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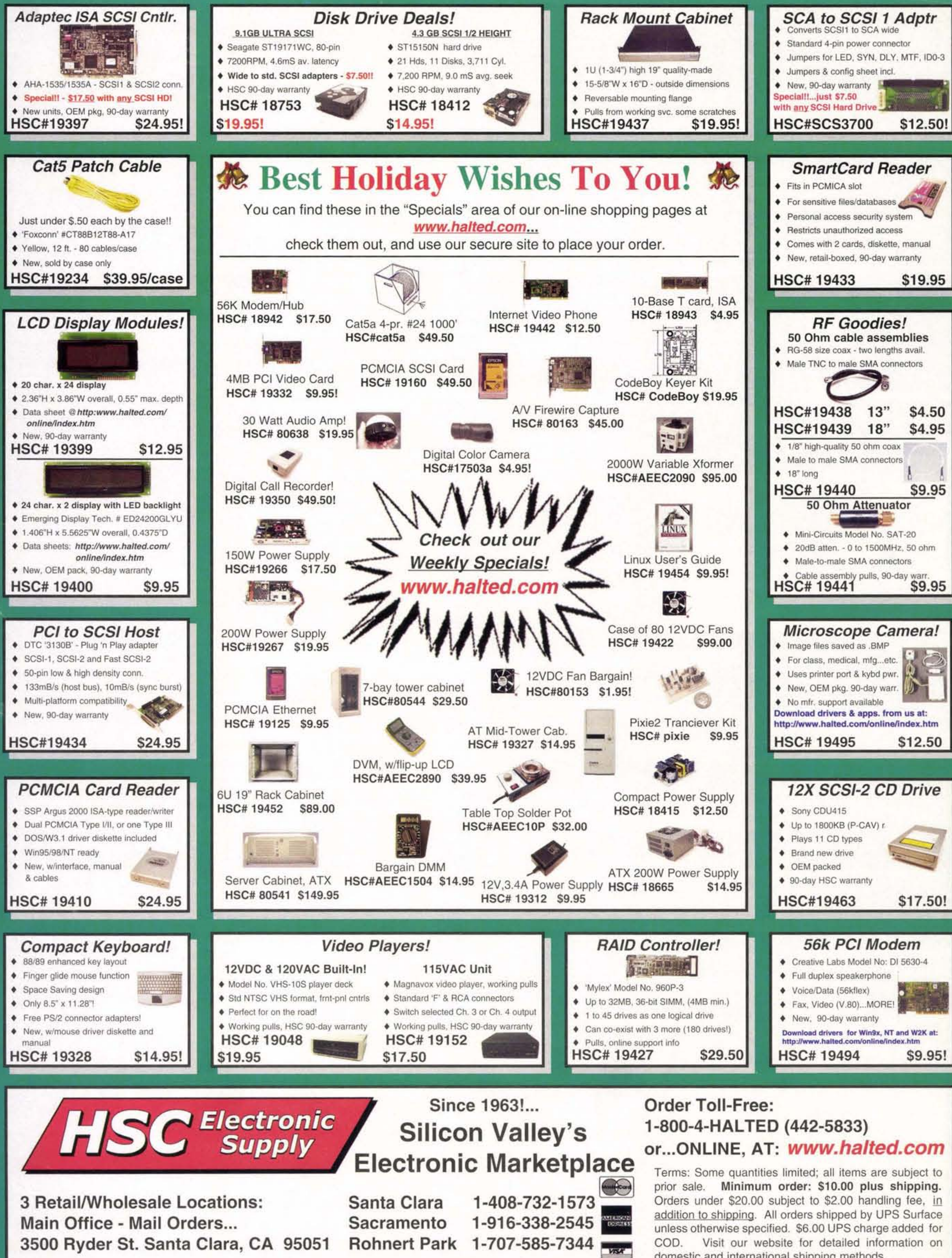
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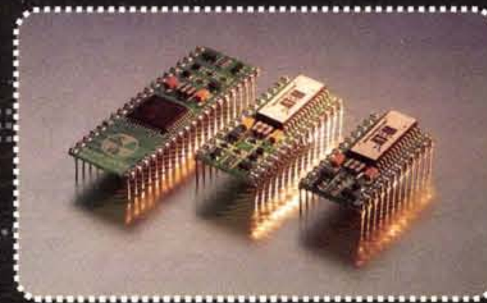

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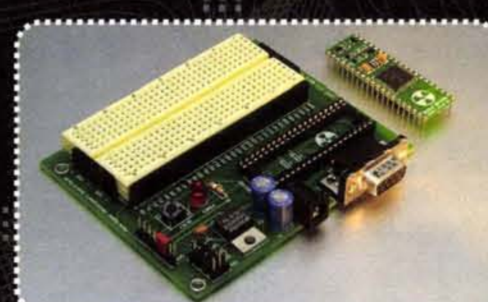

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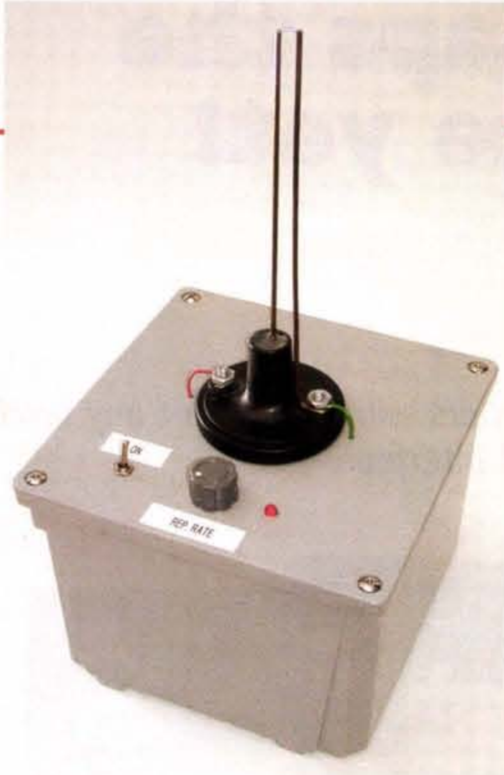

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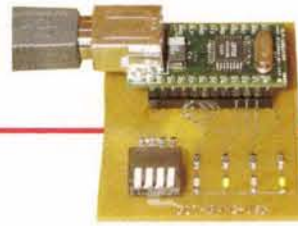

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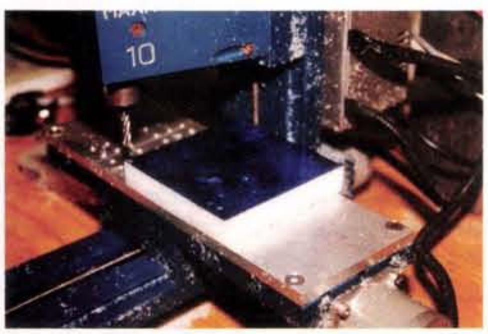

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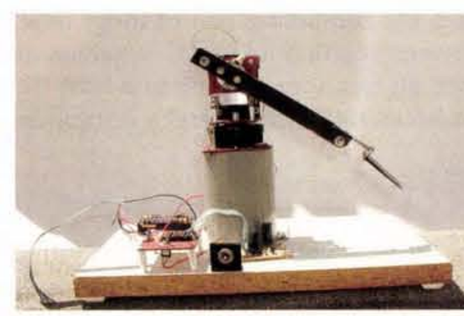

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Bit-Bang USB — Perhaps the easiest USB interface yet!

By Don L. Powrie

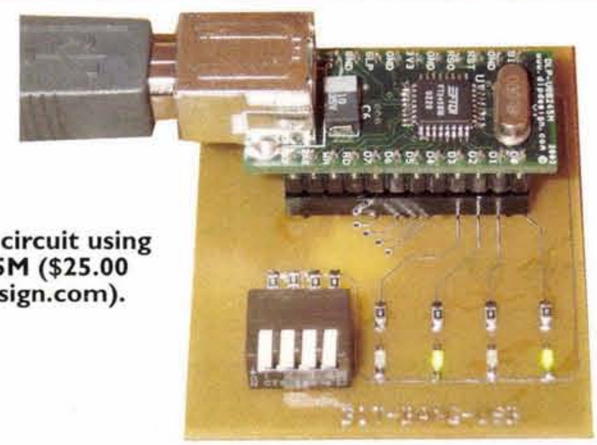
The enhanced functionality of the new FT245BM device provides developers with just about any level of experience the ability to easily connect to the USB interface.

Considering the complexity of the USB interface, using a USB port to toggle an LED is a little like using a sledgehammer to drive a small nail. But that is exactly what this article is going to show you how to do.

Just imagine being able to control a bank of eight relays, read eight switches, or a mixture of both — all via USB using a single chip with no microcontroller or firmware required! In the arena of "easily-implemented USB," the folks at FTDI (www.ftdichip.com) have done it again by releasing their new FT245BM USB-FIFO and FT232BM USB-UART devices.

This article will also show a rather simple design for a low-frequency arbitrary waveform generator; again, with no microcontroller required. By combining one of these new devices with FTDI's royalty-free drivers (compatible with Windows 98/ME/2000/XP), users can interface an electronic device to a host PC via USB in a matter of minutes or hours rather than weeks or months.

Figure 1.



Switch and LED circuit using the DLP-USB245M ($25.00 from www.dlpdesign.com).

FT245BM Overview

For those of you already familiar with FTDI's previous device — the FT8U245AM — the list of new features includes a new "Bit-Bang" mode (which we will cover in this article), reduced external component count, features that improve throughput performance, and support for isochronous transfers. (Consult the FT245BM datasheet for all of the details associated with these new features.)

For those of you who are new to USB or FTDI's USB-FIFO devices, please read on for a quick overview. The USB ports on the back of most of today's PCs offer a high-speed digital interface between the host PC and an electronic peripheral. Electronic devices designed around the FT245BM device can achieve host data rates approaching eight megabits per second. They also offer "hot swapping," are self-powered up to 500 milliamps (no more wall warts!), generate no interrupt conflicts to contend with, and provide the convenience of knowing that most PCs on the planet have the correct interface for your new project built right in.

The FT245BM is FTDI's second-generation USB-to-FIFO chip that makes easy work of connecting your electronic device to a host PC via USB. The electrical interface between your microcontroller and the FT245BM is comprised of eight data lines and four handshaking lines. (If you will be using the Bit-Bang mode, all that is needed are the eight data lines.) Device drivers are provided royalty free that make the FT245BM look like an RS-232 device. Once a serial port has been opened by your application program, bytes sent to the port are rerouted to the Windows scheduler and USB port via FTDI's drivers.

A second version of the device drivers based on a DLL (Dynamically Linked Library) is also available as a free download. The DLL version of the drivers offers a higher data rate, but requires that your program load the DLL at runtime. Example source code for Visual C++, Visual Basic, and other programming languages illustrating how to load the DLL are

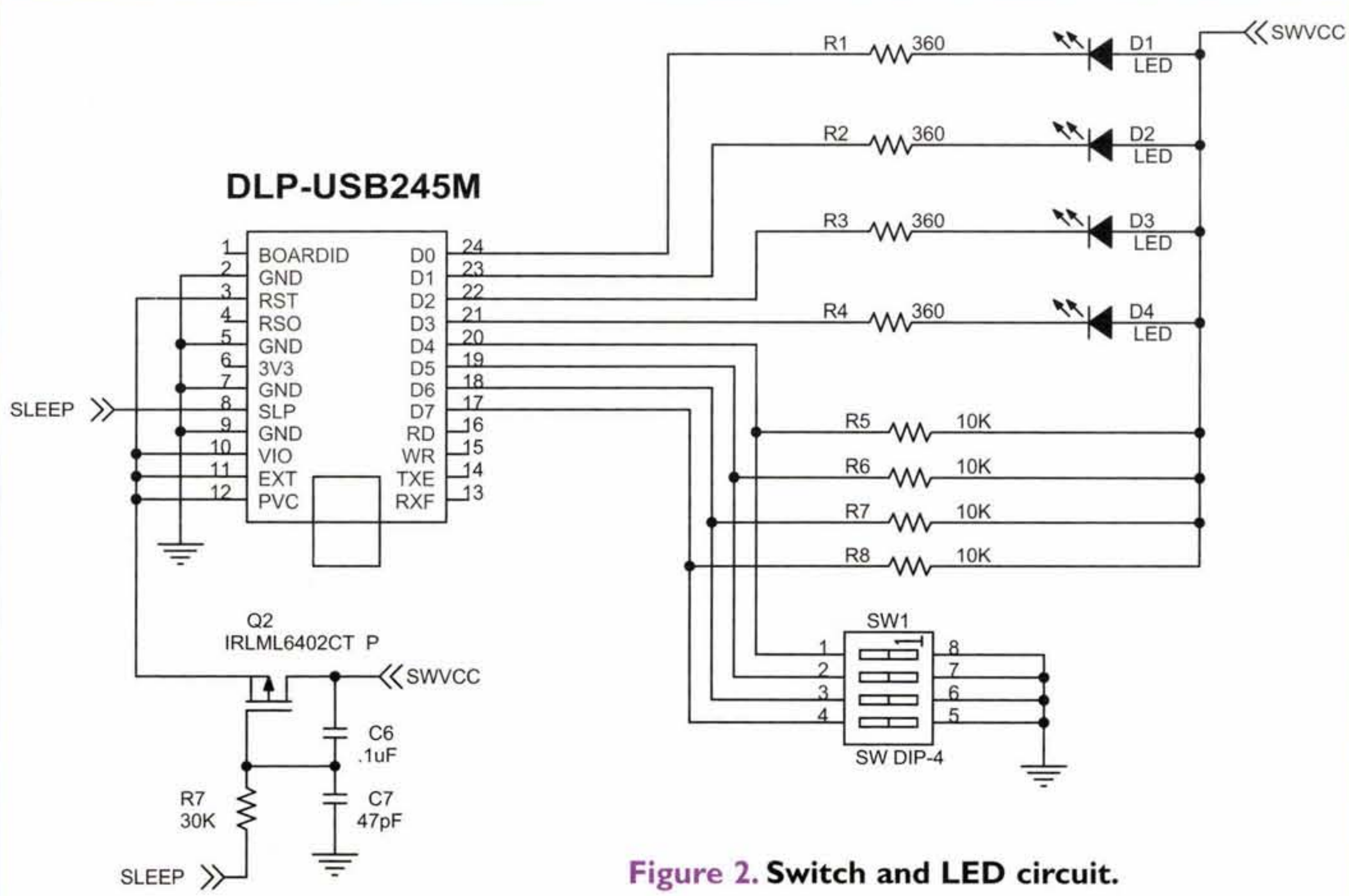


Figure 2. **Switch and LED circuit.**

available for download from both the **ftdichip.com** and **dlpdesign.com** websites.

The FT245BM is only available in surface mount form from FTDI. You can either design a PCB yourself and use a fine-tipped soldering iron to solder the chip in place or use the DLP-USB245M module as shown later in this article. The DLP-USB245M takes advantage of the new features of the FT245BM and allows for easy integration into your hardware design via its standard 0.6-inch DIP interface. Features of this module include an EEPROM for storing description strings, up to an eight-megabit-per-second data rate, and full compatibility with FTDI's royalty-free drivers. A datasheet for this module (including a schematic) can be downloaded from **dlpdesign.com**.

Bit-Bang Mode

Both the FT232BM and FT245BM devices support the new Bit-Bang mode. Utilizing the Bit-Bang mode requires that the application program running on the host uses the DLL version of FTDI's USB device drivers. Keep in mind that the Bit-Bang mode is a side feature of sorts in that the primary intention of the FT245BM is to interface a microcontroller/DSP/FPGA/etc., to a host PC. The Bit-Bang mode is simply one of the latest features of this extremely useful little chip. For a more detailed description of what the FT245BM can do for your next project, refer to my earlier articles that discuss the FT8U245AM in the May '01 and Nov. '01 editions of *Nuts & Volts*. (Both of these articles are available for review on-line through the **dlpdesign.com** site.)

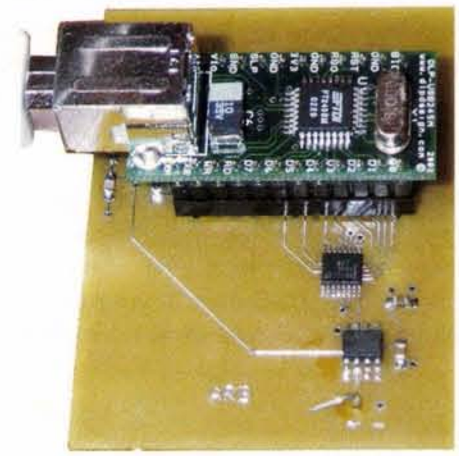
Four commands are used to access the Bit-Bang mode. The first — FT_SetDivisor() — controls the rate at which data is latched to the output data lines on the chip. For example:

```
FT_STATUS status;
USHORT dta;
Dta = 0x400;
status = SetDivisor(dta);
if(status != FT_OK)
{
    CString str;
    str.Format("Data entered (%d) is not a valid divisor.",
dta);
    AfxMessageBox(str);
}
```

This allows data to be clocked out on the eight data lines at a predetermined rate. Note that in Bit-Bang mode there is no output line provided for "latching" data into an external device — the data simply appears on the eight data lines. One of the eight data lines could, however, be used as a latch requiring that the host software keep track of the state of both the seven-bit data and the latch line separately. The second command — FT_Write() — actually sends the data to the FIFO memory in the FT245BM where it waits to written to the output data lines. The third command — FT_SetBitMode() — allows you to select which bits are inputs and which are outputs. This command is also used to enable and disable the Bit-Bang mode. For example:

```
//enable bit bang mode
status = SetBitMode(0x0f,
0xff);
if(status == FT_OK)
{
    //bit bang mode active
}
```

Figure 3.



Arbitrary Waveform Generator

This code will activate Bit-Bang mode (second parameter of SetBitMode) with D7 through D4 set to be inputs and D3 through D0 set to be outputs (first parameter of SetBitMode).

The forth command — FT_GetBitMode() — is used to read the current state (high/low) of the eight data lines.

Data that is transferred from the FIFO to the output data lines is latched on the lines until a different byte is sent. No external buffer or latch is required to maintain the status of the data lines while in Bit-Bang mode. (When not in Bit-Bang mode, data is only held on the data lines as long as RD# is held low.) This technique is demonstrated in the next section in which I will use the sledgehammer to drive a small nail ...

Switch/LED Example Circuit

Figure 1 shows a DLP Design DLP-USB245M module configured into what is probably the simplest implementation of a USB device ever seen. The circuit (Figure 2) will allow the host program to read the state of the four switches and turn each of the four LEDs on or off individually with no microcontroller required. In fact, if Version 2.0 of the DLP Design Test Application (more on this later) is used to control this circuit, then no software development of any kind is required to toggle the data lines.

Driver transistors and relays for USB control of up to eight relays could replace the switches and LEDs. With some additional external circuitry, devices like event timers, device programmers, etc., could also be developed that require no firmware.

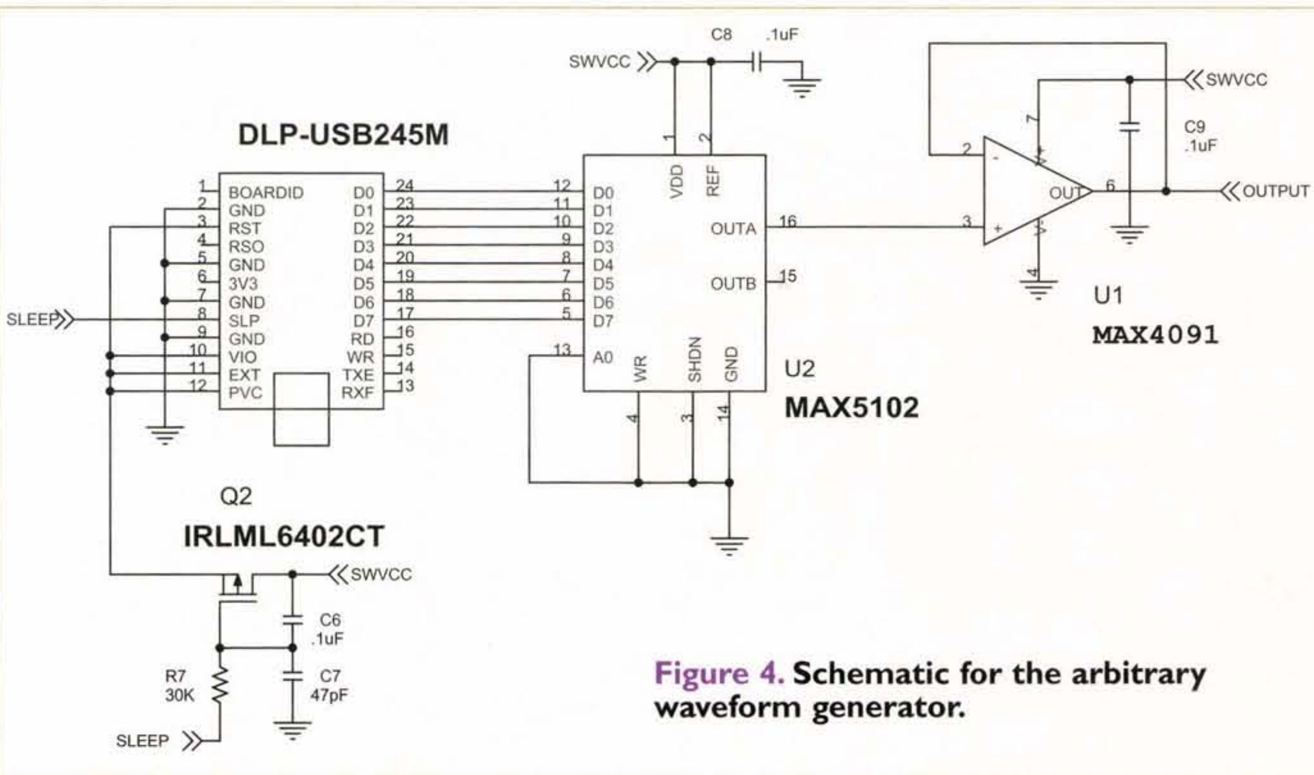


Figure 4. Schematic for the arbitrary waveform generator.

Both this circuit and the next employ a P-channel MOSFET to control power going to the target electronics. Once Windows has enumerated the DLP-USB245M module, the FT245BM takes its SLEEP# line low. This circuit could also be used to control power to higher-current applications since the RC network connected to the gate of the MOSFET sets the rise-time (limiting the inrush current) for the power going to the target electronics. **Note:** Care must be taken to ensure that all target circuitry does not exceed the maximum 500mA (assuming direct connection to a host computer or self-powered hub) available from the host USB port. If your peripheral is connected to a bus-powered hub, then it must draw no more than 100mA.

Arbitrary Waveform Generator

Figure 3 illustrates another design that takes advantage of the new Bit-Bang mode. The DLP Design DLP-USB245M is used once again to prevent having to work with the surface-mount FT245BM device. In this example, circuit (Figure 4) — a simple eight-bit DAC — is used to create a rather basic low-frequency arbitrary waveform generator. The data latch in the DAC is placed in transparent mode such that the data that shows up at its parallel input is passed directly through to the device's output without the need to be latched by an external device. By setting the update rate using the FT_SetDivisor() command, the update rate into the DAC can be controlled, and relatively precise waveforms can be generated. The desired waveform can be created on the host PC and then written to the FT245BM via USB for recreation by the DAC. (Additional circuitry could also be added to expand the output voltage beyond the 0-5 volts provided by the USB port.)

Test Application

So you say you don't want to have to write an application program for the host? Well, you may not need to depending upon the complexity of your application. If all you want to do is send a few bytes to the USB device and observe the response coming back, then the DLP Design Test Application (available as a free download from **dlpdesign.com**) may be all that you need. This application is compatible with both versions of FTDI's device drivers, and it is the perfect companion for helping debug new designs. A second version of the Test Application (Version 2.0) that supports all of the latest features in FTDI's USB DLL drivers (including Bit-Bang mode) is also available for a shareware-level fee of $20.00 ($13.00 with the purchase of any DLP Design product).

Conclusion

As mentioned earlier, the Bit-Bang mode only utilizes one small feature of the FT245BM device ... but just imagine the possibilities!

An electronic device that fits in the palm of your hand, requires no other power source, works with just about any PC, and requires no microcontroller or in-depth knowledge of USB. The enhanced functionality of the new FT245BM device provides developers with just about any level of experience the ability to easily connect to the USB interface. **NV**

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Events, Advances, and News From the Electronics World

by Jeff Eckert

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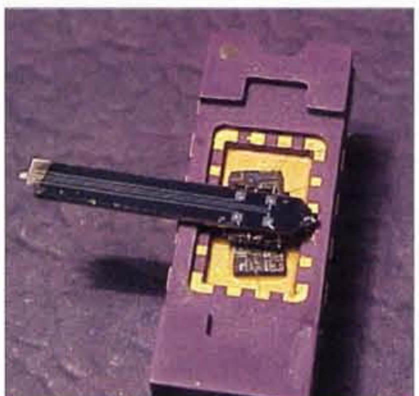
Advanced Technologies

Atomic Batteries May Produce Power for Decades



The prototype device uses a copper cantilever 2 cm long. Future nanofabricated versions could be smaller than 1 cubic millimeter. Copyright © Cornell University, all rights reserved.

Miniaturization has been a highly successful trend in terms of electronic circuits, but the batteries that power them seem to be stubbornly large and cumbersome. However, researchers at Cornell University (**www.cornell.edu**) have built a microscopic device that could supply power for decades to small electronic devices by drawing energy from a radioactive isotope.

The device — designed by Amit Lal, Cornell assistant professor of electrical and computer engineering — converts the energy stored in the radioactive material directly into motion. It could directly move the parts of a tiny machine or generate electricity in a form more useful for many circuits than has been possible with earlier devices. This new approach creates a high-impedance source that is suited for powering many types of circuits.

The prototype is made up of a copper strip 1 mm wide, 2 cm long, and 60 μm (millionths of a meter) thick. It is cantilevered above a thin film of radioactive nickel-63 (an isotope of nickel). As the isotope decays, it emits beta particles (electrons) at energy levels that are too low to penetrate skin (and therefore harmless). The emitted electrons collect on the copper strip, building a negative charge, while the isotope film, losing electrons, becomes positively charged. The attraction between positive and negative bends the rod down. When the rod gets close enough to the isotope, a current flows, equalizing the charge. The rod springs up, and the process repeats.

The half-life of nickel-63 is over 100 years, *so a battery using this isotope might continue to supply useful energy for at least 50 years.* Other isotopes offer varying combinations of energy level versus lifetime. And unlike chemical batteries, the devices will work in a very wide range of temperatures. Possible applications include sensors to monitor the condition of missiles stored in sealed containers, battlefield sensors that must be concealed and left unattended for long periods, and medical devices implanted inside the body.

In terms of mechanical applications, the moving cantilever can directly actuate a linear device or move a cam or ratcheted wheel to produce rotary motion. A magnetized material attached to the rod can generate electricity as it moves through a coil. Prof. Lal has built versions of the device in which the cantilever is made of a piezoelectric material that generates electricity when deformed, releasing a pulse of current as the rod snaps up. This also generates a radio-frequency pulse that could be used to transmit information. Alternatively, Lal suggests, the electrical pulse could drive a light-emitting diode to generate an optical signal.

Music from Outer Space

With scientific instruments on NASA's Voyagers, Galileo, Cassini, and other spacecraft, University of Iowa physicist Dr. Don Gurnett has been recording waves that pass through the thin, electrically-charged gas pervading the near-vacuum of outer space. In a flash of creativity, he converted the recorded plasma waves into sounds, much as a receiver turns radio waves into sound waves. "I've got a cardboard box full of cassette tapes of sounds that I've collected over nearly 40 years," he said.

Gurnett's tapes have now inspired a 10-movement musical composition called "Sun Rings." The Grammy-nominated Kronos Quartet premiered "Rings" at the University of Iowa's Hancher Auditorium in Iowa City, IA, on Oct. 26, 2002. Composer Terry Riley, selected for the project by Kronos' artistic director, compiled an assortment of melody fragments and ideas from the spacecraft recordings collected near Jupiter, Venus, and other planets. Riley listened carefully to some crackling and squealing patterns from the magnetic field the Galileo spacecraft discovered surrounding Jupiter's largest moon, Ganymede. "It sounded to me like a voice saying, 'beebopterismo,' so that's the starting point for one of the movements," he said. "Beebopterismo" comes just before movements named "Planet Elf Sindoori" and "Earth Whistlers."

"Sun Rings" directly incorporates some recorded sounds from Gurnett's scientific instruments into the live performance and also uses string instruments to mimic and build upon those elements. Riley added parts for a choir "to further emphasize that this work is largely about humans as they reach out from Earth to gain an awareness of their solar system neighborhood," he said.

The Kronos Quartet has scheduled performances of "Sun Rings" in 2003 in Houston, San Francisco, London, and California's Orange County, so watch the newspapers if you want to catch a performance in your neighborhood. In the meantime, you can hear samples of the inspirational sounds at **www.pw.physics.uiowa.edu/~jrp/sounds/sounds.html**.

Computers and Networking

HP Puts Vatican Library Online

Hewlett Packard (**www.hp.com**) and the Holy See recently announced a joint project designed to give millions of people online access to the vast artistic and cultural heritage of the Vatican's Apostolic Library, one of the most prestigious collections of manuscripts, documents, and antique texts in the world. The new part of the Holy See web site (**www.vatican.va/**) will include images of manuscripts that until now have been accessible only to professional scholars and professors.

The Apostolic Vatican Library specializes in paleography, history, art history, classical literature, and philology. It contains 1.6 million printed volumes (antique and modern editions), 8,300 incunabula (i.e., books printed before 1501, of which 65 are printed on vellum), 150,000 manuscripts and records volumes, 300,000 coins and medals, and more than 100,000 prints.

The Vatican Library dates back to Pope Nicholas V (1447-1455), whose notable private collection came to form the first nucleus of the present library. Sixtus IV later gave juridical form to the library conceived by his predecessor with the bull Ad decorem militantis ecclesiae (July 15, 1475). The humanistic character of the library has been enhanced over the centuries by many acquisitions of prestigious libraries and manuscripts.

The catalog of modern printed volumes has been available online since 1985. The print catalog, which contains about 10,000 records with accompanying images, can also be accessed via the Web. The web site provides multiple-language access, with versions in German, English, Spanish, French, Italian, and Portuguese.

"Red Storm" Supercomputer Project Begins

The US Department of Energy's Sandia National Laboratories (**www.sandia.gov**) and Cray, Inc. (**www.cray.com**), have announced finalization of a mult-iyear contract, valued at approximately $90 million, under which Cray will collaborate with Sandia to build a new massively parallel processing (MPP) supercomputer called "Red Storm." Cray will deliver a system with theoretical peak performance of 40 trillion calculations per second (teraOPS) using two calculations/clock cycle, or 20 teraOPS using one calculation/clock cycle. Red Storm is expected to become operational in 2004 and will use the upcoming Advanced Micro Devices, Inc. (**www.amd.com**), Opteron™ processors connected via a low-latency, high-bandwidth, three-dimensional mesh interconnect network based on HyperTransport™ technology. This system is expected to be at least seven times more powerful than Sandia's current "ASCI Red" supercomputer when applied to actual weapons problems. ASCI Red was the first supercomputer delivered under the Advanced Simulation and Computing Program (ASCI) program.

According to a Sandia representative, the computer will allow modeling and simulation of complex problems that until recently were believed to be impractical, if not impossible. Calculations that would have taken months a decade ago will now be done in a matter of minutes. The primary application of Red Storm will be in support of the nation's nuclear weapons program.

Circuits and Devices

Wireless Charging Available for Mobile Devices

A new product from MobileWise, Inc. (**www.mobilewise.com**), is designed to allow you to operate and recharge a range of mobile devices (laptops, PDAs, cell phones) without plugging them into a power supply. The technology is based on

MobileWise electricity base with a PDA device. Courtesy of MobileWise, Inc.

the company's chipset that consists of a base and adapter, the latter of which is attached to the mobile device, allowing the device to draw electricity from the base unit.

According to MobileWise, the adapter chip can be integrated externally into most existing laptop computers and other portable electronic products. Connecting directly to the device power input, it has a small footprint and does not require any redesign of the electronic circuits within the device.

The flat surface of the base resembles a small desk blotter. Once a MobileWise-enabled device is placed anywhere on the base, it will be powered and charged as if plugged to an electric outlet. Power is delivered to a mobile device regardless of its location or orientation on the Base's surface, and multiple mobile devices can be charged and powered simultaneously.

The company sells the chipsets to mobile, networking, and power accessories OEMs, so don't look for the product in your local computer/electronics shop. The gadget is an interesting concept, but is plugging in the MobileWise device significantly easier than plugging in any other charger? Eventually, the marketplace will decide.

Switching Chip Achieves 40 Gbits/s Rate

Switching chips are the engines that drive the majority of communications equipment, moving voice telephone calls, wireless Internet data, video streaming files, and other types of communications signals through network systems. Recently, Agere Systems

Agere's PI-40SAX switch. Courtesy of Agere Systems.

(**www.agere.com**) introduced what it claims is the world's fastest switching chip, capable of operating at least four times faster than other single-chip switches.

The new chip — called the Protocol Independent Stand-Alone Switch (PI-40SAX) — switches voice, data, and video signals at an aggregated switching speed of 80 gigabits per second (Gbits/s). This guarantees a minimum of 40 Gbits/s of speed and bandwidth. According to Agere, competing systems can achieve an equivalent speed only by using three or more chips. This chip reduction is said to reduce communications equipment switching costs by nearly 70 percent.

The chip enables a network to simultaneously switch 320,000 voice and data calls, which is enough bandwidth to handle the voice and data telecommunications switching needs of the population of Pittsburgh, PA. It can handle time division multiplex (TDM) bytes, asynchronous transfer mode (ATM) cells, and Internet protocol (IP) packets, which are the three major technologies used to transport information through communications equipment. The chip is targeted for use in various types of wireline and wireless communications equipment, including digital subscriber line access multiplexers (DSLAMs), radio network controllers, routers, and multi-service platforms. Agere is specifically targeting the enterprise, metro, access, and core transport market segments where these types of equipment are deployed. The device is priced at $520.00 in production quantities of 10,000.

Industry and the Profession

Samuel J. Palmisano Elected IBM Chairman

The IBM board of directors has elected Samuel J. Palmisano to the position of chairman of the board, effective January 1, 2003. Mr. Palmisano will succeed Louis V. Gerstner, Jr., who will retire from the company and from the IBM board of directors at the end of this year.

Mr. Palmisano, 51, is currently IBM's president and chief executive officer. He succeeded Mr. Gerstner as CEO of IBM in March 2002. He served previously as IBM's president and chief operating officer after holding senior leadership positions in virtually all of IBM's operating units. He became a director of IBM in July 2000.

Since becoming CEO, Mr. Palmisano has led major initiatives to position the company for profitable growth and industry leadership. Among the key initiatives are the acquisition of Pricewater houseCoopers Consulting and several software companies, the pending sale of the hard disk drive business, a major realignment of the microelectronics unit, and the outsourcing of desktop PC manufacturing.

A graduate of The Johns Hopkins University, Mr. Palmisano joined IBM in 1973 as a sales representative in Baltimore, MD. **NV**

Samuel J. Palmisano, IBM's new chairman of the board (left), and Louis V. Gerstner, outgoing CEO. Photo courtesy of International Business Machines Corp., unauthorized use not permitted.

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

We carefully removed these batteries from unused 4 battery "trays" intended as part of a power backup system. They are in mint condition. Regular price of this battery is about $90ea.The type LC-X1228P is your chance to perk up those heavy duty power projects. Perfect for powering battle bots, telescopes and as part of a solar power system. Even your fish finder, underwater camera or smaller trolling motor. The list is endless. Don't be left out of this opportunity. The size is a manageable 6.5"W x 6.9"H x 4.9"D, weight is 22 lbs. Heavy duty, lead post type connections with 6mm bolt holes. Use two in parallel for 56Ah WOW! Ltd. qty.

PANA-1228P.....$39ea. 2 for $59, See web site, for other configs.

NEW! 20WATT, C BAND, SOLID STATE AMPLIFIER! HEAVY DUTY, INDUSTRIAL QUALITY.
Made by Toshiba for Hazeltine

New old stock, Hazeltine P/N 333325, Beautifully made with base bachined from a sold block of aluminum. Specs: RF output pwr. 43.5dBm @ 5061MHz, Spurious harmonics, x2 >-53dBc, x3>-53dBc, Thermal cutoff, 82 deg.C, Rise time, full output less than 400nsec max., 50nsec typ. Protection for RF open, RF load, primary power loss. Operating power +15VDC @14A max., -15VDC @ 300mA max., +5VC @ 190mA max. There are UHF connectors for RF in, out and monitor. A DB-15 connector for control, WE HAVE NO PINOUT or DATA for this connector. Power input via screw terminals. We would like to have the info for the control connector!

CBAND-20W AMP.....$99ea.

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

Simply connect ANY standard NTSC compatible VIDEO SOURCE to the completely self contained, 500mW, mini (3" x 2.5" x 0.75") transmitter. Omnidirectional patch antenna included inside transmitter housing. Now you can transmit up to several miles clear line of sight! Using the companion, external antenna receiver is simply a matter of connection the antenna to the attached 36" long cable, terminated in a male N connector. The receivers video output works with any TV or VCR. Receiver is powered by 12DC @300mA. Receiver size is: 6"L x 3"W x 1.5"H, The transmitter is powered by 5VDC @ 450mA. (all AC power supplies and cables included). Choose your choice of a 14dB YAGI antenna or a 24dB Parabolic antenna. (see description of antennas at bottom of this page).

NOVEMBER SPECIAL, AST-LR-YAGI..................$299 set.
AST-LR-PARABOLIC.......$349 set.

NEW, GM-DVR100, DIGITAL VIDEO RECORDER,

Digital Recording provides superior quality images, Hard disk hot-swapping capability, Pre-Alarm image recording, Compatible with most multiplexers, Time lapse and real time recording, Refresh rate up to 60 Fields, Quick Search by date/time, alarm events & recording list, playback of recorded video at various speeds, On-screen setup menu and system timer, Password protection, Stable Non-PC based proprietary system, Built-in M-JPEG compression/decompression, Audio recording capability, Selectable time-lapse speeds, Data can be stored in CompactFlash, Operation status record log, Continuous, Alarm, Pre-Alarm & Scheduled Recording Modes, User-selectable settings for image rate, quality and resolution, NTSC

GM-DVR100, DIGITAL VIDEO RECORDER.........$679ea.

NEW & IMPROVED, SONY X-VIEW, 0.003Lux, UNDERWATER B&W CAMERA, 16X MORE SENSITIVE. Now with 12 INTERNAL, INFRA-RED LEDs!

Sleek black anodized, BRASS, housing. O-Ring sealed & WATERPROOF down to 60feet. Adjustabe mount included. Specs: 1/3" CCD, 400 Lines res.,super 0.003 Lux sensitivity, AGC, Auto Shutter. 12VDC @200mA, 4mm, 78° FOV lens, A real glass lens. NTSC video out. Superior construction. SENSITIVE to IR. Ultra small Size only: 1.25"diam. X 2" long. With 60 ft. cable. Perfect as a remote area, pipe or ductwork inspection camera. Excellent for general outdoor use. **GM-300KX-12.....$179**

NEW, 2.4GHz VIDEO + STEREO AUDIO TRANSMITTER and RECEIVER PAIR

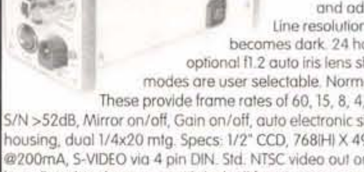
Simply connect ANY VIDEO SOURCE to the completely self contained 2.4GHz transmitter. All cables supplied. You can transmit up to 700 feet clear line of sight! Companion matching receiver works with any TV or VCR. Internal patch antennas. 12DC. (all pwr. adapters and cables included) Can also be used to transmit VCR or camcorder output to another TV for remote viewing. Brand new, boxed set. **OCTOBER SPECIAL, AST-1..........$89 set.**

SONY EX-VIEW CCD for the best "ASTRONOMICAL" PERFORMANCE available in an uncooled affordable camera! With 600 Lines Resolution. NEW! 0.00005 Lux, Black & White

State of the Art Video, Our GMV-EX-6K, Takes the Prize. For covert, military & scientific applications, this is it. Unbelievable 0.00005Lux @ f0.8 performance is enhanced through low speed electronic shuttering, digital frame integration and advanced DSP. Auto sensitivity mode starts as it becomes dark. 24 hour surveillance is possible with the optional f1.2 auto iris lens shown below. Seven Gain/Shutter modes are user selectable. Normal, X4, X8, X16, X24, X32, X64. Frame rates of 60, 15, 8, 4, 3, 2 and 1 per second. Auto/off BLC, S/N >52dB, Mirror on/off, Gain on/off, auto electronic shutter 1/60 to 1/120,000 sec., Alum. housing, dual 1/4x20 mtg. Specs: 1/2" CCD, 768(H) X 494(V), with 380K pixels, 12VDC ±1V@200mA, S-VIDEO on 4pin DIN connector. Std. video out on BNC. Size: 51mm x 51mm x115mm long. Regulated power supply incl. All functions externally controlled. C-mount lens not included.

