly, the manual LCD code required by the BS2, BS2e, and BS2sx requires a bit more space than the built-in commands used by the BS2p and BS2pe.

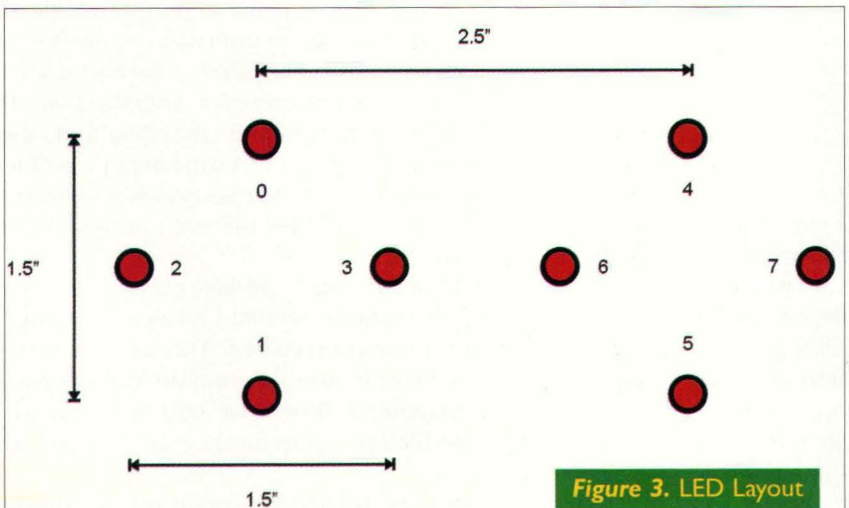


Figure 3. LED Layout

There are two additional sections of code that use conditional compilation:

```
LCD_Command:
  #IF (_LcdReady) #THEN
    LCDCMD E, char
    RETURN
  #ELSE
    LOW RS
    GOTO LCD_Write_Char
  #ENDIF
```

This first subroutine sends a command to the LCD. We use this to do things like clearing the LCD, moving the cursor, etc. Notice that there is a RETURN when we're using a BS2p or BS2pe, but when using other Stamps, we set the RS line low then jump to the LCD_Write_Char subroutine. The reason is that the mechanics of transferring a byte to the LCD are the same. The byte gets interpreted as a command or character based on the condition of the RS line. When using a BS2, for example, the RETURN from this subroutine call will actually be at the end of LCD_Write_Char. This is why we use GOTO in LCD_Command instead of another GOSUB — it keeps the RETURN stack cleaner, and the program will actually run a bit more efficiently.

```
LCD_Write_Char:
  #IF (_LcdReady) #THEN
    LCDOUT E, 0, [char]
  #ELSE
    BusOuts = char.HIGHNIB
    PULSOUT E, 3
    BusOuts= char.LOWNIB
    PULSOUT E, 3
    HIGH RS
  #ENDIF
  RETURN
```

As you can see, LCD_Write_Char really does all the work. To keep things simple, we use a zero in the command field of the BS2p/BS2pe command. This means we won't do anything except write the character, which is what we do in the BS2/BS2e/BS2sx code.

Also note that we set the RS line high when leaving the routine. This will cause the next call to this routine to default to character mode. The only time the RS line is taken low is when we pass through the LCD_Command subroutine.

Hypno-Goggles

Now that we can write to an LCD with any BASIC Stamp, let's get to the heart of our program and how we can use very small LCDs to create an effective UI for our blinking LED goggles. Since the LCD is so narrow, one of the routines we'll find handy is a means of scrolling a long string through the window.

Let's take a look:

```
LCD_Scroll_String:
  DO
    char = crsrPos
    GOSUB LCD_Command
    FOR idx2 = 0 TO (scrWidth - 1)
      READ (eeAddr + idx2), char
      IF (char = CR) THEN EXIT
      GOSUB LCD_Write_Char
    NEXT
    IF (char = CR) THEN EXIT
    eeAddr = eeAddr + 1
    PAUSE LcdScrollTm
  LOOP
  RETURN
```

This routine requires three variables to be set up before calling: crsrPos points to the first (left-most) position of our scrolling window; scrWidth is the width of the scrolling window; and eeAddr points to the (CR-terminated) string we'll print. This string is stored in a DATA statement.

