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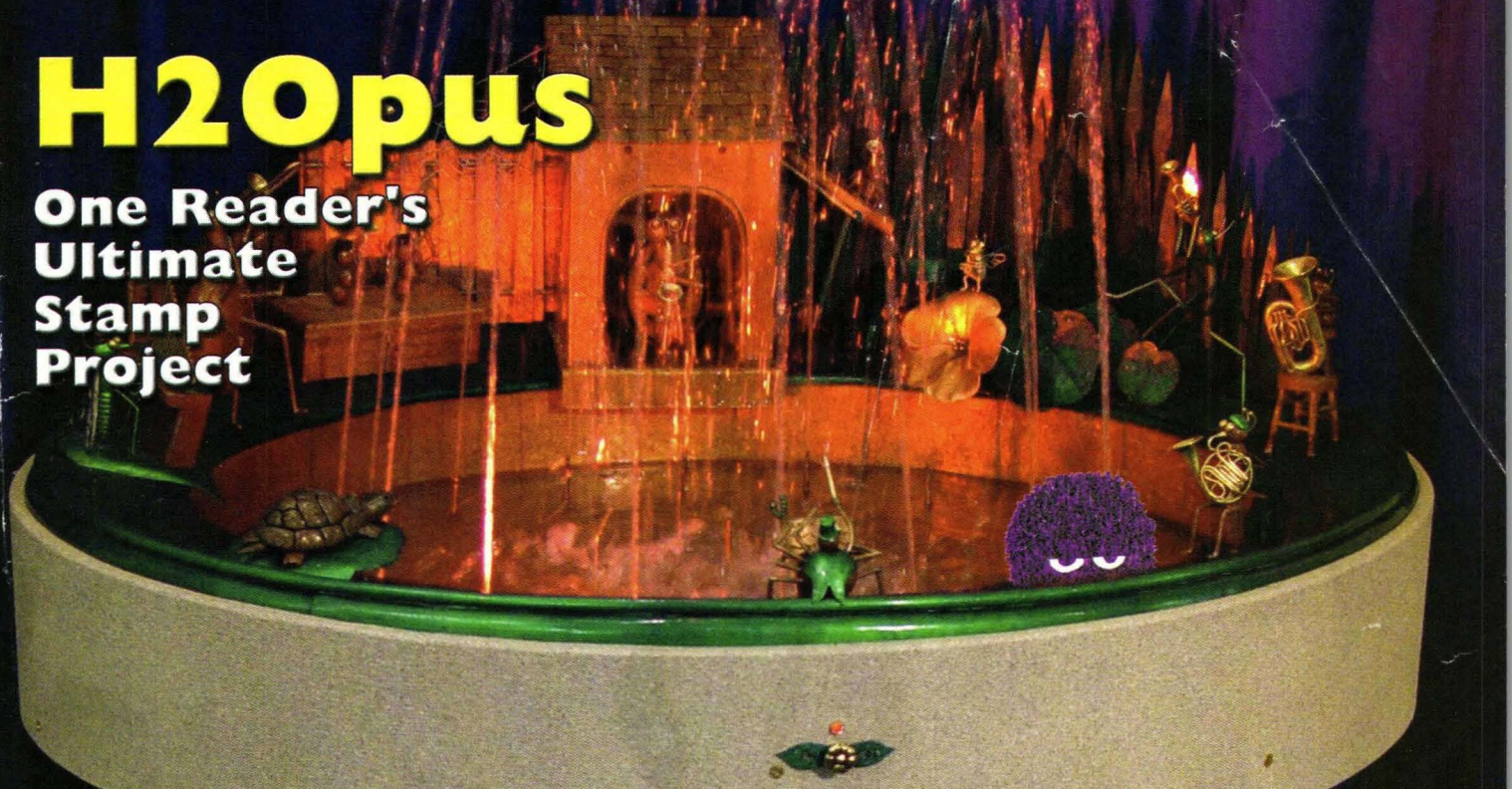

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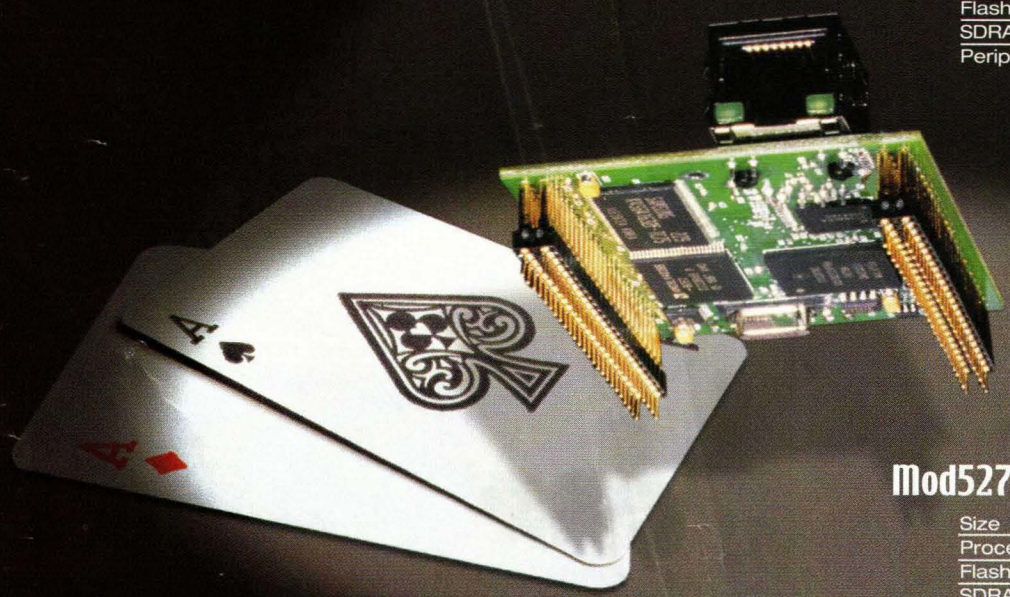

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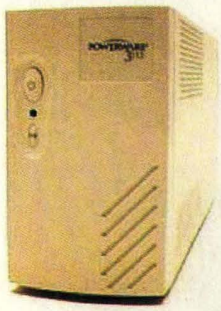

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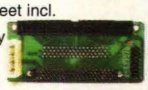

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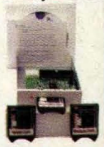

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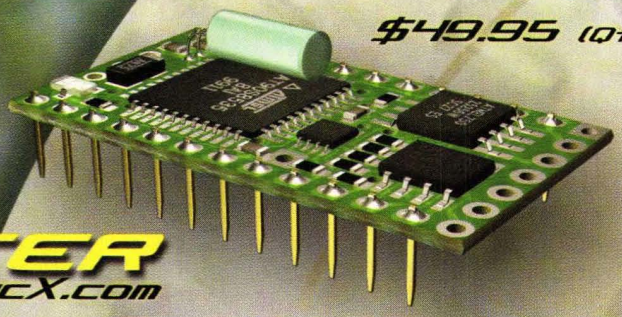

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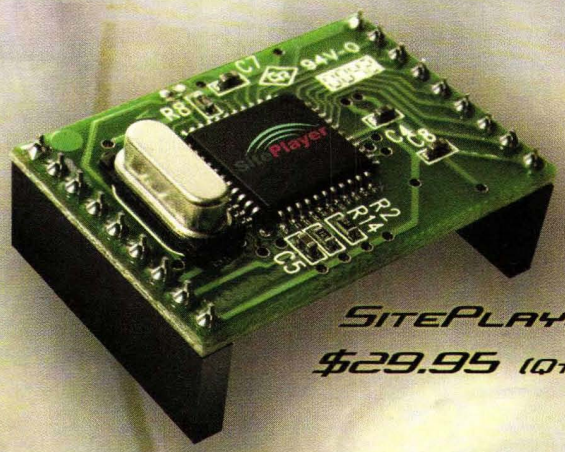

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Reader Feedback

Dear Nuts & Volts:

In the April '03 issue, George Whitaker wrote an article in the "Just For Starters" column about diode theory. He is teaching CCF (Conventional Current Flow), which is outdated material as seen in your published article on page 40 of your July 2002 issue by Louis Frenzel.

If I were a beginner and knew from my science class that electrons are the current carriers in wires, this article would be negating all I had learned. I thought someone ought to mention it, since the author failed to do so.

By the way, anyone who still thinks that current travels from positive to negative is now challenged to defend their faith and explain how any common heated cathode vacuum tube works. It seems to me that electrons are the pieces of matter that move from the negative cathode to the positive plate through a vacuum. I wish Louis had used vacuum tube theory to support electron flow, as this hammers the nails in the CCF coffin as far as I'm concerned. Gee, I wonder why they are called "electron" tubes?

Kevin Kaas
via Internet

Response:

I concede that in the theoretical sense, you are right. My approach, both in my books and in my own thinking, is to take a practical approach. In my book, I tell the student that I don't expect them to design a diode or integrated circuit; I just want them to be able to visualize what is going to happen and what to do if it doesn't. My approach is purely practical.

In fact, in my books I admit to the reader that I have sometimes compromised theory in order to simplify the result. I want them to understand the result without having to deal with what happens on a molecular level. An auto mechanic can be extremely good at repairing engines without having the theory necessary to design one.

I agree, however, that we should run your letter and my explanation. The readers can make up their own minds as to which approach they wish to take.

George Whitaker

Dear Nuts & Volts:

I teach a Tech Prep Electronics class and find there are students who love to experiment, your publication is a great source for locating materials and unusual electronic devices.

Peter Mayeux
via Internet

Dear Nuts & Volts:

Great magazine! Seeing the PIC stuff is getting me back into electronics.

William Clugston
via Internet

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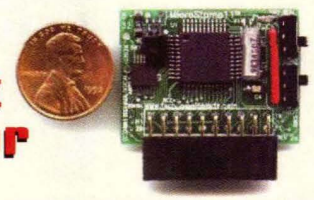

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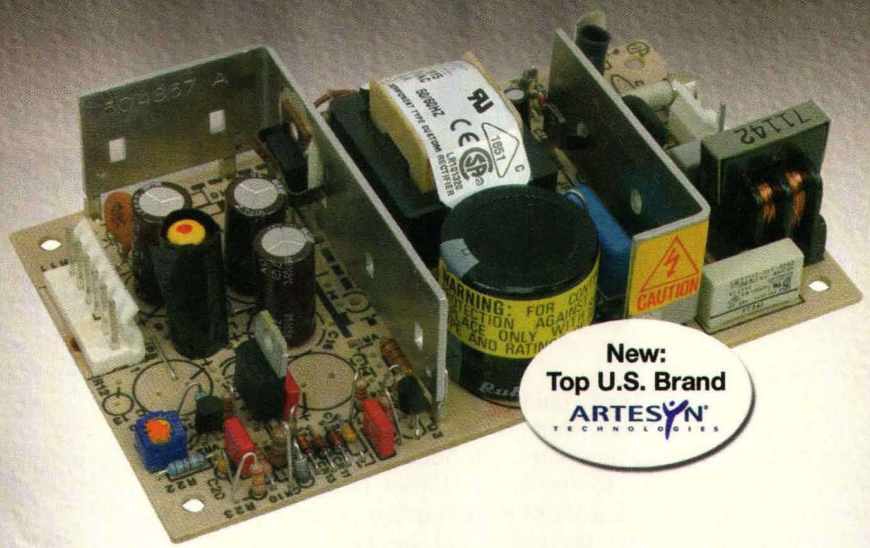

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Sport Description

No doubt most of you have watched at least a couple episodes of BattleBots or Robot Wars — robots fighting on TV. It's even more likely that you've read articles in this magazine detailing some of the coolest bots in the game. I believe this is the first series written showing what it takes to get started in this new techno-sport.

There is one thing you should understand when getting into this. It is not all about destruction. In fact, it's mostly about learning. Builders spend months researching, designing, building, and testing their creations — only to spend a few minutes in the arena against their opponents.

When the match is over, both teams rush back to the pits to figure out the best way to get their machines back in working order for the next bout. One of the greatest things about all this is that teams typically help each other get ready, even if they caused all the damage. There is a tremendous sense of community between builders.

Costs — The first question almost everyone asks about a fighting bot is "How much did it cost?" There are those that put tens of thousands of dollars into their bots. You don't have to do that to get started. In fact, there are a lot of people getting started for less than $100.00 by building one pound bots. I'm going to concentrate on a 12-pound bot that can be built for around $600.00 — less if you shop around.

Getting you to build the same thing I do is not my goal. You should choose your own design and try to build it from parts you have readily available and attempt to get started as cheaply as possible. You might even save a little more cash if there is a competition within driving distance.

Rules — To get started building for a local competition, you will need to know the rules of the game. Thanks to a new organization called the Robot Fighting League (**www.botleague.com**), many local events are using very similar rule sets. The RFL was started for this and a couple other purposes. Now, everyone should be able to build and compete in several different competitions with little or no modifications to their bots. Complete rule sets for all the RFL member organizations are available on the RFL web site.

The major rules theme in all but a few organized competitions is that only kinetic energy weapons are allowed. That means hammers, spinners, and lifters. That also means you can't strap a shotgun or plasma cutter to your bot. Flames are allowed in some competitions but most leave them out because it is too difficult to get the fire marshal to approve them for use in the venue. The other major theme in the rules is the weight class. There are about nine different weight classes that you can build in starting at one pound and going all the way up to 390 pounds. Very few competitions allow all weight classes.

Figure 1. Compound & Flat Wedge Designs. Top of photo shows the compound wedge design I used on a 220-pound bot called MiniRip. It is made of steel and is stationary. Bottom of photo shows the flat wedge design I used on a 30-pound bot called Dagoth. It is made of polycarbonate and is hinged so that it can be effective if the bot is flipped upside down.

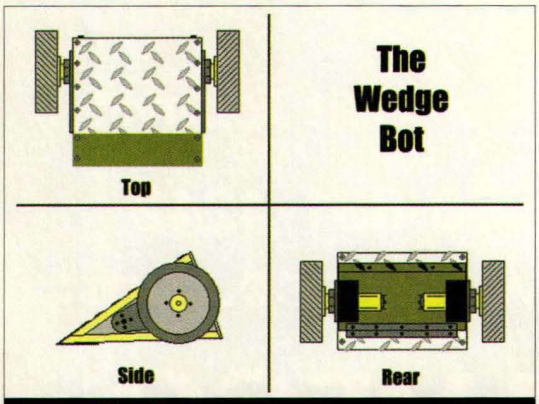

Figure 2. Article Wedge Design. This is a concept drawing of the wedge I want to build in the article. The wheels extend beyond any surface so that the bot cannot be pinned. You may want to leave the axle long on the wheel side so that they protrude a few inches past the wheel. This will insure that the bot cannot be pinned by laying it over on its side.

Safety — Safety is the most important thing to keep in mind when building or competing. Personal safety while building and testing the bot is your responsibility. Don't use a torch if you don't know how. Get some help. Don't stand too close when driving. Event safety is a shared responsibility between you and the event organizer. The organizer will provide a safe venue for you to play, but you must recognize proper behavior in this setting. Among other things, don't grind or weld in the pit area and never turn on your bot without a frequency clip.

Getting Started

There are several questions you

have to ask yourself when getting started. You have to know the rules. You have to figure out what materials to use. You must come up with a strategy. There are a couple more we'll cover later. Since you've checked out the RFL web site, you already know the rules and which materials are not allowed.

Different types of bots require or inspire different strategies. I've chosen the wedge bot for this article. The wedge bot can fair well against spinner bots. When it comes to bot weapons, there is always a rock-paper-scissors relationship. No single design is the killer app. The wedge is one of the simplest designs to build. The compound wedge has a rounded profile and slopes upwards sharply — much like a bulldozer blade. The flat wedge is just that — flat. For simplicity's sake, we will incorporate the flat wedge into our design, although I like the compound wedge better.

So, my strategy is to get under my opponent and push them around the arena, slamming them into the walls and/or using arena hazards as my offensive weapons. I also want the bot to be effective if it gets flipped over. To do this, I'll shape the main body like a piece of cheese and have the drive wheels extend above and below it. The wheels will also extend past the back end of the wedge, making it impossible for any opponent to get us off our wheels and stick us there. Now that the strategy is set and a basic design is derived from what we want to accomplish, we can get down to the "nuts and volts" of the bot itself.

Figure 3. Airtronics Pistol Grip Remote. A very simple, two-channel 75MHz radio for use on land and water vehicles only. Customarily, the wheel is used to steer and the trigger is used as a throttle. A model airplane elevon mixer is required to accomplish this task in a tank drive system. Purchased at **www.towerhobbies.com**.

Remote Controls

You have to have a way to control the little beast. My preference is to slap a PIC controller in there and let it run by itself, but since the game is for remote-controlled bots, we'll have to choose a remote control unit.

The standard ground frequency in the US is 75MHz — and that is exactly what the rules call for. The rules also specify FM instead of AM. However, I've got a couple Airtronics, 75MHz, AM radios lying around, so I'm going to use one instead of buying a new controller. After all, I don't plan to compete this bot except in the driveway.

If that is your plan as well, you can pick one up at **TowerHobbies.com** for about $50.00. This is a two-channel radio. The drive mechanism requires both channels to operate. If you plan to build a bot with an active weapon, you should start out with a radio that has at least three channels.

Tank Steering

Most of you know what tank-style steering is, so I won't go into great detail. Basically, it is accomplished by turning on one side of the bot or the other or both to get it to go in the direc-

Figure 4. Ohmark brand elevon mixer. This mixer has two inputs and two outputs. It plugs in directly between the receiver and the speed controllers and mixes the signals to achieve a smooth tank drive system with a pistol grip radio. More expensive computerized radios will have this function built in. Purchased at www.planes-wings-things.com. Part# MK1.0. (Planes, Wings & Things is going out of business. You can get mixers at **www.robotlogic.com**.)

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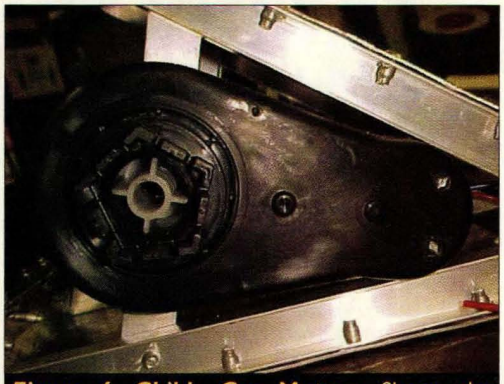

Figure 6. Childs Car Motors. Shows the pentagon-shaped fitting of the motor housing. This shape is what turns when electricity is supplied to the motor. The white, nylon part is stationary at all times. A special hub and axle assembly is required to mount the wheels. Purchased at **www.allelectronics.com,** CAT# DCM-192. (All Electronics is currently out of stock, but these motors can be found in surplus warehouses and yard sales.)

tion you want. Tank steering is most easily accomplished with a joystick-style radio since you can control each side of the bot separately.

When using a pistol grip radio like mine, ordinarily the trigger controls the throttle and the wheel controls the steering. This means I have to use a device to combine the control channels so that they work with the tank steering design. This specific device is called an elevon mixer, and is generally used in model airplanes.

You can pick one up on the Internet at several places for between $16.00 and $40.00. I'm using one from my parts box that came from www.planes-wings-things.com (going out of business, you can get mixers at **www.robotlogic.com**) called the MK1.0. The high-end mixer can be found at **TeamDelta.com** and has a feature that you might like to use on your bot. It will invert the control channels if the bot gets flipped upside down. If you don't have the invert feature, forward becomes reverse, left becomes right, and so on while driving. It's something I'm used to already, but wouldn't advise.

RC Problems

Every so often you will run into problems with your radio control system. There are three things that you can pay attention to in order to minimize the gremlins. The first is the radio power supply. Keep the transmitter and receiver batteries charged. If just one of these batteries drains, your bot won't do a thing. You can replace the receiver battery with a Battery Eliminator Circuit (BEC). The BEC converts the main drive battery voltage down to five volts to run the receiver. You can do the same with a 7805 voltage regulator, but you won't get the true ground isolation offered by a BEC. That ground isolation will help battle another problem that creeps up on your radio. **TeamDelta.com** also has BECs for sale.

Power wire noise and RFI created by the sparking of a motor's brushes can cause loss of radio signal. The BEC can help with the power wire noise. Capacitors will help with RFI. Some builders install a single capacitor across the brushes of each motor in the bot. Other builders install two more caps — one from each brush to the motor housing. Start with caps between 0.1uF and 0.01uF. Be sure to get caps rated for three times the operating voltage since high-voltage spikes can be generated.

The third common problem with your radio will be antenna placement. Do not seal your receiver antenna inside a metal box, like the body of your bot. My bot here will have a polycarbonate rear end so the signals will be able to get in. If your bot is completely made of metal, you will need to mount your antenna on the outside.

Motors, Wheels, and Speed Controllers

The radio system has been figured out. Next up, we have the motors and electronic speed controllers (ESCs). There are so many ESCs available for combat robot use that you can pick your motors and then choose the controller that will handle the voltage and amperage requirements. Since this is a small, light bot, I decided to use a six-volt motor and gearbox from a child's power car. You can pick these up for $6.50 each at **AllElectronics.com**. The downside is that you have to adjust your wheel size to get the speed you want since the gearing is already in place. Simple math will tell you what size wheels you need.

The output shaft turns at 60 RPM. Your wheel will spin at the same rate. Sixty RPM is slow for a combat bot, even with very large wheels. I plan to run the motors at 8.4 volts instead of six. This will increase the speed of the output and the current drawn. Though the RPM won't quite double, I'm going to plan for it for simplicity's sake. So at 120 RPM, I started to figure out what wheels I needed to reach a target top speed of between four and eight feet per second. That is a little bit slow, but for a beginner bot, I'd rather keep it slow and controllable than have the driver lose control and tear something up. Ordinarily, I try to get a top speed of between 10 and 15 feet per second. You can do whatever you like.

A little math reveals that an eight-inch wheel at 120 RPM will give us a top speed of about four feet per second. First, convert

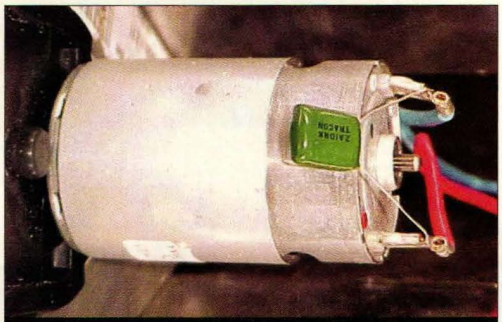

Figure 5. Motor Capacitors. Shows a single capacitor connected between the brushes of the motor to help suppress electrical noise. You can connect one capacitor from each brush to the motor housing if you continue to experience erratic control over the bot. Start with caps between 0.1uF and 0.01uF.

Convert ft/sec to in/min

$$\frac{4\,\text{ft}}{1\,\text{sec}} \left| \frac{60\,\text{sec}}{1\,\text{min}} \right| \frac{12\,\text{in}}{1\,\text{ft}} = 2880\,\text{in/min}$$

Find circumference of wheel

$$C = \frac{\text{Speed}}{\text{RPM}} = \frac{2880}{120} = 24\,\text{inches}$$

Find diameter of wheel

$$D = C/\pi = 24/3.14 = 7.64\,\text{inches}$$

Figure 7. Conversion Math for Wheels. Shows each step of mathematically deciding on a proper wheel size to be used with the specified motors.

four feet per second by using conversion factors and you get 2,880 inches per minute. Divide that by the RPM of your motor and you will have 24 inches per revolution, or the circumference of your wheel. Circumference is equal to Pi times the wheel diameter. Since we know the circumference, divide it by Pi and we'll have the wheel diameter of 7.64 inches.

Summary

So far, I've only been able to hit a little detail of what is to come in the following articles. I've talked about the sport — if you call it that — of combat robotics, if you call them robots. It doesn't matter to me, really. I'm having fun and I think you will too. You should definitely look at the RFL web site for rules and competitions in your area. We've chosen our style of bot and strategy for this project and have decided on the radio control system and drive motors.

Next month, we'll pick our wheels, speed controllers, and batteries. I'll tell you about all the different speed controllers available today. We'll also pick some materials and start putting the frame together. **NV**

Chris Hannold has been an electronics and robotics hobbyist for 20 years. He's been involved in combat robotics for over five years with the following accomplishments: Published by McGraw-Hill in August 2002 — *Combat Robots Complete* —ISBN 0-07-140888-6; Will be published by McGraw-Hill in June 2003 — *Combat Robot Weapons*; Organizes and produces the combat bot event, NC Robot StreetFight; Competed in Comedy Central's BattleBots, TNN's Robot Wars, and TLC's Robotica; Designed and built 10 combat robots; and Maintains a website with over 600MB of pics and video at **www.ncrsf.com**.

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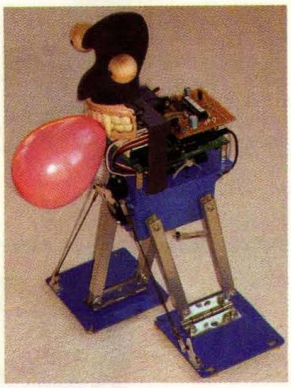

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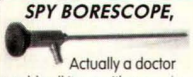

Actually a doctor would call it a anrithroscopic borescopes. Super high quality medical grade. Direct view eyepiece & standard 90 degree ext. light port. Size: 6.5"L X 7.5mm diam. SS tube with the objective end optic angled 30 degrees for easy viewing of surrounding area. This can get you in a tight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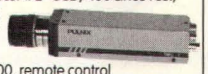

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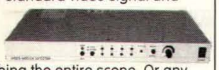

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Choose from the LARGE, 24dB, 10 deg. beam width or the MEDIUM, 20dB, 13 deg. beam width PARABOLIC DISH. (shown far left) each provides an environmentally sealed "N" type male termination attached to a 30" long cable. Large size is 27" x 30" and weighs 5.3 lbs, the medium size is 20" x 24" and weighs 3.6 lbs. Can be either horizontal or vertical polarization. Quasi Log Periodic end fire array feed. Both have a commercial quality, light grey, powder coat finish. California Amplifier P/N's: 130135 & 130120. Omnidirectional types, one is a "Rubber Duck" style, the surface mount (shown near left) offers a black, 1/4 wave radiator. The overall size is 3.5"H x 2.7" diam. base. A five foot long RG58-AU cable is terminated with a gold, SMA female connector. The 9db omni, Proxim P/N 7014-05, (shown near right) is a ridgid tube, 24"L x 1.6" max. diam.

Weatherproof, Std. 2" pipe mtg. hardware incl. Female TNC connector. Both omnis are black. A UV stable, polycarbonate, radome protects the 13.9dB YAGI, type PC2415N from Cushcraft. (shown far right) Max. input power is 500 Watts, the 15 element, one piece radiating design is extremely rugged. Size is 26" L, weight is 1 pound. Antenna is terminated through a pigtail connector to a "N" type female connector. **PARABOLIC 24dB..$129, PARABOLIC, 20dB..$99, DESK OMNI..$5ea, 9db OMNI..$69ea, YAGI..$89ea.**

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- ✔ Built-in mixer - 2 line inputs, 1 mic input
- ✔ Line level monitor output
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The all new design of our very popular FM100! Designed new from the ground up, including SMT technology for the best performance ever! Frequency synthesized PLL assures drift-free operation with simple front panel frequency selection. Built-in audio mixer features LED bargraph meters to make setting audio a breeze. The kit includes metal case, whip antenna and built-in 110 volt AC power supply.

FM100B	**Super-Pro FM Stereo Radio Station Kit**	$259.95	**$269.95**
FM100BEX	**1 Watt, Export Version, Kit**	$329.95	**$349.95**
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Professional 40 Watt Power Amplifier

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- ✔ Frequency range 87.5 to 108 MHz
- ✔ Variable 1 to 40 watt power output
- ✔ Selectable 1W or 5W drive

At last, the number one requested new product is here! The PA100 is a professional quality FM power amplifier with 30-40 watts output that has variable drive capabilities. With a mere one watt drive you can boost your output up to 40 watts! And this is continuously variable throughout the full range! If you are currently using an FM transmitter that provides more than one watt RF output, no problem! The drive input is selectable for one or five watts to achieve the full rated output! Features a multifunction LED display to show you output power, input drive, VSWR, temperature, and fault conditions. The built-in microprocessor provides AUTOMATIC protection for VSWR, over-drive, and over-temperature. The built-in fan provides a cool 24/7 continuous duty cycle to keep your station on the air!

PA100	**40 Watt FM Power Amplifier, Assembled & Tested**	$549.95	**$599.95**

Synthesized Stereo FM Transmitter

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- ✔ Fully synthesized 88-108 MHz for no drift
- ✔ Line level inputs and outputs
- ✔ All new design, using SMT technology

Need professional quality features but can't justify the cost of a commercial FM exciter? The FM25B is the answer! A cut above the rest, the FM25B features a PIC microprocessor for easy frequency programming without the need for look-up tables or complicated formulas! The transmit frequency is easily set using DIP switches; no need for tuning coils or "tweaking" to work with today's 'digital' receivers. Frequency drift is a thing of the past with PLL control making your signal rock solid all the time - just like commercial stations. Kit comes complete with case set, whip antenna, 120 VAC power adapter, 1/8" Stereo to RCA patch cable, and easy assembly instructions - you'll be on the air in just an evening!

FM25B	**Professional Synthesized FM Stereo Transmitter Kit**	$119.95	**$139.95**

Tunable FM Stereo Transmitter

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- ✔ Tunable throughout the FM band, 88-108 MHz
- ✔ Settable pre-emphasis 50 or 75 µSec for worldwide operation
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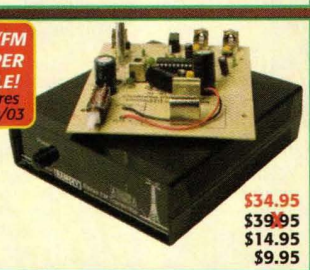

The FM10A has plenty of power and our manual goes into great detail outlining all the aspects of antennas, transmitting range and the FCC rules and regulations. Runs on internal 9V battery, external power from 5 to 15 VDC, or an optional 120 VAC adapter is also available.

		$34.95
FM10A	**Tunable FM Stereo Transmitter Kit**	**$39.95**
CFM	**Matching Case & Knob Set for FM10A**	**$14.95**
FMAC	**110VAC Power Supply for FM10A**	**$9.95**

Professional Synthesized AM Transmitter

- ✔ Fully frequency synthesized, no frequency drift!
- ✔ Ideal for schools
- ✔ Microprocessor controlled

AM/FM SUPER SALE! Expires 6/30/03

Run your own radio station! The AM25 operates anywhere within the standard AM broadcast band, and is easily set to any clear channel in your area. It is widely used by schools - standard output is 100 mW, with range up to ¼ mile, but is jumper settable for higher output where regulations allow. Broadcast frequency is easily set with dip-switches and is stable without drifting. The transmitter accepts line level input from CD players, tape decks, etc. Includes matching case & knob set and AC power supply.

AM25	**Professional Synthesized AM Transmitter Kit**	$89.95	**$99.95**

Tunable AM Transmitter

AM/FM SUPER SALE! Expires 6/30/03

- ✔ Tunes the entire 550-1600 KHz AM band
- ✔ 100 mW output, operates on 9-12 VDC
- ✔ Line level input with RCA connectors

A great first kit, and a really neat AM transmitter! Tunable throughout the entire AM broadcast band. 100 mW output for great range! One of the most popular kits for schools and scouts!

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AM1	**Tunable AM Radio Transmitter Kit**		**$34.95**
CAM	**Matching Case & Knob Set for AM10**		**$14.95**
AC125	**110VAC Power Supply for AM1**		**$9.95**

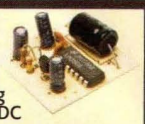
Mini-Kits... Fast, Easy, FUN!

Tickle-Stick

The kit has a pulsing 80 volt tickle output and a mischievous blinking LED. And who can resist a blinking light! Great fun for your desk, "Hey, I told you not to touch!" Runs on 3-6 VDC

TS4 **Tickle Stick Kit** **$12.95**

Super Snoop Amplifier



Super sensitive amplifier that will pick up a pin drop at 15 feet! Full 2 watts output. Makes a great "big ear" microphone. Runs on 6-15 VDC

BN9 **Super Snoop Amp Kit** **$9.95**

Dripping Faucet

NEW!

Produces a very pleasant, but obnoxious, repetitive "plink, plink" sound! Learn how a simple transistor oscillator and a 555 timer can make such a sound! Runs on 4-9 VDC.

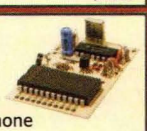
EDF1 **Dripping Faucet Kit** **$9.95**

LED Blinky

Our #1 Mini-Kit for 31 years! Alternately flashed two jumbo red LED's. Great for signs, name badges, model railroading, and more. Runs on 3-15 VDC.

BL1 **LED Blinky Kit** **$7.95**

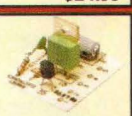
Touch Tone Decoder



Strappable to detect any single DTMF digit. Provides a closure to ground up to 20mA. Connect to any speaker, detector or even a phone line. Runs on 5 VDC.

TT7 **DTMF Decoder Kit** **$24.95**

Electronic Siren



Produces the upward and downward wail of a police siren. Produces 5W output, and will drive any speaker! Runs on 6-12 VDC.

SM3 **Electronic Siren Kit** **$7.95**

Universal Timer

Build anything from a time delay to an audio oscillator using the versatile 555 timer chip! Comes with lots of application ideas. Runs on 5-15 VDC.

UT5 **Universal Timer Kit** **$9.95**

Voice Switch

Voice activated (VOX) provides a switched output when it hears a sound. Great for a hands free PTT switch, or to turn on a recorder or light! Runs on 6-12 VDC and drives a 100 mA load.

VS1 **Voice Switch Kit** **$9.95**

Tone Encoder/Decoder

Encodes OR decodes any tone 40 Hz to 5KHz! Add a small cap and it will go as low as 10 Hz! Tunable with a precision 20 turn pot. Runs on 5-12 VDC and will drive any load up to 100 mA.

TD1 **Encoder/Decoder Kit** **$9.95**

RF Preamplifier

Super broadband preamp from 100 KHz to 1000 MHz! Gain is greater than 20dB while noise is less than 4dB! 50-75 ohm input. Runs on 12-15 VDC.

SA7 **RF Preamp Kit** **$19.95**

Touch Switch

Touch on, touch off, or momentary touch hold, your choice! Uses CMOS technology. Runs on 6-12 VDC and drives any load up to 100 mA.

TS1 **Touch Switch Kit** **$9.95**

Hobby Kits

Build It, Learn It, Achieve it, *ENJOY IT!*

Electrocardiogram Heart Monitor

- ✔ Visible & audible display of your heart rhythm
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- ✔ Monitor output for your scope
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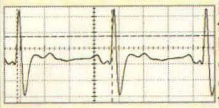

Enjoy learning about the inner workings of the heart while at the same time covering the stage-by-stage electronic circuit theory used in the kit to monitor it. The three probe wire pick-ups allow for easy application and experimentation without the cumbersome harness normally associated with ECG monitors. Operates on a standard 9VDC battery.

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

Ion Generator

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

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

IG7	**Ion Generator Kit**	**$54.95**	**$64.95**
AC125	**110VAC Power Supply**		**$9.95**

Plasma Generator

- ✔ Generate 2" sparks to a handheld screwdriver!
- ✔ Light fluorescent tubes without wires!
- ✔ Up to 25kV @ 20 KHz!

This is one heck of a neat kit! Hey, it really serves no purpose other than producing stunning lighting displays, drawing big sparks, scaring the neighbors and performing lots of high voltage experiments. It can also be used for powering other experiments; let your imagination be your guide! The high voltage at the terminal won't electrocute you, so it's relatively safe, but it can burn you, so use caution. Runs on 14 VAC but can also be run from 5-24VDC so the output voltage can be directly adjusted.

PG13	**Plasma Generator Kit**	**$64.95**
PS12	**14VAC Output 110VAC Power Supply**	**$19.95**

High Power LED Strobe Light

- ✔ No more HV or Xenon strobe tubes!
- ✔ Super Bright LED's - won't burn out!
- ✔ Audio triggered or variable flash rate!

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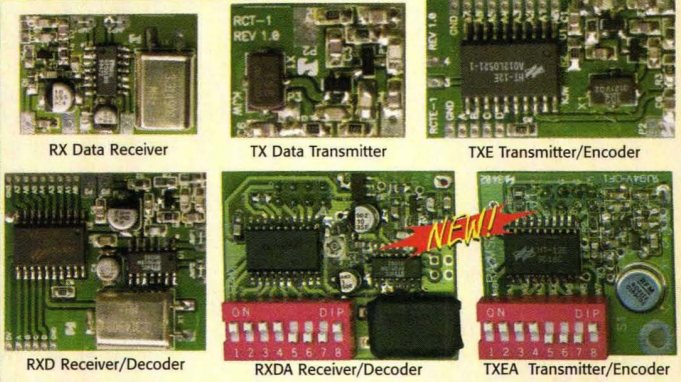

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Circle #30 on the Reader Service Card.

by Gerard Fonte

The Business of Electronics Through Practical Design and Lessons Learned

In The Trenches

Managing People

Managing people is something most engineers will be required to do at some point in their career. Either workplace advancement places them in a management position or else, as an entrepreneur, they are required to hire and supervise employees. In either case, the engineer is often not prepared for such a change in roles. This can lead to problems.

The Management Dilemma

First of all, there is a general problem that occurs when managing technical or scientific people. Should the manager be technically-oriented or should the manager be business-oriented?

The technical manager will have a better grasp of the technical aspects and can make better technical decisions. However, such a person often has little or no training in how to manage people. This can result in personality conflicts and significant friction. Part of this problem stems from the personality traits and educational background of technical people, in general. (Note the "in general" phrase, please.)

Technical people are used to solving problems logically. Often this problem solving is done privately. The person researches the problem, runs tests, and comes to a conclusion. Then this conclusion is presented and defended. So, this person can often equate any criticism as a personal attack. Additionally, this person, in a manager role, may not recognize that emotional issues as well as logical ones need to be addressed. People are emotional. And emotions are important to the well-being of any person.

However, the technical manager can often provide assistance in solving technical problems. What's more, a good technical manager can play an important leadership role in developing the talents of other technical employees. Clearly, these reasons are important considerations for a technical manager.

A business manager has different problems. Obviously, this person cannot provide technical assistance in problem solving. This tends to isolate the technical employees from management. This can result in a serious division between management and the technical staff. Additionally, business decisions about technical issues do not always make sense to the staff. This can create the impression that management is clueless, arbitrary, and dysfunctional. Finally, this manager must depend upon others to explain the technical details. This makes him vulnerable to manipulation by those he listens to.

The good points of a business manager are that this person understands how the engineering group fits in with the rest of the company. Additionally, the business manager usually has a better understanding of how to work with people. This manager usually can provide better financial and business decisions. And, since he is not personally involved in the technical issues, he can dispassionately choose between alternatives.

Most companies recognize this dilemma. Sometimes, they put a "technical manager" as the head of a department. This is a person who has both experience as a manager, as well as some technical background, but often not an engineering degree. This is obviously a compromise. But, it often works well. Unfortunately, sometimes these people are hired from outside the company. This is because of fear from "The Peter Principle."

The Peter Principle

In 1969, Dr. Laurence Peter published a small book called *The Peter Principle: Or Why Things Always Go Wrong*. It's based on common sense and observation. The premise is that successful people are promoted again and again until they reach a position where they fail and are no longer promoted. Since companies rarely demote people, the result is that "people are promoted to their level of incompetence."

Companies don't demote people because that would acknowledge that the company made mistakes. That's not good for the company. Additionally, demotions are generally worse that being terminated. The demoted person feels a sense of failure and clearly no longer has much likelihood of advancement within the company.

Finally, companies don't want to terminate workers that performed well in the past. That's not good business, either. So, because of concerns for failure, a minority of companies are reluctant to place engineers into management roles directly.

Why Engineers Often Fail as Managers

The first and most significant reason is the lack of "people skills." Let's face the truth — most engineering-type people tend to be nerds (I include myself, here). We are happy when learning or doing something new. We tend to work as individuals and are very independent. And, generally, we do not win popularity contests. However, once this is recognized, we all have the ability to learn and develop these people skills. Remember, learning is something nerds do well.

Here are a few "Dos and Don'ts" to get you started.

Don't micro manage. When giving assignments, let the person solve the problem in his own way. This is often very hard to do. A manager tends to feel that his way is best. After all, he is the manager! Yet, there are many ways to solve problems. And, in the process of problem solving, learning occurs. If you force someone to follow your solution, they will not learn as much, resent your intrusion, and feel stifled. Conversely, giving latitude increases creativity,

productivity, and good will. Give the person precise goals, but let that person achieve them on his own.

Don't command. Sometimes people feel that if they're in charge they must speak with authority. Some people enjoy this because it makes them feel important. It's almost always a mistake. People don't like being ordered around. A company is not a military organization. Instead, develop a team attitude. Say, "I need you to do ..." rather than "I want you to do ..." This subtle change in wording makes a big difference in disposition.

Listen to what others say. You may be smart, you may be experienced, and you may be the manager. But, other people have important things to say. Never disregard any comment, suggestion, or criticism from anyone. New ideas are precious and fragile. If you ridicule one, you will never get another. Repressing creativity is never useful in a technical area. More importantly, take any criticism very seriously. It takes a lot of courage to criticize a manager. That means that it is not without merit. What's more, you can be sure that your superior is aware of it, as well.

Put yourself in their place. Think of how you would like your superior to act to you, then act that way to your staff. I'm sure you want your superior to be honest, open, and helpful to you. So be that way to others. This is just common sense, and it works in most any social situation.

Management Theory and Styles

Management theory has three general management styles called X, Y, and Z. These are based upon the perception of the worker attitude. A brief overview is useful as an introduction to management theory. New theories are always being developed. There are lots of books available on the subject.

Theory X says that people don't like to work and you have to push them to do so. This style depends on rigid management rules and behavior. Threats of disciplinary action are fairly common. Motivation is based on fear. Better performance is felt to be the result of greater monetary reward.

Theory Y says that people like to work. This style fosters creativity. It assumes that people want increased responsibility and involvement in organizational development. Just provide the tools and the people will work happily and responsibly. Engineers tend to fall into this group.

Theory Z is the "Japanese" style of management. This involves both the perception of the worker by management and the perception of management by the workers. In general, this style softens the lines between management and worker. It emphasizes broadening of skills with job rotation and generalization rather than specialization.

However, each of these theories is both right and wrong. The truth is that no single approach will work for all people. These theories say more about the manager than they do about the workers.

A good manager will use the proper style for each person in his group. One person may require an "X" style of management. Another, the "Y" style. Others may need various styles at different times or situations. Yes, this is hard. It takes work to understand what each individual worker wants and needs. But that is what makes a manager good.

Discipline and Anger

When things go wrong, it seems to be human nature to get angry and immediately blame someone. This is the wrong thing to do. If someone drops an oscilloscope, it is perfectly reasonable to curse at the loss of the instrument. It is absolutely unacceptable to curse at the person who dropped it. It is rare that the mistake happened on purpose (and if it did, you have major problems). So the proper response is to calmly (stress "calmly") figure out what happened and correct the problem.