GMV-EX6K...$529 High performance 6mm, f1.2 Manual Iris Lens...$69

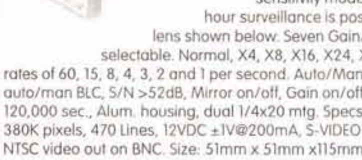
"BUDGET ASTRONOMICAL" PERFORMANCE, 600 Lines Resolution. NEW! 0.0001 Lux, Black & White, NIGHT VISION CAMERA!



State of the Art Video, Our GMV-6K, Takes the Prize. For covert, military & scientific applications, this is it. Unbelievable 0.0001Lux @ f0.8 performance is enhanced through low speed electronic shuttering, digital frame integration and advanced DSP. Did we mention 600 Line resolution? Auto sensitivity mode starts as it becomes dark. 24 hour surveillance is possible with the optional f1.2 auto iris lens shown below. Seven Gain/Shutter modes are user selectable. Normal, X4, X8, X16, X24, X32, X64. These provide frame rates of 60, 15, 8, 4, 3, 2 and 1 per second. Auto/off BLC, S/N >52dB, Mirror on/off, Gain on/off, auto electronic shutter 1/60 to 1/120,000 sec., Alum. housing, dual 1/4x20 mtg. Specs: 1/2" CCD, 768(H) X 494(V), with 380K pixels, 12VDC ±1V @200mA, S-VIDEO out on 4 pin DIN. Std. NTSC video out on BNC. Size: 51mm x 51mm x115mm long. Regulated power supply incl. All functions externally controlled. Lens not included.

GMV-6K...$449ea. High performance auto iris lens, 12mm, f1.4..$129

NEW! 0.005 Lux, COLOR NIGHT VISION CAMERA! UNBELIEVABLE LOW LIGHT PERFORMANCE.



State of the Art Video, Exclusive ON SCREEN, menu driven setup of all camera parameters! For covert, military & scientific applications that must be color, this is it. Unbelievable 0.005Lux @ f1.2 performance is enhanced through low speed electronic shuttering, digital frame integration and advanced DSP. Auto sensitivity mode starts as it becomes dark. 24 hour surveillance is possible with the optional f1.2 auto iris lens shown below. Seven Gain/Shutter modes are user selectable. Normal, X4, X8, X16, X24, X32, X64. These provide frame rates of 60, 15, 8, 4, 3, 2 and 1 per second. Auto/Man. white balance 3200° to 10000°K, auto/man BLC, S/N >52dB, Mirror on/off, Gain on/off, auto electronic shutter 1/60 to 1/120,000 sec., Alum. housing, dual 1/4x20 mtg. Specs: 1/2" CCD, 768(H) X 494(V), with 380K pixels, 470 Lines, 12VDC ±1V@200mA, S-VIDEO out via 4 pin DIN connector. Std. NTSC video out on BNC. Size: 51mm x 51mm x115mm long. Regulated power adapter included. All functions can be externally controlled. c-mount lens not included.

GMV-3K-OSD......$449ea. Superior Auto Iris lens, 12mm, f1.4....$129

NEW, PRICE BUSTER, GM-210 "MINI CCD STEALTH CAM" Top quality, black and white, mini CCD camera at a super price. Packaged in a super rugged cast aluminum housing that fits like a glove! (Not flimsy sheet metal) Removeable mounting bracket included as well as an 8", plug in cable with BNC video & DC power jack for, no sweat hook up. Why fool around with an open P.C. board? Now you can have the GM210 for the same price as a simple board camera • 1/3" • 420 Lines • 0.3 Lux • AGC • Auto Shutter • Power, 12V @100mA • 270k pixels • Standard 4 mm, 78° FOV lens • Focus from 10mm to infinity • NTSC video • 2 ounces • Size: 1.8" Square x 1.3" deep, including lens. **GM-210 STD........$49ea**

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

BRAND NEW, VIDEO MOTION SENSOR.

The model VM-10 connect to any standard video signal and you've got an electronic "watchman" diligently watching the entire scene. Or any adjustable sized area within the scene. Such as a doorway or even a drawer or cabinet. A state of the art security aid. The unit will close a contact when it senses a change. Auto or manual reset. Internal buzzer with volume control and adjustable on time. VCR record and VCR stop output. (use with time lapse VCR.) 110VAC powered. Adjustable sensitivity. Video loop through. **VM10....$179ea.**

NEW! 6.8" LCD COLOR, TFT, ACTIVE MATRIX DISPLAY, A huge 23sq. inch VIEWABLE AREA, Super Deal. 2.8X the VIEWING AREA of a 4" WOW! We wish you could see the color saturation and resolution of this superior LCD display. Excellent contrast ratio, high quality, full color images are comparable to a CRT. Perfect, portable, general purpose color monitor for standard NTSC color or B&W video. Fully compatible with all our cameras as well as Camcorders, VCR's, DVD's etc. OEM "component" style unit has no outer cabinet. Designed to be installed in YOUR housing via four mounting tabs as shown. Specs: Resolution, 1152H x 234V, 270K Pixels! Viewing angle, Top 10°, Down 30°, Left 45°, Right 45°. Brightness, 300 nit, Size: W x H x D (mm/in), 157.2 x 122.6 x 8.0, 6.2" x 4.83" x 1.1", Weight, 10oz. Supplied with 30" input cable. Video input via BNC jack , 12VDC input via a standard barrel connector.

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

PULNIX, TMC7 INDUSTRIAL 1/2", COLOR CCD CAMERA, with Pentax Lens. For No Compromise Performance.

Specs: 1/2" CCD, 460 Lines resolution, 768H x 494V Pixels, 2 Lux sens. @f1.4, Auto/Man AGC, Auto/Man Shutter: 1/60 to 1/10,000 remotely controllable via 6 pin connector (not incl.) Auto/Man white balance, Manual gain and hue controls are external. Complimentary color filter. 12VDC @320mA, Pwr supply incl. Pentax, 16mm f1.4 lens, A real glass lens. Included. Std. NTSC video out on BNC. Y/C (S-Video) output available on 12 pin connector supplied. Superior construction. Compact size only: 1.6"W x 1.25"H x 5.5" long. Perfect for use in process monitoring, medical, surveillance and microscopy. Used, excellent condition, Regular price $600. Limited quantity.

PULNIX, TMC-7.............$139ea. or 2 for $249

NEW, SECURITY MONITOR. NOW YOU HAVE THREE CHOICES!

Commercial quality, Hi-resolution B&W and Color monitors. Brand new, 90 day warranty. BNC video in and loop through. Rugged black steel case. Three models are available: choose a 9" or 15" Black and White with 1000 lines of resolution or a 14" color with 450 lines of resolution. You will be amazed at how much better they will make your video look! There is no substitute for a real monitor. With UL, FCC and FDA approvals.

SPECIAL, BWMONITOR-9HR....$94 ea.
BWMONITOR-15HR........$159ea.
COLORMON-14HR.........$219ea.

SPECIAL PURCHASE, 2.4GHz ANTENNAS, PERFECT for LONG RANGE VIDEO or WIRELESS LAN APPLICATIONS. FIVE MODELS AVAILABLE, ACHIEVE PERFORMANCE YOU THOUGHT IMPOSSIBLE SELECT from FIVE MODELS: TWO OUTDOOR PARABOLIC or A RADOME PROTECTED YAGI, OMNI DIRECTIONAL Right Angle WHIP or TABLE TOP MOUNT AS WELL!

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 part no's are: 130135 and 130120. The two omnidirectional offerings, shown left and right are "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 straight 1/2 wave whip is 4.4"L and features a right angle mounted, female SMA connector. Perfect for portable applications. Both omnis are black and very rugged. 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...$129ea., PARABOLIC, 20dB...$99ea., DESK OMNI...$5ea., WHIP OMNI...$3ea., YAGI....$89ea.

Circle #51 on the Reader Service Card.

by Gordon McComb

Robotics Resources

Under-$200.00 Robot Kits

Not long ago, and in this galaxy no less, amateur robot builders had few choices. Mail order retailers specializing in robotics were rare. Everyone knew all about the few ready-made robots that were available, like the HERO, RB5X, and Androbot — and could recite their specifications (and price!) from memory. Standard components used in robots, such as ultrasonic sensors and microprocessors, were available from a select few distributors and manufacturers, often at high prices. When an electronics magazine ran a robot construction article, it was a blessing, and many of us rushed to build it.

How times have changed. Today, there are literally thousands of sources for assembled robots, kits, parts, and other components for the robot-building craft. There are several dozen mail order companies that specialize only in hobby robotics, and more appear monthly. With the growing interest in amateur robots has come a dramatic increase in providers of robot information and products.

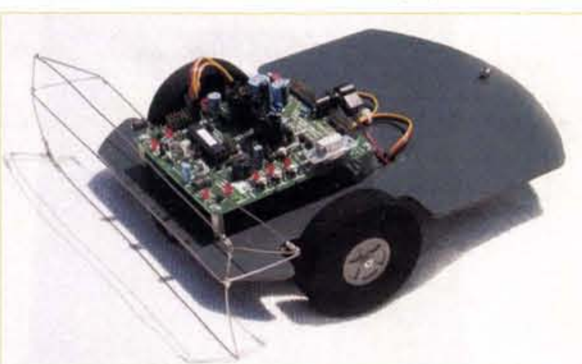


Figure 1. Libby (Blue Bell Designs) comes assembled, just add batteries.

Which brings us to Robotics Resources, a new column for *Nuts & Volts*. The purpose of this column is to provide timely "where it is, how to get it" information on a wide variety of robot sourcing. In this issue and those to follow, we'll cover kits, sensors, motors, microcontrollers, mechanical parts, hardware, bases, specialty components, and many other parts that make up the typical — and even atypical — amateur robot. We'll also spend plenty of time exploring other robotics resources, like free informational sites on the Internet, user groups and clubs, competitions, and lots more.

We begin this month with coverage of under-$200.00 robot kits, one of the fastest-growing market segments of the biz. Because it deserves special coverage of its own, this time around, I'll skip LEGO, K'NEX, Fischertechnik, and other robot kits that are provided as part of a larger construction set. Next month, we'll concentrate on those kits that retail for over $200.00.

I'll begin this column with what will be three common refrains: First, I'm always interested in learning about new robotics products and sources. If you'd like to contribute a resource, please write to me at the email address shown later in the Make Contact box.

Second, many of the components that I'll be discussing are available through a number of outlets. It is impractical for me to list every reseller each time, so I won't even try. Some distributors and resellers may feel left out, but I'll try to be as democratic as possible. If I don't list a particular source this time, I'll try to for another product category in a future column.

And third, because of space considerations, for the most part, I'll provide just the web site of the resource, rather than the full mailing address, email, and phone number. If the resource wants to share this information, it's readily available on the web site with just a few clicks of the mouse.

OWI/MOVITS Robots

Available from a variety of sources, including the following (this is but a small selection):

www.elekit.co.jp/
www.robotikitsdirect.com/
www.hobbytron.com/
www.elenco.com/
www.electronickits.com/
www.robotstore.com/

Exported from Elekit in Japan, the OWI/MOVITS is a line of affordable robot kits priced at $20.00 to over $100.00. Kits are available for several skill levels: many of the products in their "beginners" line include rudimentary mechanical robots that lack sensors, and are more accurately classified as motorized toys. Several beginner-level robots require soldering, but most do not. Construction involves assembling plastic and metal pieces with the included hardware and miniature fasteners.

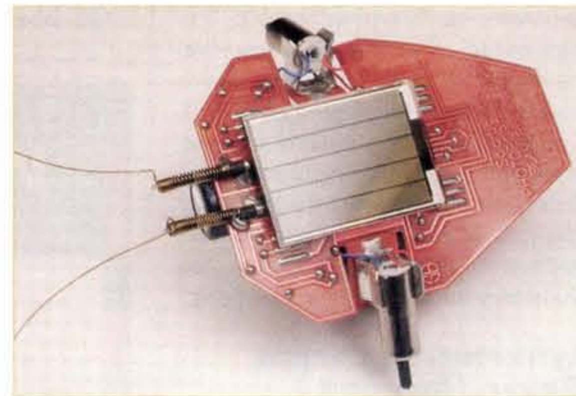


Figure 3. The Photopopper (Solarbotics) is solar powered and moves along on two direct-drive high-efficiency coreless motors.

Intermediate- and advanced-level kits include a line follower, a motorized robotic arm, and the WAO II and G programmable robot kits. The WAO robots can be connected to a PC via an optional interface.

The OWI/MOVITS robots are useful as both learning kits and as hackable platforms. Wire-controlled kits like the Soccer Pro can be retrofitted with a microcontroller and H-bridge for autonomous operation. The robotic arm trainer (model OWI-007) is a popular hacker project that's been written up in various magazines, books, and web sites. For $90.00, you can buy the special interface card and cable for it, but you can build your own for less. It connects to the parallel port of your PC, and can be programmed with QuickBasic or other programming platforms that allows access to the parallel port.

Mark III Mini-Sumo Robot

PARTS
www.portlandrobotics.org/
Sold via distributors, including:
Tim Rohaly
www.junun.org/MarkIII/
Parallax, Inc.
www.parallaxinc.com/
Competition-Robotics (UK)
www.competition-robotics.com/

Designed by the Portland Area Robotics Society (PARTS) for Mini-Sumo competitions, the Mark III is available as a complete low-cost kit ($92.00), and comes with chassis, wheels, two R/C servo motors (modification required for continuous rotation), control board, Fairchild QRB1133 or QRB1134 photo reflector for line following, dual Sharp GP2D12 infrared distance measuring sensors, and a PIC16F877 microcontroller operating at 20 MHz. Assembly is required. The Mark III is one of the more fully-featured robots in its price-range, but do note it is quite small: the robot measures about 3 inches square. And though it's designed to be small and light enough to enter Mini-Sumo contests, it can also be used for line following, maze solving, and other small-robot competitions and demonstrations.

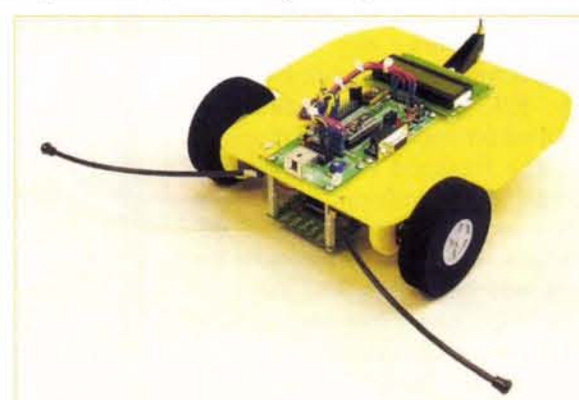


Figure 2. The Carpet Rover 2 (LynxMotion) can be purchased as a basic kit, or as a combo with additional parts, such as a BASIC Stamp II microcontroller.

Libby

Blue Bell Designs
www.bluebelldesign.com/

Libby is a pre-assembled robot consisting of a custom processor board that sits atop a plastic base. The drive for the robot is two already-modified R/C servos; the wheels are Dave Brown Lite Flite foam tires commonly used with model airplanes. Price is $199.00.

The heart of Libby is the control PCB, which contains a BASIC Stamp 2p40 microcontroller, as well as a separate, custom-programmed "co-processor" that handles low-level functions: infrared proximity, servo motor control (with speed ramping), five-channel analog A/D, touch sensors, and eight separate timers. Blue Bell Designs offers the co-processor chip, and the PCB control board, separately, should you wish to use them in your own robotic creations.

LynxMotion Carpet Rover, Hexapod I

LynxMotion

www.lynxmotion.com/

LynxMotion offers a broad line of custom-manufactured robot kits, many of them made with a distinctive laser-cut yellow acrylic plastic. If you see a yellow robot running around the room, it's probably from LynxMotion!

Most of the company's full kits tend to be over $200.00, but a few fall within the range we're discussing this month. These include the Carpet Rover I Robot Kit ($191.00 for combo kit), the Carpet Rover II Robot Kit ($115.00 for basic kit), and the Hexapod I Robot Kit. The Carpet Rovers are dual-wheel designs with Hitec HS-422 ball bearing R/C servos (modification required for continuous rotation).

The Hexapod I is a six-legged "linked gait" walking robot. The robot uses three standard R/C servos for walking: two servos move the front and back legs, and the third servo "tips" the robot from side to side to achieve the traditional tripod walking gait. The gait is "linked" in that the right front/rear and left front/rear legs are mechanically connected. We'll cover additional LynxMotion kits next month, including their line of four- and six-legged non-linked walking robot kits.

Budget Robotics ScooterBot, Budget BotBase

Budget Robotics

www.budgetrobotics.com/

Constructed of lightweight expanded rigid PVC plastic, the ScooterBot and Budget BotBase kits are priced for robot builders with limited cash. The ScooterBot is a two-deck 7" diameter robot that runs under R/C servo power (the servos are pre-modified for continuous rotation). The tires are 2-1/2" diameter rubber urethane. Cost is $49.00 for a version without a controller; with a BOE Board controller, the kit sells for $149.00.

The Budget BotBase is intended as an expandable starter kit, and retails for $19.95. The kit includes a 5" diameter plastic base, dual gear-motor, rubber wheels, and battery holder. An ideal controller for the BudgetBot base is the Handy Cricket ($60.00, Gleason Research).

In the interest of full disclosure, I'll mention Budget Robotics is a company that I operate with my son. We decided to start the business to answer the dearth of affordable robot kits and parts.

Basic Micro Explorer Robot

Basic Micro

www.basicmicro.com/

Basic Micro is best known for their microcontrollers and microcontroller programming systems. They

Gordon McComb is an avid (perhaps even rabid) robot builder. He is the author of the best-selling *Robot Builder's Bonanza* and the *Robot Builder's Sourcebook*, both from Tab/McGraw-Hill. He works in the film industry by day, and builds 'bots by night.

also offer the Explorer Robot, a small two-wheeled vehicle equipped with the Atom Super Development Board, and an Atom 24 microcontroller module. The Atom 24 is similar to the Parallax BASIC Stamp or Basic-X microcontrollers and, in fact, shares the same pin assignments of both of these products.

The Explorer Robot is driven by two R/C servos, and comes complete with two Sharp distance proximity sensors. The base of the Explorer Robot is punched aluminum. Slots that run the length of the base allow you to arrange the layout of the electronic components to best suit your needs.

Rogue Blue

Rogue Robotics
www.roguerobotics.com/

The company's premiere product — Rogue Blue — is constructed of three 8" diameter 1/32" thick laser cut aluminum discs that have been blue powder coated — hence the colorful name. Drive is via pre-modified R/C servos and 3" foam wheels, all of which are included in the base price of $109.00. The discs stack onto one another with aluminum "risers;" the motors and C-cell battery holder are mounted on the bottom disc, leaving the other two for sensors and additional equipment.

Do note that the base price of Rogue Blue contains just the body, servos, wheels, and C-cell battery holder. Kit prices are higher if you want a controller. The company resells the Parallax BOE board, as well as the SimmStick development board that accepts the full line of SimmStick microcontroller expansion products (see http://www.dontronics.com/). The StampStick 2SX board is included. With either controller, the price of the full kit is $220.00.

BEAM Robots

Various vendors, notably:

Solarbotics
www.solarbotics.com/

JCMInventures
www.jcminventures.com/

Robot Store/Mondo-Tronics
www.robotstore.com/

HVW Tech
ww.hvwtech.com/

Bug'n'Bots
www.bugnbots.com/

BEAM robots are based on the principle that less is often more. They use simple mechanisms and electronics to achieve many of the same functionalities as larger and more complicated robots. As a result, BEAM robots tend to be affordable — typical kits sell for under $90.00, and many are less than $50.00. Soldering is usually required, and the circuit board for the robot serves double-duty as its structural body. Mechanical construction tends to be minimal, as most BEAM robots either hop or roll on non-geared motors. Many BEAM kits are solar powered, though a few are designed to run off batteries.

A prime source for BEAM kits is Solarbotics, who offers a variety of solar- and battery-powered kits, such as the Photopopper and HexPummer. The company also sells individual parts for building your own BEAM robots from scratch.

The Cybug products from JCMInventures are among the more striking ready-made BEAM kits available. Example: Their Queen Ant is shaped like an ant, and the board uses a bright red (instead of the usual green) solder mask. Many of the other products from JCMInventures also use specially-shaped PC boards to add character to the robots.

EasyBug, EasyBot

EasyBot/Michael Berta Ent
www.easybot.net/

EasyBug and EasyBot are

Figure 4. Expand the EasyBot (EasyBot/Michael Berta Ent) motorized base with a microcontroller and other electronics.

"starter" bases, designed to be expanded with a microcontroller, sensors, and additional electronics. Prices for both are in the $100.00 range. The EasyBug is a six-legged walking robot base that employs three R/C servos (included). The robot frame is punched from 0.050" aluminum, and comes with all parts and hardware to build the robot — just add a microcontroller capable of operating the servos.

The EasyBot is a two-wheel differentially-steered 7.5" diameter robot platform, also punched from aluminum — in a wide assortment of colors no less. The design incorporates multiple "decks" for adding an assortment of options. Gearmotors and wheels are included with the kit. This is a good all-purpose base if you're looking to build your own robot, but don't want to bother with the mechanical aspects.

Honorable Mentions

And here are even more robot kits ...

Bawtz
www.bawtz.com/

Resellers of robot kits from Rogue Robotics, Solarbotics, JCMInventures, and Parallax.

Johuco, Ltd.
www.johuco.com/

Offers G.R.A.K, Muramator, and Photovore kits, all under $100.00.

Kadtronix
www.kadtronix.com/

Starter robot bases designed for expansion; products include the Workman Mobile Robot Platform, and a variety of metal base frames.

Milford Instruments, Ltd.
www.milinst.com/

Based in the UK, but ships worldwide, Milford offers the StampBug walking robot, Big Foot two-legged walking robot, and Alex, an animatronic/robotic head.

Norland Research
www.smallrobot.com/

Kit of parts for turning a Texas Instruments scientific calculator into a robot! Also sells S.A.M., a fun plastic add-on base for an existing robot.

Real Robotics/Cybot
www.realrobots.co.uk/

UK-based magazine where each issue comes with parts to build a complete robot. You can purchase back-issues; as of this writing, the magazine is not yet distributed within North America.

RobotBooks.com
www.robotbooks.com/

RobotBooks.com is a reseller of a number of kits including OWI, Solarbotics BEAM, JCMInventures, and several other brands.

Robot Store/Mondo-Tronics
www.robotstore.com/

Mainly a reseller of robot wares, Robot Store offers dozens of kits from Tamiya, Velleman, OWI, and others. If you're looking for a kit, odds are the Robot Store has it.

Tab Build Your Own Robot Kit
www.tabrobotkit.com/

Microcontroller-based robot kits, including a sumo competition kit, for under $100.00. The kits are from book publisher Tab/McGraw-Hill; they are available at bookstores and robotics specialty retailers..

Tamiya
www.tamiyausa.com/

Inexpensive plastic and wood kits include the Wall Hugging Mouse, manually remote-controlled robotic bulldozer (a great expansion base for your own robots), and a "dung beetle" infrared-controlled miniature robot.

Velleman Robot Kits
www.velleman.be/

Robotic creations, such as motorized dinosaurs, cars, and turtles, out of plastic and punched plywood; some require soldering. A number of mail order firms, such as Jameco, resell the product. Visit the web site for a list of distributors. **NV**

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

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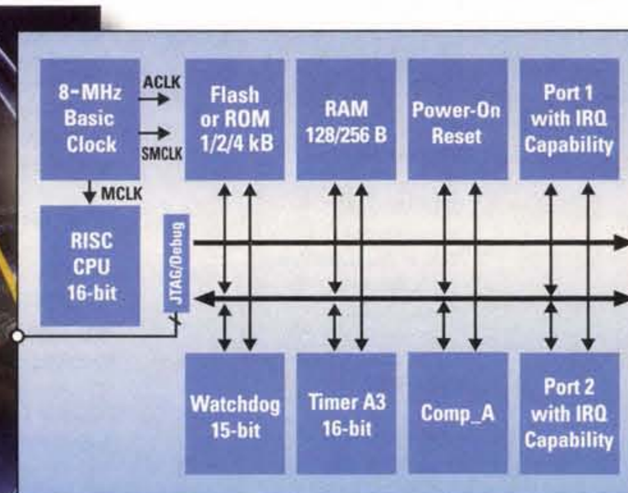

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Easy CNC Machining With GCG

By Matthew Evans

Improved and expanded version of GCG that will generate control code for many other features.

In my first article for *Nuts & Volts* (Oct. 2000), I wrote some MS Qbasic code to generate a G-code control file for a small CNC milling machine. The article ended with a free version of a program named GCG that would generate the control file for milling circles and circular pockets. Now I would like to share a much improved and expanded version that will generate control code for many other features. Don't worry, it's still free. The whole idea behind GCG (*G* *C*ode *G*enerator) is to make my hobbies easier by removing the mistake-prone drudgery of typing, cutting, and pasting hundreds of lines of G-Code for every machined part I need to make. Since I am basically a damn nice guy, I'll give it to you so that we both can concentrate on designing and machining parts instead of typing CNC code.

The control file generated by GCG is called G-Code, the industry standard for controlling the tool path of a CNC mill or lathe. G-code is defined by the Electronic Industries Association as an "interchangeable variable block data format for positioning, contouring, and contouring/positioning numerically-controlled machines." It has been around for quite a while and most CNC machines will accept one version or another.

Although it is relatively easy to understand and create G-code, it becomes annoyingly boring and repetitive creating it for small horsepower machines typical to the hobby machinist. You have to type in all the required lines for the start depth of a cut and then copy and paste them as the depth of the cut increases. For the bearing pocket in my first article, that would have been over 200 lines! With GCG, it takes only a few minutes to enter the information required and let the computer do the grunt work.

The casually observant reader will notice some slight differences in the milling machine since the last article (see Photo 1). Most obvious would be that there appears to be nothing holding the pre-cut slab of delrin to the machine. It is being held in place by double-sided tape. Since we are taking small cuts — due to the 1/12 horsepower spindle motor — I have found that double-sided tape is sufficient to secure the part. The tape I use is called polyken, a carpet tape. It is strong enough to hold the part, easy to remove, and does not leave a sticky residue. Tape eliminates the need to hold the material down with blocks, as seen in the photos from my first article. Eliminating the hold-down blocks allows cutting around the outside of the part without having to move anything. The part can also be pre-cut closer to the finished size to save some machining time.

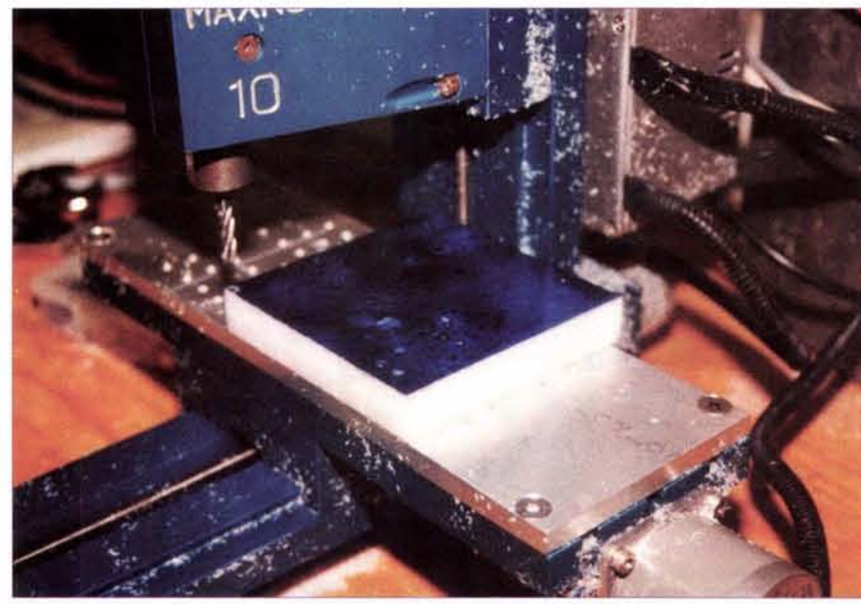


Photo 1. The band saw cut Delrin blank taped to the milling machine table.

Figure 1.

```
GCG VERSION 2
CURRENT TOOL DIAMETER IS   .25
CURRENT FEED RATE IS  5
CURRENT VERTICAL INCREMENT IS  .05
CURRENT HORIZONTAL (RADIAL) INCREMENT .05
AVAILABLE FEATURES
0  QUIT
1  ADD DIAMETER
2  ADD HORIZONTAL LINE
3  ADD VERTICAL LINE
4  ADD POINT TO POINT LINE
5  ADD ARC
6  ADD PATH
7  RECTANGULAR POCKET
8  DRILL POINT
9  CHANGE TOOL PARAMETERS
CHOOSE 0-9? 9

CHANGE DEFAULT TOOL PARAMETERS
0 RETURN TO MAIN MENU
1 CURRENT TOOL DIAMETER IS   .25
2 CURRENT FEED RATE IS  5
3 CURRENT VERTICAL INCREMENT IS  .05
4 CURRENT HORIZONTAL (RADIAL) INCREMENT IS   .05
ENTER 0-4? 4
NEW HORIZANTAL INCREMENT ? .23
CHANGE DEFAULT TOOL PARAMETERS
0 RETURN TO MAIN MENU
1 CURRENT TOOL DIAMETER IS   .25
2 CURRENT FEED RATE IS  5
3 CURRENT VERTICAL INCREMENT IS  .05
4 CURRENT HORIZONTAL (RADIAL) INCREMENT IS   .23
ENTER 0-4?
```

The second difference is that there is an aluminum tooling plate mounted on top of the machine's X-Y table. The tooling plate was milled flat on one side on a real (i.e., big) milling machine, them mounted on the X10. It was then fly cut so that its surface was perpendicular to the X10's spindle. This left a flat surface suitable for double-sided tape.

GCG is a feature-based program. A 'feature' in this case is a circle, line, arc, or a combination of lines and arcs that form a tool path to be machined. Some other features are circular and rectangular pockets. What GCG does is ask you a few questions about the feature, format the G-code lines for that feature, and write them to a file. Because GCG formats the file with the feature information before the code, you can easily edit the output file to add or remove features. The file is then read by the CNC control software, which controls the steppers or servos on the machine itself.

So far, there are two types of features: *tool path* and *finished size.*

For an example of a *tool path* feature, look at the drawing (Figure 6) of the top view of the test block. There are nine points that the tool must go through: one through eight as shown in the drawing, and then from eight to one to cut the last corner and close the path.

This will be done with the 'read points' option of the path feature, where the points are read in from a text file. The properly formatted

Figure 2.

```
GCG VERSION 2
CURRENT TOOL DIAMETER IS   .25
CURRENT FEED RATE IS  5
CURRENT VERTICAL INCREMENT IS  .1
CURRENT HORIZONTAL (RADIAL) INCREMENT .23
AVAILABLE FEATURES
0  QUIT
1  ADD DIAMETER
2  ADD HORIZONTAL LINE
3  ADD VERTICAL LINE
4  ADD POINT TO POINT LINE
5  ADD ARC
6  ADD PATH
7  RECTANGULAR POCKET
8  DRILL POINT
9  CHANGE TOOL PARAMETERS
CHOOSE 0-9? 7
RECTANGULAR POCKET
TOOL DIAMETER IS   .25
ENTER LOWER LEFT POINT X,Y? .708,.843
ENTER UPPER RIGHT POINT X,Y? 3.293,2.658
Y INCREMENT IS  .23
DEPTH INCREMENT IS  .1
ENTER START DEPTH ? 0
ENTER FINISH DEPTH ? .2
```

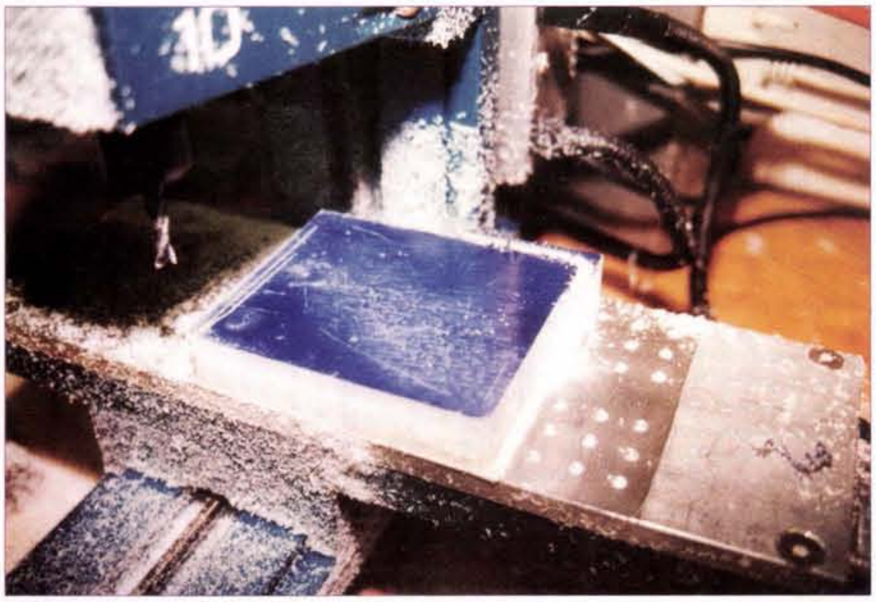


Photo 2. The test fixture after cutting the path feature.

text file appears below.

```
9,0, -0.73,0.05
1, -0.125,0.25,0,0
1, -0.125,3.25,0,0
2,0.25,3.625,.375,0
1,3.75,3.625,0,0
2,4.125,3.25,0, -.375
1,4.125,0.25,0,0
2,3.75, -0.125, -.375,0
1,0.25, -0.125,0,0
2, -0.1
```

The first line contains the number of points, the start depth, end depth, and the depth increment. The second through N+1 lines, where N is the number of points, starts with the segment type (i.e., G-Code) X location, Y location, I value, and J value. For segment type 1 — a line — the values for I and J are 0 and are not used to create the G-Code line describing a line. However, they are still needed by the 'read points' option so that the GCG stays in the right place while reading the file. There are probably neater, more programmerish type ways of doing this, but it works. Notice that the last point is directly on top of the first point, but that the segment information is different. The following is a portion of the G-code text file generated by this input file.

```
G01 Z-.050 F3
G01 X -.125 Y 3.250
G02 X 0.250 Y 3.625 I 0.375 J 0.000
G01 X 3.750 Y 3.625
G02 X 4.125 Y 3.250 I 0.000 J -0.375
G01 X 4.125 Y 0.250
G02 X 3.750 Y -.125 I -0.375 J 0.000
G01 X 0.250 Y -.125
G02 X -.125 Y 0.250 I 0.000 J 0.375
```

Photo 3. The test fixture after cutting the two inside rectangle features.

Although this is a very simple example of the path feature, you'd have to type in the above code 14 more times to cut outside of the block. See Photo 2 for the results. Any number of points can be in the text file for any combination of lines and arcs. Remember that we are using GCG to generate the large amount of data needed to cut on a small machine with limited horsepower. As always, check the code with a screen plotter before cutting on a machine. Figure 4 is a screen plot of the output from the above "read points" option.

A *finished size* feature calculates the tool path from the finished size input by the user and default tool diameter data. Both the circular and rectangular pockets are *finished size* features. The path feature is a *tool path* feature; it generates code for the tool path directly. The user enters points in X & Y, and GCG creates lines and arcs between the points for the tool to follow.

For an example of a *finished size* feature, look at the drawing of the rectangular block (Figure 5). There are two rectangular pockets cut out of the middle, one .200 deep and one .325 deep. All you do with GCG is input the lower left corner, the upper right corner, and the depth. The program does the rest. You can use the default values for the vertical and horizontal feed or change them from the main menu.

The corners for the .200 deep rectangle are X_1=.708 Y_1=.843 and X_2=3.293 Y_2=2.658. The corners for the .325 deep rectangle are X_1= .833 Y_1= .968 and X_2=3.168 Y_2= 2.533. The result of these few entries is a 3 KB file. Since the file for these rectangles is so big, I'll change the values of the horizontal and vertical feeds to create some code that is much more picture friendly. The default values for the vertical and hor-

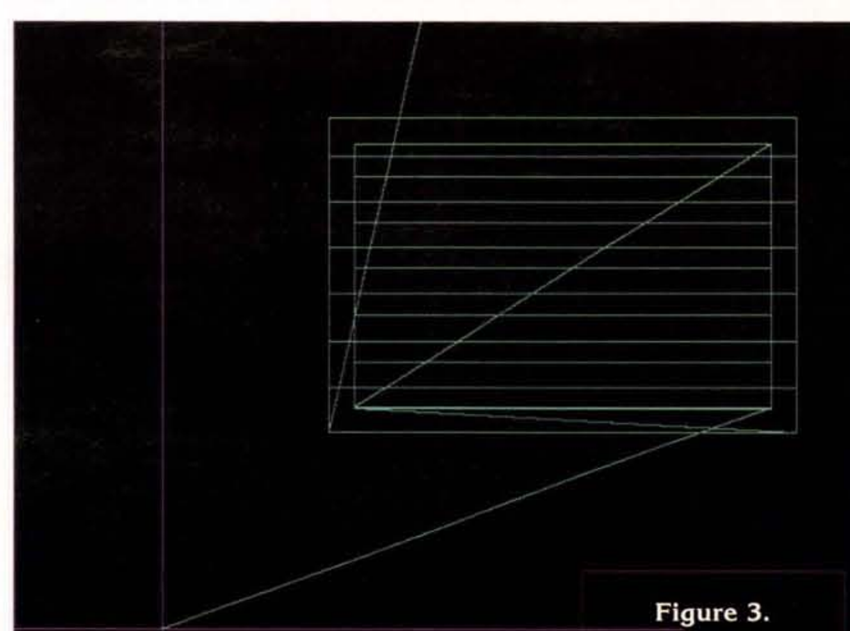


Figure 3.

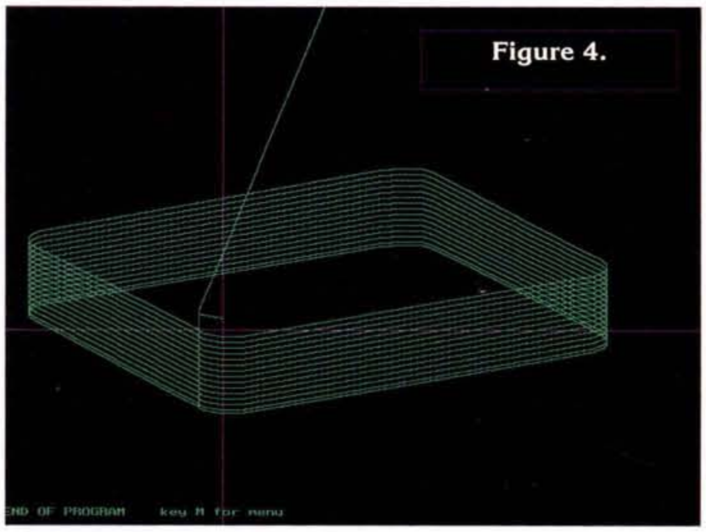


Figure 4.

izontal feeds are both .050 inches. The picture friendly values are .1 for the vertical and .23 for the horizontal. I wouldn't use these values on my mill because the z-axis hamster's union would go on strike due to being overloaded.

Figure 1 shows a screen capture of GCG's main menu and the option to change the default parameters. Note the current values shown in the upper portion. Figure 2 shows a screen capture of the data you need to input for the first of the two rectangles. Note that the current values in the upper portion of the screen have changed to the values entered in Figure 1. The code generated by GCG for these features in a sidebar, the screen plot is Figure 3 and the finished features are shown in Photo 3.

GCG is again free, I wrote it to make machining parts easier on small machines. There are several other new features not described here, but you can download the file and play with them yourself.

