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by Jeff Eckert

TechKnowledgy 2002

Advanced Technologies

Night Vision for Cars a Step Closer

Indigo Systems Corporation **(www.indigosystems.com)**, a manufacturer of infrared cameras and telecommunications devices, recently announced a strategic partnership with Autoliv, a company that deals with automotive safety systems. The alliance is intended to jump start the development of affordable infrared devices for use in automobiles and other vehicles, extending a driver's night vision capability up to three times beyond the area covered by conventional headlights. Using technology developed in conjunction with the US Army, tiny cameras that detect heat radiated by objects are calibrated to be sensitive to the wavelength of humans and animals. This provides a broader and longer view than obtainable with conventional headlights, allowing the motorist to see not only farther down the road, but also to detect animals and pedestrians on the roadside.

In practical terms, the cameras are likely to be mounted close to the driver's head where they will not interfere with normal vision. The display will be on a television-like screen that can be stowed away in the instrument panel during daylight hours.

An Indigo Systems Merlin infrared camera shows car in the road ahead (note hot area of exhaust system) and a pedestrian outside the headlight beam. Photo courtesy of Indigo Systems.

When the driver switches on the night vision system, the transparent screen will swing into position in front of the driver, and the infrared view will be displayed on the screen.

General Motors has already paired with Indigo as a "Cooperative Source Partner" in this same effort to establish industry standards and solutions to night vision systems. At present, the technology is too expensive for consumer-level devices and has been used mostly in military applications. However, like the once-expensive global positioning system (GPS) equipment, costs are expected to fall quickly.

Computers and Networking

Speedier File Transfer Available

One of the most annoying aspects of using a computer is the time it takes to transfer files, particularly over wide-area networks such as the Internet. Using file transfer protocol (FTP) and transport control protocol (TCP), the sending and receiving computers engage in a relatively slow dialog in which the sender transmits a packet of information to the receiver, waits for it to acknowledge that the packet has been received, and only then transmits the next packet. This is one of the reasons why your 56k dial-up connection will never transfer files at anything close to that rate. But a new approach has been devised by Digital Fountain **(www.digitalfountain.com)** that eliminates the send-acknowledge process. According to the company, it would typically take 10 hours to transmit a 2 GB file across the Atlantic over a 10 Mbps network. But with the company's "Transporter Fountain" system, it would take just half an hour.

The key is the use of the patented "Meta-Content" technology, which ignores the sequence and timing with which packets are sent and received, and simply counts the packets to make sure that the right number have arrived. It also uses proprietary algorithms that encode and send a model of the data rather than the data itself, which is decoded at the other end.

Two versions of the system are available. Transporter Fountain 1000 is a single rack-mount appliance that includes 5 GB of storage and supports data rates up to 10 Mbps. Transporter Fountain 3000 requires three racks, includes 85 GB of storage, and supports rates up to 70 Mbps. The bad news is that you need a server at each end, and prices are .00 for the low-end version and $150,000.00 for the other. But who knows? In a few years, maybe there will be a $99.00 version for use with dial-up modems.

Computer-Aided Composting

Many of us feel that our desks and computer systems occasionally become overloaded with, metaphorically speaking, manure. But if you are having problems with the real thing, don't go another day without Co-Composter, developed by Cornell University's Department of Biological and Environmental Engineering and Waste Management Institute **(www.cfe.cornell.edu/wmi/Compost/CoCompost.html)**. The software was developed by Prof. Douglas Haith and Jean Bonhotal and is offered free of charge to farm managers and composters who "want to meet toughened environmental regulations while making the most of excess animal waste."

An Excel® spreadsheet model for the planning of co-composting systems for mixtures of dairy manure and other organic wastes, Co-Composter provides mass and volume balances, area estimations, and a cost analysis of alternate composting systems based on user input.

Co-Composter consists of seven worksheets:

- User Input Page
- User Output Page
- Background
- Mass Balance
- Areas and Volumes
- Pad and Building Costs
- Turning and Handling Costs

According to Cornell, most users will usually need to use only the input and output pages, where most of the data can be entered and the results are presented. Co-Composter models a range of conditions and can handle municipal solid wastes, bulking materials, animal bedding, yard wastes, and manure separation. The primary data outputs are the physical dimensions of composting components, equipment requirements, compost quantities and characteristics, energy requirements, and system costs.

Circuits and Devices

ID Chip Generates Controversy

A new product with unsurpassed potential for intrusive and repulsive application is the VeriChip miniaturized identification device recently introduced by Applied Digital Solutions **(www.adsx.com)**. Ostensibly intended for use in a variety of medical, security, and emergency applications, the device — which measures 12 by 2.1 mm — can be implanted under your skin, after which it transmits an RF signal that contains a unique ID number plus any other data that has been stored in the chip. The information is picked up by a scanner that displays the data or transmits it via telephone or Internet to a central storage facility.

According to the company, "Inserting the VeriChip device is a simple procedure performed in an outpatient, office setting. It requires only local anesthesia, a tiny incision, and perhaps a small adhesive bandage. Sutures are not necessary." How can you resist?

Suggested uses include implanting the device alongside pacemakers, artificial joints, medication pumps, etc., to allow medical personnel to access information about the devices and patients. Less appetizing possibilities include having a virtual Visa card implanted in your arm, employers demanding that you have one installed for security purposes, and use of the devices as electronic national ID cards to be accessed by government agents. Privacy advocates are alarmed (see, for example, **www.orwelltoday.com**), but Applied Digital expects to sell between $2.5 and $5 million worth of the chips in 2002, with most initially sold in South America and Europe in conjunction with pacemakers and defibrillators. About one million similar devices have already been implanted in dogs and cats.

Emergency Cell Phone Charger

Let's say you set sail from a tropic port, aboard a tiny ship, for a three-hour tour. Sure, the mate is a mighty sailin' man, and the skipper brave and sure. But soon the weather starts getting rough, the tiny ship is tossed, and you end up aground on an uncharted desert isle.

Worse still, your cell phone batteries are dead, which means that you may be there for a long, long time. What can you do?

Well, you need have no fear if you have FreeCharge, a portable, self-sufficient power source for wireless phones jointly developed by Motorola, Inc. **(www.motorola.com)**, and Freeplay Energy Group **(www.freeplayenergy.com)**. FreeCharge can be powered either by its hand-cranked wind-up generator or charged by DC input via the phone's own adapter. According to the unit's specifications, only 45 to 60 seconds of cranking will charge its nickel metal hydride batteries sufficiently to provide up to three to five minutes or talk time or several hours of standby time. If you can keep cranking for 35 minutes, you will achieve a full charge. FreeCharge also comes equipped with an LED light indicator, which tells users the unit is delivering a charge and suggests the optimal winding speed.

The adapter must be matched to your phone model. At present, adapter modules are available for most major models of Motorola phones, with other modules for most major brand cellular phones expected later this year. Freeplay also markets a line of radios and other devices that employ multiple energy sources including solar panels, rechargeable batteries, and wind-up generators.

The retail price is $65.00.

On Dec. 20, 1951, EBR-1 lighted four bulbs with the world's first usable nuclear electrical power.

Photo courtesy of Idaho National Engineering and Environmental Laboratory.

Industry and the Profession

Nuke Power Is 50 Years Old

In case you missed the event, last December 20 was the 50th anniversary of nuclear power generation. The reactor was the Experimental Breeder Reactor 1 (EBR-I), designed and operated by Argonne National Laboratory **(www.anl.gov)** and built by Bechtel Group, Inc.

On that day in 1951, scientists and technicians readied for the first test of the power-generating system. "We got the reactor critical, which was a rather slow process," according to retired Argonne scientist Kirby Whitham. "Generating steam for the first time was a problem, because we hadn't done it before. Technicians were running everywhere, measuring temperatures and so on.

"It took quite a while to get the turbine up to speed, then we had to load the generator. The generator put out 440 volts, so we used four light bulbs wired in series."

Argonne personnel load radioactive material into the core of EBR-1.

Photo courtesy of Idaho National Engineering and Environmental Laboratory.

When the bulbs lit up, "we didn't clap our hands or anything," Whitham said. "We were just glad it worked."

EBR-I provided the first proof that breeding is possible. On June 4, 1953, the US Atomic Energy

Commission announced that EBR-I had become the world's first reactor to demonstrate the breeding of plutonium from uranium.

In 1962, EBR-I became the world's first reactor to produce electricity with a plutonium core. For the next year, the reactor provided valuable data on breeding in a plutonium-fueled reactor and helped to improve scientists' understanding of the behavior of plutonium in an operating reactor.

On Dec. 30, 1963, its scientific mission complete, EBR-I was officially shut down. Today, more than 100 nuclear power plants provide 20 percent of the electricity consumed in the United States. More than 435 reactors provide some 17 percent of the world's electricity, and dozens of more plants are under construction around the world.

Motorola, Nokia File $3 Billion Lawsuit

Motorola Credit Corporation **(www.motorola.com)** and Nokia Corporation **(www.nokia.com)** have filed a suit in US District Court for the Southern District of New York to reclaim more than $3 billion from Telsim Mobil (Telekomunikasyon Hizmetleri A.S.), a Turkish telecommunications company controlled by the Uzan family. The suit alleges 13 separate counts of wrongdoing, including four counts of criminal activity in violation of the Racketeer Influenced and Corrupt Organizations Act, commonly known as "RICO." The RICO counts allege that members of the Uzan family entered into loan arrangements with Motorola and Nokia with the intention of defrauding the two companies.

Motorola is seeking more than $2 billion in compensatory damages and Nokia seeks more than $700 million in compensatory damages. The two companies are also seeking to collect punitive damages, as well as treble damages under the four counts relating to RICO. Finally, they also are asking the courts to restore the collateral for Motorola's and Nokia's loans, which was wrongfully devalued by the Uzans.

The complaint claims that "through an elaborate scheme of deceit and intimidation, the Defendants committed numerous crimes and offenses against Plaintiffs Motorola and Nokia, the ultimate purpose and result of which was the theft of more than $3 billion from the companies."

The money loaned by Motorola and Nokia was to be used for the purchase of base stations, switching equipment, telephones, and other equipment needed for the development of a GSM and 2.5G wireless network in Turkey, as well as payment toward the acquisition of a license from the Turkish government to develop this network. The suit alleges that some of these funds were diverted for other purposes and to other Uzan-controlled entities and little — if any — of the funds were ever meant to be repaid by the Uzans. The suit also alleges that the Uzans' illegal scheme to defraud Motorola and Nokia fits a pattern of "the Uzans' long-standing practice of defrauding investors and co-venturers by obtaining goods and funds based on false assurances that their debts would be repaid, and then seeking to escape their obligations through criminal fraud and extortion."

It appears that the Telsim Mobil public relations department faces quite a challenge. **NV**

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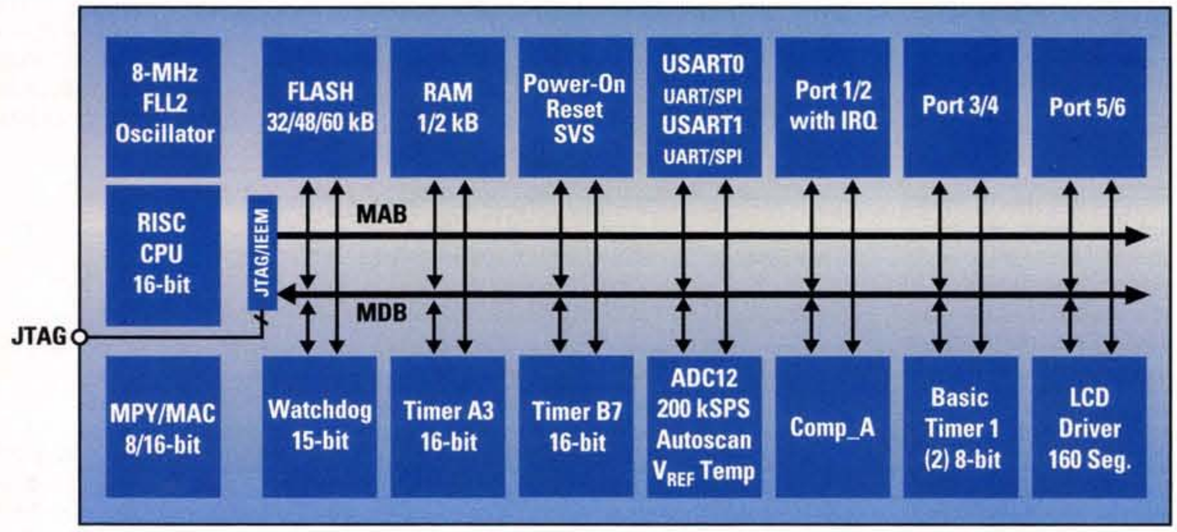

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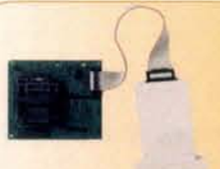

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TEXAS INSTRUMENTS

Learning RVK-Basic Part 3

By Bob Vun Kannon

RVK-Basic is a free Basic compiler for the Atmel AVR line of microcontrollers. You can download a copy of this compiler from the *Nuts & Volts* web site. With this compiler, you can write and compile very fast, efficient programs for most of the AVR microcontrollers.

In this article, we will learn how to measure and control time using RVK-Basic. It is assumed that the reader has learned the material presented in Parts 1 and 2 of this series. If you missed the previous article, get a back issue.

Time measurement and control is probably the most used function of a microcontroller. It is for this reason that even the smallest AVR chip — the 1200 — contains a counter-timer and the largest of the AVRs contains three counter-timers. Counter-timers are useful.

Time Control

First of all, let's write a program to control time on a development board. I am going to write this code for the STK200 board where the B port is connected to the LEDs. If you are using an STK500 board you can just jumper port B to the LEDs.

The first new statement we will use in this exercise is the PAUSE statement. This statement allows you to cause the program flow to stop for a specified time. To specify the time, just follow the PAUSE with the desired time in milliseconds. For example, if we want to make an LED flash once per second, it will need to be on for one-half second and off for one-half second. So we could turn it on or off and then just pause for 500 milliseconds. This is done by:

```
PAUSE 500
```

The PAUSE statement allows a wide latitude of time. You may specify times as small as 10 microseconds (PAUSE 0.01) and as large as 16 seconds (PAUSE 16000) when using a 4 MHz processor clock. Please read the documentation about the PAUSE statement in the RB.TXT file supplied with the compiler. One more useful statement is the TOGGLE. This statement will simply change the state of the output of a single pin. So here is a program to flash the B,4 LED once per second. I have chosen a 1200 for the processor and I have used the MHZ statement to tell the compiler that we are running on a development board where the clock is 4 MHz.

```
DEVICE 1200
MHZ 4
MAKEOUT B,4

DO
    TOGGLE B,4
    PAUSE 500
LOOP
```

The diligent student is expected to compile and execute this program and then modify it to do something different!

Time Measurement

The next problem is different: instead of controlling time, we will measure time.

When we used the PAUSE statement in the above program, we actually used the eight-bit counter in the chip called TIMER0. What the compiler did for us was to set up the timer and start it running at a speed appropriate to the time we specified and then wait until the timer overflowed before resuming program flow. If that sounds complicated, it's because it is, but the compiler solved the problem for us.

In our next program, we will measure the period of a frequency coming in on the D,0 pin. To do this, we wait for a rising edge of the input pin. At that time, we will read the TIMER0 counter to learn what the period of the signal was and then initialize TIMER0 back to 0 and wait for the next edge.

Let's assume that we need to measure a frequency down to 20 Hz. The timer can be "prescaled" by 1, 8, 64, or 256. That is, the frequency going into the timer will be the processor clock divided by whichever of those prescale values we pick. TIMER0 is an eight-bit timer, that is it counts from 0 to 255. So the frequency at which it overflows is 256 times slower than its own clock. So let's calculate the overflow frequency of this timer as a function of prescale value.

Overflow frequency = Processor clock / prescale / 256

Prescale	Overflow frequency (Hz)
1	15,625
8	1,953.13
64	244.14
256	61.04
1024	15.26

Since we want to measure down to 20 Hz, we need a counter that won't overflow at that frequency, so our prescale will be 1024. For the fun of it, after we have measured the frequency we will write that number (the period of the signal) out on port B so that it can show up on the LEDs. That way, the diligent student can hook a signal generator up to his development board and see the result change on the LEDs as he changes the input frequency.

Here's the program.

```
DEVICE 1200
MHZ        4

DIRPORT D,IN
DIRPORT B,OUT

INBIT last,D,0
period = &HFF

DO
  OUTPORT B,period
  INBIT temp,D,0
  IF last = 0 THEN
    IF temp | 0  THEN
' this is where we read the counter
      TIMER0 READ period
' this is where we reset the counter
      TIMER0 ON 1024
    END IF
  END IF
  last = temp
LOOP
```

A comment is necessary about the notation of numbers in RVK-Basic. You may specify a number as hexadecimal (base 16) by prefixing it with "&H". You may also choose to write a number in binary by using a prefix of "&B". So the statement in the program

```
Period = &HFF
```

sets the variable "period" to a value of 255 decimal.

Again the student is exhorted to try this program out.

Gee, that was fun, but how can we handle more than one frequency input at a time? There is a way and it is only a little more complicated than the previous example. What we will do is let the counter run freely. Each time that we get an appropriate edge on an input, we will simply read the counter. The period of that signal is then the difference between the current reading and the previous counter reading. This type of math deserves a comment. Let's assume that the incoming frequency is five clock periods of the counter-timer. If we get an edge when the timer reads 254, the next edge will occur when the timer reads 03. Using byte variables, if we subtract the earlier value from the latter, we will find that

```
03 - 254 = 5
```

This is true in byte arithmetic because the computation overflows and leaves a carry bit set, but the answer still comes out to be 5. Expressing this in binary, we would have

```
00000011
- 11111110
00000101
```

So we can see that our process of subtracting successive readings will always give the correct answer so long as the input period is less than the overflow period of the timer. Let's assume that our input frequencies won't fall below 20 Hz again. So we will set the count up to freerun and then just watch for edges on the two signals. In the following program, I do all this but I have not provided an output path for the result. The periods for the two signals are in the byte variables per0 and per1.

```
DEVICE 1200
MHZ        4

DIRPORT D,IN
TIMER0 ON 1024
per0 = &HFF          'period count for D,0
per1 = &HFF          'period count for D,1

DO
'make measurements on D,0
  INBIT tempd0,D,0
  IF last0 = 0 THEN
    IF tempd0 | 0  THEN
      TIMER0 READ temp
      per0 = temp - temp0
      temp0 = temp
    END IF
  END IF
  last0 = tempd0

'make measurements on D,1
  INBIT tempd1,D,1
  IF last1 = 0 THEN
```

```
IF tempd1 | 0 THEN
   TIMER0 READ temp
   per1 = temp - temp1
   temp1 = temp
  END IF
 END IF
 last1 = tempd1
LOOP
```

The student is now expected to copy this program and compile it. There's no point in running it as it stands because there is no output. I recommend you modify this program to output per1 or per0 on port B. When you have that working, try making the output on port B selectable via a push button on D,2. Another idea is to compare per0 with per1 and set or clear a single LED based on which is bigger. Have fun!

In the next article, we will continue to build our skills in using the compiler. We will take up using the A/D converter and the UART.

See you then. **NV**

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Reader Feedback

Dear Nuts & Volts:

As the former chief engineer for a company that produced (among other things) TV commercials, I would like to clear up a common misconception about the audio level of TV commercials being louder than normal program audio.

TV commercials are NOT recorded at a higher level than regular TV programs. In fact, tapes would be rejected and returned by the engineering departments of most TV stations, and especially the networks, if they exceeded standard program level specifications.

TV commercials only SOUND louder, because they very often are recorded using a compression algorithm that decreases the overall dynamic range and then squeezes it all up towards the acceptable top limit of the VU scale.

Another way of describing it is that in a normal program, the audio may "peak" occasionally, but the audio in a TV commercial is constantly at its peak. The end result is that it SEEMS louder to the human ear, but is in actuality NOT recorded any louder than any other audio on TV.

I agree, however, that regardless of whether it is actually louder or only perceived as louder, the end result is equally annoying!

I enjoy your magazine and

Continued on Page 57

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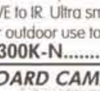
Sleek black anodized, BRASS, housing is O-Ring sealed & WATERPROOF. Adjustabe mount included. Specs: 1/3" CCD, 400 Lines resolution, 0.05 Lux sensitivity, AGC, Auto Shutter. Operates on 12VDC @200mA, 4mm, 78° FOV lens, A real glass lens. NTSC video out. Superior construction. SENSITIVE to IR. Ultra small Size only: 1.25" diam. X 2" long. With 60 ft. cable. Great for outdoor use too. **NEW, GM300K-N........$99**

NEW, lower cost, High quality, MINI BOARD CAM,



1/3" CCD, 420 Lines Res., 0.3 Lux sens., AGC, Pwr. from 9 to 12VDC @100mA, 266K PIXELS, 3.7mm, 92° FOV lens,A real glass lens. Auto shutter from 1/60 to 1/100,000 sec. Focus from 10mm to infinity. Std. NTSC video out. 1/2 ounce! SENSITIVE to IR. Size: 1.25"sq. x 1"d. Connections via a 3" pigtail with PC board connector. **GM-1000B-STD........$45ea.**

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.............$149ea. or 2 for $249**

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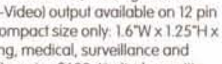

Connect four or eight std. video signals and they will be sequentially output to the dual rear panel BNC outputs. Front panel user adjustable, variable dwell 1 to 15 sec per channel. Auto/manual switching with channel bypass. Compact only 8.6"W x 3.7" D x 1.75" H, ac powered. Video loop through.**GM-34, 4 Chan...$65, GM38, 8 Chan...$75**

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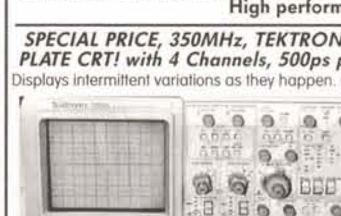
Features include: Interactive infrared illuminator with 10 high power, wide angle LEDs @ 880nm . See objects 60 feet away during total darkness. A super quality 5 element, glass lens, specially coated with a 100 layer optical coating. For perfect focus with white light and a crisp image under infrared. Normally impossible due to the different focal point for IR and visible light. Solid state infrared optical switch provides day time IR cut filter for excellent color. At night infrared filter will turn off to allow infrared to pass. Also, night time IR LEDs will gradually turn on with proper amount of illumination. You can also see color images such as lights and signs at night. Fog free cover glass. Specs: 0.5 lux color sensitivity. 60dB S/n ratio typical. 12" I/O cable with BNC video and DC barrel jack. 120 dB smear rejection ratio. Adjustable mount and C power adapter included. **GM450K-IR.........$199ea.**

NEW! 0.01 Lux, COLOR NIGHT VISION CAMERA! FANTASTIC LOW LIGHT PERFORMANCE. Exclusive ON SCREEN, menu driven setup of all camera parameters. NEW, STATE of the ART, GMV-35KOSD,

Perfect for covert, military & scientific applications that must be color. Unbelievable 0.01Lux @ f1.2 performance is enhanced through low speed electronic shuttering, digital frame integration & advanced DSP. Auto sensitivity mode starts as it becomes dark. 24 hour surveillance is possible with the optional f1.2 lens shown below. Specs: Shutter speed auto or manual, 1/60 to 1/120,000, 60dB S/N ratio!, 154dB Smear rejection!, AGC gain 0 dB to 18 dB. Digital gain 0dB to 12dB. Digital zoom continuous from up to 2X in 0.1X steps. Masking mode allows hiding 4 programmable zones for privacy protection. Camera on screen name. Choose you own name for the camera and display it on monitor for easy identification.) White balance modes: Auto tracking, one push or selection from 3200k, 4800k, 5600k, 7800k, and "double white balance" independent white balance circuit for both bright and dark zone, maintains correct white balance even with combined indoor and outdoor lighting. Programmable 48 zone back light compensation mode for difficult lighting situation. Negative mode for negative film reading. Mirror image and up/down selection for rear view and camera mounted upside down. Seven Gain/Shutter modes are user selectable. Normal, X2, X4, X8, X16, X24, X32, X64. These provide frame rates of 60, 30, 15, 8, 4, 3, 2, and 1 per second. Alum. housing, dual 1/4x20 mtg. Specs: 1/3" CCD, 811(H) X 508(V), with 412K pixels, 470 Lines, 12VDC ±1V@250mA, Std. video out on BNC. Std S-Video out on 4Pin connector. Size: 2"H x 2"W x 4.5" long. Regulated power adapter included. C-mount lens not included. **GMV-35KOSD.............$399ea.**
High performance lens, 4mm, f1.3...$49ea.

SPECIAL PRICE, 350MHz, TEKTRONIX 2467, MICRO CHANNEL PLATE CRT! with 4 Channels, 500ps per div. in normal room light. Displays intermittent variations as they happen. Captures the slowest one shot events with 4ns per division a 100 fold increase in the visual writing rate over conventional CRT. Features: 1 ns rise time, 500ps/Div time base, 2mV/Div. vertical sensitivity at 350MHz, 20ps time interval resolution, 1Mohm / 50-ohm input, 500Mhz trigger bandwidth, four channels. On-screen waveform cursors provide vertical & horizontal scale factors, trigger level, voltage, time, freq., phase, ratio values and mode indication. With 2 probes, pouch and manual. EX. cond. 90 day warranty. **New..$12K Now SALE, TEK 2467........$1995.**



Circle #32 on the Reader Service Card.

Driver Training Center Corrects Virtual Mistakes Before They Become Reality

The road to safe driving has taken a digital turn for the better.

GE Capital I-Sim has opened its first Driver Development Service Center in the Midwest. The new facility combines classroom instruction with new, state-of-the-art driving simulators. Whether it's truck drivers, police officers or emergency vehicle operators, the I-Sim program focuses on real-life scenarios that train drivers how to avoid accidents without endangering life or property.

"We can train truck drivers to maneuver their 18-wheelers through hazardous road conditions, or emergency vehicles to reach a disaster scene quickly and safely," says Mark Stulga, CEO of GE Capital I-Sim. "Our complete program lets drivers take classroom learning straight to a life-like simulator.

"I-Sim technology allows instructors to correct virtual mistakes before they become reality." GE Capital I-Sim's three part training approach — classroom instruction, computer-based training with a complete driver skills evaluation, and hands-on simulation time — provides drivers, at any level, with a thorough training development program, Stulga says.

In addition to the Burr Ridge training center, Stulga says GE Capital I-Sim plans to open new Driver Development Service Centers in Anaheim, Dallas, Denver, Philadelphia, and Salt Lake City. For additional information, visit www.i-sim.com.

Gateway Brings Business Services to Store Shelves

Making technology services as easy to purchase as a box of software, Gateway, Inc., now offers a variety of online training, tech support, web site, and e-commerce plans that can be bought as retail packages at Gateway stores. Depending on the service, packages may include a detailed manual, simple step-by-step instructions on getting started, and if applicable, a pre-paid calling card or an enrollment key that activates their order.

"When it comes to purchasing something intangible like a service, customers tell us they want to talk to someone in person and see demonstrations of the service — in essence, to see and touch what they're buying," said Jim Jones, vice president of segment marketing at Gateway. "Our stores give people the opportunity to do all of that, and packaging services in this manner complements their technology buying experience."

Via the Internet, customers can learn at their convenience — any time and just about anywhere. For just around $99.00 each, the packages include a full year of unlimited access to online learning courses, some of which include: Microsoft Excel; Microsoft PowerPoint; Microsoft Word; Microsoft Access; Microsoft Outlook; WordPerfect and QuickBooks 2000.

Historic 'No Payment, 0% Financing' Program For Qualified Sony Customers: Make No Payments and Pay No Interest until January 2003

Sony Electronics now has a highly flexible and comprehensive "No Payment, 0% Financing Program" available to all existing and new customers on a broad range of Sony professional products. Under the program, customers can defer all costs until January 2003 and interest payments on products of $2,000.00 or more purchased by March 29, 2002.

Once a customer is approved for the program by Sony Financial Services, the purchased product(s) will ship to the customer and the "No Payment/No Interest" period will begin. For a complete list of eligible models, the terms, and conditions, go

News Bytes

to http://www.sony.com/professional.

Better Power Alternative for Digital Cameras That Use AA Cells

If you're tired of changing your digital camera's AA batteries every few hours or waiting for AA rechargeables to recharge when you run out of juice, Electric Fuel's new INSTANT POWER™ batteries for Olympus, Kodak, and Nikon Coolpix digital cameras will provide instant relief.

These disposable power sources deliver as much as 12 hours of continuous use — up to five times more than on-board AA alkaline batteries and considerably more than AA rechargeables. Their 3300 mAh capacity makes it possible to take up to 4,000 digital photos without changing or recharging the battery, offering a special advantage for vacations, family celebrations and similar events involving lengthy photo sessions.

As an added benefit, INSTANT POWER batteries come fully charged and ready to use right out of the package. The digital camera batteries weigh just six ounces, plug into the camera's DC jack via a 36" cord, and attach to a built-in belt clip for easy carrying. They have a three-year shelf life when stored unopened in their original packaging, and will last up to three months between uses when resealed in the aluminum pouch provided. For more info, visit www.electric-fuel.com.

Circle #29 on the Reader Service Card.

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

by Jon Williams

Stamp Applications

Where In The World Is My BASIC Stamp?

A few days before I started writing this article, President Bush submitted his budget proposal to Congress. Part of the new budget calls for dramatic increases in military spending to make up for lack of technological progress in the past several years. I'm not trying to be political here. I simply want to point out that we, as civilians, do and will benefit from technology developed by our military and space programs.

Case in point: GPS, the Global Positioning System. GPS was originally developed by the military to provide precise location and navigation capabilities in a wide range of military applications. We've certainly all heard of GPS-guided "smart" bombs. The American military dropped quite a few of them on those Taliban idiots in Afghanistan. Yes, a few of them missed the mark with tragic consequences. This wasn't the fault of the weapon or the GPS system; it was a problem with the location data loaded into the bombs.

Luckily for us, the technology has been made available to the civilian world and the uses for GPS are far more friendly. GPS navigation systems in cars are very useful, particularly for those driving in an unfamiliar city. Not long ago, I went to lunch with a friend who has his car equipped with such a system. From a menu he selected his favorite restaurant and the system — using GPS and voice synthesis — "talked" us all the way there ... with a very friendly female voice, no less. He even made a deliberate mistake to show me how the system could compensate for the error. The system was very cool, telling us about approaching intersections and to be prepared to turn. It was a very impressive demonstration of GPS technology.

On a smaller scale, GPS receivers have become incredibly popular with hikers and others involved in outdoor recreational activities. One of the most popular consumer GPS units for these applications in the eTrex GPS from Garmin. Garmin actually has a family of eTrex GPS receivers. At the low end, the unit goes for about $120.00 retail. That's not too bad for a piece of equipment that can tell you where you are on the planet with an accuracy of down to 150 feet or so — much better depending on conditions. I routinely see estimated accuracies of less than 20 feet on my eTrex. While any of the models of the eTrex family will work with this month's program, the entry-level model works just fine and is what I used to test the code.

GPS Basics

There are several excellent explanations of the GPS system on the Internet (see sidebar), so I won't go into a lot of detail here. Fundamentally, the system works like this: There are 24 GPS satellites in orbit around the planet. The orbit of these satellites is very carefully controlled by the US Department of Defense. Each satellite broadcasts the precise time (using an atomic clock) and other information required by GPS receivers. The GPS unit on the ground receives signals from three or more satellites and, using some fairly tricky math, is able to triangulate its planetary position.

And all of this happens in a unit the size of a cellular telephone. Beyond basic position, the GPS receiver can tell us accurate time, speed, heading, and other information relevant to navigation. It's very neat stuff.

Getting Connected To The BASIC Stamp

Most GPS receivers output a stream of data so that it can be used by other devices. The most common format is NMEA 0183 (National Marine Electronics Association). This data is provided as a series of comma-delimited ASCII strings, each preceded with an identifying header. The data output rate is very tame: 4800 baud, N-8-1. This is no problem for the BASIC Stamp.

The trickiest part about connecting the eTrex to a BASIC Stamp is the mechanical connection. The eTrex uses a proprietary connector and the cables from Garmin are fairly pricey — about a third of the cost of the receiver itself. I can vouch for the quality though; they are made very well.

It seems that the popularity of the eTrex GPS has created a cottage industry of third party connector and cable manufacturers. In the web sites sidebar, you'll find a list of sites that will sell you the connectors and a variety of prefabricated cables that will work with your eTrex. For this month's program, I used the Garmin bare wire cable (#010-10205-00). You can either purchase that cable from Garmin or go the DIY route. If using the Garmin cable, the wire colors are shown in Figure 1.

Decoding The GPS Output

The purpose of the program this month is to "listen" to the GPS output until a certain string is transmitted, grab it when it is, and then pull all the data out of it and convert it to numbers that can be used or manipulated. To do this, we will be using the BS2p. The BS2p has a (undocumented) serial modifier called SPSTR. This modifier collects serial input and saves it in the scratchpad RAM, starting at location zero. Once the string is in the scratchpad, it can be parsed and converted as required.

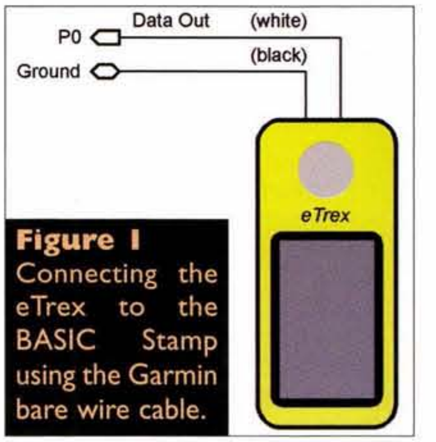


Figure 1 Connecting the eTrex to the BASIC Stamp using the Garmin bare wire cable.

The main string the program waits for is called $GPRMC — Recommended minimum specific GPS/Transit data. If you connect your eTrex to a terminal program, you'll see that the $GPMRC sentence is the first line of several that are output every two seconds (see Figure 2). The baud rate and number of characters transmitted for all of the sentences are what determine the two-second delay between transmissions.

After I had the basic code working, I decided to add another piece: altitude. This is transmitted in the same format using a Garmin-specific string: $PGRMZ. As it turns out, the altitude can be intercepted and decoded within the SERIN statement — without buffering it into the scratchpad RAM. And with the speed of the BS2p (program speed, not ground speed ...), there is plenty of time between the arrival of $GPRMC and $PGRMZ to decode the $GPRMC data.

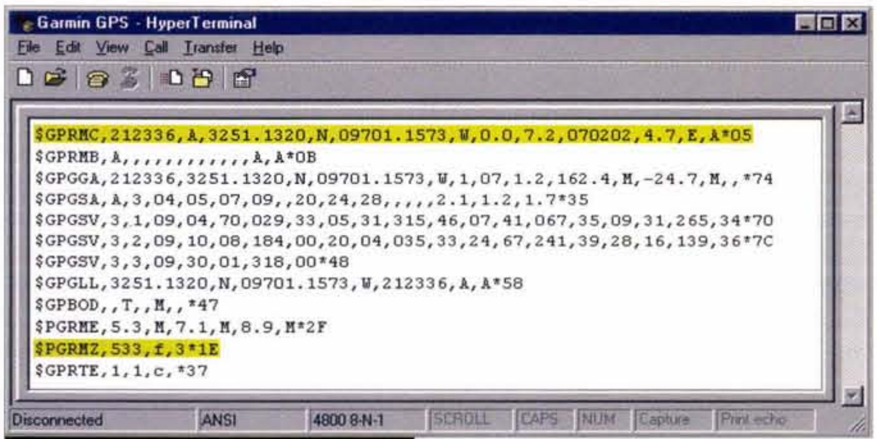


Figure 2
The $GPMRC sentence is the first line of several that are output every two seconds.