There will be times when someone simply does something wrong. For example, the PC board is too big to fit into the selected case. Again, don't vent your anger at the person. And again, find out why the mistake happened and correct the problem.

It is unlikely that the person deliberately made the PC board too large. Perhaps the specifications were wrong or outdated. Perhaps the person wasn't paying attention to the specifications. Perhaps the person couldn't understand the specifications. Whatever the reason was, identify it and learn from it. Make sure everyone gets and uses the proper specifications — have a meeting to be sure everyone knows them and supervise that person more closely to be sure the specifications are being followed. Remember, many times a failure of a subordinate is due to the failure of the manager. The vast majority of small businesses fail because of poor management.

What do you do if someone just screws up? Let's say you assign someone to meet a big client at the airport — that person leaves early, goes to a movie, and neglects to meet the VIP. Clearly, some sort of discipline is reasonable and appropriate. Exactly what that is depends upon the company, VIP, and worker. However, it is reasonable to act angry in this instance. Note that the operable word is "ACT." Again, venting anger may make you feel good, but it rarely helps any situation. It must be made clear to that person that his behavior was unacceptable.

(I recommend the book, *The One Minute Manager*, by Kenneth Blanchard. It is especially useful for disciplinary situations.) Note, absolutely all disciplinary conversations must be private. Use an office with a closed door. Cubicles are not acceptable.

Personal Stress Management

You have probably noticed that there is no situation where venting your anger is useful. So, what do you do when you feel you need to inflict grievous damage to something? After all, when you're angry, which is a very normal human response, you cannot manage well. And letting it build without release is not healthy.

One solution I, and others, have found is to get physical. Any type of strenuous physical exercise helps remove the adrenaline that the anger has generated. Some people find a lunch time run useful. Others play racquetball. I find anger can be relieved by going to the driving range and hitting a bucket of golf balls. (While imagining that the ball is something else.)

The important thing is to find something that works for you. If you don't, the anger can, and will, find some other way out. Unrelieved stress causes illness and behavioral problems. Besides, after a catastrophe has been resolved, no one will object to the angry manager going out for an hour and coming back calmer. In fact, everyone will probably appreciate it.

Praising Your People

There's an incredibly useful and powerful motivational tool that costs nothing. It's simple praise for a good job. At the start of the day, go over to that person's desk and assemble everyone else in the department. Then just say something like, "I just want to let everyone know that Bob did a great job on the widget design proposal. I personally appreciate the effort he put in to get it done on time. He did a great job!" (Note, do this in the morning, so everyone can reflect on it during the day.)

Naturally, there are any number of variations to this. A special lunch works well. An award of a simple or humorous gift is good. The important part is the person-to-person praise. Putting a note in the person's mail or paycheck has little effect. It can often backfire by demonstrating the lack of personal concern. Employee of the month awards are not as useful because they are somewhat forced. This is because someone has to be awarded each month.

Spontaneous and personal praise for specific actions is extremely powerful in creating good working relationships.

It is important not to ignore anyone. It is certainly true that some people do more than others. Additionally, some people are in position to have more opportunities to excel. Nevertheless, you must find reasons to personally praise each and every person from time to time. Typically, this should be done no less than once a year. (Praising everyone every week will be interpreted more as cheerleading rather than recognition.) A public letter of commendation to the company president after completing a large project that lists every contributor by name is always constructive.

Managing Yourself

Perhaps you've noticed that managing people means managing yourself. You probably will have to change your behavior to manage well. Certainly you will have to consider things you didn't have to consider before. Authority brings the baggage of responsibility. You are now responsible for other people's work and well-being. What's more, your success or failure depends upon those who work for you. This is a big change in your work perspective.

It may be useful to think of managing people as a new technical challenge. Remember when you had to learn about that new programming language or computer chip or software package? Treat management in the same way. Get the manuals and read them. I've suggested a couple of books that I've found useful. The library, bookstore, or web can provide more. Find a style that you are comfortable with. There is no best way to manage. It is more important that you use and understand the fundamental ideas rather than mimic the actions of someone else. The people who work for you are very perceptive and will know the difference.

There is truth to the idea that the manager is the leader of a team. Everyone on a sports team wants to win. Each player has a specific responsibility. And everyone has to succeed in order for the team to win. It is your job to foster that desire to work together toward a common goal. Learning how to do this is not impossible. Like any other subject, teamwork and leadership is learned through experience, effort, and determination.

Executive Blindness

There is a tendency for some people to lose their ethical sense of direction when moving into a management position. I call this "executive blindness." This occurs because the manager's success is now measured by the success of the department rather than any personal achievements.

The result can sometimes be a manager that only cares about results. Company rules, labor laws, contract requirements, and plain common courtesy may be sacrificed for some perceived advantage. It is important to realize that this type of manager doesn't think he is doing anything wrong.

For example, I was once asked to design an aircraft instrument using a specific design technique that upper management defined. It turned out that this method could not meet the contract specifications for accuracy. After weeks of memos and conversations, I asked "How are we going to meet the specifications?" The answer was, "We'll cheat. Everyone else does."

Then there was the manager who got angry with the workers using their sick and personal days. It is vital to realize that the union contract provided these days and no worker was taking more time off than what was allowed under the contract. Nevertheless, this manager was angry at these people and deliberately took actions to "get back" at them.

These people have lost their ability to see objectively. That's why I call it executive blindness. And it's something that can sneak up on you if you let it. The best way to avoid this is to always be open and honest with yourself and others. You can see that these two examples show people who are aren't.

If you are a subordinate to someone with executive blindness, you have a problem. These people often don't listen to reason and are convinced that their behavior is correct. Going over their head to higher management often only creates problems for you. Unfortunately, whistle blowers rarely fare well. The only solution I have found was to move.

A company transfer is often a reasonable possibility. If not, a new job may be in order. Remember that these people can often become targets for legal, corporate, or even personal actions. It isn't good to be close to a target. (A couple of years after I left the "we'll cheat" company, a number of managers in that section were indicted on federal charges.)

Managing — a New Skill

Like anything else, managing is both an art and a science. If you are willing to invest some time and effort into learning this subject, it will benefit you, as well as your workers and your company. There is truth to the statement that "Management is the art of having people who want to go in the direction you need."

Management will allow you to accomplish things you could not do on your own. No individual can create a new car, or new space craft, or new computer chip. But as a manager, you direct these people as extensions of yourself. And in doing so, you expand your ability to accomplish larger goals.

Yet, you always must remember to treat these extensions the same way you treat your hands or your mind. If you do, you will be a good manager. **NV**

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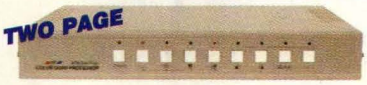

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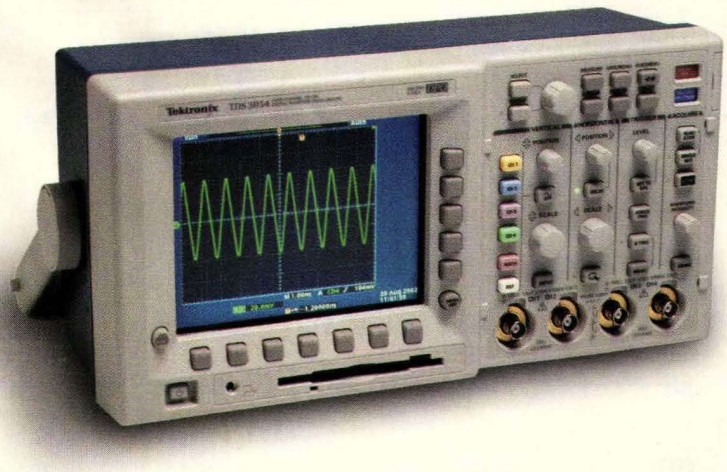

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Circle #35 on the Reader Service Card.

by George Whitaker

Basics For Beginners

Just For Starters

Working With Resistors

There are three values generally assigned to resistors: resistance, wattage, and tolerance. The resistance is determined by their internal make-up and the wattage is generally determined by their physical size. The tolerance value indicates how close to the rated value a resistor will be. That is to say, a 1,000 ohm, 10 percent resistor will actually measure somewhere between 900 and 1,100 ohms.

Carbon-filled resistors are generally used for smaller wattage applications. You can get a tremendous range in resistance values in a small package. However, carbon resistors are very limited in wattage rating. For heavier current situations, wire-wound resistors are normally used. These are physically much larger, and come in sizes up to feet in length and inches in diameter.

There are, of course, a large number of specialty resistors for specific applications. For instance, garden variety carbon resistors cannot be used in some applications because they inherently add noise to the circuit. In some audio circuits, or measurement circuits, this noise is intolerable. However, for this series of articles, we will be talking garden variety resistors.

First, let's take a look at resistances in series. In Figure 1, we have two 600 ohm resistors in series. (The omega symbol Ω stands for the word ohm.) Each resistor is 600Ω and, in series, they would add up to 1,200Ω. Resistances in series simply add. If we assume they are one-watt resistors, the circuit would still have a dissipation capability of one watt. This is because the current in a series circuit is the same at any point in the circuit, and voltage times current equals your wattage. We'll have more on wattage in a later column.

Now in Figure 2, we see two 600Ω resistances in parallel. Equal resistances in parallel will evenly divide. Therefore, our total resistance between point A and point B would be 300Ω. Note that this is true only for resistances of equal value. We will get back to figuring resistances a bit later. Right now we just want to understand what effect series or parallel has on wattage. Anyway, in this circuit, our current dissipation is now doubled. These two one-watt resistors could now handle the same current as a 300Ω, two-watt resistor. In Figure 3, we have three 600Ω resistors in parallel. The resistance from point A to point B would measure 200Ω. However, we now have three watts of current dissipation. These three one-watt resistors can take the place of a 200Ω, three-watt resistor.

In a series circuit, unequal resistances simply add, just as equal resistances would. The wattage requirement for each resistor in the series would be dependent upon how much voltage was to be dropped across that particular resistor. Or, in other words, the wattage requirement for each resistor in the series would be dependent upon its value of resistance, and would have to be figured based on the total voltage applied to the circuit, and how much of that voltage would be dropped across that particular resistor. Voltage division is another topic we will be returning to later on. For right now, we want to just learn to figure the resistance itself.

In Figure 4, we have two resistors of unequal value. One is 150Ω and the other is 220Ω. The formula shown in Figure 4 applies only to two unequal resistances in parallel. The wattage rating, again, is additive.

Where you have more than two unequal resistances in parallel, the formula in Figure 5 applies. Here we only have three unequal resistances. However, the formula allows for an infinite number. Again, the wattage rating would be the sum of the ratings of all of the resistors.

Next month, we will take a look at some more of the basic things to help get a novice experimenter going. NV

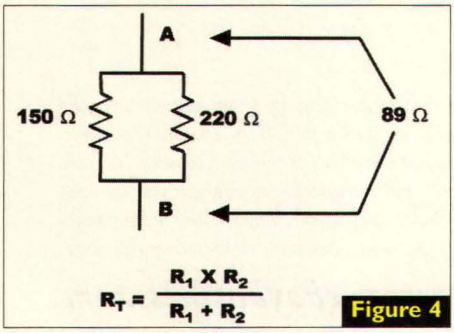

Figure 4

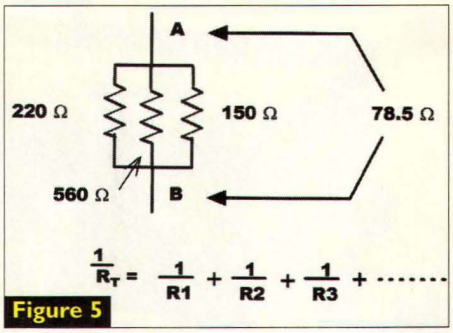

Figure 5

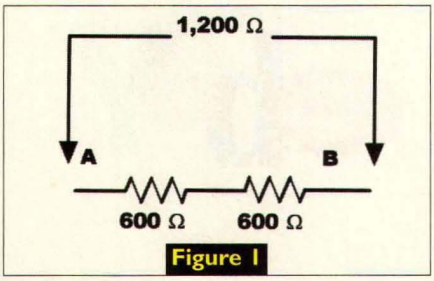

Figure 1

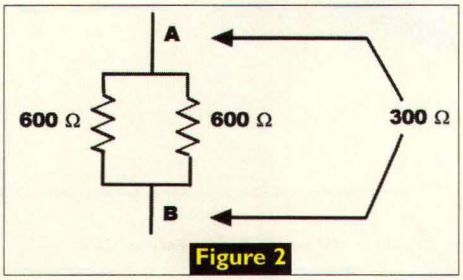

Figure 2

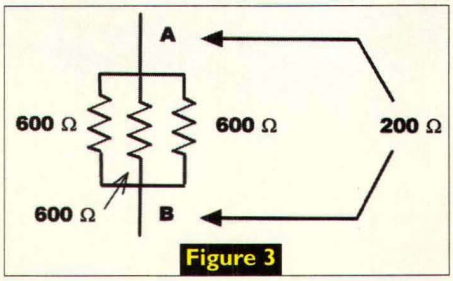

Figure 3

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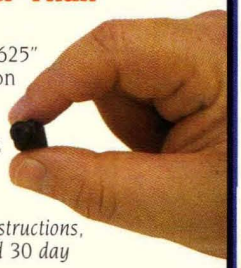

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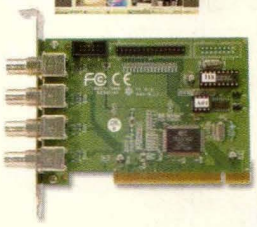

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The Latest in Networking and Wireless Technologies

Open Communication

Three unusual short range wireless techniques are getting hot.

Wireless means radio in its widest sense, but today, most people connect the term "wireless" to cell phones or to the wireless local area networks (WLANs) that are popping up everywhere. Infrared (IR) remote controls, garage door openers, and remote keyless entry devices for cars are also wildly popular wireless applications.

In addition, there are three very different wireless methods, mostly hidden or at least unknown, that are growing in use. I bet that you have not heard of them. They include magnetic induction wireless, radio frequency identification (RFID), and ultra wideband (UWB). Here is a quick introduction to these interesting short range techniques and their applications.

Magnetic Induction Wireless

If you have any background in basic electronics, you already know about magnetic induction. A transformer is the perfect example. Apply a signal voltage to a primary winding which produces current flow that, in turn, produces a varying magnetic field. The magnetic flux lines making up the field cut across the turns of the secondary winding inducing a voltage. No actual electrical connection exists between the primary and secondary windings. Power is transferred from primary to secondary via the magnetic field.

In a transformer, the primary and secondary windings are very close together, either wound on a common core, on top of one another, or side by side. But what if you separate the primary and secondary windings by a significant distance? If you don't exceed a distance you can measure with a yard stick, the magnetic lines of force from the primary — though weakened by the distance — will still reach the secondary winding and induce a voltage. This is the principle of magnetic induction wireless where the primary and secondary windings are the transmitting and receiving antennas, respectively, forming an air core transformer.

An example of a commercial magnetic induction wireless product is the LibertyLink wireless transceiver made by Aura Communications, Inc., of Wilmington, MA (**www.auracomm.com**). This single chip was designed for short range voice communications. A block diagram is shown in Figure 1. The voice signal from a microphone is connected to the audio input, amplified, filtered, and sent to a type of analog-to-digital converter known as a continuously variable slope delta (CVSD) encoder. The resulting 64 kbps serial digital bit stream representing the voice signal is then fed to a couple of first-in, first-out (FIFO) memories that control the speed of the signal to the modulator.

The digital voice then goes to a phase accumulator, basically just a counter, whose output is used as the address for a ROM that stores bit patterns representing sine and cosine waves. The phase accumulator and ROMs form a simplified direct digital synthesizer (DDS) that produces two complementary (90° out of phase) sinewave signals that, when combined, will form a Gaussian minimum shift keying (GMSK) signal. GMSK is a special form of frequency shift keying (FSK) modulation that produces a very narrow bandwidth.

The ROM outputs are fed to digital-to-analog converters that generate two signals called the in-phase (I) or sine signal, and the quadrature (Q) or cosine signal. These two signals are sent to mixers where they are combined with the high frequency carrier signal, usually a sinewave in the 11 to 15 MHz range. The well-known 13.56 MHz (actually 13.559

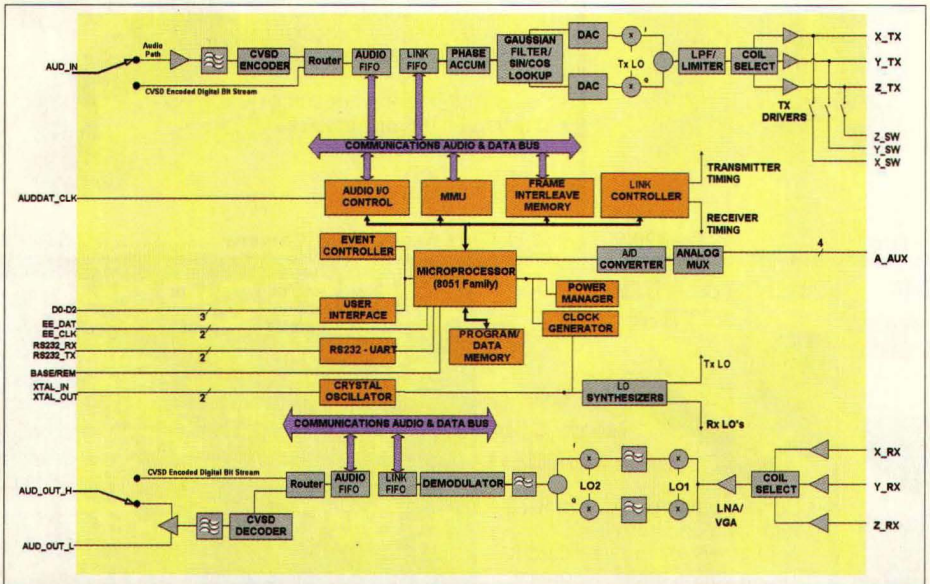


Figure 1. Complete block diagram of the LibertyLink magnetic induction wireless chip from Aura Communications.

MHz) industrial-scientific-medical (ISM) frequency designated by the Federal Communications Commission (FCC) as an unlicensed frequency is commonly used. The mixer outputs are added together and the GMSK signal is filtered and limited, and fed to one of three output amplifiers selected by the coil select switch, and then on to the output coil or antenna. More about that later.

On the receive side, a signal picked up by an input coil or antenna is amplified and selected by a coil switch, then fed to a low noise amplifier (LNA). The high-frequency signal containing the modulation is put through two levels of down conversion in mixers with sine/cosine local oscillator signals. To recover the GMSK signal, it must be divided into two quadrature signals then added. The signal is filtered and then fed to the demodulator where the original serial digital signal is recovered. This signal is then stored and delayed in FIFOs and sent to the CVSD decoder, which converts the digital bit stream back into voice.

There is lots of other stuff on the LibertyLink chip. In the center of Figure 1 is a version of the long popular 8051 embedded microprocessor. It is programmed to implement the specific communications application of the chip. This processor also controls and sequences all other operations through the various interfaces. The clocks also generate the local oscillator signals for the transmitter and receiver. In two-way voice communications, you want to be able to talk and listen at the same time. This calls for full duplex operation. The LibertyLink chip uses a time division duplexing (TDD) scheme where the two voice signals alternate, that is, taking turns but at high speed so you don't notice. You can also use the chip to transmit data other than voice by bypassing the CVSD circuits through the router circuits. The maximum raw data rate is 204.8 kHz.

Now, a word about the coil select switches at the transmitter output and receiver input. Going back to transformer theory, you probably know that maximum signal is induced into the secondary winding (receiver) when it is parallel to the primary winding, or when they are on the same axis. If one winding is at some angle to the other, the induced signal is less. In fact, if the primary and secondary windings are orthogonal, at 90° to one another, little or no signal is induced. If during a transmission, the receive and transmit antennas (coils) happen to become physically-oriented so they are orthogonal, no transmission takes place.

The LibertyLink system fixes this problem by using three coils — each orthogonal to one another. The coils are physically positioned in an X, Y, Z coordinate axis system. With each coil 90° to the others, at least one of them will be positioned to receive the signal. The LibertyLink contains circuitry that automatically selects the coil with the greatest signal strength. As it turns out, you only need one end of the communications link to have the three antennas overcome the problem.

What is the LibertyLink used for? Its primary use so far is in wireless headsets for cell phones. Headsets have become popular because they permit you to drive and do other things while talking on the cell phone. Cable linking the headset and the phone is a nuisance, so manufacturers have made the connection between the two wireless. Some headsets, like those from Sony Ericsson, use a Bluetooth wireless link. Others use the LibertyLink. It is a near-perfect short range wireless solution, as it is significantly cheaper than Bluetooth or any other wireless technique. LibertyLink is also finding its way into other applications such as automotive, industrial, and medical.

Radio Frequency Identification (RFID)

RFID is also a kind of induction wireless since it relies primarily on the magnetic field. Think of RFID as the wireless equivalent of bar coding. Bar codes are very widely used. Like many other things, we take them for granted. But if you start looking closely, you begin to ask — what doesn't have a bar code on it?

A bar code is read by shining a narrow laser beam on it and using a sensitive photo detector to pick up the reflected light pulses. The pulses form a digital signal that is decoded, then recognized in an embedded controller or computer. RFID does a similar thing by radio.

Figure 2 shows the concept of RFID. An item to be identified has an RFID tag glued to it. The tag contains a digital transceiver with a unique digital code. The tag is tiny and flat, as it is just a sliver of silicon. Attached to the tag is a coil that serves as a receive/transmit antenna. It is resonant to the carrier frequency with the accompanying capacitor.

To read the code, the item with the tag is passed near a reader or interrogator unit. The reader consists

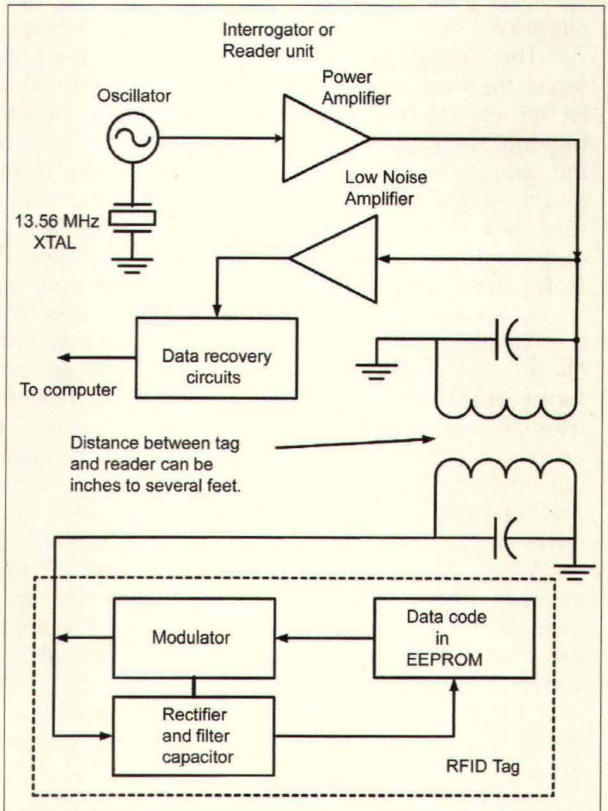
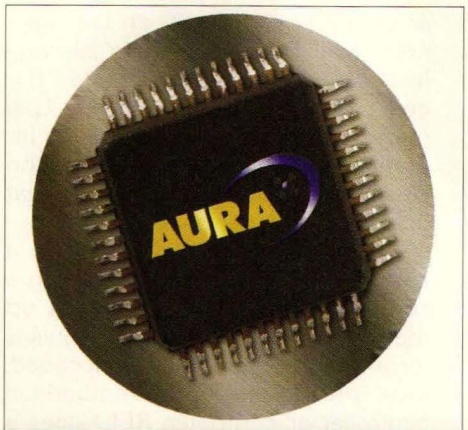


Figure 2. The concept of RFID showing the interrogator, or reader unit at the top and the tag at the bottom.



The Aura Communications LibertyLink magnetic induction wireless chip.

of a transmitter that sends a powerful radio signal to the tag. The signal picked up by the tag coil is relatively strong because the distance between the reader and tag is very short — a few inches to no more than several feet.

The resonant step up characteristic of the resonant coil also gives the signal a boost. This signal is then rectified and filtered into a DC voltage that powers the internal digital circuitry.

The unique code stored in the tag is then transmitted serially back to the reader. The small signal from the tag is amplified by a sensitive receiver in the reader, demodulated, and the code recovered. The code is then sent to a computer or embedded controller that recognizes or stores the code.

A representative RFID product is the MCRF 355/360 chips from Microchip Technology, Inc. (**www.microchip.com**). The tag uses an external pick-up coil that is usually a spiral inductor on a plastic base on which the chip is mounted. The operating frequency is 13.56 MHz.

When the interrogator signal exceeds about four volts peak-to-peak at the tag, the circuitry is activated. A voltage multiplier rectifier converts the RF to pulsating DC, which is then filtered into a continuous DC by a capacitor. This turns on the internal circuitry.

A clock running at 70 kHz activates an EEPROM where the unique identification code is stored. The code is 154 bits long. The code is then sent serially to a MOSFET switch used as a simple amplitude shift keying (ASK) modulator. The ASK modulated 13.56 MHz signal is then picked up by the reader, decoded, and interpreted. The tag is initially programmed with its special code — wirelessly, as well. A programmer or the interrogator unit sends the code to the tag which is then written into the EEPROM.

Most RFID tags work this way. Some key differences are operating frequency and modulation. The 13.56 MHz tags are probably the most popular, but tags with a frequency of 125 kHz are also widely used. Some longer range tags operate in the 900 MHz range. While most tags use passive power from the interrogator, some also use small, flat batteries to provide longer range reading. Besides Microchip Tehnology, other makers of RFID chips are EM Microelectronic, Philips Semiconductors, STMicroelectronics, and Texas Instruments.

As for applications, you have probably experienced some yourself already. The "speed passes" used on some toll roads are an example. You attach a tag to your windshield that is read by an interrogator as you zoom through the tollbooth. You have already prepaid your tolls which are automatically registered as you pass through. Another example is the Mobil/Texaco key ring device that lets you automatically charge gasoline. A reader in the pump picks up your tag and bills your account.

As RFID tags have grown in popularity and increased in volume, the prices have gone down, making them suitable for many other applications. They are particularly useful to manufacturers to track and control inventory, similar to the way bar codes are used. RFID tags are used on the larger, more expensive products. The tags can also be used to track capital equipment items, packages being shipped, baggage, and animals. Other uses include building access and security and theft prevention in retail stores. Lots of other applications are in the works as prices continue to fall.

Ultra Wideband (UWB)

Both induction wireless and RFID use magnetic induction for the wireless link. They are not what you would call real radio, despite their wireless nature. These methods use what is generally referred to as a near field signal, which is a strong magnetic field and a weak to nonexistent electric field. A genuine radio wave is made up of both magnetic and electric fields at right angles to one another. Maxwell's equations tell us that the two fields are self-sustaining as they reinforce one another as they travel through space. Ultra wideband produces a real radio signal.

UWB, as its name implies, occupies an extremely large portion of the frequency spectrum. It transmits information in the form of unique, but very narrow pulses. The pulses shown in Figure 3 look somewhat like one cycle of a sinewave, but they are not. These so-called monocycles are shaped by a special (usually Gaussian) filter that gives them their unique broadband characteristic.

Remember that the Fourier theory mathematically describes the frequency spectrum — a signal based upon its shape. Monocycles have an extremely broad bandwidth. A UWB signal is essentially described as one that has a bandwidth of at least 1,500 MHz (1 GHz) or more than 25 percent of the center frequency of the pulses. The center frequency is determined by the reciprocal of the pulse width (t_w).

For example, a 200 pS pulse width would produce an enter frequency of $1/ t_w = 1/200 \times 10^{-12}) = 5$ GHz. The 3 dB bandwidth of the resulting signal is about 1.16 times the center frequency or, in this example, 5.8 GHz.

To transmit data by UWB, the pulses are modulated. Two basic ways are to use pulse position modulation (PPM) where the time interval between the pulses is varied. A pulse that occurs earlier in time is a binary 1 and a pulse that occurs later in time is a binary 0. A form of phase shift keying can also be used. A binary 1 has one pulse phase with the positive going part occurring first while a binary 0 has a pulse of the opposite phase with the negative part occurring first.

UWB has several key characteristics that make it attractive. First, it

can use spectrum already occupied by other services. Today, spectrum space is severely limited. We have already used up pretty much all of the available spectrum, and there are ongoing battles for more frequencies. Space for more cell phone channels is a good example.

With UWB, the signal is spread over such a wide range that the signal level is very low. Using low power spread over a wide bandwidth virtually eliminates interference to any other signal in the band width. The UWB signal simply appears like low-level noise to other radios.

Second, multiple UWB signals can also share the same bandwidth because they do not interfere with one another. As a result, UWB is also a multiplexing or multiple access technique. Each UWB radio is assigned a special code and that code is used to encode the digital data. UWB receivers can recognize the signal destined for them by looking for the desired coded signal using cross correlation techniques.

A third benefit is that UWB signals are more immune to multipath effects that plague other high-frequency signals. When used indoors, wireless signals are bounced off walls, ceilings, floors, furniture, and other obstructions. This produces multiple reflected signals that arrive at the receiver at different times. This can cause signal degradation, or fading. Because UWB signals are short pulses, the effect is minimized, making UWB great for indoor wireless networks. Other UWB benefits include simple circuitry and the resulting low cost, inherent security, and low-power consumption.

UWB is really not new. In fact, it is the oldest form of wireless in existence. Marconi's first transmitters generated a UWB signal. Radio signals were produced by creating a high voltage spark across the gap of a couple of electrodes. The signal fed to the antenna had an extremely wide bandwidth. The signals were essentially untuned, in that they had no central frequency. Therefore, multiple spark gap signals did interfere with one another. Receivers could not distinguish one from another, except perhaps by their relative strength.

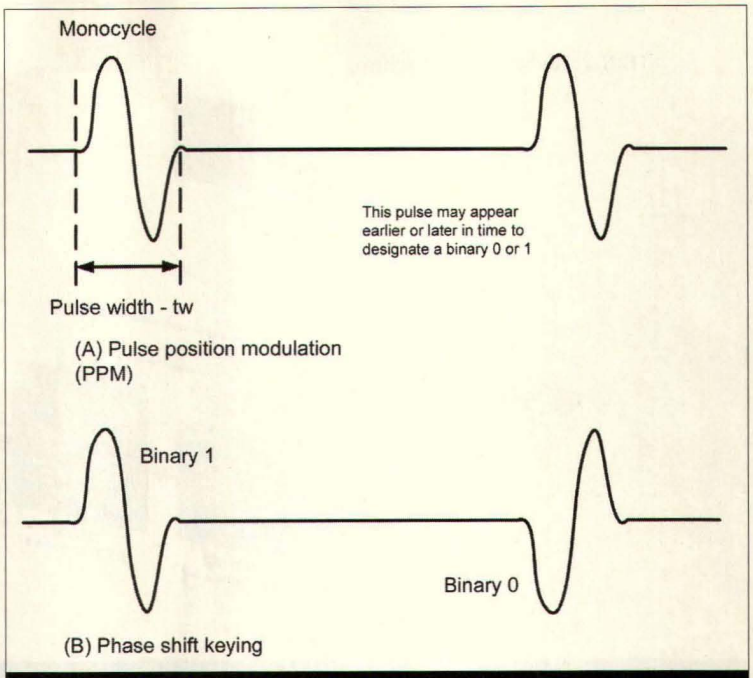


Figure 3. Ultra wideband pulses are called monocycles and generate a very wide bandwidth or spectrum. The pulses are modulated by pulse position modulation or phase shift keying.

In the 1960s, UWB was rediscovered and considerable development occurred in the following decades for government and military applications, mainly radar and secure communications. UWB was not authorized by the FCC except for such applications. Last year, the FCC finally approved low-power UWB for personal and commercial applications. UWB is assigned to the frequency range of 3.1 to 10.6 GHz — a 7.5 GHZ band. This unlicensed band

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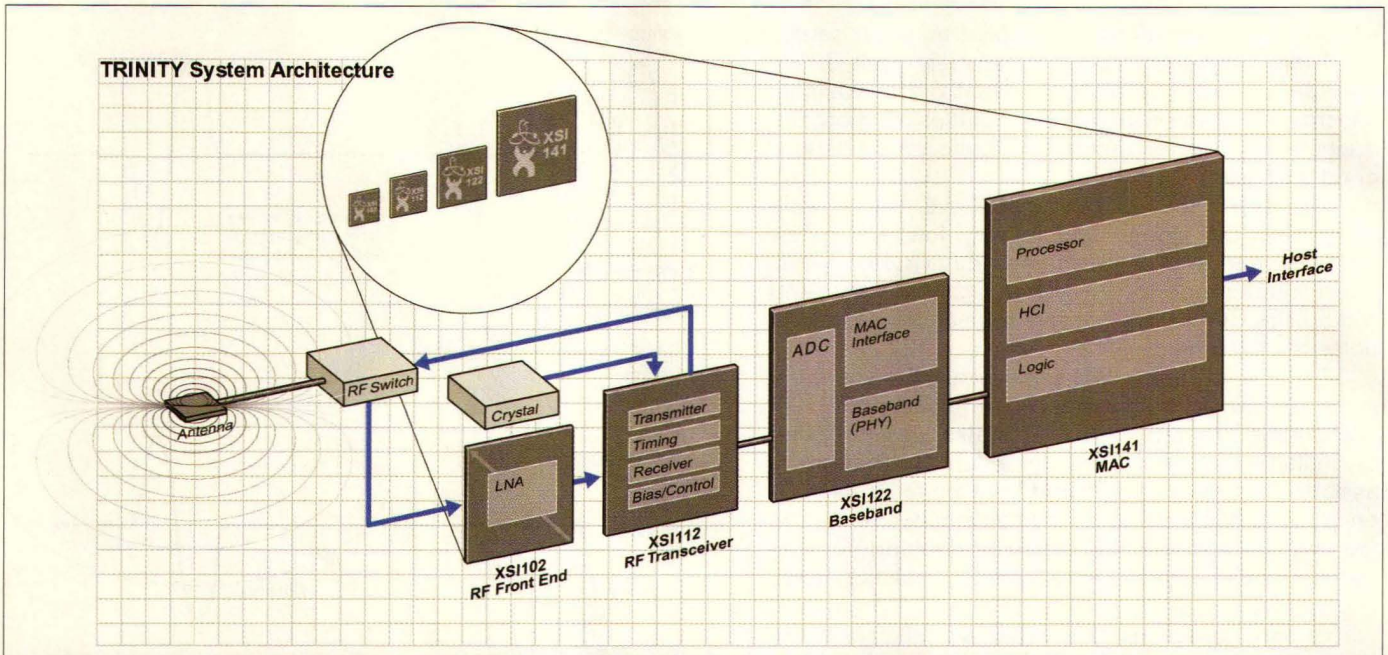

Figure 4. A commercial UWB chip set called the Trinity by Xtreme Spectrum, Inc. The interface is usually 10/100 Mbps Ethernet.

is regulated by Part 15 of the FCC rules and regulations. Anyone can use it for whatever purpose. UWB transceivers can use all or just part of it.

The power density is limited to -41 dB/MHz — a power level lower than even the stray emissions of some TV sets and computers. The commercial services in this band are limited. One of these is the 802.11a wireless local area networks (WLANs) using the 5 GHz band. With such low power signals, the range of a UWB signal is severely limited to no more than 30 meters (about 100 feet) max. That practically eliminates interference.

UWB is just now being developed. Its real value is that it can achieve very high digital data rates — far faster than other wireless techniques. Wireless LANs like the IEEE 802.11g and 802.11a standards have a maximum data rate of 54 Mbps. With UWB, data rates exceeding 100 Mbps can be achieved. If the range is restricted to only a few feet, the data rate can be as high as 500 Mbps. The current goal is 110 Mbps at 10 meters.

Higher rates have shorter ranges and vice versa. UWB is currently being studied and considered for an industry standard. The IEEE 802.15.3a personal area network (PAN) working group is working toward a standard that will greatly expedite its acceptance and deployment.

To date, few practical products are available. Only now are semiconductor manufacturers beginning to make chip sets for real applications. One available now is the Xtreme Spectrum (**www.xtremespectrum.com**) Trinity chip set shown in Figure 4. It is designed to achieve the 100 Mbps rate at a range of up to 10 meters.

Expected applications are to interconnect consumer home entertainment equipment — especially video — which requires very high data rates. UWB will also be used in cheap, short range radars for automotive applications. Some other companies making UWB chips include Philips Semiconductor/General Atomics and Time Domain. **NV**

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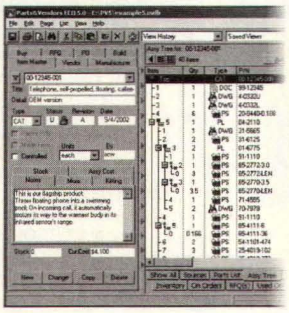

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by Jon Williams

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

Stamp Applications

Color Me Tickled

I've been around BASIC Stamps and other microcontrollers long enough that I really should be jaded, but from time-to-time a really neat device comes along. Neat new devices are like great golf games — one good one can make you forget all the bad or boring ones for the past several months.

Back in December, I was in our California office when a package arrived from a company called Bueno Systems. Inside was a bunch of plastic pieces that I dutifully assembled into what turned out to be an M&M® candy sorter. You can see a picture of this cool little machine on page 63 of the new Parallax catalog. This thing is way beyond entertaining, as it loads an M&M into a scanner, "looks" at it, and then sorts it into a specific bin for that color.

At the heart of this device — and the subject of this month's article — is the TCS230 color sensor from TAOS (Texas Advanced Optoelectronics Solutions). The TCS230 is similar to the TSL230 that both Scott Edwards and I have discussed in this column in the past. It is a light-to-frequency converter.

The difference is that the TCS230 uses an array of photo detectors — some have red filters, some green, some blue, and the rest have no filters. Using two pins, we can select which set of detectors are enabled. What this lets us do is "see" a particular primary color (or overall level if no filter is selected).

In case you forgot your high school science lessons (or you haven't been through them yet!), let's take just a second to talk about light color theory. When all the frequencies of visible light are mixed together, we get white. The three primary constituents of white light are red, green, and blue. By mixing red, green, and blue in varying proportions, we can create any color. A great example of this RGB color mixing is your television. In fact, if you get very close to the screen, you can actually see the individual red, green, and blue pixels that make up each color point on a TV scan line.

Getting back to the TCS230 ... it can't actually "see" color — it simply measures light intensity. What happens is that a given filter only allows that particular primary color to pass through, blocking the others. When we select the red filter, for example, only red light passes through so we can measure the intensity of the red light that is falling onto the TCS230. By repeating this process for green and blue as well, we're able to analyze the color that the TCS230 "sees." The color is expressed with the three values of R-G-B.

It turns out that the folks at TAOS are also fans of BASIC Stamps, so they've created an application kit for the TCS230. The kit includes the sensor mounted on a PCB with a prefocused lens, clear LEDs for illumination, and a separate adapter board that plugs into the AppMod connector on the Parallax Board-of-Education. The adaptor allows the BASIC Stamp to control two sensor PCB assemblies.

For simplicity, we're going to connect directly to the sensor board. This will let us decide which pins we want to use to control and

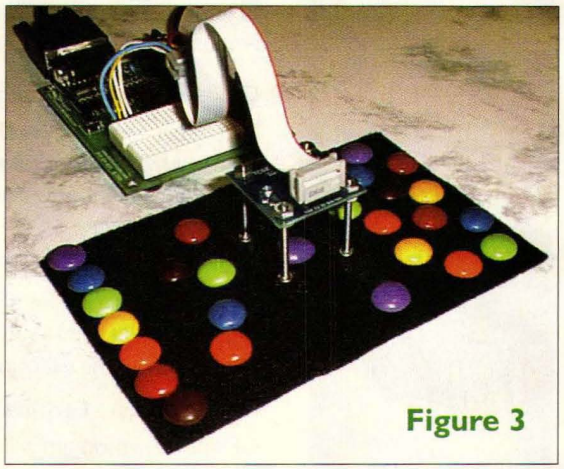

Figure 3

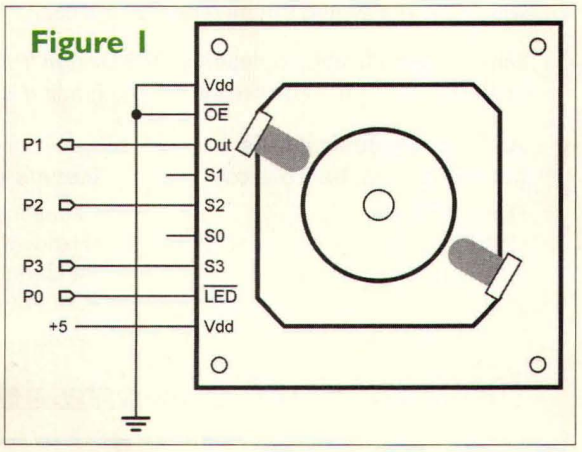

Figure 1

read the TCS230 — and we can use fewer pins. Using this minimal configuration, we need just four Stamp I/O pins to select the color filter, enable or disable the LEDs, and to read the frequency output of the TCS230.

Figure 1 shows the connections for our code. There are pull-ups on the PCB so the pins that are not connected actually get pulled high. Of note are pins labeled S0 and S1, which are used to divide the frequency output of the TCS230. Left unconnected, the output frequency is not divided.

It's important to point out that in very bright conditions, the output frequency of the TCS230 can exceed the capabilities of the BS2's **COUNT** function. In my experiments in "typical" ambient light, I haven't found this to be a problem. The sensor PCB does have a couple of open jumper connections so you can hard-wire the divider selection if you decide you need to do that, and don't want to control the divider from the BASIC Stamp.

Okay, let's get to the code and see how we can use the TCS230 to scan and identify specific colors. Now, even if you're not interested in color identification, you may want to stick with me here because there are a couple neat tricks in this program that have applicability in a lot of projects. Okay? Let's go.

Workin' Our Plan

Since I followed my "plan your work, work your plan" system I ranted about a couple months ago, let's start with our project's goals:

1. Calibrate the sensor for white (white balance).
2. Scan and store known color samples.
3. Scan and identify unknown samples.

If you've never operated a video camera, you may not have come across the term "white balance." What this is, essentially, is telling the system, "This is white." In theory, white light is composed of equal amounts of red, green, and blue light, but the truth is that the light sensors in the TCS230 (and our video cameras) are not equally sensitive to the various constituents.

So what we do is put a white target in front the sensor, illuminate it, measure the red, green, and blue levels, then create scaling factors so that the resultant levels for each color when it "sees" white are equalized. What the scaling factors do is account for the variances in sensitivity between the constituent color sensors, as well as any color bias from the illumination source.

How Green Is Green?