It is still written in Q-Basic, which everyone who owns a copy of Windows 95 or any earlier version also owns. It fits a niche of hobbyists who don't have a CAD package that is capable of generating G-code and those who don't want to fool with CAD at

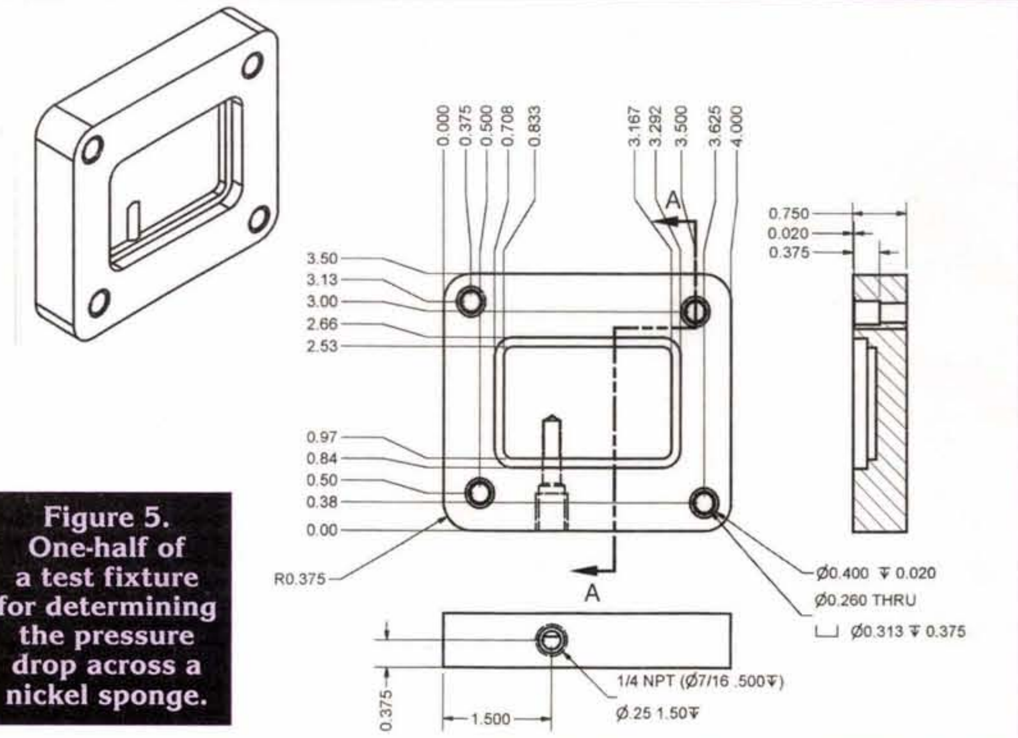
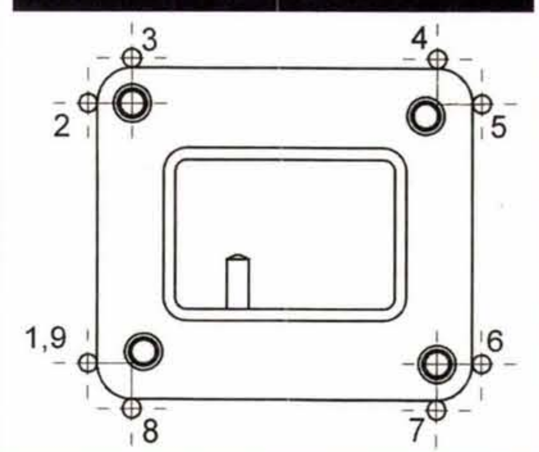


Figure 5. One-half of a test fixture for determining the pressure drop across a nickel sponge.

Figure 6. The points used by the path feature to cut the outside of the test fixture.



An excerpt from the code generated by GCG for the rectangular features.

```
(NV2-SIDEBAR.TXT)
(02-22-2002)
(THIS IS FEATURE # 1 )
(THIS FEATURE IS A RECTAN-
  GULAR POCKET)
(LOWER LEFT CORNER IS X,Y
  .708 .843 )
(UPPER RIGHT CORNER IS X,Y
  3.293 2.658 )
(START DEPTH 0 )
(END DEPTH -.2
(Y INCREMENT .1 )
(DEPTH INCREMENT .1 )
(MILL DIAMETER .25 )
G01 X0.833 Y 0.968 F10
M3
G01 Z-.100 F3
G01 X 3.168 F 5
G01 Y 1.068
G01 X 0.833
G01 Y 1.168
G01 X 3.168 F 5
G01 Y 1.268
G01 X 0.833
G01 Y 1.368
G01 X 3.168 F 5
G01 Y 1.468
G01 X 0.833
G01 Y 1.568
G01 X 3.168 F 5
G01 Y 1.668
G01 X 0.833
G01 Y 1.768
G01 X 3.168 F 5
G01 Y 1.868
G01 X 0.833
G01 Y 1.968
G01 X 3.168 F 5
G01 Y 2.068
G01 X 0.833
G01 Y 2.168
G01 X 3.168 F 5
G01 Y 2.268
G01 X 0.833
G01 Y 2.368
G01 X 3.168 F 5
G01 Y 2.468
G01 X 0.833
G01 Y 2.533
G01 X 3.168 F 5
G01 Z .1
M5
G01 X0.833 Y 0.968 F10
M3
G01 Z-.100 F3
G01 Y 2.533
G01 Z .1
M5
G01 X 3.168
M3
G01 Z-.100 F3
G01 Y 0.968
G01 Z .1
M5
G01 X0.833 Y 0.968 F10
M3
G01 Z-.200 F3
G01 X 3.168 F 5
G01 Y 1.068
G01 X 0.833
G01 Y 1.168
G01 X 3.168 F 5
G01 Y 1.268
G01 X 0.833
G01 Y 1.368
G01 X 3.168 F 5
G01 Y 1.468
G01 X 0.833
G01 Y 1.568
G01 X 3.168 F 5
G01 Y 1.668
G01 X 0.833
G01 Y 1.768
G01 X 3.168 F 5
G01 Y 1.868
G01 X 0.833
G01 Y 1.968
G01 X 3.168 F 5
G01 Y 2.068
G01 X 0.833
G01 Y 2.168
G01 X 3.168 F 5
G01 Y 2.268
G01 X 0.833
G01 Y 2.368
G01 X 3.168 F 5
G01 Y 2.468
G01 X 0.833
G01 Y 2.533
G01 X 3.168 F 5
G01 Z .1
M5
G01 X0.833 Y 0.968 F10
M3
G01 Z-.200 F3
G01 Y 2.533
G01 Z .1
M5
G01 X 3.168
M3
G01 Z-.200 F3
G01 Y 0.968
G01 Z .1
M5
(END OF FEATURE # 1 )
(THIS IS FEATURE # 2 )
(THIS FEATURE IS A RECTAN-
  GULAR POCKET)
(LOWER LEFT CORNER IS X,Y
  .833 .968 )
(UPPER RIGHT CORNER IS X,Y
  3.293 2.533 )
(START DEPTH -.2 )
(END DEPTH -.325
(Y INCREMENT .1 )
(DEPTH INCREMENT .1 )
(MILL DIAMETER .25 )
G01 X0.958 Y 1.093 F10
M3
G01 Z-.300 F3
G01 X 3.168 F 5
G01 Y 1.193
G01 X 0.958
G01 Y 1.293
G01 X 3.168 F 5
G01 Y 1.393
G01 X 0.958
G01 Y 1.493
G01 X 3.168 F 5
G01 Y 1.593
G01 X 0.958
G01 Y 1.693
G01 X 3.168 F 5
G01 Y 1.793
G01 X 0.958
G01 Y 1.893
G01 X 3.168 F 5
G01 Y 1.993
G01 X 0.958
G01 Y 2.093
G01 X 3.168 F 5
G01 Y 2.193
G01 X 0.958
G01 Y 2.293
G01 X 3.168 F 5
G01 Y 2.393
G01 X 0.958
G01 Y 2.408
G01 X 3.168 F 5
G01 Z .1
M5
G01 X0.958 Y 1.093 F10
M3
G01 Z-.300 F3
G01 Y 2.408
G01 Z .1
M5
G01 X 3.168
M3
G01 Z-.300 F3
G01 Y 1.093
G01 Z .1
M5
G01 X0.958 Y 1.093 F10
M3
G01 Z-.325 F3
G01 X 3.168 F 5
G01 Y 1.193
G01 X 0.958
G01 Y 1.293
G01 X 3.168 F 5
G01 Y 1.393
G01 X 0.958
G01 Y 1.493
G01 X 3.168 F 5
G01 Y 1.593
G01 X 0.958
G01 Y 1.693
G01 X 3.168 F 5
G01 Y 1.793
G01 X 0.958
G01 Y 1.893
G01 X 3.168 F 5
G01 Y 1.993
G01 X 0.958
G01 Y 2.093
G01 X 3.168 F 5
G01 Y 2.193
G01 X 0.958
G01 Y 2.293
G01 X 3.168 F 5
G01 Y 2.393
G01 X 0.958
G01 Y 2.408
G01 X 3.168 F 5
G01 Z .1
M5
G01 X0.958 Y 1.093 F10
M3
G01 Z-.325 F3
G01 Y 2.408
G01 Z .1
M5
G01 X 3.168
M3
G01 Z-.325 F3
G01 Y 1.093
G01 Z .1
M5
(END OF FEATURE # 2 )
G01 Z .1
G01 X0 Y0
M5
M30
```

all. It may or may not generate code that is compatible with any other machine than a MAXNC machine. If it doesn't work on yours, hack away! Even though it is free, it is still copywrited so you can fold, spindle, or mutilate it, you just can't sell it. The only thing that I do not yet have a solution for is a screen plotter to check code before machining. The screen plotter I use is part of the MAXNC package and as far as I can tell, is not sold separately. Next time, I'll show how the rest of the features work and maybe add a few. **NV**

Electronics Q&A

With TJ Byers

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist.

Feel free to participate with your questions, as well as comments and suggestions.

You can reach me at: ***TJBYERS@aol.com*** *or by snail mail at Nuts & Volts Magazine, 430 Princeland Ct., Corona, CA 92879.*

What's Up:

A schematic/project Christmas present from me to you. Eleven circuits printed here, and hundreds of others you can find on cool web sites. Happy Holidays!

CAT 5 Cable Tester

Q. I would like to know if you have a circuit diagram for testing CAT 5 cabling?

Howard Hendra
via Internet

A. You didn't say whether it was an extension cable or in-wall wiring that you want to test, so I gave you both. The first (Figure 1) tests an extension cable for opens and shorts. The twisted wire pairs are wired in series to form a complete loop. If the cable has continuity, both "okay" LEDs light. If there is a short between wire pairs, the "Shorted" LED lights. The tester is built into a small project box with the LEDs and RS-45 test sockets mounted on the front panel; the resistors are freely suspended between convenient solder points.

The in-wall tester consists of two units: a transmitter and a receiver. The transmitter module sends a 1-kHz tone over the CAT 5 wiring using a 555 astable oscillator. A digital pulse was used over a DC voltage just in case there is a coupler or hub in the link. A small speaker is used to monitor the sound at the receiver socket (J2); S1 scans the pins in sequence for testing the individual wires.

Crystal-Controlled 60-Hz Signal Generator

Q. I have a project which calls for the obsolete MM5369 oscillator and divider chip to obtain a crystal-controlled 60-Hz signal. I understand that this chip was replaced with the ECG 2046 and NTE 2046, but I can't find these, either. And what I can find on the surplus market are selling for $25.00 each (and I need several). If you could recommend any chip that could provide a crystal-controlled output of either 60 Hz or 120 Hz and/or the same with PWM abilities, I'd sure appreciate it.

John Jones II
S.W. MO

A. Yes, this chip and the LM3909 are sorely missed by the hobbyist. Unfortunately, there is no direct replacement for the MM5369. However, there are ways to imitate it using very common CMOS devices. One design uses the CD4060 14-stage ripple counter and a NAND gate, like the circuit shown in Figure 2.

The circuit uses an inexpensive 32.768 kHz "watch" crystal to generate a stable 60-Hz source. To achieve an accurate 60-Hz signal, the master clock must be divided exactly. In the case of a 32.768 kHz master clock, the divisor is 546.13 (32768/546.13 = 60). Surprisingly, the sum of the binary values 512 and 32 equals 544 — very nearly the value we're looking for. In fact, it's so close that this division produces a resultant frequency of 60.24 Hz. That's more accurate than the power company's line frequency, which commonly wanders between 59.3 Hz and 60.5 Hz. Moreover, the frequency can be fine-tuned using the 39pF variable capacitor. A monostable multivibrator made of two NAND gates expands the 60-Hz output pulse to approximately a 50% squarewave, give or take.

For 120-Hz output, wire the circuit using the CD4060 pins shown in parenthesis. If you wish a perfectly symmetrical waveform, feed the 120-Hz output pulse to a J-K flip-flop as shown in the lower right. You also asked for PWM capabilities, so I threw in a 555 monostable circuit (lower left) that is triggered from the oscillator output. Varying the one-megohm pot — which can be replaced with an FET or photoresistor — varies the duty cycle.

Audio Power Oscillator

Q. I would like to make an oscillator, with an amp and speaker or transducer, that would output at a frequency that a dog could hear, but not humans. Do you have a circuit for that?

Riley
via Internet

A. Basically what you're asking for is an electronic ver-

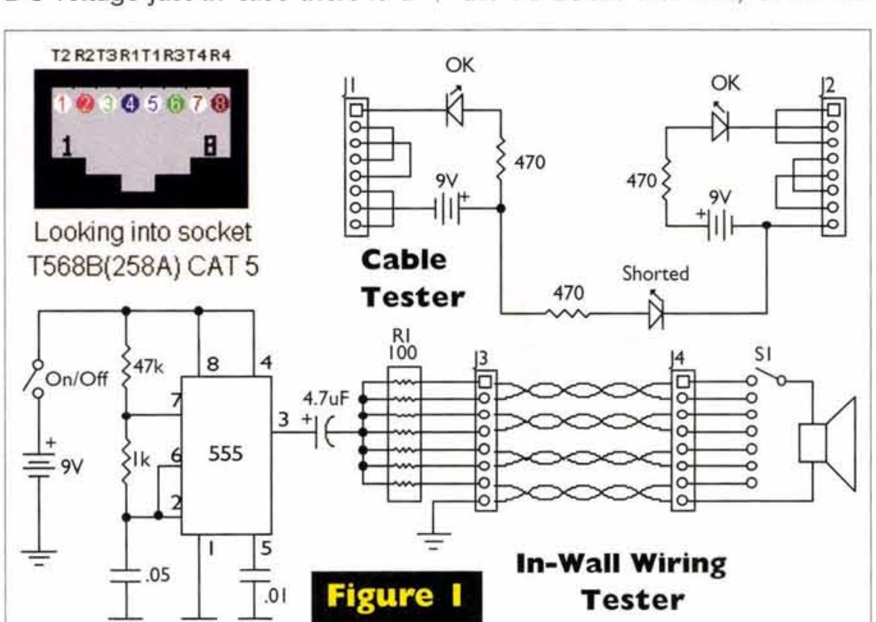


Figure 1

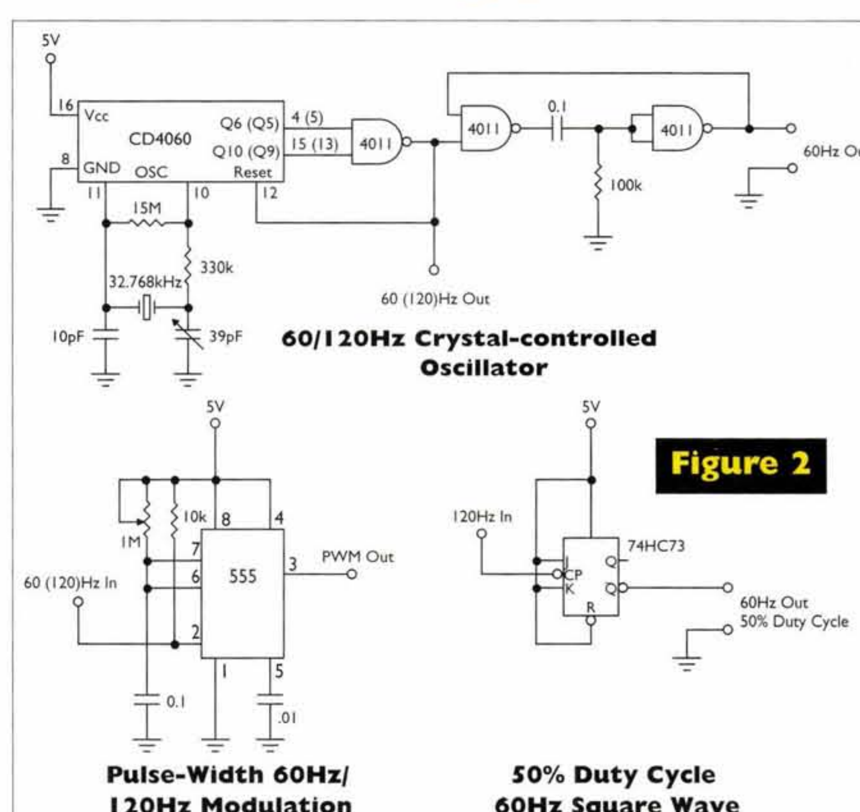


Figure 2

sion of a silent dog whistle. These range in frequency from 12 kHz to 21 kHz, with some "silent" whistles dropping down to 6 kHz. While these frequencies aren't completely silent to us, the volume is low enough and the frequency high enough that what we mostly hear is the sound of rushing air.

A simple, amplified oscillator can be made using an LM386 power amplifier (Figure 3). The frequency of the oscillator is set by C1 according to Table 1. You may notice that the relationship between capacitance and frequency isn't linear. That is, the frequency increases exponentially as the value of C1 decreases. Table 2 shows a graph of the function, from which you can interpolate C1 values of frequencies between 350 Hz and 35 kHz. The loudness of the speaker can be reduced by inserting a 25-ohm pot in series with the speaker.

Table 1
LM386 C1 Oscillator Frequency

C1	Frequency
15 pF	370 kHz
.0022 uF	35.3 kHz
.005 uF	18.0 kHz
.01 uF	9.3 kHz
.03 uF	4.8 kHz
.05 uF	2.4 kHz
.06 uF	1.5 kHz
0.1 uF	1.0 kHz
0.2 uF	470 Hz
0.27 uF	350 Hz
4.7 uF	23 Hz

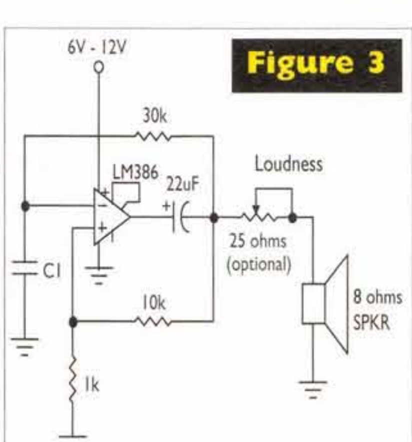


Figure 3

Sine-to-Square Wave Converter

Q. I'm looking for a circuit to change a sinewave to a squarewave. As the frequency of the sinewave varies, I need the squarewave to match and keep in sync. I want to use this squarewave with a programmable frequency divider.

David Moore
via Internet

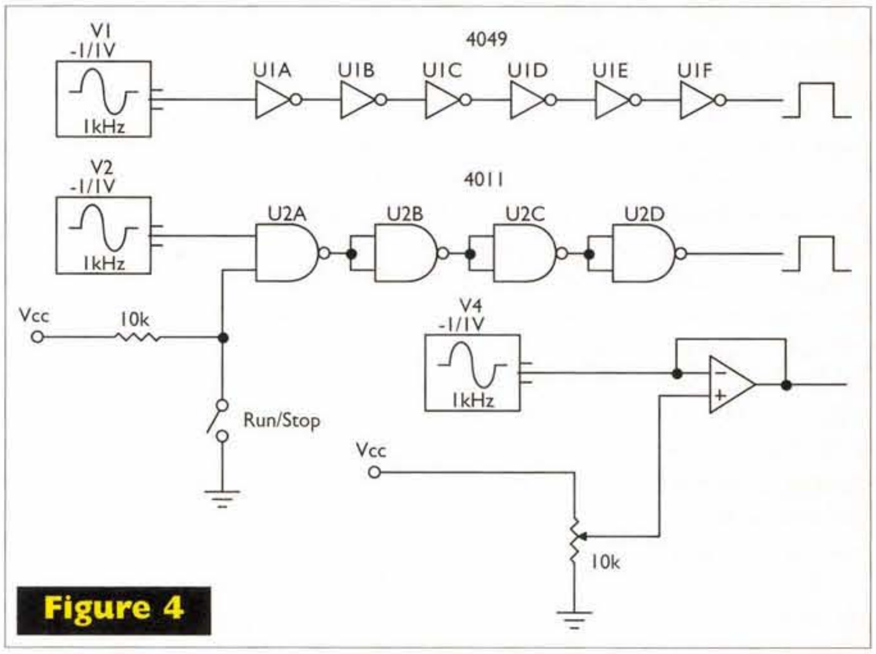


Figure 4

A. The easiest and best way to convert a sinewave into a squarewave is to run the waveform through a pipeline of logic gates. A logic gate has two threshold points where it switches from high logic to low logic. For TTL logic, these trip voltages are 0.8 volts and 2.4 volts. The result is that the slope of the sinewave must cross these points before the output of the gate switches state, hence a squarewave.

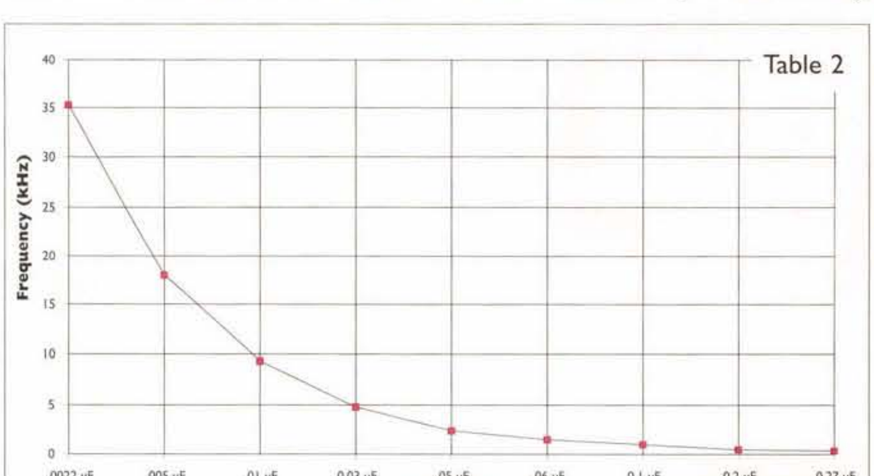
The reason for cascading the gates is to sharpen the squarewave and give it faster rise and fall times. The "converter" can be as simple as a series of buffers and inverters or NAND/NOR gates wired as inverters (which can also be used for gated operation). If you use 4000 CMOS logic instead of TTL, the trigger points can accommodate sinewaves in the range of 3 to 15 volts. Just make sure the peak-to-peak voltage of the sinewave equals the Vcc voltage of the CMOS device. Also make sure that the sinewave never goes below ground; if necessary, offset the sinewave via an op amp, as shown in Figure 4.

Unique 555 PWM Controller

Q. The speed control circuit on page 26 of the Oct. 2001 issue looks like what I've been searching for. I have a '73 Datsun 240Z with a ragged-out switch/resistor assembly, and I would like to convert it to a variable electronic control. The blower motor draws about eight amps. What modifications would it take to make this work?

Wai Lau
San Angelo, TX

A. I sure enjoyed driving my friend's 'Z' when he would let me. That was one fine car. Unfortunately, I'm not familiar with the 240Z's electrical system, but I can make a good guess based on other cars of that vintage era. First off, most switch/resistor assemblies in those days were connected to the ground side of the motor. That is, the positive terminal of the motor went directly to the battery,



and the negative terminal went through the switch assembly to ground. This arrangement made the wiring simpler and cheaper than switching the hot line.

With this in mind, I came up with the following circuit (Figure 5). It is a 555 timer circuit designed to adjust the voltage to the motor in steps of 100% (On), 60% (Med), 30% (Low), and 0% (Off) using pulse-width modulation (PWM). Because of the grounded switch restriction, though, I couldn't switch in different timing resistor values to control the fan speed.

Instead, I had to vary the trigger level of the timing capacitor by altering the internal resistance divider through pin 5. Simply put, as the resistance between pin 5 and ground decreases, so does the duty cycle until at zero ohms, the 555 quits oscillating altogether and forces the output low (Off). Grounding pin 2 (the trigger pin) does just the opposite. It prevents the 555 from oscillating by forcing the output constantly on (High).

When building this circuit, you must be aware that under the hood of that car is a lot of electrical noise — noise strong enough to destroy delicate electrical devices. Consequently, you can't use the CMOS version of the 555 chip. The TTL version is a must, and then only if you properly filter the noisy 12-volt line. Good ground connections are also a must, and the circuit should be nestled in a space that doesn't experience big swings of hot and cold.

Another PWM Controller

Q. I recently purchased an electric blanket made for use in a car or camper; it's rated 12 volts at 5 amps. The blanket was built without benefit of switches or a control unit. Even at this relatively low wattage, after a time it gets far warmer than comfort allows. I need an adjustable control unit that's both simple and easy to build. I was thinking along the lines of a flip-flop circuit with a variable duty cycle, but any design would be acceptable.

Calvin Hirmke
Broomfield, CO

A. The ideal solution would be a thermostatic controller, one that would maintain a constant temperature, but that would require sensors and a major overhaul of the blanket itself. The next best thing is as you suggest, a variable duty cycle controller, or PWM. Given your parameters, I'd guess that if you could reduce the power by half, that would be control enough. In PWM language, that translates to a High (100%) and Low (50%) setting.

The circuit I recommend uses a 555 timer configured in the astable mode (Figure 6). In the normal operating mode, the duty cycle of the output voltage is 50%, which essentially reduces the power to the blanket by half. Short out the 0.22uF timing capacitor, though, and the output is forced high, causing the IRF520 to conduct full time for full power.

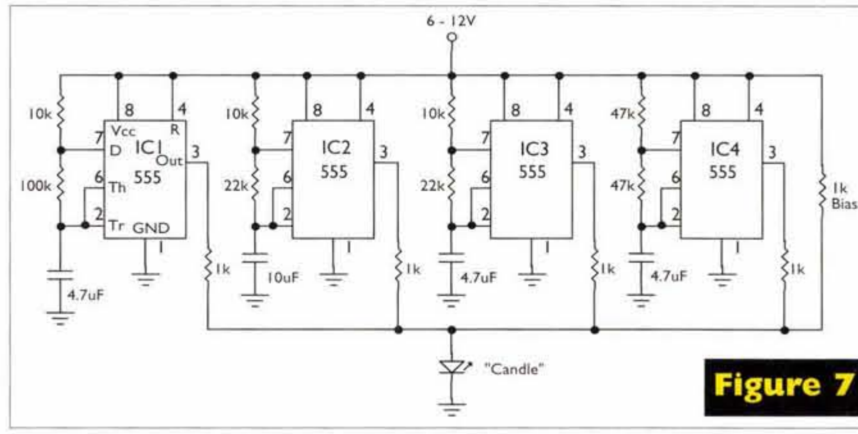


Figure 7

Flickering Flame For The Holidays

Q. Over the years, I have put together some kind of Holiday table centerpiece that uses a yellow LED to represent the flame of a candle. Well, it's getting boring. A steady light doesn't really reflect the warm flicker of a wax candle. Do you have a simple, battery-powered circuit that would add some life to the "flame?"

Alex Peterson
via Internet

A. As a matter of fact, I do. This is a circuit I have been saving for an unspecified Holiday column, so I guess now is as good a time as any to unveil my "brainchild." After studying the behavior of a flame for many years (I grew up doing my homework by a kerosene lamp and had to walk three miles to school in the snow), I determined that the flicker is pretty much random. At first, I tried adopting pseudo-random generator circuits to the task, but the results were disappointing. Either too smooth or too coarse.

Cutting to the chase, I discovered that a "gathering" of 555 astable pulse oscillators produced the most realistic effect. What it amounts to is a collection of 555 oscillators — four to be exact — each with a different frequency and duty cycle. You can see the circuit in Figure 7.

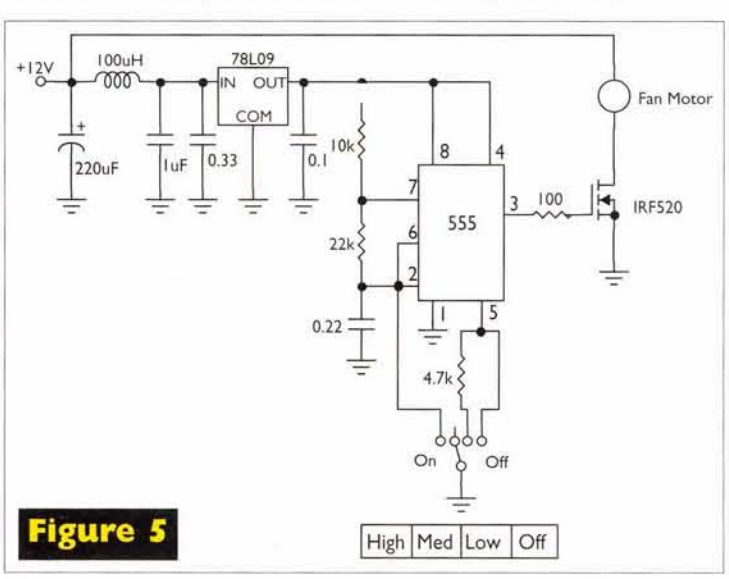


Figure 5

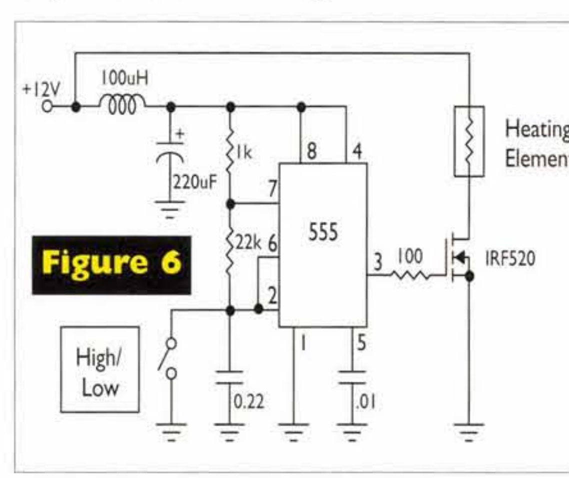


Figure 6

Table 3 - **NE558 Pinout**

Pin Function	IC1	IC2	IC3	IC4
GND	12	12	12	12
Tr	3	6	11	14
Out	1	8	9	16
R	13	13	13	13
Th	3	6	11	14
D	2	7	10	15
Vcc	5	5	5	5

The output of the oscillators are summed up using a resistance ladder made up of 1k resistors coming from the outputs of the individual oscillators. To understand the concept, let's suppose IC1 and IC2 outputs are high and IC3 and IC4 are low. If we assume that the current flow per output is 10 mA, then 20 mA of current flows through the LED at this instant. At the next instant, things may change to any current flow from zero to 40 mA, causing the LED to vary in brightness in a random pattern.

This may be well and good for some people, but I've never seen a candle flame go to full darkness as often as this circuit did. The solution was to add a bias current to the LED — a steady current flow that would give the LED a soft glow even when all the outputs were off. The bias resistor is 1k, like the rest, but you can adjust it to create the effect that works best for your LED. And while I have given values for each of the pulse generators, feel free to experiment with different frequencies and duty-cycles. I'd start with the timing capacitors (connected from the Th pin to ground).

While the circuit shows four individual 555 chips, it's easy enough to consolidate them into a single NE558 chip. Table 3 shows how to translate from four 555s to one NE558.

Speaker Mixer

Q. There just isn't enough room in my car for the individual speakers that my four ham radios demand. What I'm looking for is a circuit that would bridge the outputs of the radios and then amplify the summed audio to a single eight-ohm speaker. There is no need for separate volume controls, as each radio has a volume control, but it might be nice to have a trim pot as part of the circuit so that a rough level could be set.

Bob H.
via Internet

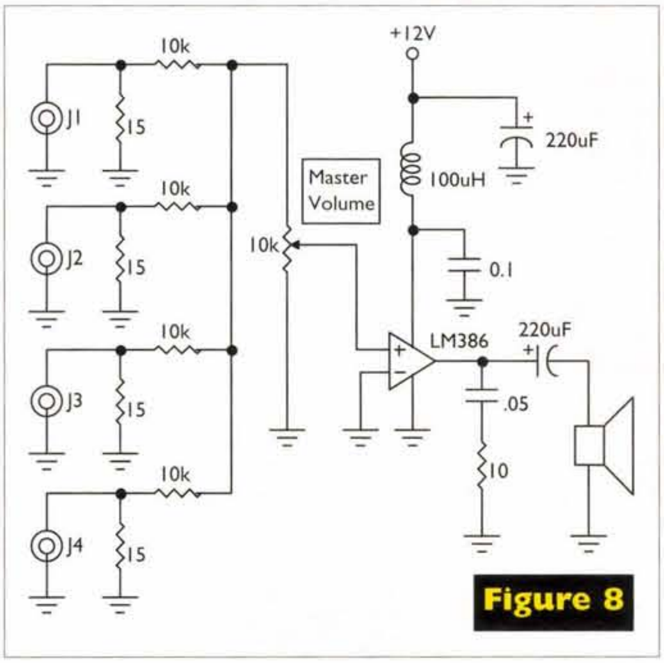


Figure 8

A. This is a common request with a relatively simple solution. A passive mixer can be made using nothing but resistors. For a network that mixes just two sources, that's all you need. But as the number of inputs increases, the output decreases, which forces you to amplify the signal. For this design, I chose an LM386 power amplifier, which should provide plenty of volume for your needs (Figure 8).

The 15-ohm resistors provide a load for the receivers to prevent voltage spikes that could destroy the output transistors/ICs. That voltage is then sent to the LM386 via a 10k resistor. When designing passive mixers, there is a balancing act between signal attenuation and interaction between the inputs. If the series resistance is too large, little signal makes it through. Too small, and you risk feedback to one of the other inputs which could damage the receiver. Because there's a follow-on amplifier, we can afford to lose signal to gain better isolation. Overall sound level is controlled by the Master Volume potentiometer.

Cool Web Sites

As winter and the holidays approach, we find more time to spend in the workshop. Personally, I find one-night projects a lot of fun during this period, and a good way to ward off cabin fever. So my Christmas present to you is a list of web sites that serve up a plethora of simple projects and lotsa schematics.

4QD-TEC - **www.4qdtec.com**

Circuits for the hobbyist - **www.uoguelph.ca/~antoon/circ/circuits.htm**

CXI Schematics - **www.mitedu.freeserve.co.uk/schematics.htm**

FC's Electronic Circuits - **www.solorb.com/elect**

Battery Back-up

Q. I am building a burglar alarm system. I would like to have a battery back-up (maybe lead-acid type) that would remain charged, and then provide back-up power in the event of a electric power outage. Could you give me a circuit that would accomplish this?

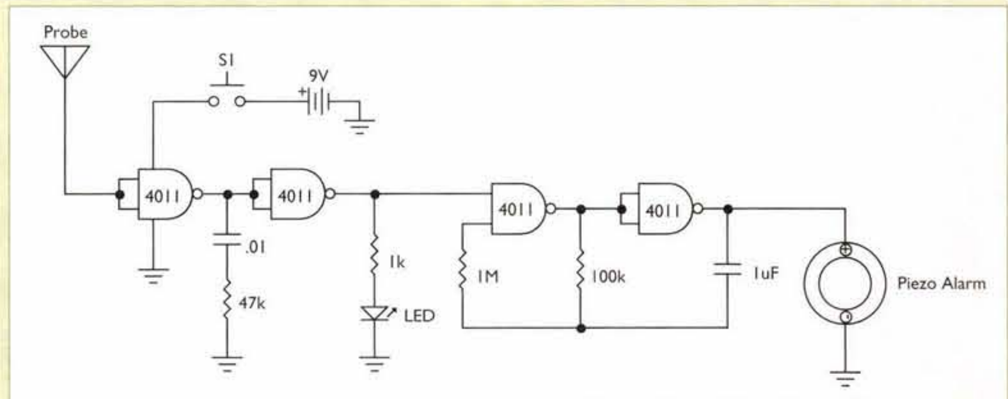
L. Manis
via Internet

A. You bet! I assume your burglar alarm system draws very little power until it's tripped, so your needs are minimal. My guess is a 1.2 Ah gel-cell would handle the job until the police get there. So the following math will target in on your application, but the design is by no means limited to the numbers I come up with. If your system draws 100 mA (and that's guessing on the high side), then a 1.2 Ah battery will sustain the system for about 12 hours.

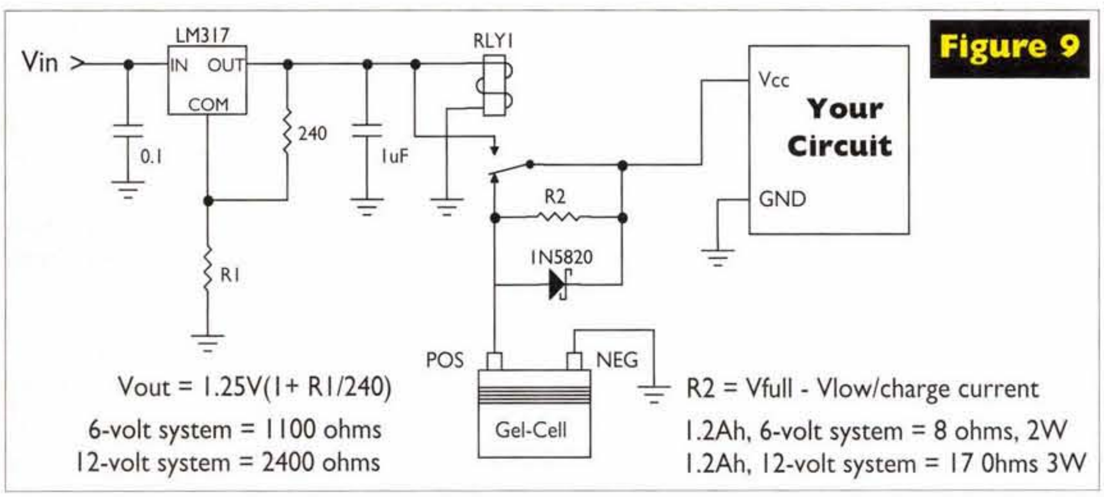
Editor's Choice

It's been a while since I had to deal with burned-out Christmas lights, but this year provided a bumper crop. In years past, I've presented a variety of circuits to locate these elusive devils. This year, I came up with a single IC version — with a twist. In addition to an LED indicator, I added the element of sound.

A 4011 quad NAND gate IC provides both functions. Because the input impedance of the gates is extremely high — something on the order of 100 megohms — they are very sensitive to electric fields — like those generated by AC wiring. When the first stage senses the radiation, its output goes low. This causes the second gate to go high and light the LED. A simple RC filter prevents false triggering of the LED from stray electrostatic noise. The stronger the electric field, the brighter the LED glows.



The second two gates form a gated oscillator that pulses a piezo buzzer. I used the RadioShack 272-060, which generates a 3.6k sound by itself that has a distinctive "motorboat" rhythm imposed by the oscillator. This circuit can also be used to drive a transducer, like a speaker or piezo element, by changing the 1uF capacitor to .01uF. In either case, the intensity and tone will change with the strength of the electric field.



Now onto the circuit (Figure 9).

This design uses a very simplistic method of charging a gel-cell. Apply a constant voltage equal to the float voltage (maintenance voltage) of the battery and limit the charging current with a resistor. As the gel-cell charges, the voltage across the resistor decreases, and the charging current drops. The drawback of this design is that it takes about 16 hours to completely recharge a fully-depleted battery. But in a normal standby system, this isn't a problem.

Finally, an equilibrium is established where the charging voltage maintains the battery at its float voltage. And here the battery sits — until a power failure occurs. This causes relay RLY1 to disengage, removing the battery from the LM317 regulator, and switches your circuit to the battery. The Schottky diode (1N5820) prevents a drop-out of supply voltage as the relay contacts switch between line source and battery.

The beauty of this design is that the charging circuit is relatively insensitive to the voltage of the system. Moving from one voltage to another is a simple matter of changing the values of two resistors — oh, and the coil voltage of RLY1.

MAILBAG

Dear TJ:

Thanks for that recent mention of Tek scope sources. We've been trying to flog a dead 21xx scope back to life, and the prospect of getting the CRT is daunting. Well, I found several used scopes on those links you mentioned going for less than the cost of a CRT, if we could even find one. Thanks!

Jim Tolson
via Internet

Dear TJ:

After reading your Oct. 2002 *Nuts & Volts* Q & A column, I had a feeling that I had seen another mention of 12VDC input ATX power supplies recently. In the Nuts & Volts Amateur Robotics Supplement #1 there is an article on page 12 titled "JACK" by Douglas Van Bossuyt and Sarah Knotts. In the last paragraph, they mention that their new mobile robot 'Jackie' will use an "industrial quality DC input ATX power supply." They also said the robot is powered by two automotive sealed gel batteries.

For more information, contact their robotics instructor Terry Coss **cosst@newberg.k12.or.us**. He should be able to tell you their power supply source and hopefully the company will not be out of business. If you are really lucky, the input will be 12 volts and not 24 VDC.

Robert Schlee
via Internet

Reader Feedback

Dear Nuts & Volts:

For once, one of my Halloween projects actually worked through the entire night! I have done a few in the past. For example, I ran a bunch of pulleys from my house to my neighbor's basketball backstop and then to my tree in front of the house. This was tensioned with a bungy cord and the system was driven by a slow speed gear reduction motor bolted up under one of the overhangs of my house. I ran a black monofilament fishing line in an endless loop around the pulleys and had ghosts and other stuff. Some were battery illuminated suspended by threads from the monofilament line. Actually, while it worked (not long), the effect was quite spectacular. Ghosts and goblins were floating across a wide area (maybe 300 feet). Very cool.

However, I didn't factor in the rotten Chicago weather (I am about 25 miles north of Chicago). Typically, it rains on Halloween. In this particular year, we had freezing rain and 40 mph winds. So, as the objects passed each other on the closed loop system, they got tangled so I had to dismantle it before Halloween.

This year, I followed the "soon-to-be-famous" Martha with much better success.

I used "Levorpse, the Corpse" from Michael's Crafts with an illuminated skeleton face, hands, and feet that are driven by three cylinders. I did get the ones you suggested from the surplus center (3/4 diameter with a stroke of 3 and 3/4). They were like new and worked great. At $6.00, they were a deal.

I got a cheapo compressor, black cat, and a two gallon tank from Menards for $60.00. Got the tees and hose and valves from Jeromy at Joint Air.