This code will run in a continuous loop until it hits the end of the string. The first step is to position the LCD cursor at the left-most window position. Next, the code will loop through the number of characters to print, pulling a character from the EEPROM, and putting it in the LCD. This works because the LCD initialization causes the cursor to advance to the right after each character print.

After printing the string segment, the eeAddr pointer is incremented and a short delay is inserted so that we can actually read the characters. When we increment the eeAddr pointer, what we're actually doing is sliding the [virtual] display window over the string. The process continues until a CR is encountered. This will cause the FOR-NEXT print loop to exit, then immediately break out of the outer DO-LOOP.

This routine is used to print a program name banner at the beginning. Once that's done, we go right into the heart of the program. The main section is a bit long, but we'll break it up into small chunks so it shouldn't be too tough to follow:

```
Main:
  char = LcdHome
  GOSUB LCD_Command
  char = LcdLine2
  GOSUB LCD_Command
  eeAddr = Controls
  GOSUB LCD_Put_String
```

We start at the top of the main program loop by making sure the LCD display is aligned by using the Home command. Then we'll move to the second line and print a controls string for the input buttons. When you download the main listing, you'll see that I've created a couple custom characters for use in the LCD. The character codes for the custom characters are embedded in the Controls string.

```
Check_Level:
  IF (mnuLevel = 0) THEN
    GOSUB Show_Pgm
  ELSE
    GOSUB Show_Freq
  ENDIF
```

Moving on, we'll check the current menu level (0 for selecting program pattern, 1 for setting frequency) and update the first line of the display accordingly.

```
Show_Pgm:
  char = LcdHome
  GOSUB LCD_Command
  LOOKUP pgm, [Pgm1, Pgm2, Pgm3, Pgm4], eeAddr
  GOSUB LCD_Put_String
  RETURN
```

The Show_Pgm subroutine uses a LOOKUP table to convert the program value (0 to n) into an EEPROM pointer address. This address is passed to LCD_Put_String and the CR-terminated string is printed on the LCD at the current character position.

```
Show_Freq:
  char = LcdHome
  GOSUB LCD_Command
  eeAddr = FrMsg
  GOSUB LCD_Put_String
  char = LcdLine1 + 4
  GOSUB LCD_Command

Write_Freq_Value:
  IF (freq < 10) THEN
    char = " "
  ELSE
    char = (freq DIG 1) + "0"
  ENDIF
  GOSUB Lcd_Write_Char
  char = (freq DIG 1) + "0"
  GOSUB Lcd_Write_Char
  RETURN
```

The Show_Freq subroutine is similar, but has a bit more work to do so we've split it into two sections (entry points). The first section moves the cursor to the start of Line 1 and prints the string from EEPROM. The cursor repositioned to the place where the frequency value is printed and the second section of code handles that. For neatness, we're going the extra mile of space-padding single-digit values. It just makes the display look more professional.

Software Debounce

When the display is updated, the final step is to wait for a button press and process the input.

```
DO
  GOSUB LCD_Get_Buttons
LOOP UNTIL (buttons > %0000)
```

This code is as simple as it looks — it scans the buttons and stays in this loop until one is pressed. Let's look at the button scan routine.

```
LCD_Get_Buttons:
  BusDirs = %0000
  buttons = %1111
  FOR idx2 = 1 TO 10
    buttons = buttons & BusIns
    PAUSE 5
  NEXT
  BusDirs = %1111
  RETURN
```

This code probably looks familiar to some of you, as we have used it in the past to debounce multiple input pins. The key here is that we have to make the bus pins inputs on entry to this routine, then reset them to outputs before we leave. The reason for this is that the program will spend more time writing to the LCD than reading the buttons, so it's best to take care of the bus set-up here than burden all of the LCD code with it.