Before we can scale our color readings, we have to take them, so let's start with an essential element of the program — reading data from the sensor. Reading any of the constituent colors from the TCS230 is very simple. We select the color filter, turn on the LEDs to illuminate the target, measure the output using **COUNT**, then turn off the LEDs. Here's the code:

```
Read_Color:
   SELECT filter
    CASE Red
      LOW TcsS2
      LOW TcsS3

    CASE Green
      HIGH TcsS2
      HIGH TcsS3

    CASE Blue
      LOW TcsS2
      HIGH TcsS3

    CASE ELSE
      HIGH TcsS2
      LOW TcsS3
  ENDSELECT

  TcsLeds = IsOn
  COUNT TcsFreq, ScanTime, rawColor
  TcsLeds = IsOff
  RETURN
```

For this routine, we will pass the constituent color selection in the variable *filter*. A **SELECT-CASE** structure takes care of setting the filter control output pins. As you can see, the actual code is shorter than the explanation. The program uses constants for the pin numbers, as well as the scan time used by the count function. Based on the TAOS examples and some experimentation, the scan time in this program is 10 milliseconds. Note that no delay is required between enabling the LEDs and using the **COUNT** function. LEDs are "instant on" devices and don't require any warm-up like incandescent and other light sources.

The value returned by this subroutine is a word variable called rawColor. Remember, this isn't scaled for color sensitivity or illumination color bias.

Fractions On The Fly

Beyond the pure "neato" factor of this program, one of the things I like best is the ability to calculate a fractional scaling factor, as required for white balancing the sensor. "Fractions?" you wonder ... "The Stamp doesn't do fractions." Well, yes and no. True, the Stamp doesn't do floating-point math, but we can multiply by a fractional value using the */ (star-slash) and ** (star-star) operators. We're going to use */ here because it allows values greater than one.

How do we do it? Let's say, for example, that we measure a level of 85 and would like to scale that level to 100. We can determine the scale factor with simple math:

factor = target ÷ measurement

Using the numbers above, we'd end up with a scaling factor of 1.176. To get this into a format that can be used by the */ operator, we have to multiply the factor by 256. Since the math we're doing is straight division and multiplication, we can actually rearrange the order a bit to

make it BASIC Stamp friendly and eliminate the integer-math truncation of the fractional part:

factor = target x 256 ÷ measurement

What we'd end up with using 85 as our measurement and 100 as the target, is 301. Going back, 301 divided by 256 is 1.175 — pretty close to the 1.176 we calculated earlier.

To white balance the sensor, then, we must place a white target in front of it, read each of the constituent colors, and then calculate scaling values for each of them.

```
White_Balance:
  filter = Red
  GOSUB Read_Color
  calRed = ScaleMax * 256 / rawColor
  filter = Green
  GOSUB Read_Color
  calGrn = ScaleMax * 256 / rawColor
  filter = Blue
  GOSUB Read_Color
  calBlu = ScaleMax * 256 / rawColor
  RETURN
```

Easy, huh? And yet, very useful in this and other projects where we want to scale a [linear] input value to a specified maximum. Okay, now that the sensor knows what white looks like, we need to "teach" it the various colors we want to identify later.

Now that we have scaling factors for the constituents, reading the calibrated RGB colors is a no-brainer:

```
Read_RGB:
  filter = Red
  GOSUB Read_Color
  redVal = rawColor */ calRed MAX ScaleMax
  filter = Green
  GOSUB Read_Color
  grnVal = rawColor */ calGrn MAX ScaleMax
  filter = Blue
  GOSUB Read_Color
  bluVal = rawColor */ calBlu MAX ScaleMax
  RETURN
```

I added in the MAX functions so that slight variations between the ambient light during testing versus white balancing won't cause a roll-over error. In my version of the program, the color values are bytes and the ScaleMax value is 100. Using the MAX function is particularly important if you decide to bump ScaleMax to 255 — you certainly don't want your readings rolling over to zero.

When you download the full listing, you'll see a color table built into the program and may wonder why we can't just use that. There are a couple really good reasons, actually. You may want to scan different colors, and even if you wanted to scan the same as I did, the lighting in your office will probably be different than in mine (ambient light affects the overall reading). And at the end of the day, anyone who has ever worked in quality control will tell you that you must make sure your test equipment is calibrated before you can use it. So let's calibrate our color scanner.

```
Calibrate_Colors:
  FOR colIdx = 0 TO (NumColors - 1)
    DEBUG CLS, "TCS230 Color Calibration: "
    GOSUB Print_Color
    DEBUG CR, CR, "Insert sample. Press a key to scan..."
    TcsLeds = IsOn
    DEBUGIN inKey
    GOSUB Read_RGB
    eePntr = Colors + (3 * colIdx)
    WRITE eePntr, redVal, grnVal, bluVal
  NEXT
  DEBUG CLS
  RETURN
```

The routine will loop through the number of colors set by the NumColors constant (the values are zero-indexed, hence the NumColors — one end control value). For each color in the table, we'll see a message screen that looks something like this:

```
TCS230 Color Calibration: Brown
Insert sample.  Press a key to scan...
```

The color name also comes from a **DATA** table, and I'll explain that in just a moment. The sensor LEDs are lit to help with alignment of small items, and after inserting the sample, you press a key (read with **DEBUGIN**), the color gets scanned, then the RGB data is stored in EEPROM. A pointer to the location of the data (the red component) is calculated using the beginning of the table (Colors) and the color index. The values are stored using a multi-byte **WRITE** statement.

Printing string names is nothing new, but I do want to share a little pointer that can be used to save space in your programs. The string names are stored with zero-terminators like this:

```
' Color Names

CN0             DATA    "Brown", 0
CN1             DATA    "Red", 0
CN2             DATA    "Orange", 0
CN3             DATA    "Yellow", 0
CN4             DATA    "Green", 0
CN5             DATA    "Blue", 0
CN6             DATA    "Violet", 0
```

Okay, here's the code that prints the color names:

```
Print_Color:
  LOOKUP colIdx, [CN0, CN1, CN2,
                  CN3, CN4, CN5, CN6], eePntr

Print_String:
  DO
    READ eePntr, char
    IF (char = TermChar) THEN EXIT
    DEBUG char
    eePntr = eePntr + 1
  LOOP
  RETURN
```

What I want to point out is that this is two subroutines in one, accomplished by creating two entry labels. The reason for this is that the first entry will **LOOKUP** the value of eePntr based on the color index, the second section will simply print the string. By doing this, we have a specific routine to print the color name, and a general-purpose routine that will print any string we point to. By "stacking" these routines so that the first falls into the second, we don't have to use **GOSUB** to call the second from the first — this saves space on the **GOSUB** stack.

The last bit of hard work is comparing the RGB data table to see if we can match the current scan values. Here's the subroutine that handles the search:

```
Match_Color:
  colIdx = 0
  DO WHILE (colIdx < NumColors)
    rgbIdx = 0
    DO WHILE (rgbIdx < 3)
      eePntr = Colors + (colIdx * 3) + rgbIdx
      READ eePntr, testVal
      testVal = ABS(testVal - rgb(rgbIdx))
      IF (testVal > ColorThresh) THEN EXIT
      rgbIdx = rgbIdx + 1
    LOOP
    IF (rgbIdx = 3) THEN EXIT
    colIdx = colIdx + 1
  LOOP
  RETURN
```

Though not too long, it looks a bit complicated. Structurally, there are two loops: the outer loop indexes through the color table, and the inner loop indexes through the three RGB components. The inner loop starts by reading the current constituent (R, G, or B) from the table, then compares it to the constituent of the scan. An array for the scanned constituents is created using that aliasing trick I showed you back in April.

```
redVal          VAR     Byte
grnVal          VAR     Byte
bluVal          VAR     Byte
rgb             VAR     redVal
```

By aliasing rgb to redVal, we can access the constituent colors as rgb(0) for red, rgb(1) for green, and rgb(2) for blue.

The comparison result ends up in testVal. Notice that we use the **ABS** operator in case the test value is less than the constituent we're comparing it to. The idea is that we're looking for an absolute variance — not just in one direction — but in both.

If the variance between the test value and the constituent color is greater than that specified by the ColorThresh constant, the inner loop will be terminated with **EXIT** and the outer loop will index to the next color. If we do happen to match all three colors, the inner loop will terminate on its own, and the outer loop will be terminated by a comparison that checks the value of rgbIdx. The value of colIdx holds the match color. If we don't find a match, the outer loop will terminate by itself, and the value of colIdx will be the same as NumColors — indicating that no match was found.

The color match routine is the trickiest part of the program, so give it a few minutes to sink in. And keep in mind that it is "tunable" with the ColorThresh constant. You can make the routine "looser" by increasing the ColorThresh value, or "tighter" by decreasing it.

Now that the hard work is out of the way, the main program loop is simple:

```
Main:
  DO
    GOSUB Read_RGB
    DEBUG "RGB = ",
          DEC3 redVal, ", ",
          DEC3 grnVal, ", ",
          DEC3 bluVal, "  "

    GOSUB Match_Color
    IF (colIdx < NumColors) THEN
      GOSUB Print_Color
      DEBUG CR
    ELSE
      DEBUG "No match", CR
    ENDIF

    PAUSE 1000
  LOOP
  END
```

The main routine is a simple loop that scans the current target, prints the RGB color values, then displays the color name if a match was found — otherwise it prints "No match." Figure 2 shows what the program display looks like when running (the "No Match" lines occur between samples being placed under the sensor). You can see my set-up in the photo. I used a piece of black felt to eliminate reflections from the table, and for fun, I decided to scan M&Ms again. M&Ms are convenient since they come in seven colors, they're easy to acquire (you can run to any corner store and pick them up), and when you're done and tired of scanning them, you have a treat. You can't beat that. Just be sure to use the "plain" variety as the peanut M&Ms have a tendency to roll around too much!

Have fun with the TCS230 and do buy an extra bag of M&Ms so that you can snack while experimenting. I'll see you next month. Until then, Happy Stamping. NV

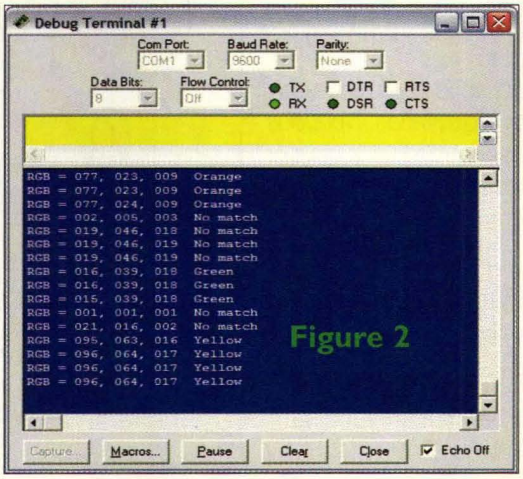

Figure 2

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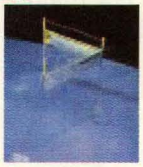

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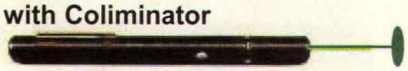

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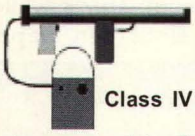

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News Bytes

Intel Researchers Teach Computers to 'Read Lips' to Improve Accuracy of Speech Recognition Software

Intel Corporation researchers now have software under an open-source license that allows developers to build computers that see and "read lips" the way humans do to better understand spoken commands.

Today's speech recognition algorithms work well when background noise is eliminated or a well-tuned headset is used, but their accuracy rapidly degrades when applications have to cope with noisy environments, such as public places.

Combined with face detection algorithms from Intel's OpenCV computer vision library, Audio Visual Speech Recognition (AVSR) software enables computers to detect a speaker's face and track their mouth movements. Synchronizing video data with speech identification enables much more accurate speech recognition, enhancing a wide variety of computer applications in noisy environments.

Faster microprocessors, falling camera prices, and 10 times more video capture bandwidth from technologies like USB2 are all enabling real-time computer vision algorithms to run on mainstream PCs. OpenCV is designed to increase innovation in this field by providing source code for a wide range of computer vision and imaging functions. Since its release in 2000, OpenCV has seen over 500,000 downloads of code and has attracted more than 5,000 registered members to its user group.

Developers are using OpenCV code in applications ranging from toys to industrial manufacturing. The software includes C source code for all of the library's functionality and a royalty-free redistribution license. Information about AVSR can be found at **www.intel.com/research/mrl/research/avcsr.htm**. The OpenCV web site is located at **www.intel.com/research/mrl/research/opencv/**.

Intel has developed a uniquely decentralized research model with more than 70 labs located around the world. The majority of the AVSR software team resides at Intel China Research Center in Beijing, China. Established in 1998, the center currently employs more than 40 computer research scientists and engineers working in research areas such as computer vision, media, Bayesian networks, compilers, and tools.

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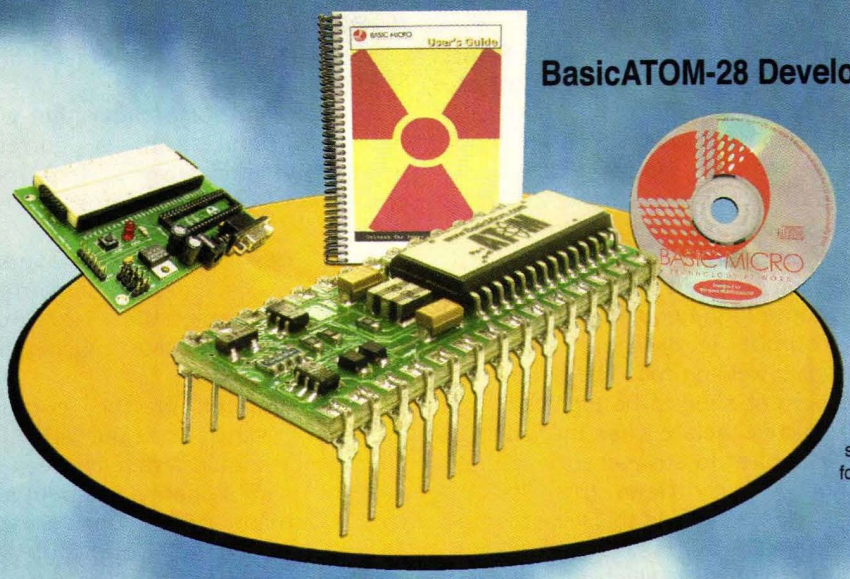

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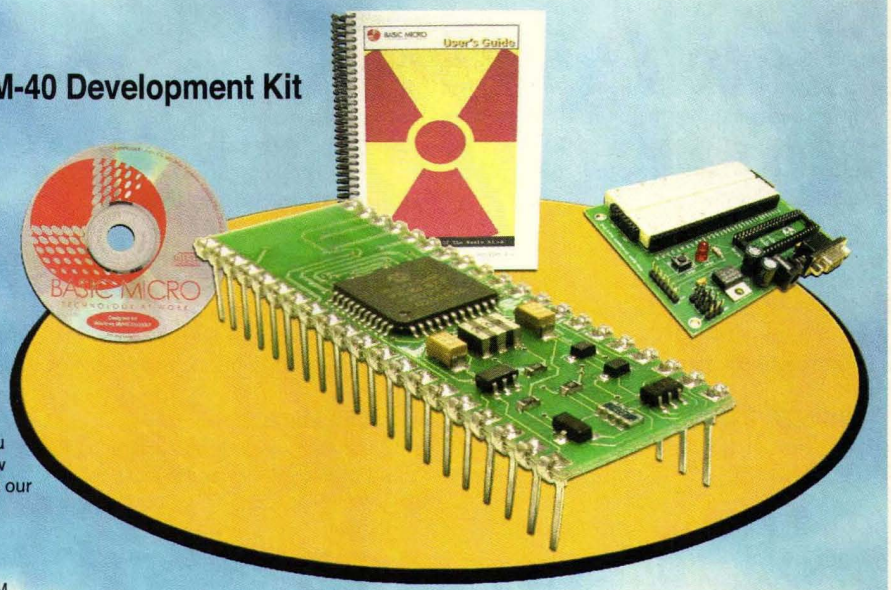

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Circle #61 on the Reader Service Card.

Tech Forum

QUESTIONS

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 that would correct this problem? Please reply via JPEG.

#6031 **Ken Schultis**
via Internet

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

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

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

#6032 **Ryan**
via Internet

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

What I need is a means of injecting a high-frequency signal into the output leads going to the handheld welding rod. The frequency and current need to be high enough to help start the arc when the welding rod is applied to a metal surface that is not perfectly clean (rust, scale, paint, etc.). I am told this will smooth the welding process when working with hard-to-start electrodes — by acting as a pilot arc, so to speak.

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

#6033 **Gordon McKittrick**
Havre, MT

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

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

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

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

#6034 **M. Harker**
via Internet

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

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

#6035 **John Bristow**
via Internet

I'm building the temperature probe project that was in the April '03 issue for monitoring a saltwater tank. I'd like to be able to log the data in a semi colon separated format at five-minute intervals. Can anyone provide the code changes to make this possible? This would make the cheapest data logger I have seen.

#6036 **Richard Shelley**
via Internet

What is the best way to make a soft power switch for a microcontroller (i.e. a momentary

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

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ANSWER INFO

- Include the question number that appears directly below the question you are responding to.
- Payment of $25.00 will be sent if your answer is printed. Be sure to include your mailing address if responding by email or we can not send payment.
- Your name, city, and state, will be printed in the magazine, unless you notify us otherwise. If you want your email address printed also, indicate to that effect.
- Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

QUESTION INFO

To be considered

All questions should relate to one or more of the following:

1) Circuit Design
2) Electronic Theory
3) Problem Solving
4) Other Similar Topics

Information/Restrictions

- No questions will be accepted that offer equipment for sale or equipment wanted to buy.
- Selected questions will be printed one time on a space available basis.
- Questions may be subject to editing.

Helpful Hints

- Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
- Write legibly (or type). If we can't read it, we'll throw it away.
- Include your Name, Address, Phone Number, and Email. Only your name, city, and state will be published with the question, but we may need to contact you.

button-press latches power to a microcontroller which can then power itself down after a predetermined time)? Is there a name for this type of functionality?

#6037 **Bob**
via Internet

I'm looking for a PWM DC motor controller for a 12-volt blower motor that draws about 13 amps at 12 volts. This motor has the negative wire permanently bonded to the frame (welded), so I do not have a two-wire connection.

All of the circuits that I've found only handle about six amps, require a two-wire connection out to the motor, a separate ground, but have a common plus. Can anyone help?

#6038 **Dave Eastman**
via Internet

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

#6039 **via Internet**

ANSWERS

[3035 - MAR. 2003]

I have several Ademco burglar alarms that send signals to central stations using a digital signal similar to a modem. I want to use a computer and modem to receive this signal, but don't know how to develop handshake signals.

#1 I have been a burglar-alarm technician for over 25 years, and am quite familiar with the Ademco line.

The Vista panel can transmit data in several formats, but they all follow the same basic protocol:

Handshake, data, repeat data, and kissoff.

The handshake is a two-three second tone of either 1,400 (low speed standard) or 2,300 Hz (Sescoa/Radionics), sent by the receiver to the dialer. This prompts the communicator to send its data at 10 pulses/sec (low speed) or 20 pulses/sec (Sescoa/Radionics). The pulse frequency is 1,900 Hz.

1 pulse = digit 1, 2 = 2, etc. A zero (0) is represented by 10 pulses.

Depending on the format (3+1, 4+1, or 4+2), the pulses define a "3" or "4" digit account number followed by a "1" or "2" digit event code. These are defined in the program of the communicator and can mean anything you wish, although there are industry standards.

The receiver then sends a kissoff (same frequency as a handshake) to the dialer if it received two successful transmissions of the data. The dialer then hangs up.

There are also two forms of transmissions that use standard DTMF (Dual Tone Multi-Frequency) for data. These are faster (three seconds vs. 15 seconds for transmission), but one of them (contact ID) does not allow customizing of the codes.

Laurence Ray Reville
Cabot, AR

#2 As a former Test Engineer for a major security manufacturer, I had to deal with testing digital dialer formats with panels from the 80's and 90's time period. The quick answer to your question is: You probably can't do what you want with a modem. Most security control panels from that era transmitted in very rudimentary formats known as 3+1 or 4+2. The "3" or "4" would be the account number and the "1" or "2" would be the alarm code(s). The handshake was simply a steady tone of 1,400 Hz or 2,300 Hz, depending on the format. I don't recall the exact duration of handshake required, but it was somewhere around 0.5 seconds to one second. There are many "flavors" of these formats with subtle differences, but they are all pretty easy to hack if you have access to a digital storage oscilloscope. After detecting a proper handshake, the control panel would respond by pulsing a carrier tone on and off. The carrier frequency was usually 1,800 or 1,900 Hz, depending on the actual format being used. Basically, to send the message 1234-56, the control would pulse the carrier on and off one time, followed by an "inter-digit" delay, then send two pulses followed by the same delay, then 3, 4, 5, 6. This "round" was generally repeated after an "inter-round" delay, after which the control waits for the ACK from the receiver (the same frequency and duration as the handshake). If it had no further data to send, it would then hang up. If it had further data, the process would repeat. Decoding this info is simply a matter of counting pulses while taking note of the appropriate delays. You can manually handshake and kissoff a panel while viewing the data on your scope. You'd need to inject an appropriate tone signal (maybe using a simple 555 circuit). But again, a modem won't do

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these formats. If you are intent on doing this, I would suggest a PIC micro and the CCS PCW C compiler, or perhaps one of the Basic modules that are so readily available.

Ademco also developed a format known as Contact ID, which is based on DTMF digits for the alarm codes and 1400-2300 handshake/kissoff tones. This has become something of a standard today, and the alarm codes are predefined (unlike the 3+1/4+2 formats, which are *not* defined). You would come closer to being able to use a modem to detect this format, but I seriously doubt you can do it. It is much easier to decode — just use a DTMF decoder and read the digits as they come in. If your panels can do this format, you might want to enable it and work with it.

You might find it helpful to download the installer's manual for your Ademco panel (or one close to it) at **www.ademcoint.com/**. I believe the Contact ID codes are listed in these manuals.

Joseph Ellis
Valdese, NC

[3036 - MAR. 2003]

I have a remote control for TV, VCR, and other equipment made by Turtle Beach that has the capability of also controlling X10 products. The setting for X10 is software controlled and I need instructions on how to set the house code on the remote.

Since it's an X10-enabled remote control, I'll relate how mine works, maybe yours will work the same or you can figure out something similar.

Setting House Code:

Press and release the X10 button.

Press and hold Setup until the LED lights steady, release.

Use the number buttons to enter the house code: A=1 ... P=16 used by your X10 transceiver (this takes the remotes RF and converts for use by the power-line modules).

Press Enter when done.

After that, it's just select device and function:

Press and release the X10 button.

Enter device number on keypad (leading zero not required).

Press function:

On: CH +
Off: CH -
Bright: Vol +
Dim: Vol -
All lamps on: power
All modules off: mute

Your Turtle Beach remote may use different buttons.

Don't forget to press another device button (VCR, CBL, DVD, or satellite) or you'll wonder why the lights go off!

Rick Detlefsen
Austin, TX

[4031 - APR. 2003]

Is there a simple way to generate or simulate a BPSK or QPSK signal for students in my lab? I'd love to be able to show them the modem constellations from the modem, but doing so is proving to be quite difficult.

Why not hook up a computer with modem to the web and tap into the phone lines with an oscilloscope to watch the packets? That and/or an old external Hays modem using software to change the settings that alter the program to produce the different packets? I know my old software had settings in the GUI to change how things work for different hook-ups.

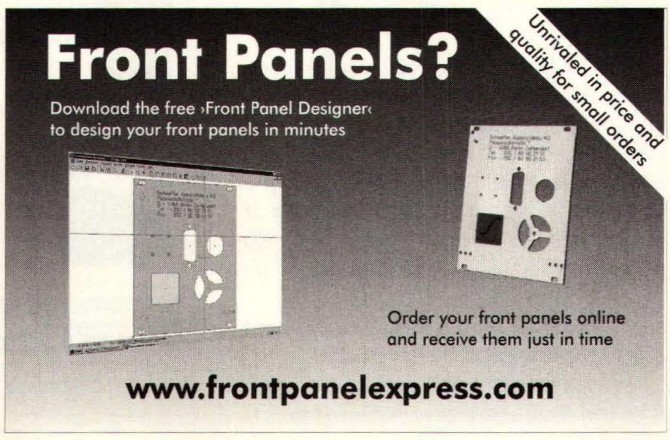
Chris
Bieber, CA

[4032 - APR. 2003]

What are the most important details to deal with video by phone lines? What is a good source of information?

#1 Videophone engineers deal with the same obstacles today as they did back in 1927 when Bell System scientists demonstrated a crude contraption capable of sending video information across telephone wires. Specifically, cramming about 6MHz of video and audio information into the 3KHz of audio bandwidth (about 33Kbps maximum data rate) achievable on a telephone line. Though devices that are available today have achieved impressive technical results, none have adequately achieved the video and audio quality (resolution, frame rate, delay, color, and audio fidelity) needed to convince consumers that Videophones are ready for prime time.

Modern designs use the ITU H.261 standard and start by digitizing the video frame to 176 pixels x 144 lines.



This is already less than 1/9 the spatial resolution that you might see on a broadcast video image. The frame rate (temporal resolution) is reduced by at least 50% to 30 frames per second and usually to as little as four FPS. Even if this image were not further compressed for transmission in 3KHz of bandwidth, it would be a very low-res image with motion usually described as "jerky."

To further reduce the amount of digital information required to transmit the video portion, video compression techniques take advantage of both spatial and temporal redundancy. Temporal redundancy is reduced first by using similarities between successive pictures. As much as possible of the current picture is created or "predicted" by using information from pictures already sent. When this technique is used, it is only necessary to send a difference between video frames. Spatial compression relies on similarities between adjacent pixels of the picture.

Through the magic of mathematics involving something called a Discrete Cosine Transform (DCT), 8 x 8 blocks of pixels are reduced to a mathematical representation that requires relatively little bandwidth to communicate.

When implemented for phone-line transmission, this technique results in pictures that are often described as "blocky." Further, errors can occur in the transmission that distort the entire block for a duration of several frames.

Telephone users expect at least telephone-quality audio. Nonetheless, modern designs compromise some audio quality by using the ITU G.723 standard which requires about 6Kbps of the 33Kbps datastream for audio. Further, the relatively lengthy transmission times and decompression latency for the video, tend to cause what is called a loss of "lip sync." Attempts to delay the audio usually make normal conversation difficult.

Since AT&T demonstrated their PicturePhone at the 1964 World's Fair, it has been apparent that most consumers don't wish to be seen by the person they are calling and engineers have not discovered any magic of math to overcome that problem.

Search the web for H.261 for a wealth of information on the subject.

John Montalbano
Middletown, NJ

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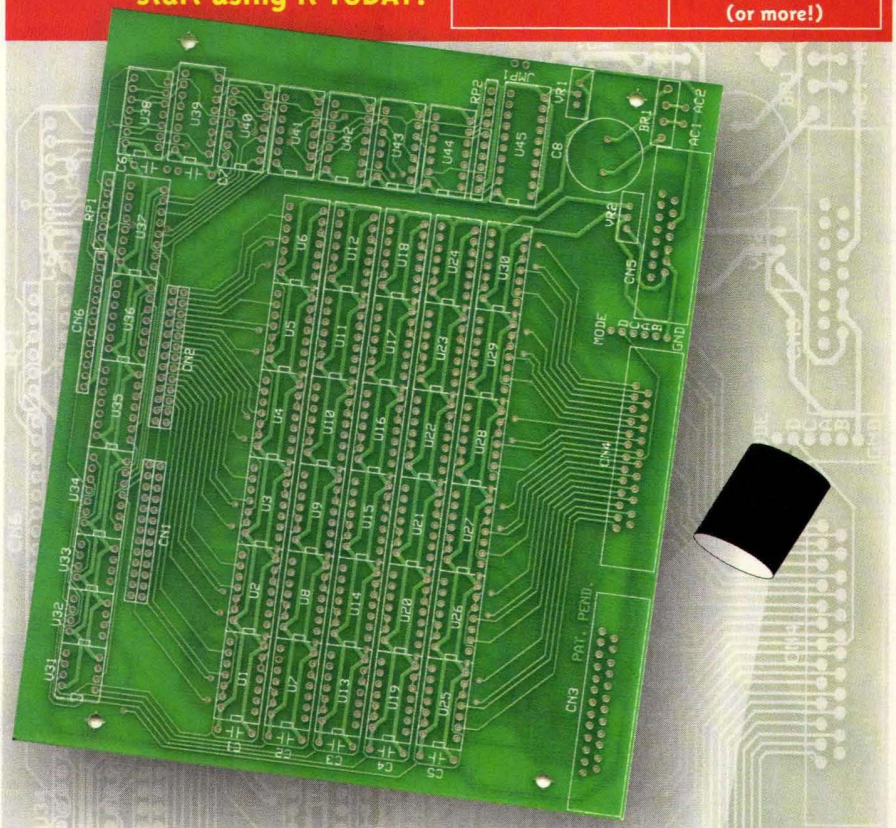

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ADV_12

#2 1) Bandwidth; 2) BandWIDTH; 3) Did I mention BANDWIDTH?

Back in the 1960s, the "picturephone" used three extended bandwidth phone pairs to get the bandwidth needed for their black & white image.

Today, digitized images in color are compressed to get some sort of motion out of the limited bandwidth. Note that the new cell phones with cameras only send stills! Bandwidth for those is even less than for wired phones.

J. D. Arbaugh
Pearblossom, CA

[4036 - APR. 2003]

Is there any translation software and external hardware adapter which allows a Mac printer (HP Deskwriter 320) to be connected and used with WIN ME or XP-based laptop computers?

There are two questions that need to be answered in order to use the HP Deskwriter 320 with Windows ME or XP. The first is how to connect the printer mechanically and electrically, and the second is how to select a good device/printer driver.

After doing a search on the web, there were two pages that came up with solutions to the connection issue. The first solution was to use PhoneNet PC to do the connection, but I believe PhoneNet is discontinued. The second actually shows pinouts and connections for achieving the desired result. The website follows: **www.pumpkininc.com/content/doc/guide/ag-2.pdf**. Even though I found no copywrite on the document, I feel it is not appropriate to excerpt from it in this forum.

A third method is to use an ethernet printserver that supports serial ports, but I won't go into details, as the hardware costs could be much more than the printer is worth.

Finally, once the connection is made, it becomes probably trial and error to select an existing device driver for HP Deskjets and install it. XP and ME do not support very early Deskjets, and the newer drivers will not work correctly on the serial port, so it will be a bit of a compromise to find a driver that works.

Joe Heck
Wrentham, MA

[4033 - APR. 2003]

It's getting harder to stay in the TV repair business. People are buying new rather than repairing their old sets. In NYC, there are many musicians who need their equipment repaired, with many of the amplifiers still using vacuum tubes. Are there any distributors who sell tubes at wholesale prices? Also where can we find schematics?

#1 I have found the best source of tubes at wholesale prices is International Components Corporation. 1-800-645-9154. In New York, where you are, call 631-952-9595. As for schematics, no problem. Peavey & Fender (along with virtually all other manufacturers) will sell you what you need at surprisingly reasonable prices. You can simply contact them through their websites, or by phone if you prefer. I have repaired instrument amplifiers for years, and was surprised to find out how few tubes actually need changing. Most problems center around some kind of abuse, such as broken-off volume controls, bad jacks, blown speakers, and very simple electronic problems such as dried-out electrolytics and off-value resistors around the output tubes. If you are now repairing TVs and VCRs, you will find that servicing musical amplifiers is a breeze!

Robert P. Kramer
Aurora, IL

#2 I repair guitar amplifiers, PA equipment, and recone speakers for musicians on the weekends as a hobby (I mostly recone speakers now). There are two good books out that I use all the time with a lot of tube amp schematics. One is *A Desktop Reference of Hip Vintage Guitar Amps* by Gerald Weber. And the other is *The Tube Amp Book* by Aspen Pittman.

Peavey Electronics sells a schematic set with about 400 schematics of their amps and PA equipment. It paid for itself a long time ago.

Magicparts.com is a good place to find parts for musical electronics (tube, high-voltage cap, etc.).

You should look into reconing speakers also. Most musicians want the original speaker in their vintage amp. And they are always blowing the PA speakers (or send the speakers to me **jsgaree@adelphiaq.net**).

Jon Garee
Newark, OH

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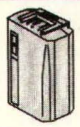

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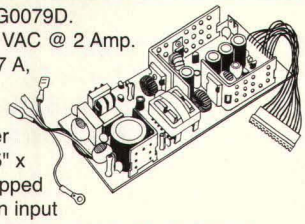

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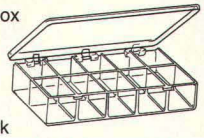

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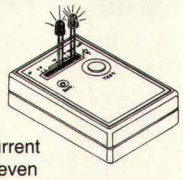

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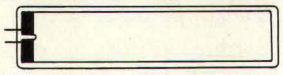

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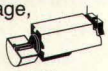
Mini-Vibrating Motor



Panasonic # KHN6ND1A. Low voltage, low current miniature vibrating motor. Operates 1.1-1.7 vdc @ 70 ma. Mounted on the 0.15" long x 0.02" diameter shaft is an easily removable offset weight. Probably used in cell phones for vibrating signal. Body size: 0.55" long not including weighted shaft x 0.28" x 0.28". PC pins.

CAT# DCM-209

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0.86" w x 1.3" h x 0.58" excluding leads. Outer leads are 1.64" long on 0.58" centers. Center wire lead.

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Li-Ion Prismatic Cell

3.7 Volt, 1400 mAh rechargeable lithium-ion cell. Made by Panasonic, the prismatic cell is 1.94" x 1.32" x 0.4" thick. Lithium-ion cells have a very flat discharge curve providing a very stable power output. Further, they don't suffer from the "memory" effect and don't need to be fully discharged before recharging. The cells have been prepped with a small custom circuit that adds approximately another 0.2" to the length of the cell. The circuit can be removed. It was designed to provide spark protection, overcharge protection, filtering and to identify the charger used with the cell. A schematic of the circuit and specs for the cell are available on our website. **CAT# BTE-45**

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AX2500 DC MOTOR CONTROLLER/DRIVER FOR MOBILE ROBOTS

Roboteq, Inc., introduces a microcomputer-based dual channel DC motor controller capable of directly driving up to 120 amps on each channel at up to 40 volts.

The AX2500 is targeted at designers of mobile robotic vehicles including Automatic Guided Vehicles (AGV), Underwater Remote Operated Vehicles (ROVs), combat robots (Battlebots), and robots for exploration, hazardous material handling, and military and surveillance applications.

The controller accepts commands from either standard R/C radio for simple remote-controlled robot applications or serial port interface. Using the serial port, the AX2500 can be used to design fully or semi-autonomous robots by connecting it to single board computers, wireless modems, or wireless LAN adapters.

The controller's two channels can be operated independently or combined to set the direction and rotation of a vehicle by coordinating the motion on each side of the vehicle. The motors may be operated in open or closed loop speed mode. Using low-cost position sensors, they may also be set to operate as heavy-duty position servos.

The controller supports a long list of features, including analog and digital I/Os for accessories and sensors, battery voltage monitoring, thermal protection, programmable acceleration, input command watchdog, and non-volatile storage of configuration parameters.

The AX2500 is built into a robust extruded aluminum case, which also serves as a heatsink for its output power stage. The large fin area ensures sufficient heat dissipation for operation without a fan in most applications.

The AX2500 is available now at $485.00 in single quantities, complete with cable and configuration software.

For more information, contact:

ROBOTEQ, INC.
1601 E. Sharon Dr.
Phoenix, AZ 85022
602-549-7535
Web: **www.roboteq.com**

Circle #37 on the Reader Service Card.

TELEPHONE OR TWO-WAY RADIO

The DTMF-2 gives you eight outputs, which can each sink up to 500mA. Drive relays and other small devices directly. Each output can be latched or momentary with delays from 0.1 seconds to 25.5 hours. Anything from a brief reset pulse to a 24-hour battery charge is possible. Keypad mode allows an output to be active for as long as a key is hit. This is ideal for camera pan and tilt control.

Other features include: Define your own codes of 1-7 digits for each function. Optional login password adds an extra level of security. Non-volatile EEPROM memory for all settings. Acknowledge and tone outputs allow radio PTT/audio and phone line audio tone confirmation of entered commands. Mute output with adjustable hang time. Readback command allows you to query the status of an output. Operates on 6-24 volts. Screw terminals for all connections. Includes case with mounting flanges.

Available for $79.95. For more information, contact:

UDDLE SYSTEMS
Orders **877-733-4351**
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Circle #36 on the Reader Service Card.

SST823, SST824 ULTRA FAST SURFACE MOUNT ANALOG SWITCH

Linear Integrated Systems is expanding its small signal discrete portfolio with another addition to its high-speed DMOS switch family.

LIS announces the availability of a new series of n-channel enhancement mode DMOS analog switches designed for high-speed switching applications which require very low "ON" resistance and low capacitance.

These ultra-fast switches offer improved accuracy, speed, and throughput, with less glitching or distortion than any JFET or multiplexer. Designed for high-frequency RF operation, the SST823 and SST824 offers the unique combination of five ohms "ON" resistance, with a reverse transfer capacitance of 3 pF. The SST823-

824 series features switching speeds of 2 nS turn-on time and a 3 nS turn-off time. The SST823 version switches analog signals up to ±7.5 volts, while the SST824 version switches analog signals up to ±10 volts. Both versions can switch currents up to one amp, and feature integrated ESD protection diodes.

In 100,000 piece quantities, pricing starts at $0.65 for the surface mount package.

These switches are well-suited for high-speed analog, optical, and video switching. Typical applications for the SST823-824 include: laser modulation for fiber optics and video switching, laser diode switching, analog-to-digital converters, digital-to-analog converters, multiplexers, and switch drivers.

For more information, contact:

LINEAR INTEGRATED SYSTEMS
Paul Norton
4042 Clipper Ct., Fremont, CA 94538
510-490-9160 Fax: **510-353-0261**
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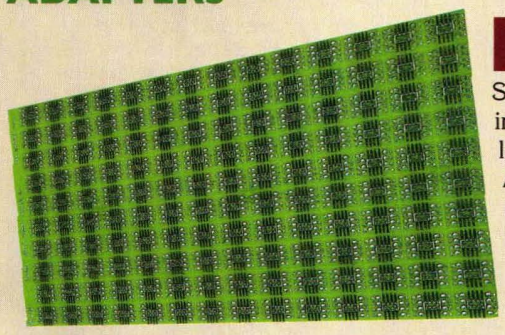
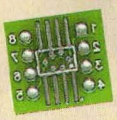
Circle #38 on the Reader Service Card.

CONTROL VIRTUALLY ANYTHING FROM YOUR ECONOMICAL SO8 SMT ADAPTERS





Bellin Dynamic Systems, Inc., introduces our latest Snap-Apart™ SMT adapter board, the P510. The P510 provides 140 SO8 adapters on a 5" x 7.6" PCB that easily snaps apart into individual adapters. The P510 is an economical solution for those and many other projects requiring SO8 adapters.

Bellin Dynamic Systems, Inc., is a provider of rapid prototyping tools for engineering development, including many other styles of Snap-Apart boards like the P510.

The P510 is currently available for $50.00 each.

For more information, contact:

BELLIN DYNAMIC SYSTEMS, INC.
211 S. State College Blvd. #319
Anaheim, CA 92806
Tel: **714-630-8024**
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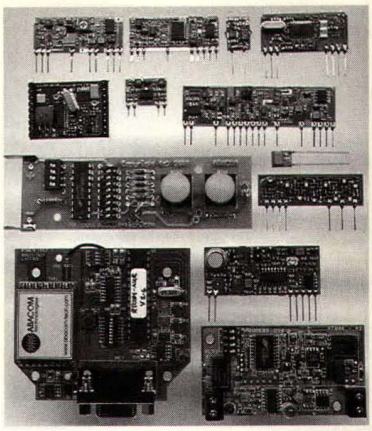

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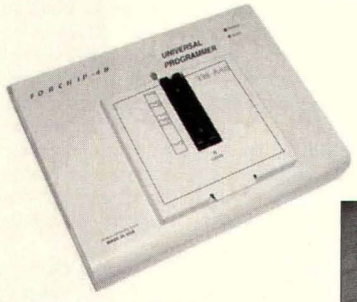

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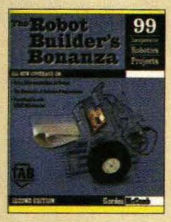
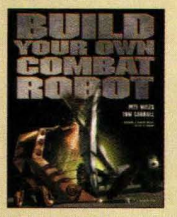
Robotics

The Robot Builder's Bonanza
by Gordon McComb



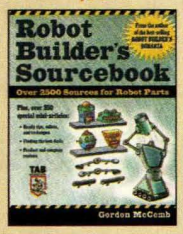
A major revision of the bestselling "bible" of amateur robotics building — packed with the latest in servo motor technology, microcontrolled robots, remote control, Lego Mindstorms Kits, and other commercial kits. **$24.95**

Build Your Own Combat Robot
by Pete Miles / Tom Carrol



Build a powerful and invincible robot for full-blown competition or just for fun using this authoritative robot resource. This team of experts gives you an inside look at the innovative new world of robotic combat, explaining the origins of the sport, as well as all the elements that go into constructing a fighting robot. Learn technical basics from motors and wiring to locomotion, and read builders' true stories from the front lines of robot competition. Whether you're mechanically minded or not, you'll find this book both entertaining and informative. **$24.99**

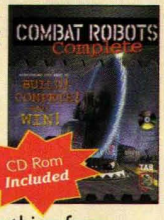
Robot Builder's Sourcebook
by Gordon McComb *NEW!*



Written by Gordon McComb, author of the classic *Robot Builder's Bonanza*, one of the most popular books ever written on amateur robotics, the Sourcebook lists over 2,500 mail-order suppliers and other sources. You'll find detailed information about the resources, including addresses and phone numbers: In short, everything you need to find – and acquire – common and uncommon robotics parts and supplies. In order to provide a true "robotics goldmine," this one-of-a-kind guide also includes:

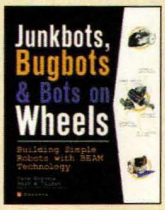
- Dozens of informative "sidebars" to help you understand essential robotic technologies such as motor types, sensor design, and how to select the best materials.
- Scores of relevant articles designed to fill-in informational gaps, stimulate thinking, and help you make the most of all the material the Sourcebook makes available to you. **$24.95**

Combat Robots Complete
by Chris Hannold *NEW!*



Here's everything you need to jump into the fascinating and fun world of fighting robots – even if you don't have advanced electronic or engineering skills. The author — a five-year fighting bot and 20-year bot veteran — offers priceless "insider info" covering everything from step-by-step guidance on constructing your first combat robot to the lowdown on the federations that sponsor or guide competitions. **$24.95**

JunkBots, Bugbots, and Bots on Wheels: Building Simple Robots With BEAM Technology *NEW!*
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.