The Code, The Code

Since the connection between the Stamp and the eTrex is electrically trivial, I'll jump right into the code. This looks like a long program but it really is fairly straightforward and there are a few neat tricks inside. Again, the purpose is to capture the GPS output and then parse out specific data and convert it to numeric form so that it can be manipulated. The output of the program is a report sent to the DEBUG screen. You can use the guts of this program as a jump-off point for your own GPS-based projects.

The Initialization section opens the DEBUG screen, draws a ruler to help us analyze the $GPMRC sentence, and sets up some labels where the GPS data is displayed. This is all pretty easy stuff. I've started using more of the built-in formatting functions available with DEBUG. Notice the constant called MoveTo. This code will cause the cursor to move to a specific X/Y location in the DEBUG screen. Another that is used a little later is ClrRt. The ClrRt code will clear everything from the current cursor position to the end of the current line. This code is handy for keeping the screen neat and uncluttered with old data.

The first line in the Main section does the work of waiting on the $GPMRC sentence and storing it in the BS2p's scratchpad RAM. As you can see, the SERIN command is set up for 4800 baud with a timeout of three seconds (3,000 milliseconds). This value make sense since the sentence should show up every two seconds. And notice that the program is actually waiting on "GPRMC," instead of "$GPRMC" as you might expect. The reason for this is twofold: the WAIT modifier is limited to six characters and I want the first data character (position UTC) to be placed in address zero of the scratchpad.

When using SPRSTR, we have to tell the Stamp how many characters to buffer. In this case, I've set the character count to 65. Usually, the $GPMRC string will be about 60 characters long. I'm going to allow 65 so that when I take this project "on the road" and the variable-width speed field gets wider, everything will be captured. Be careful when using the length specification in SPSTR — it's okay if the length is specified short, too long and the Stamp will be left waiting for more characters. That's not a problem for this program since several hundred bytes of data are transmitted after the $GPMRC string.

Now comes the real work: extracting numeric data from the string.

Some of you may have seen a little project we did at Parallax with GPS and model airplanes. Just for fun, we created a little GPS data logger from a BS2p and strapped the receiver and Stamp to the wing of a trainer aircraft. My boss, Ken, flew the plane while the program was running and when we got back to the office we were able to graph the flight path of the airplane. It was a lot of fun.

As I look back on that code, it was a bit, well ... inelegant ... and I really wanted to clean it up and make it easier to use with different GPS strings. That's what I'm presenting here.

One of the key elements of the program is a subroutine called String_To_Value. The purpose of the routine is to convert an ASCII string to a 16-bit number. The string is stored in the scratchpad. The subroutine starts by knowing the position of the first digit in the string and how many digits to convert.

Take a look at the code. The routine starts by clearing the return variable workVal. Next, the field width is checked to make sure it falls in range. We have to be a little careful when specifying a field width of five since 65,535 is the largest value that a Stamp variable can hold.

The heart of the routine retrieves a character from the scratchpad, converts it from ASCII to a number by subtracting "0" (decimal 48), and then adds the digit value into the return variable. The field width is decremented and checked for zero. If it's zero, the routine is done and the value of the field is returned in workVal. If not, the digits in workVal are shifted left to make room for the next. Since we're dealing with decimal numbers, this is accomplished by multiplying workVal by 10. Quite a lot of the work in the program is done with this routine. After calling String_To_Value, the value is moved from workVal to the specific variable used for storage.

Just a couple notes on the numeric values. The decimal portion of the latitude and longitude values are fractional minutes. To convert fractional minutes to seconds, we multiply by 60. In the case, we actually use 0.06 to get tenths since the routine returns the fractional value multiplied by 1,000.

In the past, I've used the */ (star-slash) operator for fractional values. In this case, the ** (star-star) operator is used for better precision. Star-star can only be

Web Sites Worth Checking Out

How GPS Works
- celia.mehaffey.com/dale/theory.htm

Decoding NMEA 0183 Strings
- celia.mehaffey.com/dale/nmea.htm
- home.mira.net/~gnb/gps/nmea.html

eTrex Related
- www.garmin.com
- www.firstwaypoint.com
- www.etrex.webz.cz
- www.geocities.com/etrexkb

Alternate Sources for eTrex Cables and Connectors
- www.pfranc.com
- www.gpsmemory.com
- www.blue-hills-innovations.com

BASIC Stamps and GPS
- www.parallaxinc.com/downloads/Resources/Aero%20GPS%20Brief.PDF
- www.stoneflyers.com/gps_guided_truck.htm

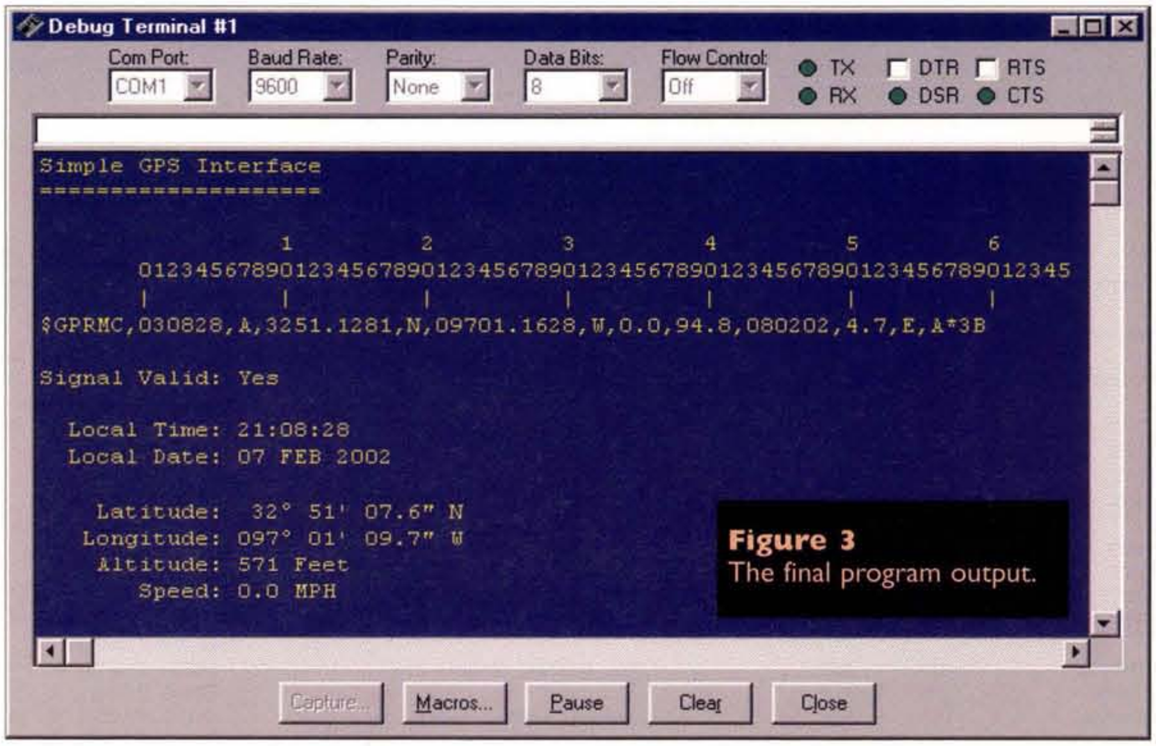


Figure 3
The final program output.

used with fractional values of less than one. To get the value for this operator, multiply the fraction by 65,536. So, 0.06 x 65,536 is 3932 ($0F5C). To use a star-star with fractional values greater than one, you need to multiply the whole portion separately. Take a look at the code that converts knots to miles per hour.

The next step in the decoding process is getting the signal validity, latitude indicator, and longitude indicator. These arrive in the $GPRMC string as letters. Since there's really no need to waste eight bits of storage for what are, essentially, binary values, the program uses a variable called flags to hold them as bits. Simple comparisons are used to set or clear the associated bits in flags.

Author's Note: For more hints and tricks on using star-star, be sure to visit Dr. Tracy Allen's web site. Tracy is the coolest Ph.D. you'll ever meet — a Stamp guru and a real regular guy! **www.emesys.com/BS2math1.htm**.

Next comes speed. The speed value (knots) starts in a fixed position but is a variable-width field. The legal values are from 0.0 to 999.9. Decoding speed is not much different from what has previously been done — the difference, of course, is that the field width is not known. The routine Mixed_To_Tenths deals with this problem by looking for the decimal point in the field. Since the decimal point is expected, the return value is in tenths.

The last bit of data that I want to collect from the $GPRMC string is the location date. This is a fixed-width field, but is it located after the variable-width speed field so finding it requires a strategy. The way it's done in this program is by counting the field-delimiting commas. I created a subroutine called Move_To_Field to handle this. To use the routine, I put the field number in field, then call the routine. When it RETURNs, the variable idx holds

```
' -----[ Title ]-----------------------------------------------------------
-
'
' File...... SIMPLE GPS.BSP
' Purpose... Simple GPS Interface
' Author.... Jon Williams
' E-mail.... jonwms@aol.com
' Started... 16 JUL 2001
' Updated... 07 FEB 2002

' {$STAMP BS2p}


' -----[ Program Description ]---------------------------------------------
'
' Reads NMEA data string from GPS receiver and parses data.  GPS string is
' buffered into scratchpad RAM with SPSTR modifier.  Once in SPRAM, data is
' parsed out based on its position.
'
' $GPRMC,POS_UTC,POS_STAT,LAT,LAT_D,LON,LON_D,SPD,HDG,DATE,MAG_VAR,MAG_REF,*CC
'
'  POS_UTC  - UTC of position. Hours, minutes and seconds. (hhmmss)
'  POS_STAT - Position status. (A = Data valid, V = Data invalid)
'  LAT      - Latitude (ddmm.ffff)
'  LAT_D    - Latitude direction. (N = North, S = South)
'  LON      - Longitude (dddmm.ffff)
'  LON_D    - Longitude direction (E = East, W = West)
'  SPD      - Speed over ground. (knots) (0.0 - 999.9)
'  HDG      - Heading/track made good (degrees True) (x.x)
'  DATE     - Date (ddmmyy)
'  MAG_VAR  - Magnetic variation (degrees) (x.x)
'  MAG_REF  - Magnetic variation (E = East, W = West)
'  *CC      - Checksum
'
' Custom Garmin string:
'
' $PGRMZ,ALT,F,X*CC
'
'  ALT,F    - Altitude in feet
'  X        - Position fix dimensions (2 = user, 3 = GPS)
'  *CC      - Checksum


' -----[ Revision History ]------------------------------------------------
'


' -----[ I/O Definitions ]-------------------------------------------------
'
GPSpin          CON     0                       ' GPS serial input


' -----[ Constants ]-------------------------------------------------------
'
N4800           CON     16884                   ' baud rate for GPS

MoveTo          CON     2                       ' DEBUG positioning command
LF              CON     10                      ' linefeed
ClrRt           CON     11                      ' clear line right of cursor

EST             CON     -5                      ' Eastern Standard Time
CST             CON     -6                      ' Central Standard Time
MST             CON     -7                      ' Mountain Standard Time
PST             CON     -8                      ' Pacific Standard Time

EDT             CON     -4                      ' Eastern Daylight Time
CDT             CON     -5                      ' Central Daylight Time
MDT             CON     -6                      ' Mountain Daylight Time
PDT             CON     -7                      ' Pacific Daylight Time

UTCfix          CON     CST                     ' for Dallas, Texas
Comma           CON     ","
DegSym          CON     176                     ' degrees symbol for report
MinSym          CON     39                      ' minutes symbol
SecSym          CON     34                      ' seconds symbol


' -----[ Variables ]-------------------------------------------------------
'
idx             VAR     Byte                    ' index into GPS data in SPRAM
flags           VAR     Byte                    ' holds bit values
valid           VAR     Flags.Bit3              ' is data valid?

tmHrs           VAR     Byte                    ' time fields
tmMins          VAR     Byte
tmSecs          VAR     Byte

latDeg          VAR     Byte                    ' latitude
latMin          VAR     Byte
latSec          VAR     Word
latNS           VAR     flags.Bit0              ' 0 = N

longDeg         VAR     Byte                    ' longitude
longMin         VAR     Byte
longSec         VAR     Word
longEW          VAR     flags.Bit1              ' 0 = E

speed           VAR     Word                    ' in tenths of mph
altitude        VAR     Word                    ' in feet

day             VAR     Byte                    ' day of month, 1 - 31
month           VAR     flags.Nib1              ' month, 1 - 12
year            VAR     Byte                    ' year, 00 - 99

char            VAR     Byte                    ' byte pulled from SPRAM
workVal         VAR     Word                    ' for numeric conversions
eeAddr          VAR     workVal                 ' pointer to EE data

field           VAR     Nib                     ' field #
fldWidth        VAR     field                   ' width of field


' -----[ EEPROM Data ]-----------------------------------------------------
'
NotValid        DATA    "No", 0
IsValid         DATA    "Yes", 0
DaysInMon               DATA    31,28,31,30,31,30,31,31,30,31,30,31
MonNames        DATA    "JAN",0,"FEB",0,"MAR",0,"APR",0,"MAY",0,"JUN",0
                DATA    "JUL",0,"AUG",0,"SEP",0,"OCT",0,"NOV",0,"DEC",0


' -----[ Initialization ]--------------------------------------------------
'
Initialize:
  PAUSE 250                                     ' let DEBUG open
  DEBUG CLS                                     ' clear the screen
  DEBUG "Simple GPS Interface",CR
  DEBUG "===================="

Draw_Ruler:
    FOR idx = 0 TO 65
      IF (idx = 0) THEN Print_Ones
      IF (idx // 10) > 0 THEN Print_Ones
      DEBUG MoveTo, (7 + idx), 3, DEC1 (idx / 10)
    Print_Ones:
      DEBUG MoveTo, (7 + idx), 4, DEC1 (idx // 10)
    Print_Ticks:
      IF (idx // 10) > 0 THEN Next_Digit
      DEBUG MoveTo, (7 + idx), 5, "|"
    Next_Digit:
  NEXT

Draw_Data_Labels:
  DEBUG MoveTo, 0,  8, "Signal Valid: "
  DEBUG MoveTo, 0, 10, "  Local Time: "
  DEBUG MoveTo, 0, 11, "  Local Date: "
```

the position of the first digit in that field. Once the position of the date field is known, the rest is easy.

One last thing to do with the $GPMRC data ... I live in Dallas, TX, which is six hours behind UTC time reported by the GPS receiver. Correcting for the offset isn't very hard, it just takes a bit of code because there may be a date change as well. The time and date correction code looks for a day cross, then adds or subtracts a day based on the UTC offset specified by the program. The only thing this code doesn't do is account for leap years.

Since negative values are stored in two's-compliment form, bit 15 will be set in negative numbers. This fact is used by the BRANCH line to direct the code to adding or subtracting a day — with month and year correction, if necessary.

I mentioned earlier that we've played with attaching GPS units to model airplanes. Doing that, it would be nice to know the altitude. One thing to understand is that GPS altitude from civilian receivers is terribly inaccurate, but we're willing to pull it out anyway. Later, we'll experiment with some of the higher-end Garmin units that have barometric altimeters for better accuracy.

The altitude is broadcast in the Garmin-specific $PGRMZ string. The cool thing about this is that it's a whole value in a single field so we can grab it on-the-fly using the DEC modifier. When the comma after the altitude field is hit, DEC terminates and the value is stored in altitude.

We Got It, Let's Show It

Okay, now the latest $GPRMC string is safely stored in RAM, its data is parsed out, so it's time to display the results of the program's cool code. First comes the display of the raw $GPMRC string. The display routine is fairly simple. Since the header isn't actually captured with SERIN, it gets printed manually. Then, one-by-one, characters are retrieved (with GET) from the scratchpad and displayed on screen. Remember that these are ASCII characters so there is no conversion requirement.

Since the string length can vary, what the program does is look for the asterisk which comes right before the two-digit checksum. Once the asterisk is detected and printed, it's a simple matter to GET and print the next two characters. Finally, the rest of the line is cleared with ClrRt in case the current string was shorter than the previous.

Next, the signal validity is printed. To make the display a little user-friendly, zero-terminated strings are stored in EEPROM and printed using Print_Z_String. If the signal was good, the values are printed, otherwise the screen is cleared. Done! The final output of the program is shown in Figure 3. Notice that the time and date have been corrected for the six-hour difference between Dallas and UTC time.

What Will You Do With It?

Okay, it's your turn. Now that you know how to get GPS data into your Stamp, what will you do with it? Me? Well, I'm thinking about driving to my brother's house in Ohio this summer so I have this idea about creating a "head up" speedometer reading (reflecting large seven-segment displays off the front windshield) and, using a Quadravox QV306, having the system tell me the time, inside and outside temperatures, estimated time to my next waypoint ... and anything else I can figure out. It should be fun. If it works like I hope, I'll write about it when I get back to "Big D."

Until next month, have fun with GPS and Happy Stamping! **NV**

Resources:

Jon Williams
jonwms@aol.com

Parallax
599 Menlo Drive, Suite 100
Rockin, CA 95756
(888) 512-1024
www.parallaxinc.com

```
  DEBUG MoveTo, 0, 13, "    Latitude: "
  DEBUG MoveTo, 0, 14, "   Longitude: "
  DEBUG MoveTo, 0, 15, "    Altitude: "
  DEBUG MoveTo, 0, 16, "       Speed: "


' -----[ Main Code ]----------------------------------------------------------
'
Main:

  ' wait for $GPRMC string and store data in SPRAM

  SERIN GPSpin, N4800, 3000, No_GPS_Data, [WAIT("GPRMC,"), SPSTR 65]
  GOSUB Parse_GPS_Data                      ' extract data from SPRAM

  ' wait for GARMIN custom string
  ' -- use DEC to extract altitude

Get_Altitude:
  SERIN GPSpin, N4800, 2000, Show_GPMRC_String, [WAIT("PGRMZ,"), DEC altitude]

Show_GPMRC_String:
  DEBUG MoveTo, 0, 6, "$GPRMC,"             ' print header
  idx = 0                                   ' start at position UTC

Print_GPRMC_Char:                           ' print the $GPRMC data string
  GET idx, char                             ' get char from SPRAM
  DEBUG char                                ' display it
  IF char = "*" THEN Print_Checksum         ' look for checksum indicator
  idx = idx + 1                             ' point to next char
  GOTO Print_GPRMC_Char

Print_Checksum:
  GET (idx + 1), char                       ' get first checksum char
  DEBUG char                                ' display
  GET (idx + 2), char                       ' get second checksum char
  DEBUG char, ClrRt                         ' display, clear to end of line

Show_Report:
  DEBUG MoveTo, 14, 8                       ' was the signal valid?
  LOOKUP valid, [NotValid, IsValid], eeAddr ' get answer from EE
  GOSUB Print_Z_String                      ' print it
  DEBUG ClrRt                               ' clear end of line
  IF (valid = 0) THEN Signal_Not_Valid

Signal_Is_Valid:
  DEBUG MoveTo, 14, 10, DEC2 tmHrs, ":", DEC2 tmMins, ":", DEC2 tmSecs

  DEBUG MoveTo, 14, 11, DEC2 day, " "
  eeAddr = (month - 1) * 4 + MonNames       ' get address of month name
  GOSUB Print_Z_String                      ' print it
  DEBUG " 20", DEC2 year

  DEBUG MoveTo, 15, 13, DEC2 latDeg, DegSym, " ", DEC2 latMin, MinSym, " "
  DEBUG DEC2 (latSec / 10), ".", DEC1 (latSec // 10), SecSym, " "
  DEBUG "N" + (latNS * 5)

  DEBUG MoveTo, 14, 14, DEC3 longDeg, DegSym, " ", DEC2 longMin, MinSym, " "
  DEBUG DEC2 (longSec / 10), ".", DEC1 (longSec // 10), SecSym, " "
  DEBUG "E" + (longEW * 18)

  DEBUG MoveTo, 14, 15, DEC altitude, " Feet"
  DEBUG MoveTo, 14, 16, DEC (speed / 10), ".", DEC1 (speed // 10), " MPH "
  GOTO Main

Signal_Not_Valid:
  DEBUG MoveTo, 14, 10, "?", ClrRt          ' clear all fields
  DEBUG MoveTo, 14, 11, "?", ClrRt
  DEBUG MoveTo, 14, 13, "?", ClrRt
  DEBUG MoveTo, 14, 14, "?", ClrRt
  DEBUG MoveTo, 14, 15, "?", ClrRt
  DEBUG MoveTo, 14, 16, "?", ClrRt
  GOTO Main


' -----[ Subroutines ]--------------------------------------------------------
'
No_GPS_Data:
  DEBUG CLS, "Error: No GPS data detected"
  PAUSE 2500
  GOTO Initialize                           ' try again


Parse_GPS_Data:
  idx = 0 : fldWidth = 2                    ' UTC hours
  GOSUB String_To_Value
  tmHrs = workVal

  idx = 2 : fldWidth = 2                    ' UTC minutes
  GOSUB String_To_Value
  tmMins = workVal

  idx = 4 : fldWidth = 2                    ' UTC seconds
  GOSUB String_To_Value
  tmSecs = workVal

  idx = 9 : fldWidth = 2                    ' latitude degrees
  GOSUB String_To_Value
```

```
  latDeg = workVal

  idx = 11 : fldWidth = 2                ' latitude minutes
  GOSUB String_To_Value
  latMin = workVal

  idx = 14 : fldWidth = 4                ' latitude fractional minutes
  GOSUB String_To_Value
  latSec = workVal ** $0F5C              ' x 0.06 --> tenths of seconds

  idx = 21 : fldWidth = 3                ' longitude degrees
  GOSUB String_To_Value
  longDeg = workVal

  idx = 24 : fldWidth = 2                ' longitude minutes
  GOSUB String_To_Value
  longMin = workVal

  idx = 27 : fldWidth = 4                ' longitude fractional minutes
  GOSUB String_To_Value
  longSec = workVal ** $0F5C             ' x 0.06 --> tenths of seconds

  ' get non-numeric data

Get_Valid:
  GET 7, char
  valid = 1                              ' assume valid
  IF (char = "A") THEN Get_Lat_Dir       ' it is, so skip
  valid = 0                              ' set to 0 if not valid

Get_Lat_Dir:
  latNS = 0                              ' assume North
  GET 19, char                           ' check it
  IF (char = "N") THEN Get_Long_Dir      ' confirm
  latNS = 1                              ' set to 1 if South

Get_Long_Dir:
  longEW = 0                             ' assume East
  GET 33, char                           ' check it
  IF (char = "E") THEN Get_Speed         ' confirm
  longEW = 1                             ' set to 1 if West

  ' get variable length data

Get_Speed:
  idx = 34
  GOSUB Mixed_To_Tenths                  ' convert "xxx.x" to number
  ' speed = workVal                      ' speed in knots (tenths)
  speed = workVal + (workVal ** $2699)   ' x 1.1507771555 for mph

  ' get date
  ' -- past variable data, so we need to use field search

Get_Date:
  field = 8                              ' set field to find
  GOSUB Move_To_Field                    ' go get position
  PUT 125, idx                           ' save date position

  fldWidth = 2
  GOSUB String_To_Value
  day = workVal                          ' UTC day, 1 - 31

  GET 125, idx                           ' get stored position
  idx = idx + 2 : fldWidth = 2
  GOSUB String_To_Value
  month = workVal                        ' UTC month, 1 - 12

  GET 125, idx                           ' get stored position
  idx = idx + 4 : fldWidth = 2
  GOSUB String_To_Value
  year = workVal                         ' UTC year, 0 - 99

  ' adjust date for local position

Correct_Local_Time_Date:
  workVal = tmHrs + UTCfix               ' add UTC offset
  IF (workVal < 24) THEN Adjust_Time     ' midnight crossed?
  workVal = UTCfix                       ' yes, so adjust date
  BRANCH workVal.Bit15, [Location_Leads, Location_Lags]

Location_Leads:                          ' east of Greenwich
  day = day + 1                          ' no, move to next day
  eeAddr = DaysInMon * (month - 1)       ' get days in month
  READ eeAddr, char
  IF (day <= char) THEN Adjust_Time      ' in same month?
  month = month + 1                      ' no, move to next month
  day = 1                                ' first day
  IF (month < 13) THEN Adjust_Time       ' in same year?
  month = 1                              ' no, set to January
  year = year + 1 // 100                 ' add one to year
  GOTO Adjust_Time

Location_Lags:                           ' west of Greenwich
  day = day - 1                          ' adjust day
  IF (day > 0) THEN Adjust_Time          ' same month?
  month = month - 1
  IF (month > 0) THEN Adjust_Time        ' same year?
  month = 1                              ' no, set to January
  eeAddr = DaysInMon * (month - 1)
  READ eeAddr, day                       ' get new day
  year = year + 99 // 100                ' set to previous year

Adjust_Time:
  tmHrs = tmHrs + (24 + UTCfix) // 24    ' localize hours
  RETURN

' **********************************************
' Convert string data (nnnn) to numeric value
' -- idx      - location of first digit in data
' -- fldWidth - width of data field (1 to 5)
' -- workVal  - returns numeric value of field
' **********************************************

String_To_Value:
  workVal = 0
  IF (fldWidth = 0) OR (fldWidth > 5) THEN String_To_Value_Done

Get_Field_Digit:
  GET idx, char                          ' get digit from field
  workVal = workVal + (char - "0")       ' convert, add into value
  fldWidth = fldWidth - 1                ' decrement field width
  IF (fldWidth = 0) THEN String_To_Value_Done
  workVal = workVal * 10                 ' shift result digits left
  idx = idx + 1                          ' point to next digit
  GOTO Get_Field_Digit

String_To_Value_Done:
  RETURN

' ******************************************************
' Convert string data (nnn.n) to numeric value (tenths)
' -- idx     - location of first digit in data
' -- workVal - returns numeric value of field
' ******************************************************

Mixed_To_Tenths:
  workVal = 0

Get_Mixed_Digit:
  GET idx, char                          ' read digit from speed field
  IF (char = ".") THEN Get_Mixed_Last    ' skip decimal point
  workVal = (workVal + (char - "0")) * 10 ' add digit, move data left
  idx = idx + 1                          ' point to next digit
  GOTO Get_Mixed_Digit

Get_Mixed_Last:
 GET (idx + 1), char                     ' point to tenths digit
 workVal = workVal + (char - "0")        ' workVal is in tenths
 RETURN

' ************************************************************
' Find field location after variable-length data (i.e., speed)
' -- field - field number
' -- idx   - returns position of first digit in field
' ************************************************************

Move_To_Field:
  idx = 0
  IF (field = 0) THEN Move_To_Field_Done ' if zero, we're there

Get_Char:
  GET idx, char                          ' get char from SPRAM
  IF (char = Comma) THEN Found_Comma     ' is it a comma?
  idx = idx + 1                          ' no, move to next char
  GOTO Get_Char

Found_Comma:
  field = field - 1                      ' was comma, dec field coutner
  idx = idx + 1                          ' point to next char
  IF (field = 0) THEN Move_To_Field_Done ' if field = 0, we're there
  GOTO Get_Char

Move_To_Field_Done:
  RETURN

' *********************************************
' Print Zero-terminated string stored in EEPROM
' -- eeAddr - starting character of string
' *********************************************

Print_Z_String:
  READ eeAddr, char                      ' get char from EE
  IF (char = 0) THEN Print_Z_String_Done ' if zero, we're done
  DEBUG char                             ' print the char
  eeAddr = eeAddr + 1                    ' point to the next one
  GOTO Print_Z_String

Print_Z_String_Done:
  RETURN
```

Xerox's Alto: The Time Machine

by Edward B. Driscoll, Jr.

Micro Memories

There's a scene near the end of TNT's 1999 made-for-TV movie "Pirates of Silicon Valley" which portrays Bill Gates (played by Anthony Michael Hall) and Steve Jobs (Noah Wylie) as the Austin Powers and Dr. Evil of the computing world – where Jobs realizes that Gates, in the middle of developing software compatible with Apples, also has a soon-to-be-released graphical operating system called Windows, designed to compete with the Macintosh.

Jobs: What is this? This is like doing business with ahhh-like a praying mantis, huh? You get seduced, and then eaten alive afterwards?

Gates: Get real, will ya? You and I are both like guys that had this rich neighbor – Xerox – that left the door open all the time. And you go sneaking in to steal the TV set. Only when you get there, you realize that I got there first. I got the loot, Steve! And you're yelling, "that's not fair! I wanted to try and steal it first!"!!??

Like most movies, it's a compressed and simplified version of what really happened. But there's no doubt that the subtext of the scene is absolutely true: Whether you're a Mac or a Windows user, your computer owes a big debt to the folks at Xerox's Palo Alto Research Campus, more popularly known as PARC.

Putting It All Together

The engineers at PARC didn't invent all of its components (though they did invent a lot of them), but in the early 1970s, they built the Alto, the first computer that brought together everything computer users today take for granted: a stand-alone computer (rather than a shared mainframe) with a graphical user interface, being viewed on a CRT, controlled by both a mouse and a keyboard, able to do what-you-see-is-what-you-get (WSYWIG) word processing, able to cut and paste text. And it printed it to a laser printer, which was connected via Ethernet.

Sound familiar? Sound exactly like the computers we see today in our homes and offices? How all this came about – and the end result – is a legendary story of Silicon Valley. Chris Garcia, the Historical Collections Coordinator of the Computer History Museum (see the July 2001 *Nuts & Volts*) says, "The whole Xerox PARC thing is probably more important than any other story in computing, from the 1970s."

Alan Kay, arguably the chief visionary behind the Alto, called it "the time machine," and indeed, it did appear to be something from the future. It marks the watershed from which the old, pre-1970s paradigm of computing, built around big, shared mainframes, with difficult to use input devices, gave way to personal computers (a term invented by Kay). The one computer for one person concept began at Xerox PARC.

$7,000.00 for the Memory Alone

Of course, nowadays, lots of people have more than one PC. Their prices have dropped to the point where an under $500.00 PC is more than powerful enough for millions of people, and allows millions more to have multiple PCs in homes and small businesses, connected to each other via Ethernet. But when the Alto was envisioned, the memory for it alone cost $7,000.00. The 1979 versions of the Altos were equipped with up to 512 kilobytes of RAM – an astonishingly tiny size when compared to the hundreds of megabytes which today's PCs routinely ship with (keep that in mind, next time there's a $39.95 for 256MB of RAM sale at the local CompUSA). "We were thought to be the most reckless and profligate people in the world for having 512K bytes when we went out the door," David Liddle, one of the developers of the Alto and its later commercial version, the Xerox Star recently joked.

Garcia says, "They were sort of trying to make the microcomputer, as we know it today, using materials from the '70s. It also used Diablo disk packs – big old single disk packs – that were probably, I think, 18 inches across."

Garcia says the Altos "were really, really slow, and if you were doing a drawing, or say, mapping a trajectory (there was a game on there, where you tried to shoot a little target along the way, and you could do some really complex stuff with it), one of the ways you would make it speed up was turn off your monitors."

The Star and Alto

Err, doesn't that sort of defeat the purpose of a computer game, you have to turn the monitor off? "Well, you didn't have to, it just sped it up by about five minutes!" Garcia says.

The Birth of WSYWIG

Of course, the Alto was never designed to compete with the first video games that Nolan Bushnell and Atari were building up the road in Sunnyvale. Much of the Alto's revolutionary hardware and software was built around word processing. Michael Hiltzik, the author of *Dealers of Lightning: Xerox PARC and the Dawn of the Computer Age* (Harperbusiness, 2000. ISBN: 0887309895), an invaluable and in-depth look at the history of PARC says, "Word processing was the most important thing, because it was something that these guys understood well, as a program that had a great deal of utility." Even the monitors on the Alto and the Star were designed, portrait style, to represent an 8 x 11-1/2 piece of paper standing up.

The PARC engineers would show their Altos to friends who would frequently respond by saying, "Hey, I've got a paper due. Can I write it on your Alto?" The engineers at PARC would sneak their friends in, in the middle of the night to write papers on their Altos, who would then marvel at how professional their papers would look as they were ejected from a laser printer connected via Ethernet.

Hiltzek says, "the engineers at PARC could see their friends going nuts about this, and they knew that this was going to be a major thing. And you had people like Chuck Geschke and John Warnock, who were graphics experts, who began to develop fonts, and solve the problem of sizing fonts on the screen, and creating them in a way to get the what-you-see-is-what-you-get effect, and they went off and founded Adobe on that principle."

Another Xerox PARC engineer, Charles Simonyi wrote Bravo, the original word processing program for the Alto. Eventually, Hiltzik says, Simonyi "got hired as like employee number 40 at Microsoft, and brought Bravo with him. And he then converted Bravo to what is today Microsoft Word. And I believe that it's said that there's still code in the source code to Word that you can trace back to Bravo."

The Time Machine Gets Run Over

If their technology was so good, why did Xerox get run over by Apple and Microsoft? In a nutshell, economics.

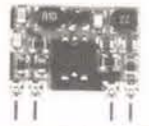
Xerox released the Star — the commercial version of the Alto — in April 1981. It was targeted at Fortune 500-type corporations, using the same marketing models by which they successfully sold their copiers for many years. Unfortunately, Xerox set the price for the Star at $16,000.00 a pop, and aimed it at executives.

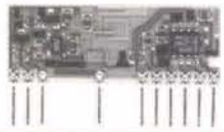
Hiltzik says "They put 30,000 of these units out into the marketplace, and I talked to people whose secretaries had them, and who loved them — they never wanted to give them up. And it was a radical departure from anything anybody had ever seen."

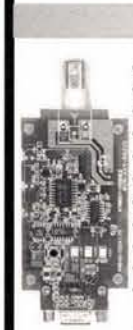
So what was the problem they ran into? Four months after the Star was released, in August of 1981, the IBM PC was launched. "Compared to Star, it was a flint age device," Hiltzik says. There were no graphics, very little power, no connectability to other machines, much less a laser printer, but they were selling for $2,000.00 to $5,000.00 each, making them much, much cheaper than the Star. "With the IBM PC," Hiltzik says, "not only could you equip a secretary with a $3,000.00 or $4,000.00 piece of equipment, you could give it to her boss, too."

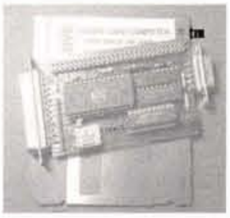
And, of course, prior to that, Steve Jobs of Apple toured PARC, along with several of his engineers. And several of Xerox's PARC employees, soon began taking jobs with Apple and Microsoft, and taking their engineering alchemy with them.

And the rest is history. The rich neighbor had been broken into, and the young pirates of Silicon Valley were off and running. **NV**









TECH FORUM

QUESTIONS

How can I measure the voltage and frequency of the discharge from a Tesla coil? It utilizes solid-state components and a flyback transformer. I assume the voltage to be several thousand volts and the frequency to be about 60 KHz.

I have access to an o-scope, frequency counter, and an assortment of multimeters.

3021 Victor Maciejewski
Rochester, NY

I help out my local school system from time to time and recently installed an independent PA system in the gymnasium. I would like to tie this system into the school-wide PA system so that when there is a school-wide announcement, it could use the speaker system that is in place in the gym.

The Gym teacher uses the gym PA system to play music during class and it would be really nice to have the gym speaker system switch to the school-wide PA during those school-wide announcements.

3022 Rick Simard
Freeport, ME

I've admired radio clocks for a while. I plan to make a PIC clock next. Is there a chip I can integrate in for self-setting time?

3023 Matt Maberino
via Internet

Does someone have a good schematic and parts list of a PC-based stepper motor controller that a beginner could build for a three-axis controller? Or where can I find a kit?

3024 Les
les@antigopro.net

I have a 5.7" LCD display made by AND and I need the pin out assignment. The part number is CS057Q-010.

It has a 15-pin male connector on one side of the display board and two wires — pink and white — wired to a three-pin female connector on the other side of the display board.

The three-pin female connector connects to a three-pin male connector on a much smaller second board which also has a four-pin connector.

I have contacted the manufacturer, Purdy Electronics via email at Purdyelectronics.com. They have advised that module is no longer produced and that they cannot help. I would appreciate anyone that might have the pin out information or data sheets.