For those who haven't seen this in the past, it's very easy. The routine assumes the buttons are pressed. It reads them and ANDs the current inputs with the buttons value. If a button isn't pressed (at all or due to "bounce"), then the input will be zero and that ANDed with the button's value will clear the input for this routine. What this means, then, is that a button must be pressed on entry to this routine and for the duration of it, to register as a valid button press.

Before writing the program, I decided that only one button at a time would be looked at and in a specific order. If a button was pressed, it would be processed and the rest ignored on this particular scan. The first thing that is checked is the "Run" button. If pressed, it will launch the LEDs using the current program selection and flash frequency.

```
IF (btnD = Pressed) THEN Run_Program
```

Nothing tricky here — just reiterates how cleanly variable aliases and program constants can make our code.

Hypno-Patterns

As it turns out, there are two types of programs: flashers and sequencers. Flashers basically have two states, while sequencers have three or more patterns that will run in sequence on the LEDs. Example code is available on the *Nuts & Volts* website (**www.nutsvolts.com**) to complete your "hypno-project."

Funny how a seemingly "simple" application on the outside can be moderately complex on the inside. Keep this in mind when you're planning future projects. You know the old saying, "It's harder than it looks."

Oh, the little girl in Photo 1 is my wildly cute niece, Marissa, testing the hypno-goggles created by her favorite "Uncle Jonny." The effect? Lots of giggles, but no out-of-body or other parapsychological experiences.

A Reminder

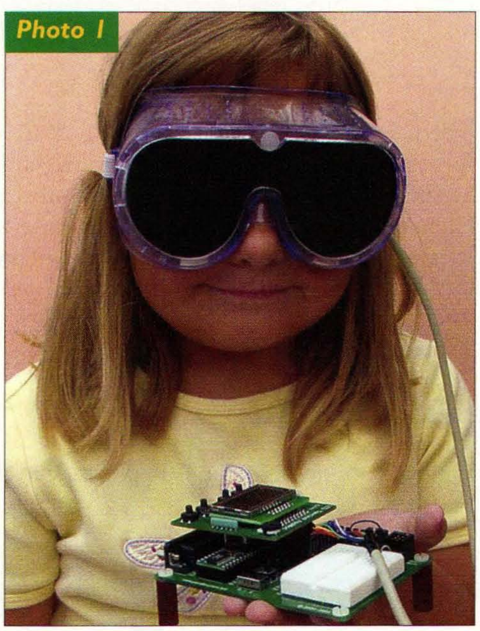
For those of you who may be new to *Nuts & Volts* or just recently discovered "Stamp Applications," you may be wondering why I seemingly skipped over a lot of details regarding the LCD. The reason is that between Scott Edwards and me, we've covered a lot of LCD ground in this column. "But I didn't know about *Nuts & Volts* back then ... ," you protest. No problem. You can read all the previous issues of this column from the comfort of your own PC. *Nuts & Volts* has very generously allowed Parallax to republish back-issues as PDF files, and if you want them for your desk, you can get them in printed volumes, as well. You can find the back issues on the Parallax web site under Downloads \ Nuts & Volts Columns.

What's Next?

I did this project because I'd been asked to do a menu-based LCD project — the hypno-goggles element just fit into a current personal interest. I have also been getting a lot of requests for more GPS-related material. That's what we'll do next month. We'll look at a GPS-based digital dashboard that I actually "test drove" on my vacation drive from Dallas to Columbus, OH. With directions from the Internet and the mileage readout from my project, I was able to drive from my home to my brother's without any hiccups. I'll show you how next time.

Until then, Happy Stamping! **NV**

Photo 1



Resources

Jon Williams
jwilliams@parallax.com
Parallax, Inc.
www.parallax.com

Ed Note: Any "hypnotic" effect generated by the LEDs in this project is purely coincidental as all scientific brainwave synchronizers employ complex feedback sensors. But have fun just the same!