I modified a standard motion detector floodlight from Heath to turn on the 12V supply for the valves, boom box for Boris Karlov's Monster Mash, lights for skeleton, and a strobe. No relays, no electronics, no nothing. I was pretty desperate due to lack of time. As the kids (including my wife and neighbors) walked up my driveway, the thing kicked off at just about the right time. Coupled with the lights, strobe, and creepy music, it was way cool. After some planning, I built the entire thing in one day. It worked flawlessly the entire Halloween night.

Good design Walt! I am looking into the Christmas train next.

William Deutschmann
via Internet

Dear Nuts & Volts:

Walt, I went to the trouble of building your Halloween decorations and really enjoyed the experience. My only problem was that I ended up in the hospital and did not get to use it. Now I will have to figure some way to make it have Santa Claus jump out of the chimney.

For the air cylinder, I made good use of a piece of one-inch plastic conduit with a regular plastic pipe cap glued to one end. The other end, I fitted with another cap, but drilled a hole through the side of the cap and pipe and secured it with a cotter key. A hole in the end of the cap left room for the piston rod which was made from a quarter-inch rod threaded on one end. A piece of leather was soaked with water and jammed through a short piece of conduit and trimmed for a cup washer and allowed to dry. A couple of steel washers on either side of the cup washer finished the job. It was all junk in the shop except for the leather ($1.00 bought enough!) for me to supply three friends with scrap and have enough left to throw away. After all the labor, a friend suggested that I should have used an old door closer.

Richard French
via Internet

Continued on Page 70

Exploring and Experimenting With Lasers and Their Properties by Stanley York

Laser Insight

If you are a regular reader of this column, you'll know that some time ago, we looked at the pulsed laser, and in particular the Cr:ruby laser (*Nuts & Volts*, March 2002). In that article, I had briefly introduced the concept of laser pulsing and Q-switching. The relationship between the flashlamp pulse, the raw laser pulse, and the Q-switched pulse were discussed, and the importance of proper timing between them. When it comes to measuring high-intensity light pulses, and especially the relative timing between them, the most common way of measuring them is with a high-speed photodetector and fast oscilloscope.

Wide bandwidth oscilloscopes are quite reasonably priced these days, and many experimenters have access to one either at home or at work. There are also many surplus stores that offer deep discounts in used test equipment.

Unfortunately though, commercial high-speed photodetectors are harder to find, and rather expensive. There do not seem to be too many of these on the surplus market either, but once in a while, you can find them at specialty houses.

The detection of optical pulses has a long history, actually preceding the laser by many years. In fact, Einstein's explanation of the photoelectric effect is considered by many as the start of the wide acceptance of the light photon. But light detectors go even further back than this. Calibrated optical detectors had to be in existence at the time Planck first measured and then explained the blackbody spectra, around the turn of the 20th century.

The communications industry now relies heavily on the detection of high-speed optical pulses, and the trend to go faster and faster in communications speed, and the volume of data that has to be transmitted, has spurred on the electro-optical industry to find better, cheaper, and faster materials from which to make the next generation of electronic components.

At the beginning of the computer age — a mere 20 years or so ago — a computer running at a few MegaHertz was top of the line, superfast, and enormously expensive. For the common man, anyway. These days, a small laptop computer has vastly greater power, runs hundreds of times faster, and above everything else, is so cheap when you compare dollar-for-dollar than those early machines. Newer materials, better and faster production methods have all contributed to this trend in semiconductor-based technology.

I recently spent some time in Korea, and believe me, there are a lot of things going on over there that suggest more changes are coming in the entertainment and communications fields. As you read this column, I will again be in Korea, this time for about three months, working on some projects both in the laser industry, and in commercial electronics. I'll give you some details of my trip after I get back.

Photosensors

There are many different types of photosensors available now, some of which would make good laser pulse detectors, some not. This month, I'd like to look at these sensors and see which devices are usable, and describe how we can speed up a seemingly slow photodiode, perhaps to the point where it becomes suitable for use with a pulsed laser.

Since we are living in a solid-state age, I won't even consider the vacuum tube photosensors. Although saying that, there was an application I was involved in a few years ago that actually used a high-speed vacuum photodiode ... but, I digress.

I'm sure that most readers are familiar with light-dependent-resistors (LDRs). Most early light-beam detectors used this type of light sensor. The problems associated with LDRs are typical of the resistor: temperature drift, aging, response to different light wavelengths, and slow response. For applications in controlled environments, and with relatively slow changes in light level, the LDR was and still is quite satisfactory. But as faster response times were needed, as well as more reliable and predictable operation, the number of light-sensitive devices grew. LDRs still have their uses, but for any high-speed application, their characteristics are far from ideal.

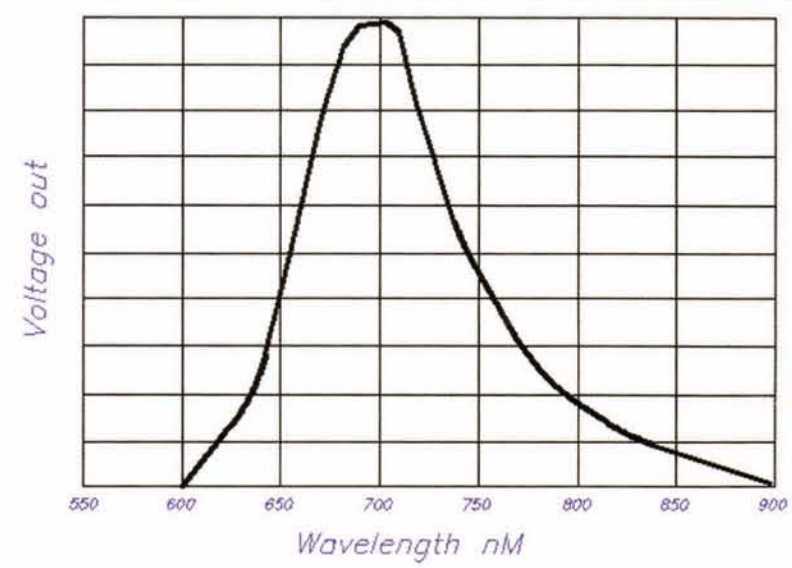


Figure 19-1. Spectral response of a typical photovoltaic diode.

Semiconductor photosensors

The next thing to hit the markets was the semiconductor photosensors: photodiodes and phototransistors. This is where we will spend some time this month.

There are two types of photodiodes: the photovoltaic type, and the photoconductive type.

The photovoltaic types produce a potential difference across the diode junction when light impinges upon it. Light energy causes the formation of electron-hole pairs (the current carriers) in the diffuse region of the junction. The higher the energy of the light (that is brighter light or shorter wavelength), the greater the release of current carriers and the greater the potential difference developed. Photovoltaic diodes tend to have a peak in their response around the middle of the visible spectrum, as shown in Figure 19-1. The sensitivity of the device depends on the energy gap of the materials used in the diode. In addition to germanium and silicon, cadmium selenide (CdSe), cadmium telluride (CdTe), and cadmium sulphide (CdS) are among the most commonly-used materials for photovoltaic diodes.

In the photoconductive diodes, the diode has to be biased with a DC supply voltage. The PN junction is normally reverse-biased as shown in Figure 19-2. Normally, the only current able to flow in this circuit is the reverse-leakage current (also called the dark current).

Under zero illumination, the dark current is very small. Light energy again causes the formation of electron-hole pairs, which are then swept across the junction by the electric field developed in the depletion region. The result is a current flow — a photocurrent — that is proportional to the effective irradiance on the junction. Photoconductive diodes typically have a low-temperature coefficient, and the response times are usually in the sub-microsecond range. The spectral response (i.e.,

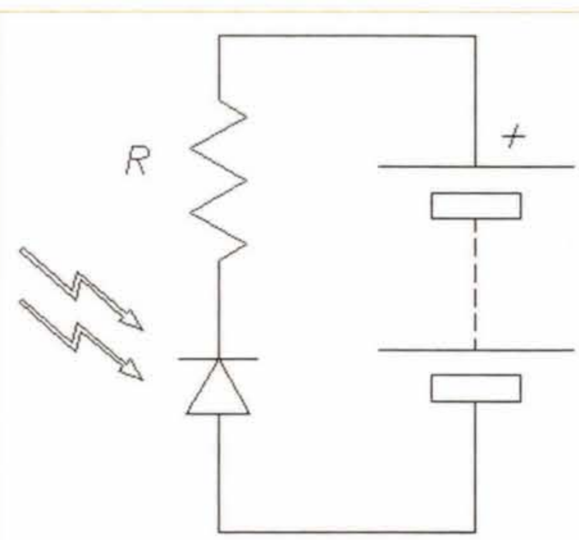
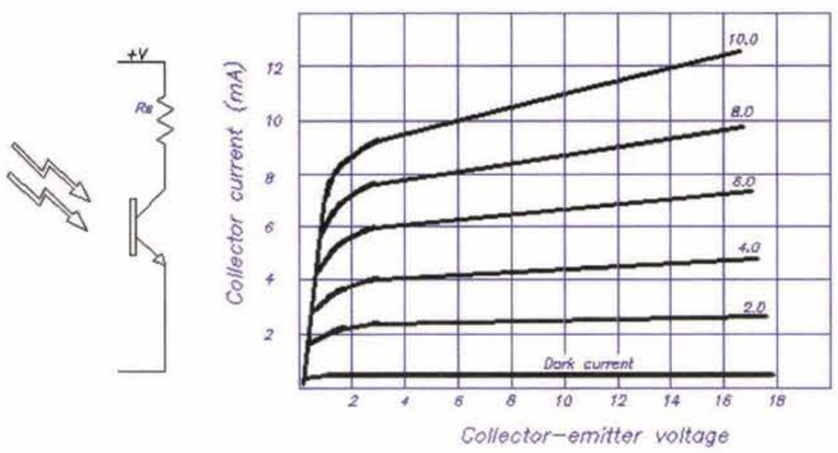


Figure 19-2. Reverse-bias is normally applied to a photoconductive-type diode.

Figure 19-4. Circuit symbol for a phototransistor and typical collector characteristics. (Note, base is normally left open.)



the device's response to color) and the speed of the device can be tailored by the geometry and doping of the junction. If the junction area is increased, the device will be able to collect more light and thus become more sensitive. But only at the cost of increased junction capacitance and reduced speed.

The addition of the reverse-bias current greatly reduces the diffusion of majority carriers across the junction. The minority carriers still move around as usual. When light photons hit the PN junction, minority carriers drifting from the bulk material into the diffusion region of the junction are swept across the junction by the absorbed energy, and contribute to the flow of photocurrent. Light energy falling on the bulk material does nothing, since minority carriers generated away from the junction will recombine long before getting to the diffusion region. Since the flow of current depends on how many minority carriers are drifting into the junction, it follows that this is also a relatively slow process, since most of the carriers are generated within the bulk (neutral) regions of the material.

In order to liberate more minority carriers in a given space, and allow those carriers to move more freely into the junction area, a slightly different diode construction is used: the PIN diode. Figure 19-3 illustrates the difference in construction between the PN photodiode and the P-I-N photodiode.

All considerations so far have been focused on the absorbed optical energy and knowing where it is absorbed. If the light photons hit the bulk material, they do nothing to increase current flow. Similarly, if the light photons go through the material, again they will do nothing, since they were not absorbed in the active diffusion region.

In Figure 19-3a, if a light photon were to hit the contact area, it would shadow the underlying surface and do nothing. If the light were to pass around the contact and be absorbed deep in the N region, again it would do nothing because the minority carriers are likely to recombine before drifting into the diffusion region.

It would be better, from many aspects, if the minority carriers were generated where the field is large, and the charge transport (i.e., the velocity) is due to a fast drift rather than a slow diffusion. This can be accomplished by adding an intrinsic region (i.e., a high-resistance layer) between the P and N layers as shown in Figure 19-3b. This construction is known as a P-I-N diode.

These days, most high-speed photodetectors for laser work are of this variety. If the intrinsic layer is thick compared to the optical absorption length, then most of the photocurrent will be generated in the layer, where the field is largest. Any carriers liberated in this region are immediately swept to the appropriate contact. There is also another very important advantage: since the intrinsic layer separates the two depletion-layer charges of the junction, the junction capacitance is lowered (like putting an insulator between the plates of a charged capacitor).

This effect further contributes

Figure 19-6. How ringing affects apparent pulse shape.

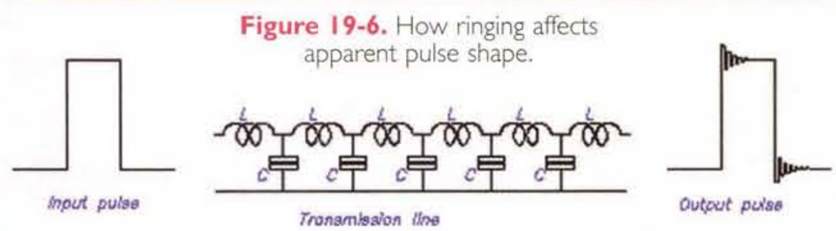
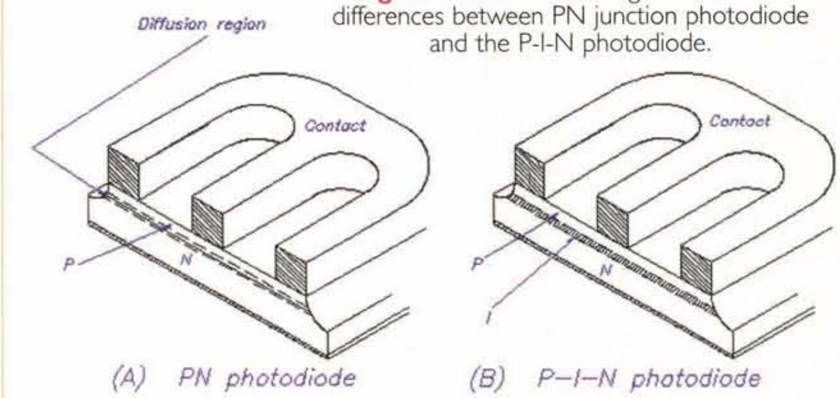


Figure 19-3. This drawing illustrates the differences between PN junction photodiode and the P-I-N photodiode.



to a faster photodiode. The further application of a reverse bias to the junction effectively forces those plates further apart, lowering the capacitance even more. Photodiodes of this construction type can have rise times (see sidebar) down in the low nanosecond range.

There is one more type of photoconductive diode: the avalanche diode, and it has a different operating mode to the PN or PIN diodes. In a laser, photons stimulate the release of energy from other excited particles in the lasing medium. This happens during the photons transition down through the medium, when particle collisions occur. The same thing is true when electrons and holes move through a semiconductor junction. The particle collisions cause an avalanche of free carriers. Diodes using this effect are called avalanche photodiodes.

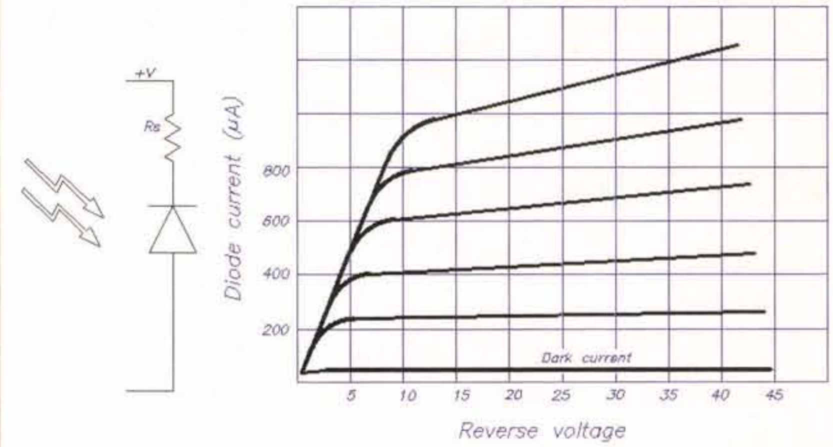
The second generation carriers move under the influence of the electric field set up across the junction, and can lead to the creation of a third generation, and so on. These devices are essentially high-gain devices, and are very sensitive. However, they are noisier than their less sensitive counterparts, and are prone to thermal runaway unless carefully controlled.

Phototransistors (Figure 19-4) have widespread uses in all types of photosensing applications, particularly where saturation switching is required. You may remember we built a laser-based revolution counter some time ago that used a phototransistor as the detector or sensing element. This type of transistor is good in this application, but it must be carefully calibrated for use as a laser pulse detector.

A relatively low light level input may be enough of a drive signal to run the collector current into saturation. This is okay if all we need to do is sense that a light is present or not, but it tells us nothing about the relative scale or intensity of the light. However, this is no good for a laser pulse detector because the output from the sensor should follow precisely the relative intensity of the laser pulse. This being said, it should be obvious now that if the light detector were to saturate, any further increase in light intensity would go unnoticed by the detector. So each phototransistor used in this application must be carefully biased so that it operates in a linear region of its collector current.

The graph in Figure 19-4 represents a normal collector current/collector voltage characteristic for a constant base drive (or light level input). Unfortunately, the expected range of light levels to be produced from any laser is quite unpredictable. The light level reflected from a diffuse white reflecting wall will be different

Figure 19-5. Circuit symbol for a photoconductive diode and typical reversed-biased characteristics.



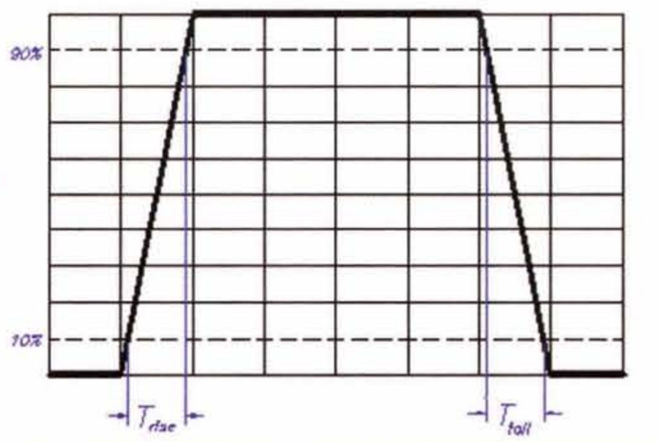


Figure 19-7. Rise and fall times of a pulse.

from the reflections from a dark, light-absorbing surface, for instance. So, from any standpoint, the results obtained from a photodetector of any kind, is purely relative.

The nature of phototransistors, with the characteristically sharp "knee," makes it generally unsuitable for making relative light amplitude measurements. For this reason, photodiodes are by far the more popular choice when it comes to designing instruments for the relative measurement of light pulses.

When measurements are made using photodiodes, it must be remembered that diodes also saturate. Too much light will cause them to avalanche, just as the avalanche photodiodes are designed to do. To avoid this situation, it is customary in laser labs and in industry to take test shots and add neutral density filters to the front of the detector. Doing this reduces the amount of light entering the photodiode aperture and puts the diode in a linear portion of its characteristic curve (Figure 19-5). This procedure ensures that when consecutive pulses are fired, the photodiode will produce an output that is an accurate representation of the relative intensity of the light pulses. This is very important when accurately known pulses are required. In holography, for example, a pulse laser is used to illuminate the motion of a fast moving object, or perhaps an engine part under stress. If the laser pulses are not properly characterized, then the exposure to the holographic plate becomes unpredictable.

If you remember the discussion early in this series, we touched upon the importance of spatial and longitudinal mode structure of the laser beam. In high-speed holography using a pulsed laser, interference fringes from bad longitudinal mode paths can ruin an otherwise decent hologram. A high-speed photodiode will allow the resonator mirror alignment and etalon adjustments to be made that reduce these modes to the point where they become insignificant.

When we were discussing the junction capacitance a few paragraphs back, we saw how the response time of the photodiode is tied in with the charging of this junction capacitance. To increase the charge rate, and thereby reduce the risetime of the diode, the series resistor Rs in Figure 19-5, should be made small. Typically, in commercial devices, the output impedance is 50 ohms to match the characteristic impedance of transmission lines and minimize ringing that occurs in these lines when pulses are transmitted down them. Ringing distorts the electrical pulse form and must be reduced as much as possible. Figure 19-6 illustrates the effects of ringing on an electrical pulse on a transmission line. The individual inductors and capacitors indicated in the drawing represent the distributed inductance and capacitance down the length of the transmission line. The square pulse sent into the input of the line sets up resonant peaks at the sharp transition points due to the distributed LC of the line, and these peaks distort the output pulse as shown. To correct this situation, or at least to compensate for it, we have to make sure the impedance of the transmission line is matched to the output impedance of the photodetector.

The rise time of a pulse (electrical or optical) is normally given as the time required for the signal to get from 10% of its final value, to 90% of its final value (Figure 19-7). Similarly, the fall time of a pulse is the time taken for the pulse to fall from 90% of its starting value to 10% of the starting value. This is the generally accepted method of specifying pulse sources, and the instruments used to measure them, such as oscilloscopes, pulse counters, etc., to measure risetimes, simply increase the scale of the signal present on the oscilloscope trace until the peaks of the pulse reach the zero and 100% graticule lines, then read the time between the 10% and 90% marks. In this example, the timebase is 1mSec/division. The risetime of the pulse (the amplitude isn't important here) measured between the 10% and 90% marks is 0.8 mSec. So the risetime is 800 microseconds (0.8mSec).

Next month, we'll make a photodetector based on the principles we've seen in this issue. As always, if you have any questions regarding lasers or optics in general, or if you have any suggestions for future columns, please send me some email. I always answer everyone who contacts me, even though it sometimes takes a while. My email address is: **stanley.york@att.net**. **NV**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Make the season bright for your favorite electronics nut ...
Find out how on Page 35!

Amateur Robotics

Sequence Programmable Robotic Arm System

Oftentimes, robotics can be a difficult and expensive passion that an electronic experimenter can pursue. The hardcore robotisist is undaunted however, for supplying a project merely presents a challenge to one's ingenuity, for one is after all, a robot builder.

Having built anything robotic, you know that parts can be found in the most interesting places. You know, one man's trash is another man's treasure. For that reason, and in the spirit of ingenuity, the information is presented here for building an affordable robotic arm. Wherever possible, exact parts identification and specifications are included.

THE T-4 DEMONSTRATOR

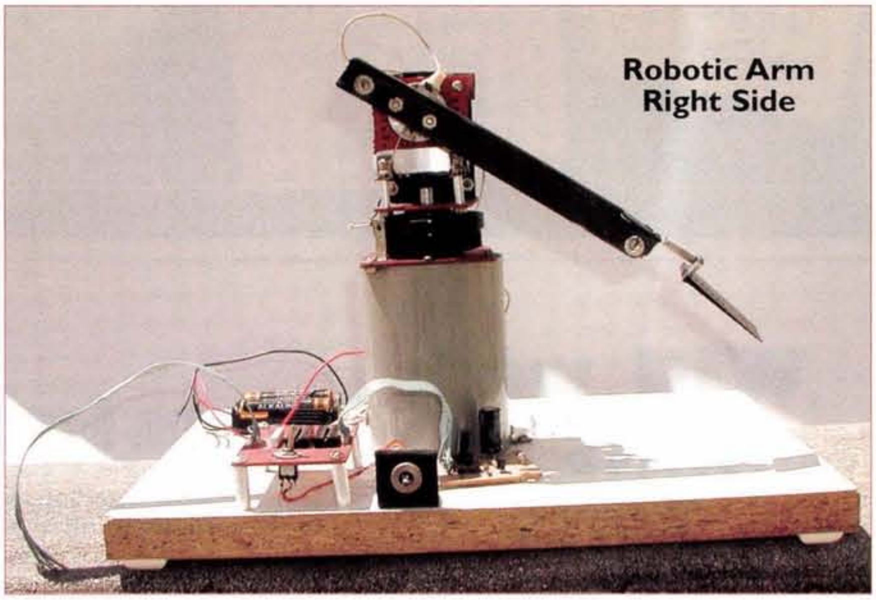
The arm motor and gear box that were used in the T-4 demonstrator were found in a broken toy that was discarded. A motor gear box assembly that you may find or purchase may be different, but with custom modifications, you can still apply the principles described here.

MOTORS

The arm lift and lower motor were a discarded child's toy that I removed the motor and gearbox assembly from which is represented in Figure 2 by letter E. It operates on a single 1.5-volt battery which is encased in a double AA battery holder. To attach the gearbox to the swivel base required cutting some small boards to lock down and stabilize the drive system. A hole was cut in circuit board R to accommodate the drive shaft. To secure the board to the gearbox, a small piece of circuit board (letter I) was cut and attached with two screws, while L brackets provided support and the connection to another circuit board (letter C). Circuit board (letter K) and wood support (letter D) combine with L brackets to complete the arm platform.

A pre-drilled hole in the center of the circuit board platform (letter C) is to accommodate the shaft of the turn motor. Next, a large plastic slip gear which was obtained from a discarded tape recorder, is glued to the platform and a long pin is heated and inserted into the top gear to provide a stop.

Another circuit board is used to mount the motor (letter A) to its housing, a piece of plastic PVC (letter S). This motor was purchased at a local surplus electronics store for $2.00 and it is a larger, heavy-duty six-volt DC motor that will operate with a 1.5 battery at a slower, more desirable speed, and still have enough torque. The complementary plastic gears are attached to a bushing that fits over the motor shaft. Metal spacers can often serve as perfect bushing adapters. Brackets (letter L) serve as a physical stop, as well as an electrical stop for the turn system.



Robotic Arm Right Side

ARM

Once again, the "trash" proved to be a good place to find parts, like an old discarded FM receiver which contained a tuning pulley (letter H) that matched the diameter of the gearbox axial.

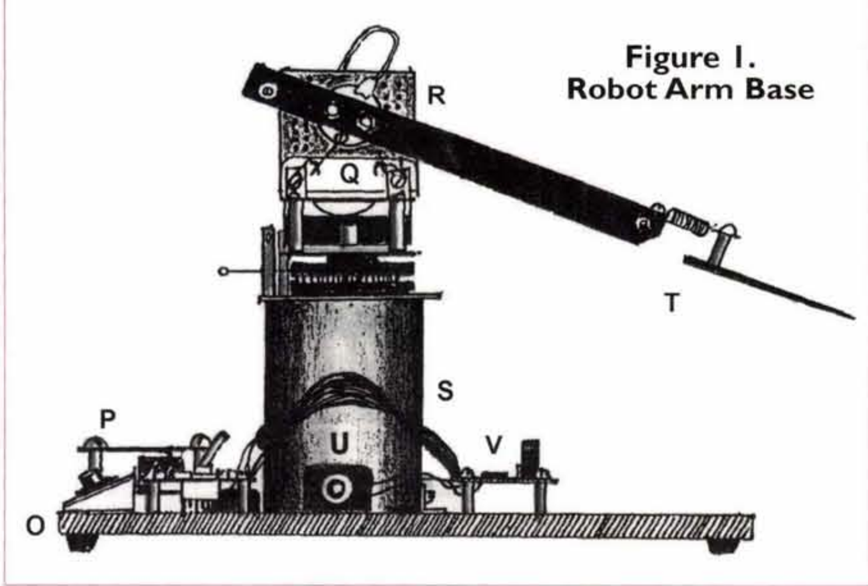


Figure 1. Robot Arm Base

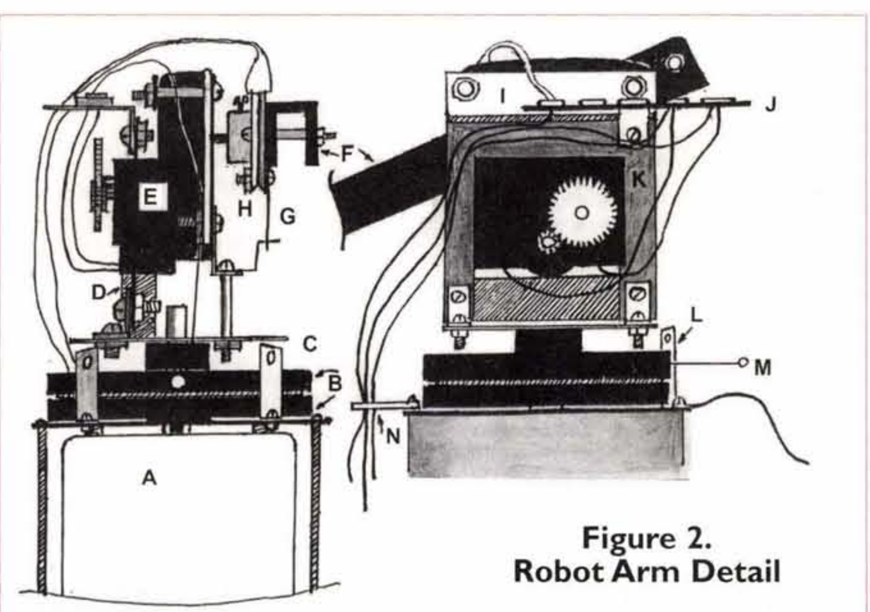


Figure 2. Robot Arm Detail

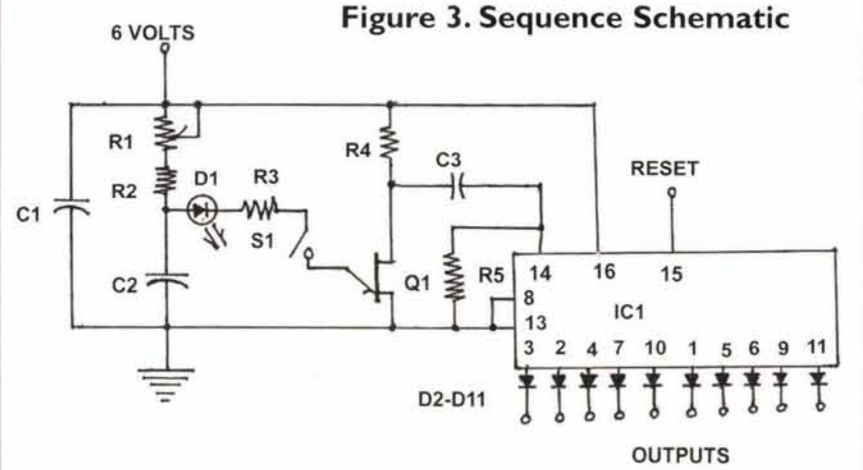


Figure 3. Sequence Schematic

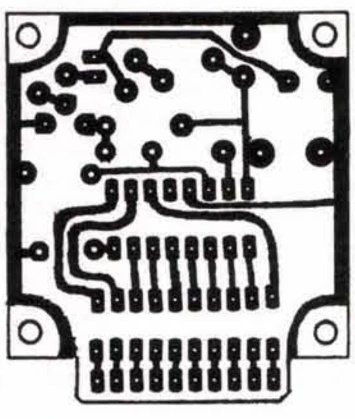


Figure 4. Sequencer Foil Pattern

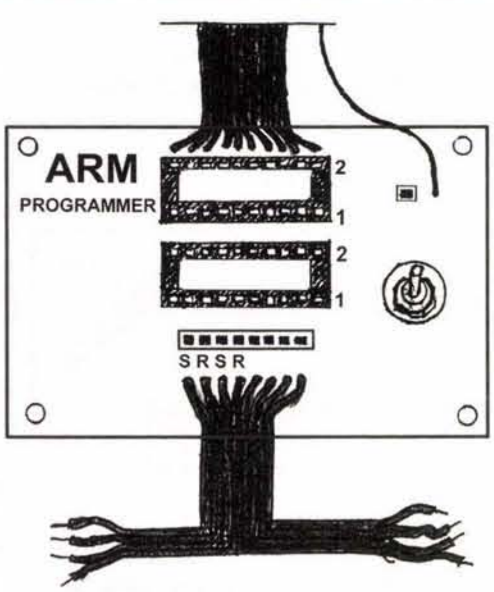


Figure 5. Programmer Board

Four holes were drilled in the pulley: two for mounting the arm (letter F), one for mounting the stop pin (letter G), and one for the reset wire. Because the pulley is made of aluminum, you can't solder a wire to it, so the wire should be stripped back long enough to wrap around and solder to itself. Check the wire for electrical continuity and then place a rubber cap over the connection. This assures that movement will not place continual strain on the contact point and helps prevent breakage.

Safety pins can be attached as a mechanical stop, as well as an electrical stop (letter G). The arm itself is made from small planks of Balsa wood. It is light yet strong and is available at local hobby stores. Since the arm is essentially hollow, wires to manipulators can be tucked inside. A terminal strip (letter J) is provided to connect the various devices and a short piece of plastic (letter N) keeps the leads organized and out of the way.

ELECTRONICS

The drive unit for the arm (letter V) is a 4017 decade counter that is driven by a simple variable speed unijunction transistor pulse generator. Switch S1 enables the user to start or stop the sequence at any time, while potentiometer R1 determines the speed of the sequence. Resistor R2 prevents the speed from exceeding practical limits and an LED monitors the pulse rate. The 10 sequencer outputs are fed to 10 1N914 diodes that function as an isolation matrix. The outputs on the circuit board are not in sequential order, so you must select the proper numerical order at the other end of the computer ribbon cable. Potentiometer R1 and switch S1 are mounted on another circuit board for easy control access.

Two 10-pin IC sockets allow you to program arm movement and any type of manipulator you may choose (more on this later). The channels are wired to the sockets so that the arm and manipulator action can be programmed with small wires. Anything less than a 10-stage program can be reset by feeding a wire back to pin 15 of the sequencer.

POWER

Relays are used to switch battery power to the operating motors. Since motors create lots of power spikes, it is a good idea not to use the same power source for the computer components. Four 555 timers are used to trigger the relays that provide the turning motion (left and right) and lifting motion (up and down). Only one of these actions should be activated at a time. When a turn or lift is complete, the mechanical stop sends a signal to pin 4 of the timer to turn it off.

PROGRAMMER

To assure a versatile arm, a programming patch board has been provided (see Figure 5) to determine both the number and sequence of procedures; 10-pin IC sockets were used for the programming outputs from the sequencer. A set of eight different colored input terminals were cut from a 20-position SIP socket, as well as a single jack to provide reset access. Small wires were used to patch any of the

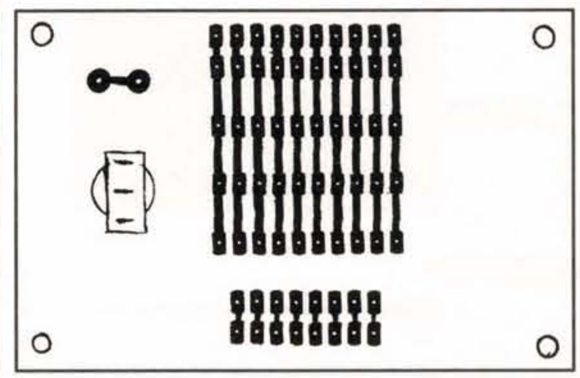


Figure 6. Programmer Foil Side

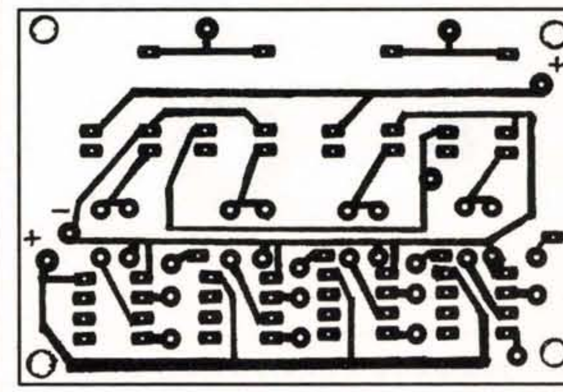


Figure 7. Foil Pattern

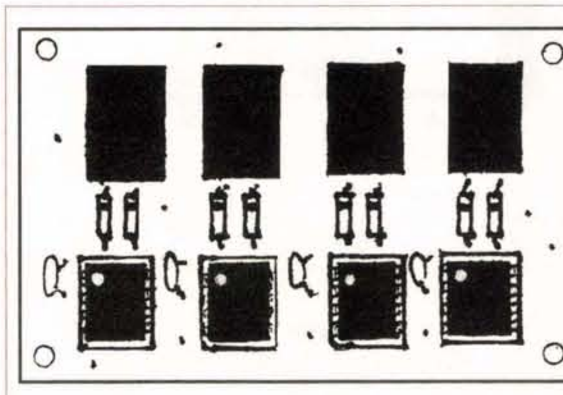
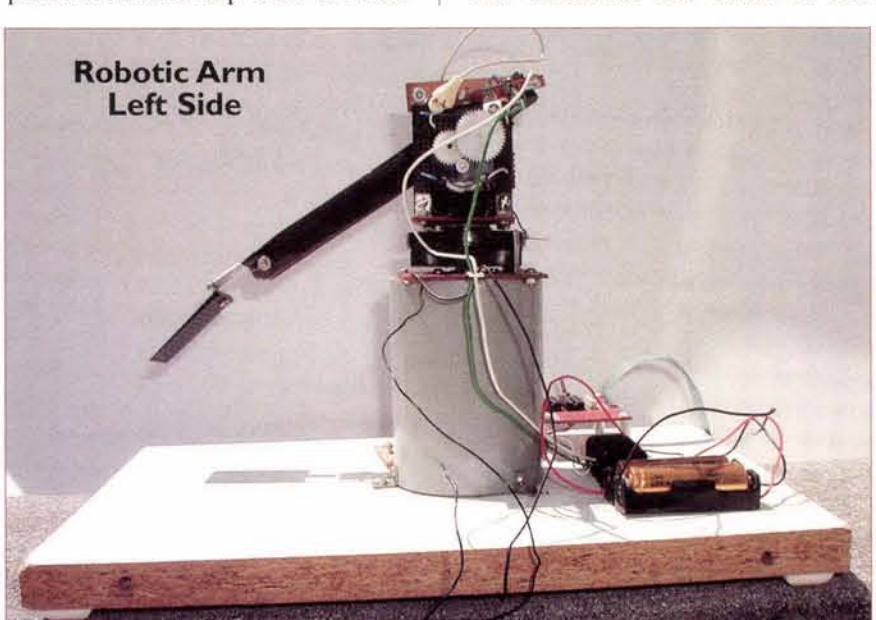


Figure 8. Circuit Board Layout

Robotic Arm Left Side



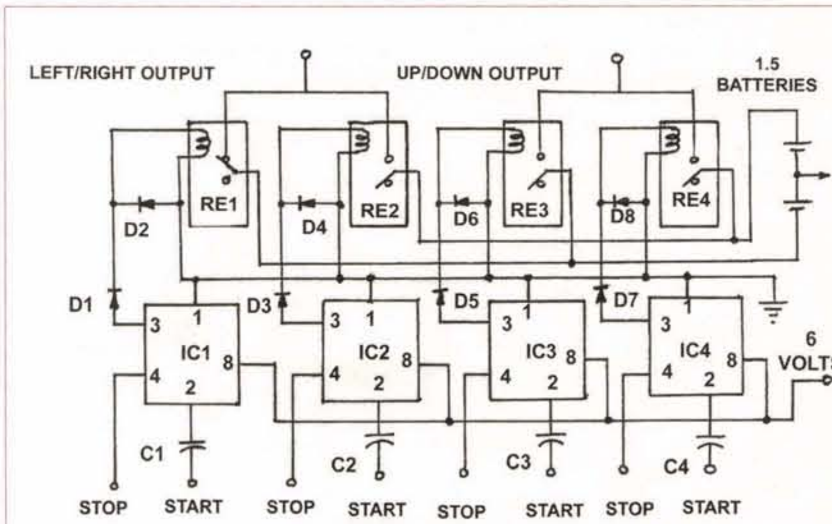


Figure 9. Relay Board Schematic

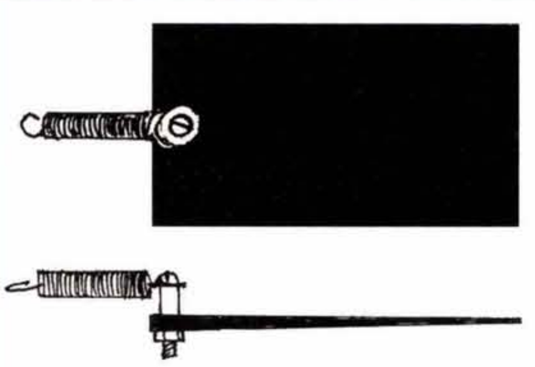


Figure 10. Shade Manipulator

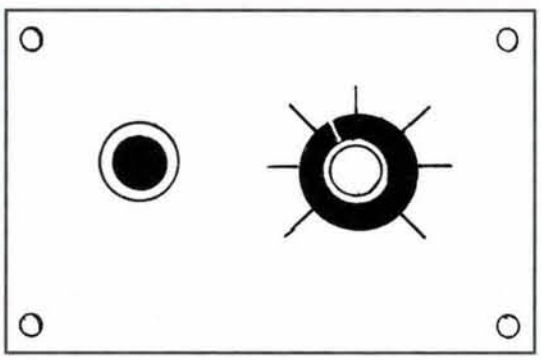


Figure 11. Initiator Board

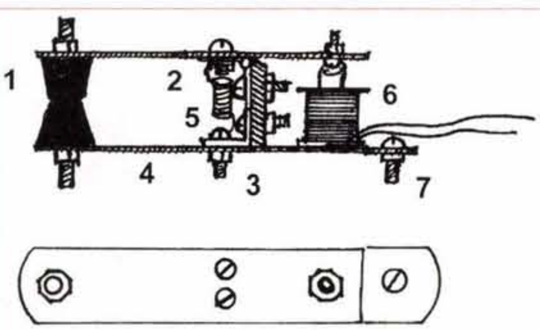


Figure 12.
Grasping Manipulator

outputs to the set, reset channels of the lift, and turn motors of the arm. It would be a good idea to make the first stage a pause before repeating the series. Four other inputs can accommodate manipulators or other devices that you may want to add in the future. The power switch is also located on the programmer board. Manipulators may require additional circuitry, like that shown in the Figure 5.