3025 David Kamulski
Oxford, MI

I am currently in my second year of GCSE electronics and as a main project have decided to make an airband radio. Unfortunately, I am having a serious problem finding a circuit suitable for this purpose and would appreciate any help.

3026 Paul
via Internet

How does a DC clamp meter work? Is it based upon Hall-Effect transistors?

Can someone provide a low-cost circuit for a 10-60 amp DC clamp meter using a digital panel meter?

3027 Qui Nguyen
via Internet

I want to drive an LCD display from a computer with a VGA output using a VGA/NTSC converter. The display has a NTSC input and a resolution of 1152H x 234V. Would this work for displaying text and graphics? The VGA is 640 x 480 and I wonder if this would work with the resolution of the display.

3028 David Kamulski
Oxford, MI

The clock in my 1989 Mercury has a problem. The digits light and it keeps time, but the set functions don't work. I tried cleaning the contacts and this was no help. Also, the resistor seems to be running hot. Appreciate any tips on getting this thing to work?

3029 Art Millin
via Internet

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.

ANSWERS

[10213 - JAN. 2002]

I've been trying to rig up a simple time delay circuit so the power on/off button on my PC has to be held for several seconds to operate.

From what I can tell, the ATX motherboard has a pin that is ground and a pin that is about 3.4 volts connected to the on/off switch. I've tried to come up with a simple resistor-capac-

itor circuit to accomplish the time delay, but so far my efforts have failed.

My computer, monitor, printer, and scanner are plugged into a power strip which has an on-off switch that is out of the way, so if I had your problem, I would disconnect the CPU power switch. However, if you want to make a time delay circuit, this one will do it.

C1 keeps the base current flowing to the transistor while it is turning off the power source (the 3.4-volt pin).

The capacitors are Tantalum for low leakage.

The 900 numbers are

[110111 - NOV. 2001]

I am looking for schematics or designs for an IR repeater. I've found a few designs on the Internet, but the emitter and transmitter need to be hard wired together. A wireless design would be ideal.

#1 A remote control extender, which does not have these drawbacks was described in the *Radio Electronics 1991 Electronic Experimenters Handbook*. It used only commonly available parts (LM339, LM741 etc.) and a PC board was available through Fen-Tek, P.O. Box 5012, Babylon, NY 11707-0012.

Walter J. Heissenberger
Hancock, NH

#2 A simple "wired" IR repeater circuit can be built with an inexpensive IR receiver module such as RadioShack part #276-0137, a 555 timer, an IR LED attached to a short two-wire cable, and several "glue" components.

The basic idea behind such a repeater circuit is that the IR module receives the IR signal from the remote, which is riding on a 40KHz carrier. The IR module removes the carrier and sends the signal to the 555, which is set up as a 40KHz oscillator. The output from the 555 is then fed to the base of a transistor which is used to drive the IR LED attached to the end of the cable.

Assuming you have access to the Internet, a repeater circuit which makes use of these parts is shown at **www.nysaes.cornell.edu/cc/staff/pool/electronics/irrepeat.html**. (Just scroll down about half-way on the page to see the diagram).

If you need more distance, you might want to look into the IR repeater sold by RadioShack, catalog #15-1959. This device uses RF rather than a cable to send the signal to the remote IR emitter. At around $50.00, it's more expensive than the do-it-yourself approach, but it might be worth it if the extended range (up to 100') is an issue.

Mark Winters
Orem, UT

#3 There are a wealth of circuits and consumer products for improving the range of IR. The best solution depends on the range required, the number of devices that need to be controlled, the environment, and the application.

Short range solutions aim to improve reliability within a single room.

Your best options include moving equipment away from direct sunlight (always a good idea with electronic equipment, anyway) and increasing the power of the transmitter with a booster.

Medium range solutions start with the IR repeater in your question and include several room-to-room ready-built products offered by Home Automation Systems (HAS) and MCM. The two designs listed below under "Repeaters" are very very close to the build-it-yourself design you wanted.

For long range and whole-house needs, **MCM** and **HAS** carry an overwhelming number of solutions. One family of products converts IR to simple electrical signals carried over regular zip cord to home theater equipment and IR emitters in an adjoining room. Other products convert the IR signal to RF which is transmitted through the air (or over the TV coax system) to receivers anywhere in the home.

Finally, **HAS** carries products that convert IR to X-10 signals which travel throughout the home on the AC power lines.

Check both websites for over two dozen transmitter and receiver products. Some very sophisticated arrangements are described.

The articles referenced under "Theory" are listed in case you want to experiment with IR and roll-your-own design. **Digi-Key (1-800-344-4539, www.digi-key.com), JAMECO (1-800-831-4242, www.jameco.com)**, MCM (see below), and **Mouser Electronics (1-800-346-6873, www.mouser.com)** carry a wide selection of IR modules, PICs, BASIC Stamps, and general electronic needs.

MCM Electronics
650 Congress Park Dr.
Centerville, OH 45459-4072
Tel:**1-800-543-4330**
Fax:**1-800-765-6960**
www.mcmelectronics.com
50-6485 - IR Repeater (wired)
2-6680 - IR-to-RF Repeater/Extender
21XX - Family of IR-to-RF Modules

Home Automation Systems, Inc.
17171 Daimler St.
Irvine, CA 92614-5508
Tel: **1-800-762-7846** (orders)
1-949-221-9200 (Customer Service & Tech Support)
Fax: **1-800-242-7329**
www:smarthome.com
8220A & 8210RCA IR-to-RF room-to-room repeater/extender
81XX Family of products relays IR signals by RF, wires, coax, or X10.

REPEATERS

"Q&A" Column, (TJ Byers), ***Nuts & Volts***, Mar. '99, Page 81. An IR Tx/Rx repeater pair.

"Build a Remote Control Relay Station," (John Yacono), *Popular Electronics*, May '94, Page 69. This is precisely what the reader wanted. It's based on a 555 and $5.00 worth of parts.

THEORY

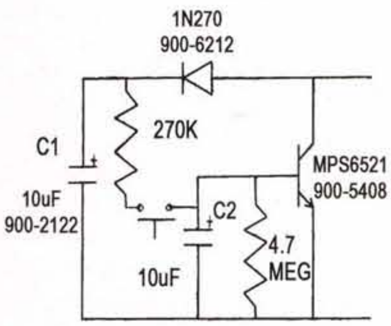
"Control from the Couch," (Jon Williams), ***Nuts & Volts***, Aug. '01, Page 20 (An excellent look at IR projects using a BASIC Stamp.)

"Build an IR Remote Control Toggle Switch," (Fred Blechman), ***Nuts & Volts***, Sept. '00, Page 32. (IR Remote ON/OFF Switch based on an IR module and three transistors! No 555, no uP — Does anyone remember transistors?)

"IR Remote Decoder," (Terry J. Weeder), ***Nuts & Volts***, Feb. '98, Page 38. An excellent IR tutorial, as well as the design for a PIC-based Rx.

Bob Miller
Trenton, NJ

RadioShack.com part numbers.



Russell Kincaid
Milford, NH

[120110 - DEC. 2001]

I would like to put a sensor at each of my 20 air conditioning units and wire them back to a panel in the shop, so I can just look and see if they are running by what temperature the air is.

I would like a small digital display with a wire going to the sensor (longest run would be about 900 ft.).

#1 Chris Salter did not specify what air conditioning (AC) parameter he wants to monitor. Assuming that he is interested in air cooling (not dehumidification with reheat) and does not want to alter the wiring of each AC unit, he might try using a pair of current mode temperature sensors for each of his AC units. These are off-the-shelf devices made by Maxim, National Semiconductor, and others, available for $2.00 or less each.

Set up one sensor in the output air stream of each AC unit, the other in its input air stream. These can be wired to a monitoring panel using a common supply (+) conductor and two separate returns, a total of three conductors per AC unit.

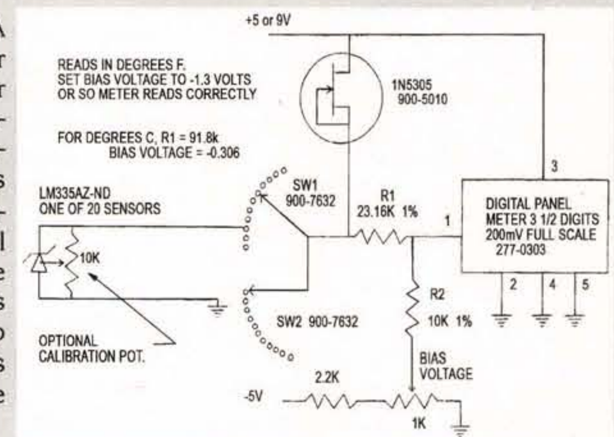
Use of current mode devices eliminates the effects of modest power supply fluctuations and connecting wiring voltage drop.

Observe the voltage and power limits and appropriate wiring materials and methods as detailed in article 725, etc., of the National Electrical Code (NEC). The 2002 NEC has been published, but most jurisdictions are still using the 1999 edition.

At the monitoring panel, use the outputs of each sensor pair as inputs to a comparator, again cheap generic ICs, which can be set up to indicate a temperature difference of less than one which reflects normal operation. This approach confirms that both the cooling and air handling functions are working. Individual LED indicators and/or a wired OR to a single LED would allow for easy monitoring. If (an) audible alarm(s) is/are required (a) 555, or some other timer, could be added to minimize nuisance alarms.

D. Cameron Smith
via Internet

#2 The LM335A temperature sensor outputs 10mV per degree C and is linear with temperature, so all that is needed is translation to the digital meter input. The translation provides 1mV per degree F to the meter so it reads the temperature directly.



Without calibration, the temperature error can be ±2 degrees C, but when calibrated, you cannot expect better than ±1 degree F.

I could not find a 20-position rotary switch, so I used two 11-position switches with position 11 open. I considered using five quad analog switches with three dual and four-bit shift registers to sequentially switch them, but that was too complicated and would introduce an additional error due to the switch resistance.

Parts are available from Digi-Key **(www.digikey.com)** and RadioShack **(www.radioshack.com)**. The part numbers ending in -ND are from Digi-Key, those starting with 900 or 2xx are from RadioShack.

Russell Kincaid
Milford, NH

[1025 - JAN. 2002]

I am trying to record a movie from DVD to VHS tape. But, when I press record, the brightness cycles from very bright to very dark. I tried using the s-video jack and the regular video jack with the same results.

Why does this happen and what I can do about it?

You are seeing the effects of Macrovision DVD copy protection, also known as the Analog Protection System (APS).

It is currently used on the majority of DVD-Video discs to degrade unauthorized copies made on VCRs. DVDs have activation bits that instruct the DVD player to add analog copy protection to the output video, so it is present regardless of which video output you connect the VCR to.

The changes in brightness are caused by the addition of pulses to the video that occur during the vertical blanking interval, which is the period of time when the electron gun in a TV resets itself from the bottom right of the screen to the top left. These pulses should not affect the image displayed on the TV, but do totally confuse a VCR's automatic gain control circuitry.

Another part of the scheme changes the colorburst information to cause lines across the picture when played back on a VCR. For more information see **www.macrovision.com/**.

I am not sure under what circumstances, if any, it is legal to eliminate Macrovision protection that might be causing problems.

From a technical point of view, there are two main approaches to this problem. Some DVD players have the ability to turn Macrovision off, see **www.area450.com/** and **www.dvdcity.com/** for some examples.

The other approach is to purchase or build a video stabilizer that restores the integrity of the video signal, such as those sold by **www.bgsales.com/**.

There are lots of schematics for do-it-yourself video stabilizers on the web, like **www.electronic-projects.net/projects/video_stab/index.shtml**.

Henry Berg
Menlo Park, CA

12011 - DEC. 2001

I have several clocks that set themselves from NIST atomic clock *radio signal. The signal is so weak where I live that only the one in the attic can get this signal.*

Is there a repeater that can retransmit the signal to the rest of the house? Or, is there possibly a transmitter I can connect to a PC, because it can get the correct time from the Internet.

I have no direct familiarity with these clocks, but can offer the following about how they work.

First, it must be determined if the clocks in question are receiving the WWV/WWVH (5, 10, 15 MHz) or the WWVB signal (60 KHz). The time information is encoded in these signals as a "time code." One bit of this code is sent each second. For the WWV/WWVH signals, a 100 Hz sub-audible carrier is used. For the WWVB signal, a 10 dB change in carrier is used.

If the clock is receiving the WWVB signal, most likely the receiver is using a ferrite rod antenna. It may be necessary to reposition the clocks having problems. Consider the proximity of the house wiring to the clocks. After all, 60 KHz is a harmonic of 60 Hz. And Romex cable and the old knob and tube wiring in old houses make wonderful 60-Hz transmitting antennas. It may be possible that the clock receiver is being "desensed" by power circuits in the house. A non-elegant solution would be a receive antenna in the attic feeding a 1 to 3 dB gain RF amp. This amp should not be broadband. Place a small coil antenna behind each affected clock. Make sure the receive antenna is no where near any of these coil antennas, otherwise a very nice feedback loop will occur and no telling where the intermod frequencies will appear.

As for using the PC ... you will need to build a transmitter on the proper frequency and modulate it in the proper format. Sorry, more trouble than it's worth. There are FCC Part 15 considerations and interference from the WWV/WWVH/WWVB signals. But consider this ... a 120 VAC wall clock accuracy is based on the 60 Hz line frequency which must average 60 Hz over any 24 hour period. If this didn't occur, the power grids could never be interconnected. Okay, so it's a pain to reset all of these clocks after a power failure.

For more information about the timecode encoding on the WWV/WWVH and WWVB signals, check out **www.boulder.nist.gov/timefreq**.

Information about CHU (Canada) is a little more complicated to find. Start your search at **www.cisti.nrc.ca** or look for possible links at **www.tycho.usno.navy.mil**.

Finally, a trivia question ... which government organization is the "Master Time Keeper" for the United States? A hint ... it's not NIST.

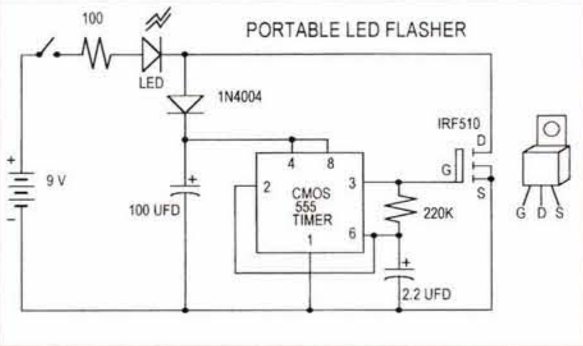
Douglas Hall
Windsor, NJ

[1028 - JAN. 2002]

I'm looking to design and construct a small amber flashing light for nighttime bicycle riding, which can be worn on the waist band or other visible areas.

#1 A simple battery-operated flasher can be constructed using a CMOS 555 timer chip, N channel MOSFET, and a few components as shown in the schematic. It can be operated by a common nine-volt battery, or any similar power source.

Power for the 555 timer is derived through the 1N4004 diode, which charges up the 100uFd storage capacitor to about eight volts. When the output of the timer chip (pin 3) goes high, the MOSFET is turned on, shorting out the timing circuit and lighting the LED.



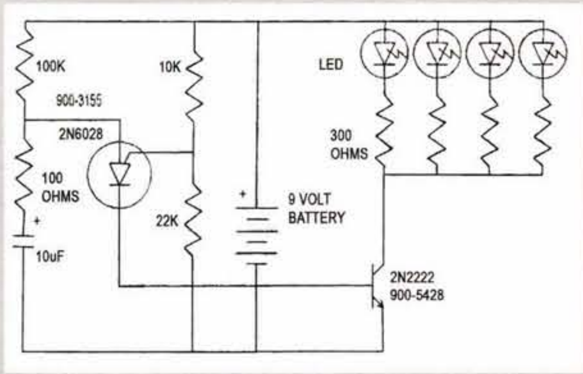
When the 555 output goes low, the transistor turns off and current through the LED is very small, effectively extinguishing it.

Using the 220K and 2.2uFd timing components shown, the flash rate is a very effective 100 flashes per minute.

Anthony J. Caristi
Waldwick, NJ

#2 I built this circuit to check it out. It blinks about once per second and draws less than one milliamp from the nine-volt battery. It should last over 500 hours.

I checked it out at night with one LED, it was not really noticeable beyond 200 feet, so I added three more. You could have a total of eight LEDs without overloading the 2N2222.

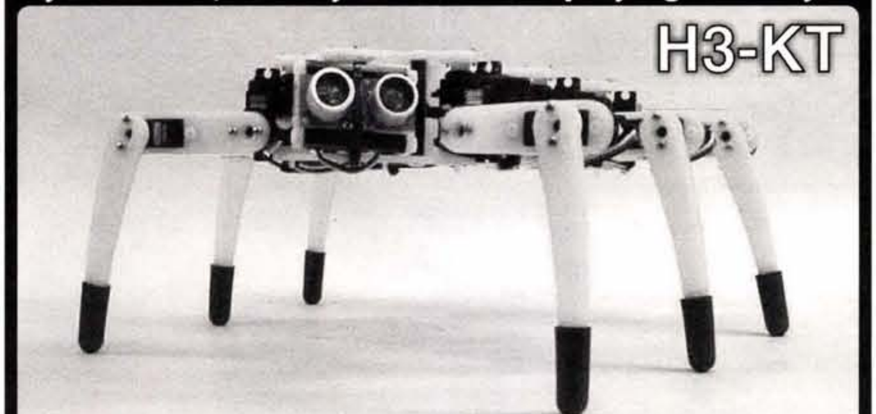


The 900 numbers are RadioShack.com part numbers.

Russell Kincaid
Milford, NH

#3 The easiest way to accomplish this is through the use of a blinking LED in the base circuit of a switching transistor. A resistor is required from base to emitter to turn the transistor completely off at low LED current. A resistor in the collector circuit is required to limit the amber LED or LED array's current. The value of this resistor will depend upon the forward voltage, battery voltage, and desired current. High brightness/efficiency types will keep the battery current low and the weight down.

Walter Heissenberger
Hancock, NH



Events Calendar

The Events Calendar is a free service for publicizing electronic events such as amateur radio hamfests, flea markets, etc. If your organization is sponsoring an event and would like a free listing, contact us at least 60 days in advance. Include your flyer, estimated attendance, name of the person to contact, and phone number.
While we strive for accuracy in our calendar, we can not be responsible for errors or cancellations. The information contained in this column is for the use of the readers of *Nuts & Volts* and may not be republished in any form without the written permission of T & L Publications, Inc.

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Fax 909-371-3052
E-mail
events@nutsvolts.com

MARCH

MARCH 2002

MARCH 2

AR - RUSSELLVILLE - Hamfest. Arkansas River Valley AR Foundation, John Evans WB5BHS, 501-967-6001.
Email: jevans@cswnet.com
Web: www.cswnet.com/~arvarf/hamfest.htm
CA - REDDING - Hamfest. Shasta Cascade ARS, Jim Bremer KE6OUA, 530-222-8001.
Email: ke6oua@arrl.net
FL - NEW PORT RICHEY - Hamfest. Gulf Coast ARC, Rick Brown AG4JN, 727-934-8741.
Email: ag4jn@arrl.net
Web: www.gulfcoastarc.org/
KY - CAVE CITY - Hamfest. Cave City Convention Center, I-65, Exit 53. 7:30am-2pm. VE testing. Talkin: 146.94/34. Mammoth Cave ARC, Jim Erskine KD4GNN,
Email: mail@chirotoons.com
NJ - PARSIPPANY - Hamfest. PAL Bldg., 33 Baldwin Rd. Splitrock ARA, Maria Turner KB2VKP, 888-511-SARA.
Email: hamfest@splitrockara.org
Web: www.splitrockara.org
OK - ELK CITY - Hamfest. West OK ARC, Earl Bottom N5NEB, 580-821-0633.
Email: n5neb@logixonline.net
TN - KNOXVILLE - Hamfest. Kerbela Temple, 315 Mimosa Ave. 8am-4pm. Talkin: 144.83/145.43 or 146.52 simplex. Shriners of Kerbela ARS, Paul Baird K3PB, 865-986-9562

MARCH 3

PA - GREENSBURG - Hamfest. Foothills ARC, Tim Bartlow K3TB, 724-834-6517.
Email: k3tb@yahoo.com Web: www.geocities.com/foothills007
VA - ANNANDALE - Hamfest. Northern VA Community College, 8333 Little River Turnpike (Rt. 236). VE testing 9am. Talkin: 146.31/91 & 146.685-. Vienna Wireless Society, Jim Parsons W4JTP, 703-392-0150.
Email: w4jtp@aol.com
Web: http://winterfest.home.att.net
WI - WAUKESHA - Hamfest. SEWFARS, Gary Pierce N9LGE,
Email: sewfars@hotmail.com
Web: www.sewfars.com

MARCH 9

AR - HARRISON - Hamfest. Boone County Fairgrounds, Hwy. 65B. VE testing. 8am-2pm. North AR ARS, Bill Rose N5VKF, 870-741-7074. Email: billrose@cox-internet.com
Web: www.qsl.net/naars/hamfest/index.html
AZ - SCOTTSDALE - Hamfest. Scottsdale ARC, Ed Nickerson WU7S, 480-949-5162.
Email: bnickers@qwest.net
FL - PORT CHARLOTTE - Hamfest. EARS & PRRA, Larry Brown KD4KVE, 941-625-0830.
Email: kd4kve@aol.com
NC - CHARLOTTE - Hamfest. Charlotte County Fairgrounds. 7am-5pm. Talkin: 147.255+. PRRA & EARS, Vic Emmelkamp, 941-473-5560. Web: www.fcrosby.com/hamfest/index.html
ND - WEST FARGO - Hamfest. Red River Valley Fairgrounds. 8am-3pm. VE testing.
Web: www.rra.org
WA - PUYALLUP - Hamfest. Mike and Key ARC, Michael Dinkelman N7WA, 425-867-4797 days or 253-631-3756 eves.
Email: mwdink@eskimo.com
Web: www.mikeandkey.com

MARCH 9-10

LA - RAYNE - Hamfest. Rayne Civic Center, 300 Frog Festival Dr. VE testing. Talkin: 146.820-600, 147.030+ 600 PL. LCARC,
Web: www.w5ddl.org
NC - CHARLOTTE - Hamfest. Mecklenburg ARS, Tom Hunt KA3VVJ, 704-948-7373.
Email: hamfest@w4bfb.org
Web: www.w4bfb.org

MARCH 10

CANADA - BC - NEW WESTMINSTER - AR & Electronics Flea Market. Burnaby & New Westminster ARC, Bob Kungl VE7KW, 604-524-9177.
Email: VE7KW@rac.ca
MA - AMHERST - Hamfest. Amherst/Pelham Regional Middle School, 170 Chestnut St. Exams. Talkin: 146.940- & 145.130+ 71.9 PL. Mount Tom Amateur Repeater Assn., Bob Meneguzzo K1YO, 877-481-8131.
Email: k1yo@arrl.net Web: www.mtara.org/hamfest/flea.html

MARCH 15-16

OK - CLAREMORE - Hamfest. Green Country Hamfest Committee, David Jackson KE4OPA, 918-622-2277. Email: info@greencountryhamfest.org
Web: www.greencountryhamfest.org

MARCH 16

CT - POMFRET - Hamfest. Eastern CT ARA, Paul Rollinson KE1LI, 860-928-2456.

COMPUTER SHOWS

AGI Shows, 317-299-8827
E-Mail: info@agishows.com
http://www.agishows.com

Blue Star Productions
612-788-1901
www.supercomputersale.com

Computers And You
734-283-1754
www.a1-supercomputersales.com

Computer Central Shows
630-782-4625
Fax 630-834-2594
E-Mail: cc@gats.com
www.computercentralshows.com

Computer Country Expo
847-662-0811
Web: www.ccxpo.com

Five Star Productions
810-379-3333
E-Mail: jeff@fivestar
www.fivestarshows.com

Gibraltar Trade Center, Inc.
734-287-2000 Taylor, MI
E-Mail: taylor@gibraltartrade.com
www.gibraltartrade.com

Gibraltar Trade Center, Inc.
810-465-6440 Mt. Clemens, MI.
E-Mail:
mtclemens@gibraltartrade.com
www.gibraltartrade.com

KGP Productions
1-800-631-0062, 732-297-2526
E-Mail: kgp@mail.com

MarketPro, Inc., 201-825-2229
www.marketpro.com

MarketPro, Inc., 301-984-0880
E-Mail: md@marketpro.com
http://marketpro.com

ComputerShow
770-663-0983
E-Mail: narisaam@aol.com
Web: www.shownsale.com

Northern Computer Shows
978-744-8440
E-Mail: inquiries@ncshows.com
Web: ncshows.com

Peter Trapp Computer Shows
603-272-5008
Web: www.petertrapp.com

Email: ke1li@arrl.net

FL - FT. WALTON BEACH - Hamfest. Playground ARC, Louis Carter KF4HRM, 850-243-4315 or 815-461-0859. Email: parcfest@w4zbb.org Web: www.w4zbb.org

FL - STUART - Hamfest. Martin County ARA, David Millard KE4AMW, 561-288-7100. Email: millard@onearrow.net Web: www.qsl.net/martin

MI - MARSHALL - Hamfest. Southern MI ARS & Marshall HS Industrial Arts Club, John Malinowski N8BGM, 616-781-4540. Email: n8bgm@aol.com

NJ - CLINTON - Hamfest. North Hunterdon Regional High School, Rt. 31. VE testing. Talkin: 147.375. Cherryville Repeater Assocation II, 908-788-4080. Web: www.qsl.net/w2cra

WV - CHARLESTON - Charleston Area Hamfest & Computer Show. William H. (Jack) Kibler K8WMX, 304-722-3150. Email: k8wmx@juno.com

MARCH 16-17

GA - MARIETTA - Hamfest. Kennehoochee ARC, Bob Butler W4RBB, 770-579-9420. Email: w4rbb@arrl.net Web: http://qsl.asti.com/hootch /KARC-HamF.html

TX - MIDLAND - Hamfest. Midland ARC, Larry Nix N5TQU, 915-699-5441. Email: oilman29@home.com Web: http://www.w5qgg.org

MARCH 17

IL - STERLING - Hamfest. Challand Middle School Gymnasium, 1700 6th Ave. VE testing. Sterling-Rock Falls ARS, Lloyd Sherman KB9APW, 815-336-2434. Email: lsherman@essexl.com

OH - MAUMEE - Hamfest. Lucas County Recreation Center, 2901 Key St. 8am-2pm. Talkin: 147.27+. Toledo Mobile Radio Assn., Paul Hanslik N8XDB, 419-385-5056. Email: kb8iup@arrl.net Web: http://tmrahamradio.org

PA - MONROEVILLE - Hamfest. Palace Inn. 8:30am-3pm. Two Rivers ARC, Bill Hetrick N3LQC, 412-751-1937. Email: n3lqc@home.com Web: www.qsl.net/w3oc/hamfest.htm

WI - JEFFERSON - Hamfest. Tri-County ARC, John Satterlee WA9SAB, 920-563-6381. Email: satterle@ticon.net

MARCH 22-23

NE - NORFOLK - State Convention. Elkhorn Valley ARC, Dave Thege N0XBN, 402-371-3550. Email: n0xbn@arrl.net Web: www.qsl.net/evarc

MARCH 23

FL - PLANTATION - Cy Harris W4MAQ Memorial Free Flea. Northeast parking lot of Motorola (8000 W. Sunrise Blvd). Talkin: 146.79 -600. Robin Terrill N4HHP, 954-583-3625. Email: kg4chw@arrl.net Web: www.geocities.com/bcepn /freeflea.html

IN - MICHIGAN CITY - Hamfest. Michigan City High School, 8466 W. Pahs Rd. 8am-2pm CST. Michigan City ARC, Inc., Ron Stahoviak N9TPC, 219-325-9089

TX - WEATHERFORD - Hamfest. ARC of Parker County, Jerry Thompson K5JWT, 817-594-8091 or 817-597-6789 (mobile). Email: k5jwt@arrl.net

MARCH 23-24

PA - PHILADELPHIA - Robot Combat. East Coast Hobby

Events Calendar

Show, Ft. Washington Expo Center. Sat: 9am-6pm, Sun: 10am-5pm. Northeast Robotics Club, Ed McCarron, 610-583-6136 eves. Email: emccarron@robotconflict.com Web: www.robotconflict.com

MARCH 24

IL - GRAYSLAKE - Hamfest. North Shore Radio Club, Jacob Fishman NEONS, 847-291-4160. Email: ne0ns@arrl.net Web: http://www.ns9rc.org

NC - KINSTON - Hamfest. Down East Hamfest Assn., Doug Burt W4OFO, 252-524-5724. Email: jeanhd@icomnet.com

OH - MADISON - Hamfest. Lake County ARA, Roxanne N8BC, 440-209-8953 (9am-9pm). Email: lcarahamfest@hotmail.com Web: http://hamnet.org/lcara

MARCH 30

TX - BRENHAM - Hamfest. Washington County Fairgrounds. 8am-12pm. Talkin: 147.260 +.600. Brenham ARC, Dan Lakenmacher N5UNU, 979-836-8739. Email: briang@comwerx.net Web: www.alpha1.net/~barc

Ultrasonic Distance Measurement Using the MSP430

By Murugavel Raju

The ultrasonic distance measuring system presented here is based on the MSP430F413 which belongs to the Texas Instruments MSP430 family of ultralow power 16-bit RISC microcontrollers. The MSP430F413 was selected for this design because of the choice of its peripherals and the integrated LCD driver.

The measurement is initiated by the system by transmitting a burst of ultrasonic sound waves towards the subject and then receiving the corresponding echo. The integrated analog comparator — Comparator_A in the MSP430 — is used to detect the arrival of the echo at the system. The time taken for the ultrasonic burst to travel the distance from the system to the subject and back to the system is accurately measured by the MSP430.

Assuming the speed of sound in air at room temperature to be 1100 feet/second, the MSP430 computes the distance between the system and the subject, and displays it using a two-digit static LCD, driven by its integrated LCD driver. The distance is displayed in inches with an accuracy of ±1 inch. The minimum distance that this system can measure is eight inches and is limited by the transmitter's transducer settling-time. The maximum distance that can be measured is 99 inches.

The amplitude of the echo depends on the reflecting material, shape, and size. Sound-absorbing targets such as carpets and reflecting surfaces less than two square feet in area reflect poorly. The maximum measurable range is lower for such subjects. If the amplitude of the echo received by the system is so low that it is not detectable by the Comparator_A, the system goes out of range, which is indicated by displaying the error message E.

Theory of Operation

Ultrasonic distance measurement is based upon the reflection of sound waves — defined as longitudinal pressure waves in the medium in which they are travelling. Subjects whose dimensions are larger than the wavelength of the impinging sound waves produce reflected waves called the echo.

If the speed of sound in the medium is known and the time taken for the sound waves to travel the distance from the source to the subject and back to the source is measured, the distance from the source to the subject can be computed accurately. This is the principle of this distance-measuring device. Here the medium for the sound waves is air, and the sound waves used are ultrasonic, since it is inaudible to humans.

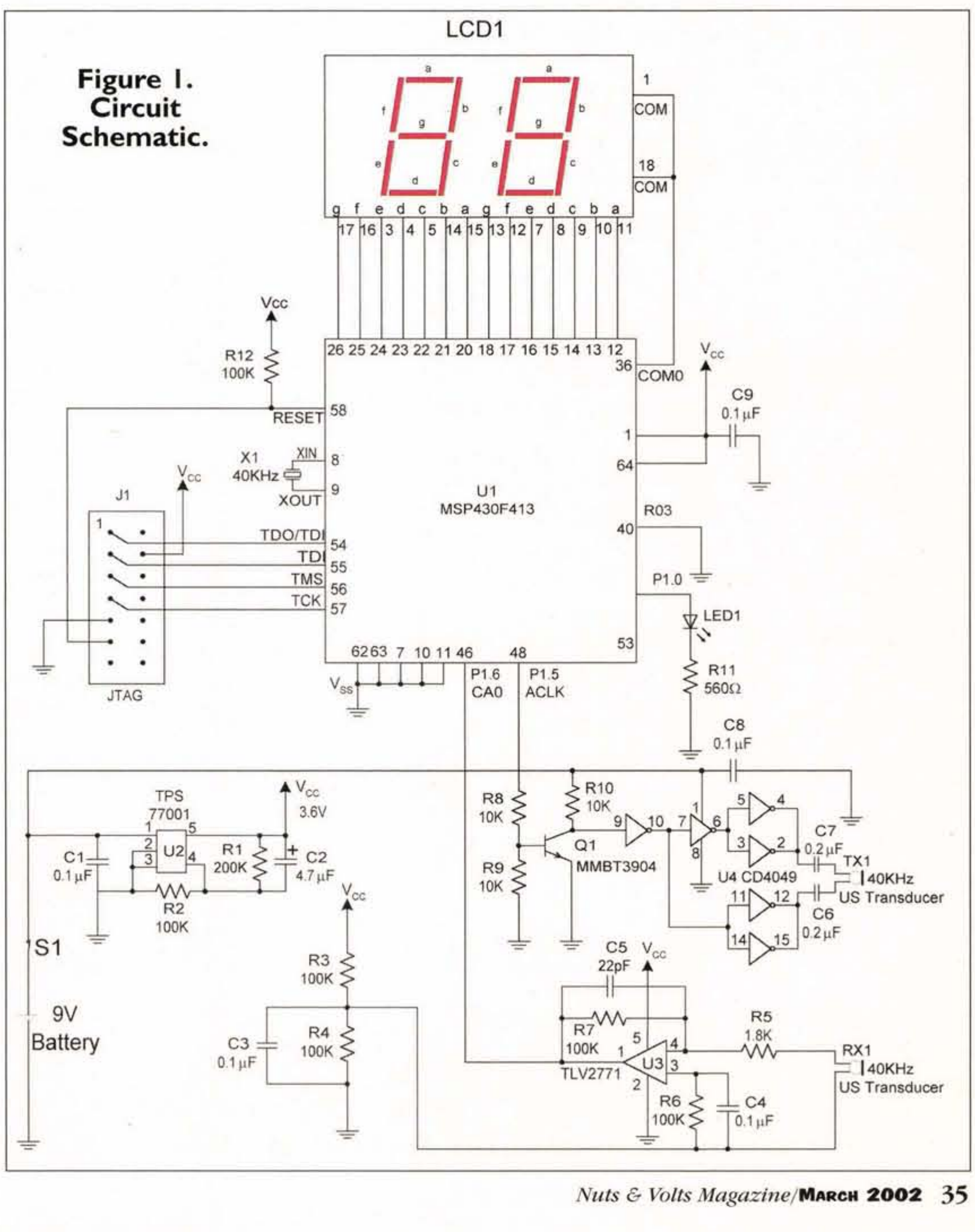
Assuming that the speed of sound in air is 1100 feet/second at room temperature and that the measured time taken for the sound waves to travel the distance from the source to the subject and back to the source is t seconds, the distance d is computed by the formula $d=1100 \times 12 \times t$ inches. Since the sound waves travel twice the distance between the source and the subject, the actual distance between the source and the subject will be d/2.

Circuit Description

The elements used to transmit and receive the ultrasonic sound waves in this system are 40-kHz ceramic ultrasonic transducers. The MSP430 drives the transmitter transducer with a 12-cycle burst of 40-kHz squarewave signal derived from the crystal oscillator and the receiver transducer receives the echo. The 16-bit timer Timer_A in the MSP430 is configured to count the 40-kHz crystal frequency such that the time measurement resolution is 25 ms, which is more than adequate for this application. The measurement time base is very stable as it is derived from a quartz-crystal oscillator.

An operational amplifier amplifies the echo received by the receiver transducer and the amplified output is fed to the Comparator_A input. The Comparator_A senses the presence of the echo signal at its input and triggers a capture of Timer_A count value to capture compare register CCR1. The capture is done exactly at the instant the echo arrives at the system. The captured count is the measure of the time taken for the ultrasonic burst

Figure 1. Circuit Schematic.



to travel the distance from the system to the subject and back to the system. The distance in inches from the system to the subject is computed by the MSP430 using this measured time and displayed on a two-digit static LCD.