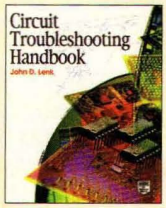
$24.95

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

Troubleshooting

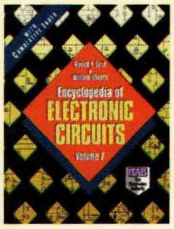
Circuit Troubleshooting Handbook
by John D. Lenk



When it comes to troubleshooting, no other book even comes close — hundreds of circuits are covered in this exhaustive handbook. The result is the most comprehensive and reliable circuit compendium ever assembled. 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**

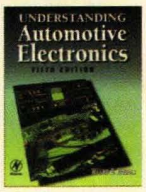
Electronics

Encyclopedia of Electronic Circuits Vol. 7
by Rudy Graf



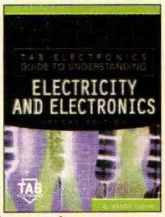
Designed for quick reference and on-the-job use, the Encyclopedia of Electronic Circuits, Volume 7, puts over 1,000 state-of-the-art electronic and integrated circuit designs at your fingertips. This collection includes the latest designs from industry giants such as Advanced Micro Devices, Motorola,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

Understanding Automotive Electronics *Fifth Edition*
by William B. Ribbens



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

Guide To Understanding Electricity & Electronics
by Randy Slone



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2nd Edition by Myke Predko

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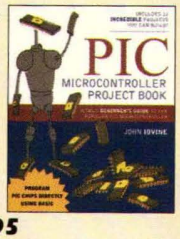
PIC Microcontroller Project Book
by John Iovine

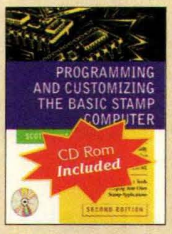


This project-oriented guide gives you 12 complete projects, including: using transistors to control DC and AC motors, DTMF phone number logger and distinct ring detector and router ... home automation using X-10 communications ... digital oscilloscope ... simulations of fuzzy logic and neural networks ... and many other applications. **$29.95**

Programming & Customizing the 8051 Microcontroller
by Myke Predko

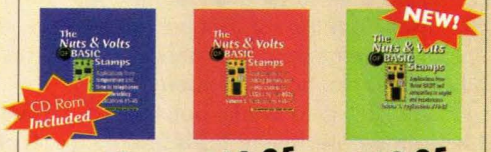
Programming and Customizing the 8051 Microcontroller puts you in control of the 8051's architecture and instruction set — and even supplies a baker's dozen of ready-to-build example applications, programs, and circuits. Best of all, the included CD-ROM supplies source code for the book's experiments and applications. **$39.95**

Programming & Customizing the BASIC Stamp Computer
by Scott Edwards



This edition moves you briskly from electronic foundations through BASIC Stamp "Boot Camps" and an intelligent traffic signal simulation to build a robotic bug with whisker sensors, a time/temperature display, and a data-logging thermometer. **$39.95**

The Nuts & Volts of BASIC Stamps Volumes 1-3



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In 1995, Scott Edwards began authoring a column on BASIC Stamp projects in *Nuts & Volts Magazine*. The column quickly became a favorite of *Nuts & Volts* readers and continues today with Jon Williams at the helm. *The Nuts & Volts of BASIC Stamps* is a three-volume collection of over 90 of these columns.

Volume 3 is new and contains columns 76-92!

Home Entertainment

Build Your Own PC Home Entertainment System
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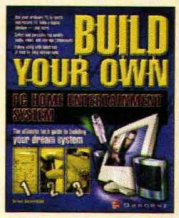
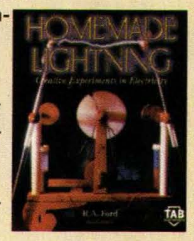


Learn to use PC DVD drives, DVD recorders, and massive hard drives to create a home entertainment system that's comparable to what you'd enjoy from expensive, individual components. Who needs the movies? Now, you can achieve stunning audio and top quality video results through your PC. This book shows you how to build your own home entertainment center using an ordinary PC. Watch and record TV shows and movies, put your entire CD collection on your hard drive, and listen to radio stations from around the world. **$24.99**

High Voltage

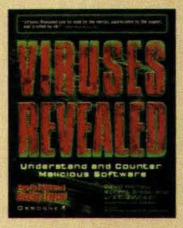
Homemade Lightning: Creative Experiments in Electricity
by R.A. Ford



Enter the wide-open frontier of high-voltage electrostatics with this fascinating, experiment-filled guide. You'll discover how to make your own equipment, how electricity is used in healing, and the workings of many experiments in high potential physics! **$24.95**

Computer Hacking

Viruses Revealed *NEW!*
by David Harley / Robert Slade Urs Gattiker



This detailed guide offers full-scale coverage and analysis of the origin, structure, and technology behind computer viruses, and addresses current methods of detection and prevention. By learning exactly how viruses do what they do, you'll better understand how anti-malware technology works — and be able to evaluate and implement practical solutions to protect your system. You'll get insight into the various types of malicious software — including Trojan horses, macro viruses, and worms — and also learn about virus hoaxes. **$39.99**

Hacking Exposed: Network Security Secrets & Solutions, Fourth Edition
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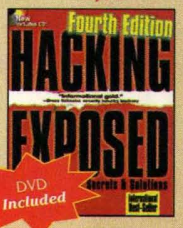

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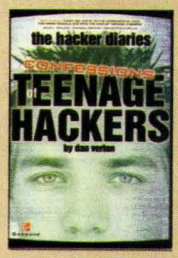
The Hacker Diaries: Confessions of Teenage Hackers
by Dan Verton



Through fascinating interviews with FBI agents, criminal psychologists, law-enforcement officials — as well as current and former hackers — you'll get a glimpse inside the mind of today's teenage hacker. Learn how they think and understand the internal and external pressures that pushed them deeper and deeper into the hacker underground. **$24.99**

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Third Edition by Joe Carr

This revised and updated guide gives you the best ways to design, build, and test today's radio frequency circuits. It's filled with projects and experiments that make it easy to apply RF principles to real-life applications. **$39.95**

by Aaron Dahlen

Stamps Meet Playstation

Be in "Control" of Your Next BS2 Project

This Month's Projects

The Fuzzball Rating System

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

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

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

Let the soldering begin!

Are you looking for a cost-effective user interface for your next BASIC Stamp (BS2) project? Give the Sony Playstation® 2 (PS2) controllers a try. For as little as $10.00, you can have a 16-button serial switch panel in the form of a generic Sony Playstation (PS2) controller. Or, you can control your next BASIC Stamp (BS2) project using the analog joysticks found on the PS2 controllers.

This article outlines the experiments I have performed with the PS2 controller. In the first section, the basic operation and interfacing the PS2 controller to a BS2 is discussed. Then I will demonstrate how to control a four-axis robotic arm (Photo 1) with the PS2 controller via a BASIC Stamp.

An Idea is Born

This idea started as a simple search for a two-axis joystick. I went to the local department store and had no luck finding anything remotely like what I was looking for. But, what I did find were inexpensive generic Playstation controllers with two joysticks built into them. I had no idea if I could get it to work, but for $9.95, it would keep me entertained for a few hours.

When I got home, I opened the controller only to find a silicon "blob" on the board. I obviously needed more information. After a quick search on the web, I found the pin out and basic signal specifications of the PS2 controller. That's all I needed. I fired up my BASIC Stamp 2 Board of Education, and soon I had the PS2 controller and Stamp talking to each other.

Playstation Controller

The Sony Playstation controller (Photo 1) contains two analog joysticks and 16 switches (the last two switches are activated when the joysticks are pushed down). Interface to the BASIC Stamp is accomplished via synchronous serial communications. Synchronous communications is similar to the asynchronous serial communications, such as the COM port found on your computer. It does, however, require a clock signal in addition to the receive and transmit signals. The PS2 controller also requires an "attention" signal before it will respond. This last signal is required since the PS2 controllers are often multiplexed with other controllers or devices on a common buss.

Hardware Connections

The PSX controllers uses a simple synchronous data transfer scheme. It requires four "data" lines in addition to ground and +5VDC. Please refer to Schematic 1.

Data:
Data from the PSX controller to the Stamp. A pull-up resistor R1 is required.

Command:
Commands from the Stamp to the PS2 controller.

Clock:
Synchronous clock under Stamp control — we must invert this signal. Transistor Q1 and resistors R2 and R3 form a NOT gate.

Attention:
Command from Stamp.

Ground:
Connect to the same ground as the BS2 is using.

+5VDC:
Connect to a convenient +5VDC. Do not use the Stamp's Vdd output or you may damage your Stamp!

Some of you may question why I chose to design and code the project using a transistor inverter. Why not develop the inverted clock using software? True — the hardware design would have been simplified. However, my objective was to make this project as simple to understand and implement as possible. With this goal in mind, I believe it is better to add the extra hardware and retain the ability to use the SHIFTIN and SHIFTOUT commands of the Stamp.

Those of you with experience programming the Stamp can challenge yourselves to operate the PS2 controller without the transis-

*The reader must **a)** possess knowledge on programming the BS2. Additional information and many useful examples are available at **www.parallax.com; b)** have access to a PC capable of programming the BS2; and **c)** have access to basic hand tools to access the Lynxmotion kit.*

tor inverter. Figure 1 shows the timing relationship between the signals. Notice that all signals are active low. To start communication, the Attention line is enabled (held low). Then the "send data command" (HEX 01 and 42) is sent using the BS2 SHIFTOUT command. The Playstation controller is then read using the SHIFTIN command.

The Algorithm

The pseudo code algorithm for talking to the PS2 controller is quite simple:

Step 1 - Select the PSX controller by setting Attention low.
Step 2 - Send the start command ($01).
Step 3 - Send the request data command ($42).
Step 4 - Read and discard first byte (this byte indicates if the controller is in analog mode).
Step 5 - Read two bytes of data for switches.
Step 6 - Read an additional four bytes for joysticks data (optional).
Step 7 - Set the attention line high.
Step 8 - Done

The code found in Program 1 displays the PS2 controller data in the Stamp DEBUG window. **(Program 1 can be downloaded from www.nutsvolts.com.)** The output is divided into six columns. A typical output line looks like this:

11111111 11111111 128 128 128 128

This tells you that the PSX controller is up and running — remember to select analog mode or else the last four numbers will all read "255." The first 16 binary digits tell you the status of the individual switches — they are normally high. Any button that is pushed will output a 0. The next four columns indicate the position of the joysticks. The actual number will vary slightly, as the joysticks do not always return to exact center.

As you run this program, you will notice one of the peculiarities of the Stamp. All leading zeros are suppressed so the data will sometimes appear to shift to the left as the buttons are toggled. Figure 2 correlates the PS2 button to their corresponding bit locations.

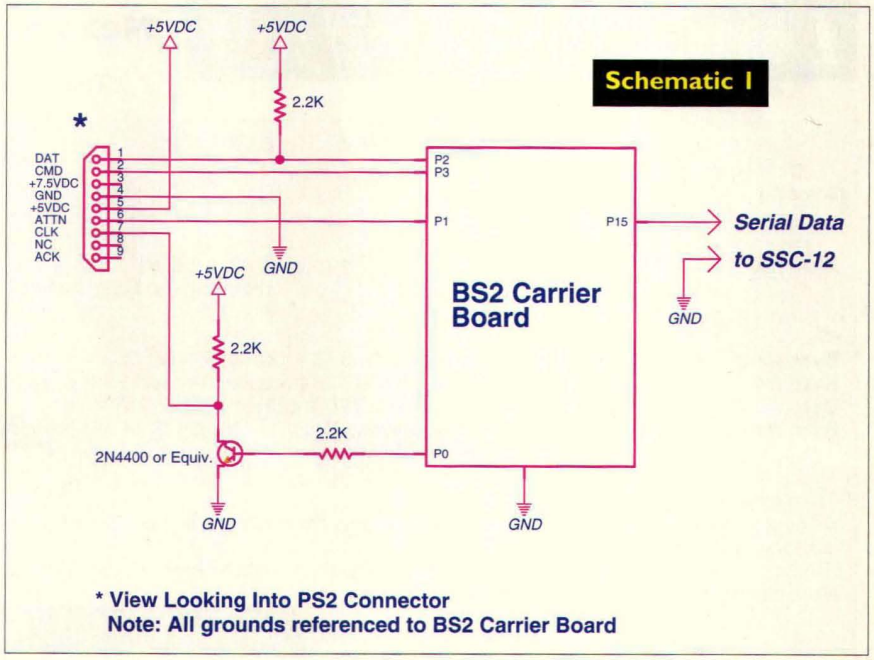
Lynxmotion

After I had the Playstation-to-BS2 interface working, I wanted something challenging to control. That's when I remembered the advertisements in this magazine. I emailed Lynxmotion and received a quick response with some suggestions on how to implement this design. I then purchased a Lynx 5 robotic arm kit, a SSC-12 servo controller, and a Next Step BASIC Stamp carrier board. This is a natural combination with the BS2/PS2 controller, and it really is a lot of fun to play with. The kit arrived complete with all parts and full documentation. I was very impressed by the attention to detail and precision put into the kit. Part identification was easy, as each part is clearly pictured in the assembly manual. I will now give a quick introduction to each of the components used in this project. Then we will get to the specifics of interfacing the robotic arm to the BS2.

Photo 1. Complete project — Lynxmotion Lynx 5 control via Parallax BASIC Stamp with a Sony Playstation controller used as an input device.

Lynx 5 Arm

The Lynxmotion 5 arm has four-axis of motion (base,



shoulder, elbow, and wrist) plus grip. Each joint is controlled by an R/C servomotor. The shoulder joint is composed of two servomotors in parallel for increased torque. The arm can pivot 180° and can stretch out to about 14 inches. It has the strength to pick up small items. The mechanism had very good repeatability. In my experiments, it always returned to the same location — give or take a tenth of an inch.

SSC-12

The Lynxmotion SSC-12 servo controller (Photo 2) greatly simplifies the software requirements in controlling the robotic arm. All five of the servos are connected to the SSC-12 (refer to Block Diagram 1). To control a servo, the BS2 outputs a serial string. A typical BS2 command is outlined below:

SEROUT 15, $4054, [255, 128 + 0, 128]

SEROUT	Serial output command
15	Output data on pin 15
$4054,	9600 baud, eight-pit no-parity, inverted (dec 16468)
255	Attention SSC-12
128	Select servo 0, move it to the new position at a rate equal to 1.27 full range)
128	Set servo to mid position (values range from 1 to 254)

The greatest benefit that comes from using the SSC-12 is speed. Since the SSC-12 remembers the servo positions, there is no need to constantly update the positions. The BS2 can then spend the majority of its time interrogating the PS2 controller. It only updates the servo positions when an appropriate button is activated. This greatly increases the time response to the user commands, making it easier to control the robotic arm.

Be careful when first applying power to the SSC-12. Physically place all the arm joints to their mid-range positions. If this is not done, the servos will violently move until they are at their mid-range positions. Please note this that is not a defect of the SSC-12. It is a problem inherent with R/C servos. There is simply no way of physically knowing where the servo will be when power is first applied. There are other ways of preventing this start-up problem. You could, for example, command the servos to an off-state by sending zeros for position. You could then command each servo to its rest position. I have not included this code in the examples and leave it up to your experimentation.

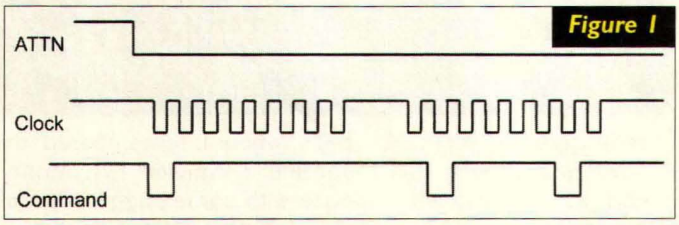


Figure 1

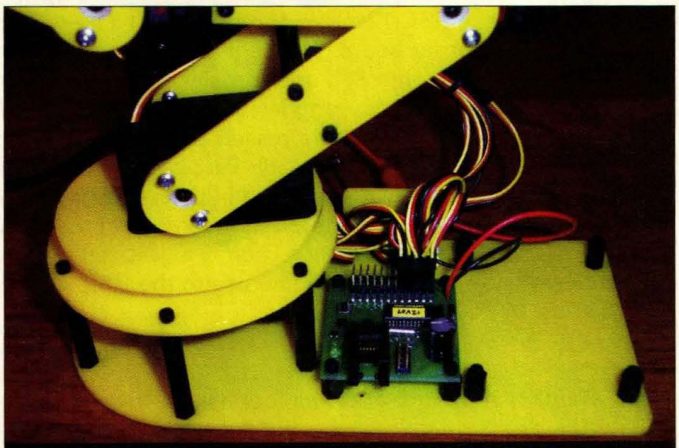


Photo 2. Close-up of the Lynxmotion Lynx 5 robotic arm and the SSC-12 servo controller.

	B7	B6	B5	B4	B3	B2	B1	B0
Byte #1	L ctrl L arrow	L ctrl D arrow	L ctrl R arrow	L ctrl U arrow	Start	* R joy button	* L joy button	Select
Byte #2	Square	X	O	Triangle	R #1 shoulder	L #1 shoulder	R #2 shoulder	L #2 shoulder
Byte #3	* # % Right joystick left / right, 128 = center, 0 = left, 255 = right							
Byte #4	* # % Right joystick up / down, 128 = center, 0 = up, 255 = down							
Byte #5	* # % Left joystick left / right, 128 = center, 0 = left, 255 = right							
Byte #6	* # % Left joystick up / down , values vary from 128 to 255, joystick divided into two sections full up yields 128, mid = 128 or 255, down = 255							

* Analog mode only.
# The joystick data values vary linearly with position. For example, if you were to push the left joystick halfway up, byte 6 would read 64.
% Not all controllers use an eight-bit analog-to-digital converter. There will be seven, eight-bit steps if you use an inexpensive controller.

Figure 2. Playstation to Bit Location.

Next Step Carrier Board

The Next Step board is a solid prototyping board for the BASIC Stamp. It contains two LEDS, two switches, two pull-up resistors, and connections for up to 16 R/C servos.

One of the worst problems faced while coding any project is loose connections. To solve this problem, I wire-wrapped the carrier board onto a large piece of perfboard (Photo 3). To this larger board, I added the connections for the PS2 controller and an LCD display. There is plenty of room left over for future experiments. The socket for the PS2 controller was removed from a MADCATS brand extension cable I purchased at a depart-

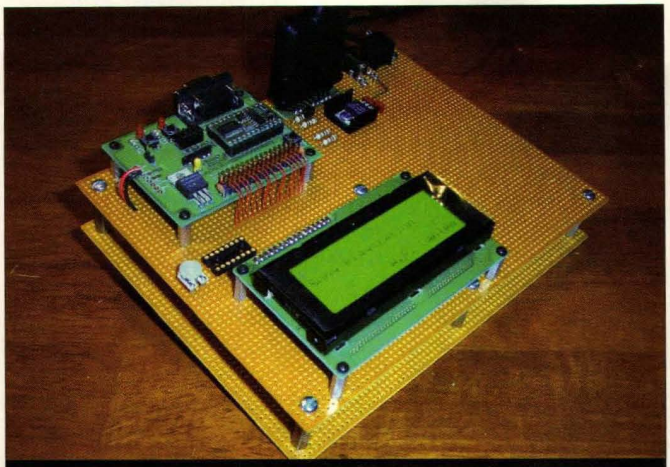


Photo 4. Close-up of the Playstation connection. The +5VDC regulator supplies power to the Playstation controller and the LCD display.

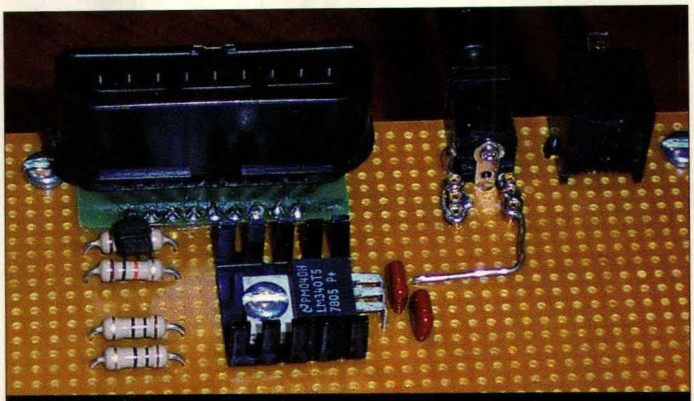


Photo 3. Lynxmotion BASIC Stamp carrier board and connection for Playstation controller mounted on perf board. (LCD display not documented in program examples.)

ment store (Photo 4).

Controlling the Arm

Block Diagram 1 shows how to connect the Lynx 5 to the BASIC Stamp. The code to control the robot arm is included as Program 2 available for download on our website (**www.nutsvolts.com**). Substitution greatly simplifies the code. In the Equates section of this program, each arm movement is assigned to a particular button of the PS2 controller. For example, the O button is assigned to move the base toward the left. Substitution greatly simplifies the process of reassigning the PS2 buttons. If you wanted to swap the directions of base movement, simply swap the equates PS2B2.bit5 and PS2B2.bit7.

The initialization section of this code sets all of the arm position registers to their mid-range positions. This step is required so that the position registers agree with the initial power up positions of the SSC-12 servo controller. As mentioned before, be sure to physically place the arm joints to their mid positions before powering up the arm. This will prevent a jerk at start-up and result in a longer servo life. After the position registers are assigned, they are sent to the SSC-12 sent to servo controller.

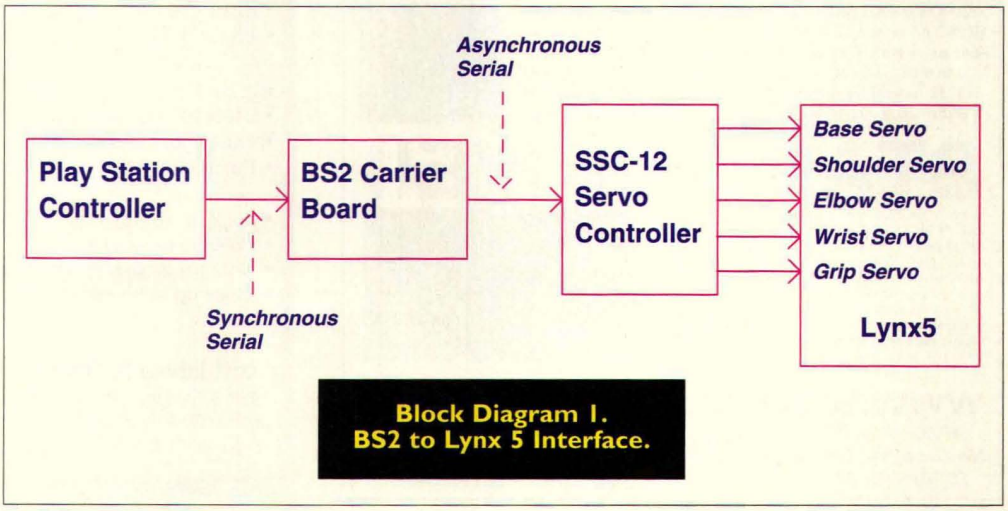
The read_PS2 controller code has been trimmed to accept only the inputs of the 16 buttons. The status of the buttons is stored in bytes PS2B1 and PS2B2. The Equates section of the code is where each button is assigned to a particular movement of the arm. For example, if the operator depresses the Playstation O button, bit 5 of the PS2B2 will toggle indicating an active switch.

The final portion of the code tests if any of the PS2 buttons have been activated. The code labeled is_base_L is typical of each of the button tests. The first line tests the button associated with moving the base left. If active, i.e., logic 0, the code continues with the is_base_L portion otherwise it vectors to the is_base_R routine. The next line tests if the base is at its left most position. For the SSC-12, normal values are 1 to 255. The third line actually changes the position. The last line updates the SSC-12 servo controller, which then updates the appropriate servo.

Several different ways were evaluated to update the servo positions. This straight-line version isn't very elegant, but it worked the best. It has the advantage of speed since the SSC-12 is updated only when an actual change in servo position occurs (serial communication with the BS2 is very slow even at 9,600 baud). This code, as written, also allows for multiple simultaneous arm movements. There is a noticeable slowdown when two or more servos are active.

Final Thoughts

The old adage — you get what you pay for — still holds true. Watch out for cheap controllers. If you are only using the digital functions, go for the cheap controllers and skip the rest of this paragraph. But, if you are using the analog



Block Diagram 1. BS2 to Lynx 5 Interface.

joysticks spend the extra money and purchase a true Sony or other top-model controller. The first reason to spend the extra money is to get full eight-bit resolution on the joysticks. To save money, the inexpensive controller read the joysticks with five-bit analog-to-digital converters. With five bits, you only get 32 steps over the full range of the joystick, whereas a more expensive controller will have 256 steps. Also I have had problems with noisy joysticks. On one $9.95 controller I purchased, neither of the joysticks were stable enough to use predictably.

Wireless controllers are available for the Playstation. I have not tried one, but I see no reason why they would not work in this application.

The Lynxmotion robotic arm performs very well. The SSC-12 servo control is almost a necessity when using the BS2. As a challenge, try to multiplex the PS2 controller with other serial devices — only the attention pin must be dedicated to an individual controller. A serial memory device could be added to the Stamp. You could then "teach" the arm a series of moves. Multiple positions could be stored in memory and then played back later. Keep on coding! NV

Resources

www.stndev.btinternet.co.uk/psxpads.txt
www.stndev.btinternet.co.uk/usb2psx.gif
http://laurent.saintmarcel.free.fr/psx/

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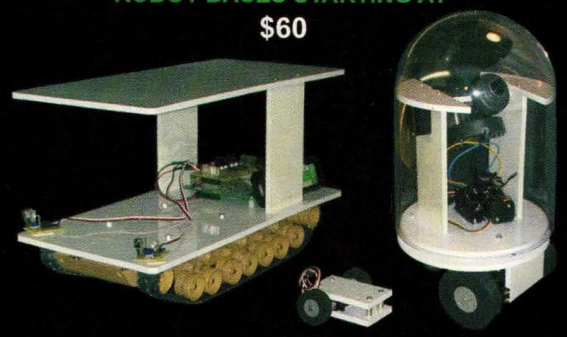
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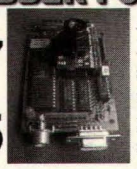
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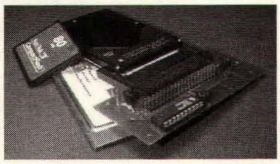
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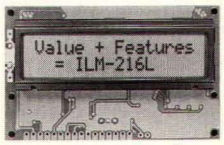

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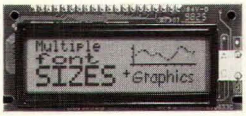

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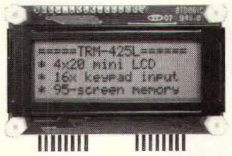

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Autonomouse

The all-too-familiar fear of mice is gone! Build your own "rodent" that's actually fun to have around!

Looking for a fun way to make a small robotic vehicle, and dispose of some of those old mice you may have lying around at the same time? I had about six computer mice in various stages of disrepair, and I didn't know what to do with them. I couldn't bring myself to just throw them away. But then it hit me. I've always been interested in robotics, and autonomous vehicles, so I thought, "What about an autonomouse (note the "e" on the end)?"

I've had a couple of Genius mice over the years, and during the time I had them, they served me well. When they died, I tossed them into a box in the garage with other assorted electronic junk, and there they sat. I don't like to throw things like this away. For one thing, there are some really small switches inside, plus the optical components. Having an interest in robotics like I do, makes you save small switches and mechanisms like this, and I'm sure I'm not the only one who feels this sentiment.

The body of the autonomouse (or robomouse, whatever you prefer to call it) can be any kind of mouse that has enough room inside (once you gut it) to fit a motor, some wheels, and a battery.

Preparing the mouse body

Start by taking the mouse apart and removing all the works inside. Leave the body intact, but remove all support members on the bottom part of the mouse that would have held the ball and supported the PC board. With the Genius, you'll need to cut away a lot of plastic material from the inside of the top cover, as well (where the keys are), otherwise you won't have room for the motor and battery (see Figure 1). Cut off as much as you can with wire cutters and finish off with a piece of sandpaper wrapped around a block of wood. You'll find if you get the inner surface reasonably flat, you'll have just enough room to mount a small motor and battery. Also, you should cut off the small extensions on the underside of the keys. These are the pads that contact the small buttons on the PCB. Cutting them out will give a little more room for the obstacle sensing switches and control board.

Obviously, with so little space to work in, you have to find a small motor and wheel assembly. When I made my mouse, I had some odd wheels lying around from another project, and I made a simple carrier for the wheels and a pivoting assembly for the motor.

Take the bottom of the mouse and cut two wheel slots to suit the wheels you have and the spacing between them, as seen in Figure 2. With mine, I cut away the Teflon pads on the bottom of the mouse, and then cut deeper into the plastic, until I was able to break away the plastic that was under the Teflon. I then took a flat file and made the slots a little wider and smoothed the sides to prevent the wheels from catching as they rotate. If your wheels, or the spacing between the wheels, make the assembly too large to fit inside, you can always have them outside the mouse, like outriggers.

Wheel and motor assembly

Figure 3 shows the method I used to make the motor/wheel assembly. As I mentioned, I had a set of wheels and a decent stock of motors from which to choose, so I decided to make my own drive train. You can follow this assembly if you wish, or you can buy something from your local hobby shop, or perhaps you can accidentally "lose" one of your kids' toy cars, and take the drive train out of there. Either way, you probably will have to work on it a little before everything will fit, and still allow the top of the mouse to be reattached. Again, if you need to, you can always bring the wheels outboard from the

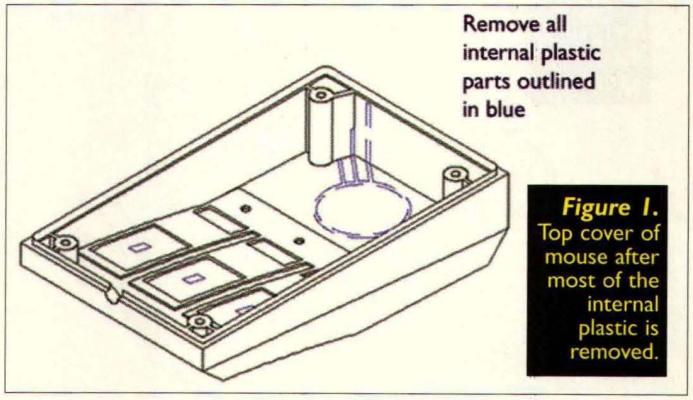

Figure 1. Top cover of mouse after most of the internal plastic is removed.

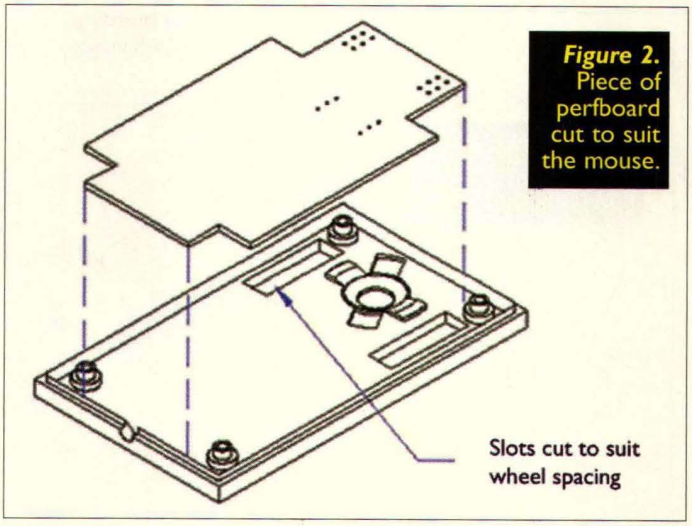

Figure 2. Piece of perfboard cut to suit the mouse.

sides of the mouse.

Get a piece of perfboard and cut it to fit the inside of the bottom of the mouse as shown in Figure 2. The long notches at one end allow the wheels to run freely when the assembly is mounted in the mouse body. The shorter notches allow the board to fit between the front attachment posts.

The wheels I used were about 3/4-inch in diameter, and about 3/16-inch thick, and had a thin layer of rubber on the rim. I assembled these on a common axle, and locked both wheels to prevent slipping. Since there is only one motor, you need to lock both wheels to the axle, otherwise your mouse will just turn in circles. I used a short length of #2-56 threaded rod as the axle. With one wheel locked in place, get a small piece of Teflon sleeving and slip it over the shaft before mounting the other wheel. The Teflon will define the distance between the wheels, so get it right to the slots in the bottom of the mouse. The sleeving gives you something to hold the shaft to the lower mounting plate, yet allows the shaft to turn freely.

Put the wheel assembly on the perfboard and thread a small piece of copper wire through the holes in the board, then across the Teflon sleeve to hold the shaft to the board as shown in Figure 3. Thread a second piece of wire around the Teflon sleeve and twist both pieces to hold the shaft firmly to the board. Next, make sure the wheel assembly is centered on the perfboard and run a bead of hot-melt glue or epoxy over the Teflon sleeve and let things sit awhile and set up. The wire will hold things in place until the glue sets.

The motor I used had enough shaft resting on one wheel rim to drive the wheel by friction. Slip a piece of heat-shrink sleeving over the shaft for extra grip.

The motor was intended to run off 3VDC nominal, and had a mounting flange attached to it. Unfortunately, the flange was too big to allow the top cover to fit on the mouse, so I had to remove the flange and perform a minor 'operation' on it to make it fit. I left mounting holes in the flange on one side of the motor only, and used them to mount the motor to the perfboard plate. Use small pieces of wire to anchor the motor to the board, using the holes in the flange. Don't tighten the wire too much, though. Leaving the motor free to hinge a little allows any eccentricities in the wheel to be taken up. To make sure the motor doesn't bounce off the rim of the wheel and behave erratically, I added a thin, weak extension spring with a hook at both ends to hold the motor in firm contact with the wheel rim. Alternatively, you could hook up a rubber band to do the same thing. Figure 4 shows details of the motor and wheel mounting after assembly.

When the assembly is complete, connect a 1.5-volt battery to the motor and see that it turns freely, and that the wheels rotate without sticking or slipping.

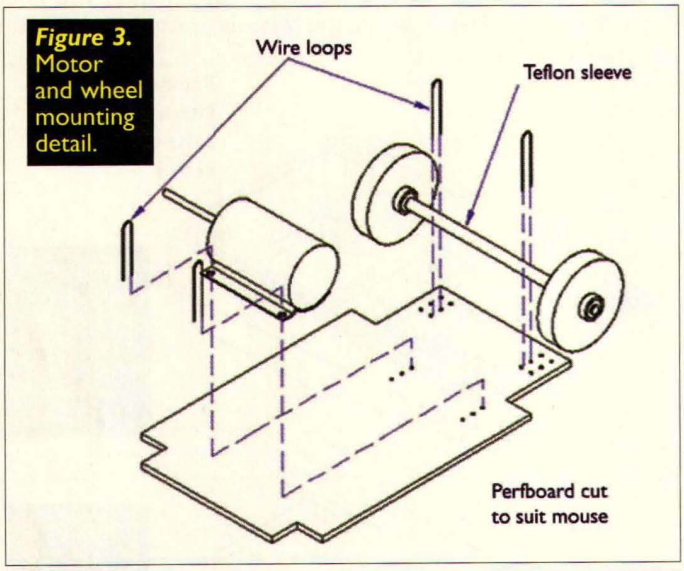

Figure 3. Motor and wheel mounting detail.

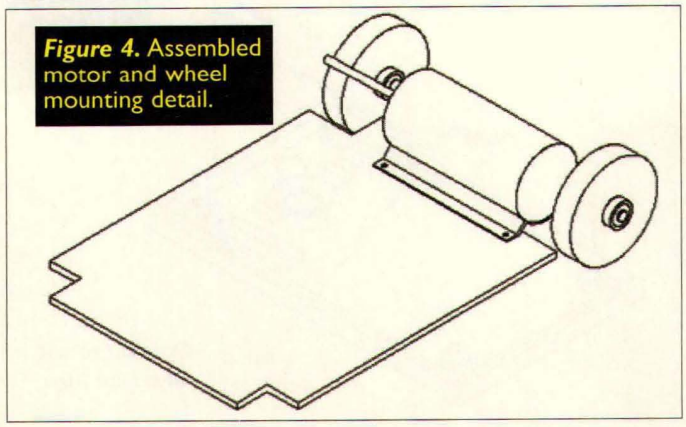

Figure 4. Assembled motor and wheel mounting detail.

Power control and obstacle sensors

In order for our little toy to exhibit some autonomous function other than travel in straight lines, we should add some kind of sensor to reverse the motor drive if it runs

PARTS LIST

1 — MC14011 CMOS Quad NAND gate
Q1 — 2N3904 NPN
D1 — 1N4001
C1 — 0.01µF
C2 — 10µF
R1 — 150k
R2 — 6.8M
R3 — 150k
R4 — 2.7k
R5 — See text
K1 — PC mounting relay DPDT Digi-Key part #PB289-ND or equivalent
M1 — Small electric motor, see text
S1 — SPST switch
BY1 — Alkaline battery, Duracell #21/23 12V or equivalent

All resistors 1/4W, all capacitors 25VDC

Miscellaneous:

An old two or three button computer mouse (non-working preferred). Perfboard, copper-clad PC board, solder, thin flexible wire, #34 or #36 magnet wire, small wheels, small ID brass tubing, and various mounting hardware.

No special tools are required, although if the constructor had a Dremel-type rotary tool it would make life easier. In addition, a soldering iron, hot-melt glue gun, a small drill, and a few hand tools are all that is required. No special skills are required, except perhaps for manual dexterity.

into something. Nothing would cause loss of interest quicker than a motorized vehicle that tried continuously to run through a wall or, perhaps get stuck in a corner.

For a mouse, whiskers would seem to be appropriate, and the whiskers are shown in Figures 5 and 6 — two sets of whiskers, in fact.

The upper set of whiskers pivot about a vertical post, and detect when an obstacle in front of the mouse is hit. These whiskers also turn the front wheel, and cause the mouse to back away in an arc during the reversal time. This realigns the mouse relative to the obstacle, and when it starts to run forward again, allows the mouse to steer by the obstacle. The detect circuit is triggered and causes a reversal of motor drive for a fixed time period, which allows the mouse to back away and turn from the path of the obstacle. The lower set of whiskers pivot about a horizontal axis, and detect the edge of a table or platform, and will reverse the direction of the drive motor for a fixed time period, if the mouse is about to run off an edge.

There is not much room in the body of the mouse, and careful adjustment of the sensor whiskers is required if they are to work as intended. Use stiff wire to make the whiskers, or you'll constantly be reshaping or adjusting them. In my version, I used straightened paper clips. The small diameter brass tubing holding the two lower whiskers can be found in most model or hobby shops. Make sure that in the free state, the two lower whiskers try to reach the lowest position, but are prevented from doing so by the wire that forms one side of the reversing switch. Don't let the lower whiskers fall too low — if the ends fall below the level of the table, the mouse will get stuck on the edge, and will not be able to back away.

You need to set the trip point very close to the running point (just touching the surface). In the upper whiskers, you'll need to solder a small washer to the wires for the pivot point, otherwise it will not be able to maintain the correct position on the pivot post. Use a #2-56 or #4-40 screw as the pivot post, but do not tighten the screw too much. When these whiskers hit an object, they will turn the front wheel, and cause the motor to reverse in the same manner as the lower whiskers. See the close-up view of the whiskers in Figure 6.

The whisker assembly is mounted to a small piece of copper-clad PC board, cut as shown to fit around the front steering wheel. Cut the copper across where the two brass tubes will be soldered, as seen in Figure 6, and connect the two small isolated pads together. This forms one side of the edge detector switch. Make a small coil of wire using #34-36 magnet wire, and connect one end to the steering wheel assembly, and the other end to the edge detector switches. Making a small coil reduces the springiness of the wire and reduces the influence the wire has on the steering. Drill a hole that will take a #4-40 screw to hold the assembly to the lower part of the case. See Figure 8 for details.

Photo 1 shows my version of the autonomouse right before installing the battery. Note that the board is angled slightly. The battery will drop in behind the motor. The small projection you see on the right side of the motor and above the hole where the ball normally fits is a piece of wire I soldered to the motor case for the small extension spring I mentioned earlier. The red and blue wires crossing the motor will be soldered to the battery and switch later.

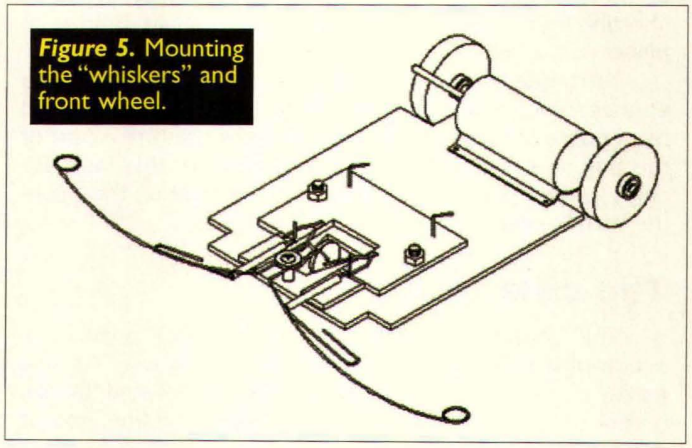

Figure 5. Mounting the "whiskers" and front wheel.

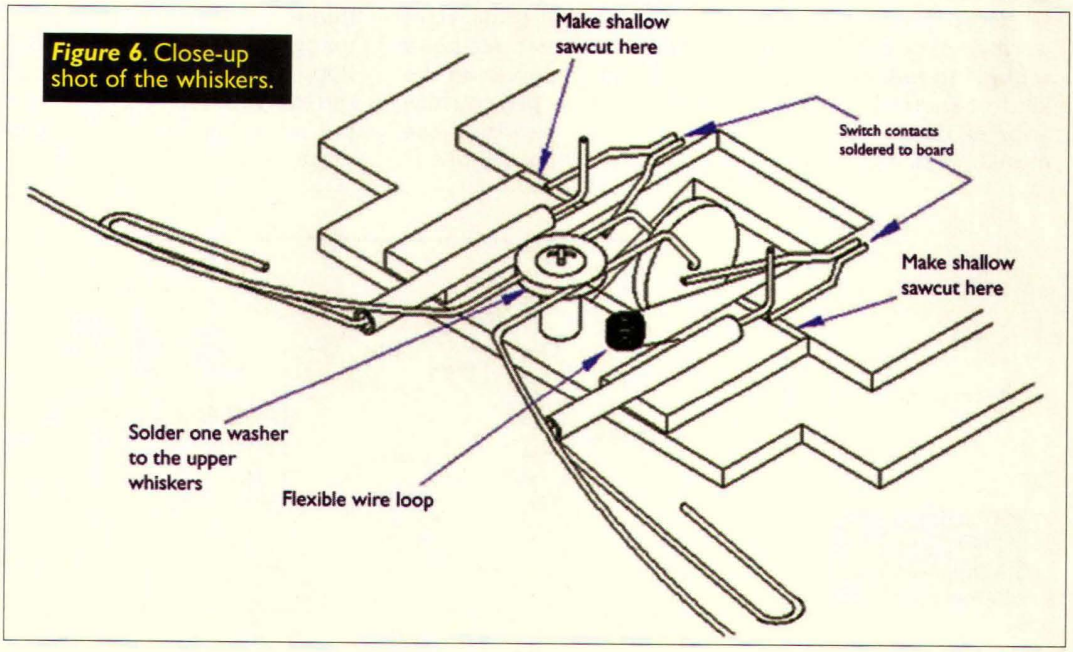

Figure 6. Close-up shot of the whiskers.