PATCHING CHARTS

A page of programming charts (Figure 16) is included to enable you to document any new patches. If you need more, just make some copies of the charts for the future.

Different color pens will help you identify the order of functions. Two examples are shown to get you started. Since the first stage is not used, row 1 is not used. Orange was chosen to indicate the patch connection that moves the arm from left to right. Blue was chosen to indicate stage 3 which lowers the arm. Stage 4 is represented by the color brown and raises the arm. Green is the color that resets the arm back to the left. Position 6 lowers the arm once again and stage 7 raises it. At stage 8, a black patch is used to reset to stage 1. The second patch is identical with the addition of a magnetic manipulator, represented by red for on and purple for off.

CONSTRUCTION

The entire unit is mounted on a piece of Formica-covered press-board. This makes the project look professional and provides a stable base for all the components. Rubber feet keep the unit from scratching desk or table tops.

All circuit boards are mounted with round head screws and spacers. The main motor tube is secured to the base with three mini angle brackets. Battery holders are fastened with small wood screws and the wall unit power jack is held in place with a heavy gauge angle bracket that, once again, was retrieved from the trash.

MANIPULATORS

For this article, a shade manipulator (letter T in Figure 1) is used to cover light-sensitive devices for demonstration purposes. Other manipulators — such as magnetic — can be made from a machine screw and large washers as shown in Figure 14. The amount of turns of wire needed to produce an effective magnetic attraction will depend upon the gauge of wire you use and how many turns. This type of manipulator is easy to experiment with and can be used with as little as a 1.5-volt battery.

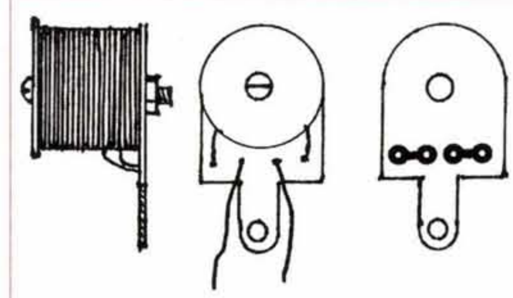


Figure 14.
Magnetic Manipulator

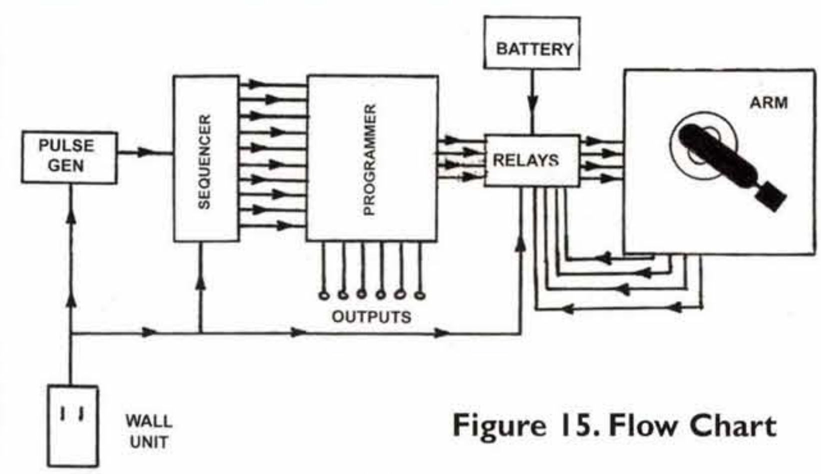


Figure 15. Flow Chart

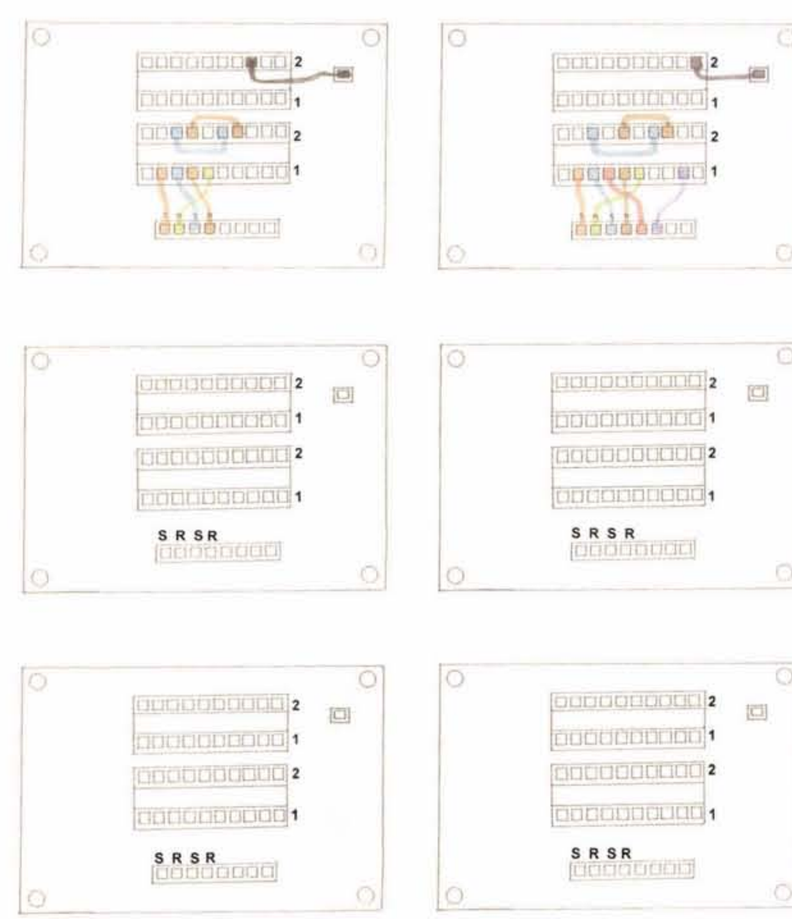


Figure 16. Robotic Arm Programming Charts

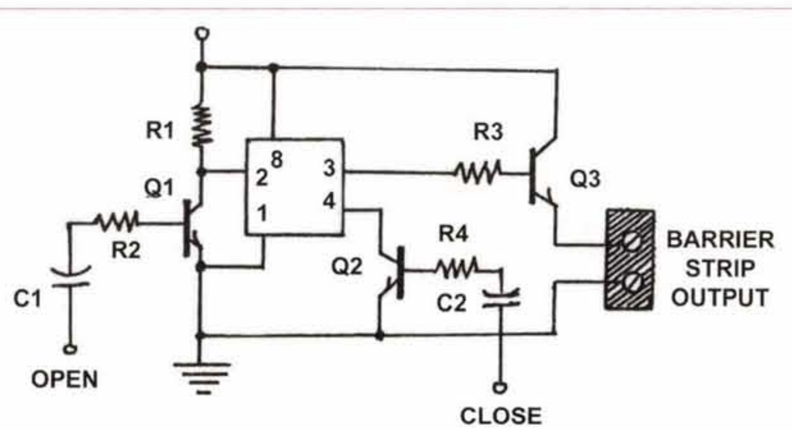


Figure 13. Grasping Manipulator Schematic

Conducting manipulators are made of metal and designed to bridge contacts and complete circuits. Like the shade manipulator, the conducting manipulator is a passive device and requires no wiring.

Grasping manipulators should be kept simple and lightweight. The grasping manipulator (see Figure 12) uses rubber feet as graspers (number 1) and is attached to two metal pieces (number 4) that are connected together with an angle bracket (number 3) and a hinge at the top (number 2). A small piece of wood with a beveled edge on top is used to allow the hinge to open.

A solenoid (number 6) is used to open the manipulator and a mounting screw (number 7) is used to attach it to the arm. A circuit to operate the grasping manipulator has also been included (Figure 13).

INITIATOR BOARD

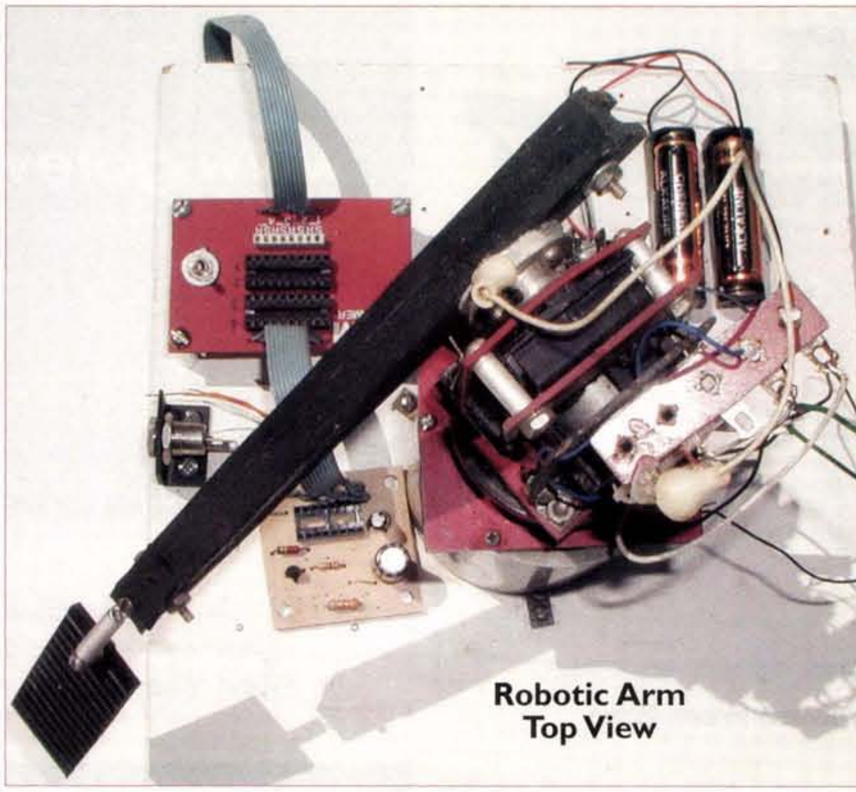
Switch S1 and potentiometer R1, are mounted on a separate circuit board to provide more convenient access. Either a toggle or push-button type may be used according to your personal preference. Potentiometer R1 controls the speed of the activity and should be adjusted to give a little time between actions.

OPERATION

As you can see in Figure 15, a pulse generator triggers a 10-stage sequencer that, in turn, produces a programmable number of stages to a relay circuit board. The relays isolate the computer power supply by accessing battery power to the two drive motors. Mechanical stops also serve as electrical turn off signals to disengage the relay drive circuit.

The sequence of the simplest operation procedure is lift-turn-drop-lift-turn-drop ... this completes one cycle of operation. Set and reset are used as action designators; set meaning a right turn for the swivel motor, and reset meaning a turn back to the left. The lifting of the arm is indicated by set and dropping the arm is reset.

More elaborate patches will utilize more stages of the sequencer and may involve manipulators of one sort or another. The magnetic manipulator, for example, can pick up small metal objects and transport them from one side to



Robotic Arm Top View

PARTS LIST

RESISTORS
R1 — 250K Pot.
R2 — 33K
R3 — 100 ohm
R4 — 15K
R5 — 220K

CAPACITORS
C1 — 1000 MFD 16 volt
C2 — 10 MFD 35 volt
C3-C8 — >1 MFD

TRANSISTORS
Unijunction Transistor
2N4891

SOCKETS
2 — 20-Pin sockets RadioShack 276-1991
1 — 20-Position SIP socket RadioShack 276-1975
4 — 8-Pin DIP sockets RadioShack 276-1995
5-Lug tie terminal strip RadioShack 274-688
1 — Four-position dual row barrier strip DC input jack RadioShack 274-1576

DIODES
10 — 1N914
1 — LED

RELAYS
DEG-QUAZ-SS-1050
5-VDC single pole
Double throw relay RadioShack 275-240A

CIRCUIT BOARDS
1 — Mini board RadioShack 276-148
1 — IC PC board RadioShack 276-159
4 — Copper clad boards 2-13/16 x 1-13/16

WIRE
Computer ribbon
Connecting wire
Small gauge flexible connecting wire

GEARS
2 — 2-inch plastic slip gears
1 — 1-inch aluminum turner pulley

SCREWS
16 — 1-1/4 inch round head wood screws
8 — 1/2-inch wood screws
7 — 1/2-inch machine screws and nuts

SPACERS
8 — 3/4-inch aluminum
5 — 1/4-inch aluminum

L BRACKETS
Seven miniature
Two long

ARM
3 — Balsa wood planks cut to 6-1/2 inch lengths

SPRING
Manipulator mounting spring

MANIPULATORS

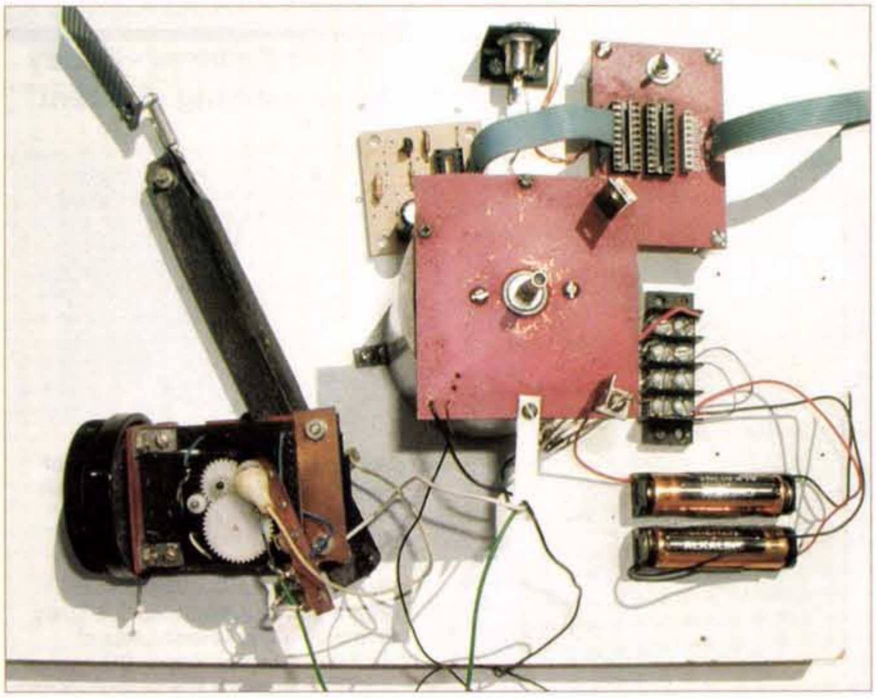
SHADE
1 plastic carpenter's shim or any similarly shaped dark piece of plastic will do.

GRASPING
2 — Small rubber feet
2 — Metal pieces
1 — Small hinge
1 — Miniature L bracket
5 — Small machine screws and nuts
1 — Small solenoid

CONDUCTING
Any metal piece that will meet the physical and conducting requirements of the circuit.

CIRCUIT BOARD
R1 — 100K resistor
R2-R4 — 1K resistors
R3 — 2K2 resistor
C1-C2 — .1 capacitors
IC — 555 Timer
Barrier strip, two position

MAGNETIC
1 — 1-inch machine screw and nut
2 — 3/4-inch diameter washers
1 — 3/4-inch x 1-inch circuit board
Small gauge coil wire



Top View With Arm Removed From Base

another. Experimentation is the key to finding the manipulator of the choice, but you are a robot builder and no stranger to experimenting.

CONCLUSION

You may not find all of the parts for this project as shown, for many of them were foraged from trash bins. The article is meant as a guide to inspire your creativity. What you will find on *your* safari through the world of discarded treasures is not predictable, however, what is presented here will hopefully inspire your ingenuity ... so get started. **NV**

Circle #63 on the Reader Service Card.

Automated 256 Message Interface

By Mark Van Steenburgh

Reserve as much of the BS1 code space for your control application as possible, and use a PC for display of up to 256 pre-determined messages.

As many BASIC Stamp (especially BS1) users know, storage resources are at a premium. No complaints here, for the price of a BS1, you get a lot of features. This article focuses on reserving as much of the BS1 code space for your control application as possible, and uses a PC for display of pre-determined messages. Up to 256 of them, in fact.

For those of you that read my last article that ran in Oct. 02 — "Simple Interface Uses Common Tools" — this application uses the same basic tools (BS1, InByte, and MS Excel). Since the details of how the byte of data is passed from the BS1 to the MS Excel application was outlined in detail in the above-mentioned article, I will not re-iterate them here.

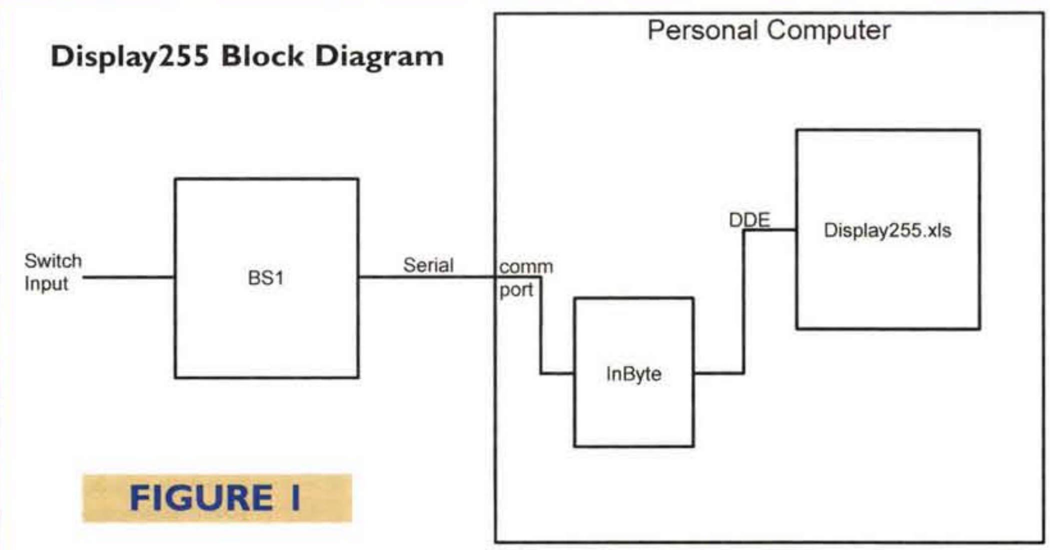


FIGURE 1

The Application

We will use a BS1 (BASIC Stamp 1) running a simple random number generating program (reminiscent of the magic eight ball; see Figure 1). The user will — by pressing a push-button switch connected to the BS1 — cause a random number between 0 and 255 to be generated and sent to the PC. The number, in byte form, is sent serially and is received by InByte (running on the PC) and made available via DDE (Dynamic Data Exchange) to our Excel application. The Excel application will use the byte of information to look up the pre-assigned message for display to the user (see Figure 2).

InByte

InByte is a simple interface program for Windows PCs that reads a byte of data arriving on a serial port (see Figure 3). InByte is also a DDE server. This allows access to the byte of information using Microsoft Excel via DDE. InByte can be downloaded at http://www.emergingtech-llc.com/downloads. For more information on InByte, see the Emerging Technologies, LLC., website or my last article.

Excel Interface

Now that we have figured out that Excel is capable of much more than bean counting, let's take a look at another "out-of-the-box" Excel application. This application makes use of the byte of data received from our BS1 in a different manner than in the last article. We will take a look at the byte and use two different methods to look up pre-stored messages.

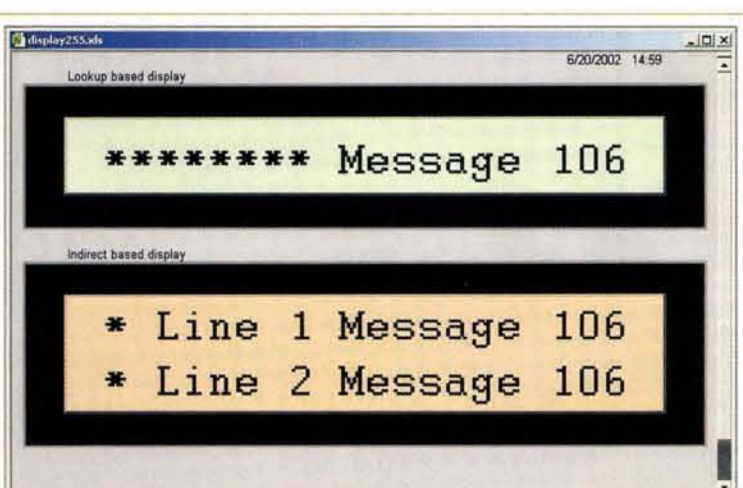


FIGURE 2

Two different message displays have been created. The first is a lookup-based display, set up to look similar to a 20-character single line LCD. The second, an indirect-based display is set up to look like a 20-character, two-line LCD. At the top right hand corner of the display screen, the computer date and time are displayed.

To keep this relatively simple, we will use only cell-based formulas (no VBA macros). Our interface will use three Excel functions: lookup(), indirect(), and now(). We will also make use of range names and sheet (tab) names.

Workbook Convention — Once again the application uses a simple convention for keeping track of the automation. Cells are formatted to indicate to the programmer how they are used. The formats are as follows: cells with yellow background contain formulas; cells with blue fonts indicate the data is used elsewhere; cells or groups of cells (a range) assigned a range name have a double line border. The only exception to this convention is the operator interface page. This page is formatted for appearance to appeal to the user. In this case, the sheet tab "display" (see Figure 4).

Using Sheet Names — In this application, sheet names are used. They appear on the tabs located near the bottom of the workbook window. Many of us are accustomed to using sheet names. For those of us who are not, naming the sheets becomes useful in writing formulas that read easily. This may not be important in a small application, but as your application grows, you will find yourself thankful you have used sheet names. You can name the sheet by right clicking (the other mouse button) on the

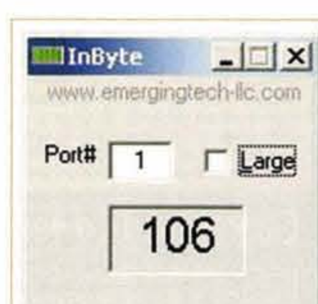


FIGURE 3

Automated 256 Message Interface

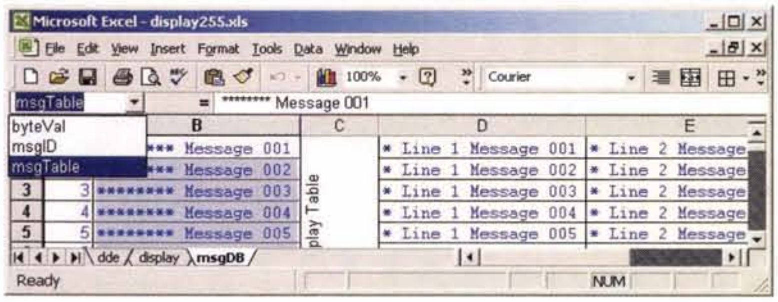


FIGURE 6

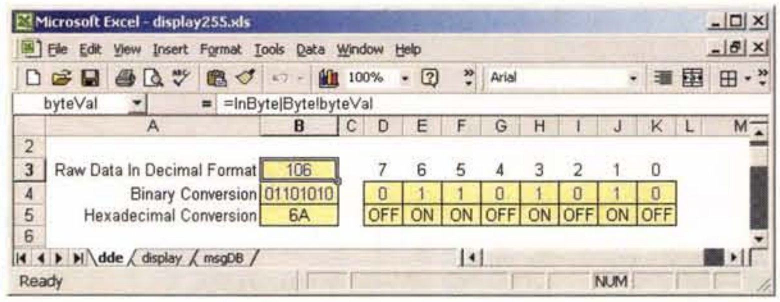


FIGURE 4

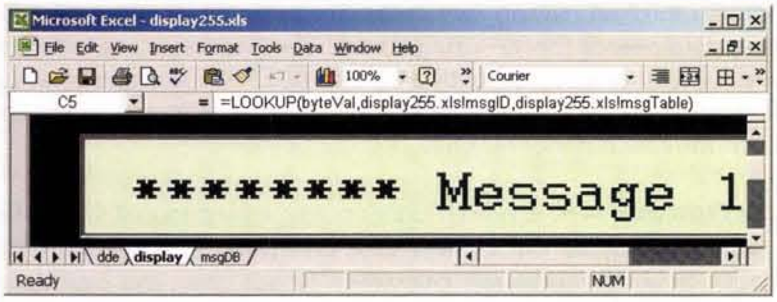


FIGURE 7

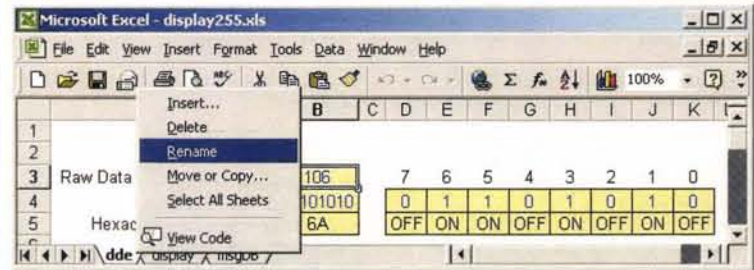


FIGURE 5

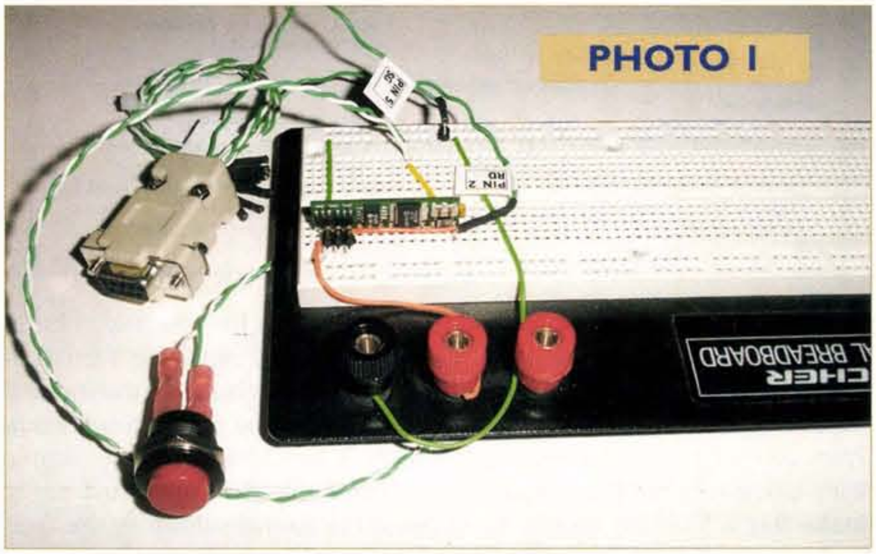
sheet tab and selecting rename (see Figure 5).

Using Range Names — Let's take a look at range names. Most of us know that cells in an Excel spreadsheet are identified by their column and row location. For example, A1 is the first cell located in column A and row 1. A range of cells is denoted A1:B2, which includes cells: A1, A2, B1, and B2. To make this a bit easier on the programmer, ranges can be named. In our application, there are three range names used: byteVal, msgID, and msgTable. Range names can be viewed by clicking on the pull-down box next to the formula box in the formula bar. Selecting the range name "byteVal" will take your cursor directly to that range in the spreadsheet. Formulas are more readable using the range name to represent the data contained within the range. Range names can be created in a couple of ways. The easiest is to select the range of cells to be named by highlighting the cells, then click in the range name box in the formula bar, type over the highlighted cell location with the range name, and hit the enter key to complete (see Figure 6). Range names can also be managed from the menu by clicking INSERT then NAME. For more information on range names see Excel help.

The Lookup Function — Moving on, let's take a look at the lookup() function. There are two ways to use lookup, vector and array. We will be using vector. The vector lookup formula is seen below. The function syntax is: =lookup(variable to look for, range to look in, range to get results from). For more detailed information, search Excel help for lookup(). In our application, we will look up the variable byteVal in the range msgID and return the results from the range msgTable. Note that range names are used for the InByte value (byteVal), lookup ID (msgID), and results table (msgTable). These ranges can be found on the msgDB tab of the workbook (see Figure 7). Understanding the function, note that with changes in byteVal (which happens when the user presses the button on the BASIC Stamp), lookup will find the message (on the msgDB tab) that corresponds with the message ID, and display it on the simulated 20-character LCD display on the display tab. Pretty cool, eh?

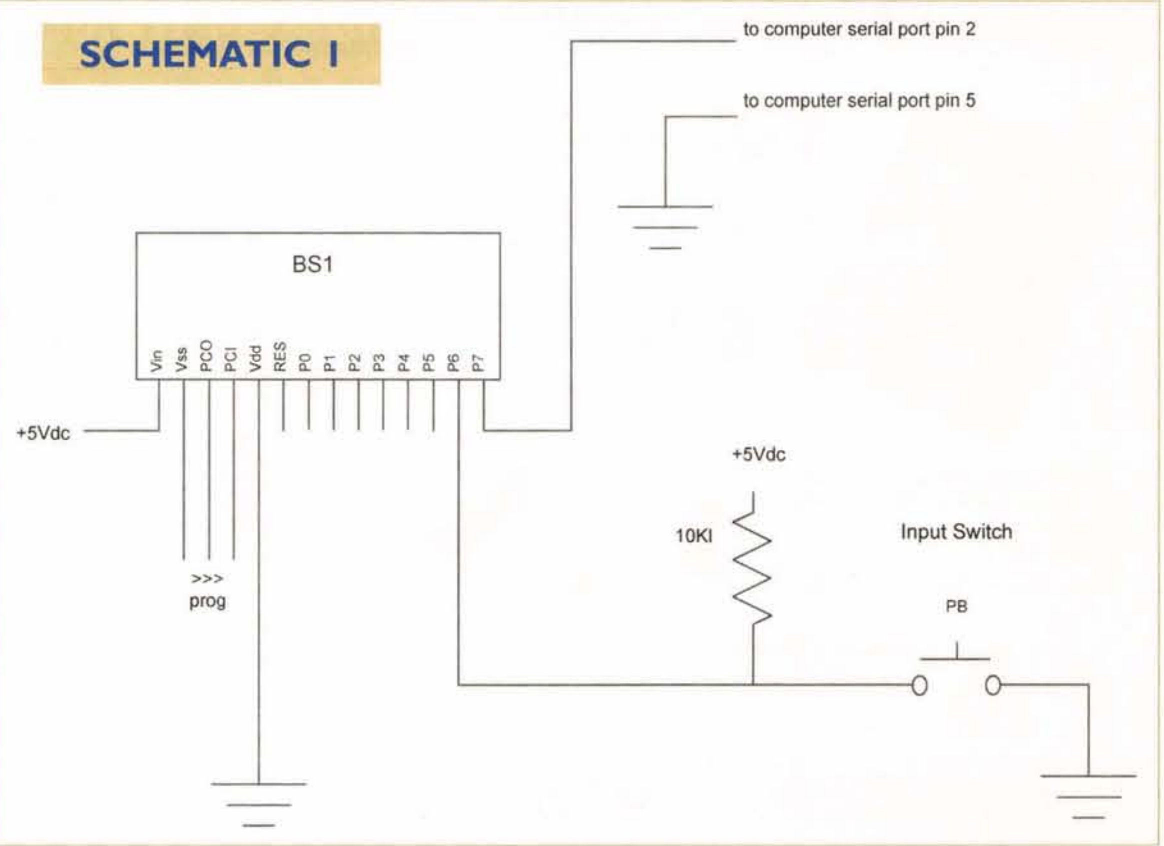
The Indirect Function — How about another approach to this task? The simulated 20-character, two-line display found on the display tab uses the function indirect(). This approach may be easier to set up, but may be a bit more difficult to visualize how it works (just one man's

PHOTO 1



opinion). There are a number of different ways to use indirect(). We will be discussing the way it is used in this application only. For additional information on using indirect(), search for indirect() using Excel help. Having said that, take a look at the formula in cell C12 on the display tab (see Figure 8). The syntax used is: =indirect("sheetname!ascii character representing the column",& expression representing the row to

SCHEMATIC 1



LISTING 1

```
'Description:  display255 Program for BS1 for use with
'              InByte and display255.xls
'File Name:    dsply255.bas
'Author:       Mark Van Steenburgh
'              Emerging Technologies, LLC.
'              (920)684-0216
'              www.emergingtech-llc.com
'Date:         06/25/2002
'----------------------------------------------------------------------
Symbol oneShot = bit0   'bit storage for one shot
Symbol memBit = bit1    'bit storage for one shot memory bit
Symbol inputSw = bit2   'bit storage for input switch
Symbol notMemBit = bit3 'bit storage for inverse of memory bit
Symbol wordStore = w2   'storage for ranmdom word, we will look at low byte
Symbol byteStore = b2   'temp storage for byteVal to verify byteVal changed
Symbol byteVal=b4       'name for lower byte of w4 (wordStore)
'
'---------------------< Intialization >--------------------------------
Dirs = %10000000  'set all pins as inputs except pin7
'
'---------------------< Main Routine >---------------------------------
Start:
      notMemBit = memBit^1                  'the main code is one
      inputSw = pin6^1                      'shot based. This means
      oneShot = inputSw & notMemBit         'only one new message is
      if oneShot = 1 then newMessage        'sent after the input
Resume:                                     'push button swtich is
      memBit = oneShot | inputSw            'pressed.  Another
goto Start                                  'message will not be sent
                                            'until the PB is released
End                                         'and pressed again.
'
'---------------------< Sub Routines >---------------------------------
newMessage:
   random wordStore                         'store a random value
   if byteVal = byteStore then newMessage   'we only look the lower byte,
                                            '  make sure it has changed
   Serout 7, N2400,(byteVal)                'send the new random byte serialy
   byteStore = byteVal                      'store the byte for later check
   goto Resume                              'go back to where we left off
End
```

FIGURE 8

look in). This formula will return the data found in the row and column indirectly specified; in our case, always column "d" and row 1 through 256 of sheet msgDB. You can see as the byteVal changes, the indirect function selects one of the 256 messages for display on the display tab. Also, you will notice the second line of the indirect-based display simply uses column "e" in the msgDB sheet (see Figure 9). You could easily make this a four-line display by copying the formula down to the next two rows on the display tab and adding data in rows "f" and "g" on the msgDB tab.

There are a couple of subtleties you may have noticed. First is the use of ampersand (&) in the formula. Ampersand is used to concatenate data in a formula (simply join data). For more information on concatenating data search for "&" using Excel help. Second is the offset of one from the row number to the byteVal variable. This is required since there is a message zero, but not a row zero. Hence, the messages are offset from the row number by one.

The Now Function — The now() function was added to cell C1 of the display sheet to display the current date and time. This function will update each time the workbook calculates. In our case, the workbook will calculate each time byteVal changes. Therefore, the date and time displayed represent the date and time of the last new message.

BASIC Stamp

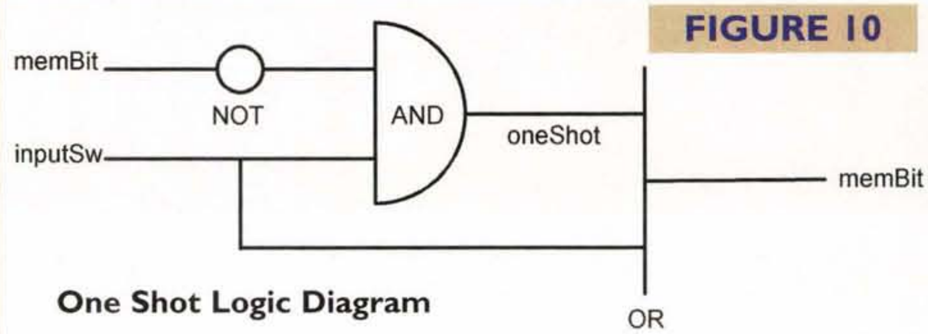
Refer to Photo 1. In our continuing effort to keep things simple, the example BASIC Stamp hardware is set up for a single push-button switch input (on pin 6) and a serial output (on pin 7). The Stamp program is designed to demonstrate the Excel-based display. Very little Stamp resources are required to drive the display. In this example, a random number generator is used to generate a number between 0 and 255 based on a press of the push-button switch (see Schematic 1).

Once again, you will find a few subtleties with the BS1 program (see Listing 1). First, the use of the random instruction requires specification of a word variable to store the random number generated (or in the case of the BS1, pseudo random. See the BS1 user manual for more information on the BS1 random instruction and how it works). Our application uses only a byte variable. To accomplish this, the variable W2 is defined as wordStore, which is made up of byte variables B4 and B5. B4 (defined as byteVal, in our case) is the lower byte of W2 (for more information on the memory map of the BS1, see the BS1 user's manual). Since we are only looking at the lower byte of the random word, we need to verify that the lower byte has changed since the last random value, and if not, run random again. This is accomplished by storing the last byteVal in the byteStore variable and then comparing them with each new byteVal.

Second, a one-shot routine is used to be sure only one new random byte is sent out serially with each press of the input switch (see Figure 10). Without the one shot, new random bytes would be continuously generated and sent as long as the input switch is held on. The one shot uses the logic shown above. The input switch is monitored and compared to a memory bit. Once the input switch is activated and the one-shot output is generated, the memory bit remembers this and

FIGURE 9

FIGURE 10



One Shot Logic Diagram

prohibits any further output until the switch is released and pressed again.

Lastly, based on the BS1 memory map, W0 can be addressed by B0 and B1 (its lower and upper bytes) and also by bit0 through bit15. Our application makes use of bit0 through bit4. So, we need to be conscious of the fact that as we use those bits, B0 and W0 are changing. So, we don't want to define B0 or W0 for any other use that would impact bits 0 through 4.

In Conclusion

Making use of simple available tools once again has made for some unique automation. The BS1 has significant resources remaining for your custom code and we have kept our use of MS Excel to simple formulas.

I have found — and I hope you will agree — that low-cost applications like this one are handy for many users. Hobbyists can accomplish their applications with little money, professionals can prove application aspects prior to buying specific hardware, technicians and laboratory users can flexibly gather information for short-term tests using readily-available tools, and some of us can just have some fun without buying anything.

For more information on the BASIC Stamp, visit the Parallax web site at **www.parallaxinc.com**. InByte, display255.xls, and dsply.bas are available for download from the Emerging Technologies, LLC., website: **www.emergingtech-llc.com/downloads**. **NV**

Mark Van Steenburgh is the founder of Emerging Technologies, LLC. Mark has been a part of the automation industry since 1986. He can be reached at **mvansteenburgh@emergingtech-llc.com** or **(920) 684-0216**.

Part 2: Broadband Communications

by Louis E. Frenzel

Open Communication

HOW TO PUT 10 POUNDS INTO A FIVE-POUND BAG Or Squeezing Higher Data Rates Into Narrower Bandwidths

In Part 1 of this column (Aug. 2002 issue), I talked about baseband transmission where the binary data to be transmitted is connected directly to the cable. This is common in local area networks (LANs) where the data is carried between personal computers by way of twisted pair cable or coax. But what happens if you want to transmit the data by radio? You can't just connect the binary data signal directly to an antenna. It just doesn't work like that.

What you really have to do is generate a radio signal called a carrier on the desired frequency then add the data signal to it. The carrier frequency positions the signal in the frequency spectrum where the FCC says you can operate. The process of adding the data signal to the carrier is called modulation.

Modulation modifies the radio carrier signal in accordance with the data. The modulated carrier containing the data is amplified and applied to an antenna where it is transmitted wirelessly to a remote receiver. The, data therefore, rides along with the radio signal to the receiver. At the receiver, a demodulator circuit extracts the original data from the modulated carrier. This is what we call broadband communications.

Virtually all radio signals are broadband as they use modulation to package the data to be sent. But you can also use broadband modulation techniques for transmitting data over a cable. Such broadband techniques not only permit higher data rates to be achieved in narrow bandwidths, but also it permits multiplexing operations that allow two or more data signals to be transmitted concurrently on the same medium.

Today, much of binary data is transmitted by broadband methods. Some good examples are modems used for accessing the Internet, cable TV, and all wireless data transmission.

Data Modulation 101

If you are a communications wonk like me, you already know that there are three basic types of modulation: amplitude modulation (AM), frequency modulation (FM), and phase modulation (PM). The use of these forms of modulation in traditional analog communications is well known. Broadcast AM and FM radio, TV sound is FM, CB radio is AM, ham radio operators use FM and SSB and continuous wave or CW code, both the latter being a form of AM. Family radios use FM as do the older original AMPS cell phones. But today, everything is going digital if it isn't already. And these basic modulation methods are used in digital data transmission.