Immediately after updating the display, the MSP430 goes to LPM3 sleep mode to save power. The Basic Timer1 is programmed to interrupt the MSP430 every 205 milliseconds. The interrupt signal from the Basic Timer1 wakes up the MSP430 to repeat the measurement cycle and update the display.

Figure 1 shows the circuit schematic diagram of this application. The MSP430F413 (U1) is the core of this system. (Reference [1] is the data sheet for this device.) LCD1 is a two-digit low-voltage static LCD driven by the integrated LCD driver. R03 is connected to VSS, and R13 and R23 are left open for static-LCD-drive mode operation of the LCD peripheral. A 40-kHz crystal X1 is conveniently chosen for the low-frequency crystal oscillator to match the resonant frequency of the ultrasonic transducers used in this application.

R12 serves as the pull-up resistor for the reset line, and the integrated brownout-protection circuit takes care of brownout conditions. C9 provides power-supply decoupling to the MSP430 and is located close to the power supply lines of the device. A 14-pin box header (J1) allows JTAG interface to the MSP430 to provide in-circuit debugging and programming using the MSP430 flash emulation tool. LED1 is provided to indicate measurement cycles. Port pin P1.5 is configured to output the buffered 40-kHz squarewave — ACLK — required by the ultrasonic transmitter. The output drive circuit for the transducer is powered directly from the nine-volt battery and provides 18 VPP drive to the ultrasonic transmitter. The 18 VPP is achieved by a bridge configuration with hex inverter gates U4-CD4049. (Reference [6] is the data sheet for this device.) One inverter gate is used to provide a 180-degree phase-shifted signal to one arm of the driver.

The other arm is driven by the in-phase signal. This configuration doubles the voltage swing at the output and provides the required 18 VPP to the transmitter transducer. Two gates are connected in parallel so that each arm can provide adequate current drive to the transducer, while capacitors C6 and C7 block the DC. Since the CD4049 operates on 9 volts and the MSP430 operates on a VCC of 3.6 volts, there is a logic level mismatch between the MSP430 and the output driver circuit. Bipolar transistor Q1 acts as logic-level shifter between these two logic levels.

Operational amplifier U3 is the five-pin high-slew-rate TI operational amplifier TLV2771. (Reference [5] is the data sheet for this device.) This amplifier has a high-gain bandwidth and provides sufficiently high gain at 40-kHz. The operational amplifier is connected in an inverting amplifier configuration. R7 and R5 set the gain to 55 and C5 provides high-frequency roll-off. R3 and R4 bias the non-inverting input to a virtual mid-rail for single-supply operation of the operational amplifier. The amplified ultrasonic signal swings above and below this virtual mid-rail. The high Q of transducer RX1 provides selectivity and rejection of unwanted frequencies other than 40 kHz. The output of the operational amplifier is connected to the Comparator_A CA0 input of the MSP430 via port pin P1.6.

The Comparator_A reference is internally selected to be 0.5VCC. When no ultrasonic echo is received, the voltage level at CA0 is slightly lower than the reference at CA1. When an echo is received, the voltage level increases above the reference and toggles the Comparator_A output CAOUT. R3 can be fine-tuned for the required sensitivity and the measurable range can be optimized.

The MSP430 and the ultrasonic signal amplifier circuit are powered by a regulated 3.6-volt supply, derived from the nine-volt battery via TI LDO TPS77001. (Reference [4] is the data sheet for this device.) Resistors R1 and R2 program the regulator output voltage to 3.6 volts. C1 and C2 are the recommended supply capacitors for correct functioning of the regulator. The transmitter driver is powered directly from the nine-volt battery. Switch S1 functions as the power-on switch for this application.

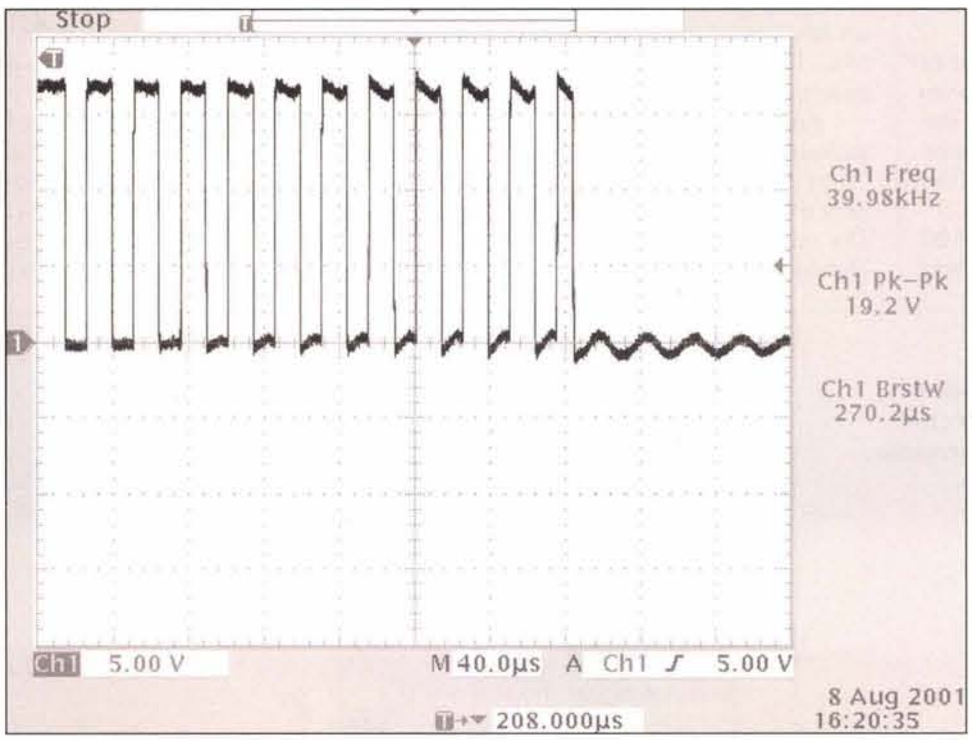


Figure 2. Oscilloscope Trace of the Transmitter 40KHz Burst.

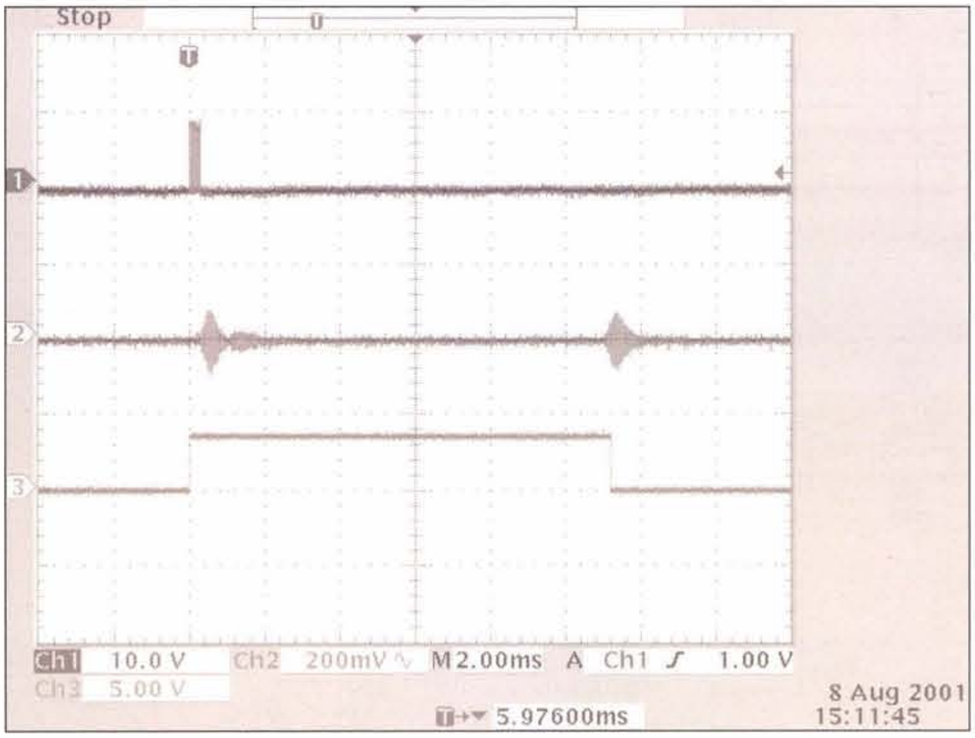


Figure 3. Oscilloscope Trace for One Measurement Cycle.

Construction

I built the prototype using a double-sided through plated PCB designed out of 'expresspcb.com.' I used the MSP430F41x flash emulation tool (MSP-FET430P410) to develop and debug the code and to program the device. You can also use the MSP430 serial programmer (MSP-PRGS430) to program the MSP430 device. Both tools use the JTAG port of the MSP430 to communicate with the device. The flash emulation tool (FET) has the advantage of providing in-system-debugging capability. The FET tool is a low-cost MSP430 development tool offered by Texas Instruments and combined with the JTAG on-chip emulation logic of the MSP430 rules out the requirement of ICE (in-circuit emulator) for microcontroller application development.

Software Ultrasonic.s43
Init_Device

This subroutine initializes and configures the peripherals used. The Watchdog Timer is disabled first. A software delay is provided to

References

Franco, Sergio. *Design with Operational Amplifiers and Analog Integrated Circuits.* New York: WCB McGraw-Hill, 1998.

Texas Instruments Datasheets:
MSP430x41x mixed signal microcontroller datasheet (SLAS340)
MSP430x4xx Family User's Guide (SLAU056)
MSP430 Family Mixed-Signal Microcontrollers Application Reports (SLAA024)
TPS770xx Ultra Low-Power LDO Linear Regulators (SLVS210)
TLV277x Family of High-Slew-Rate operational amplifiers (SLOS209)
CD4049UB, CMOS Hex Inverting Buffer/Converter (SCHS046A)
MSP430x41x Application report (SLAA136)

allow the low-frequency oscillator to stabilize. The FLL+ multiplier is set to 64 for a MCLK frequency of 2.56 MHz. P1.0 is configured as output for the LED. The unused port pins are configured as outputs and port pin P1.5 is configured to output the buffered ACLK frequency of 40KHz. The Basic Timer1 is enabled and configured to provide a 150Hz LCD frequency and also interrupt the CPU periodically every 205 milliseconds to initiate a measurement cycle.

The Comparator_A is configured with 0.5VCC internal reference and the CAPD bits are set to disable the input buffers for the comparator-input pins. The LCD module is turned ON and configured for static mode operation to drive the two digit static LCD in the application. The LCD memory locations are cleared such that the LCD displays '00' initially. The Basic Timer1 interrupt and the global interrupt enable are enabled finally so as to allow the Basic Timer1 to periodically interrupt the CPU.

Mainloop

The mainloop updates the LCD with the value stored in the buffer DIGITS and then puts the MSP430 to LPM3 sleep mode. The MSP430 remains in sleep mode until a Basic Timer1 interrupt occurs and the BT_ISR returns it to active mode. Now a measurement cycle is initiated. Timer_A is configured to 16-bit up-mode and ACLK is selected as the clock source for Timer_A. CCR1 is set to compare mode with a value of 12 so as to output 12 cycles of 40KHz burst on P1.5. Next, a delay of 36 ACLK cycles is allowed for the output transducer to settle. This is realized by setting CCR1 in compare mode with a value of 36. During these CCR1 compare wait states, the MSP430 stays in LPM0.

Now the system is set ready to receive the echo via the receiver transducer. The Comparator_A is configured to await the echo and, at the instant of the echo, it provides a capture interrupt. The Timer_A count is captured in the capture compare register CCR1 and the value is the measure of the time taken for the ultrasonic burst to travel the distance from the transmitter transducer to the subject and back to the receiver transducer. The count value is adjusted by adding 48 to compensate for the time lost in the 12-cycle burst and the 36-cycle transducer settling time delay. The adjusted value in CCR1 represents the exact time interval from the instant of the start of the burst to the instant of the start of the echo at the system.

Next, the math subroutine is called to compute the actual distance in inches and then return the result. If the system is out of range, the echo signal is not received and the Comparator_A does not provide a capture interrupt. The MSP430 stays in LPM0 until the next Basic Timer1 interrupt wakes it up. The CAIFG bit in the CCTL1 control register is tested now to make sure that the echo was never received. To indicate this condition, a value of 0xBE is stored in DIGITS to display E on the LCD. The program finally loops back to Mainloop to update the LCD and go back to LPM3 sleep mode. The next Basic Timer1 interrupt returns the MSP430 to active mode to repeat the program execution sequence.

Math_calc

The Math_calc subroutine takes care of the mathematical calculations required in this application. The adjusted 16-bit value from CCR1 is stored in the variable Result and is the representation of the time taken for the ultrasonic burst to travel the distance from the system to the subject and back to the system. Since the Timer_A counts in 25mS steps, the equivalent value in time will be Result x 25mS.

Assuming the speed of sound as 1100 feet/second at room temperature, the Result from the Timer_A counts works out to be six counts per inch of distance. Therefore, dividing the Result by 6, we get the required value of the distance in inches.

To achieve the required precision with the available integer math of the MSP430, the 16-bit Result is first multiplied by 100, then divided by 6. This 16 x 16-bit multiplication is done by the subroutine Mul100. The 32-bit result is stored in the variables htX100_msw and htX100_lsw.

This 32-bit result is then divided by 6 and the result is stored in the variable DIGITS. The value in DIGITS is in hexadecimal format. The hex2bcd subroutine converts this hexadecimal value to BCD (binary coded decimal) value and the last two digits of the BCD number are discarded to compensate for the multiplication by 100 done earlier. The resulting two-digit value is returned to the variable DIGITS.

BT_ISR

The Basic Timer1 interrupt subroutine BT_ISR manipulates the bits in the status register SR residing in the stack such that the MSP430 returns to active mode on return from this ISR. This allows the MSP430 to continue to execute the code following the LPM3 instruction in the Mainloop.

Display

This subroutine updates the two-digit static LCD with the value in the variable "DIGITS." The segment data for the static display is stored in the look-up table "LCD_Tab." The LCD memory is loaded with the required segment data by correlating the numbers in the "DIGITS" and indexing to the required location in the "LCD_Tab" look-up table.

Delay

This subroutine does a 16-bit software delay. No registers are affected as the variable to be counted down by software is assigned to the TOS (top of stack). After the delay is timed out, the SP (stack pointer) is incremented back to the original value before returning from this subroutine.

Conclusion

The integrated analog Comparator_A, the 16-bit Timer_A with hardware capture/compare registers, the Basic Timer1, and the LCD driver peripherals simplify this ultrasonic distance measurement application design and provide a system-on-a-chip solution. The average current consumed by the application is 1.3-mA during a 15-inch distance measurement. This includes the quiescent current of the LDO U2, Opamp U3, and the CMOS hex inverter U4. The opamp alone has a quiescent current of 1mA and the remainder of the circuit current consumption is 300mA. The LED draws 5-mA while it is ON.

The MSP430 draws an average current of 2.1mA with the LCD active all the time, the MSP430 sleeps in LPM3 most of the time, and the CPU resource used by this application is only 5.6%. Since the speed of sound is temperature-dependent, the measured reading will be less accurate at temperatures other than the room temperature. Simple thermistor-based temperature measurement and distance compensation could be employed in this situation to allow the system to measure accurately over a wide range of temperature.

The measured distance and temperature data could also be stored into the Flash memory, if required. The measurement range can be increased by adding receiver gain stages and using a multiplexed LCD to read out as many digits as required. **NV**

Murugavel Raju currently works as Systems Engineer for Texas Instruments. He was selected as the Worldwide winner of the first Texas Instruments Analog Challenge in the year 1999 **(www.ti.com/sc/cash)** and won the grand prize. He may be reached at **m-raju1@ti.com**.

Computer Interfacing: Part I

Getting In and Out of "the Box"
An Introduction to Computer Interfacing

By David A. Ward

One of the most enjoyable and stimulating aspects of personal computers and programming, to me, is connecting the PC up to the outside world and inputting data from real world sensors (such as temperature sensors) and controlling devices (such as stepper motors). In other words, getting in and out of "the box."

I have come away from several computer science courses disappointed that they never dealt with anything outside of the PC "box" itself.

Interfacing PCs to the outside world can be an expensive proposition if you purchase commercially available cards and accessories. Another problem is finding the software you need for interfacing or at least the information needed to make the software you currently use perform input and output operations.

This article is the first in a series of five that will introduce the basics of computer interfacing. Reasonably-priced hardware will be presented and software examples will be shown in both QBASIC and Visual BASIC. The QBASIC examples will be given first since they are the easiest to follow and the most straightforward. However, in an effort to make the software more up-to-date and Windows 95/98 compatible, Visual BASIC examples will also be introduced.

To begin with, let's take a look at what's available in the PC architecture that can be used for interfacing. There are several different types of expansion slots presently available on PC motherboards but these articles will only deal with the oldest and simplest one, the eight-bit ISA (Industry Standard Architecture) expansion slot (see Figure 1). The eight-bit ISA expansion slot consists of a PCB (printed circuit board) edge connector with 62 pins, 31 on each side. The pins in this connector can be grouped into three types of buses: the data bus, the address bus, and the control bus, as well as pins for power and a clock signal. We won't get into all of the 62 pins here but only discuss those that pertain directly to interfacing.

The data bus consists of eight bi-directional connections, D0 through D7. The eight pins allow data to be either sent out or written from the PC motherboard to a card placed in the expansion slot or for eight bits to be input or read from the card into the motherboard. Since there are only eight data bits, the data transfers are limited to the range of 00000000 (binary) through 11111111 (binary) or 0 (decimal) through 255 (decimal).

The address bus has 20 lines available — A0 through A19 — however, only the first 10 lines (A0 through A9) will be needed for typical interfacing projects. The PC I/O map that assigns and standardizes address ranges for devices such as printer ports, disk drives, etc., provides for 32 addresses for prototyping beginning at 0300 (hexadecimal) through 031F (hexadecimal) or 768 (decimal) through 799 (decimal).

Activating your interfacing projects in these 32 addresses reduces the chances that any other device in the PC will be activated at the same time as your interfacing circuitry.

The control bus contains lines that control such things as the direction of data flow. Although the ISA expansion slot has over 20 control lines, only a few are required for typical interfacing. The most important are: IOW, IOR, and AEN. When the IOW (input/output write) line goes low, the computer will be writing data out to the expansion slot. This line can be activated or asserted in QBASIC using the "OUT" command that has the following syntax: OUT Address, Data, for example; OUT 768, 234.

When the IOR (input/output read) line goes low, the computer will be reading or inputting data from the expansion slot. This line can be asserted with the QBASIC command "INP" which has the following syntax: INP(Address), for example; X = INP(769). Of course, both the IOW and IOR lines would never be asserted by the computer at the same time; the data cannot flow in two directions at the same time. The AEN or address enable

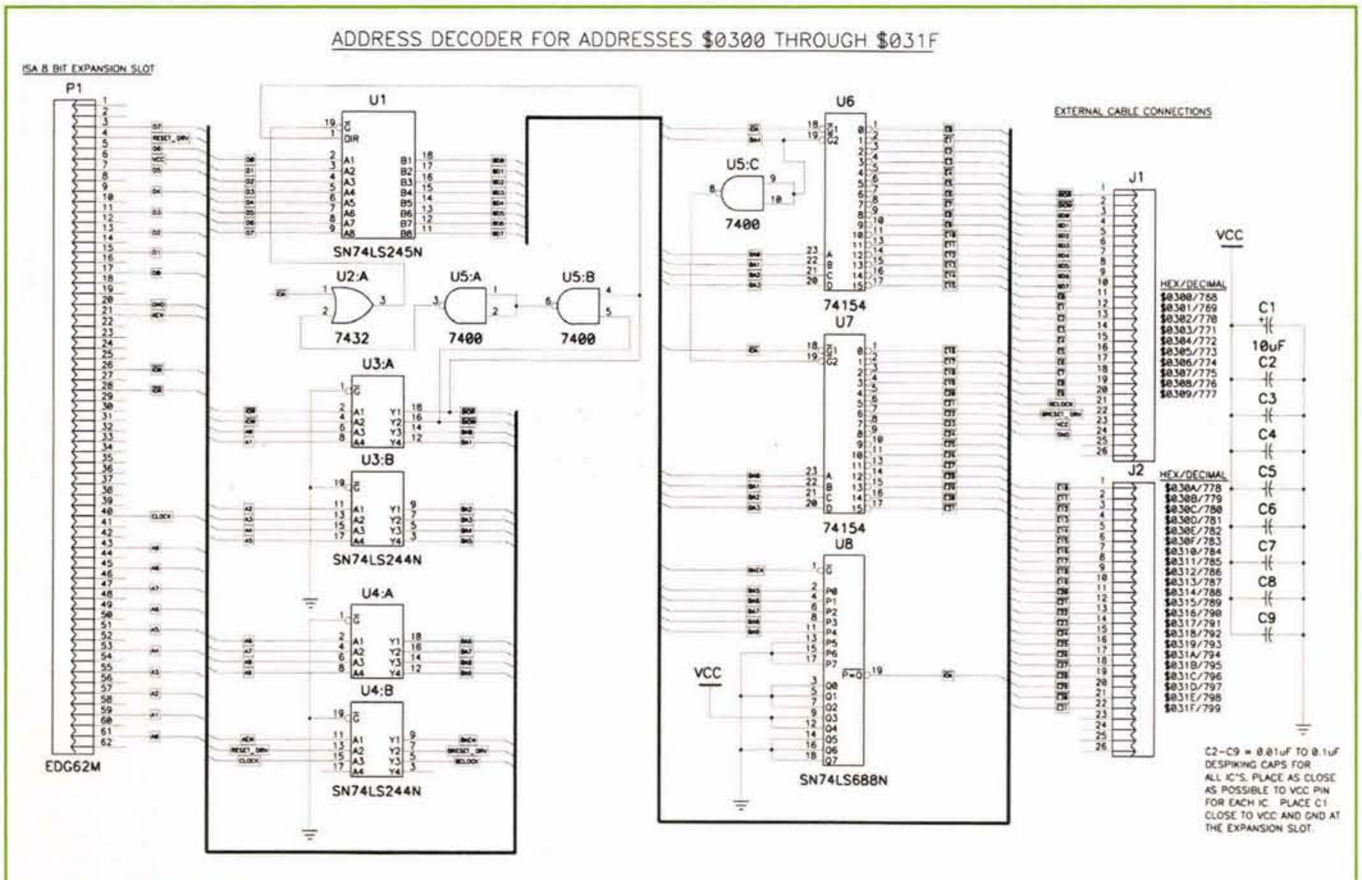


FIGURE 2

Tompkins/Webster, INTERFACING SENSORS TO THE IBM PC, Copyright 1988, PP.68, 69. Adopted by permission of Pearson Education, Inc., Upper Saddle River, New Jersey.

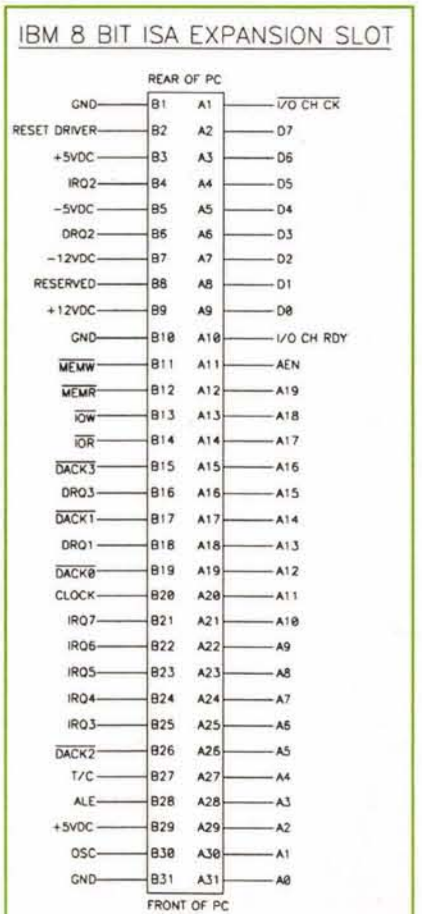


FIGURE 1

line is also an important control line when using the expansion bus. If this line goes high, it can be used to prevent bus collisions between two devices trying to use the data bus at the same time. The AEN line will go high when another device takes control of the expansion slot when performing operations such as DMA or direct memory access.

Now that we've looked at the ISA expansion slot on the PC motherboard, it is time to look at the circuitry that will fit in that slot to provide the correct address decoding and make the appropriate lines available for interfacing, see Figure 2. On the left side of the schematic diagram is the 62 pin ISA expansion slot which is labeled P1. On the right side of the schematic are two 26 pin connectors, J1 and J2, which connect to ribbon cables to take the needed lines out of the computer to a breadboard for the external interfacing circuitry.

The circuitry in the center area of the schematic provides two major functions. First, it decodes the 32 addresses in the prototyping area and provides an active low enable signal for each of these addresses, E0 through E31. Secondly, it buffers all of the necessary lines that will go out to the external interfacing circuitry. Buffering places a chip or gate between each ISA expansion slot line and the external circuitry. The buffered lines are marked with a "B" so that data line D0 becomes BD0, etc.

Buffering serves two purposes. First, it — hopefully — prevents any electrical damage caused by the external interfacing circuitry from getting back into the PC's motherboard. Secondly, buffering provides you with a known fan-out availability for your external circuitry.

For instance, if you were to connect directly to, say, data line D0, you would have no idea of how many other devices were also connected to that same line and therefore, no idea of what that data line's fan-out load or capability was. If D0 is buffered, however, you can see exactly how many devices are connected to it and plan accordingly.

0	3	0	0	Hexadecimal Address
A15 A14 A13 A12	A11 A10 A9 A8	A7 A6 A5 A4	A3 A2 A1 A0	Address Lines
X X X X	X X 1 1	0 0 0 X	X X X X	U8 Lower Range 0300
X X X X	X X 1 1	0 0 0 1	1 1 1 1	U8 Upper Range 031F
		X X X 0	0 0 0 0	U6 Lower Range 00
		X X X 0	1 1 1 1	U6 Upper Range 0F
		X X X 1	0 0 0 0	U7 Lower Range 10
		X X X 1	1 1 1 1	U7 Upper Range 1F
				X = Don't Care

FIGURE 3

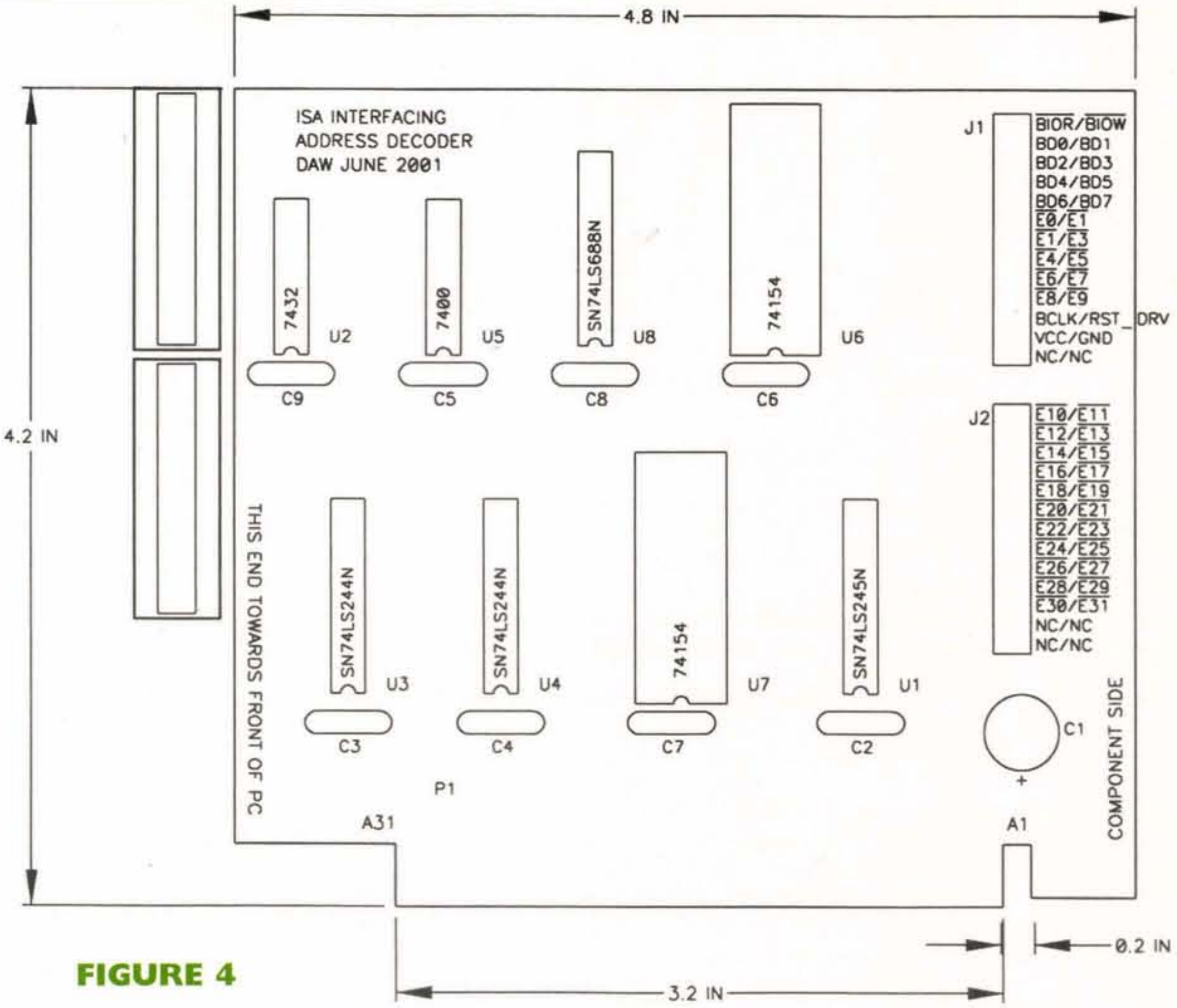


FIGURE 4

That was a brief overview of how the address decoder/buffer circuitry functions. Now we can look at its functions in detail, chip by chip. U1 is a 74LS245 tri-state octal bus transceiver. With its DIR or direction pin, pin 1, it can either send data out to the external circuitry (DIR pin high) or let data flow from the external circuitry into the PC's motherboard (DIR pin low).

The data direction through U1 is controlled by the BIOR line. U1 is enabled when pin 19, G, is taken low; this will occur when either a read or write operation is called for and the proper address range is triggered from the IOA line or input/output address line. If U1 is not enabled, pin 19 is high, the data lines will be put in a high impedance or high "Z" state which, in effect, electrically disconnects the lines from the PC's data bus, thus preventing data bus conflicts and computer lock-up. Gates U2:A, U5:A, and U5:B logically tie the BIOR, BIOW, and IOA signals together so that U1 is only enabled when properly addressed during a read or write operation. IC's U3 and U4 are 74LS244 tri-state octal drivers which are always enabled and carry signals in one direction only, out from the PC motherboard.

They buffer address lines A0 through A9, control lines IOR, IOW, and AEN, as well as the reset driver line which will go high while the PC's reset button is depressed, and finally, the bus clock signal. The bus clock signal measured 8.2MHz on a 133MHz Pentium computer I was using. This signal is available for any of your interfacing ICs that may require an external clock signal.

U6 and U7 are 74154 4-to-16 line decoder/demultiplexer ICs which provide the 32 enable lines, E0 through E31. They are essentially the lower end of the address decoder because they connect to address lines BA0 through BA3. Only one of

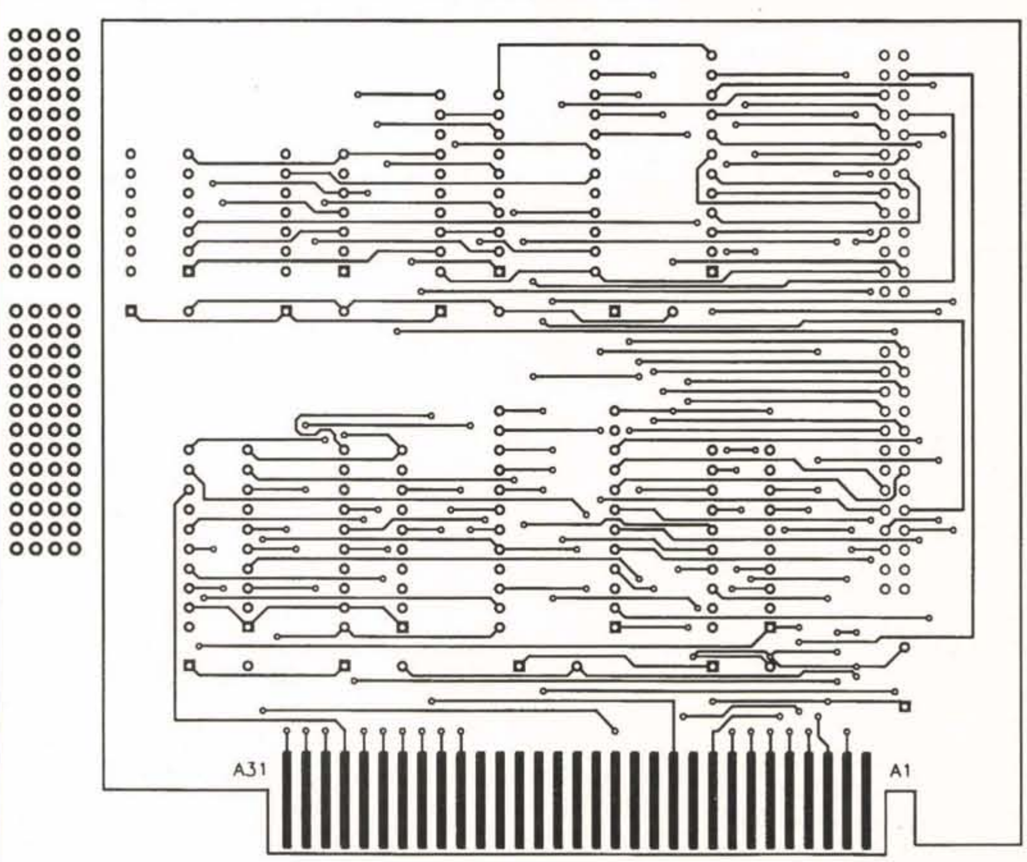


FIGURE 5

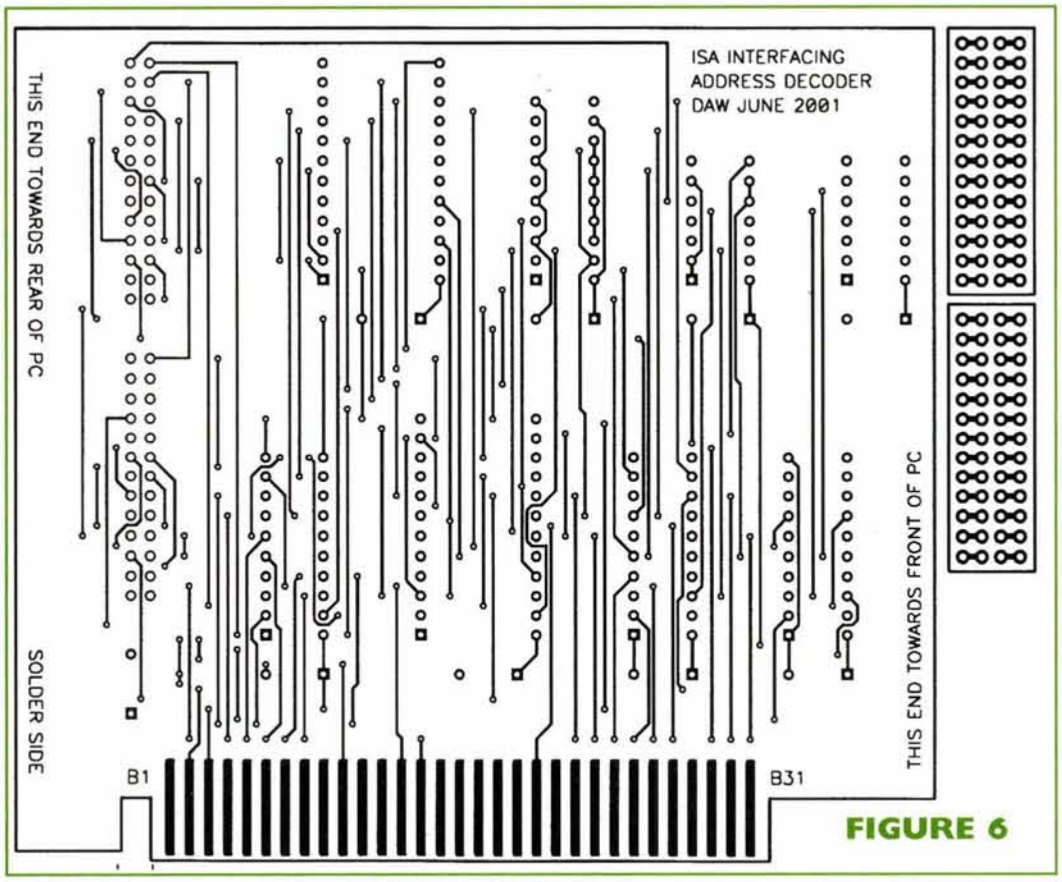


FIGURE 6

facing ports such as; A-to-D (analog-to-digital) converters, and input and output with non-TTL level devices (such as motors) will need to be addressed in subsequent articles.