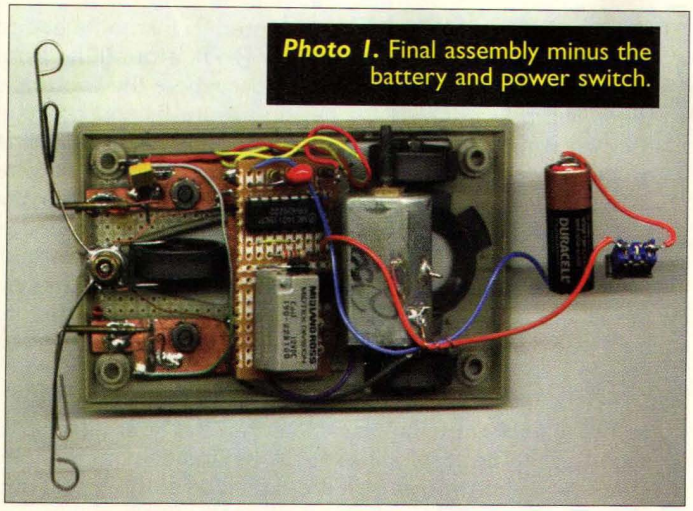

Photo 1. Final assembly minus the battery and power switch.

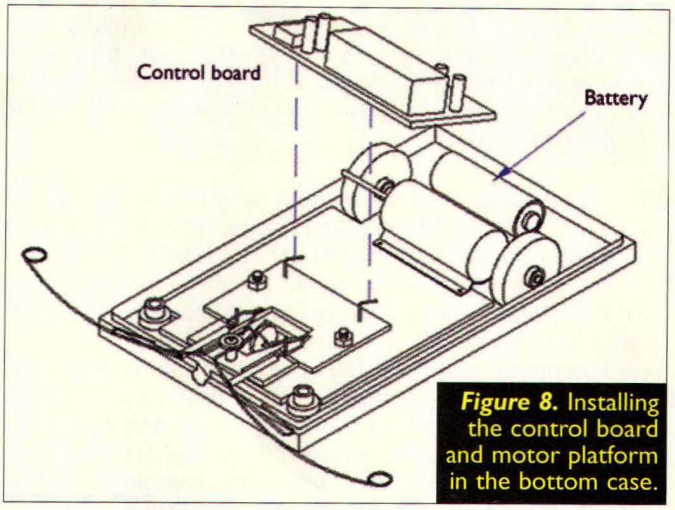

Figure 8. Installing the control board and motor platform in the bottom case.

Cut a hole in the top of the mouse case for the power on/off switch. I used a small switch from a discarded pocket radio (I told you I never throw anything away!) and inserted it through the hole from the top. This gives a little more room on the inside, and prevents anything from shorting out. Use a spot of hot-melt glue to hold it in place.

You'll need some short lengths of fine, flexible wire to connect everything together and, once again, the old mice come in handy. The flexible cables that are a part of the mouse contain some very fine wire for this task. Be careful when you peel back the outer insulation though — the wire is very thin and could easily break.

The control circuit

The control of motor drive and motor reversal is accomplished by the circuit shown in Figure 7. As you can see, the circuit is very simple, and contains all the elements required for obstacle and edge detection, motor drive, motor reversal, and reversal timing.

Build the circuit as compactly (if that's the right word!) as possible, using perfboard and point-to-point wiring. No layout is given since it really depends on the kind of mouse you have and the components you use and, of course, how much room you have inside the mouse. With a Genius, there is room for a board about 1" x 1-7/8". The relay is a small PC mounting type that has a footprint similar to a 16-pin DIP package. You should be able to get this relay from Digi-Key or RadioShack. Other components are standard. If you are careful with the layout, you should be able to lay the finished board in between the motor and the wheel assembly. In mine, I soldered a couple of PC pins to the copper-clad board and bent them over to support the board from underneath. Before I bent them, however, I slipped on a short piece of heat-shrink sleeving to prevent anything from shorting out. See Figure 8 for details.

The battery is soldered directly into the circuit because there isn't enough room to put a holder in place. Make the wires long enough so that the battery can sit in the space behind the wheels as seen in Figure 8.

Looking again at the schematic diagram in Figure 7, when turned on, K1 is not energized, and power is supplied to the wheel motor by the normally-closed contacts of K1. The motor is wired so that it tends to drive the mouse forward.

U1a and U1b form a simple one-shot monostable that is triggered by the edge detector and obstacle detector switches. It only takes a light touch to trigger this flip-flop. U1c and U1d form a buffer to increase the drive to the transistor Q1 via R4. D1 prevents the back EMF from the relay from destroying the transistor when the relay drops out.

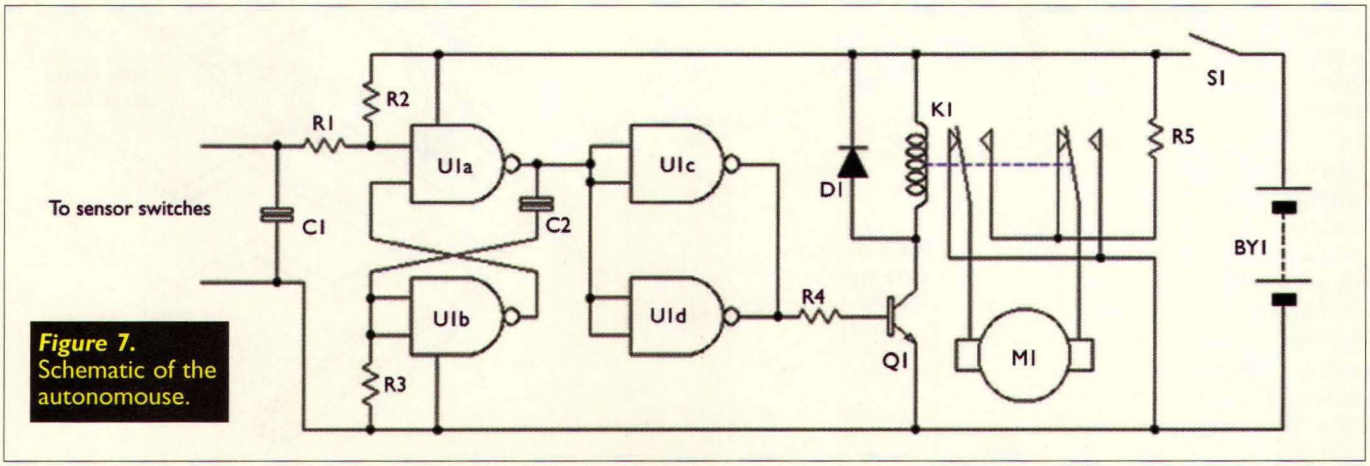

Figure 7. Schematic of the autonomouse.

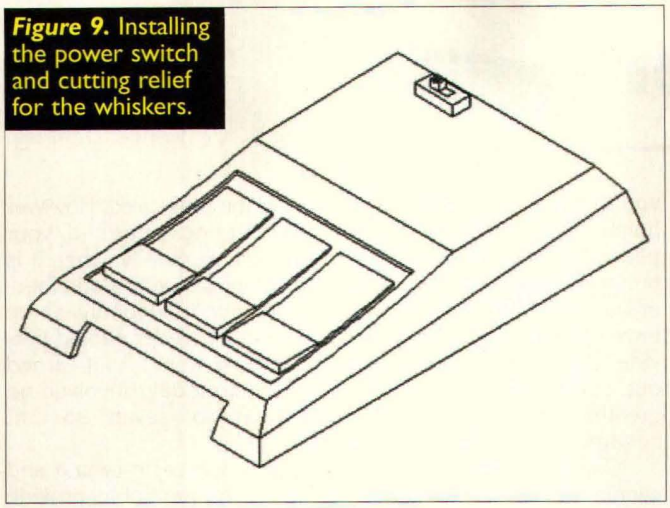

Figure 9. Installing the power switch and cutting relief for the whiskers.

While moving forward, the mouse will tend to move in a somewhat straight path (depending on how good your wheel assembly and alignment is). If an obstacle touches one of the upper whiskers, or if an edge is detected by one of the lower whiskers, then pin 1 of U1a will be pulled low, albeit momentarily.

When thus triggered, the flip-flop starts its timing cycle, determined by C2 and R3. Here, the timing is about two-three seconds. During the timing cycle, Q1 is turned on, pulling in the relay K1. K1 contacts are wired so that the voltage being supplied to the motor is reversed during the timing period, reversing the rotation of the motor, and driving the mouse backward, away from the obstacle or edge. During the motion backward, there is a natural tendency for the front wheel to turn one way or the other. When this happens, it turns the mouse away from the obstruction.

After the timer circuit times out, K1 de-energizes, and returns to its former state — the voltage across the motor returns to normal, and the mouse continues on its way. While constructing this project, I was careful to obtain a motor that drew as small of a current as possible. This is because of the limited power available from the battery. To make sure I didn't run the motor so fast that it crashed before the reversal circuit could trigger, I installed a resistor in series with the motor to cut down the available current. The motor came from an old discarded camera (more useful junk!) and drew about 30mA at 3VDC. I was able to use three 100 ohm 1/4-watt resistors in series for R5 in my unit, and nothing got warm.

You'll need to calculate the value of the resistor you need for your motor. Simply take the voltage of your motor and the current rating, and subtract the voltage from the battery. The voltage that's left, and the current you have will tell you the resistor you need using Ohm's Law (R = E/I). In my case, 12 - 3 = 9 volts or 9/0.03 = 300.

Figure 9 shows the relief cut into the front edge of the upper part of the mouse case. This is to allow the whiskers to move freely, and allow the steering wheel to make a turn on hitting an obstacle. As a finishing touch, make a hole in the rear end of the case to take a short length of cable for a "tail." Replace the case top carefully, so as not to disturb the obstacle switches, and let the fun begin.

NV

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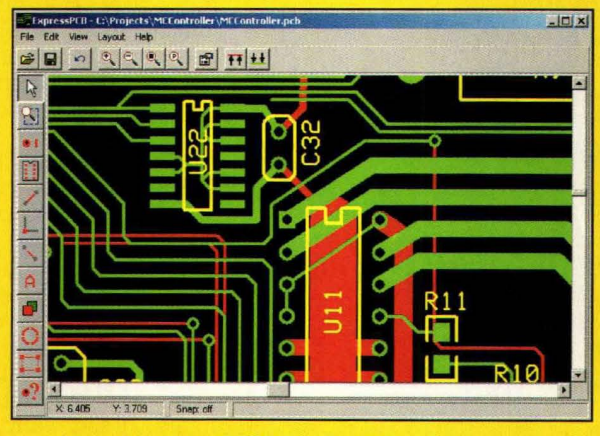

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by David Ponting

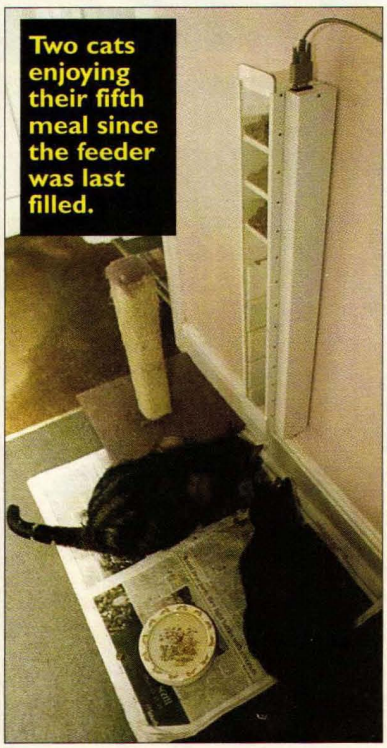
The Cat Feeder

Part 1

Your cats won't even know you're gone!

The trouble with pets is that they tie you to the house and prevent you nipping off for the odd weekend simply because they need to be fed regularly. We have two cats. They are wonderful company and we wouldn't be without them for the world, but my wife and I are recently retired and it would be nice to be able to exploit our new freedom and leave them for a few days at a time without having to rely on the kindness of neighbors popping in daily to feed them. There are always kennels, of course, but cats are unsettled by unfamiliar surroundings and you can't overlook the cost! I investigated professionally-made cat feeders at the local pet store. Basically, I found two kinds. The first had no more than two closeable compartments which could be set by a clockwork mechanism to open at different, predetermined times up to a maximum of 36 hours into the future. It was made of thin, flexible plastic and it seemed to me that a couple of determined cats would have it apart in no time.

The second type consisted of a dish divided into four quarters, each of which could be filled with food. An inverted bowl-like cover with a quarter segment cut away fit on top of the dish, exposing a fourth of the food immediately. A clockwork motor rotated the upper lid very slowly indeed, exposing further sections as it wound down also over a 36-hour period. This method gave three future feeds, but its biggest drawback was that the rotation of the upper lid exposed the next meal infinitesimally slowly and my two cats were driven to desperation as the next segment inched into smell and view. In fact, they quickly found that they need not wait. They could tip the whole thing over and get the lid completely off. Consequently, it became obvious that if my wife and I were going to get any vacation time away from our home, we needed a bespoke cat feeder which would be substantial, reliable, and above any other consideration, able to feed the cats over a much longer period than just a day and a half.



Two cats enjoying their fifth meal since the feeder was last filled.

So what were our requirements? We started with something of a plus — our two cats had been properly brought up (from our point of view) and ate only dry food. Consequently, in our cat feeder, we had no need to keep future meals fresh and/or refrigerated. Further, I took the advice from our local veterinarian and she was pretty clear that with sufficient drinking water, dry food is generally better for cats anyway. She also said that if your cat tells you that it will only eat the moist stuff, be reassured. However finicky it might appear to be, when your back is turned, your pet will always eat (and enjoy) dry food eventually, when it is hungry enough to try it. So the design of our automatic feeder was to be built with only dry food in mind. Secondly, as we have two cats, I arbitrarily decided that the feeder should provide food for both for a period of up to a week. As it turned out, building a device to feed them for eight days involved no greater complexity than feeding them for seven, so that became part of the specification.

Thirdly, as we normally feed our cats every morning and evening, I wanted the feeder to have the potential to provide each cat with half a full day's food twice during each 24-hour period. This would be an option to use when we were only going to be away from home for short periods. But for absences of more than four days, the feeder needed to be capable of providing a double, full-size feed just once a day and the cats would have to put up with that. Fortunately, they do not squabble over their food and so can be fed together. And as most cats do, they frequently snack over a period rather than wolfing everything down at once.

Having decided upon the general specifications, I started to think about the construction details. I have no skill with wood. Simple electronics I can cope with, but wood seems to split if I as much as look at it. So, as far as I was concerned, the general construction had to be simple and made from a very much more user-friendly material than wood. Now, I have recently made a personal discovery in "BCE Cellular Extrusions." This is a most forgiving material designed apparently for use as "Cladding, Trims, Soffits, and Fascias" (whatever they are), and available from most good DIY, Hardware and Building Outlets. It is a kind of highly-compressed Styrofoam which can be cut, filed, drilled, and tapped and, even if your woodwork is as bad as mine, this plastic medium remains infinitely understanding. In addition, BCE is more hygienic than wood or metal, being so much easier to keep clean. In fact, it is perfect for our purpose. Cellular Extrusion seems to be available in sheets of a number of different cross sections, sizes, and angles, but I could find it in only one thickness — 3/8-inch — which is fine for our cat feeder.

The makers of dry food for cats recommend somewhere around 75 grams a day for the average adult cat and it so happens that the150 grams necessary for two cats will fit comfortably into a three-inch cube. And if your cat is too overweight to be average, I suggest that you feed for the typical and enforce a pet diet while you are away on vacation (even though you're probably defaulting on your diet). The general shape of the feeder starts as a long, horizontal, rectangular box open at both the top and at one end. It is three inches square in internal cross section, and of sufficient length to allow eight, three-inch compartments to be created inside it. Each compartment is separated from its neighbor by a hinged door made of the same Cellular Extrusion. In use, the box is attached vertically to a convenient wall. In this position, each hinged door will need to be held closed horizontally. At preset times and in order, starting with the lowest, the doors can be released to swing open, allowing the food to fall down and out on to a tray below.

The vertical dimension of the box must be sufficient to accommodate eight, three-inch compartments, as well as the

No special tools or skills are required beyond those probably every electronics enthusiast would have (fine drill, pencil soldering iron, etc.) — obviously an oscillscope would be useful — but not essential. What a constructor does need is patience and a steady hand!

material thickness of eight doors. However, since the hinge of the bottom door has to be screwed to something, I increased the height of my tube a further three inches. This resulted in an overall height of (8 x 3 inches + 8 x 3/8 inches + 3 inches) or 30 inches.

The diagram in Figure 1 shows all those pieces of the feeder box, which are made from Cellular Extrusion. The rear section of the box is 3-3/4 x 30 inches and each side piece is 3 x 30 inches. The back is screwed on to the rear edges of the two side panels, and the top is cut 3-3/4 x 3-3/8 inches to allow this piece to be screwed to the top edges of the back section and both sides. To add strength, a small piece of Extrusion, 3-3/4 inches x 2 inches is secured in place across the base of the front. All these pieces can be screwed together using one-inch No. 4 wood screws. No countersunk holes need to be cut as this plastic extrusion is soft enough to indent as each screw is tightened. But for the moment, screws should not be driven home completely as the remainder of the assembly will require that the side sections of the box be taken apart again for further work.

Finally, the eight hinged doors must be cut. These are to fit very loosely when they are held horizontal in the vertical tube. Consequently, they should not be 3 x 3 inches — but about 2-7/8 inches square. Then, using 3/8 wood screws, one face of each door is screwed to half a small hinge. When buying hinges, check that they will turn freely and, if necessary, open up the metal around the pins if they are too tight. Each hinge, when screwed centrally to the side of its door, should be positioned so that when the hinge is fully closed, its turning edge is exactly in line with the edge of the door without under- or overlapping.

Small magnets are used to hold the doors closed and a very convenient source is the reed switch — normally used as a "door open" sensor in a burglar alarm system. This type of switch (see Photograph 1) comes in two sections; the magnetic half is the one with no connection terminals. Conveniently, the flat face of this part peels away from the cylindrical section revealing a small magnet only fractionally thicker than the material of the door. The magnet may be of square or rectangular cross section — either type will do. Cutting an opening which is slightly smaller than the magnet into the door edge will allow it to be secured in place just by friction alone. See Photograph 2.

Before any magnets are fit in their doors, get all eight together and stack them one on top of the next to ensure that each magnet has the same pole uppermost. Mark this upper face on each and then, one by one, and without turning them over, fit the magnets into their doors.

When all the doors have their hinges and magnets fitted, the combinations can be screwed in place. Remove the left panel of the feeder box and mark its inner face with horizontal lines — the first three inches from the top, the second 3/8 down from that line, then three inches from that line, then 3/8 from that, and so on until 16 lines have been drawn. These represent the positions of the top and bottom faces of all eight doors. Also, draw a vertical line dividing this face exactly in two. Now the second half of the hinges can be screwed to the left panel. The lines drawn should help to get all the doors fixed central to the panel and in the correct positions, but it is probably worth mentioning that, as the doors are to drop down by rotating in a clockwise direction as seen from the front, each hinge should be underneath its door when the hinge is attached to the side panel. The correct positioning of the doors will mean that when they are held perpendicular to the left panel, the contact edge of each door will leave no gap between it and the vertical face and, therefore, the thickness of the door will prevent it from being rotated anticlockwise any further than horizontal. Check that each door rotates freely between horizontal and hanging (more or less) vertically.

Figure 2 shows how the hinge is to be attached to the side panel. The permanent magnets are secured in the center of the right edge of the door, directly under a coil as shown. More information about coils and magnets will be given next month in Part 2. One of the things we have not considered so far is how the front face of the box will be closed off. I cut a front panel out of 3/16 Plexiglas so that during testing, I could see the doors opening one by one and be reassured that they were successfully dispensing all their food. If you want the same reassurance, you will need to cut a piece of Plexiglas

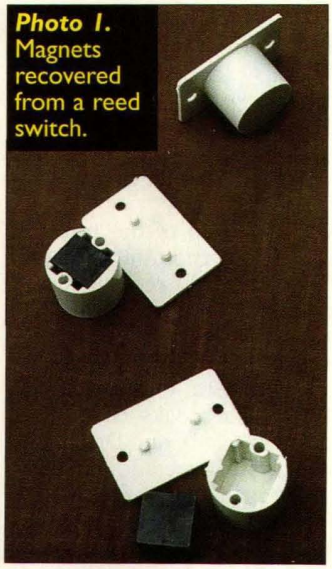


Photo 1. Magnets recovered from a reed switch.

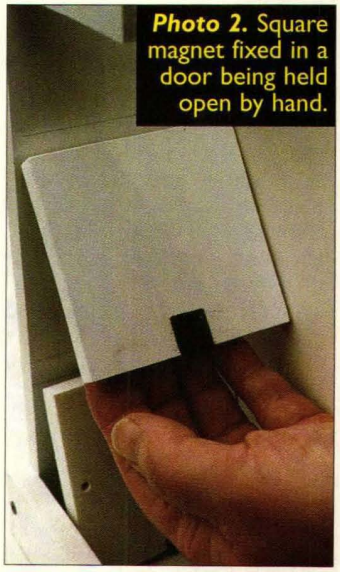


Photo 2. Square magnet fixed in a door being held open by hand.

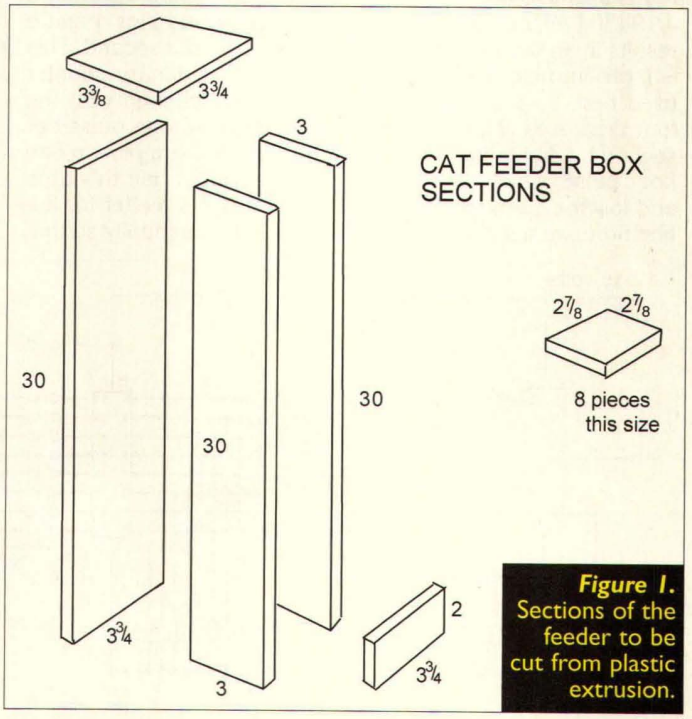


Figure 1. Sections of the feeder to be cut from plastic extrusion.

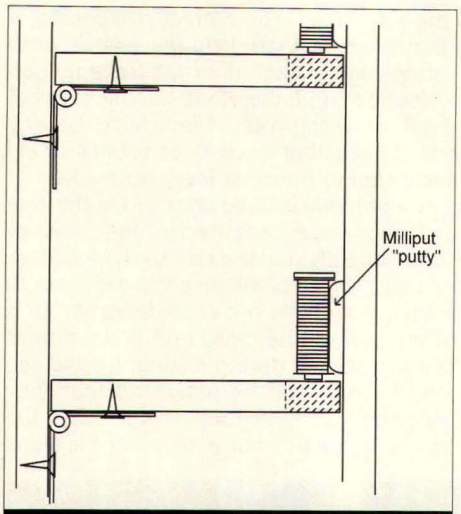
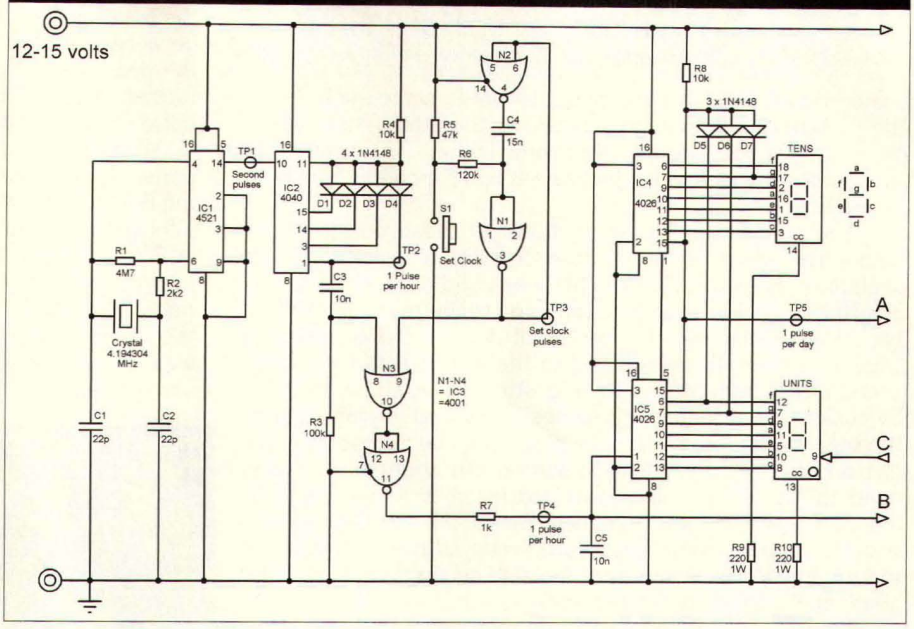


Figure 2. Diagram showing hinge and coil attached to side panels.

Figure 3. Circuit diagram of the Clock and Display circuits.



which is 3-3/4 inches wide and about 29 inches in length. This means that when in position and butt-joining the small piece of Extrusion at the bottom of the front face, the Plexiglas will overlap the top of the box by about an inch. This exact dimension is unimportant, but a little overlap at the top will allow a finger grip for removing the front face when it has been finally fitted. How it can be held in place will be discussed next month. This completes most of the mechanical construction, but before the rest is described, I want to get to the part I find more interesting — the electronics. For easier description, the full circuit breaks down into three sections — of which the first is the Clock and Display.

Cats are creatures of habit and, as all owners know, they expect to be fed at more or less the same time (or times) every day. Consequently, this design includes a real-time clock, displaying just the current hour in the 00 to 23 format. IC1 is a CMOS 4521 oscillator/divider chip. Using a standard 4.194304 MHz crystal, the circuit set up around pins 4 and 6 results in an output from pin 14 of one pulse per second. This is input into clock pin 10 of the 4040 CMOS binary counter used here as a programmable divider. When wired with the four diodes as shown, IC2 divides the input of one pulse per second by 3,600, thereby outputting directly from pin 1 a one hour pulse, which is, of course, high for about half this time and low for the other. When setting up the cat feeder for the first time, we need to be able to set the clock manually so that it displays the current hour. This is achieved with pulses from press switch S1, using gates N1 and N2 to provide the debouncing function. Gate N3 ORs the pulses produced by S1 with the once-an-hour signal, which has been differentiated by the C3/R3 combination to produce a single brief pulse each hour rather than holding pin 8 of N3 high for 30 minutes at a time. N4 performs the necessary function of inverting the output from N3. Other than during the initial set-up, the output from N4 pin 11 will just be a brief, real-time, positive pulse once each hour. R7 and C5 ensure that this signal is not corrupted by random spikes from noisy power lines.

The once-an-hour pulse drives pin 1, the clock input of IC5 — the first of two decimal counters both providing coded, seven-segment outputs. Consequently, the lower, common-cathode LED display will show the UNITS digit of the latest count and this will automatically be incremented each hour, or advanced as required by the operation of S1. In its turn, the one-pulse-per-hour input to IC5 is internally divided by 10 and outputs at pin 5 as a carry signal. This clocks pin 1 of IC4, which stores and increments every 10 hours the TENS digit display.

All that seems pretty straightforward. Unfortunately, if that were the end of the story, the display would increment from 23 to 24 to 25, and so on, with nothing to tell the clock that midnight had come and gone. However, diodes D5, D6, and D7 together with R8 form a three-input AND gate which has its output at the anodes' side of the diodes/resistor intersection. The arrival of the next hourly pulse when the real-time clock is showing 23 does increment the display to 24, and this step uniquely results in the lighting (among others) of the "g" section of the TENS figure and both the "f" and "g" sections of the UNITS. At that moment, all three inputs of the diode AND gate are high and

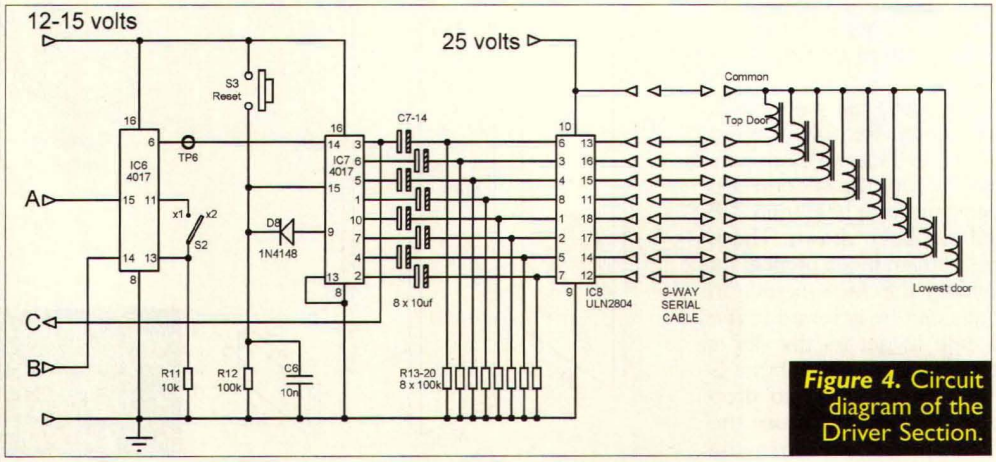


Figure 4. Circuit diagram of the Driver Section.

hence, so is its output, connected here to the reset pin 15 of both IC4 and IC5. So the appearance of 24 is too brief to see, and instead results in both counters resetting instantaneously to 00. Counting repeats from there.

I have to admit that the method shown in Figure 3 for current-limiting the 14 LED sections of the seven-segment, dual display is somewhat cheap and cheerful — here R9 and R10 (both 220 ohms and 1 watt) provide this service. The recommended way would be to have separate resistors for all 14 segments of the display ensuring that each LED lights with the same intensity, irrespective of whether the displayed figure is an eight or a one. With my method, the digit 8 shows slightly less well lit than the digit 1 because each LED is sharing the same total current whether all seven segments are lit (as in 8) or only two (as in 1). Big deal! The difference is unimportant in this application, and so far I have had no complaints from my cats that they couldn't see the time! Figure 4 illustrates the Driver section. Inputs A and B are the two signals originating from Figure 3, while C is an output signal fed back to the Clock & Display diagram and connecting there with the right-hand decimal point of the display. B provides pulses into pin 14 — the clock input of decimal ring counter IC6. There are normally 10 outputs from this type of IC, each one switching high in turn on the arrival of a clock pulse, and with the sequence repeating after the 10th. This regular counting can be interrupted and the count reset (i.e., with the first pin switched high) by briefly taking pin 15 high.

In this application, B is clocking IC8 once each hour, resulting in its 10 outputs going high in turn and then recycling. But at midnight, a pulse from A into pin 15 will reset this counter, switching the first pin high, after which further pulses from B will start the ring again from the beginning. So, seven pulses from B after resetting to 00 at midnight will make the time be 7:00 in the morning. At that hour, the output of pin 6 will have just gone high, providing a rising edge into IC7. Ten hours later at 5:00pm (17:00), the ring counter will have gone around once and its pin 6 will again go high supplying the second pulse of the day into IC7. And the cats will be fed twice. At midnight, the ring counter IC6 is reset and the process repeats with the feeder providing two meals each day at 7:00am and 5:00pm. Alternatively, S2 permits the selection of only one meal a day.

When S2 is open, pin 13 of IC6 is held low by R11. This allows IC6 to count normally. But if pin 13 is taken high during counting, whatever count has been achieved at that moment is frozen. Pin 11 is the last output to go high before the ring counter recycles and so, at 9:00am, if switch S2 is in its closed position, pin 13 is taken high by pin 11 and no further counting takes place until midnight when the counter is fully reset. Consequently, with S2 closed, the ring counter will only output at pin 6 one rising edge during each 24 hours and that will be at 7:00am. The cats will only be fed once a day. Clearly, different feeding times can be set by using an output of IC6 other than pin 6. However, the time of the first meal can only be varied between 1:00am and 9:00am and the second meal (if used) is always 10 hours later. If different meal times are required, some copper tracks on the PCB will have to be modified to accommodate using a different output from IC6.

Moving on to the second 4017 ring counter (IC7), pulses from IC6 provide clock signals at pin 14. Reset pin 15 is normally held low by R12, but is taken high either when S3 is pressed or via D8 when pin 9 goes high. Pin 9 is IC7's ninth

Circle #131 on the Reader Service Card.

output and so when it is connected to pin 15 via the diode as shown, the ring count is limited to eight stages only. With either the one-a-day or the two-a-day clock pulses from IC6, the eight active output pins on IC7 go high in turn, and as they do so, they output a short pulse into the corresponding switch of driver IC8. More about this section of the circuit will be given in the second part of this project next month.

That completes the description of the electronics which will drive our cat feeder into suppling food for a couple of cats either twice a day for four days or once a day for eight days. Next month, we will conclude with full details for making up the single-sided printed circuit board together with the completion of the feeder box and the design of the power supply which will make it all happen. **NV**

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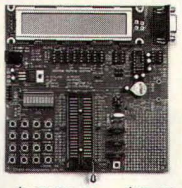

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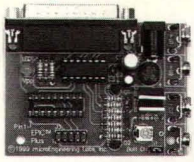

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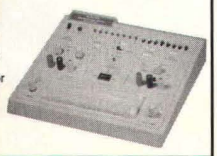

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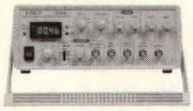

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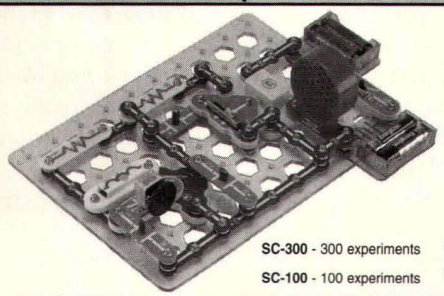

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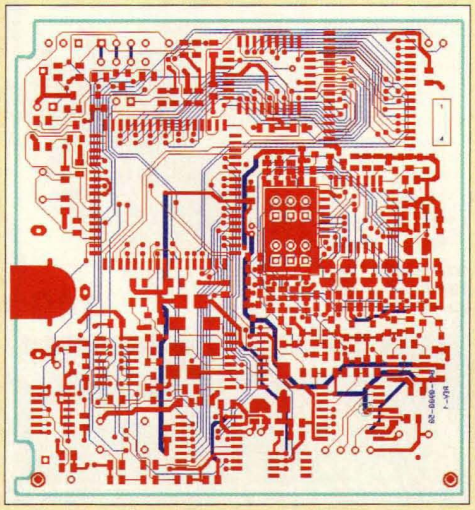
A Surface Mount Overview

Every day seems to offer new Surface Mount Devices (SMDs) that tantalize you with a wealth of capabilities you can't find in through-hole components. In fact, many types of through-holes are getting harder to find as time goes by because Surface Mount Technology (SMT) is a more profitable process for large manufacturers. SMT gives them higher device capability and it's streamlined to fit right into automated assembly. Device manufacturers are following the money. Although it looks like some through-holes will always be around, most are disappearing. There just isn't enough business in through-hole parts to justify making most of them anymore.

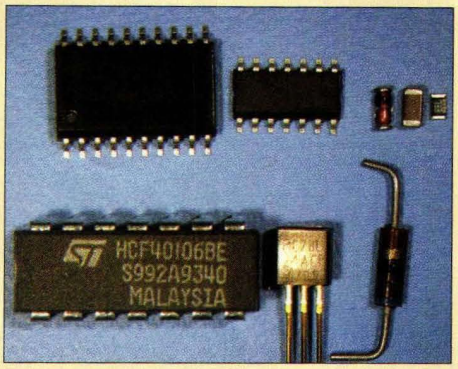
Because the length of the traces are shorter on SMT devices, they offer a real advantage in high-frequency applications. You also get more function on any given piece of real estate, which probably drives surface mount technology more than anything else.

Basically, what you can build with surface mount goes far beyond what you can build with through-hole as the SMT schematic illustrates (see below).

Still, purely surface mount may never be a reality because even digital boards have connectors to plug them into the world. Connectors produce exceptional stress on the solder joints, which is a negative for SMT. Compared to through-hole, SMDs are easier to rip off the board. So, until somebody fixes this problem, components, like connectors, will continue to rely on basic through-hole technology. In the plant, this means they wind up reflow soldering the SMDs, and use wave or selective soldering for connectors and some analog devices.



The larger size of solder joints and wide spacing between leads on through-hole boards are easy to handle for anyone familiar with hand soldering. Soldering the tighter pitch on surface mount devices is the main problem for a home workshop.



In defense of SMDs, printed circuit board has glass fibers in it arranged in an X-Y direction, not in the Z direction. The coefficient of thermal expansion in X-Y is much less than it is in Z. So, whenever you touch a solder iron to the board, it expands more rapidly in the Z direction, causing stress in the barrels of plated through-hole and via. This stress can crack the copper barrel where it joins the pad on the board surface. SMD boards are more reliable in this area than through-hole boards.

Home Workshops and SMD Assembly Problems

You'd like to take advantage of some of the newer SMD capabilities, but may have avoided it because of the problems associated with hand soldering the leads. To compensate, many of you will have mixed technology boards built to your design spec, and then send them out to be assembled at a contract shop. This can add a lot of time and expense to your project unless you're really lucky and have a buddy or a long-standing relationship with a local shop that will put your one or two boards at the top of their production schedule.

You know that screen printing your solder paste and reflowing your assembly is the method you would choose if you could. But, to date, nobody has a screen printer or reflow oven that would even fit on your workbench — let alone be affordable.

Well, guess what? Now you can have both. The following method I'm going to take you through is far from the sophistication of major screen printing and reflow equipment, but it gets the job done — even double-sided SMT boards. You can do it right in your garage or workshop. It's possible to actually cut your assembly time, increase the quality of your designs, and open the door to all the mixed

technology you want to experiment with.

I'll take you through all the steps using a new prototype stencil tool developed specifically for your home shop and (don't laugh) a common toaster oven. Face it, building SMT boards at home will never be a "piece of cake," but this new procedure should help make it a lot easier, and maybe save a little time and money by keeping more of your project in-house. Here's what we'll be working with:

Material:
- Solder Paste
- Reflow Temperature Indicator
- SMT Components
- Printed Wiring Board (PCB)

Equipment:
- Prototype stencil
- Squeegee
- SMT Placement Tools
- Toaster Oven

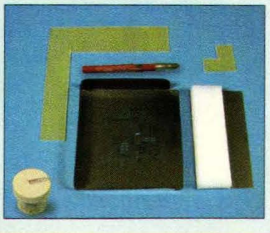
These products and materials are available from PCBexpress (**www.pcbexpress.com**), a vendor that I use to build my PCBs. Regardless of what vendor you select, all tools in home stencil kits basically work in the same way. There are only so many low-cost ways to screen print at home — and, a toaster oven is a toaster oven. Most sources have at least two levels of kits available. What you want depends on how "single source" you like to be. Of course, all kits offer complete "How-To" instructions.

Ordering Your PCB and Prototype Stencil

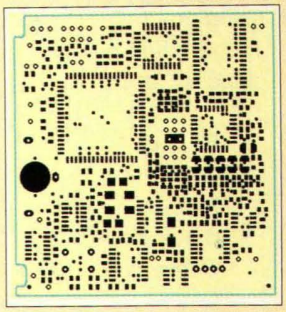
First, you need to get your prototype stencil made. Although they're not just for prototype products, I like to call these stencils "prototype" to differentiate them from standard framed production stencils. These "frameless" type of stencils run from 50 percent to almost 85 percent less than the cost of conventional stencils.

You can have your board and stencil made by a single vendor as I did, or, if you already have your boards, there are vendors that will just make stencils. In the past, I've purchased prototype stencils for existing boards from Stencils Unlimited on the Internet (**www.stencilsunlimited.com**), and I'm sure there are others you can find with a simple web search.

A Basic Prototype Stencil Kit comes with:
Prototype stencil
Squeegee Blade
PCB Holder



A Starter Prototype Stencil Kit also has:
Solder Paste
Reflow Temperature Indicator



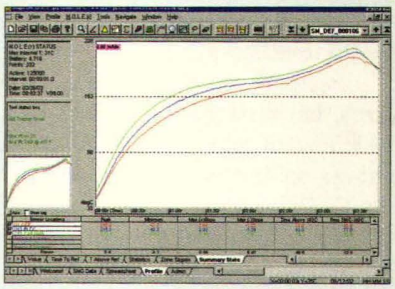
To order a stencil, you need to send the vendor your Gerber files, just as you always do to get your design made up, but in a little different way, if possible. When you send in your board design, indicate both the silk screen and solder paste layer in your Gerber files. The PCB vendor will take those files and create the prototype stencil pattern from them.

Some of you may not have a software program that can create the silk screen and stencil layer files. In this case, the vendor can use the top and bottom copper Gerber files and edit them to create the pad openings in the prototype stencil that match your board design. It's a little more involved, but a common practice — even in a professionally run production. The big electronic contract shops run into this all the time, so don't fret if you don't have the capability to create these special files. Any good PCB or frameless stencil vendor does.

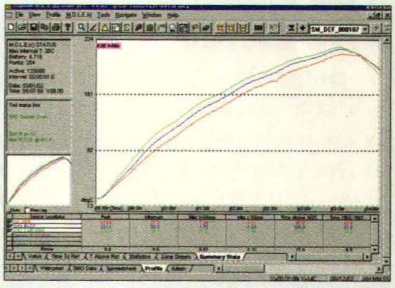
Choosing Your "Reflow" Oven

The only part of this project that you can't get from any PCB vendor that I know of, is the "reflow oven." The following toaster ovens have been tested and were found to meet the reflow requirements for most SMT PCBs — 9 x 11 inches or smaller. I can't guarantee the results you may get

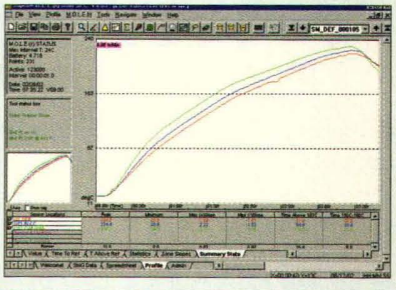
GE OVEN WITH SOLDER PROFILE



BLACK & DECKER TRO 5900TC WITH SOLDER PROFILE



OSTER 6230 & 6232 WITH SOLDER PROFILE



using any other models. This is a good size selection, and you can find most models well under $100.00 at any local discount store.

Brand	Model
GE	106632
Black & Decker	TRO5900CT
Black & Decker	TRO6100CT
Oster	6230
Oster	6232

These test results show the ovens and their associated thermal reflow profiles. You can see how close they are in capability.