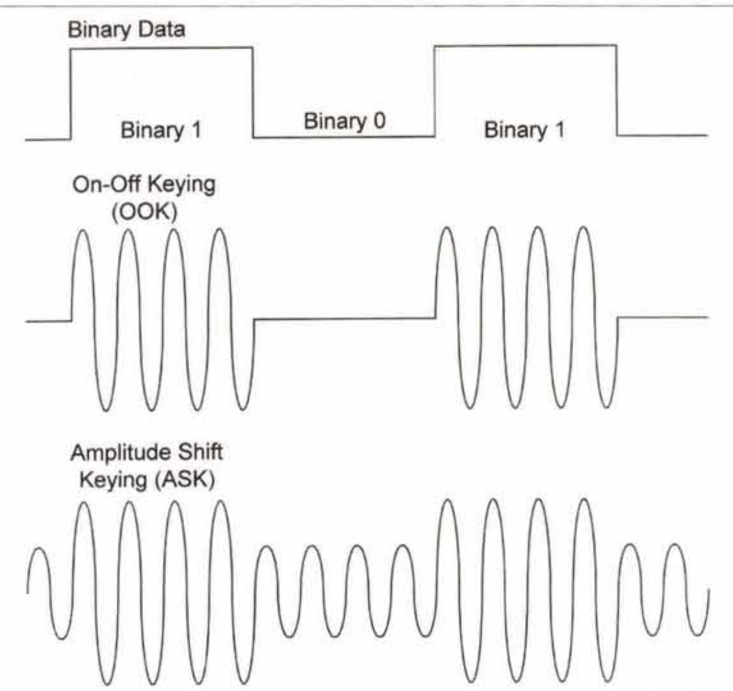
Figure 1 shows how binary 0s and 1s are transmitted with AM. The upper waveform is the binary data. The second waveform is what is known as on-off keying (OOK). The binary data simply turns the sinewave carrier signal off for a binary 0 and on for a binary 1. This is probably the simplest and cheapest form of digital data transmission.

The bottom waveform is called amplitude shift keying (ASK). A binary 0 is transmitted at a lower carrier amplitude while the binary 1 produces a higher carrier amplitude. OOK is widely used in garage door openers and remote keyless entry systems used to lock and unlock car doors. Another example of OOK is wireless Morse code transmission known as continuous wave or CW.

Information is sent as combinations of dots and dashes. To send a dot, the telegraph key is pressed for a short time and the transmitter carrier is turned on then off. A dash is sent by pressing the key for a period of time three times the duration of the dot, then off.

Figure 2 shows data transmission with FM and PM. The middle waveform shows frequency shift keying (FSK) in which a binary 1 is transmitted at a higher frequency than a binary 0. The bottom waveform shows phase shift keying (PSK) where the carrier is transmitted with one phase for binary 0 and 180° out of phase for a binary 1. Transitions from 0 to 1 and 1 to 0 are detected by observing the phase shifts. This is also known as binary PSK or BPSK. FSK is widely used in GSM digital cell phones while forms of PSK are also used in other types of cell phones and wireless LANs. Cable TV systems and dial-up modems use a complex form of modulation called quadrature amplitude modulation (QAM) that is a mix of multi-level AM and PSK. More about that later.

Figure 1

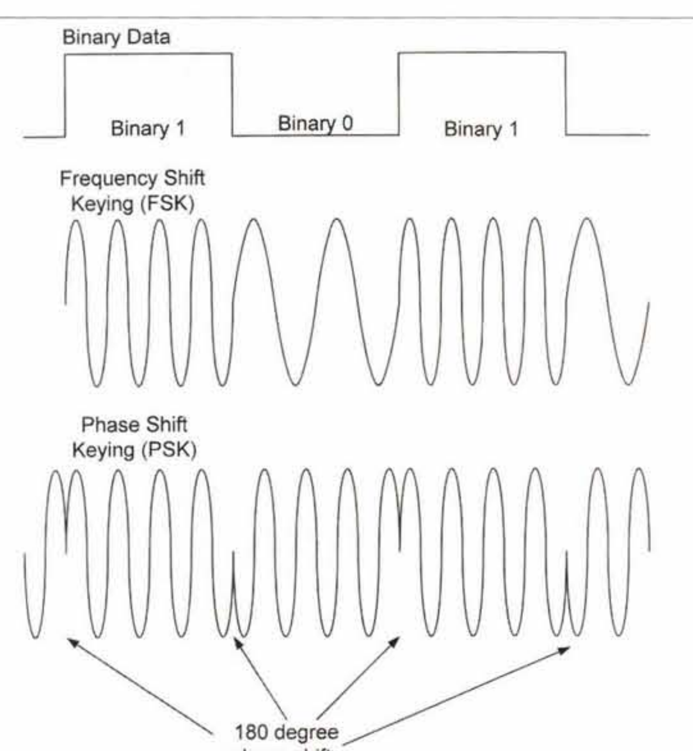


Sidebands

Modulation takes place in a circuit called a modulator. The data signal modifies the amplitude, frequency, or phase of the carrier as the method dictates. The modulation process generates some new signals called sidebands.

Sidebands are signals occurring at frequencies above and

Figure 2



below the carrier frequency. The amplitude and frequency of the sidebands are dependent upon the type of modulation used. The sideband frequencies are the sum and difference of the carrier and modulating signal frequencies. The simplest example is AM in which a sinewave tone modulates a sinewave carrier. Assume that an AM radio station on a carrier frequency f_c of 590 kHz is modulated by a 3 kHz tone f_m. Two side frequencies are produced ($f_c + f_m$) and ($f_c - f_m$) or 593 and 587 kHz. The spectrum of this signal looks like that in Figure 3.

AM broadcast stations reproduce voice and music signals up to 5 kHz. So what happens is that multiple upper and lower sideband frequencies are produced. These bands of frequencies are above and below the carrier as Figure 3 shows. As you can see then, a modulated carrier occupies a range of frequencies. The information to be transmitted like voice is contained within the sidebands. If the information is to be transmitted by radio, the sidebands have to be there. To accommodate the sidebands, the FCC allows each station to occupy a band of frequencies centered on the carrier frequency. For AM this is 10kHz. AM stations have to stay within their band to avoid interference with adjacent stations. Anyway, all radio signals take up space in the spectrum with their sidebands.

When transmitting data, the sidebands become even wider. Just consider what would happen if we tried to transmit binary data on an AM station. The speed of the data would have to be very slow because the bandwidth is limited to 10 kHz. This corresponds to a maximum data rate of 20 kbps. But don't forget if the data is a 20 kbps squarewave of alternating 0s and 1s that this produces many harmonics which will also modulate the carrier making the bandwidth of the signal much greater than 10 kHz. Rectangular pulses contain many harmonics, so if a receiver is to accurately reproduce them they must be given sufficient bandwidth so that at least some of the harmonics are transmitted.

Transmitting up to the 5th harmonic produces a pretty good replica of the original signal. If the harmonics each produce a pair of sidebands, you can bet that the total bandwidth of the signal is enormous. The bottom line here is that data signals take up lots of spectrum space because of the inherent harmonics they generate. And if the higher harmonics are not suppressed, they will lap over into the adjacent channels and cause interference. The FCC really hates when that happens.

As for FM and PM, they also produce sidebands, but many more than AM. Both produce multiple pairs of sidebands above and below the carrier creating a huge bandwidth. For example, each standard FM radio station is allotted 200 kHz of bandwidth. Modulating frequencies up to 15 kHz are permitted. The number of significantly large sidebands is determined by the modulation index *m* which is the ratio of the amount of frequency deviation of the carrier (f_d) to the frequency of the modulating signal (f_m).

$$M = f_d / f_m$$

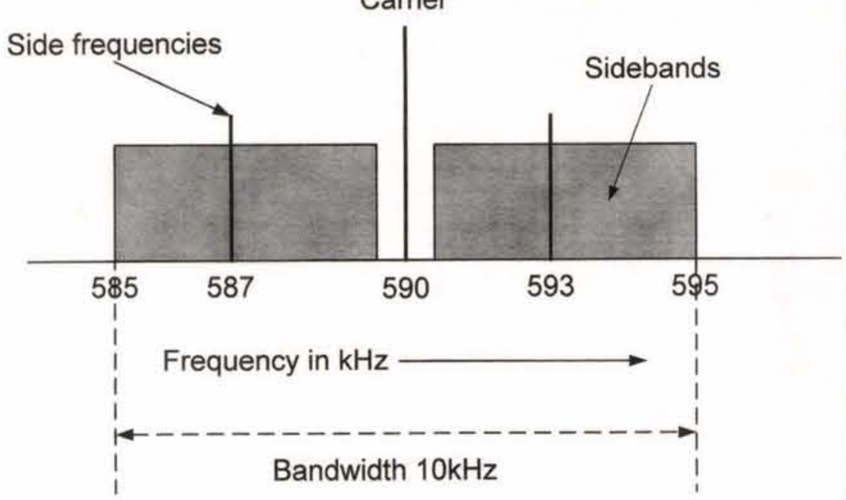
The greater the modulation index, the greater the number of sideband pairs produced and the wider the bandwidth. Obviously, FM and PM use gobs of bandwidth, but their digital versions — FSK and PSK — can be made to use less bandwidth, that is they can be made more "spectrally efficient."

FSK and PSK are basically not as spectrally efficient as OOK or ASK, but they offer another benefit that make them even more desirable than AM despite their bandwidth-hogging tendencies. This benefit is mainly that FSK and PSK are far more immune to noise than AM. As a result, data is transmitted more reliably with fewer errors with FSK or PSK. Noise is the bane of all communications systems so FM and PM are widely used to improve transmission reliability with the ever-present noise.

Now you can see why we keep coming back to this idea of bandwidth and data rate. The bandwidth of the cable or other medium limits the data rate. With wireless, the bandwidth of the assigned radio channel also restricts the speed because not only do we have to worry about the raw data rate, but also we have to figure out how to squeeze those sidebands into a limited channel so that the sidebands do not interfere with stations on the adjacent channels. The choice of the modulation plays a big role as some are — as we say — more spectrally-efficient than others. And some are far better at dealing with noisy situations than others.

The choice of the modulation depends on the final application. But in general, the wireless design engineers look for the modulation scheme that puts the greatest number of bits per second in the narrowest bandwidth. They go by a measure called bits per Hertz or bits/Hz meaning the number of bits per second that can be transmitted in one Hertz of bandwidth.

Figure 3



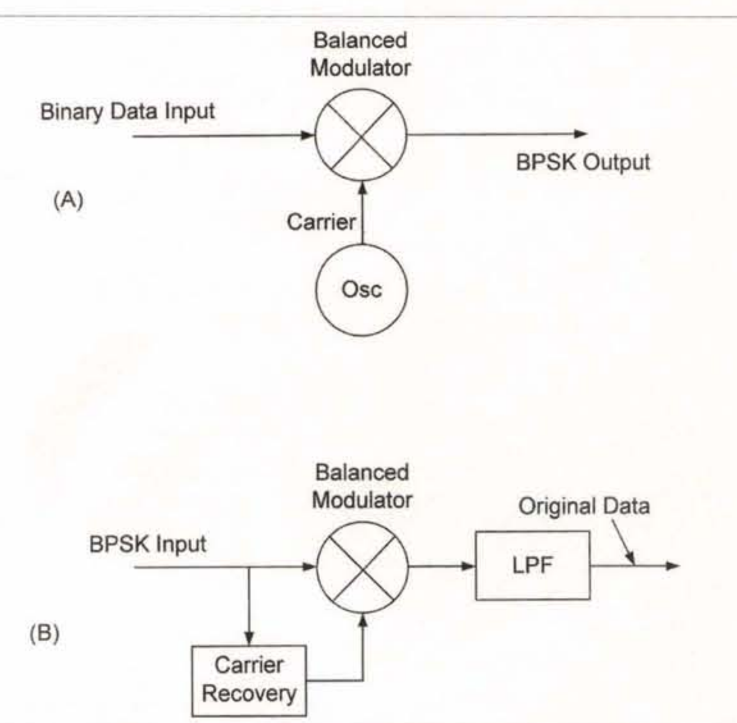
Popular Data Modulation Methods

Modulation is one of the more esoteric topics of electronics. It is highly mathematical, so unless you are up on calculus, statistics, and some other advanced math topics, it gets more than a bit mind numbing when you read about it. So rather than get into some eye-glazing math comparisons, let's just cut to the chase and discuss the most commonly-used modulation types. Engineers have already figured out over the years what works best for the various wireless applications. In a nutshell, here are the top modulation types and their key applications.

FSK — Because of the huge number of sidebands produced by FSK, its use tends to be limited to relatively slow data. FSK was first widely used in the early 300 bps dial-up telephone modems and it is still used in some low-speed industrial telemetry applications where data rate is relatively low. But by keeping the modulation index low (<1) and prefiltering the baseband binary data to reduce the harmonics, FSK can support reasonably high data rates.

The best form of FSK for data is known as Gaussian Minimum Shift Keying (GMSK). The binary data to be transmitted is first filtered in a Gaussian filter to reduce the number of harmonics in the signal. By rounding off the edges of the signal, the number of pairs of sidebands produced is reduced, thereby, reducing the bandwidth needs. Then, by selecting a modulation index of 0.5, the number of sideband pairs generated is greatly reduced. The result is that the data rate for a given bandwidth can be relatively high. The formula for computing the bandwidth of an FSK signal is:

Figure 4



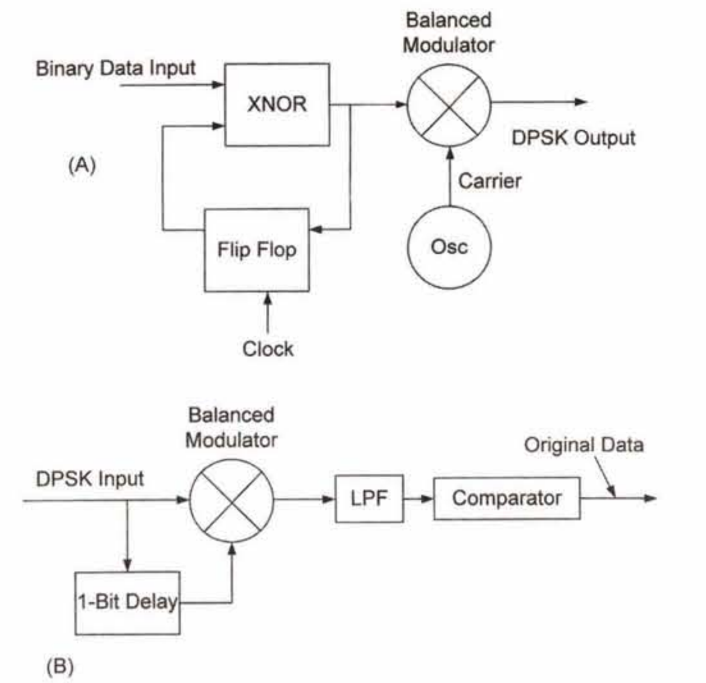


Figure 5

$$BW = 2(\Delta Df + 1/t)$$

Δf = the frequency deviation of the carrier which is the difference between the binary 0 and binary 1 frequencies.

t = the bit time of the data.

1/t is the data rate in bps also designated f_b, the bit frequency.

Assume frequencies of 1070 Hz for binary 0 and 1270 Hz for binary 1 and a data rate of 300 bps. The frequency difference or Δf is 200 Hz. The bit time is 1/300 bps = .003333 second. The bandwidth is:

$$BW = 2(200 + 300) = 1000 \text{ Hz}$$

As you can see, this signal could easily fit within the telephone voice line bandwidth of about 4 kHz.

A good example of GMSK is its use in GSM cell phones. The basic assigned channel bandwidth is 200 kHz. The basic data rate through this channel is 270 kbps. This gives an impressive 270/200 = 1.35 bits/Hz rating.

PSK — For high-speed data, it is hard to beat BPSK. Even for high data rates, the bandwidth can be minimized. And the really good news is that BPSK is very robust in the presence of noise. BPSK was really developed for use in satellite work where very long distances, low power, and difficult noise problems are involved, but where very high data rates are needed.

Figure 4A shows how BPSK is generated. A carrier signal feeds a balanced modulator or double-balanced mixer such as a diode ring lattice modulator or an integrated circuit mixer/multiplier circuit using differential amplifier Gilbert cells. (The long popular 1496 is an example.) The binary data is applied as the modulating signal. The result is an output that is the carrier with no phase shift when a binary 0 occurs and a carrier shifted 180° for a binary 1.

The demodulator at the receiver is another balanced modulator with the BPSK signal as the input and a carrier signal as the second input. (See Figure 4B.) To retrieve the data, the original carrier signal must also be recovered. That is done by a special carrier recovery circuit beyond the scope of this article. A replica of the original carrier is then applied to the balanced modulator where it is compared to the incoming signal, then filtered in a low pass filter (LPF) to regenerate the original binary data.

DSPK — While BPSK works great, its big problem is at the receiver where the carrier phase must be identical to that of the carrier at the transmitter if demodulation is to occur. Carrier recovery circuits can do this, but they are complex. And even the slightest phase difference between the original carrier and the recovered carrier can result in errors being introduced caused by incorrect phase interpretation of the balance modulator.

One way to overcome these problems is to use differential PSK or DPSK. In this technique, the phase of the received bit is compared to the phase of the previously received bit. The phase reference for the currently received bit is the phase of the previously received bit. The result is highly accurate and error-free data recovery.

Figure 5A shows the DPSK modulator. The data is fed to an exclusive NOR (XNOR) circuit where the output is a binary 0 if the input bits are different, and binary 1 if they are alike. The incoming serial bits are, therefore, compared to the previously received bit which is stored in the flip flop (FF). The resulting bit stream is sent to the balanced modulator where it modulates the carrier with either a 0° or a 180° carrier phase shift.

At the receiver, the DSPK signal is applied to the balanced modulator along with the signal which is delayed by one-bit time. A binary 0 is detected if the phase shift between the received signal and the delayed signal is zero. A binary 1 is detected if the phase comparison is non-zero. The balanced modulator output is low-pass filtered to recover the data and a comparator is used to square it up into the original serial binary data.

BPSK and DPSK are very efficient spectrally. They can easily achieve 1 bit/Hz even in relatively noisy environments. Its bandwidth is approximately:

$$BW = f_b$$

f_b is the bit data rate. If the data rate is 2400 bps, then the bandwidth required to transmit it is 2400 Hz. But that's not all. In Part 3, I will discuss what we call multisymbol modulation that produces the highest bit rates possible for a given bandwidth. **NV**

COMING EVENTS

Conventions/ Hamfests

February 1-2, 2003
Tropical Hamboree® 2003. Fair Expo Center, 10901 SW 24th St. (Coral Way), Miami, FL. Dade Radio Club of Miami, Inc., Evelyn Gauzens, w4wyr@gzinc.com, 305-642-4139. John Hall, wd4sfg@bellsouth.net, 305-226-5346.
www.hamboree.org

February 7-9, 2003
HamCation 2003. Central Florida Fairgrounds, 4603 W. Colonial Dr., Orlando, FL. Orlando ARC, Hal Prosse, 407-923-8699, kk1b@arrl.net.
www.oarc.org/hamcat/html

March 29-30, 2003
Greater Baltimore Hamboree and Computerfest. Maryland State Fairgrounds, Timonium, MD. BARC, 410-HAM-FEST (426-3378).
General Info: info@gbhc.org.
www.gbhc.org/

May 2-3, 2003
Trenton Computer Festival™. NJ Convention Center, Raritan Center. Edison, NJ. KGP Productions, 1-800-631-0062.
www.tcfshow.com/

May 16-18, 2003
Dayton Hamvention®. Hara Arena Complex. Dayton, OH.
www.hamvention.org/main.html

June 13-15, 2003
SeaPac Ham Convention. Seaside, OR. Jim Schaeffer, 503-245-2518.
www.seapac.org/inform.htm

Robot Competitions

April 13, 2003
Trinity College Fire Fighting Home Robot Contest. Hartford, CT. Jake Mendelssohn, jmendel141@aol.com.
www.trincoll.edu/events/robot/

For a complete Robot Competition List see:

http://robots.net/rcfaq.html

FIRST Robotics Competition

Registration ends 12/6/02. Regional competitions begin March 6-8, 2003.

FIRST Regionals

March 6-8, 2003
BAE SYSTEMS Granite State Regional. Verizon Wireless Arena. Manchester, NH.

March 6-8, 2003
Buckeye Regional. CSU Convocation Center. Cleveland, OH.

March 6-8, 2003
St. Louis Regional. St. Charles Family Arena. St. Charles, MO.

March 6-8, 2003
Virginia Regional. VCU Siegel Center. Richmond, VA.

March 13-15, 2003
Arizona Regional. Arizona Veteran's Coliseum. Phoenix, AZ.

March 13-15, 2003
Chesapeake Regional. US Naval Academy. Annapolis, MD.

March 13-15, 2003
UTC New England Regional. Meadows Music Theatre. Hartford, CT.

March 20-22, 2003
Central Florida Regional. University of Central Florida. Orlando. FL.

March 20-22, 2003
Great Lakes Regional. Eastern Michigan University. Ypsilanti, MI.

March 20-22, 2003
SBPLI Long Island Regional. Suffolk County Community College. Long Island, NY.

March 27-29, 2003
Canadian Regional. Hershey Center. Mississauga, ON Canada.

March 27-29, 2003
Midwest Regional. Northwestern University. Evanston, IL.

See **www.usfirst.org/** for more information.

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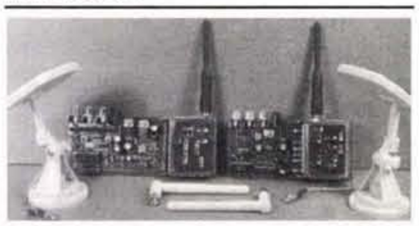

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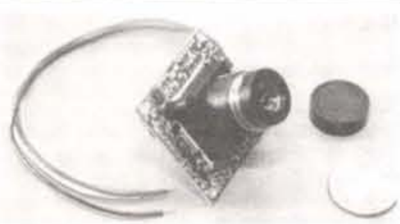

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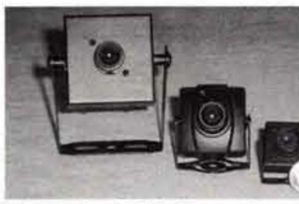

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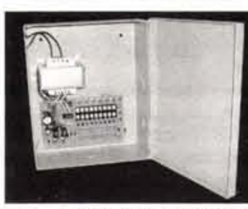

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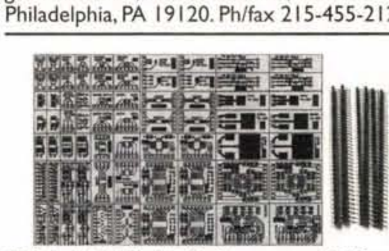

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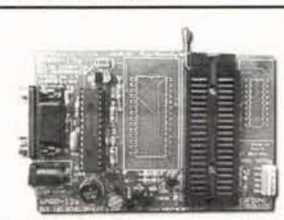

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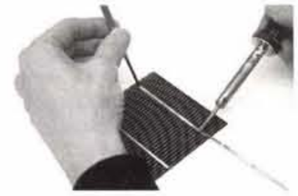

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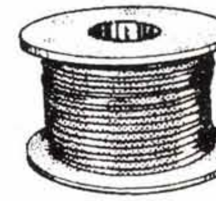

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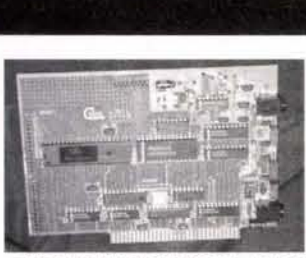

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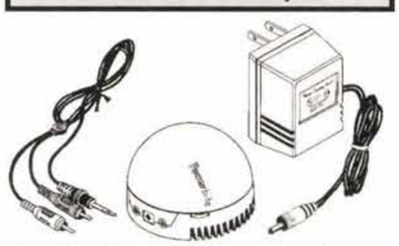

BUILD THIS FURNACE FAN CONTROL TO INCREASE THE EFFICIENCY OF YOUR CENTRAL AIR CONDITIONER

By Michael Kornacker

This timer circuit keeps the fan running an extra couple of minutes after the air conditioner compressor shuts off to extract the most cooling from your forced-air system.

In a typical forced-air central air conditioner system, when the A/C compressor turns off (after cooling your home to the desired temperature), the furnace fan turns off, too. This is normal, but there is a problem with this. The A/C condenser coil inside the furnace is still cold along with the air inside the ventilation ducts, and it all goes to waste. What I propose is to keep the furnace fan running an extra couple of minutes after the compressor turns off so that additional cooling will be achieved by continuing to pass air over the cold condenser coils and also purge the ventilation ducts of the cold, dehumidified air.

This technique is utilized on the new energy-efficient furnaces, but on the older-type systems that most people still have, all of this cold air is just wasted by sitting in the ducts and not getting into the rooms. My circuit, presented here, will overcome this deficiency and should produce a significant energy savings.

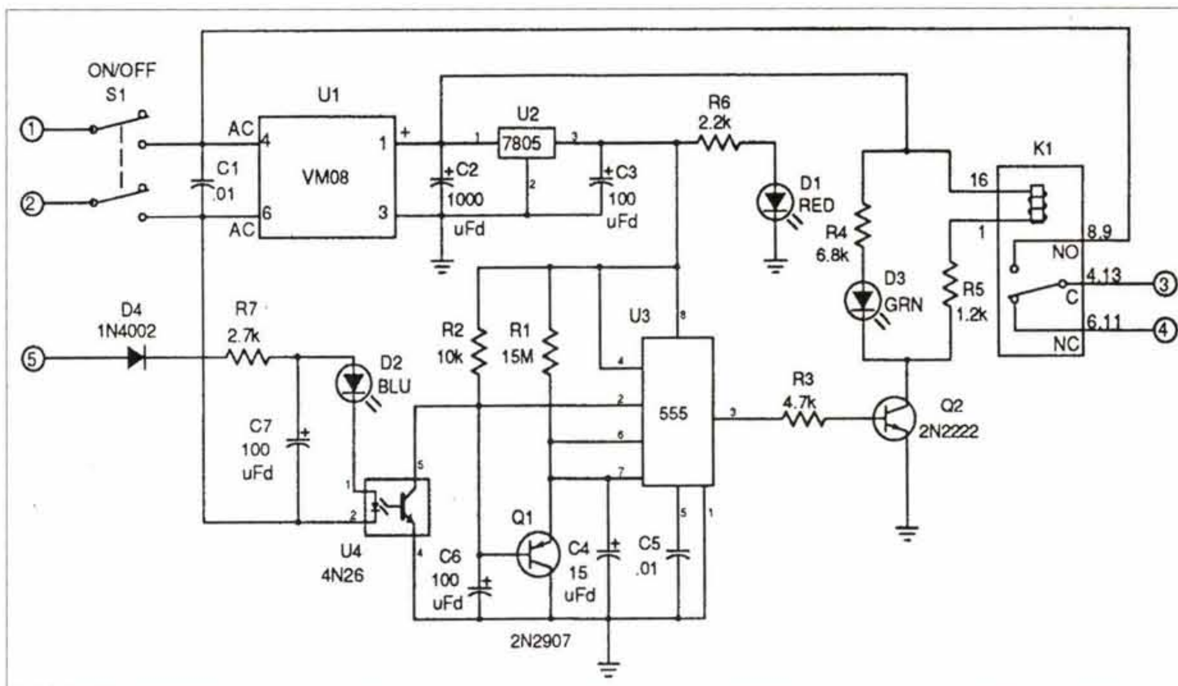

Figure 1. Fan Timer Schematic

There were three goals for this project: that it would be easy to operate, that it would maintain full functionality of, and would not interfere with the existing thermostat, heating, and cooling system.

ABOUT THE CIRCUIT

Figure 1 is the schematic for the furnace fan control circuit. The heart of the circuit is a 555 timer U3, set up as a re-triggerable monostable multivibrator. This type of multivibrator generates an output whenever there is an input signal and, even after the input signal has been removed, there is an output for the amount of time determined by the RC time constant. The time constant circuit consists of resistor R1 and capacitor C4. The time period in seconds is equal to 1.1 * R1 * C4.

The 555 is triggered by the voltage that operates the A/C compressor solenoid when it is activated by the thermostat. D4 rectifies the AC voltage and then illuminates the blue LED D2 and the LED inside the opto-coupler U4. The blue LED signifies that the air conditioner is running. When this signal voltage is present at this part of the circuit, the voltage at U3 pin 2 and the base of Q1 will go low. This signal triggers the 555 timer and sets the output at pin 3 active high.

R2 is a pull-up resistor so that U3 will not be triggered when the A/C compressor solenoid is off. PNP transistor Q1 acts as a shorting switch across C4. When the voltage at Q1 base is low, then Q1 conducts and shorts out C4 so that it will not charge up. When the thermostat turns the A/C compressor off, U3 pin 2 goes high triggering the timer and also allows C4 to charge up. When C4 is finished charging up through R1, the output at U3 pin 3 goes low.

The output of the 555 timer at pin 3 controls the relay K1 through NPN transistor Q2. When pin 3 goes high, it turns on Q2, which lights the green LED, and energizes K1. K1's normally open contacts then close, which turns on the furnace fan. The green LED when lit signifies that the fan is running. The fan will run when the A/C solenoid is energized, and then after the solenoid is de-energized, the fan will continue to run for the amount of time dictated by R1 and C4, and then the fan will turn off.

The circuit is powered from the 24-volt AC transformer inside the furnace. On-off switch S1 applies power to the full-wave bridge rectifier U1 and is filtered by C2. The voltage at the output of U1 is about 34-volts DC. This voltage is fed to the coil of K1 through R5. R5 drops about 10 volts so that K1's 24-volt coil can be operated safely. The 34-volts DC is also sent to the five-volt voltage regulator U2 to power the 555 timer. C3 filters the five-volt line and the red LED D1 acts as a pilot light. All connections to and from the circuit are through a five-lug terminal strip mounted on the circuit board.

Now, one last important point: the heating and cooling system is a very electrically noisy environment and the timer's relay also generates noise when it operates. This necessitates some special preventive measures to be taken. Glitches or voltage spikes in the system — I found — were inadvertently triggering the 555 timer at the wrong time, keeping the circuit from shutting off. C1 helps to filter out any of this noise from entering in from the power line, and R2 and C6 form a low-pass filter to prevent glitches from the power supply from getting into the trigger input at pin 2 of U3. C5 is also used to bypass noise at pin 5 of the timer. R7 and C7 form a low-pass filter for the trigger signal. All these parts will prevent any voltage or noise from falsely triggering the timer.

CONSTRUCTION

I assembled the circuit on a 3- by 4-inch piece of perfboard using wire-wrap IC sockets. The circuit is simple enough that a PC board could be made, but it isn't essential. Even point-to-point wiring could be used, but wire-wrap seems to be the easiest method. A fancy case is also not needed for this project, since it is not intended to be in plain view. I mounted the circuit board on a piece of sheet metal aluminum by using stand-offs and then drilled a hole through the aluminum at the top so that the whole device could be mounted on the furnace room wall with a screw.

Parts placement is not critical and can be left to individual tastes. All resistors, capacitors, transistors, LEDs, and the five-volt regulator were mounted and soldered on component carriers that were themselves plugged into IC sockets. Be sure to observe the correct polarity on the electrolytic capacitors, ICs, transistors, diodes, and LEDs.

For the connections from the terminal strip to the power switch and from the power switch to the relay's switch contacts, larger hook-up wire must be used (no wire-wrap here), since they must pass a large amount of current. For this, I used some wire from the five-conductor cable that I will discuss next.

INSTALLATION

To install the device, turn off the power to the furnace and air conditioner at the fuse panel. The device can be mounted on the wall next to the furnace and five lengths of wire will be needed for the hook-up to the furnace's electrical system. This wire can be obtained from your local hardware store as a five-conductor cable for home thermostats. The wires of this cable will usually be color-coded red, white, blue, green, and yellow. Prepare each end of the cable by trimming back the cable's sheathing by about four inches and exposing the five wires from each end. Strip 3/4 inch of insulation from each end of the wires.

At the device end, attach each wire of the cable to the terminal block in this order: red to #1, white to #2, blue to #3, green to #4, and yellow to #5. For the furnace connections, refer to the schematic of a typical system in Figure 2. Connect the red wire to the furnace's 24-VAC power transformer terminal usually marked as "R" for red. It should have a red wire already attached to it that goes to the thermostat. Splice them together. Splice in the white wire of the cable to the transformer's other terminal marked "C" for common.

Next, disconnect the wire (usually colored green) that goes to the A/C fan relay, and connect that wire to the green wire of the cable. Then connect the blue wire of the cable to the A/C fan relay where the green wire was just disconnected. And finally, the yellow wire of the cable must be connected to the wire going to the compressor relay solenoid in the A/C unit, that is usually colored yellow, also. Now the wire colors may not match what I said, but using Figure 2 as a guide, you should be able to figure out the proper connections.

Make sure the timer device's power switch is off. When you're done connecting the device to the furnace system, go back and recheck your connections. Then reapply power back to the furnace and A/C unit. With the device still off, you should now verify that the heating and cooling systems work as before; the timer device should not interfere with the operations of the original system.

PARTS LIST

Designator	Value	Description
D1		Red LED
D2		Blue LED
D3		Grn LED
D4	1N4002	Diode
Q1	2N2907	PNP Trans
Q2	2N2222	NPN Trans
U1	VM08	Full Wave Bridge Rect
U2	7805	+5V Reg
U3	555	Timer
U4	4N26	Opto-isolator
R1	15M	Resistor
R2	10k	Resistor
R3	4.7k	Resistor
R4	6.8k	Resistor
R5	1.2k 1/2W	Resistor
R6	2.2k	Resistor
R7	2.7k	Resistor
C1	0.01uFd	Cap
C2	1,000uFd/50V	Electro
C3	100uFd	Electro
C4	15uFd	Electro
C5	0.01uFd	Cap
C6	100uFd	Electro
C7	100uFd	Electro
S1	DPDT	Switch
K1	DPDT	12V Relay

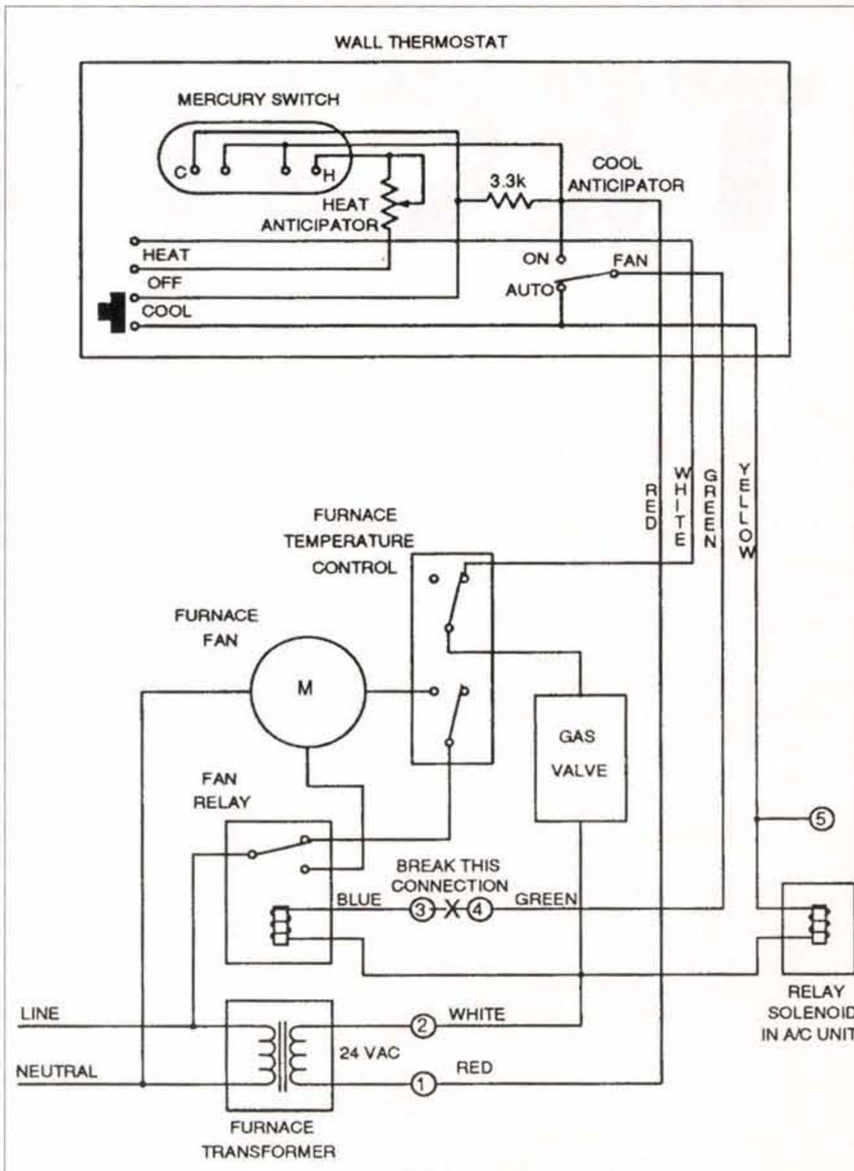

Figure 2. Residential heating and cooling systems.

USING THE TIMER

On the wall thermostat, set the heat-cool-off switch to off and set the auto-fan switch to auto. Turn on the power switch to the timer device. The red and green LEDs should immediately illuminate and the furnace fan should turn on and run. The blue LED should not be illuminated. The fan should run for about four minutes and then shut off, and the green LED should extinguish. This scenario should automatically occur every time the device's power switch is turned on in this manner.

Next, on the thermostat, set the heat-cool-off switch to cool, and set the temperature control to call for air conditioning. When the A/C turns on, the blue and green LEDs should illuminate, and the furnace fan and compressor should run. When the thermostat turns the air conditioner off, the blue LED should also extinguish, but the fan should still stay running and the green LED should still be lit.

The fan should continue to run for about four minutes and then should shut off along with the green LED. The red LED should always be lit when the power to the device is on.

The fan timer has now been verified to work and the installation and check-out are complete.

The timer device should be fully compatible with the heating system, but when the cold weather does come, you can turn off the power to the device until next summer; there's no need to disconnect anything, though. Stay cool. **NV**

TECH FORUM

QUESTIONS

I need ideas on how best to convert a logic analyzer that uses the CP/M operating system to one that will run under Windows or DOS. The original logic analyzer (a Kontron KLA-64, 64 ch., 100MHz) is run by an 8085-based CPU/control board that effects all control functions through parallel I/O ports. I propose to replace the dated 8085-based CPU/control board with a newer embedded processor board and run it under DOS or Windows.

The hardware should be a snap. But the operating software is a problem. I don't want to have to reinvent the wheel. The original logic analyzer software is contained on 5-1/4" floppies and is run under the CP/M operating system.

My biggest obstacle is how to convert the original operating software into software that will run under Windows. I envision the following to be the two biggest obstacles that I will need to overcome:

1. How do I get the original operating software off of the CP/M floppies? I believe the original 5-1/4" boot floppies utilized an ST-512/480 interface (or something like that). How can I read them into a Windows environment?

2. Once I have the original software in a Windows/DOS environment, what is the best way to turn it into software that will run under Windows or DOS? Will the original executable modules run under Windows/DOS without modification? Will the Windows/DOS loader understand their format, load it and execute it? Do I need to try to disassemble and recompile the logic analyzer's operating code?

Any ideas would be appreciated!

#12021 **George Zarin**
Glendale Heights, IL

I am trying to build a battery pack condition meter. I was thinking of using an LM3914 chip to drive an array of LEDs. The problem is the max voltage of the LM3914 is less than the nominal charge voltage of the lead-acid battery pack.

#12022 **Bryan McPhee**
via Internet

I want to bolt two cheap computer tower cabinets together so that I have space for more drives. I want the power supply in the second cabinet to supply the power to the second cabinet's drives, but how do I get the power supply in the second cabinet to "turn on" without being connected to a motherboard?

Is there anything else I need to know in order to do this?

#12023 **Peter Skye**
La Canada, CA

I have an IBM thinkpad model 500 (2603) without a floppy drive. It uses an external floppy drive part #59G7918 with a cable #59G7925. I have a drive #41H7445 with attached cable. I think the drive would work if I could re-wire the cable and put another connector on it. I can't find any cable diagrams or substitution information on the IBM website. Can anyone tell me if I can do this and how? Or am I stuck with using it without the floppy? I have heard that perhaps Dell made the drive. Is there another company's drive/cable that will fit?

#12024 **Joe**
via Internet

I fly radio-controlled model gliders made from foam so we can combat them (i.e., literally try to knock each other out of the sky)!

I have seen ideas that use infrared technology to have an IR "gun" on the nose of the fuselage and a sensor that counts the hits on the "enemies" rear or cockpit.

Are there bits and pieces that would let me put together such a setup?

#12025 **Brian**
Cooranbong, Australia

I recently purchased a Bullet Camera that I intend to install in the back of my car for a rear-view display.

The question that I have is how hard is it to mirror or reverse the camera output horizontally so that "left" on the screen is "left" in the car? Is there a company that sells a device that will do this or will I be forced to build one myself?

If I have to build it myself, how complicated is it? Any help is greatly appreciated.

#12026 **James Upton**
via Internet

I was challenged by the question of making a free-running clock using (two) 74122s and all of the necessary resistors and caps to set the timing, and LEDs to indicate the pulse at the out of each of the 122s.

I have read, seen, and made the same free runner using a 555 timer and two resistors and a cap to set the pulse timing with an LED to indicate the pulse, with no problem. Any suggestions on the wire-up?

#12027 **Gary**
via Internet

I have a "solid-state automatic charger for deep cycle 12-volt batteries. I do not measure any voltage at the terminals, but when connected to a battery, it turns on and charges. I notice a small circuit board with a transistor and three

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

Send all material to *Nuts & Volts Magazine*, 430 Princeland Court, Corona, CA 92879, OR fax to (909) 371-3052, OR email to forum@nutsvolts.com

ANSWER INFO

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

QUESTION INFO

To be considered

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

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

Information/Restrictions

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

Helpful Hints

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

diodes. What is the principle of operation of this charger?