A basic eight-bit TTL level input and output port schematic diagram is shown in Figure 7 and a close-up of a protoboard with a scope probe and two ribbon cables attached to it is shown in Photo 2. Let's look at the input port first since it employs the 74LS244 tri-state octal driver which was discussed earlier. Notice that all that is necessary to enable the port is OR'ing an enable line — E1 or whichever enable you choose — with the BIOR line, through a 7432 OR gate, U3:A. The "A" pins of the 74LS244 IC are tied to +5VDC through 47K ohm pull-up resistors (the value of the resistors is not too critical) and then connected to an eight-position DIP switch which has the other side grounded.

If a switch is left open, the bit that is input will be a +5VDC or a logic "1;" if a switch is closed, the "A" side of the IC will be taken to ground and the bit that is input will be at 0VDC or a logic "0." The pull-up resistors are necessary so that there is never a "floating input" condition on the port.

Floating inputs are IC input pins that are not connected to either ground or +5VDC, they are unconnected and are susceptible to stray electrical noise and voltages. Floating input pins can give you erratic and unpredictable results so you should always use either pull-up or pull-down resistors to prevent a floating input condition. Now all that is necessary is to write a little software to make it work. The QBASIC listing below can be used to test the input port. As the DIP switches are toggled off and on, the numbers displayed on the computer monitor should change accordingly.

their 16 outputs can go low at a time according to the data placed at their input lines, A, B, C, and D.

BA4 is connected to U6 pin 19 and then it is inverted on its way to pin 19 of U7 by gate U5:C. When address line BA4 is low, U6 is enabled and U7 is disabled, this decodes the first 16 addresses. When BA4 goes high, U6 will then be disabled and U7 will be enabled, and continue on with the remainder of the 32 addresses.

Finally, U8 is a 74LS688 eight-bit magnitude comparator IC which is the upper part of the address decoder. U8 will be disabled whenever the BAEN (buffered AEN) or address enable line goes high, which will occur when another device takes control of the PC data bus for an operation such as a DMA; this will keep U8's output, pin 19 IOA high which will prevent U1, U6, and U7 from being enabled. U8 compares the "P" pins connected to BA5 through BA9 against the "Q" pins which are tied high and low according to the address you wish to decode. When they are equal in magnitude, pin 19 (IOA) will go low, thus enabling U1, U6, and U7. You can also study the address decoding chart in Figure 3 to see how all of the address decoding takes place.

All of this circuitry is incorporated in the PCB design shown in Photo 1. The PCB artwork for this double-sided PCB with plated through-holes is included with this articl in Figures 4, 5, and 6. You can make your own PCBs from the artwork shown or they can be purchased along with their parts as a kit. (See the PCB Purchasing Information sidebar.) Note that connector J1 on the PCB contains all of the necessary lines needed for interfacing and enables E0 through E9. Enables E10 through E31 are on connector J2, so most of the time you can get by using one cable connected to J1; 10 interfacing circuits connected at one time is quite a few.

Well, that finally gets us out of the "box" with the proper address decoding and the necessary buffered data and control lines. At this time, only a basic eight-bit TTL level input port and output port will be introduced. Other types of inter-

```
CLS
PRINT "Press any key to exit"
WHILE LEN(INKEY$) = 0
  X = INP(769)      '769=E1
  PRINT X
WEND
```

Now let's take a look at the output port. The output port consists of a 74LS374 octal D flip-flop, which is enabled by OR'ing an enable line, in this case, E0 and the BIOW line. The 74LS374 IC will latch out or hold the data that is written to it until new data is received. Therefore, if you output a particular number, the LEDs will be on accordingly and remain on until another value is written to the port. Notice that the eight LEDs connected to its output side are connected through resistors to their cathodes rather than their anodes, so that the IC "sinks" their current rather than "sources" their current. This is done because the 74LS374 can only source 2.6mA of current per pin,

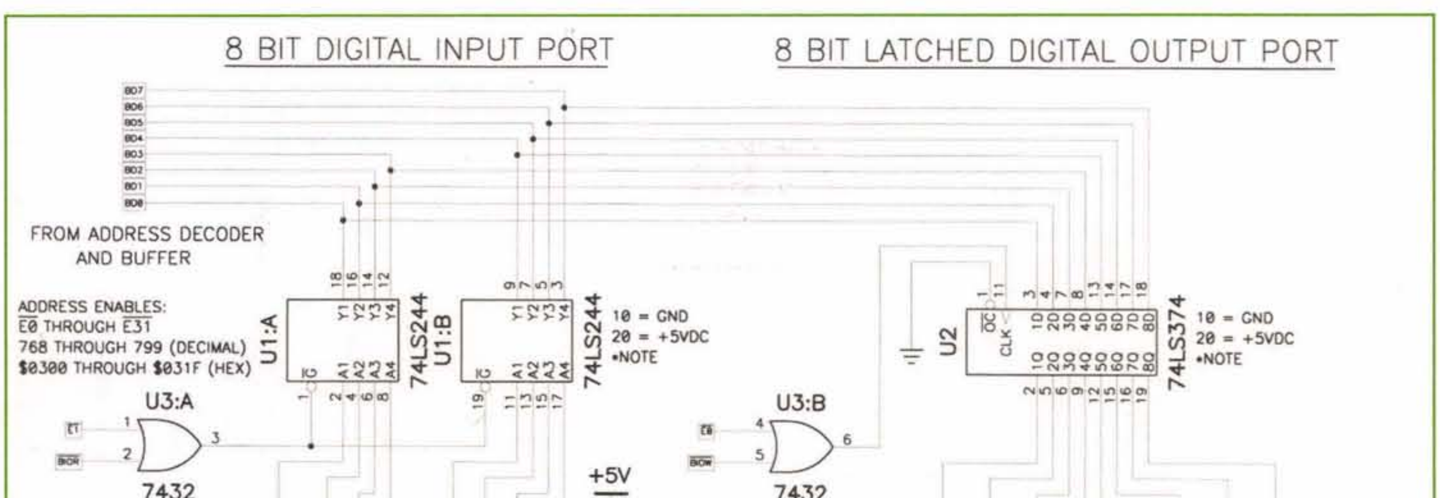


FIGURE 7

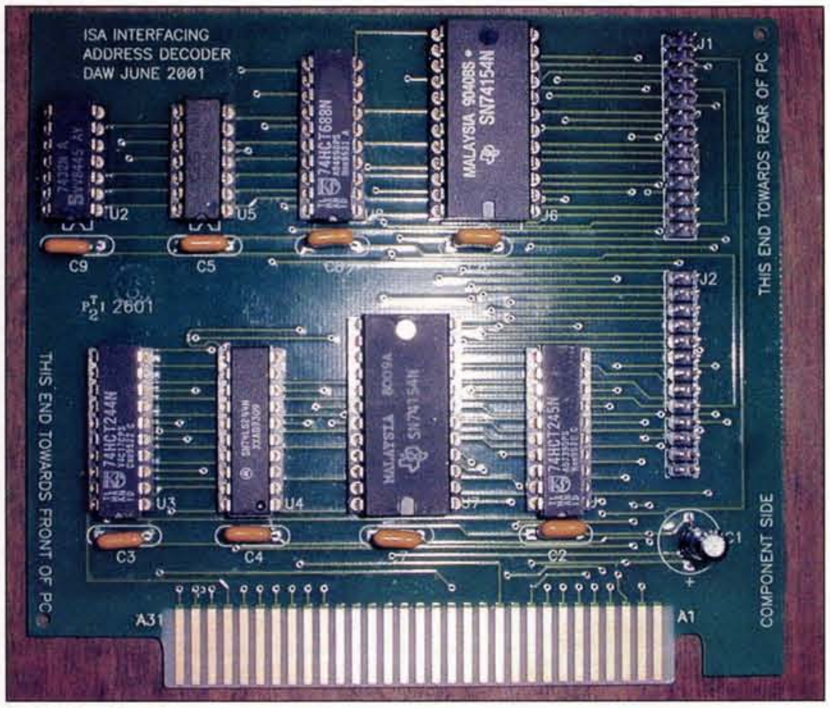


PHOTO 1

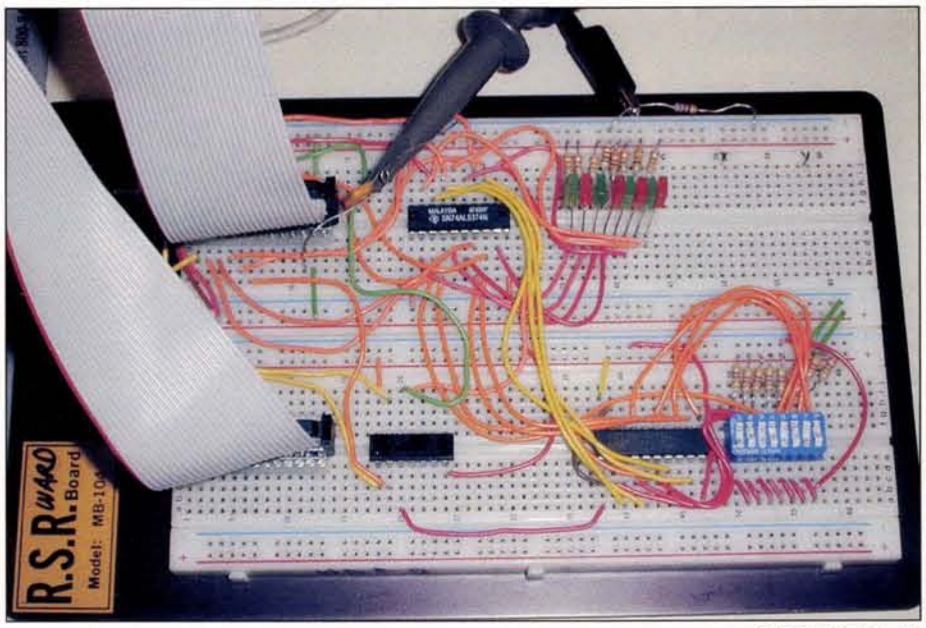


PHOTO 2

but can sink, or take to ground, 24mA of current per pin and a typical LED requires about 20mA. This causes an inverted logic at the LEDs, in other words, writing a "1" out to the LEDs will turn them off rather than on as you would normally expect. If this bothers you, it can be fixed in the software by subtracting the number you wish to output from 255; see the QBASIC software listing below. This program simply counts up from 0 to 255. If the program runs too fast or too slow for your computer, simply adjust the number that Y counts up to (it currently counts up to 1,000).

```
FOR X = 0 to 255
   OUT 768, 255 - X          '768=E0
   FOR Y = 0 to 1000: NEXT Y
NEXT X
```

Well, that's plenty to get you started. In the next installment, a Visual BASIC GUI (graphical user interface) software project will be introduced and how to build it explained in detail. **NV**

PCB Purchasing Information

Bare PCB doublesided with plated through holes, includes two break-off cable adapter PCBs for proto-boarding. **$25.00 includes shipping and handling.**

Parts kit for PCB and I/O ports, includes: eight IC sockets, 11 ICs, 11 capacitors, one eight-position DIP switch, eight LEDs, 16 resistors, 2-26 wire ribbon cables each 2-½ feet long (cables are made with IDC sockets installed), four male headers for the cables, and proto-boarding pins for the cable adapter PCBs. All parts are included to build the interfacing circuitry on the PCB and the eight-bit I/O ports excluding the proto-board. **$25.00 includes shipping and handling.**

Send a check or money order to:
David A. Ward
2261 West Skyview Dr.
Cedar City, UT 84720
Phone: 435-586-7235
(I am unable to accept credit cards.)

Item	Quantity	Description
U1	1	74LS245 Octal Bus Transceiver 20 pin DIP
U2, U3 (I/O Port)	2	74LS32 Quad 2 Input OR Gate 14 pin DIP
U3, U4, U1 (I/O Port)	3	74LS244 Tri-state Octal Driver 20 pin DIP
U5	1	74LS00 Quad 2 Input NAND Gate 14 pin DIP
U6, U7	2	74LS154 4-to-16 Line Decoder/Demultiplexer 24 pin DIP
U8	1	74LS688 Eight-Bit Magnitude Comparator 20 pin DIP
U2 (I/O Port)	1	74LS374 Octal D Flip-Flop 20 pin DIP
	2	14 pin DIP sockets
	2	24 pin DIP sockets
	4	20 pin DIP sockets
C1	1	10uF/50V Radial Lead Electrolytic Capacitor
C2-C9, 3 (I/O Port)	11	0.1uF/50V Ceramic Despiking Capacitors
	4	0.1" Straight Male Headers
	5 ft.	28 AWG 26 Conductor Ribbon Cable
	4	26 pin IDC Sockets for Ribbon Cable
R1-R8 (I/O Port)	8	47K Ohm 1/4 Watt Resistors
R9-R16 (I/O Port)	8	270 Ohm 1/4 Watt Resistors
I/O Port	1	Eight-Position DIP Switch
I/O Port	8	LEDs

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Kronos Crawler *Phase 3*

Switches & Mods

By Michael Simpson

Important Change

On the last two Kronos Crawler articles, the schematics list the pins for the VSS connection on the SN754410 chip as 4,5,13,14. This is incorrect and should read 4,5,13,12.

This month, we are going to add a couple of bump switches for object detection. Before we get started, we need to make a few modifications to the platform. These modifications will allow us to attach two bumpers to the front of the Crawler. They will also allow us to off-load some of the circuitry on the development board to a few multipurpose PC boards.

Platform Modifications

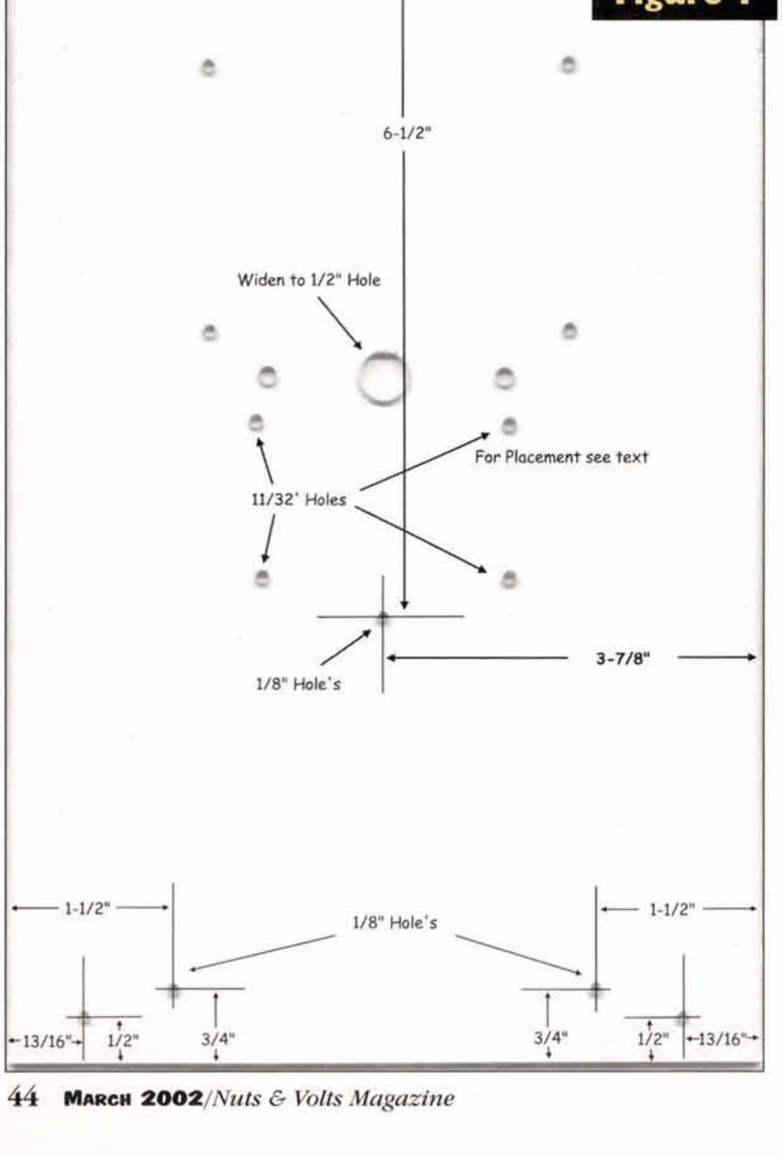
These enhancements involve drilling nine more holes and widening another. I will go through each step needed to upgrade the platform by referring to Figure 1.

Step 1
Remove the platform from the base and remove all components currently mounted on the platform.

Step 2
Widen the center hole as indicated in Figure 1. This hole is currently used to run the motor wires. Although this step is not absolutely necessary, it will make life easier in the future and will also protect the wires going through the hole.

Step 3
Place a 1/8" support hole 3-7/8" from the right edge and 6-1/2" from the back edge.

Figure 1



Step 4
Drill the four 1/8" holes near the front of the platform. These will be used to mount the bump switches.

Step 5
Drill the four 11/32" holes near the center of the board. I did not give measurements on these because the best way is to just mark the holes with the multipurpose PC board as shown in Figure 2. Placement is not that critical. I show 11/32" holes for this, but you may want to make them a bit bigger to give your mounting screws some adjustment.

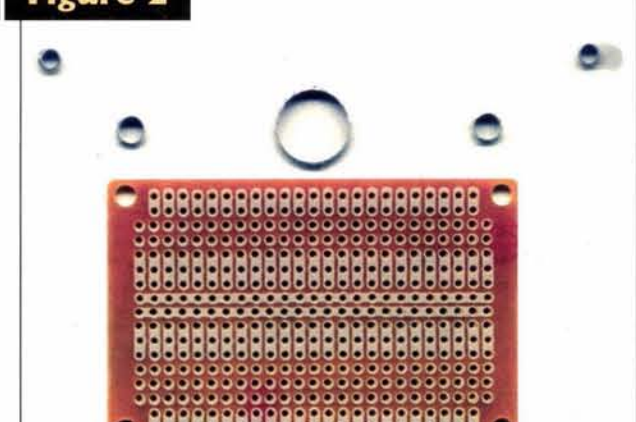
Now with the platform modifications, we can start to reassemble the Crawler. If you are going to paint your Crawler, now is the time. Remove the tracks and cover the wires. Lay the platform upside down on a flat surface and paint the bottom. Be sure to let it dry before you continue.

Step 6
Take a 3/8" rubber grommet and insert it into the 1/2" hole that you widened.

Step 7
Take four 6-32 3" machine screws and insert them into the four holes you created for the multipurpose PC board. Use four 6-32 hex nuts to attach the screws. Tighten the nuts.

Step 8
Take a 1" 4-40 machine screw and attach a hex nut. Slip on a #4 lock washer. Now take that screw and insert it into the new 1/8" support hole from the top. Attach with a second hex nut from the underside of the platform as shown in Figure 3. (Your platform should look like the one in Figure 3.)

Figure 2

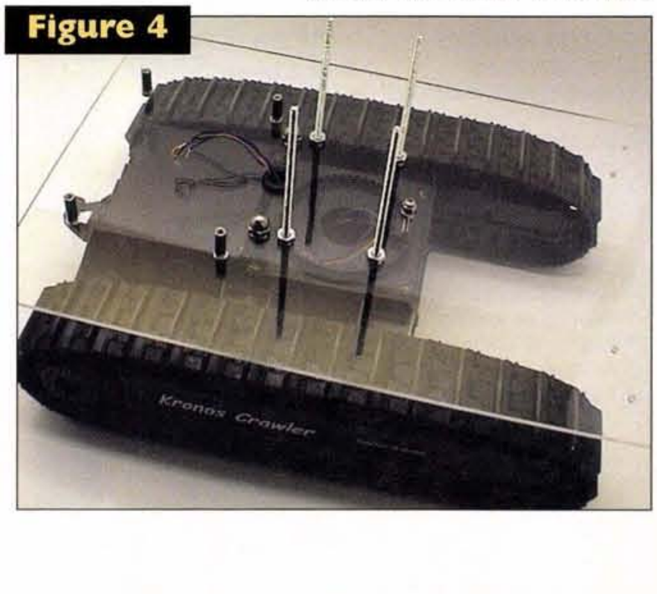


Step 9
Another enhancement I made was to use 1/2" standoffs instead of just machine screws. This allows you to remove and attach the development board without the removal of the platform.

As shown in Figure 4, take four 1/4" 4-40 machine screws and insert a #4 lock

Figure 3

Figure 4



washer on each one. From the bottom of the platform, insert the machine screws into the four development board holes on the platform. Take the four standoffs, attach them to the screws, and tighten firmly in place.

Step 10

Reattach the platform to the Crawler base using the two 10-24 Acorn nuts. Be sure to feed the motor wires through the grommet. At this point, your Crawler should look like the one in Figure 4.

Step 11

Reattach the development board to the four standoffs with four 1/4" 4-40 machine screws.

That's it for the modifications. Now with very little effort, we can add extra boards to free up our development area.

Contact Bumpers

The contact bumpers consist of two switches with mounting hardware configured in such a way that if the Crawler bumps into anything from the front, we can detect it.

We start with two snap action lever switches. The ones I used have a 2" lever. We are going to attach a 7" piece of piano wire to each lever. We will use some heat shrink tubing for this. The tubing will also keep the wire from scratching any delicate surfaces the Crawler may come in contact with.

Take a 3" piece of the 1/16" red shrink tubing and slip it over the piano wire. Leave about 1/4" excess tubing on the end. Heat the tubing and twist the excess on the end to a point as shown in Figure 6.

Now slip a 6" piece of 1/8" shrink tubing over the lever of the switch. Work it all the way to the bend in the lever as shown in Figure 7. Don't heat the tubing yet.

As shown in Figure 8, slip the non-covered end of the wire into the tubing so that it slides along the top of the lever. The wire should be flush with the bend in the lever. Heat the tubing now to secure the wire in place.

It is time to attach the wires to the switch. I prefer to use colored wire so that I can figure out which switch is which once everything is installed.

Referring to Figure 8b, start by connecting a 13" brown or black wire to the common lead of each switch. This connector is marked COM on most switches. If it's not marked on your switch, you will have to use a voltmeter to find this lead.

Next, connect a 13" yellow wire to the normally open lead on one switch and a 13" orange wire to the normally open lead on the other switch.

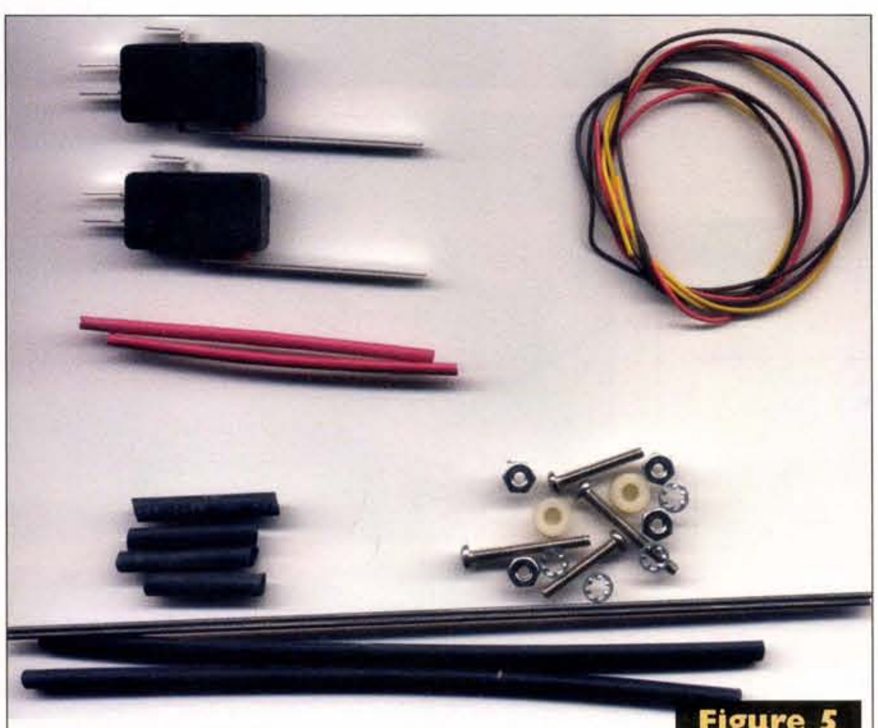


Figure 5

Figure 6

Figure 7

Solder in place and slip a 1" piece of 1/8" shrink tubing over the lead and heat.

As shown in Figure 9, attach the right bumper switch (yellow wire). Use two 3/4" 4-40 machine screws and #4 lock washers. Attach the left switch using two 1" 4-40 machine screws and lock washers. On the left switch, you should also use two 1/4" spacers between the switch and the platform. This helps keep the two bumpers from interfering with each other.

Run the wires up through the grommet. You can use the support screw we put in place earlier to help with the routing of the wires. Make sure they are up against the bottom of the platform and not rubbing on any of the tracks. If necessary, use a bit of tape to hold the wires in place.

Hook-up

Let's start by reconnecting the motor controller.

I wired up the SN754410 to a multipurpose board as shown in Figure 10. If you mount the SN754410 on one end of the board, it leaves room for enhancement later. I will be offering a serial controller for the SN754410 in the future so you only need one pin to control your motors. Also notice in Figure 10 that I added a small switch. This switch is completely optional, but it does allow me to turn off the motor power source without pulling wires.

Figure 11 shows a complete schematic of the current Crawler configuration. It even includes a few CDS cells that we will be using in a future article.

At this point, I need to make a few points. Many of the pin assignments on the Atom have been changed. I did this to exploit another feature of the microcontroller.

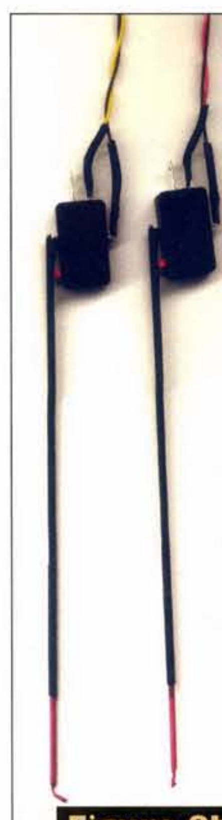


Figure 8b

Figure 8

The Atom has two PWM signal generators, and even though both use the same timing circuitry for the frequency, they both can have separate duty cycles. This allows control over the individual tracks on the Crawler.

Why would you want to do this? No two motors are exactly alike. You may find that the Crawler slowly pulls to one side or the other when it travels in a straight line. By tweaking the left or right track, we can correct this.

With the motor controller mounted on a multipurpose board, we are ready to mount it on the mounting screws. Before we do this, we need to add a 1/4" spacer as shown in Figure 12.

In Figures 13 and 14, you can see my controller board and battery placement. The headers make it very easy to wire the board without solder-

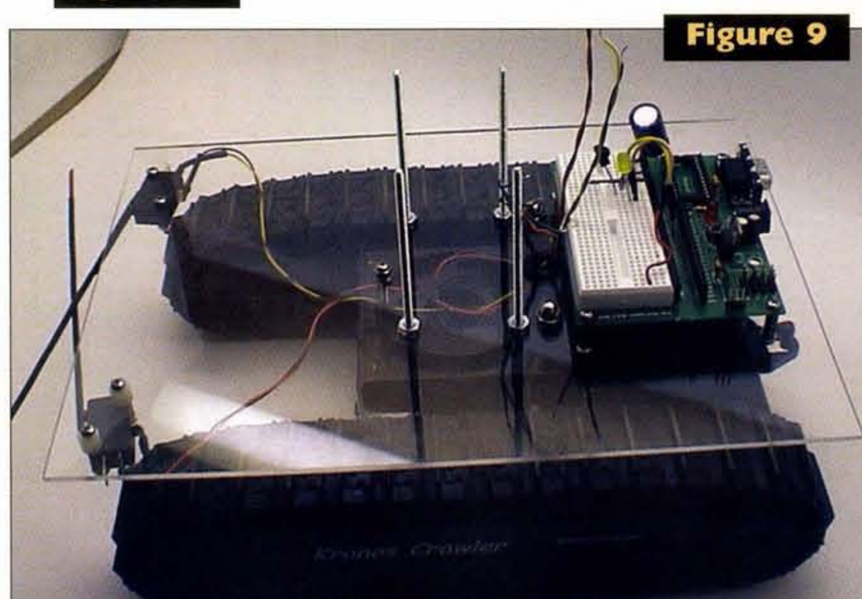


Figure 9

ing.

Figure 15 shows the Crawler with a second base mounted on the top of the mounting screws. This gives you lots of room for expansion and experiments.

The Program

This program was designed to reflect the modifications we made to the schematic, so you will notice the motor controller definitions have changed. The IR routines now also reflect the new lead we are using there.

As far as additions go, we have added a checkbumpers routine that will stop the motors if either bumper comes in contact with an object while the Crawler is moving forward.

The extra PWM generator code has also been added to each of the speed subroutines. Tweak these as necessary if your Crawler drifts to the right or left.

For instance:

```
HPWM 1,10000,9900 : Return 'Left track
HPWM 0,10000,10000 : Return 'Right track
```

will cause the Crawler to very slightly drift to the left.

```
HPWM 1,10000,10000 : Return 'Left track
HPWM 0,10000,9900 : Return 'Right track
```

will cause the Crawler to very slightly drift to the right.

One last addition was a small routine that will place the Crawler into a search mode. You enter this mode by hitting the #9 on the remote.

The Crawler will move forward until it encounters an object, then will back up and turn to move forward again.

In Closing

I started using rechargeable batteries and I feel a word of caution is needed. Rechargeable batteries can put out quite a bit of current all at once and easily start a fire if shorted out. This is one of the reasons I installed the switch to remove the motor power.

I have also used two four-cell battery holders for this project. This is a total of eight batteries. With rechargeable batteries at 1.2 volts each, that's 9.6 volts. With 1.5 volt drop across the motor controller, that gives us 8.1 volts, which is a bit more than the six volts the motors are rated at. By lowering the duty cycles, we can compensate for this.