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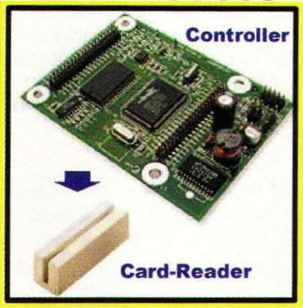

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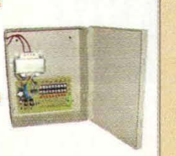

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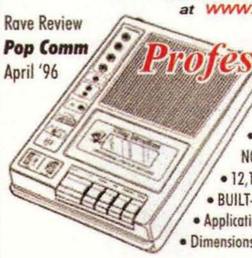

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Tech Forum

QUESTIONS

After the big blackout, my Panasonic VCR, model PV-8662, no longer works at all. Panasonic does not provide any support other than telling me to take it in to a service center for more than I paid for it. Sam's has no Photofact listed for this unit.

I know that the internal fuse blew and one power supply transistor as well. However, I don't have the know how to go much further without a schematic. Any suggestions?

#10031 **Anonymous via Internet**

I need to read the serial data stream from a Sony Walkman player. I have a vision impaired friend who needs to see the Track No. information. This (and much more) is available through the Headphone Interface and USB port.

I can read the information at the Headphone Interface on two older models, but not the newer units.

I have at my disposal a DSO to analyze the data. I used a controller to generate a sync pulse, but still can't find the data of interest.

#10032 **Jon van Gelder Calimesa, CA**

I am 13,000 feet from the phone company office and am told that I can only get 768K download and 128K upload on the Internet. Yet if I was 11,000 feet away, I could get 1500K download and 256K upload speeds.

It seems to me that all I would need is a bi-directional amplifier that covers the DSL bandwidth with low noise to increase my speeds. Is this true and can you refer me to a source where I can buy or build one?

#10033 **Howard Epstein Atkinson, NH**

I am looking for a speed sensor that would work well with a microcontroller such as the Motorola 68HC11. I also need an ultrasonic distance sensor that can be reliable up to 60 feet. They have to be cost effective, light, durable, and usable in an outdoor enviroment.

#10034 **Matt Vieweger via Internet**

Can anyone tell me where to find a simple frequency allocation chart for terrestrial American digital radio (DAB-T) and television (DVB-T)?

#10035 **Reijo Siivonen Finland**

I am looking for a circuit that is a laser light activated switch. It should be activated by a standard red laser pointer and also be immune to ambient light (from incandescent, flourescent, and other similar light sources). The output from the switch would give a pulse to activate a timer (i.e., a 555 timer IC or similar device).

#10036 **Ian R. Adlon via Internet**

I am trying to build a down counter using the ICM7216 four-digit up/down counter (the modulo 60 version) and cascade them to create an eight digit counter. Unfortunately, the only way I've found to load the counters with numbers is using expensive BCD switches. I need a way to use a keypad instead, possibly using the 74C922. If this is possible, how do I do it since the 7216 strobes each of the BCD switches to get its input?

#10037 **Ian Adlon via Internet**

I have taken the output from my PC sound card and run it into the phono input on the back of my stereo. I have this loud hum coming from my speakers along with the

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2) Electronic Theory
3) Problem Solving
4) Other Similar Topics

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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.

audio from my PC. I remember back in the early 60's, someone designed an impedance matching amplifier that would eliminate the hum from any input source. Does anyone have a design for such a device?

#10038 **Ronald Ledford via Internet**

My Kenwood TS440S is beginning to present symptoms (frequency drift and intermittent dots in the display) of PLL unlock. Service bulletins at **Kenwood.net** suggest that replacing a fist full of diodes with new diodes of any of these types — 1S2588,1SS91S, and BA282 — will cure the problem.

Additionally, I have heard that 1S1587 diodes can be used. However, I have been unable to find a source for these parts that will send or sell me just a few. I haven't tracked down the manufacturers of all the parts. However, the BA282 seem to be made by Vishay.

Can anyone recommend a supplier for any of these parts?