#12028 **William E. Horton**
Forestburgh, NY

ANSWERS

[11023 - NOV. 2002]

I want to use a single computer in my home to provide resources from several rooms. I need an Inverse KVM or keyboard-mouse switch to allow me to control a single computer from up to eight different locations.

Does someone know of any place that sells a circuit that can be used to detect mouse/keyboard activity and switch that pair of KMs to a central computer?

Buster, what you are describing is terminal services which comes standard with Windows 2000 server. Basically, what you would do is implement a Windows 2000 network throughout your home. That may seem like a lot, but you are already going to have video, keyboard, and a mouse in every room. Why not spend $50.00 per room and get some old computers that can run Windows 2000 Professional?

The way you are wanting to implement this will take lots of cables running to every room. You could implement a wireless network throughout your home and implement terminal services without having to drill a single hole or pull a single wire (a mouse, monitor, and keyboard will take lots of cable).

Windows 2000 professional will run on a 133MHz machine with a 1 gig hard drive and 64 meg of RAM.

Networking professionals regularly receive such machines in on trade, and will sell them for next to nothing.

Windows terminal services allows you to completely control a computer from another, which is what you are trying to do.

Dan Lash
Rome City, IN

BUILD AN EMERGENCY CELL PHONE CHARGER

By Anthony J. Caristi

Be secure knowing that your cell phone will operate no matter where you go.

The cell phone industry has been growing at a phenomenal rate, and if you don't already have a wireless phone, you probably have been considering it. Cell phones are powered by rechargeable batteries, and because of this you need to remember to maintain that charge. This will be a daily ritual for those who place a heavy demand upon their portable telephone.

The usual method used to keep the battery charged is to connect the phone, overnight, to an AC-powered charger. An alternate method is to use a charger that can be powered through a 12-volt DC receptacle in a vehicle. These charging systems have electronic circuitry that provides a fast charge without danger of overcharging, which can damage the battery. Since the cell phone provides a solid sense of security no matter where you go, it is important to remember to charge the battery periodically. But a rechargeable battery self-discharges, and it loses capacity as it ages. Suppose your battery runs out of charge at the most inopportune time, when you are neither near an AC receptacle or your vehicle? The answer to this is to build the emergency cell phone charger described here.

This is a compact electronic circuit, powered by solar energy, which is small enough to fit in a pocket or briefcase. It derives its power from sunlight, or even strong artificial light, that will provide sufficient energy to charge the battery so that an important call can be made. It also generates enough power for instant "standby" status of the cell phone. While you may never run into the problem of a totally discharged cell phone battery, it would be nice to know that you can't run out of power no matter where you go. The electronics for the charger are extremely simple, and the parts low in cost. The circuit is designed for 3.6-volt cell phone batteries, which are the most common in use today.

ABOUT THE CIRCUIT

Refer to the schematic diagram. Power to operate the circuit is provided by a set of 10 solar cells connected in series. When placed in full sunlight, one solar cell is capable of delivering about 0.45 volts DC into a load. Under artificial light conditions, a typical cell will probably generate less voltage, depending upon the intensity of the light and the distance between the solar array and light source. Solar cells are available in many sizes, and this circuit will require a solar array capable of producing about 4.5 volts at 50 milliamperes of load current. The battery charging rate is approximately 25 milliamperes, depending upon its terminal voltage under charge. To achieve the desired charging current, at least 10 individual solar cells are connected in series to make an array.

Cell phone batteries are typically Lithium-ion cells that have a nominal terminal voltage of about 3.6 volts. Older cell phones used three Ni-Mh or Ni-Cad cells connected in series to provide 3.6 volts for the phone. Since the Lithium-ion cell is far superior to other battery chemistries, it is the cell phone battery of choice today. This circuit will work with any type of 3.6-volt rechargeable battery. In order to use as few solar cells as possible in this application, the circuit has been designed with a DC-to-DC switching regulator that steps up the input voltage provided by the solar cells. Thus, by having just three or four volts available from the solar array, the step-up regulator provides about six volts for charging. The voltage output of the regulator remains fairly constant with varying amounts of light striking the solar cells. U1 is a step-up DC-to-DC CMOS regulator chip that is capable of operation with input voltages of two volts or more. The output voltage of U1 is controlled by a pair of resistors (R1 and R2) connected in series across the output of the regulator, pin 5 to circuit common. The center junction of the series string is connected to pin 7 of the chip, which acts to maintain a voltage of 1.31 volts at this point. The resistor values have been selected to provide about 6.4 volts output at pin 3.

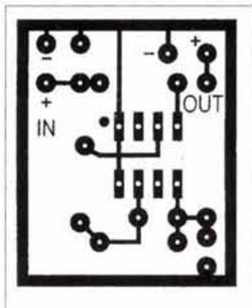


Figure 1. Full size view of the printed circuit board as seen from the copper side.

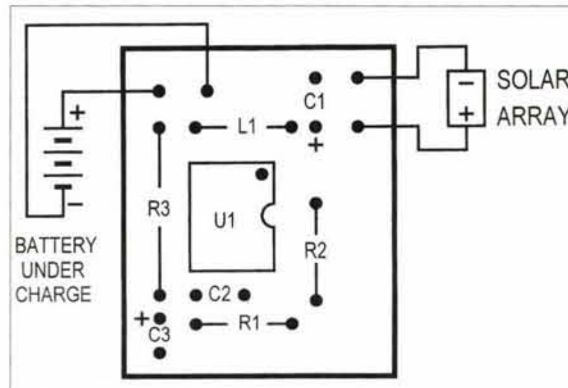


Figure 2. Parts placement shown from the top of the board. Note connections to solar array and battery under charge.

Using a 4.5-volt solar array for power, efficiency may be about 75%. Thus, a 25 milliampere charging current will require a solar cell current of perhaps 50 milliamperes. R3 is a current limiting resistor that controls the battery charging current. With the resistor values indicated in the schematic diagram, this current will be about 25 milliamperes when the solar array is placed in full sunlight. Since this is an emergency charger, it is not necessary to provide maximum charging current to the battery as is done by an AC or vehicular-operated charger. Operating the circuit for just a few minutes will store sufficient energy in the battery to make that important call. Since the charging current is relatively small, there is no likelihood of overcharging the battery.

CONSTRUCTION

Construction of the emergency battery charger consists of three parts, which are: the circuit assembly board, the solar array, and the mechanical configuration that mates the cell phone to the charger. This project will test the ingenuity of the builder to assemble the parts into a small and convenient package that is practical to operate and convenient to carry with the cell phone. The circuit itself is simple enough to be wired on a perfboard, but for a professional looking project, a printed circuit (Figure 1) may be used. If you do not wish to etch and drill your own board, one may be obtained from the source given in the Parts List.

Refer to Figure 2 for the location of all parts of the board. It is important that the integrated circuit and electrolytic capacitors be placed correctly into the circuit as shown. Any polarized component placed backwards will result in an inoperative circuit, and may cause damage to itself or other parts.

Figure 2 also illustrates the connections to the solar array and battery under charge. Use flexible #22 gauge insulated wire for the input and output connections to the board. Different colors will help in avoiding misconnections. When the board has been completed, examine it very carefully for proper component placement. Be sure all solder joints are shiny and smooth, and there are no opens or shorts between closely-spaced conductors. It is far easier to correct problems at this stage rather than later on if you discover that your battery charger does not work.

SOLAR ARRAY

The solar array will consist of 10 individual solar cells connected in series. Each solar cell should be capable of delivering at least 50 mil-

SOURCES OF SUPPLY

Mouser Electronics, 1-800-346-6873; **www.mouser.com**

Digi-Key, 1-800-344-4539; **www.digikey.com**

Edmund Scientifics, 1-800-728-6999; **www.scientifics online.com** (solar cells)

Note: The following parts are available from A. Caristi, 69 White Pond Road, Waldwick, NJ 07463.

Etched and drilled PC board @ $9.95
U1 @ $5.95. Please add $4.00 postage/handling.

liamperes when placed in full sunlight. The cross sectional area of a solar cell determines its current capability. A typical 50-milliampere solar cell may measure just 10 millimeters by 20 millimeters. By using 10 cells connected in series to produce 4.5 volts at 50 milliamperes, the total size of the array would be 40 by 50 millimeters. Individual cells are connected in series plus-to-minus to form the desired array. They may be cemented to a flat sturdy board for rigidity, using silicone rubber or epoxy. Alternatively, complete arrays that deliver the correct voltage and current are available from various supply houses. One such distributor is indicated in the Parts List. The solar array should be connected to the circuit board using flexible wires. Connect positive-to-positive, and negative-to-negative as shown in the schematic diagram. Use a DC voltmeter to positively identify the polarity of the solar array.

PRELIMINARY TEST

The circuit board should be tested before final assembly of the charger to ensure that it is working properly. The battery under charge is not used for this test. A source of adjustable, regulated, well-filtered DC voltage may be used to power the circuit with the solar array disconnected. Alternatively, the solar cell array can provide the power if it is exposed to full sunlight.

For a test load, use an ordinary LED and 100-ohm resistor connected in series. This load will draw about 22 milliamperes from the charging circuit. Observe polarity of the LED so the test load will draw current when it is connected across the output terminals of the charger. Set the power source to 4.5 volts, and connect it to the input of the circuit board (C1) with the positive lead going to the positive side of C1. The negative lead of the supply is connected to circuit common. The LED should be lighted, and the current drawn from the power supply should be about 40 to 50 milliamperes. Lower the output voltage of the supply to 3.0 volts, and note that the LED remains at about the same brightness.

Set the input voltage to 4.5 volts. Do not exceed six volts. Measure the voltage across C3. Normal indication is about 6.4 volts. If the above measurements are correct the preliminary test is completed. If not, review the following paragraphs to isolate and repair the fault. Check carefully the polarity of the test LED. It will not light if it is not correctly wired. Check the value of the load resistor connected in series, 100 ohms.

Measure the voltage at the positive side of C1 to verify that it is at least 3 to 4.5 volts, the same as delivered by the power source. If not, check the wiring and power source voltage and polarity. Check the resistance of L1, which should be less than 10 ohms. Measure the voltage at pins 1, 3, and 8 of U1. Normal indication is zero. If not, check circuit wiring and be sure that U1 is placed into the circuit properly.

Circuit oscillation may be verified by examining the waveform at pin 4 of U1. Normal indication is a series of pulses, five to 10 microseconds wide, with an amplitude of four volts peak-to-peak or more. The waveform will vary with changes in applied voltage from the power source. If no waveform is present, check the values of L1, R1, R2, and C2. Check all solder joints, and look for circuit opens and shorts. Verify that U1 has not been placed in the circuit backwards. Check C1 and C3 for proper polarity. If necessary, try a new chip.

If the circuit is oscillating, but the voltage at pin 5 of U1 is not 6.4 volts, verify that the circuit is powered by at least four volts. Check the values of R1 and R2. Check the load resistance value, 100 ohms. When the fault has been located and corrected, proceed with final assembly that includes connecting the solar array, circuit board, and phone holder together.

CELL PHONE CONNECTION

There are two methods that are used to provide charging current to the cell phone battery. One way is through a miniature connector that completes the required connections between the battery and charger circuitry. Older cell phones use a charging cradle in which the cell phone rests as it is being charged. Either method can be used in this project. If your phone uses the connector system, you will need to obtain a plug either from another charger, or your cell phone dealer or service agency. If your AC-powered charger is the cradle type, this project will bring into play your constructive ingenuity as you design and build your own cradle. Of course, you might be able to obtain for free an old or non-saleable charger from your dealer, and use only the required parts. If so, just discard any circuitry associated with the charger.

PARTS LIST

- **C1** — 100 uFd 10-volt radial electrolytic capacitor
- **C2** — 100 pF 50-volt ceramic disc capacitor
- **C3** — 330 uFd 10-volt radial electrolytic capacitor
- **L1** — 220 microHenry inductor, Mouser 70IMS5-220 or similar
- **R1** — 392K 1/4 watt 1% metal film resistor
- **R2** — 100K 1/4 watt 1% metal film resistor
- **R3** — 100 ohm 1/4 watt carbon resistor
- **U1** — MAX631CPA step-up switching regulator IC (Maxim)
- Solar array: 10 series connected cells rated at 50 milliamperes

For either method of charging, you will need to identify the two connections (+ and -) to the cell phone battery itself. While some commercial chargers may use four connections to the cell phone, this project requires just two. Extra connections on an AC-powered charger are used to control the charging rate so that the battery receives a fast charge without danger of overcharge.

First, determine the actual connections and polarity of the battery in the cell phone. While this can be done using a DC voltmeter, a load should be used to ensure that the actual battery terminals are being identified. This may be accomplished by using a common LED which has a 100-ohm resistor connected in series with it. Place the series test assembly across a pair of terminals on the cell phone, or a pair of wires on the connector that is plugged into the phone. When the LED is lit, the battery terminals have been identified. The polarity of the battery can be determined by noting the polarity of the LED. Otherwise use a DC voltmeter to be sure. Once the positive and negative terminals of the battery connections are known, it is a simple matter to wire the battery circuit properly to the output of the charger as indicated in the schematic diagram.

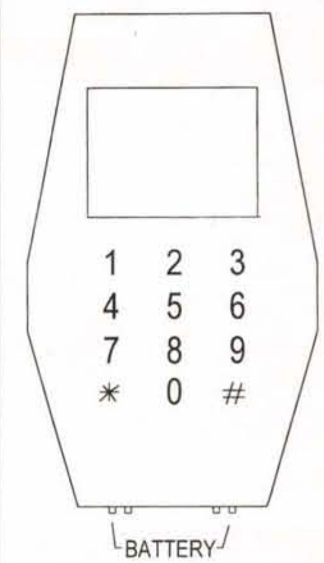


Figure 3. Older cell phones have external battery connections and are charged in a cradle. Newer phones utilize charging receptacles.

FINAL TEST

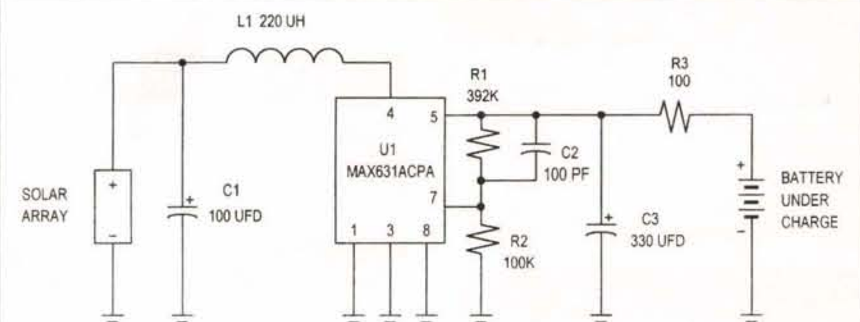
When the final wiring is completed, the final test will verify that the battery is being charged when the solar array is placed in sunlight or strong artificial light. To make the test, connect the cell phone to the charger. Cover the solar array so that no light strikes it, and use a digital DC voltmeter to measure the terminal voltage of the battery. Normal indication will be about 3.6 volts.

Expose the solar array to strong light while monitoring the voltmeter. After a minute or two, you should see an increase of terminal voltage, however slight. This verifies that current from the charger is being supplied to the battery. If no increase in voltage is apparent, check the connections between the battery and charger. Verify that the polarity is correct. If the solar array does not provide the required 4.5 volts in full sunlight, check the series connections of the cells to be sure that all are connected plus-to-minus.

USING THE CHARGER

The cell phone should not be left connected to the charger unless it is placed in strong light to charge the battery. This will avoid any possibility of discharging the battery through the charger circuitry. When placed in strong light, the charger will allow the cell phone to be instantly set to standby mode even though the battery is virtually dead. To make a call, sufficient time must be allowed for the battery to store the required amount of charge. For best performance, always face the solar array perpendicular to the source of light. The amount of time that the charger must be operated will depend upon the current required by the cell phone during talking time. (Standby current draw is very much less that talk-time draw.) The talk-time current can vary over a wide range from cell phone model to cell phone model. The best way to determine the talk-time operating current for your phone is to contact the manufacturer or service agency. An approximation of cell phone current draw can be calculated

Continued on page 77



Emergency cell phone charger schematic.

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BUILD YOUR OWN DESKTOP JACOB'S LADDER

By Karl P. Williams

Build this amazing, battery-powered, high-voltage Jacob's Ladder that is safe enough to sit on your desktop.

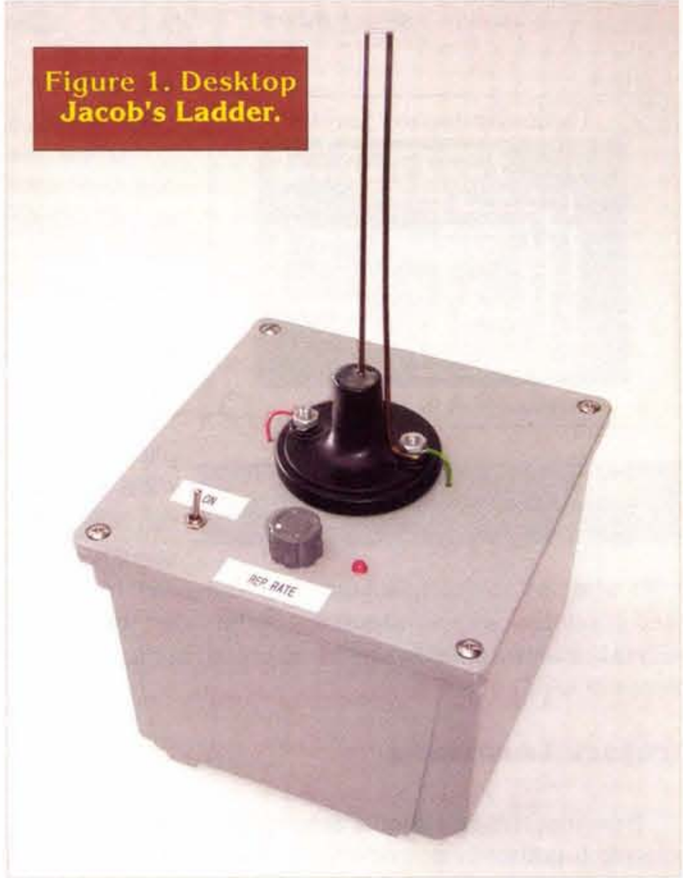


Figure 1. Desktop Jacob's Ladder.

High voltage in the form of lightning has fascinated human beings and inspired mythology since the beginning of time. The Greeks worshiped Zeus as the supreme ruler of the sky who wielded the powerful thunder bolt. Men such as Wimshurst, Van de Graaff, and Tesla were inspired to create and control these powerful forces in their laboratories and the basic designs of these high-voltage devices have not changed much over the years. These machines were typically large, power hungry, and dangerous with the risk of electrocution and fire.

A popular display of high-voltage electricity is the Jacob's Ladder with its climbing arcs of plasma. This device has been made popular by the motion picture industry where it is often seen in the laboratories of evil geniuses and scientists. It is said that the name of this device originated with Hollywood special effects artists. Apparently, it was named after the biblical character Jacob who saw a vision of an angel ascending to heaven on a ladder.

The Jacobs Ladder presented in Figure 1 will allow you to create the excitement of high-voltage arcs safely on your desktop. The circuit is powered by a 12-volt DC battery pack and outputs over 30,000 volts. The circuit design allows the repetition rate of the high-voltage pulses to be varied by a potentiometer on the front panel. Each time a high-voltage pulse is triggered, a light emitting diode on the front panel is also activated. This educational project demonstrates the principles of high voltage and is also a great attention-getter.

Circuit Description

The circuit shown in Figure 2 is designed around the popular 556 timer IC that consists of two 555 timers in one 14-pin package. The circuit uses the timer located on pins 8 through 13 (timer 2) to produce a squarewave at a frequency determined by capacitor C2 and the value of trim potentiometer R8. The squarewave produced, switches an IRF530 power MOSFET to drive the primary coil of a standard automotive ignition transformer like the one pictured in Figure 3. This ignition coil is inexpensive and can be found at most automotive parts suppliers or at a local junkyard. The ignition transformers secondary coil output is connected to a metallic rod, as is the negative terminal connector.

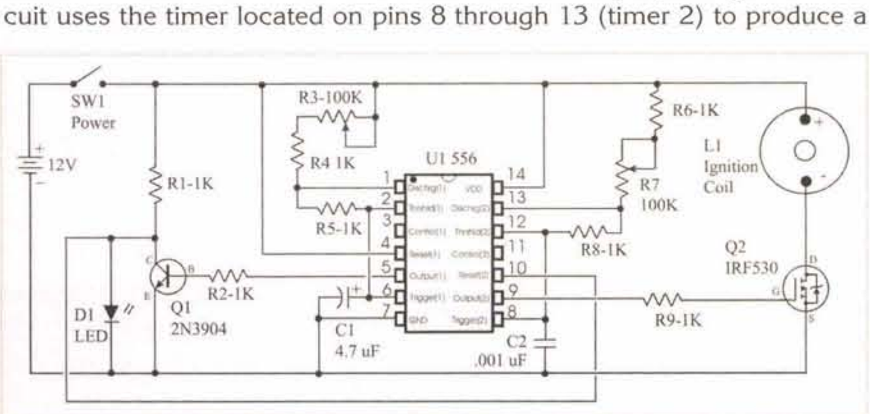


Figure 2. Desktop Jacob's Ladder schematic diagram.

The two metallic rods run parallel to each other at a distance of approximately a quarter of an inch as shown in Figure 1. The high voltage produced between the two rails ionizes the air causing a plasma arc to form and climb upward along the rails, giving an eerie effect. The first timer of the 556 — which is located on pins 1 through 6 — is used to set the repetition rate of the high-voltage pulses in adjustable intervals between 0 and 1 seconds as determined by capacitor C1 and potentiometer R3 (mounted on the control panel). This is accomplished by using the output from timer 1 to switch transistor Q1. The collector of transistor Q1 is connected to the reset pin of the second timer and to light emitting diode (LED) D1. When the transistor is switched on by the first timer's output pulse, the second timer starts running and the LED is turned on. This allows for slow pulsing plasma arcs across the rails or fast, continuous arcs. The LED on the front panel is turned on every time a high-voltage arc is produced.

Figure 3. Automotive ignition transformer.

Construction

The circuit is easiest built by fabricating a circuit board using the artwork shown in Figure 4. The circuit board can be produced using whatever method you are comfortable with. The finished printed circuit board is also available for purchase at the authors' web site located at **www.thinkbotics.com**.

If you don't want to fabricate a printed circuit board, the circuit is simple enough to construct on a 2-1/2 x 2-inch piece of standard perforated circuit board (holes spaced 0.10-inch

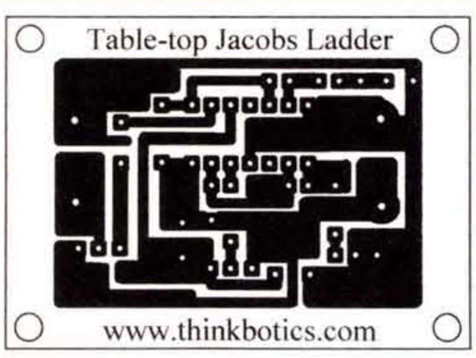


Figure 4. Printed circuit board foil pattern.

on centers) using point-to-point wiring, if you wish.

Once the circuit board has been etched, drilled, and cut, use Figure 5 and Table 1 as a parts placement and wiring guide. Solder all parts and wires in place after they have been placed. Do not hook the wires to the ignition coil at this point. Solder a 14 pin IC socket where part U1 (556 timer) is shown. Place the 556 timer IC in the socket with pin 1 located closest to R5 when all soldering is complete. Cut seven-inch lengths of #18 insulated connector wire to attach the battery clip, switch, potentiometer R3, LED D1, and the ignition coil L1 as shown in Figure 5. You will need eight pieces of wire in total.

Project Enclosure

Now that the electronics are finished, it is time to put all of the components together in an enclosure. The project enclosure that will be discussed is an electrical junction box that can be purchased from Home Depot. The box measures six inches in length and width, and is four inches tall with a removable lid that is held in place with four corner screws. Any plastic case of similar dimensions can also be used. Drill the mounting holes in the top panel in the approximate locations with the drill bit sizes as shown in Figure 6. The middle hole can be cut with a 2-1/8 inch hole saw like the one shown in Figure 7.

When all of the holes have been drilled in the lid, the automotive ignition coil, power switch, repetition rate potentiometer, and LED should be mounted as shown in Figure 8. The wires that connect to the positive and negative terminals of the ignition transformer are fed through the small 3/32-inch holes on either side of the 2 1/8-inch hole in the center where the ignition transformer is to be mounted. Refer to Figure 5 and Figure 8 to ensure that the positive wire is fed through the left hole and the negative wire through the right. Mount the ignition transformer in the 2 1/8-inch hole in the center of the lid with the transformer's positive terminal positioned on the left side. If the transformer does not fit snugly, then secure in place with hot glue. If you find that the hole is too small, then file the edges until the transformer fits.

Fabricating the High-Voltage Arc Rods

The next step is to fabricate the high-voltage arc rods that form the 'ladder.' Use a metal coat hanger to cut two rods 7-1/4 inches in length. Each rod will need to be bent at one end so that they can be attached to the high-voltage output contact and negative connector terminal of the transformer. Refer to Figure 9 as a bending guide and Figure 1 to get an idea of how the rods need to be shaped. You will need to use a pair of pliers and a pair of vice-grips when bending. A table vice can also be used to hold the rod in place while bending. It might take some trial and error to get the rods bent into their proper shapes.

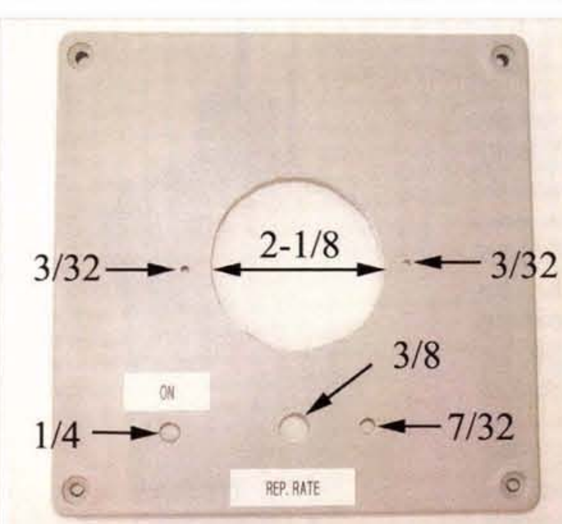


Figure 6. Approximate drilling locations and drill bit sizes for the front panel.

Make a U-shaped bend at the end of the negative connector arc rod — as shown in Figure 9 — so that the end fits snugly around the connector and stands vertically when fastened. Bend one end of the high-voltage output arc rod in a circular fashion, so that it fits snugly into the circular metal contact at the center of the transformer's high-voltage output. When the rods fit correctly, use a utility knife to carefully scrape the shellac off of the metal at the ends that contact the high-

Figure 7. Hole saw with a 2-1/8 inch diameter.

Figure 5. Parts placement and wiring diagram.

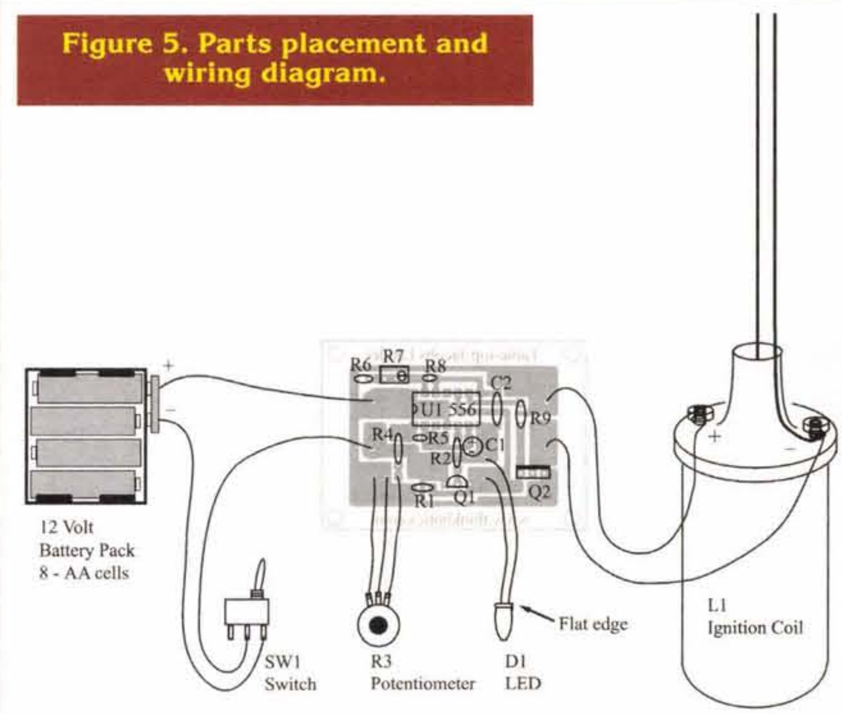


Table 1. Desktop Jacob's Ladder Parts List

Part	Quantity	Description
Resistors		
R1,R2,R4,R5,R6, R8,R9	1 each	1K ohm, 1/4 watt
R3	1	100K ohm potentiometer with a 3/8-inch threaded mounting shaft
R7	1	100K ohm trimmer potentiometer
Capacitors		
C1	1	4.7 uF electrolytic
C2	1	.001 uF ceramic
Semiconductors		
Q1	1	2N3904 NPN general-purpose transistor
Q2	1	IRF530 N-Channel power MOSFET
U1	1	556 Dual timer IC
D1	1	Red light emitting diode
Misc.		
IC socket	1	14-pin IC socket
PCB	1	Printed circuit board available from: www.thinkbotics.com
L1	1	12-volt automotive ignition transformer available at automotive parts suppliers
SW1	1	SPST power switch
Battery pack	1	12-volt battery pack, eight AA cells
Battery clip	1	9-volt type battery clip
Hook-up wire	5 feet	#18 insulated wire
Project case	1	Plastic junction box 6" wide x 6" length x 4" tall available from Home Depot
Knob	1	Instrumentation knob for R3
Metal coat hanger	1	Used to fabricate the arc rods
Hot glue		Hot glue and glue gun to fasten arc rod

Karl P. Williams is an independent robotics researcher, electronics experimenter and software developer who lives in Ontario, Canada. He has hosted a robotics web site for the last four years (**www.golden.net/~kpwillia**) and has been inventing, building, and programming robots since the early 1980s. He is currently employed by Mitra Imaging (**www.mitra.com**), a leading medical imaging software company recently acquired by AGFA. He is the author of a robotics book titled *Insectronics: Build your own six legged walking robot* (ISBN: 0-07-141241-7) that will be published by McGraw-Hill professional in the fall. He can be contacted at **www.thinkbotics.com**.

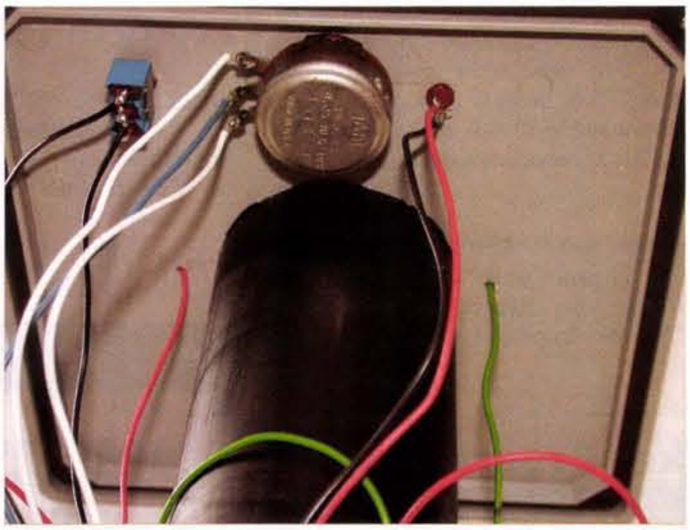


Figure 8. Underside view of the control panel.

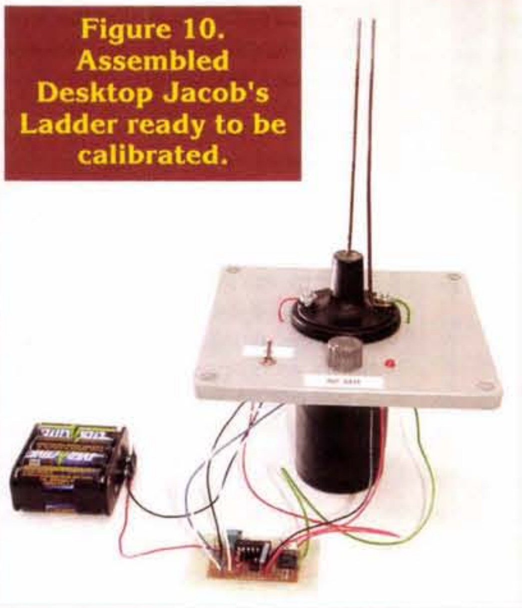


Figure 10. Assembled Desktop Jacob's Ladder ready to be calibrated.

voltage output and the negative connector. Also use the utility knife to scrape the shellac off of the rod along its length.

Push the high-voltage output rod (shown in Figure 9) into the transformer's middle connector and position it so that it is centered and stands up vertically. Fasten the rod into place by filling the space around the high-voltage output terminal and the arc rod with hot glue. Place the other arc rod around the negative connector. Hook the negative wire from the driver circuit up to the negative terminal, as well, and secure both in place by tightening the nut. Fasten the positive wire to the positive terminal of the ignition transformer and secure in place by tightening the connector nut. Refer to Figure 10 as a guide when gluing the high-voltage arc rod in place and when connecting the negative arc rod and wires from the driver circuit to the positive and negative connectors. When both arc rods are in place, there should be a space of approximately a quarter of an inch between the two. The rods should remain parallel from the bottom to the top. You can make slight adjustments to the position of the rods by gently bending them with your hands.

Calibrating the Circuit

Attach the 12-volt DC battery pack to the battery clip as shown in Figure 5. Rotate potentiometer R3 (repetition rate) all the way to the left. Use a small screwdriver to rotate trim potentiometer R7 all the way to the right. Turn the power switch to the on position. Slowly rotate R7 to the left until hot, blue arcs are produced between the arc rods. Experiment with the position of R7 until you find the setting where the strongest arcs are being produced. Rotate R3 to the right to decrease the amount of time between arcs, as desired.

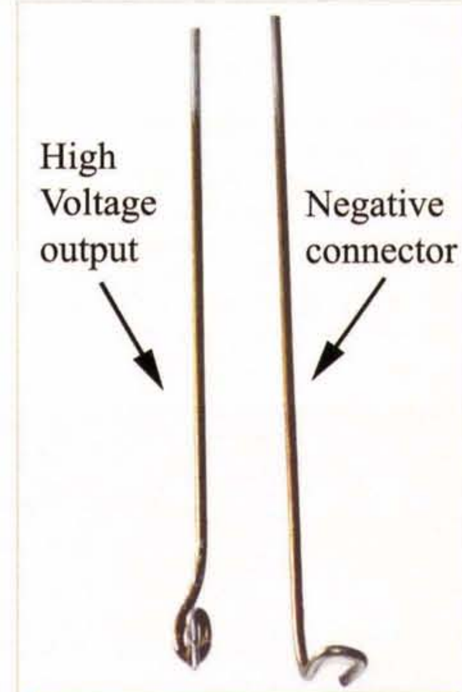


Figure 9. Bending guide for the arc rods.

When the circuit is calibrated, it can be placed inside the project box along with the battery pack. The lid should be secured in place with the four screws that came with the box. This project is battery powered so that the Jacob's Ladder is portable enough to be used anywhere and because the driver circuit can be used for other portable projects that may be discussed later. Note that this project should not be run continuously for long periods of time unless a heatsink is added to the power MOSFET Q2 and ventilation holes are drilled in the side of the case. A 12-volt DC 'wall-wart' type of transformer can easily be added if you plan on operating the unit where AC power is available. Use a label maker to indicate the on/off positions of the power switch and to label the repetition rate control knob. **NV**

Reader Feedback

Continued from Page 29

Walt Noon's Response:

I like your cylinder! Here's another great one:

Get a length of 2" PVC pipe and two end caps. Use another 3/4 schedule 40 or better PVC pipe for your piston rod. On the end of the piston rod, glue PVC pipe caps of progressive size one inside the other until you you have a piece that fits the inner diameter of the 2" pipe and has a cap at its center that attaches to the 3/4 rod. (This is how you make your piston.)

Using spade-type drill bits (usually used on wood), drill a hole for your rod to go through in the center of one of your 2" end caps.

Finally, attach an ordinary solenoid sprinkler valve to your airline, and thread it in to the bottom of the cylinder (which is the remaining 2" cap).

Use primer and PVC glue to assemble the whole cylinder.

You now have a cylinder of MASSIVE power, and any length you want to make it! All for under $20.00, valve included!

Walt Noon

Dear Nuts & Volts:

Thank you for publishing Mark Van Steenburgh's article "Simple Interface Uses Common Tools" in *Nuts & Volts.* It was very helpful.

Douglas Oeste
via Internet

Dear Nuts & Volts:

I enjoyed the article ("Simple Interface uses Common Tools") in *Nuts & Volts* very much.

Steve Yang
via Internet

News Bytes

LOCAL BUILDERS HOST ROBOT RUMBLE

The Northeast Robotics Club is sponsoring a Combat Robot competition to be held on Saturday, February 22 and Sunday, February 23, at the Motorama Indoor Races and Speed Show, located in Harrisburg, PA. Over 100 robots built by competitors from all over the country will be entered. Robot weight classes included will range from one pound, and weights to 60-pound lightweights.

Even if you don't have a robot to enter, feel free to stop by and visit on Friday the 21st. Robots will be on display at a meet-and-greet, and the public will be invited to take a closer look, and possibly try out robots like you have seen on TV. The NERC is a rapidly growing group of robot builders with a membership centered on the Philadelphia region. Check out **www.robotconflict.com** for more information, or to enter a robot in this competition. For further information, contact Ed McCarron at **emccarron@robotconflict.com**.

Beach Cities Robotics Team 294 Ready to Mentor New Teams

Beach Cities Robotics Team 294 is ready to mentor new teams from local public, or private high schools who sign up to participate in FIRST's (For Inspiration and Recognition of Science and Technology, www.usfirst.org) 2003 season. Event registration is open from Oct. 1, 2002 through Dec. 13, 2002.

The team meets at RUHS Auto Shop, 620 Diamond St., Redondo Beach, CA, three times a week; 4pm-7pm Tuesdays and Thursdays, 10am-4pm Sundays. Interested 9th-12th graders attending MCHS or RUHS, parents, and interested public can stop by to see what's going on. Call 310-944-9334 for more details or go to **www.bcrobotics.org**.

by Jon Williams

Stamp Applications

It's All About Angles

On my visit to the California office in October, I was handed a pile of sensors to evaluate and work with — a couple of them we're going to look at here. So let's finish off the year where we started last month, with an angle on sensors; specifically those that give us an indication of angle.

Have I ever told you about my buddy, Chuck? Chuck is a great guy. He's friendly, he's personable and he loves BASIC Stamps. Truth be told, Chuck is actually the grandfather of the BASIC Stamp. That's right, Chuck's son Chip invented the BASIC Stamp way back when. Since then, Chuck has been very involved in Stamps and has been an integral part of BASIC Stamp development since the BS2sx days.With a background in aerospace, the Chuck-Dawg (my nickname for him since he labels those who please him as "good doggies") enjoys connecting sensors of various types and arrangements to the BASIC Stamp. It's safe to say that he's passionate about sensors; he is always on the lookout for new sensors and how they can be connected to the BASIC Stamp to solve various engineering problems.

Memsic 2125

The first sensor we'll look at is the Memsic 2125 dual-axis accelerometer. The 2125 is identical to the ADXL202, but uses a different technology. Inside, the Memsic 2125 actually has a small heater that warms a "bubble" of air. When the sensor moves, this heat bubble moves and is detected by thermopiles that surround the heater. Changes detected by the thermopiles are conditioned and the outputs are pulses (one for each axis) that correspond to the forces acting on the sensor.

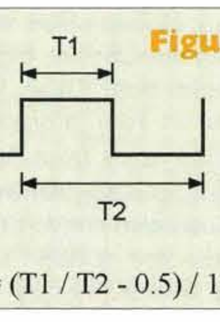
The Memsic 2125 comes in a surface-mount package so Parallax has made a DIP carrier that is convenient for prototyping. In addition to the X and Y pulse outputs, an analog output for die temperature is available [for compensation when needed]. You'll need a separate analog-to-digital converter to measure the temperature output.

Let's keep our focus on acceleration. Take a look at Figure 1. This shows the pulse output from the 2125 and the formula for calculating acceleration. For the Memsic 2125GW (that we'll use), the output range is ±2g and the value of T2 is fixed at 10 milliseconds. For 0g, the T1 output will be five milliseconds; a 50% duty-cycle.

As you can see, the math is pretty easy. Here's how we handle it with the BASIC Stamp:

```
Read_X_Force:
  PULSIN Xin, HiPulse, xRaw
  xRaw = xRaw * 2
  xGForce = ((xRaw / 10) - 500) * 8
  RETURN
```

Figure 1



A (g) = (T1 / T2 - 0.5) / 12.5%

Since the Memsic 2125 output is a pulse, we'll use **PULSIN** to measure it. Remember, though, that the value returned by **PULSIN** is in two-microsecond units. We can adjust for this by multiplying the raw pulse width value by two.