What's Next

More sensors. **NV**

For updates and enhancements, be sure to visit the Kronos Robotics web site at **www.kronosrobotics.com**

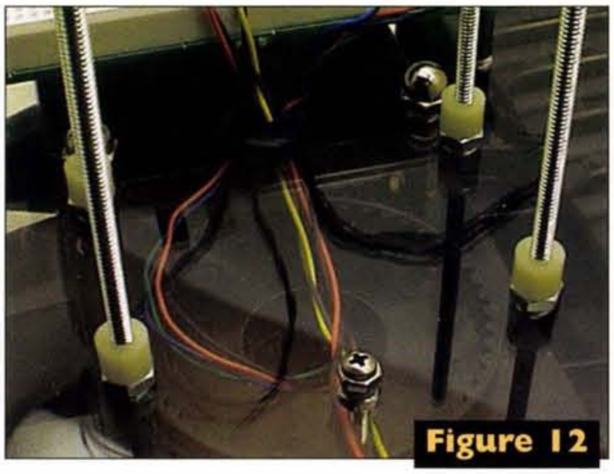


Figure 12

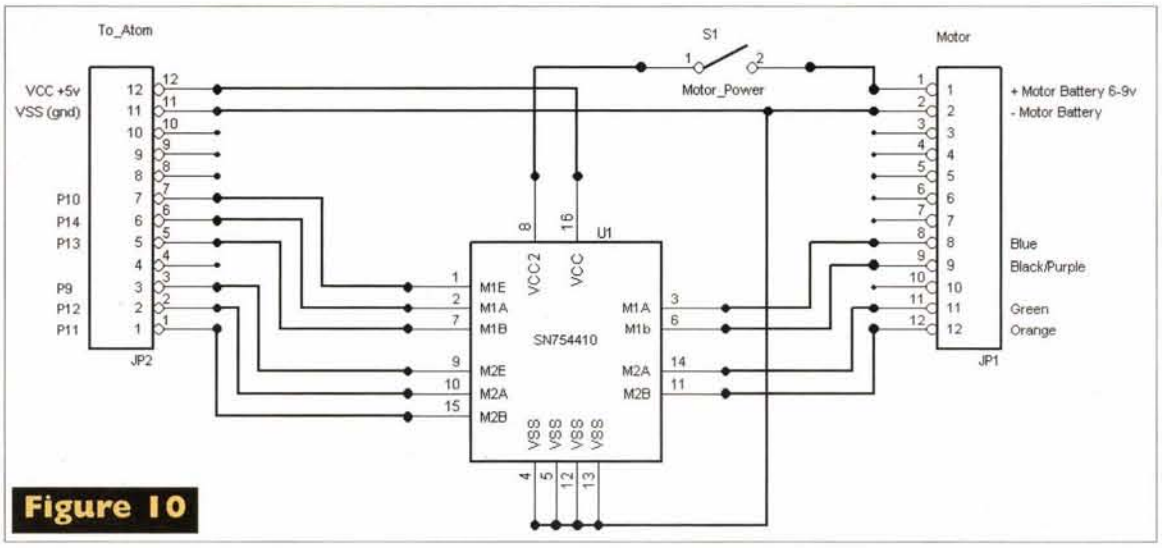


Figure 10

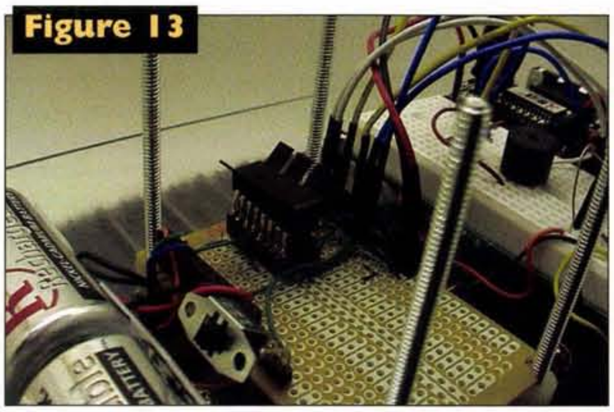


Figure 13

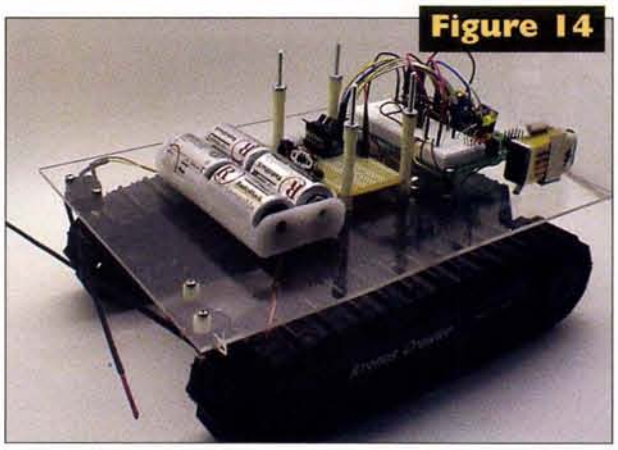


Figure 14

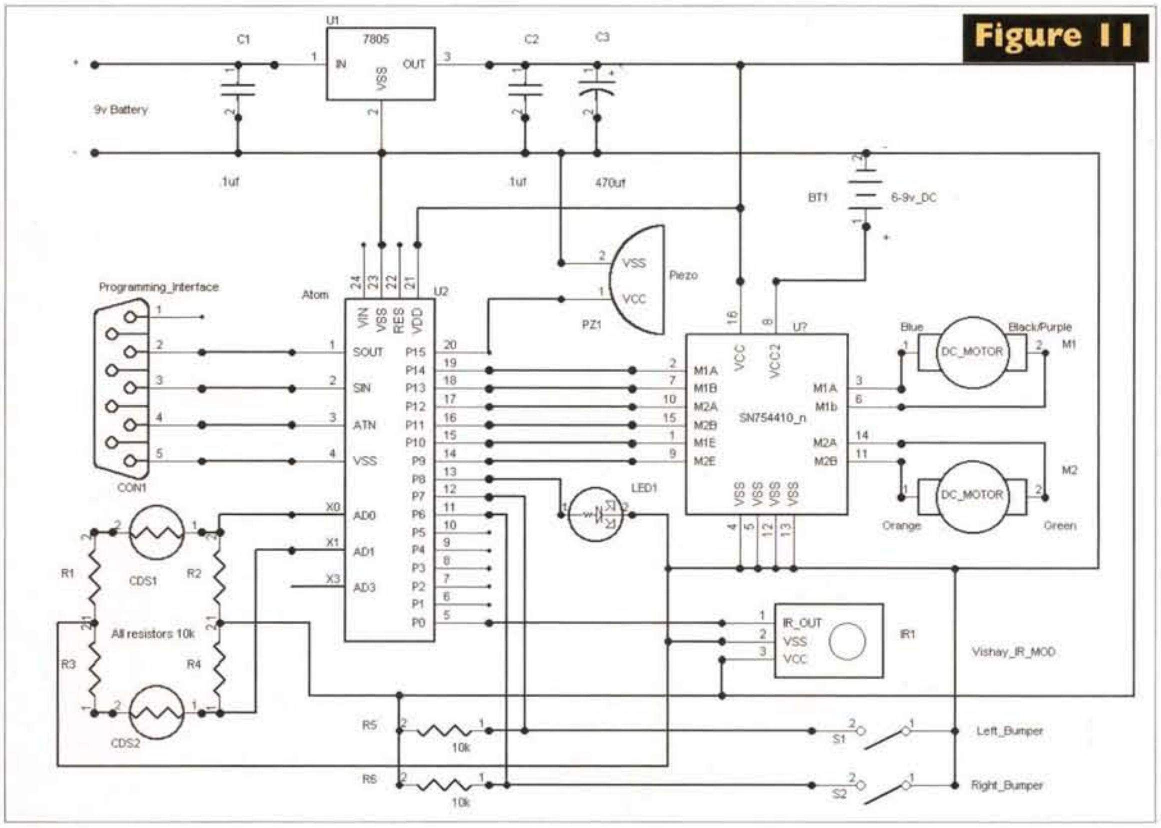


Figure 11

Figure 15

Program Listing 1

```
'----------------------------------------------------
'IR Settings
'----------------------------------------------------

devicecode var byte
cmdcode var byte

'Holds the pulse width of the current bit under test
bitvalue var word

'Holds the divisor for testing the width of each pulse
level1value var word

'In this case 1200ms or longer will be a high state
level1value = 1200

'We will devide bitvalue by level1value to determine
' if bitvalue is less than 1200 (high state pulse width value).
'If it is then the bit is 0 other wise its 1.

' By using some simple integer math I can still scan each
' bit in time for the next. Had I used an IF statement
' we would eat too much time between pulses in the stream.

'We use this as a form of IR indication
output 8 'LED
output 15 'Piezo alarm

'----------------------------------------------------
' Motor Settings
'----------------------------------------------------
'-------- Sets up the constants for the motor controller
M2InputA Con 12
M2InputB Con 11

M1InputA Con 14
M1InputB Con 13

'-------- Setup the ports for motor controller
Output M1InputA
Output M1InputB

Output M2InputA
Output M2InputB

'-------- Setup the initial speed
gosub CrHigh

main:

 gosub checkbumpers

 gosub getsonycode

 '---- Time out (no key pressed)
  if devicecode = 0 and cmdcode = 0 then
   gosub Crstop
   low 8 'Turn indicator off
   goto main
  endif

 high 8 'Turn indicator on

'---- Reverse ----
  if cmdcode = 17 then 'CH -
   gosub Crrev
   endif

'---- Forward ----
  if cmdcode = 16 then 'CH +
   gosub Crfwd
   endif

'---- spin left ----
  if cmdcode = 19 then 'Vol -
   gosub CrLspin
   endif

'---- spin Right ----
  if cmdcode = 18 then 'Vol +
   gosub CrRspin
   endif

if cmdcode = 1 then
   gosub Crlow
   gosub beep1
   endif
if cmdcode = 4 then
   gosub Crmed
   gosub beep2
   endif
if cmdcode = 7 then
   gosub Crhigh
   gosub beep3
   endif
if cmdcode = 8 then
   gosub searchmode
   endif

Goto main

checkbumpers:

 'see if ether bumper is pressed
 if in7 = 0 or in6 = 0 then

  'If ether motor is moving forward then stop
  if (in14=1 and in13 = 0) or (in11=1 and in10=0) then
   gosub Crstop
   gosub beep1
   endif
  endif

 return

'--------------------------------
' Simple Piezo sounds
'--------------------------------
beep5:
 high 15
 pause 50
 low 15
 pause 50
beep4:
 high 15
 pause 50
 low 15
 pause 50
beep3:
 high 15
 pause 50
 low 15
 pause 50
beep2:
 high 15
 pause 50
 low 15
 pause 50
beep1:
 high 15
 pause 50
 low 15
 return


searchmode:

 'Test right bumper
 if in7=0 then
  gosub Crrev
  pause 1000
  gosub CrLspin
  pause 1000
 endif

 'Test left bumper
 if in6=0 then
  gosub Crrev
  pause 1000
  gosub CrRspin
  pause 1000
 endif

 gosub Crfwd

goto searchmode

'--------------------------------
' This is the main IR routine
' It populates cmdcode and
' devicecode variables
'--------------------------------
GetSonyCode:

'Clear the Irbits
devicecode=0
cmdcode=0

getstartbits:

'We have to clear the variable used with the pulsin command
as
' the Atom will not clear the variable if it times out.
bitvalue =0

Pulsin 0,0,bitvalue
if bitvalue = 0 then
  return
endif

if bitvalue < 2000 then getstartbits

'At this point we are ready to get the command
'code (7 bits)
pulsin 0,0,bitvalue
cmdcode.bit0 = bitvalue/level1value
pulsin 0,0,bitvalue
cmdcode.bit1 = bitvalue/level1value
pulsin 0,0,bitvalue
cmdcode.bit2 = bitvalue/level1value
pulsin 0,0,bitvalue
cmdcode.bit3 = bitvalue/level1value
pulsin 0,0,bitvalue
cmdcode.bit4 = bitvalue/level1value
pulsin 0,0,bitvalue
cmdcode.bit5 = bitvalue/level1value
pulsin 0,0,bitvalue
cmdcode.bit6 = bitvalue/level1value


'Now lets get the device code (5 bits)
pulsin 0,0,bitvalue
devicecode.bit0 = bitvalue/level1value
pulsin 0,0,bitvalue
devicecode.bit1 = bitvalue/level1value
pulsin 0,0,bitvalue
devicecode.bit2 = bitvalue/level1value
pulsin 0,0,bitvalue
devicecode.bit3 = bitvalue/level1value
pulsin 0,0,bitvalue
devicecode.bit4 = bitvalue/level1value

return

'----------------------------------------------------
' Motor Routines
'----------------------------------------------------

'----------------------------------------
' Speed routines
' You can tweek the left and right tracks if
'   find the crawler pulls to left or right.
'----------------------------------------
Crlow:
 HPWM 1,10000,7500 : Return 'Left track
 HPWM 0,10000,7500 : Return 'Right track
 return

CrMed:
 HPWM 1,10000,8000 : Return 'Left track
 HPWM 0,10000,8000 : Return 'Right track
 return

CrHigh
 HPWM 1,10000,10000 : Return 'Left track
 HPWM 0,10000,10000 : Return 'Right track

 return

'----------------------------------------
' Crawler movement routines
'----------------------------------------

Crfwd:
 gosub rfwd : gosub lfwd : return

Crrev:
 gosub rrev : gosub lrev : return

CrLspin:
 gosub rfwd : gosub lrev : return

CrRspin:
 gosub rrev : gosub lfwd : return

Crstop:
 gosub loff: gosub roff : return


'----------------------------------------
'    Motor Routines
'----------------------------------------

'-------------Left Motor (M1)
Lfwd:
 High M1InputA : Low M1InputB : Return

Lrev:
 Low M1InputA : High M1InputB : Return

Loff:
 Low M1InputA : Low M1InputB : Return

'----------- Right Motor (M2)
Rfwd:
 High M2InputA : Low M2InputB : Return

Rrev:
 Low M2InputA : High M2InputB : Return

Roff:
 Low M2InputA : Low M2InputB : Return
```

The Parts

All items listed below are available from Kronos Robotics; **www.kronosrobotics.com**

Motor Controller

Item	Qty	Description	Part #
U1	2	SN754410	#MDR1
JP1-JP2	2	12-pin female header	#H3
S1	1	SPDT	#S8TOG
PCB	1	Multipurpose printed circuit board	#PCB1

Item	Qty	Description	Part #
U2	1	Atom	#ATM1
IR1	1	Vishay IR Module	#IR2
	1	Atom development board	#ATM3
CDS1-CDS2	2	Photocells	#PC2
R1-R6	6	10K Resistors	#resistors
PZ1	1	Piezo Alarm	#PZ1
C3	1	470uF Capacitor	#C470-50
LED1	1	LED with integraded resistor	#LED5YR
	1	Dip Heatsink	#HSDIP
	1	9V bat. connector w/pwr connector	#CO5
	1	Four cell C battery holder	#BH4C
	1	9V Battery holder clip	#BH9V
	1	Crawler Base	#RB1
Hardware	1	Complete Hardware Kit for Platform	#KCHWK1
Bumper Kit	1	Complete Bumper Kit for Crawler	#KCBK1
	1	Crawler Platform	#RB2
	1	Sony Compatible Remote Control	#RMT1

by Stanley York

Laser Insight

In this series of articles, we have covered many different laser types, and looked in some depth at how some of these lasers operate and are used. If you hadn't guessed it already, most of my laser career has been with industrial laser systems. I have worked on a few scientific laser projects, and a few SDI-related projects and they are, of course, much more demanding. In terms of stability, mode structure, and service repeatability anyway. This month, I want to introduce another laser type — one we haven't discussed yet.

Pulsed lasers

All the lasers we have discussed so far in this series have had one thing in common: they all use a continuously excited medium. That is, a continuous discharge through the lamp or gas mixture. The type I want to discuss this month does not use continuous excitation by arclamp or high-voltage discharge through a gas to excite the laser medium, but instead uses a pulsed excitation source. The excitation source could be a high-voltage discharge through a low-pressure gas, or else a flashlamp. Not the kind of flashlamp you would take on a camping trip, but a high voltage, high current Xenon flashlamp. This kind of lamp is rather like an overgrown version of a camera flashlamp, and uses essentially the same technology to charge and discharge.

Lasers of this type have very high round-trip gain characteristics, and can produce enormously high peak power output — not just in tens of kilowatts as I described in the laser marker article last month — but in megawatts, gigawatts, and even terawatts! Mega = 106, Giga = 109, and Tera = 1012.

I was looking around the internet while researching some information for this article, and found a very good website showing many high power pulsed laser system setups. The page loads about 7Mb of photographs and sketches, so you'll have to be patient. The URL is http://home.achilles.net/~jtalbot/history/laserimages.html. Most of these images are taken from research labs around the world, and give you some ideas as to how enormous and complex some of these laser systems are.

I'll explain how these high powers are possible soon, but first let's go back in time a little, and take a look at the first laser ever made.

The first laser to be demonstrated anywhere in the world, was developed at Hughes Labs in 1960, and used a synthetic ruby crystal as the lasing medium. (Actually, the lasing medium was chromium, the synthetic ruby was made from aluminum oxide, and was the host material.) It was a pulse-pumped system, excited by a helical flashlamp, as shown in Figure 10-1. The ruby rod was held concentrically in the flashlamp as shown, and one end was completely silvered, and acted as the fully reflecting mirror. The other end was only partially silvered, and acted as the output mirror. Silver was used because it was a good broadband reflector of all visible wavelengths.

The flashlamp was triggered by a high-voltage generator through a spark gap, discharging a high-voltage capacitor through the lamp. The trigger pulse was fired into the trigger electrode shown between the lamp and the rod; the electric field crossing the lamp was sufficient to initiate the discharge. When the flashlamp fired, the capacitor discharged very quickly through the lamp (on the order of about a millisecond). The resulting flash caused a rapid population inversion in the chromium atoms, and effected a very high round-trip gain in the resonator (between the mirrored ends of the rod).

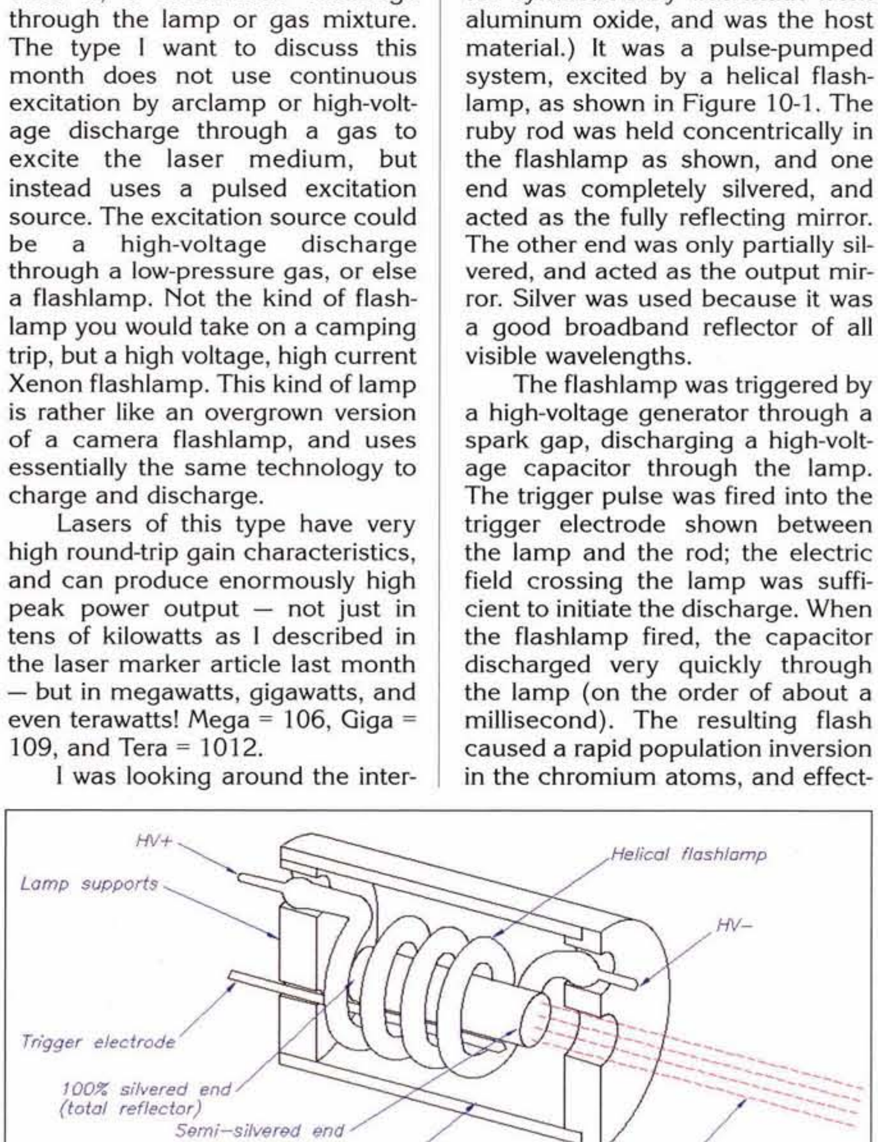


Figure 10-1 This drawing shows the basic arrangement of the first laser demonstrated — a pulsed Ruby system.

There were no standard ways of measuring pulsed laser energy at this time (1960), and so a makeshift 'standard' was introduced to rate laser energy. If a laser could penetrate a razor blade in one shot, it would be rated at one Gillette. If it could penetrate two blades in one shot, it would be rated at two Gillette, and so on. Eventually, of course, a more reliable and traceable standard was devised to measure pulsed laser energy. The unit of energy is the Joule, named after James Prescott Joule, the noted English scientist and inventor. Joule did much of the research to link heat with work, power, and energy. The Joule is equal to one watt acting for one second, and is roughly equal to 0.24 calorie. When calculating the peak power of a laser pulse, it is customary to measure the laser energy in Joules, measure the width of the laser pulse in seconds, and divide the energy by the time to get the peak power.

As an example, suppose we have a pulsed laser system that emits a 200mJoule pulse, and we measure the pulse width at 10 μSeconds at the FWHM (Full Width, Half Max) points. Now divide the energy by the time to get the peak power. So,

0.20/10 x 10-6
= 20,000watts

Thus, it is relatively easy for us to generate very high laser power levels, if we can do it in a short enough time period. Later in this series, I will describe a couple of simple pulsed laser systems that anyone may build. With them, you may be able to produce enough energy to penetrate a couple of razor blades (one or two Gillette).

I will warn you now though, that the power supplies we will be building for these lasers are lethal, and anyone not familiar with the dangers of working with high voltage should not attempt to build them.

These days, there are many ways of measuring laser energy, and one method that is popular now is the thermopile. In this device, a blackbody absorber (see sidebar) is placed in intimate contact with a simple thermopile. When the pulsed laser beam hits the blackbody, the energy is converted to heat that then warms the thermopile. The small voltage difference between the sides of the thermopile is amplified and calibrated as input energy in Joules (J), millijoules (mJ), microjoules (μJ), and even picojoules (pJ).

Laser amplifiers

Pulsed laser systems lend themselves very well to amplification of the output beam. How it works is this: A conventional pulsed laser oscillator is aligned so that the output beam enters an upcollimator. I briefly mentioned these early in this series of articles, but in case you missed it, an upcollimator is essentially a telescope, but used in reverse. Instead of the light entering the larger lens (as in a conventional telescope), the laser light is projected through the smaller lens. On its passage through the telescope (sorry, upcollimator), the beam is expanded by the lenses. It then passes through the amplifier stage, where the pulsed energy delivered to the amplifier rod may be added to the oscillator beam. Normally, the amplifier stage of a laser system is larger in cross-section than the oscillator, and is therefore pumped much harder. The upcollimator serves to expand the primary beam so that the maximum volume of the amplifier medium is used. This ensures that the maximum energy can be extracted from the amplifier. See Figure 10-2 to see how this arrangement looks. Further amplifier stages may be added as indicated in some of the photos and drawings show in the website mentioned earlier.

Q switching

Amplifiers are one way to increase the energy output from a laser system, but in doing so, consume a lot of energy. If the goal is to achieve higher peak power without necessarily increasing the energy, another technique — 'Q' switching — is the method most often used.

If you are a regular reader, you may remember I discussed 'Q' switching in last month's article on laser markers. In that application, a quartz block is made to physically vibrate within the CW laser resonant cavity, thereby producing a physical interruption to the beam similar to a mechanical shutter (this process is known in laser circles as an AO Q-switch). During the 'closed' period of the cycle, energy in the laser rod rises to above the normal CW level. Laser action cannot take place because the shutter is closed. When the shutter opens briefly (10 µSec), the high gain in the laser rod causes the release of a giant pulse of laser power, dumping most of the built-up energy into a single pulse, lasting about 50-150nSec. The peak power reached using this method may reach several tens of kilowatts.

In the pulsed laser, such a 'Q' switch would be unsuitable. The rise time of the shutter is too slow, and is difficult to synchronize the opening of the 'shutter' to the highest peak on the rod pumping cycle. The method of choice here is to use a different kind of 'Q' switch, known as an EO Q-switch (Electro-optic Q-switch) and sometimes called a Pockels cell or EO modulator. See Figure 10-3 for the laser layout using a Pockels cell.

In the Pockels cell, the 'shutter' effect is done through polarization switching, rather than physically blocking the beam, and is consequently several orders of magnitude faster than AO-Q switching. The Pockels cell is a block of material that exhibits a different refractive index when a voltage is applied across it. In other words, under conditions of zero voltage, the material has a certain refractive index. However, when a bias voltage is applied across the input and output faces of the block, the refractive index assumes a different value. For an unpolarized input beam, there will be little change in the output. For a linearly polarized beam, however, it is a different story. Some time ago, I discussed polarized laser beams, I hope you remember some of that because here it is again!

In a polarized laser beam, the electric and magnetic fields are mutually perpendicular to the plane of propagation. If such a beam were passed through an activated Pockels cell, the plane of polarization would be rotated in accordance with the crystal material, the applied voltage, and the wavelength of the laser beam. It is important to note that different wavelengths require different excitation voltage across the cell to affect the rotation in polarization. As an instance, the half wave voltage for a linearly polarized laser beam of 546.1 nM (Green) is around 2.9-3.4kvolts for a KD*P (Potassium Dideuterium Phosphate) crystal. There are other crystal types used for Pockels cells, but KDP allows the use of lower voltages. See Figure 10-4 for an explanation of the layout of a laser cavity containing a Pockels cell.

In Figure 10-4, the laser cavity is equipped with the normal laser components, plus two polarizer crystals (1 and 2), and an EO Q-switch. Here, the two polarizer crystals are arranged on either side of the Pockels cell, with their polarization axes vertical. With an unmodulated Pockels cell (no bias voltage applied), the laser will emit a pulse of laser light with the electric field vertically polarized. Being unmodulated, the Pockels cell will exert no influence on normal laser action, and the beam is able to pass

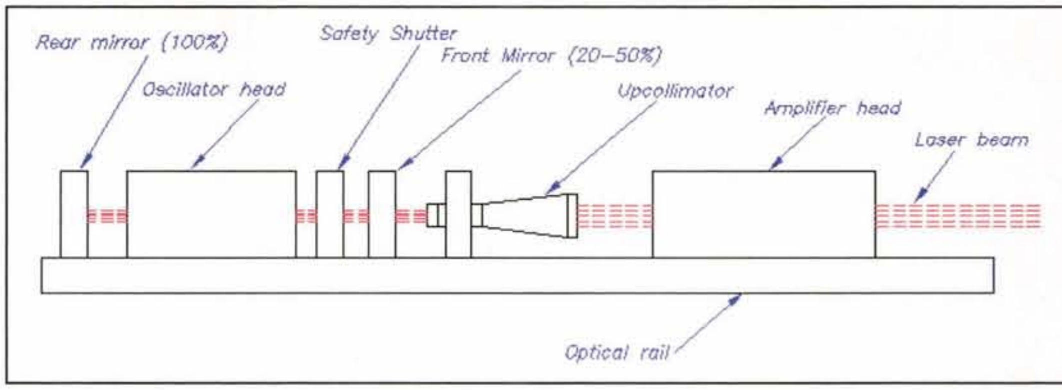


Figure 10-2 This drawing shows the basic arrangement of an oscillator-amplifier set-up.

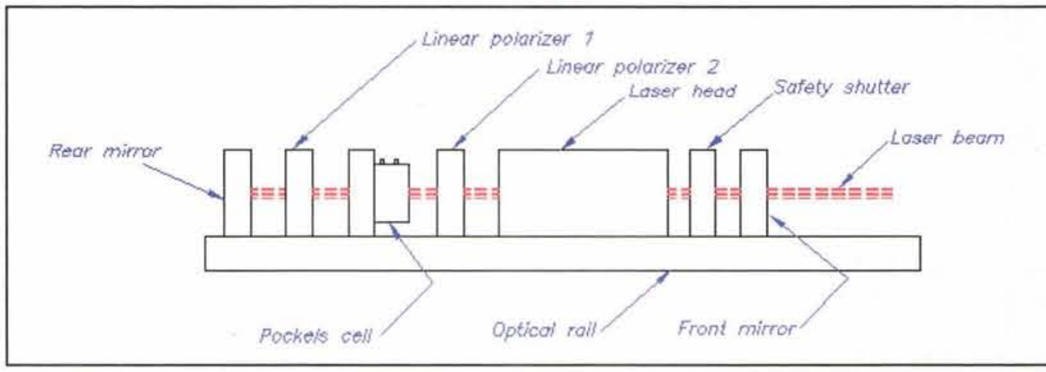


Figure 10-3 This drawing shows a typical arrangement of a pulsed laser equipped with a Pockels cell "Q" switch.

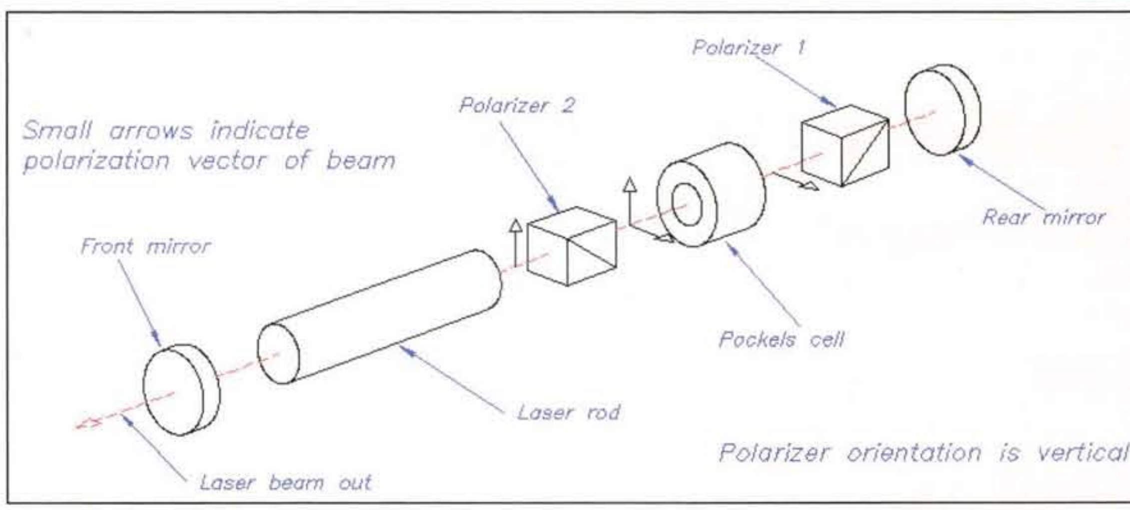


Figure 10-4 This drawing illustrates the mechanism of Pockels cell operation.

through unchanged. The two polarizer crystals will strongly polarize the exiting beam, so that the output beam is vertically polarized.

If a bias voltage is applied to the Pockels cell, it will cause transmitted polarized light through the cell to be rotated according to the wavelength of light, the material used for the Pockels cell, and the applied voltage, as mentioned above. A potential of about 3,000 volts DC across the faces of the cell will cause a rotation of 90° in the polarization axis of 546nM light in the green part of the visible spectrum. If the beam is intercepted by a second polarizer, as in the case illustrated, the beam will be attenuated because the polarization axes of the beam and the polarizer are different. Remember when I discussed polarization a few months ago, I suggested an experiment where crossed polarizer plates can block light passing through? Well, here is an application that uses that principle.

In the lay-out illustrated, the light leaving the rod and entering polarizer 1 has its electric field oriented vertically. On passing through the biased Pockels cell, the electric field is rotated through 90°. Since the electric field is now horizontal, it cannot pass through the second polarizer without being dramatically attenuated. Thus, by introducing this lossy element to the cavity, laser gain is reduced to the point where normal laser action cannot take place because of the low round-trip cavity gain.

During a laser firing, the bias voltage is held on the Pockels cell to prevent laser action. At a critical point in the lamp discharge, the bias voltage is reduced to zero, allowing very high gain in the cavity, and producing a gigantic laser pulse of much shorter duration than would normally be provided.

Normal flashlamp times vary around one millisecond or so, and in normal laser action, this would result in a laser pulse of somewhat shorter duration (perhaps 500-800 µSec). If the EO Q-switch is fired at the proper time, a pulse of perhaps 25-50nSec is possible, with peak power levels greatly exceeding one megawatt! Figure 10-5 shows the general form of a conventional laser pulse, with a Q-switched pulse superimposed on it. Note the scales used to indicate the normal mode pulse and the Q-switched pulse.

It is customary to trigger the EO Q-switch shortly after the laser pulse reaches its peak in power output (or where it would be if it were allowed to lase normally). The trigger point is usually synchronized to the leading edge of the lamp firing pulse, and the delay time determined by experimentation. The optimum output is normally met when the output beam reaches a peak in power output, and this corresponds roughly with the shortest pulse time.

In the graph shown, the lamp is fired at T = 0. The lamp begins to discharge the capacitor, and reaches a peak in intensity at T = 250 µSec. During the discharge, the laser energy starts to build up in the rod, and normally would produce an output beam that followed a similar curve to the flashlamp envelope. Thus, the peak output would occur at roughly the same time as the lamp peak. In the Q-switched mode, the laser is prevented from issuing a beam until the rod is fully saturated in upper level electron activity. When triggered, the laser gain goes from zero to high gain in a few nanoseconds, releasing the built-up energy in the rod as one giant pulse of laser light. Peak power levels can easily reach several tens of megawatts for a short time, until laser energy is depleted from the rod. For the type of laser discussed here, typical Q-switched pulses range from a few nSecs up to 100nSecs.

There is a lot more I would like to tell you about these pulsed lasers, but I've used up all my space again, so I guess I'll save it for later. In forthcoming columns, I will be describing other pulsed lasers, and

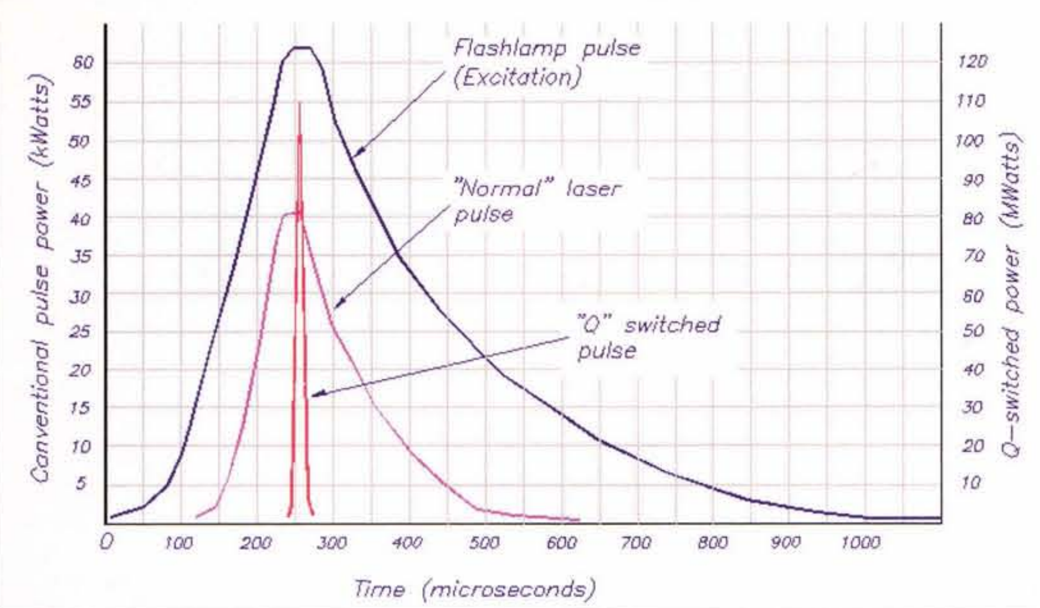


Figure 10-5 This graph illustrates the timing sequence between the conventional mode laser pulse and the Q-switched pulse.

will also describe some simple lasers we can construct and run some interesting experiments with. So don't go away, some of the best is yet to come. I'd also like to remind you that your ideas and comments are welcome. I have received a number of requests for an article on building a small CO_2 laser, and I will be working on this for a future issue. If you have any interesting ideas for projects, you can reach me here, care of this magazine, or you may email me at stanley.york@att.net. **NV**

A blackbody absorber is a device that will absorb all radiation striking its surface. There are theoretically no reflection losses.

I don't want to get too technical in this series, but if you are interested in reading more about blackbody radiation and absorption, there are many very interesting websites dedicated to this subject.

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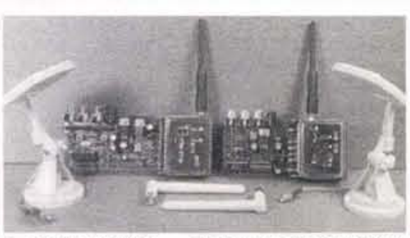

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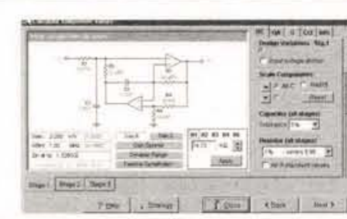

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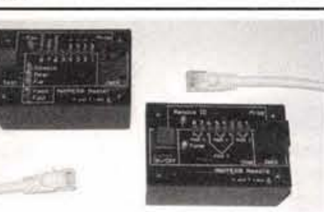

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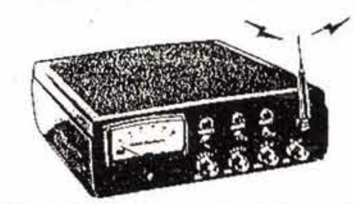

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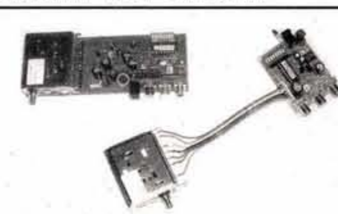

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SECURITY DISTRIBUTORS needed for our complete line of products. See our product features in the center color spread on page 43. **www.matco.com and call 1-800-719-9605**.

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SEE THE NEW MATCO PRODUCT FEATURES AND PRICES in the color center spread on page 43.

5" AND 5.5" LCD high definition color monitors w/stereo. 960 x 240 pixels w/brightness and tint controls. Attractive enclosure with built-in speaker. Great for security or general purpose use. Both models have a small compact footprint, with an ultra-bright display, RCA inputs NTSC or PAL. Special price with regulated power **$249/each**. Matco, Inc., Schaumburg, IL, 1-800-719-9605, sales@matco.com or visit/order on-line at www.matco.com

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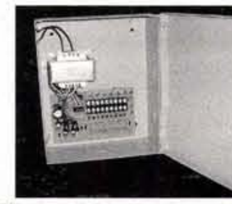

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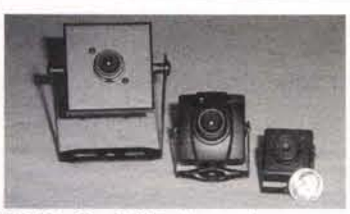

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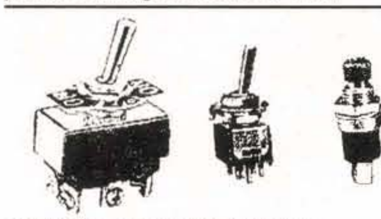

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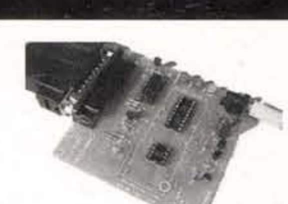

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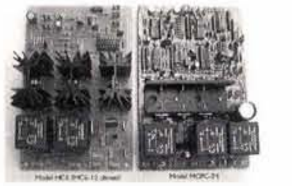

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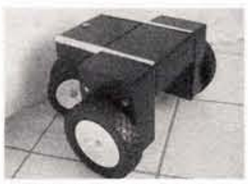

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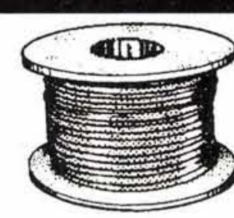

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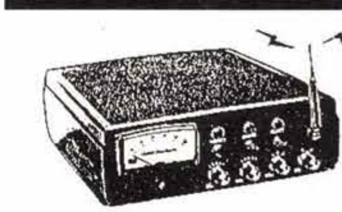

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Tullamarine 3043
www.dontronics.com

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Alexandria 22312

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2701 Westland Ct. #B
Cheyenne 82001

Reader Feedback

Continued from Page 13

patronize as often as possible the many advertisers you have in the San Francisco Bay area. Particularly HSC Electronic Supply and Alltronics, both of whom I "discovered" through your magazine.