Considerations Regarding Solder Paste and Components

Solder Paste: There are lots of solder paste manufacturers. Some don't provide printable paste in containers less than 500 grams. For a small number of PCBs, this would be expensive. What you want is standard eutectic tin/lead solder. This is typically available in either small jars or in the syringes that are used in rework stations. Most vendors providing home prototype stencils will have small jars of solder paste available, like the one shown here. Be sure to check on this. Solder paste in small quantities costs around $0.25 to $0.50 per gram.

Paste for rework typically comes in 100 grams syringe sizes, but also has a lower percent of metal so the paste will flow through the syringe easier. Repair paste may slump on fine pitch components causing solder shorts. On QFPs, you may have to clear solder shorts with a fine-tip solder iron. Because of this, some manufacturers do not recommend using this type of paste for screen printing applications. But it's your choice.

A Few Cautions

Solder Paste: Most standard solder paste is shipped in a cold pack. It has a longer shelf life if refrigerated. Before using the solder paste remove it from refrigeration and let it warm to room temperature (*do not store solder paste in the refrigerator or with food*). If you do not have a safe place to refrigerate the solder paste, store it in a cool, dry place. Some prototype stencil vendors and solder paste vendors can provide a type of solder paste that does not require refrigeration, so again, be sure to check on this.

Solder paste contains lead. You have to dispose of unused solder paste and rags with solder paste on them as hazardous material. Talk to your solder paste supplier about taking this hazardous material back for recycling. If the solder paste supplier won't take this material back, he can usually tell you how to dispose of it safely.

Components: There are far too many types of SMDs to go into here. But suffice it to say, if you want it done, there is a device for any application you can think of. Ask your component manufacturer or supplier.

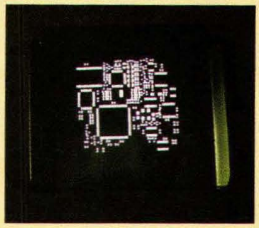
All SMD component manufacturers provide the solder process thermal requirements for the components they produce. Always request this and control the oven profile to conform to this data.

Some SMT components have restricted thermal process requirements. Be sure to verify that all components can be processed using a standard SMT procedure, as described here, before you buy them.

The leads on all SMDs are delicate — some more than others. The finer the pitch, the easier to damage the leads. Handle as little as possible, and if applicable, keep in their holders until ready for placement. It's best to use a vacuum wand to place very fine pitch devices.

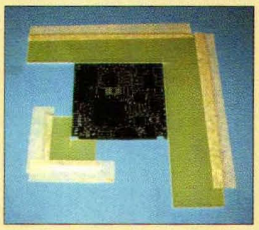
Building Your Board

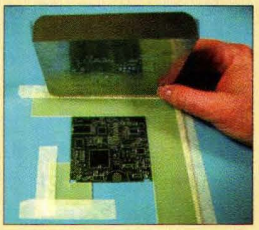
1. Set up your prototype stencil.



Important: All work surfaces should be conductive and grounded.

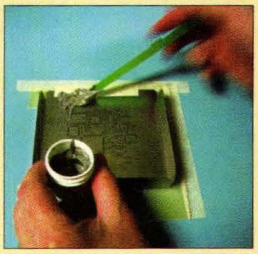
Prototype Stencil: The prototype stencil is a stainless steel foil (five to 10 mils thick) with openings cut through to allow the solder paste to be deposited onto the PCB lands (pads). To prevent the PCB from moving, you can tape it down or make a smaller square and use it as indicated.





- Place the large L-shaped board holder on a flat surface and tape it down to prevent it from moving.
- Place the PCB into the board holder.
- Place the small L-shaped board holder next to the PCB and tape it down to prevent it from moving.
- Align the prototype stencil over the PCB SMT land pattern (SMT pads) and tape it to the large L-shaped board holder.

2. Apply the solder paste using your prototype stencil.



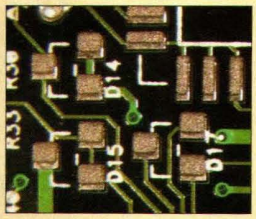
Remember: If using refrigerated solder paste, be sure to remove it from refrigeration and let it warm to room temperature. Before printing with solder paste provided in a jar, stir it for five minutes. Do NOT store paste that is not delivered in a cold pack in a refrigerator.

Place the solder paste on the prototype stencil to one side of the hole pattern. Spread the solder paste the full width of the hole pattern.

Squeegee: The squeegee is a flexible blade of stainless steel used to roll the solder paste over the prototype stencil, forcing the solder paste through the prototype stencil and onto the PCB lands.

While holding the prototype stencil in contact with the PCB, take the squeegee and place it on the prototype stencil outside the solder paste. *Tilt it 15 to 20 degrees from the vertical (toward the solder paste), and drag it and the solder paste across the hole pattern. Hold a light to medium pressure on the squeegee against the prototype stencil. Carefully lift the prototype stencil away (UP) from the PCB. *You may have to experiment a little to find the best angle for the type of solder paste you're using.

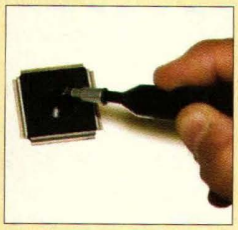
Inspect the solder paste print to ensure all the lands have solder paste on them and the paste is not smeared. If the print is not good, immediately use a spatula to remove the solder paste from the PCB. Clean the paste that remains on the PCB with alcohol and a clean rag. Let the PCB dry and print the solder paste again.



3. Place components.

Important: Keep the time between printing the solder paste and placing the SMT parts on the solder paste short. The paste manufacturer can guide you on the maximum time between printing and placement.

Place the SMT parts on the PCB using tweezers or a handheld vacuum placement tool. (Use a magnifying glass, if needed, to align fine pitch leads to the land pattern.)



4. Using reflow temperature indicators.

There are two reasons to use a temperature indicator. First, to create good solder joints, solder paste has to reflow, or melt, at a certain temperature and stay at that temperature (liquidous) for a given amount of time. When you buy your paste, this information is provided by the solder vendor. Next, your SMDs are temperature-sensitive, so you want to know how long they can be exposed to the reflow or melt temperature without damage. A temperature indicator is designed to tell you this by the way it reacts within the oven.

There are several types, but the one I use looks like a big crayon. I use this to make a mark on the board.

Some of these are hard to mark with, so I often just shave off a tiny bit of flakes onto the board with a knife tip. You might want to slice a small piece off. Either way works fine. It melts at the specified temperature.

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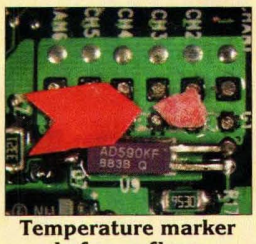
Different temperature indicators have different colors. For this process, the indicator marks are light in color. They look a little like dust on the board — almost like flakes of talcum powder. When they melt, they slump and change color. This particular one goes from light pink in color to a clear red, so it's easy to see. Obviously, it has to be near the window of the toaster oven where you can readily see the change.

5. Reflow your assembly in the toaster oven.

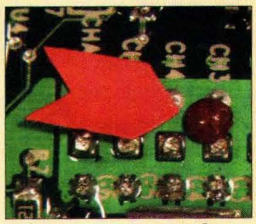
Important: Before reflowing starts, turn the oven on to heat up – a minimum of five minutes. Set the oven to bake and set the temperature to the highest baking temperature setting (450 to 500°F).

Before placing the PCB in the oven, mark it on the top side next to the edge that will be nearest to the oven door, with the reflow temperature indicator (413°F).

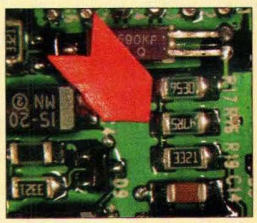
Make sure that you can see the temperature-stick mark through the oven door. If the edge of the board has a breakaway, do not mark the breakaway, mark the edge of the PCB. If there is not a clear area on the edge of the PCB, mark the interior of the PCB next to a large component (PLCC or QFP) with the reflow temperature indicator.



Temperature marker before reflow.



Temperature marker after reflow.



NOTE: The edges and corners of the PCB will be hotter than the interior of the PCB. If the temperature marker is used on the interior of the PCB, the corners and edges may get too hot and damage the board or the SMT components.

When the temperature-indication mark melts, remove the board from the oven. Be careful not to disturb the molten solder joints. Place the board on a surface and let it cool until near room temperature. Inspect the solder joints using your solder joint inspection criteria or the IPC 610 requirements.

If you have more than one board, place the next PCB in the oven after marking the board with the temperature stick. If any of the solder joints on the first board did not reflow properly, mark the PCB next to the location that did not reflow with the temperature indicator (413°F). Use this location to control the reflow length for the subsequent boards, or to redo the reflow process on the original board.

A flashlight can help when watching the temperature indicator material

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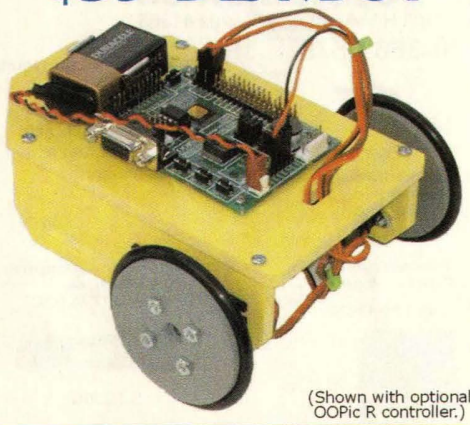

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Cautions and Handy Information

Warning: Using Common Sense

- Solder paste contains lead. Do not eat or drink around solder paste.
- Do not use a toaster oven to prepare foods after it has been used for solder paste reflow.
- Wash hands after working with solder.
- Oven is hot — use insulated gloves and safety glasses while working around hot equipment.
- Some SMT components have restricted thermal process requirements. Verify that all components can be processed using a standard SMT process as described in this procedure.
- Do not store cold pack solder paste in a refrigerator used for food, and never store room temperature solder jars in a refrigerator.

Solder Paste Shopping Guide

If you have questions about paste, you want to talk to a reliable source — usually someone other than a distributor. Solder paste manufacturers will always answer your questions and you can easily find them on the Internet (search on "solder paste"). You can sometimes purchase small quantities directly from some manufacturers. A better bet might be smaller distributors or you can purchase solder paste as an option in many prototype stencil kits. Here are a few well-known paste manufacturers in alphabetical, not priority order, and definitely not the only sources around. This is just a sample for your information:

AIM
Amtech
Cobar
EFD
ESP
Heraeus, Inc.
Indium Corporation of America
Kester Solder
Multicore
OMG
Qualitek International, Inc.
Senju

A handy link to almost all paste manufacturers is:
www.ecd.com/emfg/instruments/Paste/PasteMfg.asp

Learn How to Recognize a Good Solder Joint

I'm sure that many of you are either associated with, or at least aware of, the Institute for Interconnecting and Packaging Electronic Circuits (IPC). This is the best source I can point you to regarding all the guidelines you need to build and inspect a product-worthy board assembly. The documents below are extremely helpful, even if you're an old pro. You can order them — and much more — directly from IPC at the address below.

- IPC 610 is an industry SMT solder joint quality standard
- IPC/EIA J-STD-001C: Requirements for Soldered Electrical and Electronic Assemblies
- IPC-D-279 Design Guidelines for Reliable Surface Mount Technology Printed Board Assemblies

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change in form. When using a toaster oven, this visual method is the only reliable reflow guide. You have to watch the material to judge reflow time. Every board is different, so time is not a good control (one minute, five minutes, 20 minutes, etc.). There just isn't any "average reflow time" for these types of projects. To suggest any would only confuse the issue and could actually hurt, rather than help, your project. Remove the PCB after the temperature-stick mark melts, let it cool, and inspect the solder joints. Repeat the above steps until all your PCBs are reflowed. Turn oven off.

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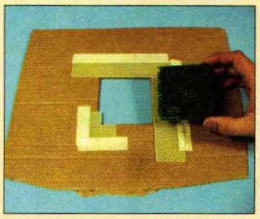
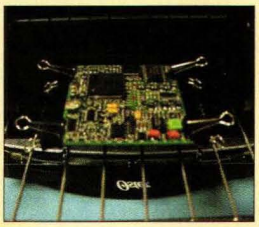


6. Screening a double-sided board, side two.

After populating and reflowing the side with the smallest components, repeat the process on the side with the larger SMT parts. This sequence will keep the largest and heaviest parts from hanging upside down during reflow, reducing the likelihood that they would fall off. Molten solder has very high surface energy, and can hold most SMT parts, even upside down.

Print the second side with the PCB on cardboard (cardboard is the easiest, but you can use wood or any non-static generator) that is large enough to attach the L-shaped board holder and your board assembly. Use cardboard that is thicker than the populated PCB and thick enough to function as a support for the screening process.

The cardboard should be cut out to clear the SMT components from the first reflow. Again, make sure all work surfaces are ESD safe or grounded.



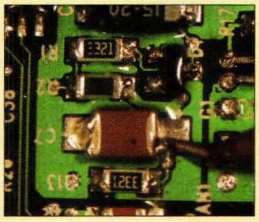
7. Reflowing side two.

When you reflow the second side of the PCB, the whole assembly has to be held off of the oven shelf with standoffs. You'll damage the SMT solder joints from the first reflow if you lay the board directly on the oven shelf.

You can use any material that can withstand the oven temperature to create standoffs to hold the board, but the very best is scrap FR4 material. You probably have some old board scraps laying around, but if not, just prop the assembly up on a couple of pieces of metal, or anything that is not going to be affected by the heat of the oven. I used large binder clips for this board and they worked fine.

8. Touching up defective solder joints.

Touch up any solder defects with a solder iron. Use a fine tip on the solder iron and don't let the tip touch the body of the SMT parts. Set your solder iron temperature as low as possible. A solder iron that is set to a high temperature can thermal shock SMT components.



That's it. You now have your finished boards, ready to test and use in your latest project. Make sure you handle your SMT and mixed technology SMD board(s) carefully. They're not as rugged as 100 percent through-hole, but what you can create with them is far beyond anything you could ever get with only through-hole. Experiment. Have fun. **NV**

Questions? Contact me and I'll do my best to help. Bob Rook, SCT Engineering, 513 Sweetleaf Dr., Brandon, FL 33511; 813-505-0728; **sctengfla@msn.com**.
For information on the Prototype Stencils:
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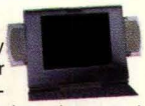

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No. 720-0361N Retail $19.95 $5.95 (ea.)

Mini 6/12 Volt Siren

Mini siren requiring 6/12 volts DC with 7" leads. Dimentions 2-3/8" x 1-1/2" x 1-1/2".

No. 180-0113N $4.95 (ea.)

12 VDC Hobby Motor

High speed hobby motor boasts over 16,000 RPM at 12 VDC. 1.2 Amp Overall size: 1-1/2" diameter x 3" long.

1/8"(D) x 3/8"(L) Splined shaft. Two 2.5mm mounting holes on face are 1" O.C. This motor is also reversible. MFG: Johnson

No. 420-0570N $1.25 (ea.)

12 VDC Worm Gear Motor

12 VDC worm gear drive motor has two speeds. High speed is 106 RPM at 4A, and low speed is 41 RPM at .91A. A 2.25" offset is attached to the 3/8" threaded shaft. The offset has a universal joint on one end. Originally designed as windshield wiper motor for 2000-2001 Saturn "L" Series cars.

No. 420-0578N $12.95 (ea.)

115VAC 4-5/8" Ball Bearing Fan w/ tach

115 VAC 50/60 HZ, 18 Watts, 106 CFM, 5 Blade Metal Construction, Metal Body Construction, Ball Bearing, Terminal Leads, Size: 4-5/8" SQ x 1-1/2". Fan also has three wire signal generator output. MFG: Papst. Manufacturer Part Number: 4606ZH.

No. 290-0671N $11.95 (ea.)

19" Rack Mount

7 ft tall 19" wide rack mount. Ideal for audio or netowking equipment. Unassembled with 2 base angles, 2 top angles & harware. Choice of charcoal or mill finish.

No. 220-0378N (charcoal)
No. 220-0380N (mill) $69.95 (ea.)

Category 6 Plenum Wire

The latest in network wiring. Up to 1 GHZ bandwidth. Great for use with many new commercial or home automation systems. 24 awg solid twisted 4 pairs. Plenum. Color: Natural. Length 1000' pull box. MFG Belden, MFG P/N: 7882A

No. 631-0334N $99 (box)
No. 631-0347N (PVC) $69 (box)

400 Watt Metal Halide Light with Bulb

Model MHSE-W-400-277F-F1. 18" diameter aluminum shroud with glass bottom. 277/120 V (currently wired for 277v but can be easily changed). Great for warehouse, grow lights, barns or other indoor use. This item must be shipped oversized. Please call for shipping charges. Used, excellent condition.

Part No. 360-0554N $69.00 (ea.)

Gentact 10" Linear Actuator

Operates on 24 VDC, includes attached 115 VAC converter. 18" long retracted, 28" long fully extended, 9.5" wide, 5" high. Includes wired remote control. Torque rating of 1300+ pounds! Limit switch at both ends. 110 to 24 VDC converter has a safety switch.

No. 340-0001N $99.95 (ea.)

Lightbox with High Intensity LED

A black mini light box with back lighting and a high intensity LED bottom light is great displaying your small valuables or any number of other items. Measures 9.75" deep 8.25" tall and 6" wide. The inside display area is 4" deep 6.25" tall and 5.5" wide. It has a translucent back and a hole on the bottom for uplighting. Power comes from a 115VAC to 12VAC wall transformer. Back lighting comes from a 5.25" mini florescent bulb (F4T5/CW) and bottom lighting from a circuit board with 15 high intensity LEDs. (Fig B)

No. 360-0548N $15.95 (ea.)

Same as above, but with 1, "U" florescent tube FT18DL/830)

No. 360-0549N $15.95 (ea.)

Locking Case / Gun Case

10.25" high, 11" wide (not including 1.25" for lock brackets), 10.5" deep foam seal on outer door. Made of heavy duty metal. Includes knockouts on bottom for electrical connections. Weather resistant.

No. 650-0964N $24.95 (ea.)

Super Neodynium Magnets

These tiny magnets are so powerful, they still hold strong through a human finger. Each one measures 3/8" diameter x 3/16" thick.

No. 380-0095N
.50¢ (ea.) or **3 for $1.00**

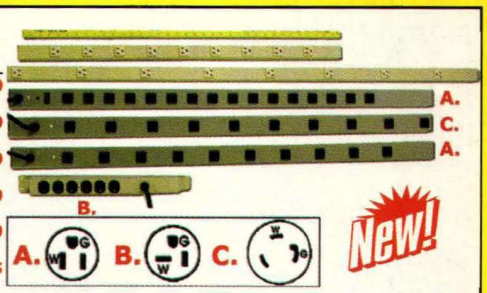
1000VA Uninterruptible Power Supply

Only 7" x 8.8" x 17.1" and weighs 43 lbs. Has 6 protected outlets and a network interface surge protection. MFG: NCR MFG P/N: 4071-1020-7194

No. 220-0314N $179.95 (ea.)

SL Waber Power Strips

Part No.	Outlets	Length	Features	Price
280-0412N	9	36"	15A, 120V, permanent mount	$19.00
280-0413N	8	60"	15A, 120V, permanent mount	$19.00
280-0406N	16	48"	15A, 125V w/cord & switch, 26' cord	$34.00
280-0409N	10	48"	20A, 125V w/cord, grey, 5' cord	$24.00
280-0405N	10	48"	15A, 125V w/cord, grey, 6' cord	$29.00
280-0423N	6	19"	20A, 125V rackmount, 6' cord	$19.95



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Satellite Radio Extension for the Whole House

by Gordon West

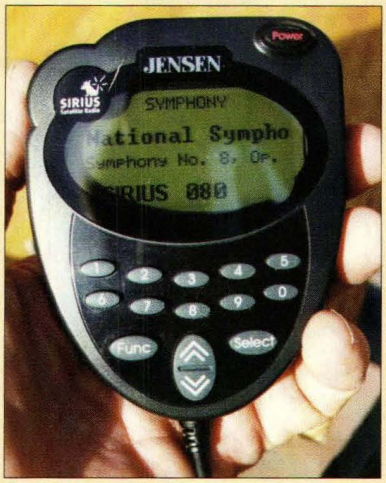
Look out Satellite TV — here is the new and improved Satellite Radio! You'll be able to hear everything you want to hear as you stretch the concept of the radio to its limits!

In 1997, the Federal Communications Commission (FCC) auctioned two licenses to broadcast satellite programming to North America from space. The frequency would be on S-band — 2.3 GHz. XM Radio and Sirius Radio were awarded the contracts, and by 2001, both satellite radio providers began launching satellites in space — Sirius with satellites in an elliptical orbit above North America, and XM out 22,500 miles with two satellites in geostationary orbit with spot beams back to North America. Both systems use their satellites as "space repeaters," simply echoing back what is beamed up to them via major-sized earth dish antenna systems.

Both Sirius and XM also identified 30 to 50 "must have reception" tunnels and underground areas, and installed opposite polarization terrestrial signals for receivers to pick up at 2.4 GHz.

XM satellite radio runs around $10.00 a month, and you pick up 100 digital channels of music, news, sports, and entertainment, with 36 of the 100 channels commercial free (**www.xmradio.com**). Sirius satellite radio also brings out around 100 streams of music and entertainment — 60 music streams with no commercials. The other 40 channels include sports, news, comedy, entertainment, and a couple of other very specialized programs, all available 24 hours a day for around $13.00 a month.

I contacted both companies almost a year ago in preparation for some feature articles on satellite entertainment radio for both marine and RV markets. Sirius satellite radio was keenly interested in satisfying both of these markets with their satellite products, and I spent some time with them in New York City looking over their studios and explaining what an RVer or a sailor might want for reception capabilities.



The hand controller reads out the category station name, the music, and channel number.

Sirius works closely with Shakespeare Electronics — manufacturers of RV and marine communication antenna systems — so it was a natural that Shakespeare soon offered a high gain Sirius satellite antenna system that works well in the open and surprisingly well inside most fiberglass vehicle roofs and aboard most fiberglass boats below deck.

If you have played around with GPS reception, you will find the same type of receiving capabilities on the new satellite broadcast radio service. Reception remains strong — even on cloudy or rainy days. Reception gets spotty if you're under a big tree, yet reception remains strong inside a fiberglass enclosure, like a boat or RV with a fiberglass roof. And just like GPS, signals disappear when you go in a tunnel, and sometimes disappear in major downtown cities.

The signals are captured by the antenna and fed to well-known manufacturer satellite receivers. XM and Sirius use different decoding schemes, so manufacturers generally don't have a receiver that could do both. And no one would really need to sign up for both services, either.

The equipment that decodes the digital streams is offered by most major mobile audio suppliers. For Sirius, I had plenty of choices from Jensen,

Twin antenna jacks for local 2.4 GHz and satellite reception.

Adjustable input for your satellite receiver black box output. Don't set this too high (or all you get is distortion)!

Panasonic, Kenwood, Clarion, Audiovox, and Prospec.

Each manufacturer provides the decoder, and the decoder outputs pigtails for your existing audio stereo system. I did some equipment tests and found that each manufacturer satellite radio decoder worked just swell in giving me crystal-clear, digital-quality, stereo reception, outputting left and right channel low-level 400 mV RMS at 10K ohm audio. You get a pair of top-quality RCA jumper cables, and in seconds, satellite radio low-level audio out to your existing audio system auxiliary input port — and presto — you now have a new radio service that adds to your existing AM and FM, plus any cassette or digital playback within your system.

Unfortunately, my little dune buggy audio system didn't have provision for external input, but each of the manufacturers have you covered with a little hideaway accessory box that takes two-channel input and converts it to DIP-switch selectable FM stereo radio output. Unplug your vehicle's external Motorola-type antenna connection, plug in the little stereo output adapter box, and then plug in your external antenna into the adapter box. With the satellite system turned on, the box feeds stereo to your existing audio system.

Turn the satellite system off, and your audio system now works off of the original outside or windshield antenna.

So this system worked well in the dune buggy — I was impressed that I could now listen to full stereo without the high ignition system noise creeping in. I could go over the meanest of sand dunes, and not have my stereo player skip. It worked so good that I found I couldn't live without satellite radio in the house, so after every dune buggy weekend, I would yank the equipment out and hook it into my big stereo system in the living room.

But then my wife wanted to hear CNN and BBC news all night long from her bedside earphone. Plus, I wanted to tune in folk music with my personal stereo when I mowed the lawn. And nothing better than a little background mood music out on the patio with a portable boom box.

I first tested to see how far I could squeak the FM stereo output of the little black box modulator. It was pathetic — maybe 10 feet at best.

So began my big search for a Part 15 stereo transmitter that would take satellite radio input, and beam me out a decent signal to get throughout the house. Despite some of the claims at the local hobby electronics store, the little FM stereo adapters would barely go beyond a room away.

But I found two manufacturers of FM wireless stereo "rabbits" for my Sirius satellite radio system that not only worked throughout all of the house, but even gave my next door neighbor adequate reception, too.

My first success with good-range stereo transmit was Ramsey Electronics — their FM 25B synthesized FM stereo transmitter kit. For $129.95, you get the kit and all of the pieces. If you have put kits together before, it will be an easy four-evening project. Everything is well laid out, and Ramsey kits always have crystal-clear instructions and procedures for testing your completed project. This newly designed kit also includes adjustable RF output, but there's absolutely no reason you would want to have it at anything other than full power out because full power out meeting Part 15 low-power, no-license rules is just barely enough to get around the house. Adding the loop output will dramatically eliminate "cold spots" in your house or office, but it requires a lot of wiring to surround your listening area.

The powerful amplified Shakespeare 2.3 GHz satellite radio antenna system.

The decoder box mounts out of sight near your amplifier or auto stereo.

C. Crane 12VDC battery eliminator module.

The FM modulator if you have no amp access.

The C. Crane has everything you need in the box.

Ramsey also offers a tempting one-watt "export version" completely assembled, synthesized, FM transmitter, priced at around $400.00. Just think, you could beam out your satellite radio signal in all directions up to a mile away *outside* of FCC jurisdiction.

In fact, Ramsey Electronics will have you sign an export certification for their FM-100EX and FM-100BWT products because both units exceed authorized output levels set by the FCC, and must not be operated within the territory of the United States.

I know it might be tempting to try it, but if you recall, a local automobile raceway doing its own little mini radio announcing incurred a several thousand dollar fine for using an export one-watt FM stereo transmitter in the United States. Just something to think about before you get *very* tempted by the Ramsey one-watt transmitter that really looks like the answer to having a good amount of signal to not fuzz and buzz and fade out as you walk from room to room with your portable headset on.

Another popular FM transmitter that works well with a satellite radio decoder is the equipment from C. Crane — Model "FM Transmitter" — fully assembled, tuned, and tested. It features a digital output for easy open-channel selection. A little telescopic whip pulls out for radiating the 100 milliwatts or so of transmit capabilities.

The C. Crane fully-assembled FM transmitter did an equal job to the Ramsey equipment under Part 15 regulations, and each with their little stock telescopic whip put out an adequate signal to *barely* make it through a 2,700 square foot house. If you don't mind running a wire loop all the way around your home, you can take those minuscule milliwatts and help fill in dead areas, plus maybe have a little left over signal that makes it to your next door neighbor.

But neither of these units would give you near the signal strength that you'll find coming in from regular FM stereo stations 50 miles away. In fact, your biggest problem will be trying to locate a quiet frequency where outside FM stereo stations don't drown out your inside satellite radio signal.

We now run the C. Crane FM transmitter inside our mobile communications unit, and it works well inside vans, motor homes, and automobiles.

C. Crane has a companion 12-volt DC adapter kit, and the little C. Crane FM transmitter can even run on two internal AA batteries. So the C. Crane Part 15 FM transmitter with LCD digital frequency display resides in the motor home, and this gives us plenty of stereo capabilities up to about 50 feet away at a campsite.

The Ramsey stereo transmitter fills up the house with great satellite radio signals, and the actual Shakespeare satellite 2.4 GHz antenna system has no problem at all bringing in the signals through a wood shake roof.

Of course, the absolute ultimate digital reception is when you hook the satellite unit up directly to your automobile stereo auxiliary input, but then you don't get the capability of wandering around with your personal stereo and hearing 100 channels of streaming audio coming in from space where both Sirius and XM compete to offer you the ultimate in satellite radio entertainment. **NV**

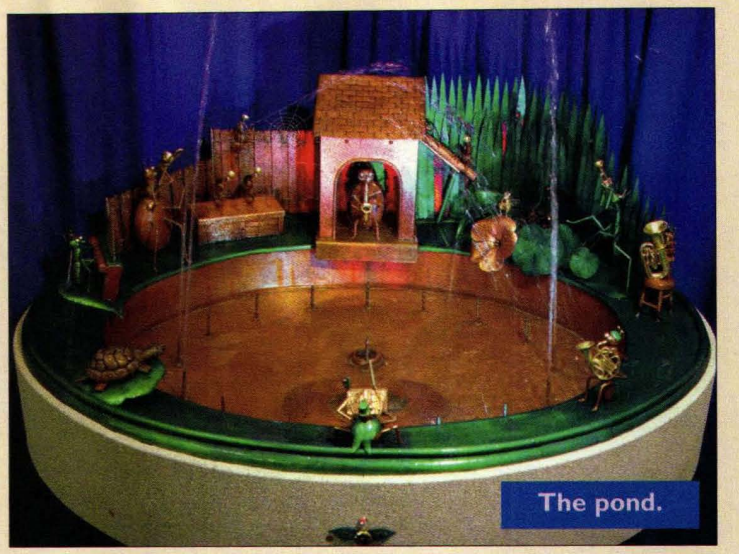
Resources

www.ramseykits.com
www.ccrane.com
www.shakespeareelectronics.com

H-2-Opus

Water, music, lights, and microcontrollers

by Victor Chaney


The pond.

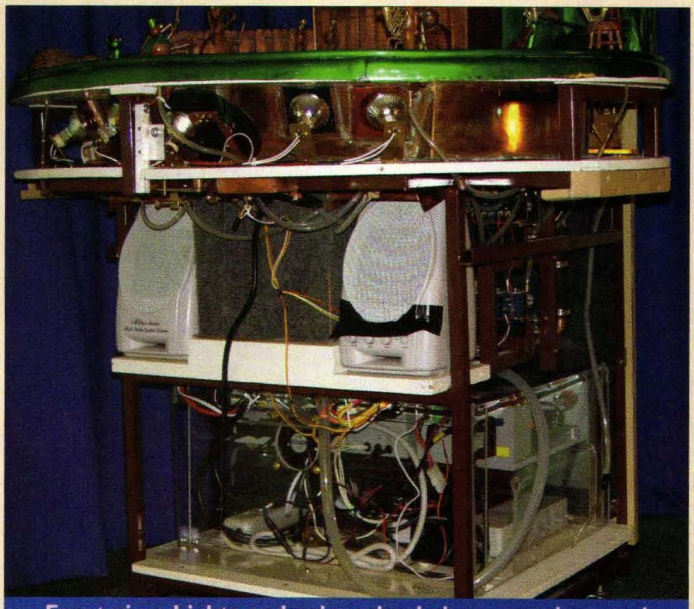
What kind of home project has 82 legs, horns, and will never have all of the "bugs" worked out of it?

The answer is "H-2-Opus," a musical water fountain. It features a scene of insects surrounding a pond of water, each with a musical instrument that squirts water.

Water fountains are all nice, but I find that ones with computer-controlled leaping streams of water are especially interesting. A local amusement park has one with arches of water jumping between ponds, which started my fascination. Disneyland and Universal Studios go a few steps farther. What finally convinced me to try one of my own was seeing the magnificent musical fountain at the Bellagio Hotel in Las Vegas. My fountain takes quite a different approach than this, but all of us who have an interest in computer-controlled motion should be mesmerized by the Bellagio's ultimate display.

What Can I Do?

Since Bellagio's lake-sized fountain won't fit in my garage (or budget), I made "H-2-Opus" to a scale that I could handle. It is controlled by MIDI and has 36 valves, five servos, seven lights, three lasers, and a fog machine. The scene and the creatures are made from copper and brass, and the metals are polished with patina, or enameled. From the floor of the pond arise 16 spouts in a big ellipse, and another spout comes from the very center. Where many of the insects just squirt the water to music, there are several special features, as well. A tiny bee sits on a flower, and when it becomes his turn to solo, he flies from his flower while playing his saxophone (squirting water) and maneuvering above the pond. Then a turtle on the other side squirts water at him before he lands back on the flower.


Front view. Lights and color wheel above, speakers and water pump reservoir in the middle, electronics below.

In the center is a hut with a saxophone-playing ladybug in it. The ladybug pivots back and forth as he plays. He "rocks out" as he blows his sax and kicks his leg to the music. Hidden inside the hut are two 10mm cubic-zirconia (CZ) which rotate, while two lasers hit the CZs from below. The laser beams are split into many beams. The lasers are taken out of laser pointers. A tiny fog machine fills the hut with fog, which makes the rotating beams of the lasers visible, and can also fill the pond with fog when desired. My whole desire for the fog machine was inspired by wanting to see the laser beams, but having a bunch of fog on the pond with the lights on it turned out to be a cool effect, and it seems that people really like it.

The ring of spouts in the pond also makes patterns of water with the music. The center spout has a servo-controlled pinch valve that can change the volume of water from this spout, and make it grow from low to high. There is a laser coming up through the stream of water in the center, which illuminates the water from inside the spout. There is also a spotlight at the base of the center spout that can illuminate the spout on the outside.

Set inside the front rim of the pond are five colored halogen spotlights. The center light has a servo-controlled color wheel, enabling this light to have four colors. The band conductor at the front also has a light inside his podium.

How it Works

The music is played on a floppy disk MIDI player (Yamaha MIDI Data Filer MDF-4), although for programming the display, I used the MIDI output of a computer. By using a music sequencing program, the events can be clicked in with a mouse. A solenoid-valve's activation can be


Ragtime four-handed keyboard player.


Ladybug, Blues Brothers on his right.


French bug, French horn.

dragged to an earlier or later time, or turned on for a different duration of time. Then I can watch it perform to a section of the music, and change the performance to suit the mood of each portion of the musical piece.

When a piece of music is choreographed with everything performing to the music, then the MIDI file is saved and added to a floppy. When the fountain performs, the MIDI player plays one tune after another from the floppy.

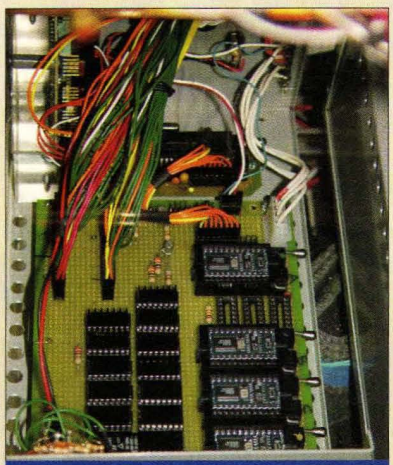
Fifteen channels of the MIDI are actually music, but the 16th channel is what controls the fountain. Each "note" turns something on, or starts a servomotor routine. There are 84 notes' worth of events in controlling everything. Some of the notes perform multiple functions together.

MIDI and Electronics

The MIDI music goes through to a sound module and computer speakers for the sound, with channel-16 notes set at volume and velocity of "1" so that they are not heard.

The 16th channel is filtered with a PIC 16F877 microcontroller. Channel 16 goes from the PIC to four BASIC Stamps (BS2SX) that actually control the fountain's parts. I am an amateur in electronics and programming (a dentist by profession), and constructed Thorsten Klose's MIDI filter as a starting point. A few modifications to his code were all I needed. A MIDI note for channel 16 is made into a byte that holds the function number and on/off status, and is sent on eight parallel lines to Stamp A.


Back view. Sound module and MIDI player on the bottom, electronics above them. Rows of valves in the middle. At the top are servos for bee x-axis and ladybug, lasers for the shack, and servo for the center valve.


The brains. Other boxes are mostly power supplies.

The Stamp A reads the byte from eight pins of the PIC. It then either turns on a light, or sends data serially to the other three Stamps to turn something else on. By splitting the duties between the Stamps, one Stamp can fly the bee in the x-axis, another Stamp fly it in the y-axis, and the last Stamp squirts the bee's saxophone while the bee flies. The BASIC Stamps work very well for an amateur like me, as they are so easy to program. Making everything perform artistically with the music took a lot of programming and reprogramming to get everything just right.

The outputs of the Stamps control servos, solenoid valves, and relays. The solenoids and relays run at 24 VDC, driven by ULN2003A Darlington transistor arrays. The relays turn on the 12VAC halogen spotlights, the motor that rotates the CZs, and operate the footswitch plug on the MDF. A solenoid also pushes a button on the front of the MDF. Transistors (2N2222) help the Stamps turn on the lasers. There are a lot of different power requirements, and what a pile of power supplies is needed! It is important to have a separate 5V supply for the microcontrollers and the servos. The servos will cause the BASIC Stamps to sometimes reset if they are on the same supply. This is most likely to happen if a big crowd or somebody important is watching.

Flying and Dancing

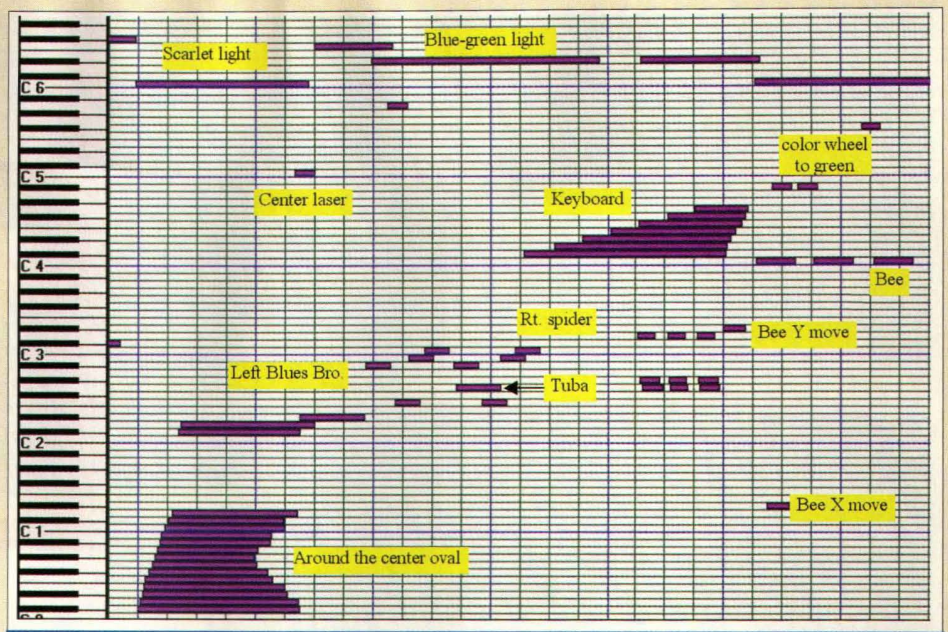
The bee "flies" by means of a scissors jack. One servo controls the y-axis direction that actually makes the bee fly in an arc — up and out from the flower. Another servo controls the x-axis direction, making the bee fly back and forth. Between the arc of the y-axis direction and the back and forth of the x-axis, the bee seems to fly in three dimensions. There are four different routines for the bee to fly, with different motions and lengths of program to go with different pieces of music. The ladybug has a servo that pivots him back and forth. A cam arrangement inside of him pulls a Kevlar thread, which lifts one leg as he goes to each side. The movement of the ladybug while shooting water from his saxophone makes for a nice effect. He has six routines from a single kick to longer programs for his "solos."

The fog is made by a small, ultrasonic fog maker that makes the water into a very fine mist,

which flows down from the inside top of the shack, and then across the pond of water.

Construction

A welded steel frame, using 3/4-inch steel tube, supports the entire fountain inside. Plywood forms the floor of the inside, and on top of this are the electronics. The electronics have an acrylic enclosure over all, and a fan keeps it all cool inside. In this enclosure is the MIDI player, sound module, microcontrollers, relays, and power supplies. Everything electrical in the fountain is protected from the water by enclosures or shields, so that if something goes wrong, all will not get destroyed by four gallons of water getting sprayed all over the inside. (This has happened a few times — Murphy's Law at work!).



The notes of Channel 16 are triggering events over time. The vertical lines are the beats of the music.

In the middle are rows of solenoid valves. I used surplus 24-volt DC valves. It is helpful if these do not use too much current, so that the driver chips can handle the load. Nearby is the lower reservoir, which contains the 500GPH submersible pump. Each supply tube has a flow-adjusting valve made from a big nut with a #8 screw tapped through the side. The screw presses a copper pad that pinches the tubing. Using distilled water keeps everything running smoothly, and is kind to the finish on the metals. Above the valves is the pond. A ring of plywood supports the base of the pond, and another ring supports the rim. Between these two rings is room for servos, lights, and mechanical drives. The white lights are colored with pieces of colored gel, like DJs use.

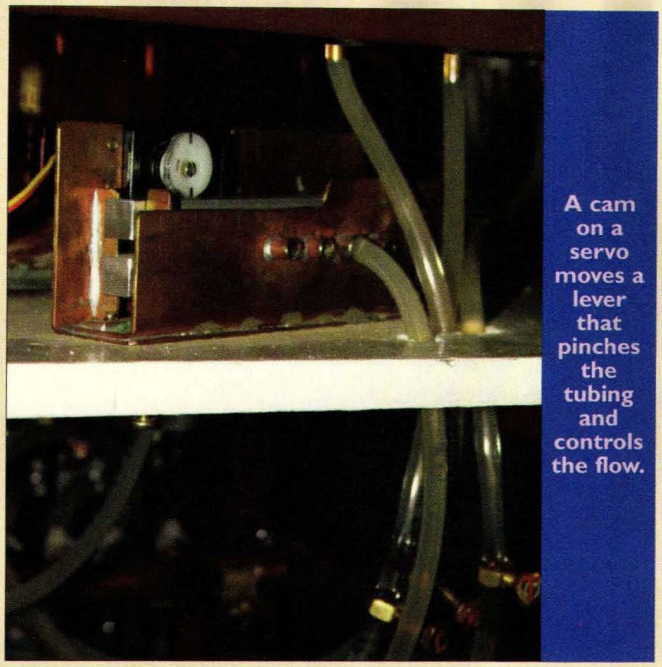
The outer part of the base is made of 1/16-inch polycarbonate sheets laminated with five layers. They are glued with solvent made for solvent-welding plastics. The skirt on the top was formed on the fountain. The base was formed on a plywood jig, using two cutouts separated by some 2x4 lumber pieces. The layers are put on one at a time, squirting solvent onto it a foot or so at a time, clamping it in place for about 10 minutes, then doing another section. When it is done, it holds its shape, and can be cut, filed, and sanded to final trim. Blocks of acrylic plastic glued inside allow the base to rest on the plywood at the edges, so then only a few screws are needed to anchor it in place. I love working with plastics — the glue joints are very strong, the material is strong, and it handles water well with no surface treatment.

The base was first painted to block the light, and make it less transparent, and then painted with a simulated rock coating. The inside is lined with carpeting to help dampen the sound of the solenoid valves. Wheels on the bottom help to manage the 250-pound weight.