#10039 **Anonymous via Internet**

I have a JVC handy-cam (Mini-DV Model DVL 505). It has a small battery that does not last long. I am a professional cameraman and I use 12 volt gel cells of various sizes all the time. The JVC AC power supply (Model AAV-40) for that camera has an extension cable that will supply DC voltage instead of the battery, if desired. The book says that the battery is 7.2 volts and that the AC power supply puts out 6.3 volts. Can I power this camera with a 12 volt gelcell that actually delivers 12-14 volts depending on charge? Will the camera accept the higher voltage with out damage? I suspect it will because devices like this can use a automobile cigar lighter adapter that sells for about $15.00 to $20.00 so I doubt there is any magic voltage regulation or adjusting circuits in them. I would like to have a knowledgeable opinion before I just plug my 12 volt battery in and watch my camera go up in smoke!

#100310 **Robert D. Gardner**

ANSWERS

[6031 - JUNE 2003]

I installed a car tachometer in my boat and it reads 2,000 RPM higher than required — no useful reading at the top end. Is there a circuit to correct this?

#1 If your tach reads 2,000 RPM when the engine is not turning, it must be defective and should be replaced. If you have installed an electronic tach designed for a four-cylinder engine and are using it on a six cylinder, it will read 50% high. Similarly, if the four-cylinder tach is used on an eight-cylinder engine, it will read 100% high (double). If the output is a digital display, I doubt there is an easy fix, but if the output is an analog meter, you could use a resistive voltage divider to reduce the reading.

#2 Try a tachometer from a motorcycle. I know that using a car tach on a motorcycle, say a Harley Davidson, can cause this type of issue. Try taking an old tach from a Harley and see what you get.

I had to create a divider using a microcontroller once. It was used for a speedometer, but it may work for what you need.

Dan Miller
via Internet

[6039 - JUNE 2003]

Does anyone know of a circuit diagram to connect an IDE HD/CD to a parallel printer port?

I am using a parallel port CD-ROM drive on an older spare laptop, since the original CD-ROM died and a replacement was extremely expensive. It works, but it is slow. I would recommend you go with at least a USB 1.0 connection. Better would be a Firewire, USB 2.0 or PCMCIA connection. All of them are commercially available and this magazine or the Internet are valuable sources of information. HSC advertises in *Nuts & Volts* and they have a PCMCIA to IDE interface for about $30.00. They have also a PCMCIA reader for $25.00. This is hard to beat and you can get PCMCIA on a desktop. It took me six hours to format a 100GB external hard disk through USB 2.0, which is one of the fastest connections around.

Walter Heissenberger
Hancock, NH

[7036 - JULY 2003]

I need an economical way to measure the fuel consumption in my 1981 DeLorean. It has a Bosch CIS, mechanical fuel injection system and the fuel flows to the fuel distributor and back to the fuel tank.

One possibility is using two fuel flow sensors. One in the feed and one in the return and then subtracting the two numbers. I believe I can approximate the fuel flow by measuring the position of the "air metering plate." Since the air/fuel mixture is held pretty constant, the position of this plate might give valuable info.

How can I measure the relative position of this plate or fuel or air flow?

#1 There are a variety of systems available for auto and marine applications. It appears that they all use the same sensor and it is the main cost of the system. A complete dual sensor (supply and return) system generally sells for under $500.00 — not unreasonable when each sensor sells for approximately $200.00. See **www.blackwatchmarine.com/catalogs/fuel/catalog_fuel.asp** for example. If a broad approximation is acceptable, dropping the one (return) sensor will cut the cost about in half.

Instead of trying to measure the plate position (e.g., with a modified throttle position sensor) and guessing its flow characteristics, I would suggest approximating fuel consumption by using engine vacuum (a MAP — manifold absolute pressure — sensor). A well-tuned, gasoline engine is remarkably consistent in its brake specific fuel consumption: 042 (small, optimized engine) to 0.50 (near race engine) gallons/HP-hr; a good starting estimate is 0.45. The horsepower produced by an engine is proportional to the pressure (vacuum) in the intake manifold. {Some older vehicles used this principle with vacuum sensing switches to turn on "economy" indicators.) The equation that could be implemented in a small microcontroller is: fuel consumption rate = 0.45 gal/HP-hr * HPmax * MAP / barometric-pressure. The barometric pressure is simply the MAP reading before the engine starts. See **www.diy-efi.org/efi332/** for an example of implementing this principle. Performing a data integration would yield the total fuel consumed (approximately). And, subtracting this value from the fuel tank capacity would yield the amount of fuel left. If the micro has sufficient program memory, an average fuel consumption could be calculated and the time until the tank was empty at the current rate of consumption.