Jim Cassedy
San Francisco, CA

Dear Nuts & Volts:

I am interested in building the Blab Blaster featured on the cover of your February issue, but have been unable to find a source for the NE570 which is the heart of the unit.

I have checked my Jameco, Mouser, Digi-Key, Edlie, All Electronics, and Hosefelt catalogs and none of them list this part.

Any suggestions as to where I can find them. (Your other readers probably have the same problem.)

Jim Schmidt

Response:

Midwest Analog Products (www.midwest-analog.com)
Allied Electronics (800-433-5700; www.alliedelec.com)
Future Active (800-655-0006; www.future-active.com)
Rochester Electronics (978-462-9332; www.rocelec.com)

TJ Byers

Dear Nuts & Volts:

Re: Rewiring a magneto phone for dial service.

First, I agree with reply #2 Mike Beaver. Don't make changes.

Second, answer #1 has several problems. Wiring the transmitter, receiver, and hook switch in series will cause the carbon granules to fuse (designed for three volts) and the receiver to get fainter with age due to line voltage (designed for a dry circuit).

Connecting the bell across the line creates a constant loop. There has to be a 1 mFd capacitor in series to prevent this. Some old phones had a capacitor, but most didn't. As Mike suggested, if you MUST change, get a common battery network and connect your components to it.

I used to work for small telephone companies that had magneto service, and now am a volunteer at a telephone museum.

David Thompson
Bucksport, ME

by Robert Nansel

Amateur Robotics

This month, as promised, I have compiled my list of robotics clubs in the United States and around the world. It is available for download on the *Nuts & Volts* website at www.nutsvolts.com. Thanks to reader Gerald Sorrels of Crestline, CA, I also have a complete schematic for the Camtronics three-axis chopper/stepper motor driver board used in my Heavy Iron CNC project. Gerald also generously contributed a schematic for a simple chopper board tester that allows you to test out the Camtronics board without a computer, which is pretty handy when you're troubleshooting your system and aren't sure whether it's the chopper board or the computer causing the trouble. I'll start with the club list.

The List Ate My Column

It's been since June 2000 that I last compiled this list, and a few of the groups on the list seem to have disappeared or gone dormant. In the meantime, several new groups have sprouted up. In June 2000, I listed 28 groups in the US and nine groups in other countries. Subtracting the lost groups, the list of US groups has grown to 32, and the international groups held steady at nine. Then, as now, I list a few internet-only clubs, but there are scads of online robotics groups on the web, far too many for me keep track of (that's what Google.com is for).

As for the regular groups, I can make no claim that this list is complete or definitive. Shucks, I can't even guarantee that all of the links or contacts are up-to-date; robotics club websites and email addresses sprout and die like fairy ring mushrooms. I spent days trying to verify the info of just the more-established groups. If you spot any errors, or (gasp!) if your club is not listed here, drop me a line.

Chopper Board Wrinkles

Dan Mauch, the owner of Camtronics, has been so busy selling — and improving — his popular three-axis chopper board kits that he hasn't got a current schematic of the board he now ships; all recent changes have been made directly to the PCB artwork and haven't yet propagated back to the schematic. The schematic shown in Figure 1 was laboriously traced out by Gerald Sorrels when he purchased his kit. I then drafted up Gerald's hand-drawn schematic using Claris CAD, and I rearranged things a bit in the process. Any errors you find in Figure 1 were probably introduced by me.

In fact, I've already found a few errors too close to deadline to fix (argh!), so I'll just give y'all a heads up. First, I neglected to include the pin 7 ground of U8 (it could happen to anybody).

More embarrassing is that the labels for the Z-step and Z-hold variable resistors got swapped with those for Y-step and Y-hold. The correct adjustment resistor labels are "VR4" for Z-step, "VR5" for Z-hold, "VR2" for Y-step, and "VR3" and for Y-hold.

Another correction, but this one comes about for a different reason. Last month, I gave the PDM chassis wiring diagram and wiring table. In both, I used "J14," "J15," and "J16," to designate the 15-pin X-, Y-, and Z-axis connectors that bring the phase drive and sense lines out to the chassis top panel. I numbered them this way because on my chopper board — which I got from Camtronics a year ago — the connector numbers stopped at J13.

Well, as I've said, Dan has kept on improving the board. My board is the revision from 4-30-2000, but in later boards, Dan added a J14 connector to make it much easier to add a fourth axis to a three-axis system. J14 — an eight-pin MTA connector — brings all the signals needed to interface to the Camtronics single-axis chopper

FIGURE 2

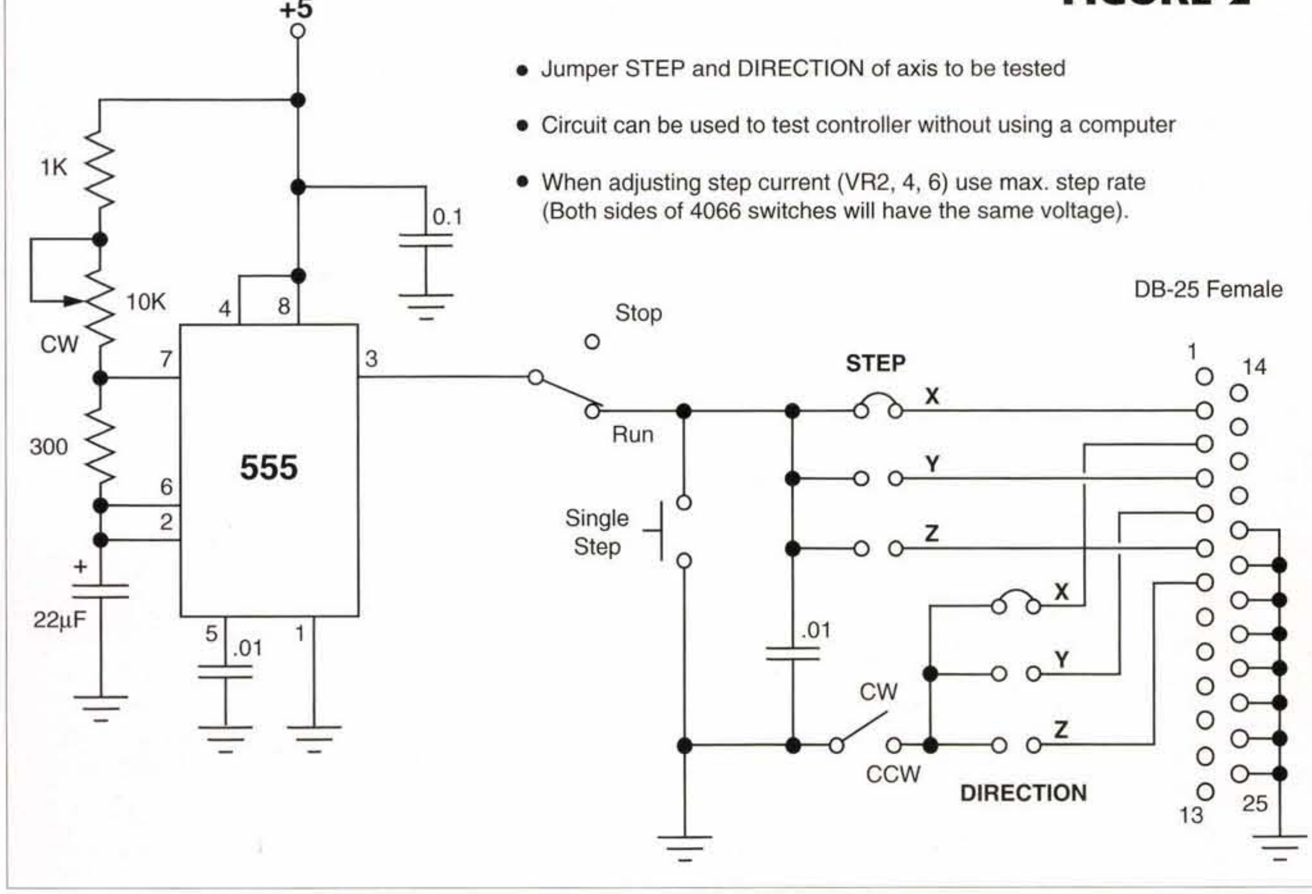
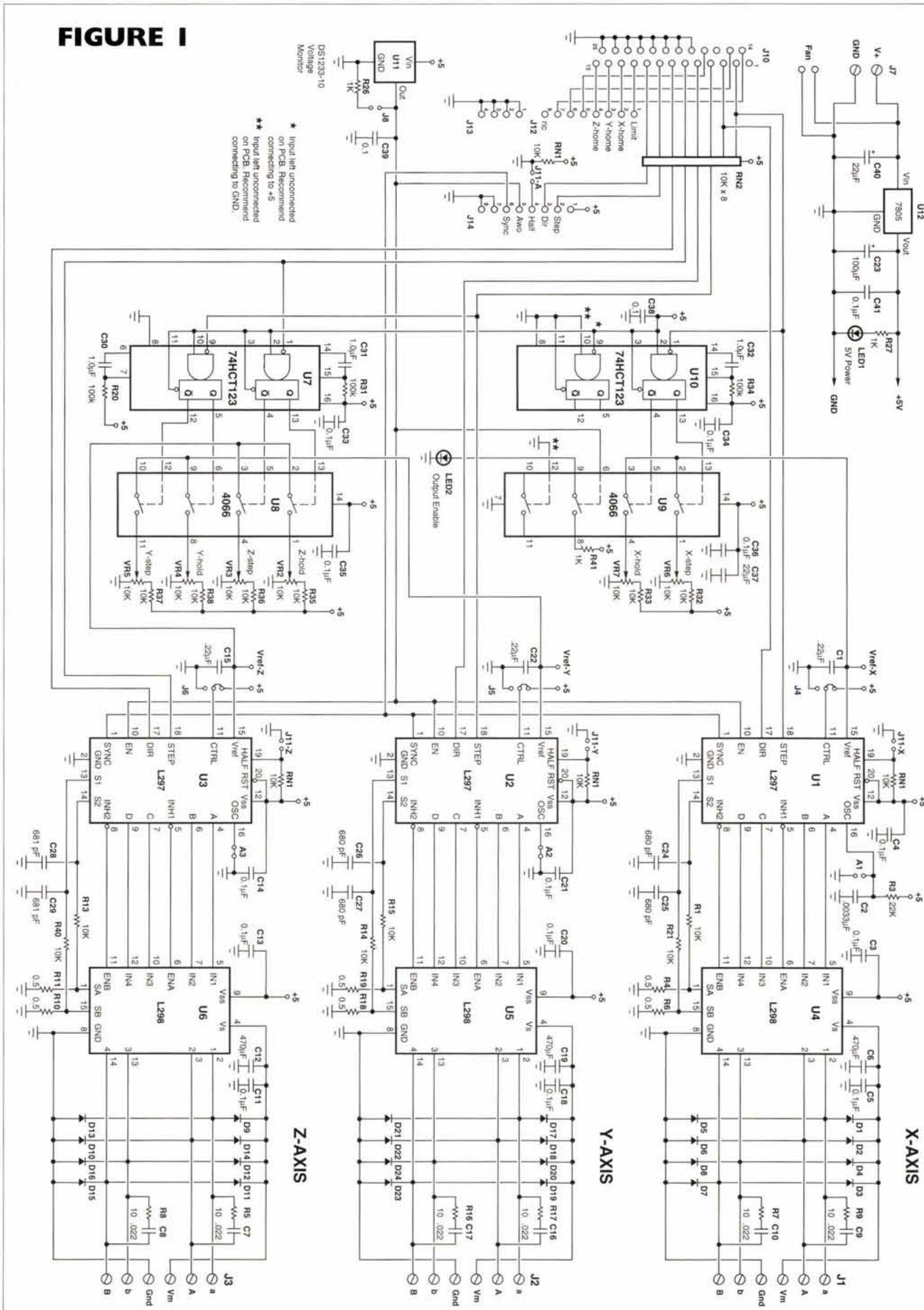


FIGURE 1



board. This is great for folks needing just one more axis. But it makes hash of my connector numbering scheme. Just to be on the safe side, henceforth those 15-pin connectors on the top panel will be known as "JX," "JY," and "JZ." And if I ever design a PDM with the optional fourth axis, that one will be known as "JA."

Wrapping Up

Gerald gives a few hints in Figure 2 — the schematic of his chopper board tester — and Dan Mauch's latest instruction manual for the three-axis board is much improved over the version I built my kit from. If you have a copy of the instruction manual from before 6-26-2001, I highly recommend that you go to Dan's website (http://www.seanet.com/~dmauch/) to get the latest version.

Anyway, that's all for now. Next time, I will take you on a brief tour of Chug, my latest robot project. It's a real smoker, so be sure to bring your welding goggles and face shields. We're gonna make some big sparks, you betcha! **NV**

If you have suggestions, questions, or comments about amateur robotics topics, you can reach me at:

Robert Nansel
Box 228
Ambridge, PA 15003

E-Mail:
bnansel@nauticom.net

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:

Do plants show fear? Discover for yourself using a Backster monitor. A collection of circuits: busy phone, five-amp current regulator, FM transmitter, and dynamic microphone preamp. Finally, all about voltage clamps and the atomic clock.

Backster Effect

Q. I've been looking for a simple circuit to detect electrical changes in plant leaves, specifically the Backster effect. While the original work was done with a conventional lie detector, my idea is to use an amplifier that would output to an oscilloscope. The input would be from two electrodes with low conductivity paste on them. Do you have any ideas on the subject?

Gary C. Grinnell
Townshend, VT

A. Clive Backster is credited with the "discovery" of what he calls "Primary Perception" and others call "The Backster Effect." His research journey started with the 1966 almost accidental rediscovery that plants respond to the spontaneous emotions and strongly expressed intentions of humans. Using an instrument to measure galvanic skin responses (GSR, a part of his polygraph), Backster attempted to determine if it would measure the moment of rehydration of a plant whose roots were freshly watered. It did not. To his surprise, though, the GSR meter registered his threat to burn the plant leaf when he spontaneously thought of the idea.

Most lie detectors use a Wheatstone bridge to measure changes in skin resistance. Unfortunately, the instrument is prone to drift and needs frequent recalibration. So much so, in fact, that NASA has replaced a good portion of their Wheatstone bridge instruments with a more stable current loop circuit. Pioneered by Karl F. Anderson, the current loop has a lower noise level than data from comparable Wheatstone bridge circuitry, and is unaffected by lead resistance. See Figure 1.

The unique part of this design is the four-terminal measuring system. A constant current, maintained by the LM10 current reference IC is passed through the sense resistor (electrodes), which generates a voltage proportional to the resistance. This voltage is measured by a high-impedance op-amp via the sense leads. Because the input impedance of the amp is substantially higher than the sense resistor, no appreciable voltage is lost through the sense leads. The 350-ohm reference resistor develops an offset voltage, which is subtracted from the output voltage to center the output at zero when the sense resistor is at equilibrium. This output can be input to any voltage measuring device, such as a DVM or oscilloscope.

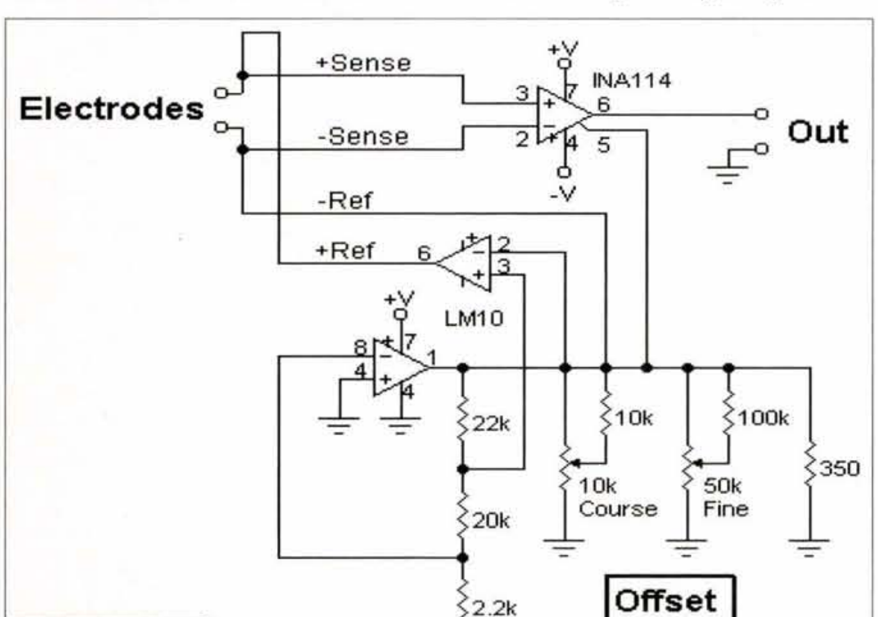


Figure 1

Busy Phone Indicator

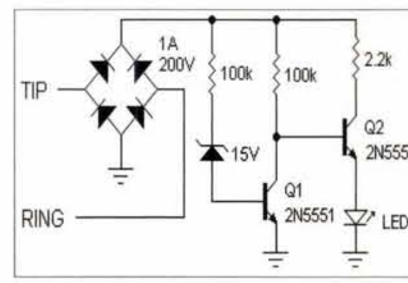
Q. I am looking for a telephone line indicator circuit where an LED can be connected to any telephone line to indicate when the line is ringing and when the phone is off-hook, similar to those used on most multi-line telephones.

L. Somers
via Internet

Q. I'm looking for a simple circuit that will light an LED at one phone jack while another phone or modem is in use (like when my wife is on the computer in another room). I've built testers that will indicate an active line active when the phone is on-hook (just an LED and current limiting resistor), but I'm not sure how to sense and display an off-hook voltage. Maybe some kind of logic gate?

Quinn Michael
via Internet

A. There are several circuits that can do what you ask, but most use a separate power supply. I kinda prefer tapping into the telephone company's power which is more stable and reliable than a wall-wart or battery. After some thought, I came up with the following design. The bridge recti-



fier isn't really used for rectification; its primary purpose is to prevent reverse polarity when plugging into a phone outlet. Most phone lines measure 48 volts on-hook and 10 volts off-hook (although this will vary by the provider and the distance to the central station). Using those parameters, when the phone is on-hook, the line voltage exceeds the breakover voltage of the 15-volt zener, which causes Q1 to turn on and short out the base voltage to Q2, turning it off.

Put A Clamp On It

Q. Could you give a description and capabilities of clamp circuits? I have searched several electronics books and magazines, but it seems to be a topic that's only covered in vacuum tube books, nothing related to solid-state. Specifically, what frequencies can be clamped? Can video and audio frequency signals be clamped to a near zero level that fluctuate as much as five volts above zero reference?

Larry Keller
via Internet

A. To begin with, a clamp refers only to voltage not frequency, which means it works with everything from DC up to the highest radio frequencies. Basically, it's a circuit which places a lid on how high a voltage can go. For example, a one-volt clamp will limit an input voltage to one volt output, no matter how far beyond one volt the input signal may stray. Below one volt, the input signal assumes its normal value and is unaffected by the clamp.

Where are clamps used? In any application that requires a limit on voltage excursions — like voltage regulators, for example. Traditional power supply regulators work on the principle of reducing a higher voltage to a lower voltage using a voltage clamp. A simple zener diode, shown in Figure 2**(a)** in the drawing below, is a perfect example of a voltage clamp. In fact, any diode can be used for a voltage clamp **(b)** by stacking them to take advantage of their forward voltage conduction. If two diodes are placed back to back, a sinewave can be converted into a squarewave **(c)** and **(d)**. Note that the ratio between the peak input voltage and the clamp voltage determines the rise and fall times, i.e., the larger the ratio, the faster the rise and fall times.

Voltage clamps are also used for audio and video signal conditioning, especially in the broadcast industry. It's no secret that TV commercials are always louder than the program. That's because they pack more audio power into the signal by clipping the announcer's voice voltage peaks using a voltage clamp **(e)**, resulting in a gain of almost 15dB more sound than without the clipping. The video signal also uses clamps, this time to block portions of the video during horizontal and vertical retrace, and for editing video tapes. Last but not least, clamps are used everyday for surge and over-voltage protection (MOVs and the like). Bottom line: Anytime you need to put a lid on a voltage, use a clamp.

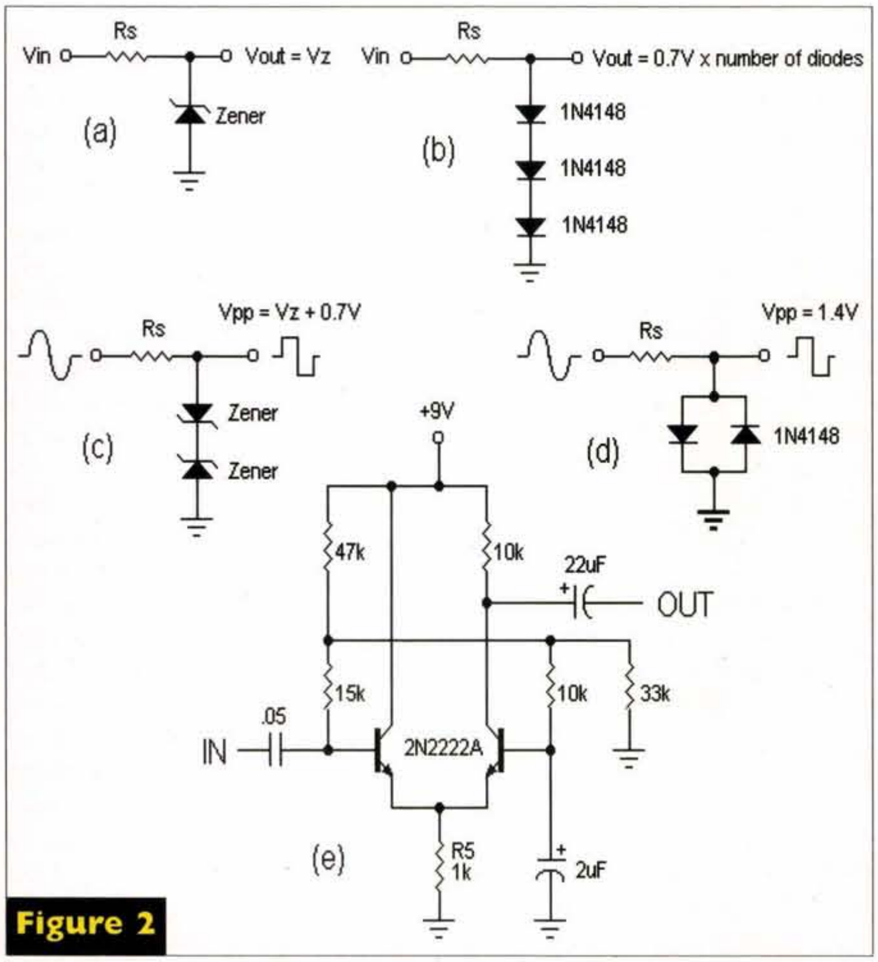


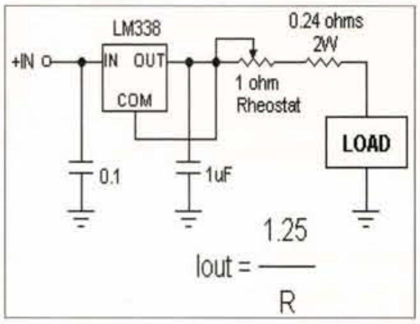
Figure 2

High-Power Constant-Current Source

Q. Do you have a schematic for an adjustable constant-current power supply? I need about three to five amps at around 24 volts DC for a plastic foam cutting wire. My present cutter doesn't control the current, which causes temperature shifts that often lead to burned-out wires.

Jim Halbert
via Internet

A. I'm not sure a constant-current source will cure all your temperature control problems, but it may go a long way toward making the cutting wire last longer. A constant-current regulator can be made using nothing more than a transistor, zener diode, and a couple of resistors. Personally, I prefer using an integrated voltage regulator, like the LM338. With proper heatsinking, this regulator will easily handle up to five amps of regulated current using the configurations shown below.



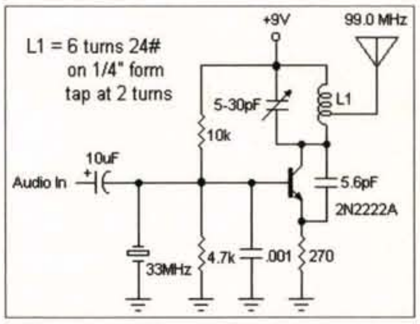
The rheostat is a high-power variable resistor that you can buy from Mouser Electronics (800-346-6873; www.mouser.com). The 0.24-ohm resistor limits the output current to five amps. The input voltage can be any source up to 30 volts DC. And that's it — except for the 0.1 and 1 uF caps, which must be placed as close to the LM338 as possible. For those readers who would like to have a constant-current source with lesser currents, you can substitute any LM78xx or LM3xx series regulator, and adjust the series resistor, R, accordingly. For example, 100 mA = 1.25/R = 12.5 ohms.

Crystal-Controlled FM Transmitter

Q. I have a small part-time greenhouse business with eight, heated greenhouses. I haven't had a heat failure yet, but I worry about it. I plan on putting a HT680 encoded transmitter in each greenhouse with an old thermostat to monitor the temperature and activate the transmitter if the temperature falls too low. In my house, there would be an AM or FM radio that would monitor the transmitters and alert me as to which greenhouse was transmitting. I have found plans for the radio decoder circuit, but cannot find a diagram for a transmitter and encoder. What I need is a crystal-controlled transmitter circuit with a range of about 300 feet.

Richard Stimpson
Freeland, MI

A. This is a simple request that can be filled by almost any wireless microphone circuit — except for the crystal-control part. Here's one of those circuits that has been modified to accept a crystal. The circuit is using the third harmonic of the crystal to generate a 99-MHz RF output. This frequency falls between the assigned FM band frequencies of 89.9 and 99.1, so there should be no interference from a local transmitter. If there is a strong local station near that frequency, you can pull the center frequency off slightly by adjusting the variable capacitor.



Cool Web Sites!

AdSubtract SE

This free utility prevents Web ads from appearing and selectively blocks cookies. The program works with Internet Explorer, Netscape Navigator, and America Online. This version displays a verification dialog box before cookies are blocked, allowing you to choose the cookies that you want to keep. Two paid versions (CE and Pro) offer advanced cookie management and give you the ability to block animations, Java and JavaScript applets, and pop-up windows.

http://www.adsubtract.com

Calculators for electronic formulas. Great for class work or just calculating the values for that tank circuit you're designing.

http://www.citlink.net/~bhamre/A_Electron/Electronic_Calc.htm

Conversion tables for area, length, power, weight, and more.

http://adamite.igs.indiana.edu/indgeol/reference/conversions.htm#A

The tuning coil, L1, is an open-air coil made by winding six turns of 24 AWG magnet wire (enamel covered copper wire) around a wooden pencil; the tap is taken at the second turn (turn 2). Parts layout is fairly critical, which means the tuning cap should be as close to the coil as possible, and it would be best if you created a printed circuit board if you plan on doing them in the quantity you describe. Ideal antenna length is six to nine inches; use nothing over 12 inches to comply with FCC rules. If you need more range, up the battery voltage from nine volts to 12 volts.

Low-Impedance Mike Preamp

Q. I have Technics RP3330 cardioid dynamic microphone rated at 400 ohms. I am trying to plug it into a Technics RS-T9023 cassette recorder which requires 60 mV or better. I bought a QK98 preamplifier kit from www.qkits.com, but it only provides 23dB of gain, which is insufficient. Even two of them in series isn't enough. I am fairly certain that I built them correctly, because it works with my Dean Markley magnetic guitar pickup. I would prefer to buy off-the-shelf, but I am not against kit building or circuit breadboards. Do you have any suggestions?

Greg Lehmann
via Internet

A. I think your problem is with impedance matching of the amplifier, and not its gain. If I interpret the QK98 design correctly, it uses a high-impedance input with a DC feedback transistor pair, which isn't optimum for a low-impedance dynamic microphone — a transducer that's normally interfaced via a 600-ohm matching transformer. I know you wanted to buy off-the-shelf or a DIY kit, but I can't seem to find one that I'd consider in your price range. Instead, I modified a circuit that I found from Elliott Sound Products at **www.sound.au.com** (sorry, they don't provide a kit at this time). See Figure 3.

The impedance matching is correct for a 600-ohm input. The gain can be varied from zero up to 40 (32dB), with an output of over one volt peak-to-peak using a dynamic microphone. The use of metal film resistors is a must to get the best possible noise performance, and the capacitors should be quality aluminum electrolytic, not tantalum. The design requires a regulated voltage of 15 volts.

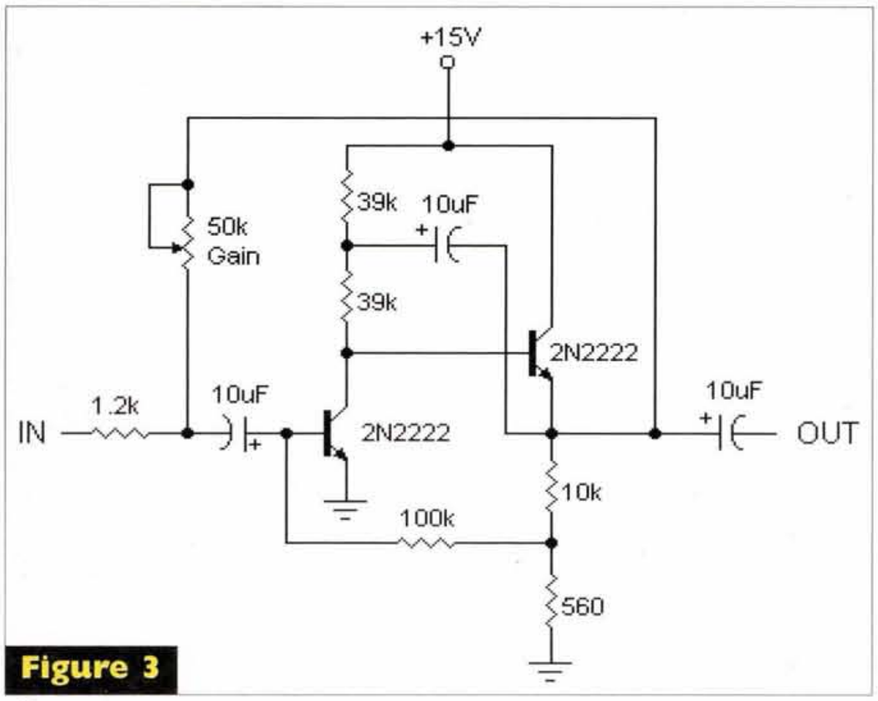


Figure 3

Auto Audio Amps

Q. I would like to monitor the current flow through my car power amp, which draws in the range of 30 to 60 amps. A DC clamp meter would be ideal because I wouldn't have to break the power lead to insert an ammeter. However, I cannot find any information on AC/DC clamp meters and how they operate. I was wondering if a PIC or similar circuit could be built to remotely monitor the current?

Qui Nguyen
via Internet

A. I suppose you could monitor the current with a PIC, but why when it can easily be done using a variety of automotive ammeters found at any auto parts store? Basically, there are three types of ammeters for car use. The most common is a series ammeter which has an internal shunt. To install it, you need to break the power wire and insert the meter, which is what you want to avoid. The second type of ammeter uses an external shunt, typically of the 50 millivolt variety. Again, the circuit has to be broken and the shunt inserted. The advantage is that you can place the shunt inside the dash and run a smaller wire to the meter itself. The third meter is called an inductive ammeter. With this meter, the circuit doesn't have to be broken. The power wire is physically clamped to the back of the meter, where the magnetic field created by the current flow deflects the needle.

Still want to use a DC clamp-on ammeter? Get your checkbook ready, because they don't come cheap. Almost all use a linear Hall-Effect sensor that generates a voltage that's proportional to the magnetic field created by the current flow. This voltage is amplified, scaled, and usually displayed on a digital readout. Check out Fluke's web site at **www.fluke.com** for more information and video demos.

Can Dead Gel-Cell Batteries Be Revived?

Q. My question is about the sealed lead-acid batteries that are in all the UPS systems and other devices. I had a dead unit that wouldn't accept a charge. With nothing to lose, I opened it by popping off the external caps (most had a small amount of pressure on them), put a few drops of water in each cell, and recharged the battery. It seems to work, but I'm not sure it's the right thing to do. Can a person do anything to salvage these units or should they just be properly destroyed?

Gary Regez
Mundelein, IL

A. Many of us have spent small fortunes on gel-cell batteries, because of their advertised advantages. We have also had them die in a short period of time. That's because gel-cells are highly susceptible to damage from two common factors: ambient temperature and the charge rate.

When the temperature of the battery goes up, gassing occurs and the plate structure begins to degrade. Elevated temperatures within the battery can result from either internal heat from overcharging, or from ambient temperatures.

In contrast to wet-cell batteries (the kind used for automobiles), gel-cell batteries are manufactured using a silica gel and acid electrolyte mixture that surrounds the plates. The charge rate of gel-cell batteries is critical, because overcharging can cause the electrolyte to gas off, and it can also elevate the battery's internal temperature. As the charge current and/or temperature increases, voids develop between the gel matrix and plate to allow for the passage of gasses. This renders that area of the cell inert, which reduces the capacity of the gel battery.

In fact, a charge rate in excess of 2.4 volts per cell can destroy a gel battery in hours. The battery chemistry is most stable between the temperatures of 60 and 77 degrees. For every 18 degrees above 75, the life of the battery is cut in half.

Can a gel-cell battery that won't take a charge be resurrected? Maybe. If a battery is completely discharged, all of the reactive materials are converted and it may very difficult to reverse the chemical reaction. However, some batteries are designed with a plate size imbalance and/or catalyst to help control gas generation and aid in deep cycle recharging. While the battery will never fully recover, it might come back as much as 80 percent.

First, remove all the charge from the battery using a medium load, like a car headlight. If necessary, get rid of the last remaining charge by shorting the battery terminals with a heavy wire for a few hours. Don't let the battery sit for long after it's totally drained, or sulfating will begin. Now, recharge the battery using a "smart" battery charger, one that monitors the charging current and/or time and adjusts it accordingly.

Now as for your "rejuvenating" method, the valve-regulated gel battery is the most common type. These types of sealed batteries have a spring-controlled valve that vents gasses at high temperatures and charging rates. Since electrolyte levels are preserved by trapping and recombining off-gasses, there should not be any need to add distilled water over the life of the battery. In fact, electrolyte levels cannot, and should not, be maintained. It appears that the water you added has filled some of the voids and provided a path for charging current. You might try replacing the pressure valves and use the recovery method outlined above, but I wouldn't hold out much hope for a long battery life.

Zero Crossing Aids More Than RFI Suppression

Q. My question is in regards to the "SCR Principles and Circuits" article by Ray Marston in the Jan. 2002 issue (page 22). The author does a great job of explaining the subject, but I would like to see the circuitry required to provide the phase delay switching shown in Figure 15. I have experimented with this using both back-to-back SCRs, as well as triacs to obtain outputs of the full (both halves) AC waveform, but can never seem to get any circuits to perform as close to the ends as the drawing shows. It would also be desirable to use an optoisolator in the design.