Copper, Brass, and Bugs

My orchestra is made of mostly copper and brass. I

Circle #108 on the Reader Service Card.



A cam on a servo moves a lever that pinches the tubing and controls the flow.

The conductor.

The tuba player.

made insects because they are whimsical, easy to make, and it does not look strange to have them in many different sizes. I used different sizes of brass tubing, brass rod, and brass balls for many parts of the insects, and sheet copper (.025") and brass (.050") for the bigger pieces. It is all soldered with a propane torch, Tin/Silver (96/4) alloy solder, and paste flux. Heat shielding compound is a wonderful clay that allows you to anchor one piece that you just soldered, and solder something else next to it without melting and destroying the joint you just made. Most everything that squirts has a 3/32-inch inside diameter.

The spiderweb and some insect wings were made of .025" stainless steel wire, soldered with hard silver solder.

I made all of the parts, including the instruments. Some pieces were soldered together from existing shapes (tubes, balls, etc.). A small lathe helped turn most of the horns. A few parts were cast from brass, using the lost-wax process. The ladybug's saxophone was cast in four pieces and then soldered together. The copper is worked by heating it red hot, then quenching it in water. It becomes softer, and can be pounded into compound shapes. As it gets shaped, it also gets harder, so sometimes repeated heating and quenching is needed to keep it workable. Pickling it in 10 percent sulfuric acid removes all of the black discoloration.

Some of the metal was colored by patina, and then coated with clear finish, that is originally made for cars. The green areas use the clear finish, with blue and green pigments from an auto body shop mixed in. The color makes a nice effect over the clean copper showing through. Some of the parts were left polished — little parts like eyes, and bigger parts especially like the instruments. The finish keeps it from tarnishing.

The top rim was first made of several layers of plywood, which was shaped to slope down to the pond. Then copper was formed around it in four pieces, and soldered together. A rim of 3/8-inch copper tubing makes a border on the outer edge.

The fountain now resides in my office waiting room, and is a big hit. People come to my office just to visit my creation. I hope to have it in the California State Fair this summer. The music is mostly big band music, with up-tempo beats, horn fills, and multiple parts. This makes for a lot of action with the water. There are six tunes in it now, including "In the Mood," "Peter Gunn," and "Don't Get Around Much Anymore." This kind of project is very fun to work on, and it is amusing to scheme up the different performing events.

This is my second fountain, the first is smaller and without music or lights. It has two BASIC Stamps controlling 27 valves and three servos, in a three-minute program of dancing water. It was a simpler project, and also very fun to make. A lot of action can be packed into two BASIC Stamps.

More information, including circuit diagrams, code, drawings, patina recipes, and other information can be found on the *Nuts & Volts* website at **www.nutsvolts.com**. My email address is chaneyv4@sbcglobal.net. **NV**

Victor Chaney is a dentist in private practice in Vallejo, CA, where he keeps the fountain on display. Before dentistry, he received his bachelor's degree in Physics. His electronics education comes from books, magazines, and the Internet. He also plays pedal steel guitar in a Rock-and-Roll/Country band, "Coyote." His last fountain, "Insectopia," won top prize — Creativity Trophy in Best-of-Show Competition at the California State Fair.

Resources

1. The Bellagio Hotel's fountain: **www.wetdesign.com/client/bellagio/index.html**
2. The MDF-4 MIDI Data Filer can be found at **www.americanmusical.com**
3. Thorsten Klose's extensive work with MIDI is at **www.ucapps.de/index.html**, and my modified version of his MIDI filter is at the *Nuts & Volts* website, used with permission.
4. Fountain foggers and other fountain supplies can be found at Artistic Delights Fountain Supplies (**www.artisticdelights.com**).
5. Solenoid valves and pumps can be found at Mendelson Electronics (**www.meci.com**).
6. Micro-Mark, at **www.micromark.com**, has telescoping sizes of brass tubing.
7. Brass balls and gears are great at McMaster-Carr Supply (**www.mcmaster.com**).
8. Incredible selection of metals, parts, and materials is at Small Parts, Inc. (**www.smallparts.com**).
9. A good reference for working and soldering metals is *The Complete Metalsmith* by Tim McCreight, available from Micro-Mark.
10. Patina chemicals and sulfuric acid are available from Bryant Laboratory (**www.bryantlaboratory.com**).
11. Urulac #9778 is a "catalyzed clear exterior coating" by G. J. Nikolas & Co., Inc. (708-544-0320) sprayed on with a little aerosol spray kit from the hardware store.

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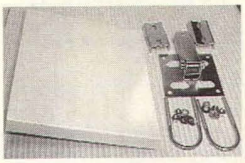

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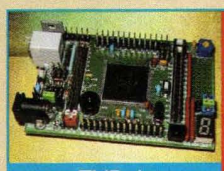

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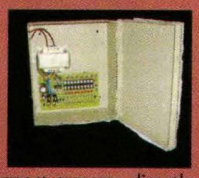

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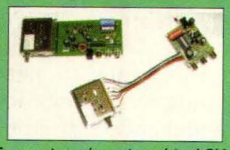

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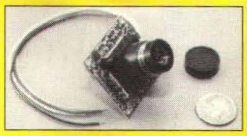

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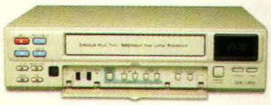

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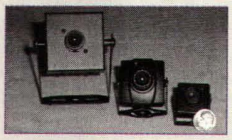

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"Where It Is and How to Get It"

Robotics Resources

Sensors for Tilt Measurement

A common means of providing a robot with a sense of balance is with a tilt sensor or tilt switch. The sensor, or switch, measures the relative angle of the robot with respect to the center of the earth. If the robot tips over, the angle of the sensor/switch changes, and this can be detected by electronics in the robot. Tilt sensors are particularly handy for walking robots as a means to provide attitude feedback. The sensors are also useful with sumo and other fighting robots as a way to indicate when the machine is about to fall or roll over.

This month, we'll look at a variety of tilt sensors applicable to small robots. Prices vary from about $10.00 to several hundreds of dollars.

Types of Tilt Sensors

Tilt sensors and switches come in various forms and packages. Common varieties include the following:

Mercury-filled glass ampoules that form a simple on/off switch. When the tilt switch is in one position (say, horizontal), the liquid mercury metal touches contacts inside the ampoule, and the switch is closed. But when the switch is rotated to vertical, the mercury no longer touches the contacts, and the switch is open. The major disadvantage to mercury tilt switches is the mercury itself, which is a highly toxic metal.

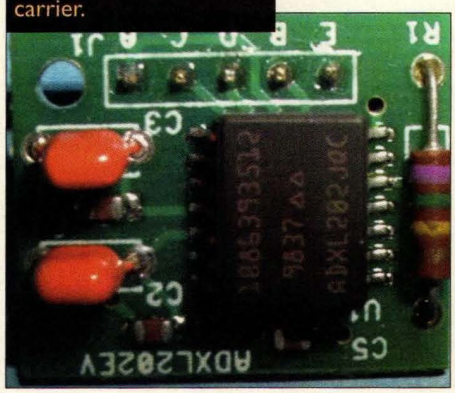

Figure 1. The ADXL202 accelerometer mounted on an evaluation board carrier.

Ball-in-cage. These all-mechanical switches are popular in pinball machines and other devices where small changes in level are required. The switch is a square or round capsule, with a metal ball inside. Inside the capsule are two or more electrical contacts. The weight of the ball makes it touch the electrical contacts, which forms a switch. The capsule may have multiple contacts to measure tilt in all directions.

Electronic spirit level sensors use the common fluid bubble, along with some interfacing electronics. A spirit level is the same kind you see on ordinary levels at the hardware store — it's merely a glass tube filled — but not to capacity — with water or some other fluid. A bubble forms at the top of the tube since it isn't completely filled. Because of gravity tilting the tube, it makes the bubble slosh back and forth. An optical sensor — an infrared LED and detector, for example — can be used to measure the relative size and position of the bubble.

Electrolytic tilt sensors are like mercury switches, but are more complex, and a lot more costly. In an electrolytic tilt sensor, a glass ampoule is filled with a special electrolyte liquid — a liquid that conducts electricity — but in very measured amounts. As the switch tilts, the electrolyte in the ampoule sloshes around, changing the conductivity between two (or more) metal contacts. Mechanical/optical tilt sensors use a pendulum or other mass to rotate a potentiometer or optical encoder in response to tilt. These are entirely solid-state — unlike spirit level or electrolytic tilt sensors — which incorporate a liquid.

Accelerometers can electronically detect the pull of the earth's gravity. The latest accelerometers are available on a single integrated circuit, making them small and relatively inexpensive. Of all the potential sensors useful for measuring tilt, accelerometers are among the least expensive. An accelerometer is a device that measures change in speed. Accelerometers are used in vehicles, rockets, even elevators. Put an accelerometer in a car, for example, and step on the gas. The device will measure the increase or decrease in speed. Most accelerometers only measure acceleration (or deceleration), and not constant speed, or velocity. Velocity information can be derived from acceleration data, however.

Although designed to measure changes in speed, many types of accelerometers are also sensitive to the constant pull of the earth's gravity. This type of accelerometer can be used to measure the tilt of a robot. This tilt is represented by a change in the gravitational forces acting on the sensor. The output of the accelerometer is either a voltage, or it can be a digital signal that indicates the relative acceleration at any given moment.

Analog Devices is a semiconductor maker, primarily of industrial and military grade operational amplifiers, digital-to-analog and analog-to-digital converters, and motion control products. One of their key product lines is the ADXL line of accelerometers, which use a patented fabrication process to create a series of near-microscopic mechanical beams. This "micro-machining" involves etching material out of a substrate. During acceleration, the beam is distended along its length. This distention changes the capacitance in nearby plates. The change in capacitance is correlated as acceleration and deceleration.

In addition to the mechanical portions of the accelerometer, all the basic interface circuitry is part of the device. In fact, looking at one of the ADXL accelerometers, you'd think they were just integrated circuits of some type. Because the basic circuitry is included as part of the accelerometer, only a minimum number of external parts are needed.

Analog Devices makes a lower-cost line of accelerometers specifically designed for consumer products. Their ADXL202 is a dual-axis device with a ± two-gram sensitivity (if you need more grams, check out the

ADXL210, which is rated at ± 10 grams). The ADXL202 has a simplified output: As acceleration changes, the timing of the pulses at the output of the device change. This change can be readily determined by a PC or microcontroller that measures the length of the pulse.

The ADXL202 is a surface-mount component, so if you want to use it with a regular prototyping board or solderless breadboard, you'll need to solder it to a carrier, then attach the carrier to the rest of your chip. Analog also sells a handy evaluation board (see Figure 1) with an ADXL202 and a standard 0.100-inch header for easy attaching to standard breadboards and solder boards.

Analog provides a datasheet and application note on using the ADXL202, and provides links to resellers of the chip on their web site (you can also buy some products directly from the company). See the web site address in the sources list.

Sources

Analog Devices, Inc.
P.O. Box 9106
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(781) 329-4700
www.analog.com

Analog Devices is a key manufacturer of precision linear semiconductors. Among their product line is the low-cost ADXL series of accelerometer/tilt sensors, which can be readily used in amateur robotics. Their web site contains copious datasheets, white papers, application notes, and other documentation. Samples can be ordered directly from the site. A number of industrial electronics distributors, such as Allied Electronics and Newark, carry the Analog line for resale.

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(973) 227-1002
www.entran.com

Manufacturer of strain gauges, load cells, accelerometers, and pressure sensors. Fairly high-end stuff here, designed for precision measurement. Web site in English, French, German, and Spanish.

Measurement Specialties, Inc.
710 Rt. 46 E. Ste. 206
Fairfield, NJ 07004
(888) 236-6746
www.measurementspecialties.com

Measurement Specialties makes and sells sensors, particularly piezo sensors using Kynar plastic. These sensors can be used for such things as ultrasonic measurement, touch, vibration, and acceleration. The company provides online buying, but the minimum order is $100.00. Some of their product is also sold by Digi-Key and other distributors, such as Images, Co. (**www.imagesco.com**). Example prices are $19.95 for a single-axis accelerometer.

Memsic, Inc.
800 Turnpike St. Ste. 202
North Andover, MA 01845
(978)738-0900
www.memsic.com

Memsic offers a low-cost, dual-axis accelerometer that is designed to be both rugged and super-sensitive. The company offers online purchasing — several models are available with different signal output types and sensitivity ranges. An example product is the MXA2312U, rated at ± two grams, with an analog output. Cost is $12.50 in single quantities.

PNI Corp./Precision Navigation
5464 Skylane Blvd. Ste. A
Santa Rosa, CA 95403
(707) 566-2260
www.pnicorp.com

PNI makes a number of ready-to-use sensor modules, including compass, radar, magnetometer, and inclinometer. Online purchasing available at the web site. Example products include the TCM2 inclinometer ($305.00).

Sensors, Inc.
5557 Pioneer Creek Dr.
Maple Plain, MN 55359
763-479-4570
www.sensorsincorporated.com

Online retailer/distributor for a number of manufacturers of industrial sensors, including HohnerCarlo Gavazzi, Cutler-Hammer, and SICK. The web site provides a number of technical app notes that are useful for learning more about sensing technologies.

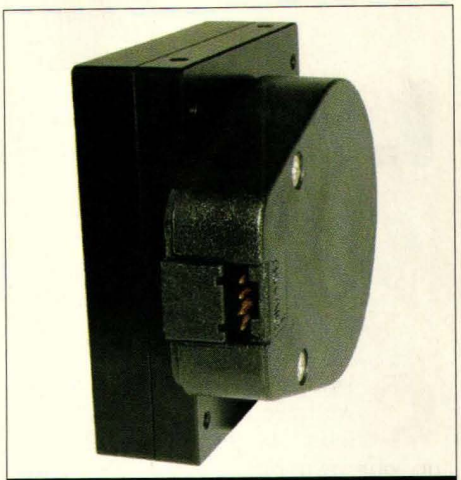

Figure 2. US Digital's T6 incremental inclinometer.

Spectron
595 Old Willets Path
Hauppauge, NY 11788
(631) 582-5600
www.spectronsensors.com

Single- and dual-axis tilt sensors and single- and dual-axis inclinometers (digital and analog outputs). Application notes available at the site.

US Digital Corp.
11100 N.E. 34th Cir.
Vancouver, WA 98682
360.260.2468
www.usdigital.com/

Manufacturer of low-cost optical encoders and inclinometer tilt sensors. The company offers both incremental and absolute tilt sensors, at prices starting around $70.00 (absolute output is more expensive). The units are available with different resolutions, up to 2,048 counts per revolution. See Figure 2 for an example of an inclinometer tilt sensor.

Make Contact

Got a great source for a nifty robot, kit, or component? Feel free to pass it along to me at robots@robotoid.com. **NV**

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. You're welcome to visit **www.budgetrobotics.com/**.

by Stanley York

Exploring and Experimenting With Lasers and Their Properties

Laser Insight

Put Your Holograms in Motion

Over the last couple of months, we have been looking at various hologram types, and set up our own optical table to make holograms. Often in scientific and engineering circles, there is a need to make holograms of objects or mechanisms under stress or in motion. The dynamic stresses imparted into any mechanism during operation can affect the mechanism's life span or accuracy, for instance.

When making a conventional hologram, it is necessary to maintain stable conditions around the optical assembly, so that the wave fronts impinging on the film plane maintain the proper spatial relationship.

Any movement of more than a half wavelength will cause wave front distortion that will mar a static hologram.

In recording dynamic events — such as gun barrel deformation during firing — it is necessary to make a double exposure to the hologram, such that two sets of interference fringes are combined.

Any part of the object that does not undergo some deformation will exhibit no change in the interference pattern, but those parts that do deform (or move) will immediately show up as a discontinuity in the interference pattern in the developed hologram.

Obviously, the two exposures have to be made very close together, time-wise, so that the recorded events are related to the same stress-inducing stimulus. Often, the time delay between these exposures is measured in low microsecond intervals, up to about one millisecond.

A special optical shutter (called a Pockels cell) is used to generate two "Q" switched pulses for each lamp flash, and I will be describing this in more detail as the article progresses. Beyond a millisecond, other methods are used to make the double exposure.

This month, I will begin to describe a simple Cr:Ruby laser. There will be a number of issues to discuss, and I expect it to take a few columns before we are done. At the end, there will be enough information for anyone with the required skills to put together a ruby laser of modest power, and definitely useful for light drilling or welding, or with additional components, for holographic purposes.

Static holograms are often made using the fast, high-intensity pulse of a ruby laser to capture an image instead of a much longer exposure if a HeNe laser were used. The wavelength of the ruby laser is 694.3nM, where the HeNe laser is 632.8nM.

The ruby laser emits a high intensity pulse of red light, and is very often used in double-pulsed holographic systems, as mentioned above. These double-pulsed systems are designed for the dynamic study of stress and movement in mechanical structures.

Over the next few issues, we will construct a small Cr:Ruby laser, and follow that with some ideas for producing a single pulse and a double pulse from this laser. It is also very often used to drill high aspect ratio holes (small diameter, deep holes) in stainless steel, or weld materials together.

Because of the low-pulse rate imposed by the laser rod, this laser cannot be used effectively for cutting applications. The power supply I will describe later will not support pulse rates higher than a couple of pulses per minute, which is typical for a Cr:Ruby laser. The most powerful ruby laser I have worked on had a maximum pulse rate of one pulse per second.

However, before we begin discussing the building of this laser, I must give out some words of warning:

Warning Warning Warning

The laser to be described is

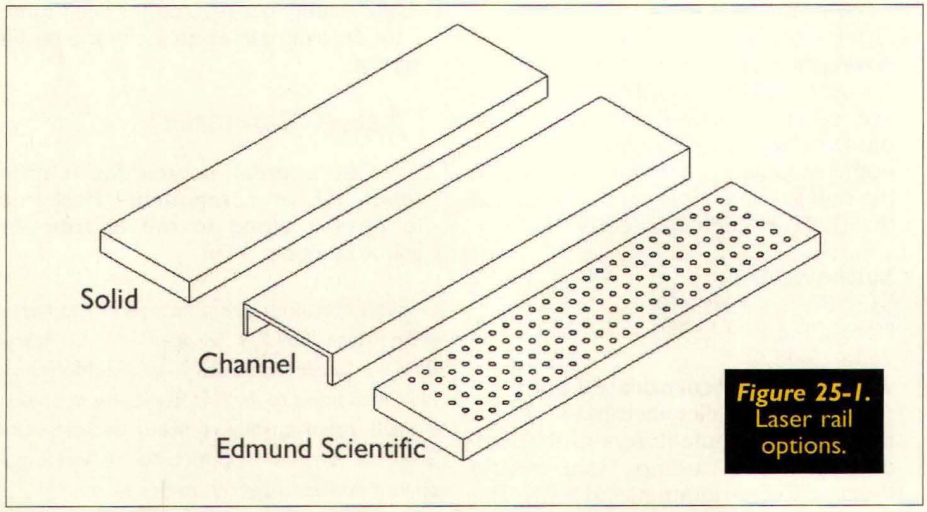

Figure 25-1. Laser rail options.

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 in to 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.

With this warning, we can now discuss the laser and its various subassemblies.

Perhaps I should also warn you that many of the parts used in this laser are expensive. The Cr:Ruby rod alone, for instance, will set you back about $1,700.00, so be sure you can justify building this laser before you start. I cannot give you an overall cost breakdown on this laser, since a lot will depend on where you obtain the many parts of the system. If you have to buy everything new, then you'd better have some pretty deep pockets.

This month, we will be concentrating on some of the mechanical parts of the system, and in particular, the optical rail. We'll switch to the cooling requirements, electronics, and controls over the next couple of issues.

The optical rail

This is probably the most important part of the laser, and the one most likely to give problems if you get low power output, or arcing damage. It's also going to be one of the most expensive parts to get made, unless you have access to a machine shop and do the work yourself. So for these reasons, we'll deal with this item first.

The optical rail consists of a massive machined or extruded rail that has a good flat mounting surface. It is important the rail be massive so that it is stable — both mechanically and thermally — especially if you intend to use it for holography.

The drawing in Figure 25-1 shows a couple of variations on the rail. The main object is to find something rigid, so either use a 3/8" or 1/2" solid piece, or for a lighter rail, use a piece of steel or aluminum channel. If you opt for the channel, make sure it is thick enough in section to put threaded holes in the mounting surface, or at least, room underneath for locknuts. If you visit your local metal distributor, you may be able to pick up a suitable piece of flat stock or channel for under $25.00 or so.

The overall length should be about 24-36 inches, and about 4-6 inches wide. The dimensions of this piece are not critical, so long as it is not twisted or bent. Of course, you'll have to drill and tap your own mounting holes for everything. Alternatively, Edmund Scientific has a good choice of optical bench plates you may use. These plates come predrilled with a large number of holes.

They are a little more expensive, but need no further work before you start to use them. Also, their hole spacing allows easy fixturing for other optical elements you may wish to add later, either to enhance the laser, or perform some other function.

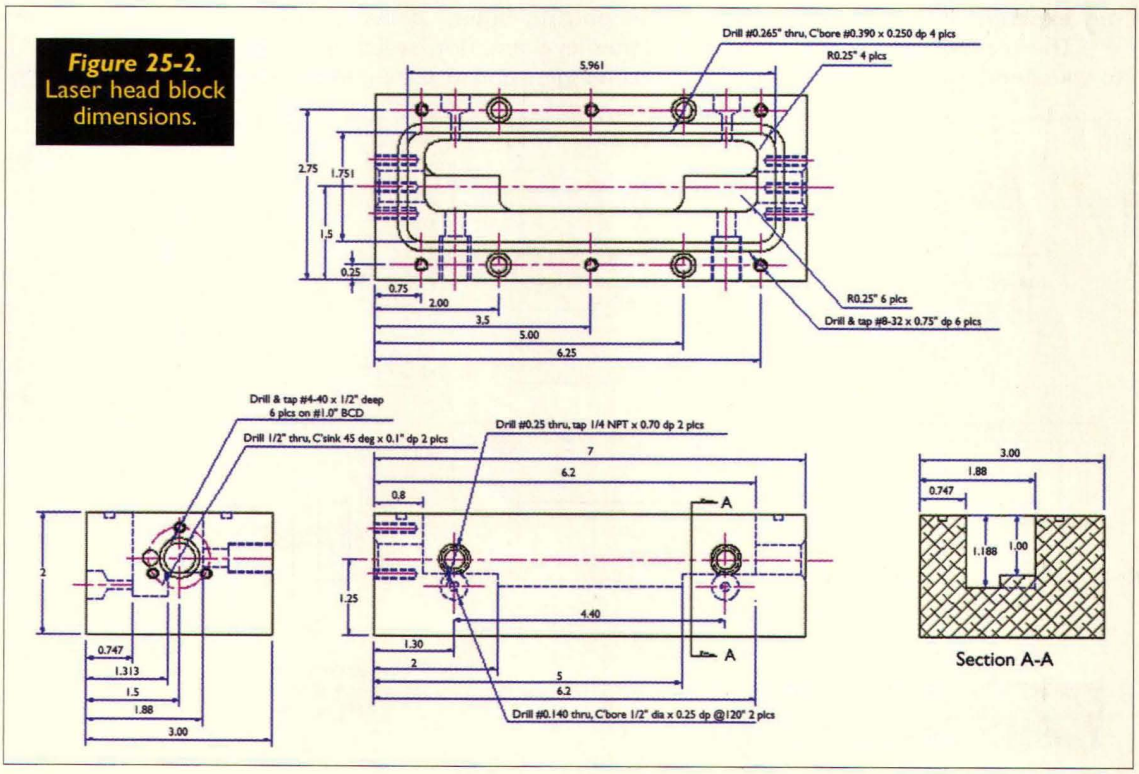

Figure 25-2. Laser head block dimensions.

The laser head

In this design, the laser head is made from a solid block of plastic, preferably Lexan, a commercial polycarbonate, machined out to accept the laser rod, flashlamp, and polished reflector. Figure 25-2 gives dimensions of a head block that is suitable for the lamp, rod, mirror mounts, etc., listed at the end of this article.

The most difficult part of this is the machining, which must be precise. I have access to a machine shop, that I use quite often, and can quickly change the design or dimensions to suit whatever I have available. I know not everyone has this luxury, and so I try to keep my designs as simple as possible so that others don't have to spend a fortune trying to copy something I have created.

The type of plastic used in this design is not really important, but I would suggest using black, carbon-free plastic (Lexan) if you can find it. It should be free from carbon to prevent any problems with the high-voltage terminals mounted inside. Other colors would be okay too, but black will give minimum light leakage when the lamp fires. This should be considered if you intend to use it in holography experiments.

The plastic should also be able to withstand a moderately high temperature without deforming or "giving" under pressure. If the high-voltage terminals develop a problem, they could start to see a change in temperature due to the high currents involved when the flashlamp fires. If the temperature of the material is such that the plastic relaxes, the holding screws will loosen, making the initial problem worse. In addition, the mounting surface may become distorted because of the mating pressure (of hold down screws, etc.) losing the alignment reference.

The head block and top should be a close fit to keep extraneous light from leaking out during firing. To help with this, and to ensure a seal against water leakage, you should machine an "O" ring groove around the top surface of the head block, as illustrated in Figure 25-2.

In a commercial laser system, the interior of the pump chamber is flooded with de-ionized water. In our system, this particular feature may be left out if you wish to keep things simple. The lamp life will be reduced, and the rod will require longer cooling-off times between shots.

If water is included, then we must also add a circulation pump, a de-ionizing filter, delivery hoses, water level and flow switches, a heat exchanger, and a temperature sensor. This will obviously complicate things, and add considerably to the expense. If you keep the pulse rate down to perhaps one pulse every couple of minutes, and by restricting the power input to the lamp, you can eliminate the water, and thus, all the other items just mentioned.

I will describe the water circuit later, but I will leave it up to you to decide whether to include it or not. I recommend it, since it will give the laser greater flexibility in that it can run harder and faster.

I have a couple of sources that I use for laser parts. One source is Kentek, Inc. I have used them on numerous occasions for my business, and they always seem to have what I need. These folks have standard laser mirrors on the shelf, and can give you almost anything you need. I'll list the phone numbers and email addresses for these and other vendors at the end of the article. If you make your own head block (following the drawings accompanying this article), then the centerline height of the laser rod is the same as the centerline height for the mirror mounts. However, if you buy a laser head from Kentek, the height may be a little different, and you should use parallel spacers to adjust the height of the lower components.

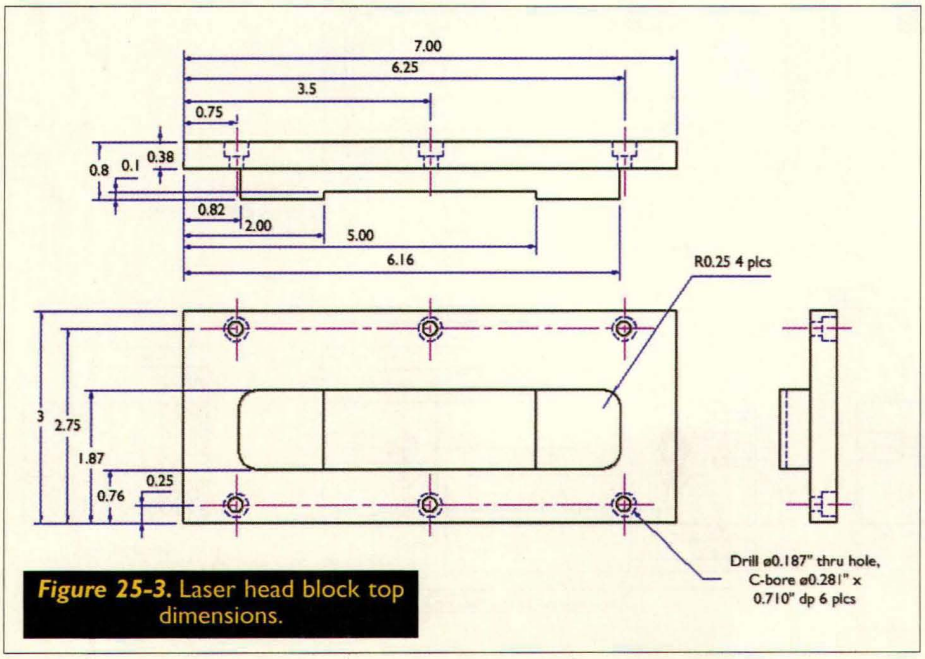

Figure 25-3. Laser head block top dimensions.

Machining the laser head

If you have the resources, you may want to machine your own head block. I have designed a simple head block for this project, and if you can make it yourself, it will be a whole lot cheaper than getting one made.

Looking at Figure 25-2, you'll see that the head block is machined out of a solid piece of plastic. This is easier than trying to piece together several smaller parts, and things cannot loosen up or move on you. It may be more wasteful of plastic, but the stability offered by a single machined part, and reduction of potential water leaks, is well worth the extra trouble.

The dimensions given for the head block relate to the laser rod size, lamp dimensions, and reflector

used in this project. If you have other parts you wish to try instead of the ones specified, you will have to change the dimensions of the block accordingly.

You have to be careful when machining plastic. Even though cutting machine tools usually have some kind of coolant flow, plastic — being a poor heat conductor — only cools on the surface. The inside remains warm for a long time.

To allow for dimensional changes due to thermal expansion when machining plastic, you should do a rough cut first to get the block close to size, but leave about 20-50 thousandths of an inch for the final machining pass. Finish the machining the next day, or after a couple of hours cooling-off period. This will allow the block to return to room temperature before the final pass, and you will find that the surface finish and dimensional tolerances are closer to what you need than if you try to machine it all in one operation.

The holes in the ends of the head should be collinear, that is, they should ideally be drilled from one end of the block to make sure they lie on the same centerline. However, most reputable machine shops can accurately locate parts like this and get the holes to line up.

Figure 25-3 shows the head block top. This part closes off the laser pump chamber, and pressure from the top on the "O" ring seal around the head block bottom seals against water leaks. Lamp changes are made easy by this design, and the optical alignment is not compromised when changing the lamp.

Shop around when you get these parts made. You'll find that machine shops vary widely in charges for doing this kind of work, and their workload will dictate how much they charge you. As another alternative, Kentek, the supplier of many of these parts, can also supply the laser head. But again, it won't be cheap. However, since they make a larger number of heads at one time, the overall cost per head is lower.

The exploded assembly drawing in Figure 25-4 is shown here for guidance in assembling the laser head. Many of the parts listed are shown in this drawing — some parts still need to be made. This list refers only to head design shown, not to any third-party source.

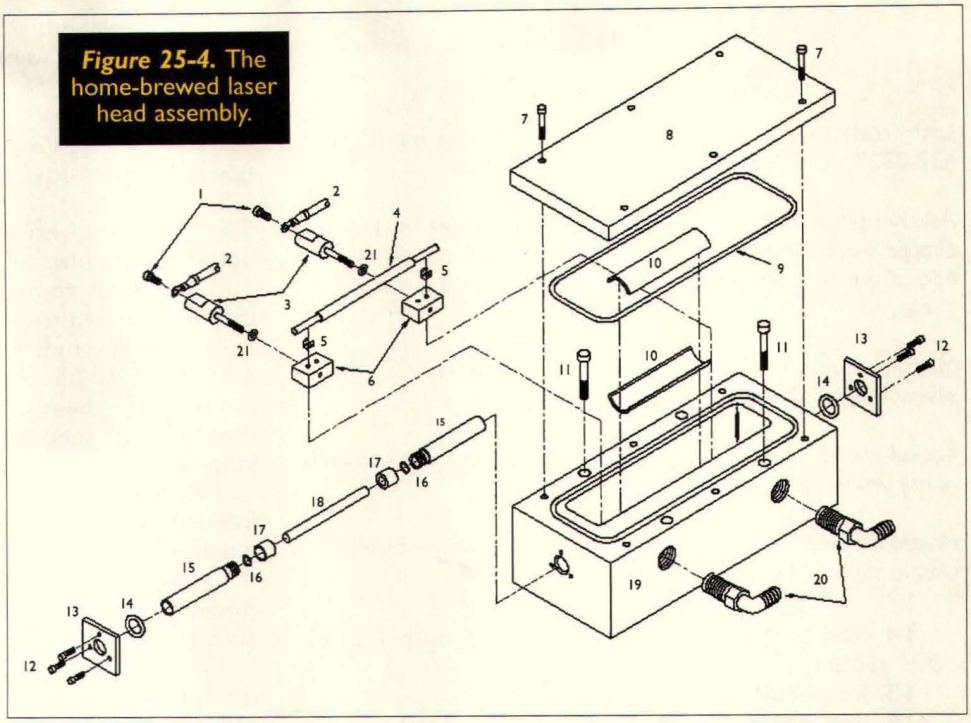

Figure 25-4. The home-brewed laser head assembly.

Key to the assembly drawing:

1. Lamp cable screws #8-32 x 1/2" (two required).

2. Lamp cables #10AWG flexible cable, terminated in #8-32 crimp-type ring lug.

3. Lamp connector screw (see text) #6-32 thread.

4. Laser flashlamp (see text).

5. Lamp support and termination clip (see text).

6. Lamp support block.

7. Laser head cover screws #8-32 x 1" (six required).

8. Laser head top cover.

9. "O" ring — Parker #2-250, nom 5" ID x 0.139" section.

10. Reflector halves (see text).

11. Head block rail mounting screws 1/4"-20 x 2" (four required).

12. Rod holder seal screws #6-32 x 1/2" (six required).

13. Rod holder seal plate.

Parts list for the optical rail

Prices listed were correct at the time of this writing and do not include delivery charges.

MF-50-75 Front Mirror 50% R @ 694.3nm 0.750" Dia. x 0.375" thick. $295.00 each three weeks delivery ARO (Kentek).

MR-100-75 Rear Mirror 99.7% R @ 694.3nm 0.750" Dia. x 0.375" thick. $295.00 each three weeks delivery ARO (Kentek).

CLR-1/4x3 Ruby Rod 0.25 inch diameter x three inches long, F/F AR/AR @ 694.3nm 0.03% dopant $1,725.00 each if in stock — delivery and price may vary depending on availability (Kentek).

LL-1048F Laser Flashlamp 2.75" arc is to be used if the rod's current length is not modified. A three-inch arc is to be used if the rod is mounted inside rod holders that will extend the rods overall length (Kentek).

Water fittings — plastic or stainless steel only "L" 1/4" NPT — 1/4" Barb. (No brass or copper.)

"O" rings and water fittings can usually be found at your local industrial supply house.

Vendors for optical components

Laser rods, mirrors, lamps, head block — Kentek Inc. (800) 432-2323; **www.kentek-laser.com**.

Ask Kentek to mount the rod for you. There may be a small charge, but believe me, it will be worth it. You may damage the end of the rod ($1,700.00+) for the sake of saving a few bucks.

Mirror mounts — Edmund Scientific (800) 363-1992; **www.edmundoptics.com**.

Nickel-plated lamp clips — RadioShack (Do not use unplated ones) **www.radioshack.com**.

Plastic for head block — Consult your local phone book for plastic suppliers in your area.

14. Rod holder "O" ring Parker #2-112, nom 1/2" ID x 0.1" section (two required).

15. Rod holder barrel.

16. Rod "O" ring Parker #2-010, nom 1/4" ID x 1/16" section Teflon (two required).

17. Rod holder end cap.

18. Laser rod.

19. Laser head block bottom.

20. Water fittings 1/4" NPT — 1/4" Barb (two required).

21. "O" ring Parker #2-007 nom 0.14" ID x 0.07" section (two required).

All "O" rings are silicon or butyl rubber, except where noted — all screws are stainless steel.

The list of items that follows are some of the items that are needed to complete the laser head and optical rail. These are mostly purchased items, and will run you a pretty hefty bill. In addition, you have to make, have made, or purchase the laser head block and top. I believe that this will keep you busy until the next issue, so I'll stop here.

There are other sources for laser parts on the Internet, so take a chance and look around. You may find cheaper parts somewhere else.

Next month, we'll look at the other items that need manufacturing to complete the laser head assembly, and start to assemble the optical rail.

If you have questions about this column, or ideas for future columns, please contact me as always at: **stanley.york@att.net**, or through this magazine. I may take a while to respond to your email, but I will respond. **NV**

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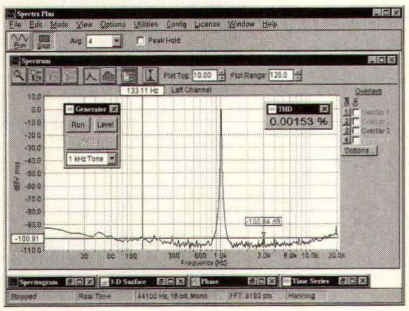

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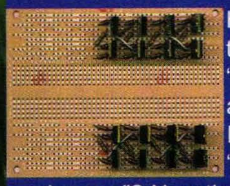

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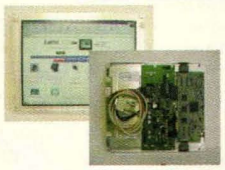

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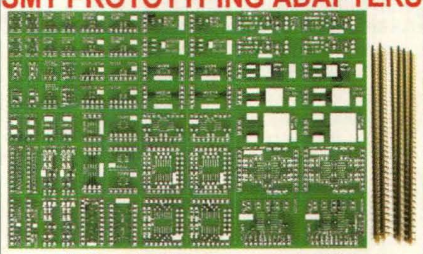

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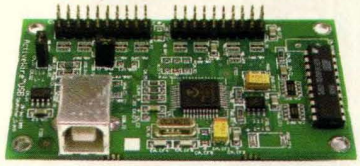

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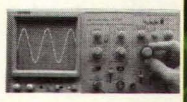

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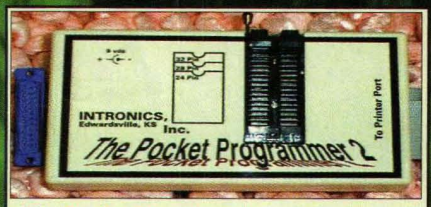

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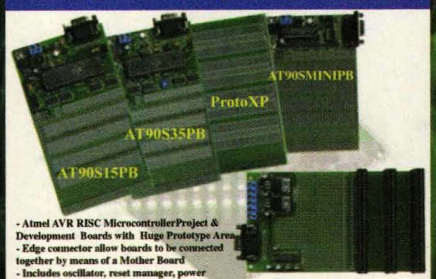

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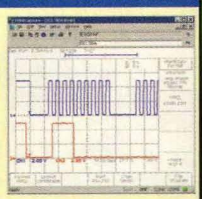

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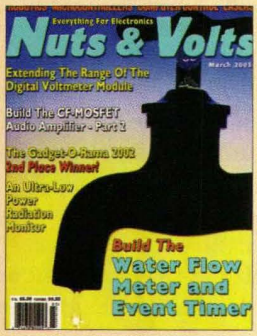

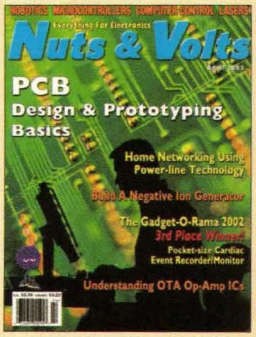

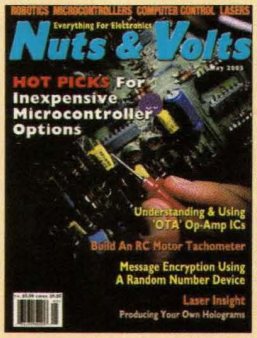

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Advanced Technologies

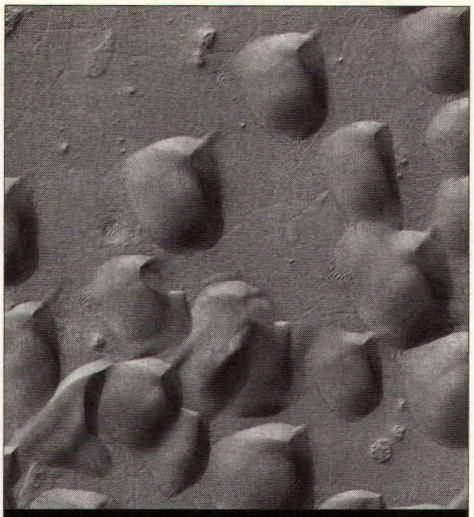
Detecting Nuclear Materials Using Muons

When you think about inspecting vehicles and suitcases for smuggled nuclear materials, you normally think in terms of x-ray systems. But researchers at the Los Alamos National Laboratory (**www.lanl.gov**) recently came up with a way to detect dense materials — such as uranium — by tracking the paths of muons as they pass through. Muons are created naturally when cosmic rays from space interact with the atmosphere, and they strike the earth's surface at a rate of about 10,000 particles per square meter. (If you are interested in particle physics, you probably already know that a muon is a member of the lepton family of charged particles and is 207 times more massive than its sibling, the electron.) The technique is actually based on one used in the 1970s by physicist Louis Alvarez, who used muon absorption to map the interior of the second Pyramid at Giza. It employs an array of simple sensors placed above and below a target, plus a computer algorithm that helps to analyze variations in the muon's paths as they pass through certain materials.

In this manner, it is possible to construct three-dimensional images of the target objects. According to a LANL representative, early tests show that it is possible to, for example, detect a one-liter block of uranium in the equivalent of a truckload of sheep. And the better the target material is shielded, the easier it becomes to detect it.

This method offers an obvious advantage over x-ray inspection in that it needs no artificial radiation source and is harmless to everyone involved. The negative aspect is that, because muons rain down in relatively low volumes, it takes about a minute to scan the average vehicle.

Mars Photos Available for Download



Sand dunes in the Wirtz Crater. Courtesy of NASA/JPL/Malin Space Science Systems.

The NASA Orbiter camera team (part of the Mars Global Surveyor project) recently announced a program of Internet postings of photos that "showcase the rich diversity of Martial landscapes." A new photo will be added every day, including weekends and holidays. The photo included here, according to K.S. Edgett and M.C. Malin of MSSS, shows a collection of sand dunes in the Wirtz Crater. The shape indicates that wind has been transporting the sand from the southwest toward the northeast. It covers an area about 1.9 miles (three km) wide and is located near 48.6°S, 25.5°W. Sunlight illuminates the scene from the upper left.

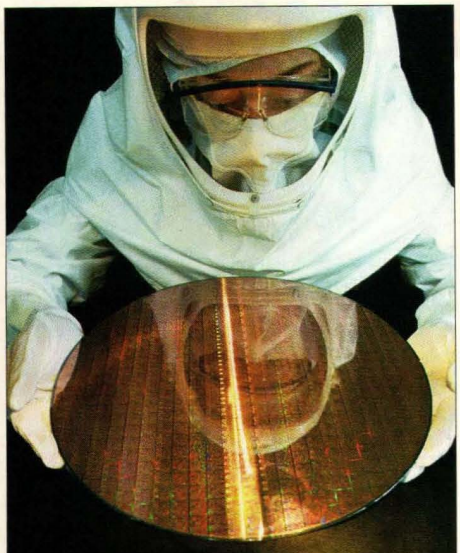
Photos can be accessed at the Malin Space Science Systems, Inc. (MSSS), web site (**www.msss.com**), which already offers access to nearly 125,000 Mars images.