Walter Nagel
Grantville, PA

#2 You might be able to measure the "air metering plate" position (also known as the throttle) with a potentiometer or the digital replacement which has a series of wipers that make contact with a series of conductive strips of different lengths. As the shaft turns, the various wipers make and break contact with the strips providing digital bits on a series of pins associated with the wipers. The automotive industry calls the potentiometers and the digital replacements Throttle Position Sensors, or TPS.

Air flow can be measured with a "Hot Wire Anemometer." A wire is heated to a particular temperature (measured by wire resistance) and placed in the air stream. The amount of power required to maintain the wire at temperature is measured. The more air flow, the more power required. The temperature and pressure of the in flowing air are also measured and factored in).

Another way to measure air flow is called positive displacement. For example, a set of fan blades is placed in the air stream and the speed at which the blades spin is measured (usually by placing magnets on the fan and a Hall Effect sensor nearby) which sense magnetic field pulses as the magnets pass by. The differential pressure drop across on orifice plate can also be used to calculate air flow. The automotive industry calls all of these devices "Air Flow Sensors." Fuel flow can be measured in a similar manner. This page **http://users.argonet.co.uk/ifel/flow/flow1.html** provides a lot of information about automotive flow measurement.

I would guess that your DeLorean has at least one of each of these sensors. You might be able to tap into their outputs. Alternatively, you might look into the details of the electronic ignition module. It might have an unused output that indicates fuel flow.

If not, there might be an after-market ignition module available that claims to improve performance and might provide the fuel consumption information for you.

Tom Tillander
Bay Village, OH

[7037 - JULY 2003]

I'm building a handheld detector to receive low-pulse energy waves from spurious non-modulated RF transmission sources. The detector only needs to be a deflection meter, etc. How or where do I obtain such a device?

A handheld meter to measure what you want is available from Alpha Lab. The device is called TriField Meter. It measures AC magnetic, electric, and radio/microwave fields.

Their address is: AlphaLab Inc., 1280 S. 300 W., Salt Lake City, UT 84101.

Telephone them toll free at 1-800-769-3754, and their website at **www.trifield.com** lists the meter and its specifications.

Ned Stevens
Grantsville, UT

[7038 - JULY 2003]

I have been trying to design an electronic circuit to work in the gigahertz frequency range, but cannot find information on what electronic components I could use or where to find such information.

Radio amateurs have been working with gigahertz frequencies for some time, with the result that a large amount of information is available. For starters, look for the *UHF/Microwave Projects* manuals, published by the ARRL and the *International Microwave Handbook* published by the Radio Society of Great Britain with ARRL. Both are available from: **www.arrl.org/catalog/** For parts and project kits, look to RF Parts Company **www.rfparts.com/** or Down East Microwave, **www.downeastmicrowave.com/** For antenna information, go to the WIGHZ microwave antenna book online, **www.qsl.net/n1bwt/contents.htm** Also, microwave articles are frequently published in *QEX Magazine*, and the "Above and Beyond" column by C.L. Houghton, published in *73 Magazine* for many years is a valuable resource.

A google search for "amateur microwave" can bring much more.

Chuck McGregor
via Internet

[7039 - JULY 2003]

How do cable companies get the different stations and numbers correct that are assigned to the correct channels?

Cable companies are able to put any program on any channel they wish. All signals that come in, whether off the air from a local broadcaster, or via satellite, are demodulated into audio and video signals, much like the "audio out/video out" signals available through the jacks on the rear of your VCR. These signals are then modulated onto a carrier of whatever channel the cable company wishes. The head end of the cable system has a modulator for every channel.