Since our T1 time is in microseconds and there are 1,000 microseconds in a millisecond, we need to multiply the T2 value and 0.5 by 1,000 to adjust the equation. This makes the math easy for the Stamp and gives us an output with a resolution of 0.001g. Finally, the divide by 12.5% part of the equation is converted to multiplying by eight (1 / 0.125 = 8) — we couldn't ask for a value much more convenient than that.

One of the many useful applications of the 2125 is to measure tilt. At Parallax, we're particularly interested in measuring tilt in robots; like our Toddler and SumoBot. In the Toddler, measuring tilt helps us fine-tune the walking algorithm and ensures that it doesn't ever lean too far to one side or the other. In the SumoBot, we're working on escape algorithms based on measuring robot tilt when the motors have stalled.

Again, we luck out, because within the range of useful tilt angles for our projects, the calculation of tilt from g-force can be handled with a linear equation.

Tilt = g x k

where k is taken from the following table (provided by Memsic):

°arc	k (°arc per g)	Error (°arc)
±10	57.50	±0.02
±20	58.16	±0.16
±30	59.04	±0.48
±40	60.47	±1.13
±50	62.35	±2.24

Now, we could take the easy route and use 62.35 as our conversion factor, but this would give us an error at low tilt angles that we really don't need to tolerate. What we'll do, then, is work backward from this data and determine the output from the 2125 at the angles specified in the chart. Then we can use **LOOKDOWN** to compare the 2125 output to the chart and a **LOOKUP** table to determine the proper tilt conversion factor.

Calculating the maximum g-force output for a given range is done by dividing the arc for a range by its conversion factor. This will give us the maximum g-force output for that range.

$10 \div 57.50 = 0.17391$
$20 \div 58.16 = 0.34387$
$30 \div 59.04 = 0.50813$
$40 \div 60.47 = 0.66148$
$50 \div 62.35 = 0.80192$

Remember that the g-force output from the BASIC Stamp code is in

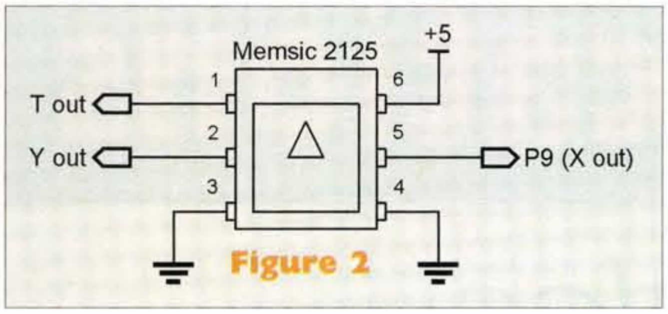


Figure 2

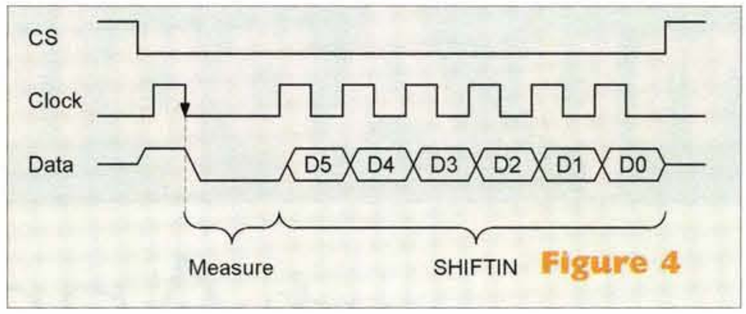


Figure 4

0.001g units, so we'll multiply the results above by 1,000 for use in a LOOKDOWN table. Let's look at the code that converts g-force to tilt.

```
Read_X_Tilt:
 GOSUB Read_X_Force

 LOOKDOWN ABS xGForce, <=[174, 344, 508, 661, 2000], idx
 LOOKUP idx, [57, 58, 59, 60, 62], mult
 LOOKUP idx, [32768, 10486, 2621, 30802, 22938], frac

 xTilt = mult * (ABS xGForce / 10) + (frac ** (ABS xGForce / 10))

Check_SignX:
 IF (xGForce.Bit15 = 0) THEN XT_Exit
 xTilt = -xTilt

XT_Exit:
 RETURN
```

The routine starts by reading the g-force with the code we developed earlier. The absolute value of the g-force is compared to **LOOKDOWN** table entries to determine the index position (in the other tables) of our conversion factor.

Again, we're using the conditional operator with the **LOOKDOWN** table. In our case, **LOOKDOWN** will identify the first location of table data that is less than or equal to (<=) the g-force value. This position is moved into the variable idx and serves as an index for the next two **LOOKUP** tables. Note that the final value in the **LOOKDOWN** table is 2000, not 802 as you might expect. This is the maximum output from the Memsic 2125 and assigns the 62.35 conversion factor to all tilt angles above 40 degrees. Remember that it's only accurate to ±50 degrees.

In order to use the ** operator — which gives us the best resolution when multiplying by fractional values - we have to separate the conversion factors into their whole and fractional elements. The first table contains the whole part, the second table contains the fractional part. The entries for the second table are calculated by multiplying the fractional portion of each conversion factor by 65,536.

All that's left to do now is the math. The g-force value is divided by 10 in each part of the equation to prevent a roll-over error, and the **ABS** (absolute) function must be used because we can't do a division on a negative number. We do a straight multiply with the whole part, use ** with the fractional part, then add them together. The result with be in 0.01 degree units.

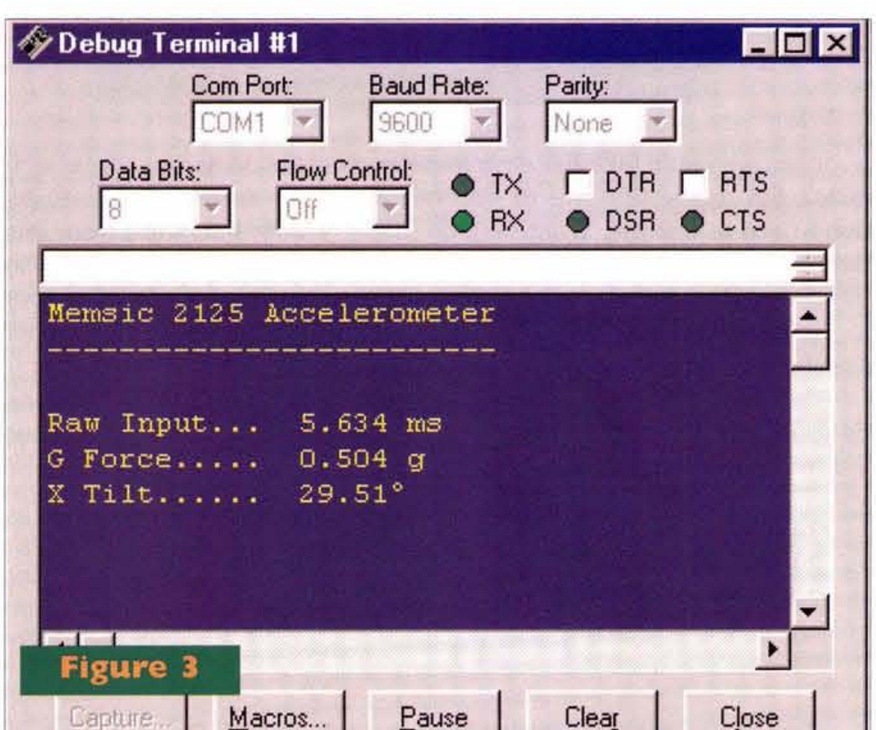


Figure 3

In order to know which direction we're tilted, we have to put the sign in. We can do this by checking bit 15 of the g-force value. If this is one, the g-force and tilt are negative.

Connect the Memsic 2125 (Parallax module) as in Figure 2 and download the rest of the demo code. If you tilt the board so that the end indicated by the pointer is higher, you'll get an output as in Figure 3.

Austria Microsystems AS5020-E

The AS5020 is a really neat little sensor; it's an absolute angular position encoder — and a gift from the Chuck-Dawg, no less.

Inside the AS5020 is a Hall-Effect sensor array, allowing it to determine the angle of a magnetic field that is placed in close proximity to its body. The output is a six-bit value which will give us one of 64 positions, or an angular resolution of 5.6 degrees.

Connecting to the AS5020 is very much like connecting to a DS1620, DS1302, AC0831, or any other three-wire device. The Chip Select (CS\) pin is brought low to activate the AS5020, then **SHIFTIN** is used to read the position using the Clock and Data lines. There is just one caveat: the AS5020 requires an extra pulse on the clock line to initiate the measurement cycle. Take a look at Figure 4 to see the AS5020 signaling.

The measurement cycle actually starts on the falling edge of the clock line after the Chip Select is taken low. Don't be fooled into thinking that you can just add an extra bit to the **SHIFTIN** function, this won't work. The reason is that **SHIFTIN** expects a data bit to be ready after each clock and, in this case, that won't happen.

What we'll do to initiate the measurement cycle is use **PULSOUT** to create that extra transition. As I just mentioned, a high-to-low transition on the clock line is what actually initiates the measurement cycle. After the measurement, we use **SHIFTIN** to collect the position value.

Here's the code:

```
Get_Position:
 LOW CSpin
 PULSOUT Cpin, 1
 PAUSE 0
 SHIFTIN Dpin, Cpin, MSBPOST, [position\6]
 HIGH CSpin
 RETURN
```

As you can see, the code follows the communication diagram step-by-step. After selecting the device by bringing the CS\ line low, the measurement pulse is created with **PULSOUT**. I threw a **PAUSE** 0 into the code for faster BASIC Stamps, but the routine works fine without it on a stock BS2. The data output from the AS5020 is six bits wide, appearing MSB first and after the clock line falls. The correct **SHIFTIN** parameter, then, is MSBPOST (sample bit post clock). Since the position value is only six bits, we need to specify that in the **SHIFTIN** function. If we leave the \6 parameter out, **SHIFTIN** would collect eight bits and the extra bits would have to be removed from the position value by dividing it by four. After we have the position, the AS5020 is deselected by taking the CS\ line high.

Simple, huh? Okay, what do we do with the data now? Well, that depends on your project. You can download a couple of interesting application notes from Austria Microsystems that show how to use the device for both angular and linear position indication.

We can also convert the position value to an angle with a bit of simple math. The position to degrees conversion factor is calculated by dividing 360 degrees by 64 positions; this gives us 5.625 degrees per position. If we multiply this by 10, we can convert the AS5020 output to tenths degrees with this line of code:

```
degrees = position */ 14400
```

For review, the */ parameter is calculated by multiplying 56.25 by 256.

Another feature of the AS5020 is the ability to reprogram its output so that you can align zero to any position you choose. This can be tricky though, because it requires a higher voltage on the programming pin and sending the position data. We don't have to go through that much trouble; we can easily calibrate a project using PBASIC.

The way we'll do it is to take an initial reading, then subtract this value from 64. This will give us a position offset. Set the project to its "zero" position, then run this code:

```
Set_Offset:
 offset = 0
 GOSUB Get_Position
 offset = 64   position
```

Resources:

Jon Williams
jwilliams@parallaxinc.com

Parallax, Inc.
599 Menlo Drive, Suite 100
Rocklin, CA 95765
www.parallaxinc.com

Memsic 2125
www.memsic.com

Austria Microsystems
AS5020-E
www.austriamicrosystems.com

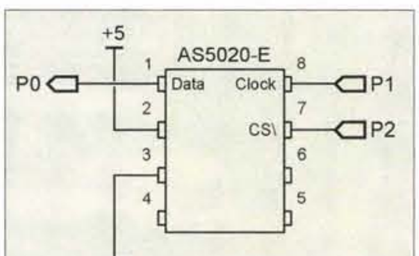


Figure 5

Now, by adding the offset to the current position, then using the modulus operator, we can adjust the output for our calibrated "zero" position. Add this line of code to the end of the Get_Position subroutine to integrate the offset:

```
position = position + offset // 64
```

Remember, the modulus operator returns the remainder of a division, so the line of code above will keep the position value between 0 and 63, which corresponds to the standard output from the sensor. The difference now is that we've set the zero position and we can reset it as required.

Happy Holidays

Wow, it's hard to believe that another year has come and [nearly] gone — time sure does fly by quickly when you're having fun, doesn't it? I appreciate all of you who have sent email or called with suggestions for the column. I sincerely enjoy hearing from you and about your projects — keep that email coming!

Next year will be very exciting, I'm sure. A big improvement is coming in the BASIC Stamp editor software and the long-awaited next-generation BASIC Stamp should probably show up in 2003, as well. Like the original BASIC Stamp, it's going to change perceptions of what an easy-to-program embedded microcontroller can do.

Finally ... on behalf of my family and my extended family at Parallax, please allow me to wish you and yours a very happy and peaceful holiday season. Let us hope that the new year brings peace and prosperity for every person, no matter their race, creed, or religion. God bless you all. NV

Double-Duty Radio Flagpoles

By Gordon West

Whether you are a ham radio operator or a shortwave/scanner radio listener, consider the telescopic aluminum flagpole.

Telescopic aluminum flagpoles work great as a disguised high-frequency antenna system, as well as a "quick up" antenna mast if you take your radio mobile or portable. Whether you are a ham radio operator or a shortwave/scanner radio listener, do consider the telescopic aluminum flagpole an important element for your radio hobby.

DISGUISED HIGH-FREQUENCY ANTENNA

If you live in a planned community that may disallow CB and ham antennas on the roof, look around and see whether or not you see nearby homeowners with a flagpole out front. Many planned communities may not have an ordinance against a flagpole; and if they give you the go-ahead, get set for some terrific worldwide radio range.

A Marconi one-quarter wavelength vertical antenna for the ham radio 20-meter band would measure approximately 16 feet. The 20-foot telescopic flagpole is almost a perfect match. For the popular 40-meter frequencies — a popular ham and shortwave nighttime band — a one-quarter wavelength vertical would be approximately 32 feet long. This makes the flagpole a little too short, but we have a solution. Since shortwave listeners and ham radio operators may want capabilities from 160 meters through six meters, or antenna lengths of 234 feet through 48 inches, a remote-mounted, okay-to-bury, automatic antenna tuner will work swell. For information on the SGC tuner, see resources.

The SGC tuner is required for ham radio transmitting and receiving. For shortwave listening, no tuner required.

In both cases, non-contaminating, waterproof, coaxial cable, buried in PVC tubing, feeds the signal from out front to your radio set-up inside the house. The automatic tuner also requires 14-gauge, two-conductor, 12-volt DC cable for power. You could also piggyback the 12-volt DC right along the same coaxial cable as what carries the radio signal, using an isolator at each end of the circuit to split out the voltage. But since you're going to run your transmission line inside PVC, you have plenty of room to add some two-conductor, as well. I like Belden #9913 or Times LMR-400 for a low-loss coax cable run to the distant flagpole out front.

The flagpole can hold some fair-sized beam antennas.

Once you have your community go-ahead on the flagpole, find a location as far away from the side of the house to minimize signal absorption. Also watch that you stay away from any overhead wires. If your planned community has underground cables, make absolutely sure you're not going to cut into them while trenching your coax cable run and digging a hole for the flagpole holder!

Flagpole drive-over mount gets Gordo on the air at a hamfest (left rear wheel).

The base of the flagpole is going to require some extra digging to accommodate the automatic tuner. I usually put the tuner in one of those kitchen, indestructible, pliable, plastic boxes. You won't be sealing the tuner box completely up because the slight amount of heat that the microprocessor generates will help drive out moisture.

If where you are going to mount your flagpole is easy to dig into, chances are you have good, soft ground conductivity. But if you're trying to dig the mast-mount into extremely dry soil, you will need to come up with your own manmade ground system. A good ground plane is absolutely necessary if you plan to transmit off the flagpole. For just reception, a little bit of ground is fine.

If you are going to be transmitting on ham or CB frequencies, you could calculate one-quarter wavelength radials, and trench-in copper pipe to act as your tuned radial system. Or if there are nearby copper

The flagpole holding a dipole antenna.

sprinkler pipes, grab onto them for a great un-tuned ground plane. You might also consider trenching-in ground screen or ground foil, available directly from Metal & Cable Corp. (See resources.)

You could also drive in ground rods, but again, make absolutely sure you don't punch through anything below other than the ground! If you have underground utilities, make absolutely sure where you are pounding in ground rods!

If you're working the tuner off the flagpole, the tuner ground lug goes to your copper ground connection, and the tuner output post ultimately goes to the base of the aluminum flagpole.

Uncommon USA is the company that I have had the best success with in working as radio antennas with their flagpoles.

The installation sleeve should be non-metallic, or you can obtain PVC to keep the mast in place. Cement the non-conductive receiver into the ground, leaving a couple of inches of sleeve exposed where you might tap into the aluminum for your antenna connection. The tuner goes within a foot, and gets covered up with grass, too.

The flagpole comes with rope and a pulley, and is made of 16-gauge aluminum. As you expand each section out, spring-loaded snaps will click in and lock the

The flagpole can even support the big three-element beam.

Close-up of flagpole inside hitch mount. Hitch mount lays down too by removing the pin.

The flagpole goes up in seconds!

Tire flagpole support works well on a hard surface, but not so well in dirt or sand.

extension in place, usually providing a good low-resistance electrical connection. Double-check that all connections holding the flag are the plastic ones supplied by Uncommon. This way you won't have any intermittent connections with the flag flying.

They also have shorter poles with less extensions, and longer poles with more extensions. If you are really serious about your worldwide operating at night, get the 25-foot telescopic flagpole.

Once everything is up, fly the flag, but don't start transmitting for a few weeks. In case you transmit into someone's telephone, or come over your next door neighbor's hi-fi, you don't want them to associate your new flagpole with the new interference they might be getting. But if you put your flagpole well out and away from the house, RFI should be at a minimum.

Regularly water the lawn to improve ground efficiency. The more efficient the ground, the more current the tuner will impress on the flagpole mast.

This same type of flagpole can be used for supporting lightweight beam antennas or vertical antennas when you are out in a vehicle. Uncommon Corporation sells both hitch-mounts, as well as drive-on aluminum mounts, to receive their telescopic flagpole. As long as you don't go overboard with the type of beam or vertical antenna you are going to mount at the top of the pole, you shouldn't need any guy ropes.

Caution: Always look up for nearby live wires before extending the flagpole up. You could be killed if the flagpole comes in contact with high-voltage wires.

I like the Uncommon Corporation flagpole better than "others" because it has an internal guide to keep each section from rotating. This makes it easy to snap up each section, and it also prevents heavy winds from accidentally turning the mast and dislodging the pop-out pins. I have tried many different flagpole manufacturers, and the Uncommon flagpole is the highest quality of them all!

Be sure to fly the colors when your flagpole is up, and now enjoy a flagpole that will do double-duty as an antenna support, as well as a live vertical antenna element. **NV**

SGC — 237 Smart Tuner
1.8-60 MHz / 3 to 100 watts
Waterproof and okay-to-bury
$339.00 suggested retail
www.sgcworld.com

Metal & Cable Corp.
330-425-8455
www.metal-cable.com

Uncommon USA
1-800-419-5880
20-foot white pole
$289.00 (show price)
Installation sleeve and collar, $20.00
www.uncommonusa.com

 Continued from page 65

by noting the milliampere-hour rating of the cell phone battery, and the talk-time that the manufacturer states in the instruction book for your phone. For example, if a cell phone has a battery that has a capacity of 900 milliampere-hours and the talk time is specified as three hours, the current draw is approximately:

$$\text{CURRENT DRAW} = \frac{900 \text{ milliampere-hours}}{3 \text{ hours}} = 300 \text{ milliamperes}$$

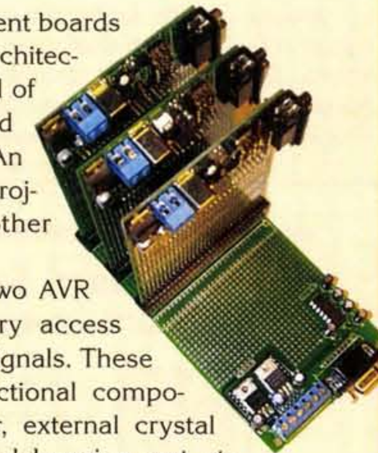
Always use the same dimensions (milliamperes or amperes, hours or minutes) for both numerator and denominator. Once the talk-time current is known, the approximate charger operating time can easily be calculated. Assuming the charger delivers 25 milliamperes to the battery and the cell phone requires 300 milliamperes to operate, the number of minutes the charger must be operated for each minute of talk time would be:

$$\text{CHARGE TIME} = \frac{300 \text{ ma}}{25 \text{ ma}} = 12 \text{ minutes}$$

Since battery charging is not 100% efficient, you should allow extra time for charging. Although the charging rate is relatively slow, you will be very secure knowing that your cell phone will operate no matter where you go. **NV**

New Product News

NESTED AVR MICROCONTROLLERS MAKE MODULAR ROBOTICS EASIER



This new family of project/development boards revolves around the popular AVR architecture. It has been designed with the goal of making robotic projects, or embedded system designs, easier and modular. An entire system consists of a series of project/development boards and a mother board

A project board contains one or two AVR microcontrollers with all the necessary access points such as ports, reset, and clock signals. These boards include all the necessary functional components such as reset voltage manager, external crystal oscillator, ISP programming port, JTAG debugging port, etc. Also, the board includes a voltage regulator and a serial communication DB9 connector in case the user wants to use it on stand-alone mode.

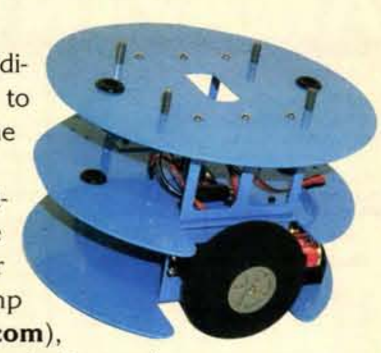
The mother board will interconnect up to three project boards by means of an edge card connector, which allows up to 62 lines to be shared. This mother board also includes functions such as voltage regulators to generate 12V and 5V power sources and a completely working serial port interface ready to plug into any PC RS-232 COM port.

Hobbyists, as well as professional designers will find the prototyping area in both project and mother boards to provide more than enough space to complete most implementations. These products are both attractively priced, and are available for ordering via the website. They can be purchased separately or in multi-part combos to expand flexibility.

For more information, contact:

Email: **Avayan@avayanelectronics.com**
Web: **www.avayanelectronics.com**

ROGUE BLUE ROBOT BASE GETS MORE BRAINS!



Rogue Robotics announces additional microcontroller support to its successful robotics platform: the Rogue Blue Robot Base.

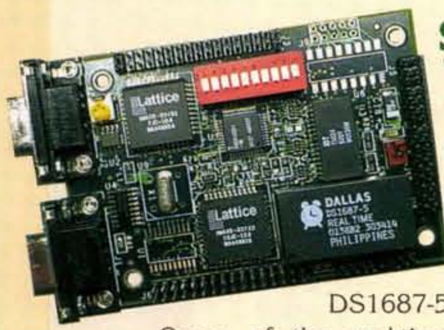
This new version allows the following boards (or "brains") to be mounted to the robot: Basic Board Jr (**www.elproducts.com**), JStamp development board (**www.jstamp.com**), Adapt12 system (**www.technologicalarts.com**), OOPIC 1 and 2 (**www.oopic.com**), Mini Robomind (**www.robominds.com**), Parallax Board of Education (**www.parallaxinc.com**), ISOPOD development board (**www.isopod.com**), Dontronics DT005 passive motherboard (**www.dontronics.com**), and the Rogue Robotics SIMMBOT system.

The Rogue Blue Robot Base is an eight-inch round base with three high levels, two central three-inch servo-driven wheels, and sensor mount mounting holes on the first and second levels for greater flexibility and ease of installation. The base is a highly stable platform for smooth surface experimentation and research. Ideal for hobbyists, educators, researchers, and robot enthusiasts.

The Rogue Blue robot base sells for US $119.00. It is also available as a full robot kit bundled with the Parallax Board of Education (US $219.00) or as a Rogue Robotics SIMMBOT (US $219.00). And for as little as US $79.00, a Parallax BOE-BOT can be upgraded to a Rogue Blue robot with the Rogue Blue BOE expansion pack.

For more information, contact:

ROGUE ROBOTICS
103 Sarah Ashbridge Ave., Dept. NV
Toronto, ON M4L 3Y1 Canada
416-707-3745 Fax **647-439-1577**
Email: **info@roguerobotics.com**
Web: **www.roguerobotics.com**



SEAFIRE SF-1004 WTH REAL-TIME CLOCK

SeaFire Micros, Inc., announces the newest member of the SeaFire 1000 Series, the SF-1004 single board computer, with the Dallas DS1687-5 real-time clock.

Some of the real-time clock features include non-volatile SRAM, power management and control, six interrupt sources, time/date power-on, external wake pin, four alarms, and time with date, month, and year.

The SeaFire 1000 series is based on the powerful Atmel AT89C51CC01 microcontroller, an 80C51 superset, complete with a CAN interface, eight-channel ADC, up to 5 PWM outputs, multiple 16B timers/counters/PCAs, and watchdog.

The SF-1004 is upgradeable to over 256kByte SRAM, and 288 KBytes flash. The microcontroller board also has up to 50 configurable I/O, an RS-232 interface, and expansion CPLDs for customizing the board through ABEL, Verilog, or VHDL. Pricing starts at $125.00 each with OEM discounts available.

For more information, contact:

SEAFIRE MICROS, INC.
www.seafiremicros.com
info@seafiremicros.com
978-317-1831

68HC9S12DP256 DEVELOPMENT BOARD

The EVBplus9S12DP256 board is a low-cost, feature-packed development board for the new Motorola 68HC9S12 microcontroller family. It is compatible to the Motorola 9S12DP256EVB board and other similar development boards from Axiom and Technological Arts, but it also incorporates many on-board peripherals that make this board a better value for users.

For engineers, it's a convenient prototype platform suitable for designers who want to rapid develop and prototype new 68HC9S12 applications. For students, it's an advanced microcontroller trainer. Use it to build a solid foundation of microcontroller expertise and to create a real world application for a senior project.

The Ep9S256DP board comes with many fully debugged, fairly complex, ready-to-run sample programs to help users to get up and running. The programs are ported from our EVBplus2 68HC11 development board and because the 68HC12 instructions are upward code compatible with the 68HC11 instructions, migrating from your 68HC11 projects into the new HC9S12 world could not be any easier.

The state of the art 68HC9S12DP256 controller is the most powerful chip in the family and it is loaded with hardware features, such as 25 MHz bus speed, 256K flash memory, 12K SRAM, and 4K EEPROM. On-chip peripherals include dual SCIs, triple SPIs, I2C, five CAN modules, two 10-bit eight-channel ADCs, eight PWMs, and eight 16-bit timers. It can also be used in evaluation and development of all other family members, such as A series and D series.

The on-board hardware includes BDM in and BDM out ports, solderless breadboard, logic probe, four robot servo outputs, 16x2 LCD display module, 4x4 keypad connector, fast SPI expansion port, speaker, four-digit seven-segment LED display, eight data-LED indicators, four mode-LED indicators, eight-position DIP switch, four push buttons, potentiometer, IR transceiver, RF transceiver, RS485 interface, three CAN ports, and dual SCI DB9 connectors. All I/O lines in the 112-pin male header and female receptacle provide an easy access for your experiments on the breadboard.

Supplied with an RS232 cable for connecting to a PC serial port and an AC adapter to power the board, the introductory price of the basic model is only $109.00. See more at www.EVBplus.com.

For more information, contact:

EVBplus.com
630-894-1440 Fax **509-461-4330**
www.EVBplus.com

POWERFUL COMPUTER MODULE WITH PROGRAMMABLE USER I/O

iCom-200 is Wilke Technology's tiny, but powerful Basic-programmed modular computer, housed in a sturdy aluminum case complete with LCD and keypad-based on the TINY-Tiger™ multi-tasking computer modules.

iCom-200 combines the efficiency and compactness of the well-known TINY-Tiger Basic computer blocks with useful peripheral components in a functional and robust aluminum chassis. Sized at only 196 x 88 x 40 mm, and weighing a mere 650g, programming iCom-200 is done in easy-to-use but powerful, multitasking Tiger-BASIC™.

With 512K SRAM and 512K EEPROM (more available), iCom-200 has a backlit 128 x 64 pixel graphics-LCD with 20-key keypad, as well as an external connector for MF2-keyboard. I/O available includes 1 x RS232, 1 x RS232/485, 4 x 10-bit analog inputs, 8 x opto inputs: 5V-12V, 8 x opto outputs; 8 x Darlington ouputs (max. 50V/500mA). Powered by 9-12 VDC, 450 mA, iCom-200 can operate at 0° to 50°C.

The iCom-200 development starter kit ($579.00) includes all the software and hardware components for development, test and programming iCom projects, including 90V-240V power supply. Programming is done in the easy-to-use Tiger-BASIC integrated development environment (ver. 5.01) with manual, sample programs and drivers, editor, Tiger-BASIC compiler, source-level debugger, and downloader for Windows 95/98/2000.

Available from stock, iCom-200-4/4 is $379.00 each.

For more information, contact:

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

Selected Titles For The Electronic Hobbyist and Technician —

The Nuts & Volts

Robotics

The Robot Builder's Bonanza
by Gordon McComb

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

Microcontrollers

AVR RISC Microcontroller Handbook
by Dr. Claus Kühnel

Comprehensive guide to designing with Atmel's new controller family, designed to offer high speed and low power consumption at a lower cost. Text is divided into three sections: hardware, software, and tools, which explains using Atmel's Assembler and Simulator. **$39.99**

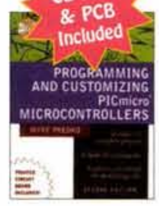
Programming & Customizing the 8051 Microcontroller
by Myke Predko

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

Programming & Customizing the HC11 Microcontroller
by Tom Fox

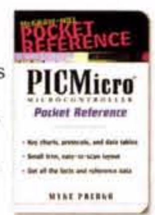
Applications bazaar for the 68HC11 microcontroller. Squeeze every last drop of power out of Motorola's wildly popular family of 68HC11 true 8-bit single chip computers! From basics to complete applications. ***$39.95***

Programming & Customizing PICmicro Microcontrollers
2nd Edition
by Myke Predko



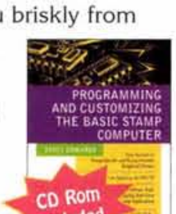
This book is a fully updated and revised compendium of PIC programming information. Comprehensive coverage of the PICMicro's hardware architecture and software schemes complement the host of experiments and projects making this a true, "learn as you go" tutorial. ***$49.95***

PICmicro Microcontroller Pocket Reference
by Myke Predko



Designed to complement Programming & Customizing the PICMICRO, this book contains a minimum of verbiage and serves as an immediate device, code and circuit look-up for experienced PICMICRO applications designers. $29.95

Programming & Customizing the BASIC Stamp Computer
by Scott Edwards



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

PIC Microcontroller Project Book
by John Iovine

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

The Nuts & Volts of BASIC Stamps Vol. I & 2

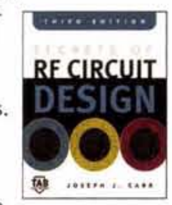
$29.95 each

$49.95 both volumes

In 1995, Scott Edwards began authoring a column on BASIC Stamp projects in *Nuts & Volts Magazine*. The column quickly became a favorite of *Nuts & Volts* readers and continues today with Jon Williams at the helm. *The Nuts and Volts of BASIC Stamps* is a collection of about 75 of these columns.

Radio & RF

Secrets of RF Circuit Design
3rd Edition
by Joe Carr

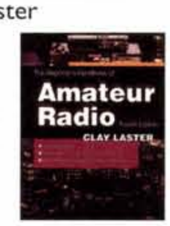


This revised and updated guide gives you the best ways to design, build, and test today's radio frequency circuits. It's filled with projects and experiments that make it easy to apply RF principles to real-life applications. ***$39.95***

Practical Antenna Handbook
4th Edition
by Joe Carr

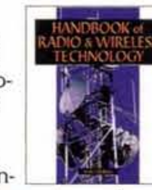
The most popular book on antennas ever written. This edition blends "the theoretical concepts that engineers and others need to design practical antennas, and the hard-learned practical lessons derived from actually building and using antennas." ***$49.95***

Beginners Handbook of Amateur Radio *4th Edition*
by Clay Laster



The revised edition of the most trusted guide in ham radio is here. This edition delivers all the guidance you need — from radio and electronics fundamentals needed to set up a transmitter to the newest equipment to revisions to the FCC rules and tests. ***$34.95***

Handbook of Radio & Wireless Technology
by Stan Gibilisco



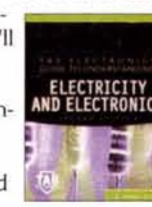
Containing more than 1,000 concise articles, this one-stop source of user-friendly insight provides blanket coverage of one of the fastest-growing areas in communications from antennas and transmission lines, to analog and digital modulation techniques, to satellite, space, and laser communications. ***$44.95***

Electronics

Practical Electronics For Inventors
by Paul Scherz

This experiment-oriented guide is loaded with over 750 hand-drawn images that support author Paul Scherz's crystal-clear, fully detailed instructions, showing you how to turn theoretical ideas into real-life gadgets. ***$39.95***

Guide To Understanding Electricity & Electronics
by Randy Slone



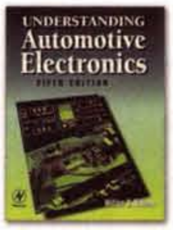
For the true beginner, there's no better introduction to electricity and electronics. You'll also find 25 complete projects that enhance your electricity/electronics mastery, including 15 new to this edition, and appendices packed with commonly used equations, symbols, and supply sources. ***$24.95***

Digital Electronics Guidebook: With Projects
by Myke Predko

Perfect for electronics hobbyists and students — even complete beginners — who want to understand digital logic and build their own low-cost logic circuits. Featuring more than 20 projects with step-by-step directions for designing, constructing, and interfacing easy-to-do TTL (Transistor-Transistor Logic) circuits. ***$34.95***

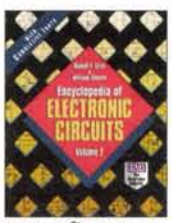
Hobbyist Bookstore

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



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

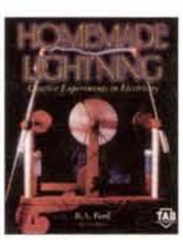
Encyclopedia of Electronic Circuits Vol. 7
by Rudy Graff



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

High Voltage

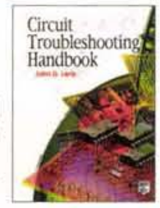
Homemade Lightning: Creative Experiments in Electricity
by R.A. Ford



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

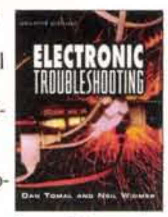
Troubleshooting

Circuit Troubleshooting Handbook
by John D. Lenk



Heavily illustrated with diagrams and schematics, it uses a standard, easy-to-follow format to help readers understand and troubleshoot a wide range of circuit types, and provides proven circuit testing techniques for all levels of instrumentation.
$39.95

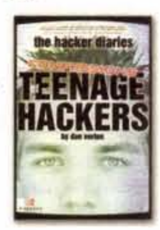
Electronic Troubleshooting *2nd Edition*
by Dan Tomal and Neil Widmer



This updated tool gives all the fundamentals needed to do successful servicing and repair work, blending traditional theory with the very latest insight into modern electronics technology. Time-saving tables, charts, and illustrations pinpoint equipment problems in a snap. Numerous reference guides, rules of thumb, and tricks of the trade all combine to assist in troubleshooting the full spectrum of devices and products more easily than ever before. ***$39.95***

Miscellaneous

The Hacker Diaries: Confessions of Teenage Hackers
by Dan Verton



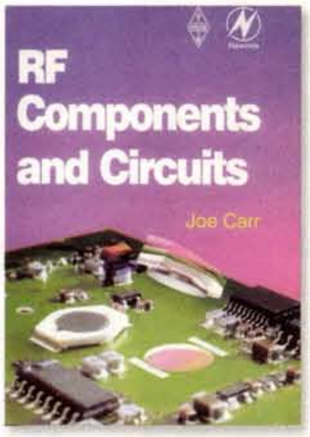
Through fascinating interviews with FBI agents, criminal psychologists, law-enforcement officials—as well as current and former hackers—you'll get a glimpse inside the mind of today's teenage hacker. Learn how they think and understand the internal and external pressures that pushed them deeper and deeper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

This Month's *NEW* Titles

RF Components and Circuits

by Joe Carr

$37.99



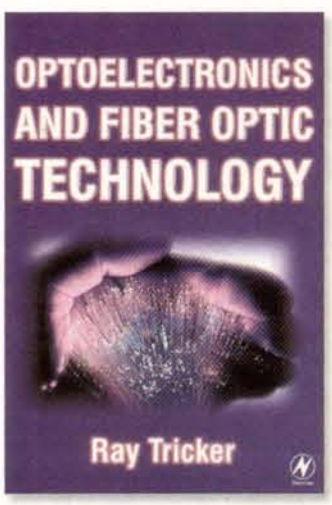
RF Components and Circuits covers the practicalities of designing and building circuits, including fault-finding and use of test equipment.

The circuits covered in this book are the heart of the electronic design of TV sets, personal mobile radio, remote control systems, mobile phones, and digital TV and radio, making it essential reading for radio and electronics engineers, students, and advanced electronics hobbyists.

Joe Carr demystifies the RF design process, presenting real-world design principles, tips, and rules-of-thumb with a minimum of mathematics. By explaining how different circuit types work, and how they can be modified, Joe provides a master-class that is essential reading for electronics experts and newcomers to RF design alike.

Optoelectronics and Fiber Optic Technology by Ray Tricker

$29.99



All the key technologies are described: types of cable, transmitters, receivers, couplers, connectors, etc., with the emphasis firmly on their selection and application. Key aspects of installation, test techniques, safety, and security are also covered in depth, making this book a genuinely useful guide for engineers and managers alike.

Topical areas such as optoelectronics in LANs and WANs, cable TV systems, and the global fiber-optic highway make this book essential reading for anyone who needs to keep up with the technology of modern data communications.

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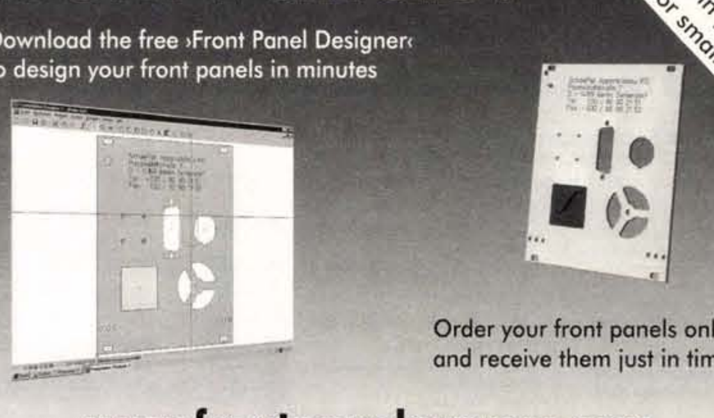

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Sold in 4 ft lengths UL
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80mm 24V(PL80B24H)	$5.95	4.25	3.95	3.28
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An intelligent multi-function counter controlledby an 8-bit micro-controller with eight-digit high bright LED display. Four measuring functions (frequency,period, total mode & self-check). Also,a 10MHz OSC.OUT.

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An affordable USB digital oscilloscope for students & hobbyists
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$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 MobileTelephone Comm systems, Cellular Phones,Cordless phones, paging systems, cable &Satellite TV as well as antenna installations.May also be used to locate hidden cameras using RF transmissions

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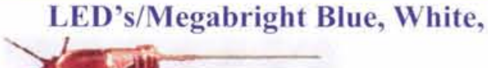

		luminous intensity @ 20mA	1	10+	100+
Megabright Blue 5mm	(L7113PBC/G)	1400	$1.95	$1.50	$1.25
Megabright Blue 3mm	(L7104PBC/G)	600	$1.95	$1.50	$1.25
Megabright White 5mm	(L7114PWC/G)	600	$2.15	$1.59	$1.35

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Single Turn 1/4" SQ. Cermet Pots (Horiz. & Vertical)
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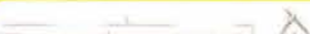

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item	length	price	item	length	price
GL3-100	4 inch	$.25/bag	GL5-400	16 inch	$2.49/bag
GL4-150	6 inch	$.49/bag	GL8-200	8 inch	$1.99/bag
GL4-200	8 inch	$.79/bag	GL8-300	12 inch	$2.79/bag
GL4-250	10 inch	$1.15/bag	GL8-400	16 inch	$3.99/bag
GL4-300	12 inch	$1.29/bag	GL10-400	16 inch	$5.49/bag
GL5-200	8 inch	$.99/bag	GL10-500	20 inch	$6.15/bag
GL5-250	10 inch	$1.39/bag	GL10-600	23.5 inch	$9.29/bag
GL5-300	12 inch	$1.69/bag	GL10-800	31.5 inch	$13.99/bag
GL5-350	14 inch	$2.29/bag	GL12-650	25.5 inch	$12.49/bag

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