Computers and Networking

Intel Breaks 3 GHz Level for Desktops and Workstations

Intel (**www.intel.com**) has introduced an improved Pentium® 4 processor, aimed at workstations and desktop computers, that provides clock rates of up to 3 GHz. The new processor boosts speed through the use of an 800-MHz system bus — an improvement over the previous 533-MHz one — and a new chipset platform that improves communications between the microprocessor to the rest of the system. The new Pentium employs Intel's "Hyper-Threading Technology" for threaded or multitasking applications to transfer information up to 50 percent faster.

For desktop applications, these tasks include accessing instant messaging while playing a favorite online game or downloading music while manipulating digital photos. Advanced digital content creation tasks such as 3-D modeling, rendering, and video editing are some of



An Intel technician holds a 12-inch wafer that contains hundreds of 3-GHz Intel® Pentium® 4 processors. Courtesy of Intel.

the relevant workstation applications.

The new 875p chipset (formerly code named Canterwood) supports dual-channel DDR400 MHz system memory and a dedicated networking bus. It includes a high-performance graphics interface, integrated USB 2.0 and a serial ATA interface, and dual independent audio engines. The latter enables users to, for example, make a PC telephone call while playing a digital music stream. In 1,000-unit quantities, the new Pentium 4 processor with HT Technology and an 800-MHz system bus is priced at $417.00. The Intel 875P chipset is priced at $53.00 with integrated RAID capabilities — $50.00 without RAID.

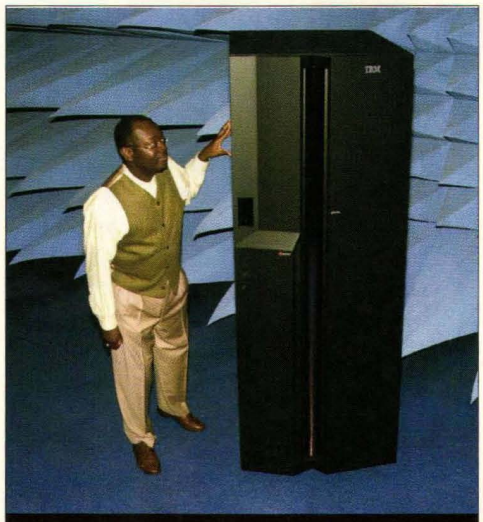
New Machine Performs Two TeraFLOPS

The National Center for Supercomputing Applications (NCSA, **www.ncsa.uiuc.edu**), located at the University of Illinois at Urbana-Champaign, recently brought online a new supercomputer that will be used by researchers in a range of scientific and engineering disciplines, including chemistry, biology, astrophysics, atmospheric sciences, materials sciences, high-energy physics, and structural mechanics. Some of the questions these researchers will investigate include how biological systems work at the molecular and atomic level, how to better understand and predict severe storms, and how to build stronger, more stress-resistant aircraft and spacecraft.

The machine is a cluster of 12 IBM eServer p690 UNIX systems consisting of 384 Power4 1.3 GHz processors with a total of 1.5 TB of memory. It replaces NCSA's 1,512-processor SGI Origin2000 array, which has a peak performance of 660 gigaFLOPS and 614 GB of total memory.

Each Power4 chip contains 174 million transistors (about 10 times as many as used by the average PC microprocessor) that are interconnected by a mile of microscopic copper wiring. Each Power4 chip contains two high-speed processors, a system switch, memory, and input and output functions.

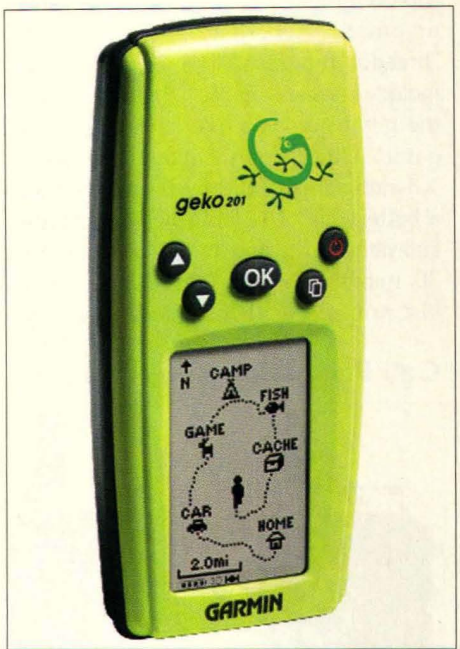
Information flows between the memory and the processor at nearly 125 GB per second. According to IBM, it is possible to link even more eServer p690s to create a supercomputer powered by more than 1,000 processors.



Rod Adkins, IBM's general manager of web servers, examines an eServer p690 "Regatta" computer, billed as the world's most powerful UNIX server. Courtesy of International Business Machines Corporation. Unauthorized use not permitted.

Circuits and Devices

Low-Cost Handheld GPS Units Available



The Geko GPS receivers offer accuracy to within 10 feet, up to 10,000 log points, and a low cost. Courtesy of Garmin International, Inc

If you have been waiting for a GPS receiver that offers enough features to be useful, but does not break your budget for unnecessary toys, Garmin International, Inc. (**www.garmin.com**), may be able to hook you with its Geko 101 or Geko 201 receiver. The Geko series is a follow-up to Garmin's eTrex product line, featuring a traditional, compact, waterproof design and a simplified user interface (with features such as one-touch waypoint marking). But the new products are smaller and lighter than the eTrex family, feature front-button functionality, and operate on two AAA batteries.

The Geko 101 is a low-cost device designed for navigational novices. It has five buttons (up/zoom out, down/zoom in, OK, page, and power/backlight) for easy operation, accuracy to within 45 feet (13.7 m), and 250-waypoint storage capacity with graphic identification to mark campsites, parking spots, and other specific locations.

The Geko 201 is an upgrade that includes the basic functions of the

Geko 101 and adds a wide area augmentation system (WAAS) to deliver accuracy to within 10 feet (3.05 m). The 201 also boasts a user-configurable trip computer and 10,000 log points for automatic recording of electronic "breadcrumb trails." The Geko 201 also includes several games that transform the great outdoors into a virtual board game. Other specifications include a 1.8-inch screen (100 by 64 pixels) and a battery life of 12 hours. The units are submersible in one meter of water for 30 minutes, meeting IPX-7 standards. List prices are $106.24 and $149.99.

Cell Phone for Bikers

Motorola's 100th Anniversary Harley-Davidson cell phones, available in two styles. Courtesy of Motorola, Inc.

So, you've saved your money, pawned the wife's jewelry, sold the television set, and rented the kids to a Nike shoe factory, thereby raising $18,000.00 to buy a new Harley-Davidson motorcycle. You've got a leather jacket, leather pants, an extra 500 pounds of chrome, and streams of leather fringe blowing in the breeze. You're unshaven, tattooed, full of Budweiser, and ready to kick butt at the drop of a hat. Life is good. But can life really be complete if you don't also own the official 100th Anniversary Harley-Davidson cell phone from Motorola (**www.motorola.com**)? Yes, Motorola has introduced two customized versions of its V60i mobile phone, offering a choice of black-and-leather or chrome-on-chrome designs — both engraved with the Harley 100th anniversary logo.

In addition to the ability to call home to let the old lady know you'll be late for the kids' soccer game, the V60i allows you to choose from several available ring tones based on popular road songs, or even compose or download other tones. Between bar fights, or while recovering from road rash, you can also play preloaded video games or access the Internet for news, weather, and stock market reports.

The phone is available in three wireless technologies: Code Division Multiple Access (CDMA), Time Division Multiple Access (TDMA), and Global System for Mobile Communications (GSM). You can buy one at your local Harley dealer, who will also help you select a service plan from a variety of wireless carriers. The price of the phone depends on the service and options you select.

There are also unconfirmed rumors about a set of Harley-Davidson Tupperware coming out later this year, which would be great for keeping cupcakes fresh while you and the gang are terrorizing small towns.

Industry and the Profession

PC Industry Doing Okay After All

Despite the many complaints from manufacturers and negative reports in the press, it appears that the personal computer industry is doing reasonably well. According to market research company Gartner, Inc., there have been three consecutive quarters of growth in that segment of the industry.

In the first quarter of 2003, worldwide PC shipments totaled 34.5 million units — a 5.5 increase from the same period in 2002. Dell was the number one vendor, with 5,828,400 PCs sold for a 16.9 percent share of the market. Second was Hewlett-Packard/Compaq, with 5,375,900 units and a 15.6 percent share. Trailing behind were IBM (1,869,800, 5.4 percent), Toshiba (1,241,200, 3.6 percent), NEC (1,162,700, 3.4 percent), and all others.

Electrical Engineering Quiz

Who is this mystery woman? Photo courtesy of Anthony Loder.

To test your knowledge of engineering history, the following multiple-choice question is offered. The woman in the photo is:

1. Wife of Fritz Mandl, Nazi sympathizer and CEO of Hirtenberger Patronenfabrik, one of the world's leading munitions manufacturers in the 1930s.

2. Hedwig Eva Maria Kiesler, a US immigrant from Vienna, a Nazi resistor, and the inventor of a widely employed "frequency hopping" technique.

3. The first woman to appear nude in a feature film.

4. Thomas Edison's wife, Gertrude, before she started drinking heavily.

As you probably suspected, it is a trick question. In fact, choices one through three are all correct. Better known as Hedy Lamarr, she worked with American composer George Antheil in 1940 to develop her idea for a technique that would allow radio-controlled torpedoes to operate free of enemy disruption.

Based on a system using 88 fre-

quencies (corresponding to the keys on a piano), they originated the technique of transmitting information synchronously on constantly changing frequencies. They were granted a patent on the concept on August 11, 1942, and immediately offered it to the US military.

Referred to as "spread spectrum" communications today, the technique is widely used in cell phones, pagers, defense satellites, and other devices. For details, visit **www.hedylamarr.org**. The aforementioned film, in case curiosity is killing you, is a Czech production called "EXTASY," made in 1932. It was greatly admired by Benito Mussolini, who owned a personal copy. **NV**

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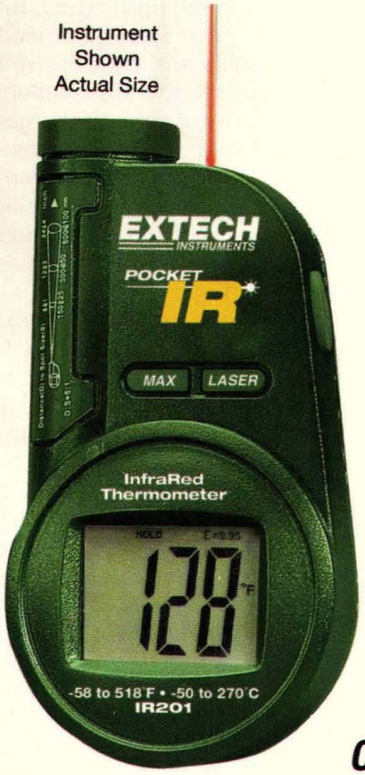

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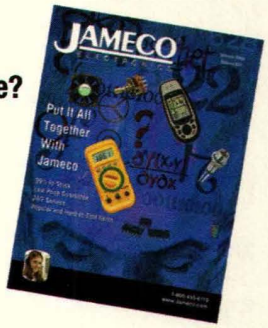

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Lots of designs for capacitors and relays. Two very simple expanded-scale voltmeters and a game show buzzer. More places for hard-to-find parts, and places to find PCB software and services. Finally, a reader demonstrates his 555 math skills.

Supercapacitors Upstage Super Battery

Q. We have an old self-winding subway or school clock that's powered by two No. 6 dry cells. The price of these dry cells has climbed to $20.00 each, and they only last about nine months. The clock rewinds every hour — a procedure that draws 200 mA for about 15 to 20 seconds. We would like a wall-mounted (plug-in) DC power supply to replace the batteries, but haven't been able to find one with a three-volt output. Do they make such an animal, or do you have a circuit that will serve the same function?

Michael K. Lenihan
via Internet

A. American Science & Surplus (847-647-0011; **www.sciplus.com**) sells two wall-warts that fit your requirements. Catalog numbers: 33615 and 25779.

However ... if you still want to keep your clock battery-operated, you can. Thanks to a technology that packs a whopping 1 Farad of capacitance (that's not a typo, 1F and not microfarads (uF)) into a package as small as a pencil eraser, you can operate your clock for a full year using AA alkaline cells.

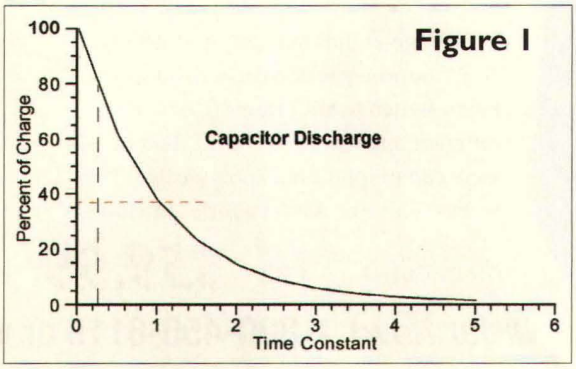

Figure 1

These new capacitors are called double layer electrolytics, or supercapacitors. The supercapacitor resembles a regular capacitor with the exception that it offers very high capacitance in a small package. Whereas, a regular capacitor consists of conductive foils and a dry separator, the supercapacitor crosses into battery technology by using special electrodes and an electrolyte. The most common structure is the double layer formed by an activated carbon.

Rather than operate as a main battery, supercapacitors are commonly used as memory back-up in PCs. Another application — and the one I will exploit here — is to improve the current handling of a battery. The supercapacitor is placed in parallel with the battery terminal and provides current boost on high load demands.

In terms of charging method, the supercapacitor resembles the lead-acid battery. Unlike the electrochemical battery, though, the supercapacitor can be recharged and discharged an unlimited number of times. Moreover, the supercapacitor doesn't require a full-charge detection circuit. Supercapacitors take only as much energy as they can accept. There's no danger of overcharge.

Now, let's get down to the business of applying this technology to your clock. First, we need to determine the size of the capacitor. This is done by calculating the power needs of the clock in comparison to time. This information is important because, unlike a battery, the voltage across the capacitor quickly decays with time (Figure 1). In fact, within the first time period (a capacitor's discharge time occupies five time periods), the voltage declines to 37 percent of

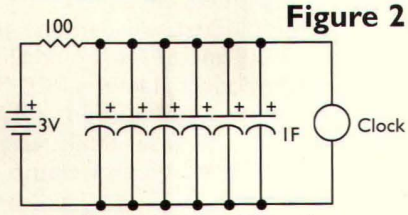

Figure 2
Supercap Clock

its original value. For reliable operation, the voltage shouldn't drop below 80 percent during the rewind period. That's about one-fourth of the first time period.

The formula for one time period is t = RC, where t is the time in seconds, R is the series resistance in ohms, and C is the capacitance in Farads. The resistance can be calculated from R = E/I, where E is three volts and I is 200 mA (15 ohms). Now we know that the time it takes to rewind is 20 seconds and the resistance is 15 ohms, so by rearranging the equation to C = t/R, we discover that the capacitance for the first time period is 1.33F. Remember, though, that we have to sustain the voltage for one-fourth that period, which increases the capacitance to 5.3F. Supercapacitors rated at 1F are easy to find, and sell for about $5.00. Six capacitors in parallel cost less than your No. 6 dry cells — and take up a whole lot less room!

To charge the capacitors, you'll need two AA alkaline batteries wired in series (Figure 2). A current-limiting resistor provides isolation from the current surge and the batteries. A 100-ohm resistor will limit the draw from the batteries to 30 mA and recharge the capacitors in about 15 minutes. Projecting this profile forward, the AA cells should last about a year before they need replacing.

One last note — when buying supercapacitors for this project, don't be tempted to use caps rated at 2.5 volts. Supercaps are very sensitive to overvoltage, and the 3.3 volts of fresh AA cells will render a 2.5-volt unit useless within hours. (Overvoltage causes the ESR to rise rapidly to the point where the cap goes open.) Use a five-volt supercap, or two 2.5-volt supercaps in series. Mouser Electronics (800-346-6873; **www.mouser.com**) has a very good selection of supercaps at reasonable prices.

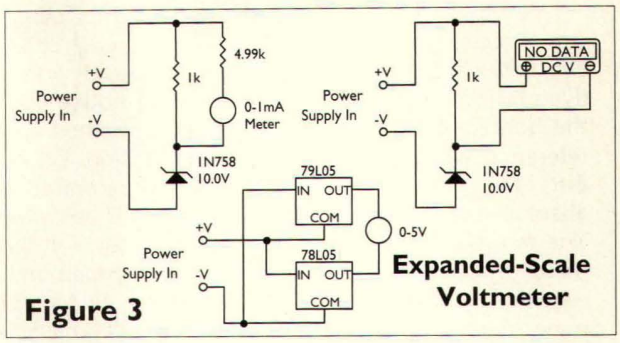

Figure 3
Expanded-Scale Voltmeter

Expanded-Scale Voltmeter

Q. I have a 13-volt power supply that I use with my mobile transceiver and would like to monitor its output voltage. Is there any way to make a meter that reads 11 to 15 volts full-scale?

Dan Supplee
Edmonds, WA

A. What you're asking for is an expanded-scale voltmeter, which can be created using several methods. Let me give you two solutions. The first, Figure 3 upper left, uses a zener diode in series with a current-limiting resistor. The zener doesn't start conducting until the input voltage exceeds the zener's voltage rating. At this point, the resistor generates a voltage that's equal to

Vresistor = Power Supply In - Vzener.

By placing a voltmeter across the resistor, it will respond to the range you wish. A DMM can be substituted for the analog voltmeter, as shown to the right.

You may note that the schematic shows a 10-volt zener and a five-volt meter. With these values, the meter will read 10 to 15 volts. I know you asked for an 11 to 15 volt range, but this arrangement takes advantage of the five-volt scale on the analog meter — and because they don't make an 11-volt zener. If you wish, you can make an 11-volt zener by stacking zeners of lower value (e.g., 6.2V and 4.7V = 10.9, close enough)

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Another way to create an expanded-scale voltmeter is by using two voltage regulators — one negative and one positive — as shown at the bottom. By using a split-voltage reference system with floating output, the zero point equals the absolute sum of the two regulators. The range is limited by the full-scale reading of the voltmeter. With the regulators in the figure, a 0 to 5-volt meter reads 10 to 15 volts; a 10-volt meter would read 10 to 20 volts. Again, a DMM is a suitable meter substitute.

Good-bye Thumper, Revisited

Q. In the Jun. '01 issue, you answered a question about delaying the turn on of the subwoofer to remove the thump. On my bench, this idea just won't work. For one thing, the time delay is only about one second. Moreover, the AC power to my load (a 150W bulb) shows only about half of the line voltage is available — an observation that my scope confirmed, in that one-half of the sinewave is clipped off. Help! I've put a lot of hours into this and have run out of ideas to try.

Terry Peters
via Internet

A. You are quite right. That circuit only switches half the waveform, which is sufficient to power my subwoofer (it uses an off-line switching power supply). What you're looking for is a full-wave switcher, which would require the addition of a triac driver (MC3010). However, a simpler design is done using a mechanical relay and a capacitor, as shown in Figure 4.

When power is applied, capacitor C1 begins to charge through the relay coil, which causes it to pull in and open the contacts. You may notice that I have a 24-volt relay connected to the rectified 110-volt AC line. Don't panic! Relays are current operated — not voltage operated. That's why there's a 10k series resistor — it limits the current to 12 mA maximum.

As C1 charges, the current decreases. When it drops below 1 mA, the relay drops out and the AC circuit is completed. Using the values shown, the delay time is about three seconds. For longer delay times, parallel additional capacitors across C1. The capacitors are garden variety photoflash units you can find in disposable flash cameras, like the Kodak Max and Fuji Flash.

Progressive Component Video

Q. What does the "P" stand for in Y/Pb/Pr? I know Y/Cb/Cr is Luminance/Component (blue)/Component (red) in the digital realm, and it uses a "C" for Component. So why use a "P" for the analog world?

John Agugliaro, CET
Product Support Specialist
Samsung Electronics America, Inc.

A. It means Progressive, and is short for the full phrase Progressive Component. The designations are the same — Luminance/Progressive (blue)/Progressive (red).

Soldering Tip: Use Shrink Wrap

Q. Do you think using locking forceps to hold a resistor flat against a printed circuit board just until it is soldered will damage the resistor or the board? Or should I just lay the component side of a PCB flat on my work surface and solder away? What do you think about using a third-hand type of clamp or vise?

Bob Cochran
Greenbelt, MD

A. I wouldn't use forceps for fear of cracking the resistor, and I've never had much use for a third-hand clamp. I find them fragile and unwieldy. I usually solder the resistors in place by simply laying the board upside down on a flat surface. First, bend the lead at a 45° angle and clip it to length, making a short hook (Figure 5). Flip the board over and solder.

For larger projects I use clear plastic shrink wrap to hold the parts in place. You can buy shrink wrap bags from ebay for about $0.25 each, or find them in most art supply stores. I first stuff the PCB with the parts, slide it into the plastic bag, then shrink it with a hair dryer. I then use an Exacto knife to remove areas of the plastic for soldering.

Printed Circuit Board Software

Q. Can you recommend software for creating the artwork to produce printed circuit boards? I'm looking for something inexpensive (under $100.00) and simple to use.

Al Lovecky
via Internet

A. I use CircuitMaker 2000 Professional for the artwork you see in my column and articles. Unfortunately, it sells for a hefty $995.00. However, you can download a decade-old version of this PCB layout software — EasyTrax or AutoTrax — from our web site (**www.nutsvolts.com**). A more ambitious freeware package Eagle Light Edition, from CadSoft (**www.cadsoft.de**), includes both

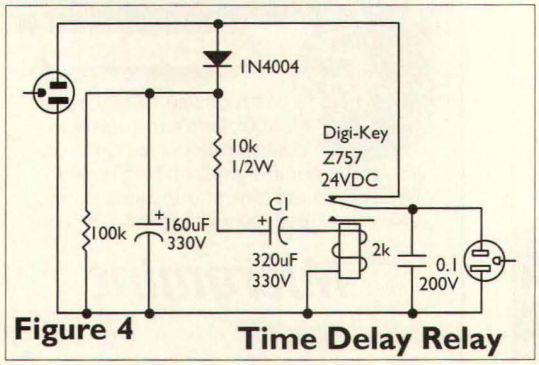

Figure 4 Time Delay Relay

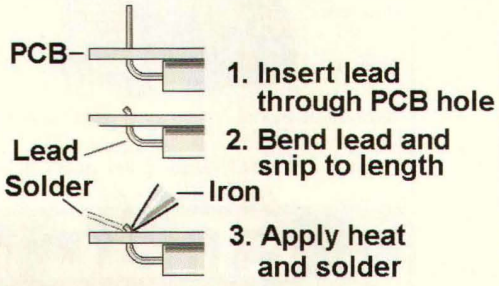

Figure 5

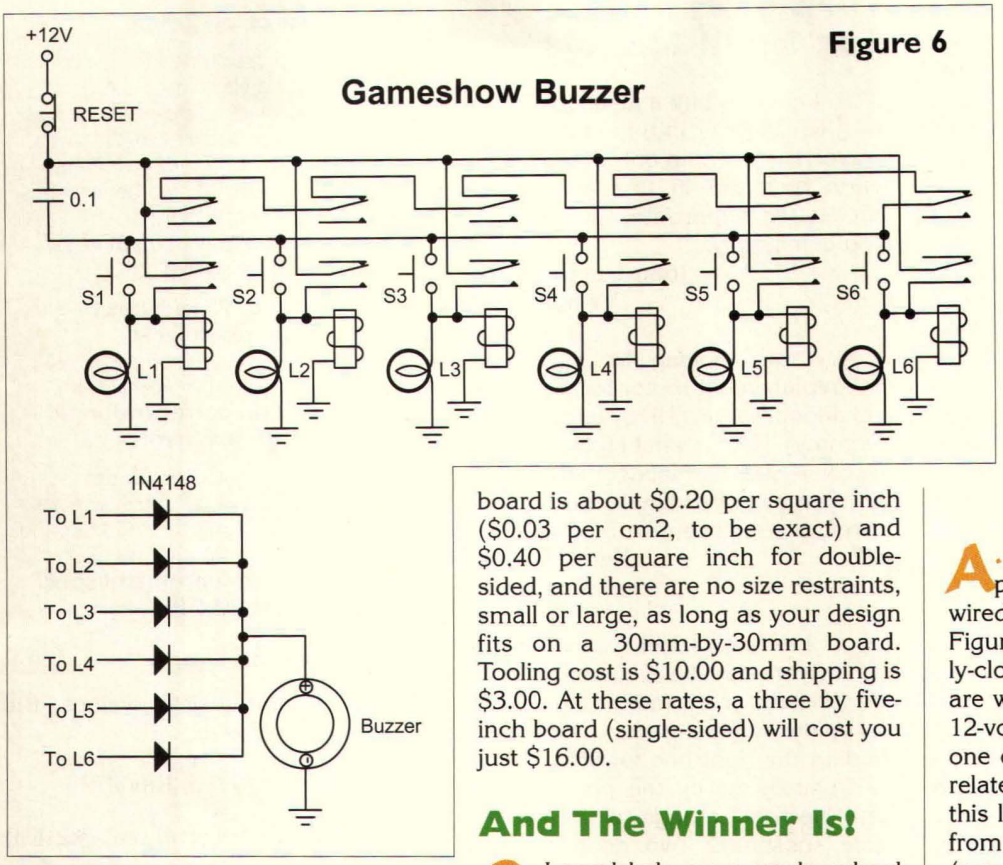

Figure 6
Gameshow Buzzer

schematic capture and PCB layout. All three programs will output to a printer, the page of which you can use to produce a PCB using a variety of techniques — methods that we have covered in past issues.

If you're willing to accept free "vertical" PCB software in exchange for a locked-in PCB service — proprietary software that forces you to subscribe to a PCB service (see "Printed Circuit Board Design/ Prototyping Basics," April 2003) — there is ExpressPCB (**www.expresspcb.com**), who will deliver three double-sided mini-boards (3.8-by-2.5 inches, no silk-screen) for $62.00.

Speaking of PCB services, the best deal in town — if your software can create Protel PCB files; most can — is from Futurlec (**www.futurlec.com**). The price for a single-sided board is about $0.20 per square inch ($0.03 per cm2, to be exact) and $0.40 per square inch for double-sided, and there are no size restraints, small or large, as long as your design fits on a 30mm-by-30mm board. Tooling cost is $10.00 and shipping is $3.00. At these rates, a three by five-inch board (single-sided) will cost you just $16.00.

And The Winner Is!

Q. I need help on a grade school teaching project for my friend's daughter — a student teacher. The project is for a 5th grade "learning quiz." The objective is to see which one of the six students has the quickest response to a question — like a TV game show buzzer.

Each of six students is given a momentary push-button switch. The first person to push the button causes a corresponding colored light to come on, and prevents the other lights from turning on. It would be nice if the action also sounded a piezo buzzer. The teacher has a button to reset the system, which is to be powered by a 12-volt wall-wart.

Carl Kolenda
Troy, MI

A. A safe, reliable way to accomplish this is to use DPDT relays wired according to the diagram in Figure 6. Notice that the NC (normally-closed) contacts of the upper bank are wired in series. This line provides 12-volts to the trigger switches. When one of these switches is engaged, its related relay pulls in, which breaks this line and prevents any other relay from being energized. The bottom NO (normally-open) contacts on the activated relay now close and connect the relay's coil to the 12-volt source, which latches the relay even after the button is released.

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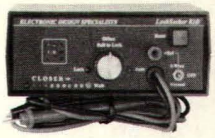

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To prevent the relay from chattering, a small capacitor is placed across the 12-volt source and the switched line — if the relays chatter or don't pull in reliably, increase the size of the 0.1uF capacitor. Pressing the reset button removes power to the circuit and causes the relay t drop out and restore voltage to the trigger buttons. This circuit is easily expanded or reduced to include any number of contestants by inserting or removing relays in the middle of the string.

The game buzzer can be wired into the circuit using steering diodes, as shown at the bottom. Basically, the diodes form an OR gate. When any of the lamps light, the respective diode becomes forward biased and provides power to the buzzer.

More Heathkit Sources

Q. I have a Heath GC-1197 digital clock that I really like a lot because it uses highly-visible incandescent bulbs that you can see in high ambient light — unlike LED displays. I have had this clock for many years and got attached to it. However, the clock chip is defective — Heath P/N 443-702 — and I cannot find a replacement for it. I tried looking in the SK and NTE manuals with no luck.

M. Sajor
Freehold, NJ

A. I get a lot of requests for Heathkit parts and information. I published a cross-reference directory for Heath-to-manufacturer web site (**www.d8apro.com/heath3.htm**) in the May '02 column, but it appears I need to repeat it with an update. The part you request is available from **www.d8apro.com/heath1.htm**. The cost is $45.00 plus shipping. A good source of Heathkit schematics is **www.circuitarchive.co.uk/heath.htm**, as is the CD "Vintage Heathkit Schematics on CD!" on ebay or directly from the seller (**te@usol.com**). The UK web site is free — the CD is $9.95 plus $3.00 shipping. These and more Heathkit web sites will be added to the PARTFIND.TXT file that you can find on our web site.

Surplus Is Source For Small Motors

Q. I need to buy a Mabuchi motor (RF-300S-12350) for a JVC DVD player. However, no one wants to sell parts anymore in this throw-away society. I'd appreciate any contacts you can supply.

John Levandowski
Valhalla, NY

Q. I am looking for a 1.5-volt replacement motor for my wife's childhood game (1970 Voice of the Mummy). Here is what I found on the motor — JAPAN Mabuchi Motor PM-26. Can you shed any light on how I can find a replacement motor?

Ken Edwards
via Internet

A. Finding small replacement motors can be a daunting task. Fortunately, small motors are plentiful on the surplus market. The trick is finding the right one for your device — I usually go by the physical size and electrical ratings to find a suitable substitute. Two good sources are All Electronics (800-826-5432; **www.allelectronics.com**) and American Science & Surplus. I believe that a DCM-196 (from All Electronics) will replace the DVD motor, and the 28759 (American Science & Surplus) should work in your Voice of the Mummy.

LETTERS

Dear TJ:

Your battery charger solution using the 555 timer was just what I needed. I was in the middle of designing a similar circuit with two comparators and some logic when I picked up the Mar. '03 issue. It would be nice, though, to list the design equations so everyone can understand how to calculate the resistor values.

Assuming R1 is between Vcc and pin 6, R2 is between pins 6 and 2, and R3 is between pin 2 and ground (Fig. 7). The equations are:

R3 = (1/3Vcc) Rtotal/Vtriplow

R2 = [(2/3Vcc) Rtotal/Vtriphigh] - R3

R1 = Rtotal - (R3-R2).

For known resistor values, the threshold points are:

Vtriplower = (1/3Vcc) Rtotal/R3

Vtripupper = (2/3Vcc) Rtotal/(R2+R3)

The 1/3Vcc and 2/3Vcc come from the internal resistor divider in the 555.

I chose my Vcc as nine volts. This makes the reference voltages three volts at pin 2 and six volts at pin 6. Also, when testing the circuit I noticed that the output switched through the Threshold input cleanly (pin 6, voltage rising), but switching through the Trigger input (pin 2, voltage falling) resulted in noise on the output. A 470pF capacitor on pin 2 solved this problem.

M.P.F.
via Internet

Cool Web Sites!

Throughout most of the 20th century, many radio and electronics companies enjoyed the status of rolling out what were recognized as groundbreaking "industry first" products. How many of these significant part numbers and designations can you recognize?
www.chipcenter.com/surveys/quiz.jhtml

Decimal to Hexadecimal Conversion Table
This chart converts the numbers 1-255 from decimal to hexadecimal form.
www.jaworski.com/htmlbook/dec-hex.htm

Hexadecimal Color Codes
A large hexadecimal chart shows the base-16 codes that represent the red, blue, and green values in colors for the web.
www.december.com/html/spec/color.html

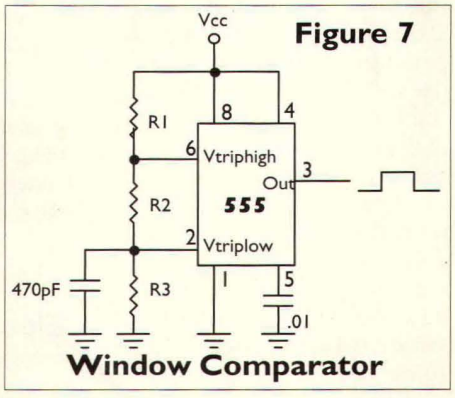

Figure 7
Window Comparator

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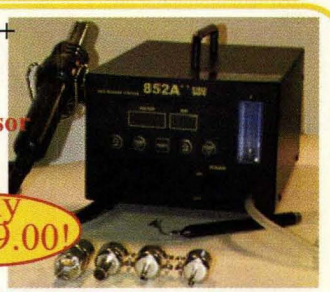

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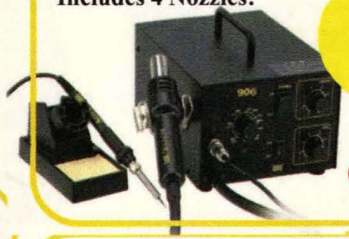

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item #
SP-150WATT...$19.95
SP-300WATT...$34.95
SP-600WATT...$64.95
SP-800WATT...$98.00

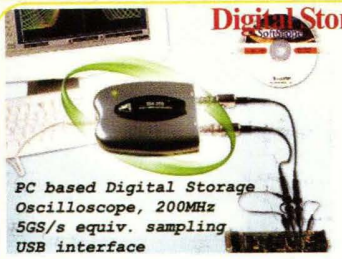
More Details at web site under"DC to AC Inverters"

12V DC to 120VAC

CIRCUIT SPECIALISTS, INC. 220 S. Country Club Dr., Mesa, AZ 85210
800-528-1417/480-464-2485/FAX: 480-464-5824

Circle #145 on the Reader Service Card.

Digital Storage Oscilloscope Module



Convert any PC with USB interface to a high performing Digital Storage Oscilloscope. This is a sophisticated PC based scope adaptor providing performance compatible to mid/high level stand alone products costing much more! Ships with two probes.
Complete details & software download @ our web site under test equipment.

item# 200DSO $869.00

2 AMP 0-18V Bench Power Supply LCD Display

input voltage: 110VAC
output: 0-18VDC
Current: 0-2A
Source Effect:<0.02%+1mV
Load Effect:<0.01% +5mV
Ripple & Noise: <1mVrms

1 5+
$59.95 $52.95

NEW!

item # CSI 1802D

Personal UV EPROM ERASER

NEW!

item# D-ERASE
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Erase Up to 4 Chips at a time
Adjustable Timer..4 to 24 minutes

Innovative 5 in 1 DMM

Integrated SOUND/LIGHT/HUMIDITY SENSORS
DCV/ACV/RES/CAP/FREQ./TEMP/RH/LIGHT/SOUND/CONT/DIODE
CSI 8209
$49.00
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Intelligent DMM with PC Interface

*Auto-Ranging
*Dual Display
*Conforms to IEC1010
*3999 counts & 38segment bar graph display
*DC voltage(autoranging)
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*Temperature measurement
*Resistance (auto ranging)
*capacitance
*diode testing
*transister check
*audible continuity

item# CSI345
Ships with Rubber Boot, RS-232 cable, Software & Test Leads & K-probe
Now Only $39.95

HandHeld Digital Storage Scopes

With DMM and 16 Ch Logic Analyzer(P3850)
Factory Clearance...Incredible Discount!
Normally Sold for $1100.00 +!now only
$299.00 (P3850DMM) & $349.00 (P3850)

50Ms/Sec. Sample Rate
Built in DMM
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RS-232 Port & Software

Brand New Units/ Not Refurbs!

Intelligent Auto-Ranging DMM

Our Most Sophisticated DMM Ever!

Large 4 Dig backlit 8000 count dual display & Analog Bargraph.
RS232 I.R. Interface/software/cable
4 display modes, True RMS value & Freq. of Min/Max values:Temperaturein F/C; relative quantity & error % of relative value at the same time...
MORE DATA @ WEB SITE
CSI 8203.....~~$189.00~~

SALE! $129.00

RF Field Strength Analyzer

$1699.

The 3201 is a high quality hand-held RF Field Strength Analyzer with wide band reception ranging from 100kHz to 2060MHz.The 3201 is a compact & lightweight portable analyzer & is a must for RF Technicians. Ideal for testing, installing & maintenance of Mobile Telephone Comm systems, Cellular Phones,Cordless phones, paging systems, cable &Satellite TV as well as antenna installations.May also be used to locate hidden cameras using RFtransmissions
Extensive Tech Details & a Special Offer At Our Web Site (www.web-tronics.com)

Details & Software Download @ our web site
Intelligent Multi-function Digital Counter

An intelligent multi-function counter controlledby an 8-bit micro-controller with eight-digit high bright LED display. Four measuring functions (frequency,period, total mode & self-check). Also,a 10MHz OSC.OUT.

item# CSI 6100
Frequency Measurements:
CH A, Range 10 to 100Mhz
CHB, Range 100Mhz to 1.3GHz
DETAILS AT OUR WEB SITE under TEST EQUIPMENT

New Lower Price!
$129.00!!

LED's/Megabright Blue, White, GREAT PRICES!

		luminous intensity @ 20mA	1	10+	100+
Megabright Blue 5mm	(L7113PBC/G)	1400	$1.95	$1.50	$1.25
Megabright Blue 3mm	(L7104PBC/G)	600	$1.95	$1.50	$1.25
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more technical details @ our web site under SEMICONDUCTORS
FLASHING red 3mm (L36BHD).....**as low as $.28 ea!**

Circuit Specialists now carries FLUKE TEST EQUIPMENT

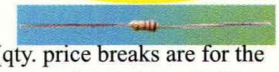
Visit our web site & view our extensive offering of new FLUKE TEST EQUIPMENT. Just go to our home page & select TEST EQUIPMENT. We've got great deals .....
New !
FLUKE COLOR SCOPES

GREAT 1/4 Watt Carbon FilmResistor Deal !

1-199	200	1000
$.07	$.01	$.003

NEW LOW PRICES

as low as **$3.00** per thousand



5% tolerance/bulk packed
All Standard Values
from 1 ohm to 10 meg ohm

(qty. price breaks are for the same value resistor. 200 lot pricing & 1000 lot pricing based on ordering in multiples of 200 or 1000 of each value)

PROGRAMMABLE DC POWER SUPPLY

item# CSI3645A

NEW!!
only $199.00 !!

*Stores up to 10 settings for fast & accurate recall
*Backlit LCD display
*High Resolution (1mV)
*PC compatible (with optional RS-232 adaptor module)
*Easy programming w numeric keypad or fast rotary code switch
*Power shut down memory function

manual pdf available @ web-tronics.com

SPECIFICATIONS@ web-tronics.com (under test equipment)

BAG of LEDs DEAL 100 LEDs for $1.50 !!

Normal brightness leds now available in RED or GREEN in 3mm or 5mm size. Your choice. Each bag of 100 costs $1.50 ! (that's 1.5 cents ea.!) Each bag contains 100 of the same led.

BAG-RED 5mm.....$1.50 BAG-GREEN 5mm..$1.50
BAG-RED 3mm....$1.50 BAG-GREEN 3mm..$1.50

Visit our website for a complete listing of our offers. We have over 8,000 electronic items on line @ www.web-tronics.com. PC based data acquisition, industrial computers, loads of test equipment, optics, I.C's, transistors, diodes, resistors, potentiometers, motion control products, capacitors,miniature observation cameras, panel meters, chemicals for electronics, do it yourself printed circuit supplies for PCb fabrication, educational D.I.Y.kits, cooling fans, heat shrink, cable ties & other wire handleing items, hand tools for electronics, breadboards, trainers, programmers & much much more ! Some Deals you won't believe !

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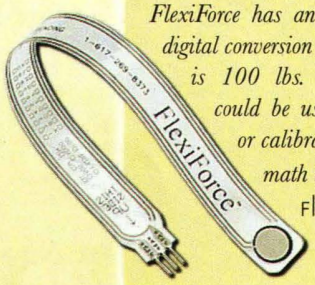
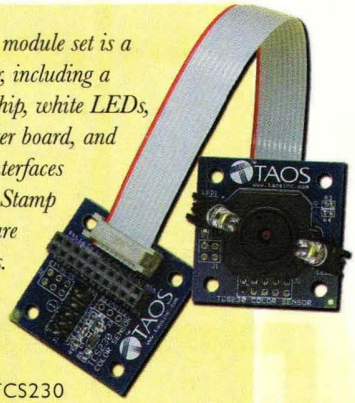
sensors!

Expand the capabilities of your next BASIC Stamp® project with a sensor from Parallax. We stock an entire line of sensors that are compatible with the BASIC Stamp microcontroller. For implementation in your projects, the sensors require a BASIC Stamp and programming board.



The FlexiForce is a thin-film sensor with linear output to pressure. The active sensing area is a 0.375" diameter circle at the end of the sensor. The conductive leads make connection to a breadboard or through-hole area simple. The FlexiForce has an ideal output for analog to digital conversion - 0 V is no force and 4.2 V is 100 lbs. The RCTIME command could be used with a LOOKUP table or calibration formula to execute some math to make the output useful.

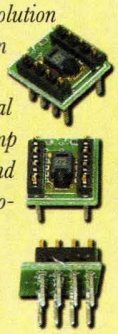
FlexiForce sensor; #30056; $13.00



The TCS230 sensor module set is a complete color detector, including a TAOS RGB sensor chip, white LEDs, collimator lens, adapter board, and connecting cable. It interfaces easily to any BASIC Stamp and can detect/measure a huge range of colors. Applications include color edge-following robots, color sorting, and color matching. TCS230 color sensor; #30054; $79.00

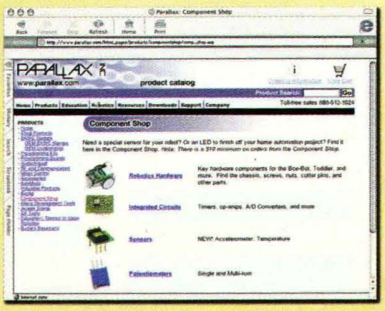
The Memsic 2125 is a low cost, dual-axis thermal accelerometer that is capable of measuring dynamic acceleration (vibration) and static acceleration (gravity) within a range of ±2g. For integration into existing applications, the Memsic 2125 is electrically compatible with other popular accelerometers and is easy to interface to the BASIC Stamp. Great to use in your next robotic, R/C airplane or alarm application.

Memsic 2125 Dual-Axis Accelerometer; #28017; $25.00



A smart sensor for both humidity and temperature, the Sensirion SHTX is factory calibrated so that it returns temperature with a resolution of 0.01° C and relative humidity with a resolution of 0.03%. The SHTX comes from the factory in a tiny package that incorporates the analog to digital interface, all that the BASIC Stamp has to do is read out the humidity and temperature values through the two-wire digital serial interface.

Sensirion SHTX Humidity Sensor; #28018; $29.00



For more information on these sensors and many others visit our "Component Shop" in the Products section of www.parallax.com. Order online 24-hours a day or call our sales department toll-free at 888-512-1024 (Monday-Friday, 7 a.m.-5 p.m., Pacific Standard Time).

PARALLAX

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