Local broadcast channels with strong signals will be assigned to a different channel number than their broadcast number. The reason for this is some of the local broadcast signal will "leak" into the TV through its plastic case. Even though what gets in is weak, it is out of phase with the signal coming through the cable. If both signals were on the same channel, you would see a "ghost" image, much like we used to see when we needed to turn our set top antenna. Out of town non-satellite broadcasters, whose signals are picked up by a high mounted, high gain antenna at the cable head end, could be on the same channel number as their broadcast channel number, as there wouldn't be enough of the broadcast signal reaching a TV directly to cause such interference.

Most cable companies also use an "offset carrier" system, where the frequency band making up each channel is slightly different from that of broadcast. This also helps reduce carrier interference from broadcast signals, as the cable ready TV isn't tuned to quite the same channel as broadcast. That is why the setup menu of TVs ask if you want to set up for "cable" or "broadcast."

Phil Shewmaker
via Internet

[70311 - JULY 2003]

Does anyone have a conversion utility or program that can convert the FCC's CDBS database to the old flat format FCC databases?

I did not find a utility to do exactly what you want, but, KC8LSY offers many utilities for the manipulation of that data on his website: **http://home.earthlink.net/˜nsadams/** or he can be reached via postal mail at: Neil S. Adams, 3381 Vandemark Rd., Litchfield, OH 44253-9520.

If he has not already written something to do this, chances are he can whip it up for you in no time.

John M. Hoyt / W5UGD
Easley, SC

[08032 - August 2003]

I have two transceivers that use an op-amp for switching between the RX and the TX control lines. The Windows programs I want to use (Hyperterminal and Procomm) do not allow or have controls for CTS or RTS which is used in RS232-type communications.

Is there a circuit that would act as a buffer and timer for the CTS and RTS lines to control the transceivers that I am using?

#1 Rather than circuitry, consider writing your own terminal software, which isn't too hard. But first, try Kermit, which is a very versatile communications program that supports RTS-CTS handshaking among many other options.

You can download a free trial version from **www.columbia.edu/kermit/k95demo.html**

Michael Covington
Athens, GA

#2 To change the port settings for a modem connection using Hyperterminal:

- On the File menu, click Open
- Right-click the connection you want to change, and then click Properties
- Click the Connect To tab, and then click Configure
- Click the Connection tab
- Click Port Settings, and then make the changes
- Click Advanced to change settings such as flow control and error correction

Here you will find a Use Flow Control check box. If you check it, you will be given the option of selecting Hardware (RTS/CTS) or Software Flow Control (XON/XOFF). Checking the hardware box should solve your problem.

Note that the changes that you make to the port settings affect only this connection.

Tom Tillander
Bay Village, OH

[08031 - August 2003]

I'm studying for my Technician class license and am learning CW for the purpose of emergency operating. Does anyone know of plans for a CW transmitter?

#1 A good start for easy-to-build CW transceivers would be Dave Benson's Rock Mite, and the little more advanced DSW-II. See: **www.smallwonderlabs.com/**

The Rock Mite is a 0.5 watt output transceiver that can be ordered for either of two QRP operating frequencies: 7040 kHz or 14060 kHz, at $27.00.

The DSW-II is a tunable transceiver for the 14.000 to 14.100 MHz range, at 4 watts output, for $150.00. Sophisticated equipment is NOT needed in setting up Dave's clever designs. See also the NJ-QRP club for other interesting QRP projects and many links to other vendors' offerings: **www.njqrp.org/**

Ed, K2MGM
via Internet

#2 It is very rewarding to see the interest that CW stills generates in the digital era. But as we all have seen, when things get ugly, high tech equipment has very strong limitations and then it is the time to revert to the classical communication modes such as CW.

I would suggest that you join ARRL and read their journal, *QST*. Alternatively, you might want to look in your local library as most of them have this journal in their collections. There you will be able to find several CW transmitters, receivers, and transceivers, each one for a different frequency band and with different requirements that can match your interest and expertise.

ARRL information can be found at **www.arrl.org**

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