Don Pomeroy
via Internet

A. The problem with low-angle triggering of SCRs and triacs is the extremely low voltages at the far ends of the sinewave. The solution is to detect when the waveform crosses the zero voltage line, from which you can accurately set a fixed delay for triggering of the SCR or triac.

In Figure 4, the transistor generates a pulse with each zero crossing of the sinewave. This pulse triggers the 555 monostable (time-delay) multivibrator, which fires the triac when the timer has expired. The blocking diode between the collector of the transistor and the center tap of the transformer guarantees that the transistor's base circuit will see the crossing voltage. Once beyond the diode, the 100uF capacitor filters the rectified DC and provides the voltage needed to power the 555 timer and optoisolator. Not only does zero-crossing triggering eliminate RFI, it lets you more accurately time the AC power duty cycle.

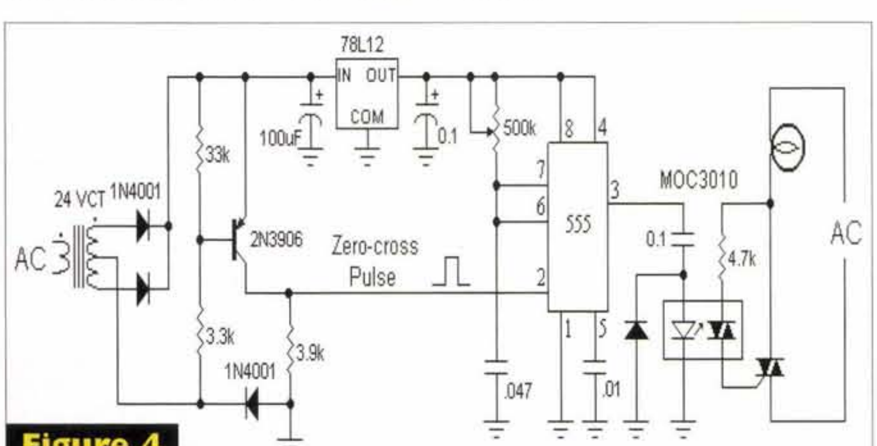


Figure 4

Accessing The Game Port From Visual Basic

Q. Can you point me to any resource explaining how to access a game port from a Visual Basic program (read the potentiometers and buttons)? I've got several books on VB, and they don't address this point.

Steve Roberts
via Internet

A. The easiest way for Visual Basic programmers to access the joystick port is to use the calls of "joyGetPosEx" and "joyGetDevCaps" (remove the quotes) in winmm.dll. In modern games, joysticks are read using the DirectInput part of DirectX gaming API. By working directly with device drivers, DirectInput bypasses the Windows messaging system. Check out "May The Force Feedback Be With You: Grappling with DirectX and DirectInput" at **www.microsoft.com/msj/defaultframe.asp?page=/msj/0298/force.htm&nav=/msj/0298/newnav.htm** for details.

Time Around The World

Q. I have a radio-controlled atomic clock that I purchased in Germany, but the clock will not keep time here. Is there a difference between the atomic time frequency in Europe than it is the US? If so, is it possible to maybe change the frequency (a crystal?) to convert it for US use?

Ray Samples
via Internet

A. The frequencies are indeed different. In the US, the frequency is 60 kHz, with its transmitter located at Boulder, CO. In Germany the frequency is 77.5 kHz, with its towers located 10 miles outside of Frankfurt. In addition, there's a third atomic clock transmitter located in Allous, France that transmits on 162 kHz. Even if you could alter the receiver to match the local clock transmitter frequency — which is very doubtful — the time formats are different. In other words, your German clock wouldn't understand a word the US transmitter is saying.

By the way, are you aware that you can access the atomic clock via the Internet? The address is **http://nist.time.gov/**. Moreover, you can have the atomic clock set your PC clock automatically. All you need is the file NISTIME-32.EXE, which you can download from our web site (**www.nutsvolts.com**). You can have the Internet update your PC clock on a on-demand or at scheduled periods, you choose.

MAILBAG

Dear TJ:

Michael Kiley wrote about auto-transformer attenuators for 70-volt speakers. **Full Compass Systems (800-356-5844; www.fullcompass.com)**, from looking at their web site, is primarily a supplier for pro-audio and music customers. Another source for these level controls is **MCM Electronics (800-543-4330; www.mcmelectronics.com)**, stock numbers 555-2022, 555-2023, and 555-2029. They come in different finishes, are rated at 25 watts RMS, and sell for just under $17.00.

Your reply to Will Smith about theremins didn't mention another source for them, **PAIA Electronics (405-340-6300; http://paia.com)**. Their ad on page 43 shows thermins at half the price of the kits from Theremin World.

Bill Stiles
via Internet

Dear TJ:

I have a concern regarding your response to Curt Powell regarding GSM/TDMA/CDMA phones. You state: "The band is divided into 395 voice channels, with a bandwidth of 30 kHz ... Between eight and 10 phone calls can be carried per channel using." I'm afraid this only applies to AMPS (Advanced Mobile Phone Service) and TDMA. (Normally the term "channel" in CDMA refers to the pilot, paging, sync, or traffic channels. However, for purposes of our discussion, I will use "channel" to be indicative of frequency.) A CDMA "channel" is 1.25 MHz-1.23 MHz, plus 10 kHz on each side that act as guard bands — and can theoretically carry up to 64 conversations — the number of available Walsh codes. In actual practice, this number ranges from 30 to 40, give or take, based upon the current noise floor. (A much more efficient use of spectrum, compared to AMPS or TDMA, I might add.) Perhaps this is a little too much information for his question. The only real correction is the bandwidth of a CDMA "channel."

Since Mr. Powell is shopping for providers, it should also be noted that CDMA uses rake receivers and employs "soft-handoffs," both of which are unavailable with TDMA. In other words, the phone should drop calls much less often than one employing TDMA.

(PS: No, I don't work for Sprint or Qualcomm. I've simply studied both technologies in my spare time, and I suppose I've become biased toward CDMA.)

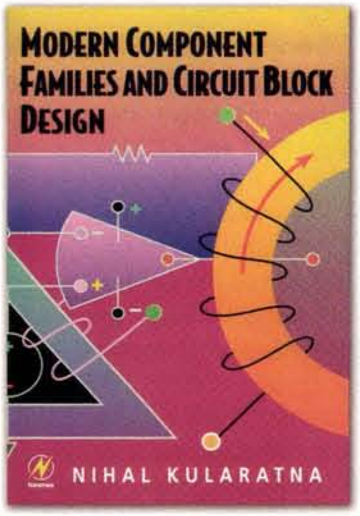
Brian Hill
via Internet

New Books

Modern Component Families and Circuit Block Design

by Nihal Kularatna

$54.99

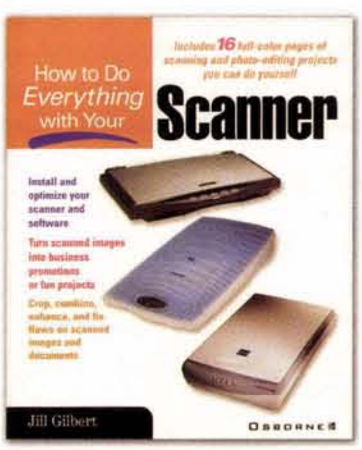


With rapid advancements in electronics and integrated circuits, it is very important to utilize the design approaches and details previously found only scattered in a vast array of application notes, engineering bulletins, and data books. *Modern Component Families and Circuit Block Design* gathers and summarizes this material in a single volume, and also provides a designer's viewpoint on modern components. This book provides a practical approach to design problems rather than a generic analysis of broad engineering issues.

How to Do Everything with Your Scanner

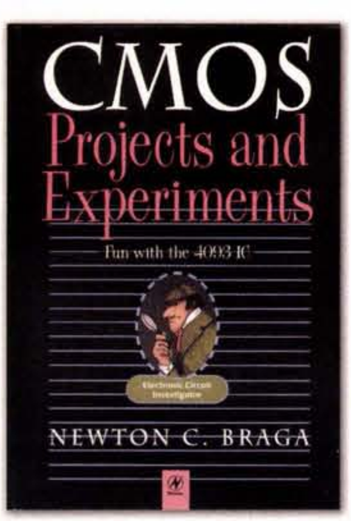
$24.99

by Jill Gilbert



Contains projects, resources, ideas, and simple instructions to help you get the most from your scanner for home or business use.

Learn to use all your scanner's features, as well as professional-caliber image-editing tools that enable you to do everything from colorizing black-and-white photos to switching heads, bodies, and backgrounds. Explore graphic concepts including color correction, resolution, and image optimizing — plus scanner repair, troubleshooting, and more. Let this great resource show you how to enhance and preserve your family memories, and create state-of-the-art, professional images — all with your scanner.



CMOS Projects and Experiments: Fun with the 4093 Integrated Circuit

by Newton Braga

$34.99

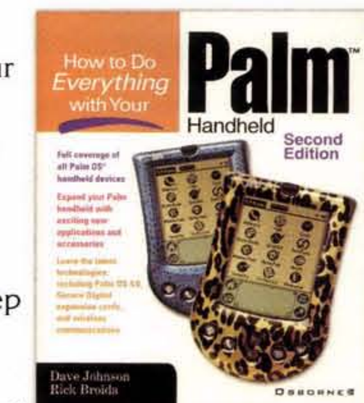
CMOS Projects and Experiments includes instructions to build over 100 unusual and useful projects. They include audio and RF devices, lamps, LEDs, timers, alarms, inverters, and much more. This book offers hobbyists and students a satisfying, practical way of learning about a hot topic in electronics today.

Among the devices you can build using this book are a touch-controlled oscillator, a light-controlled oscillator, insect repellent, a metronome, a Morse code tone generator, a CW transmitter, a two-tone siren, a neon-lamp flasher, an auto turn-off relay, a turn-off timer, a touch-controlled motor, a bistable sonic relay, a coin tosser, a freezer alarm, an ultraviolet lamp, a simple fluorescent lamp inverter, a nerve stimulator, and an experimental high-voltage generator.

How to Do Everything with Your Palm Handheld 2nd Edition

by Dave Johnson and Rick Broida

$24.95

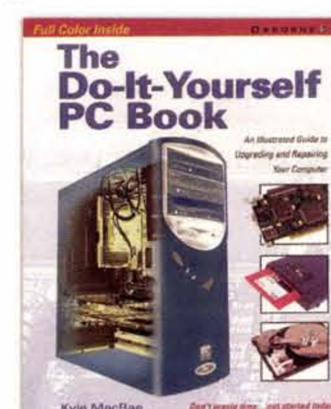


This book will help you master all the powerful features of your Palm handheld. Learn about new software and accessories, connect to the Internet, play games, manage your contacts and calendar, and much more — all in a easy to follow format. You'll get step-by-step instructions for preparing your Palm for busainess trips, beaming information to other handhelds, and even troubleshooting common problems. Learn absolutely everything about your Palm handheld by reading the newest edition of the book many say should replace the manual.

The Do-It-Yourself PC Book An Illustrated Guide to Upgrading and Repairing Your PC

by Kyle MacRae

$24.99



This highly illustrated full-color guide is the easiest way to master the art of upgrading, maintaining, and repairing your PC. Written with humor and simplicity, *The Do-It-Yourself PC Book* demystifies and explains the inner workings of your computer and makes it easy for anyone to give their old machine a boost or keep their new one in perfect working order. Each chapter features clear explanations and step-by-step instructions while the accompanying full-color photographs show you every procedure and component. You get all the essential facts quickly and painlessly in special "techie-corner" and "trouble-shooter" features.

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Triac Principles and Circuits — Part 2

By Ray Marston

Ray Marston concludes his description of triac principles and circuits in the final episode of this two-part mini-series.

Last month's opening episode of this two-part feature explained triac basics, looked at various practical triac power switching circuits, introduced optocoupled triacs, and explained basic synchronous 'zero-voltage' power switching principles. That episode concluded by pointing out that the simplest way of making a really efficient synchronous 'zero-voltage' triac-driving circuit is with the aid of a special-purpose IC that functions as an optocoupled low-power synchronous 'zero-voltage' triac that can easily be used as a slave for synchronously driving a normal high-power triac. This month's concluding episode gives practical details of such circuits, together with other triac-related circuits and information.

Optocoupled synchronous power switching

Synchronous 'zero-voltage' triac-driving circuits are widely used in modern electric heating and filament-lamp lighting control systems. Until fairly recently, several companies produced special synchronous 'zero-voltage' triac-gating ICs for use in such applications; the best known of these ICs were the CA3059 (from RCA) and the TDA1024 (from Signetics), which each had built-in AC-derived DC power supply circuitry, a zero-crossing detector, triac gate drive circuitry, and a high-gain differential amplifier/gating network.

In the mid-1990s, however, all of these ICs were made obsolete by the introduction of a new and modestly-priced type of IC that functions as an optocoupled low-power synchronous 'zero-voltage' triac that can easily be used as a slave for synchronously driving normal high-power triacs.

Several companies (including Isocom, Motorola, Sharp, Siemens, and Toshiba) manufacture optocoupled synchronous zero-voltage triacs. Most of these devices take the form of a six-pin DIL IC, as shown in Figure 1, and house a simulated triac that has its gate drive controlled via an integral photosensitive zero-crossing detector (ZCD), which can be remotely energized via an integral LED. Typically, this type of optocoupled triac has maximum AC ratings of 400V peak and 100mA RMS (with a surge rating of 1.2A for 10mS), will only trigger when the instantaneous AC voltage is below a fixed zero-cross inhibit voltage (V_{IH}) value of ±15V nominal (±25V maximum), has a maximum LED forward current rating of 60mA, has a

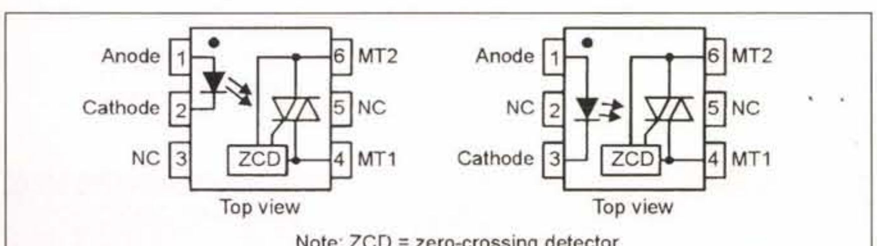
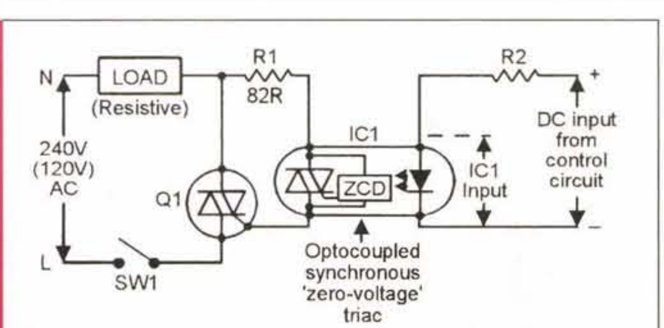


Figure 1. Typical optocoupled synchronous 'zero-voltage' triac outlines and pin notations.

Figure 2. Basic power switching circuit using an optocoupled synchronous 'zero-voltage' triac.



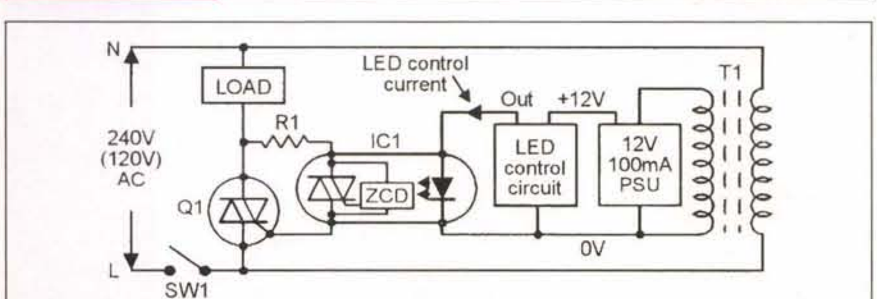


Figure 3. Basic power switching system using an optocoupled synchronous 'zero-voltage' triac.

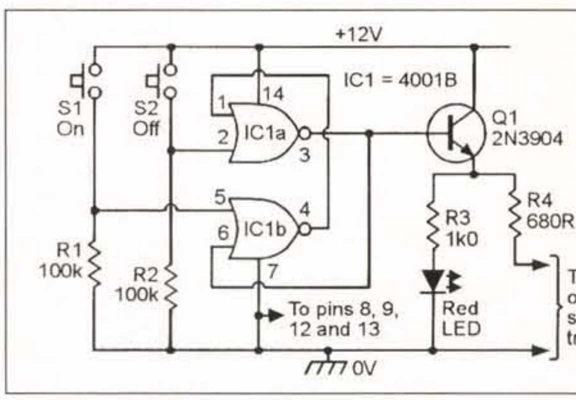


Figure 4. Dual push-button LED control circuit for use in the Figure 3 system.

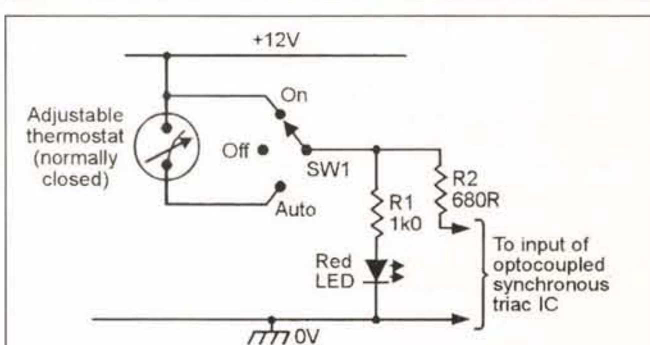


Figure 5. 'Thermostat' LED control circuit for use in the Figure 3 system.

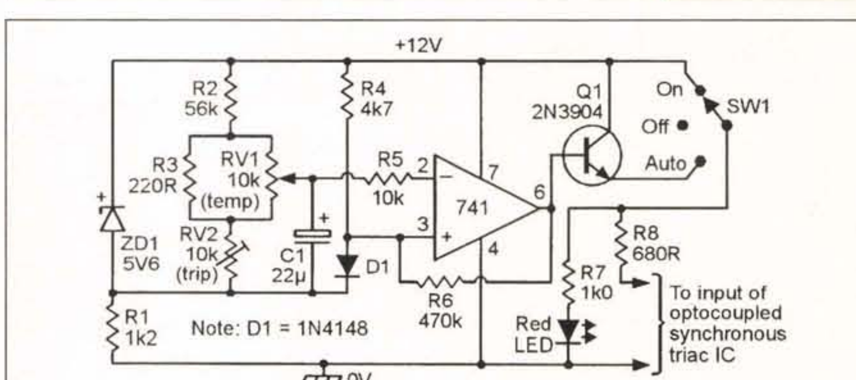


Figure 6. Automatic LED control circuit, using a silicon diode as a temperature-sensing element, for use in the Figure 3 system.

typical input current trigger sensitivity of 8mA or less, and the entire package has an isolating voltage rating of several kV.

Optocoupled synchronous zero-voltage triacs are easy to use and provide excellent electrical isolation between input and output. The input is used like a normal LED, and the output like a low-powered triac. In most practical applications, the optocoupled triac is used to activate the gate of a 'slave' triac, thereby driving a resistive AC load of any desired power rating. Figure 2 shows a practical circuit of this type, which can be manually or automatically switched on or off via a DC input current. Note in Figure 2 that R1 is used to limit the peak switch-on current of the optocoupled triac (and thus the peak gate current of Q1) at IC1's absolute maximum V_{IH} value minus 2V, i.e., typically at 23V; with the R1 value shown, the peak switch-on current is limited to 280mA. R2 is used to limit the LED input current of IC1 to a sensible working value.

Figure 3 shows one way of incorporating the above circuit in a complete electric power switching system. Here, when SW1 is closed, the AC power line is connected to both the load/Q1 circuitry and to the primary of low-power transformer T1, which has its output converted into a 12V DC supply that powers IC1's LED control circuit, which is electrically fully isolated from the AC supply. The LED control circuit can take any of a variety of forms; some simple examples are shown in Figures 4 to 7. The simplest LED control circuit that can be used in the Figure 3 system consists of an on/off toggle switch that — when closed — connects the IC1 LED to the 12V DC supply via a 680R resistor that limits the LED 'on' current to about 15mA, thereby switching the electric load fully on.

Figure 4 shows a dual push-button LED control system, in which the LED and load turn on when S1 is briefly closed, and off when S2 is briefly closed. Here, CMOS NOR gates IC1a-IC1b are wired as a manually triggered bistable multivibrator that has its output buffered by emitter follower Q1 and latches into the 'output high' state when S1 is briefly closed, thereby energizing the circuit's red LED via R3 and feeding a 15mA control current to the LED input of the optocoupled triac. The bistable latches into the 'output low' state when S2 is briefly closed, thereby killing the DC power feeds to the red LED and the triac.

The Figure 4 circuit gives purely manual on/off LED control of an electrical power load such as a heater. Figure 5 shows a simple circuit that also provides the option of automatic control via an adjustable thermostat switch that is normally closed but opens when its temperature exceeds a selected value. Here, the red LED and the electric heater are off when SW1 is in the 'off' position or in the 'auto' position when the thermostat is open, but are on when SW1 is in the 'on' position or in the 'auto' position when the thermostat is closed.

Figures 6 and 7 show high-precision versions of the basic Figure 5 circuit, with the thermostat replaced by a temperature-sensitive electronic switching circuit. The Figure 6 circuit uses an ordinary silicon diode (D1) as a thermal sensing element. Here, zener diode ZD1 is wired in series with R1 so that a constant 5.6V is developed across the two potential dividers formed by R2-R3-RV1-RV2, and R4-D1, and a near-constant current thus flows through each of these dividers. A constant reference voltage is thus developed (via RV1) between the R1-ZD1 junction and pin 2 of the 741 op-amp, and a temperature-dependent voltage with a coefficient of -2mV/°C is developed between the R1-ZD1 junction and pin 3 of the op-amp. Thus, a differential voltage with a coefficient of -2mV/°C appears between pin 2 and pin 3 of the op-amp, which is wired as a high-gain (open loop) voltage comparator with slight hysteresis applied via R6.

In Figure 6, RV1 is a linear rotary pot that is used to manually adjust the heater system's operating temperature over a ±10°C (nominal) range, and RV2 is a multiturn preset that is used to set the circuit's nominal (with RV1 at mid-scale setting) trip temperature. To initially set up the circuit, set RV1 to mid-scale, adjust the temperature of D1 to the desired mid-scale trip value, then trim RV2 so that the red LED is on, but goes off again if the D1 temperature is increased slightly (by briefly applying finger heat to D1). In practice, the circuit has a typical switching sensitivity of about 0.5°C. The Figure 7 circuit uses an inexpensive NTC (negative temperature coefficient) bead or disc thermistor, with a nominal resistance of 4k7 at 25°C, as its thermal sensing element. Here, potential divider RV1-TH1 applies a tem-

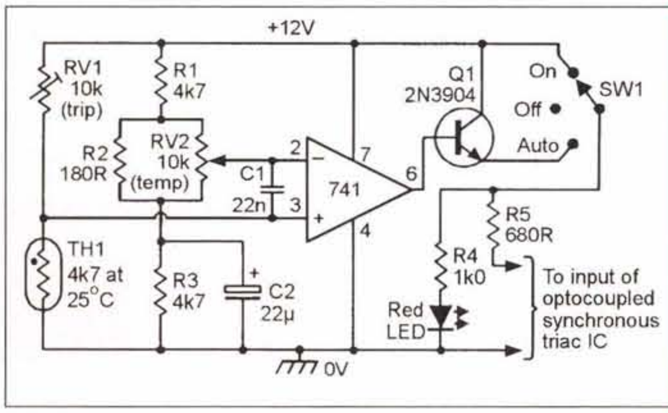


Figure 7. Automatic LED control circuit, using a NTC thermistor as a temperature-sensing element, for use in the Figure 3 system.

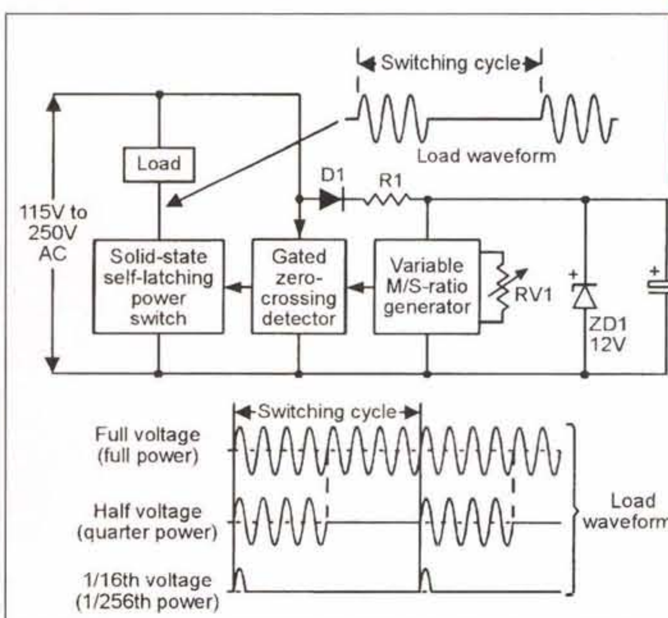


Figure 8. Burst-fire (integral cycle) AC power controller.

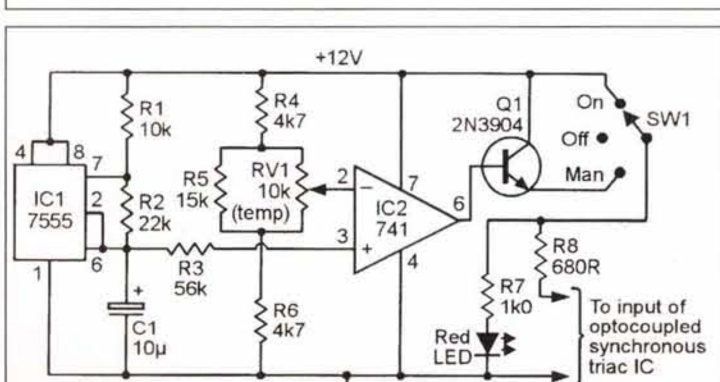


Figure 9. Manually variable 'burst-fire' LED control circuit for use in the Figure 3 system.

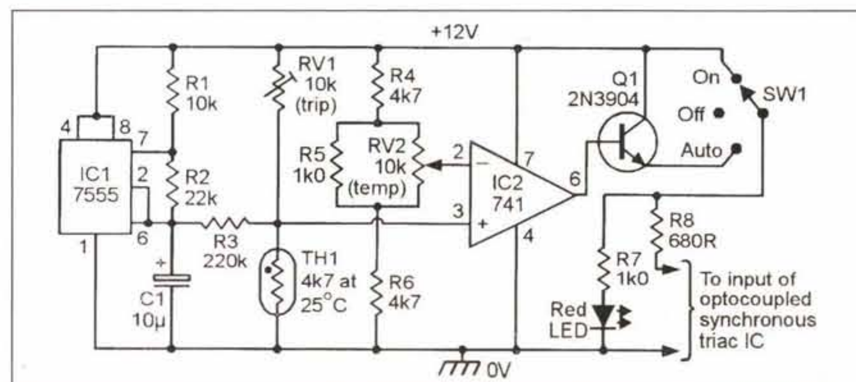


Figure 10. Fully automatic 'burst-fire' LED control circuit for use in the Figure 3 heater control system.

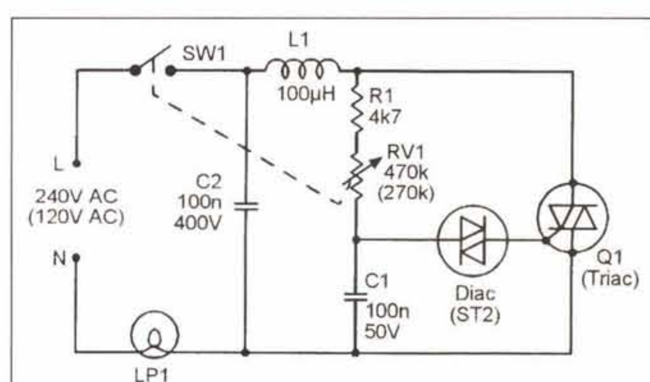


Figure 11. Practical circuit of a simple diac-type lamp dimmer with RFI suppression.

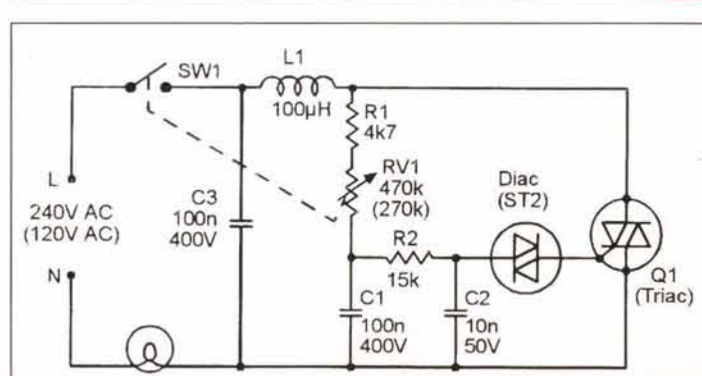


Figure 12. Improved diac-type lamp dimmer with gate slaving.

perature-sensitive voltage to pin 3 of the 741 op-amp, and potential divider R1-R2-RV2-R3 applies a preset reference voltage to pin 2 of the op-amp. The two potential dividers are actually wired in the form of a Wheatstone bridge, and the op-amp is used as a high-gain bridge balance detector; the bridge balance point is unaffected by variations on supply voltage. Capacitors C1 and C2 help to ensure circuit stability.

The action of the Figure 7 circuit is such that (when SW1 is in the Auto position) the output of SW1 is normally low but switches high and activates the red LED and the external triac when the TH1 temperature is below a value pre-set via RV1 and RV2. RV2 is a linear rotary pot that is used to manually adjust the heater system's operating temperature over a limited range, and RV1 is a multiturn preset that is used to set the circuit's nominal (with RV2 at mid-scale setting) trip temperature. To initially set up the circuit, set RV2 to mid-scale, raise the temperature of TH1 to the desired mid-scale trip value, then trim RV1 so that the red LED is on, but goes off if the TH1 temperature is increased slightly.

Note that the Figure 7 circuit has a typical switching sensitivity similar to that of the Figure 6 design (about 0.5°C), but that its thermistor has a far longer thermal time constant than the sensing diode of the Figure 6 circuit; the Figure 7 circuit is thus slower-acting than the Figure 6 circuit. Also note (in Figure 7) that the thermal 'span' range of RV2 can be increased (or reduced) by increasing (or reducing) the value of resistor R2.

Finally, note that — in all cases where an 'automatic' heater-control circuit is used to regulate the temperature of a room — the actual thermal sensor device (thermostat, thermistor, or sensing diode) must be sited roughly one meter above floor level, in a position where it can directly and safely sense the temperature of normally-circulating air; this position must be free of drafts or direct radiation from the heater, and must not be obstructed by furniture, etc.

'Burst fire' AC power control principles

There are three basic ways of controlling the AC power feed to resistive loads such as filament lamps or electric heaters via a triac. One of these is the variable phase-delay-switching system, which gives fully-variable power control and is often used in lamp dimmers, but generates substantial RFI and is thus unsuitable for driving high-power (greater than about 200W) loads. The second is the synchronous zero-voltage power switching system (see last month's Figure 19), which generates minimal RFI but gives only a simple on/off — rather than fully-variable — type of power control.

The third method of AC power control is the burst-fire integral-cycle system shown in Figure 8, in which bursts of complete half-cycles are fed to the load at regular line-frequency-related intervals. Thus, if bursts are repeated at eight-cycle intervals, the mean load voltage equals the full supply line value if the bursts are of eight-cycle duration, or half voltage (equals quarter power) at four-cycle duration, or one-sixteenth voltage (equals 1/256th power) at one half-cycle duration, etc. The burst-fire system thus gives variable power control and generates minimal RFI, and is often used to control the thermal output of electric heaters. Note that the burst-fire integral-cycle control system operates on the synchronous 'zero-voltage' triac switching principle, and practical circuits of this type can thus be made by using suitable control circuitry in conjunction with the basic power switching system of Figure 3. Two suitable circuits are shown in the next section of this article.

'Burst-fire' heater control circuits

The optocoupled synchronous circuits shown in Figures 2 to 7 all — when powering a heater load — give a simple form of control in which the heater is either fully off or is operating at maximum power. Figures 9 and 10 show circuits that drive the heater in the synchronous burst-fire mode, thus enabling the heater's thermal output to be varied over a wide range. The Figure 9 circuit enables the heater's thermal output to be varied manually, via RV1. The Figure 10 circuit varies the heater's output automatically, to maintain a room's temperature at a precise pre-set value.

The operation of the Figure 9 circuit is fairly simple. Here, IC1 (a CMOS version of the 555 'timer' IC) is wired in the astable mode and generates a repeating ramp waveform across C1. This waveform has a period of about 680mS (thus spanning roughly 68 half-cycles of a 50Hz power line waveform or 82 half-cycles of a 60Hz waveform during each period) and is centered on half-supply volts and swings symmetrically between 1/3rd and 2/3rds of supply voltage value. This waveform is fed to pin 3 of op-amp IC2 via R3, and linear rotary pot RV1 feeds a DC reference voltage that is variable from below 1/3rd to above 2/3rds of the supply voltage value to pin 2 of the op-amp, which is configured as a high-gain voltage comparator.

The net effect of the above circuitry is that IC2 converts the 680mS ramp waveform into a switched rectangular output waveform with a mark/space (M/S) ratio that is fully variable from 0:1 (output low for the full 680mS period) to 1:0 (output high for the full 680mS period) via RV1. When SW1 is switched to the Man (manual) position, this output is fed to the input of the Figure 3 optocoupled synchronous electric heater control system, where it enables the mean power input to the heater to be varied (via RV1) from zero to maximum in 68 discrete 'half-cycle' steps in a 50Hz system or 82 steps in a 60Hz system.

Finally, to complete this look at burst-fire heater control circuits, Figure 10 shows a self-regulating synchronous burst-fire heater controller that automatically varies the heater's input power to maintain a room's temperature at a precise pre-set value. Here, the circuit to the right of R3 is almost the same as the Figure 7 thermistor-controlled automatic circuit, but the IC1 circuit to the left of R3 is taken directly from the Figure 9 circuit and superimposes a 680mS ramp waveform (with a peak-to-peak amplitude of about 40mV) on the RV1-TH1 junction and pin 3 of IC2.

The net effect of the above combination is that the external heater is turned fully on (via the optocoupled triac in the Figure 3 system) if the TH1 temperature is more that (say) 1°C below a pre-set value, or fully off if it is more that 1°C above the pre-set value, but is operated in the burst-fire mode — with its M/S ratio automatically adjusted via TH1 — when the TH1 temperature is within ±1°C of the pre-set value. The circuit thus automatically adjusts the heater's thermal output level to meet the room's heating needs; when the temperature reaches the precise pre-set value, the heater does not switch fully off, but generates just enough output power to exactly match the thermal losses of the room. To initially set up the Figure 10 circuit, set RV2 to mid-scale, raise the TH1 temperature to the desired mid-scale trip value, then trim RV1 so that the red LED flashes on and off (at roughly a 1.5Hz rate) but goes fully off if the TH1 temperature is increased slightly. When experimenting with this circuit, note that the thermal 'span' range of RV2 is determined by the R5 value, and the burst-fire thermal operating span is determined by the R3 value.

Finally, note — when using burst-fire systems to control domestic electric heaters with built-in lamps — that the control system must be fed to the heater elements only, and must not be applied to the lamps.

AC lamp dimmer circuits

Triacs can be used to make very efficient lamp dimmers by using the 'phase-delayed switching' technique in which — in each power half-cycle — the triac is gated on at some controlled phase-delayed time after the start of each AC half-cycle, thus controlling the mean power fed to the lamp. All such circuits require the use of a simple L-C filter in the lamp feed line, to

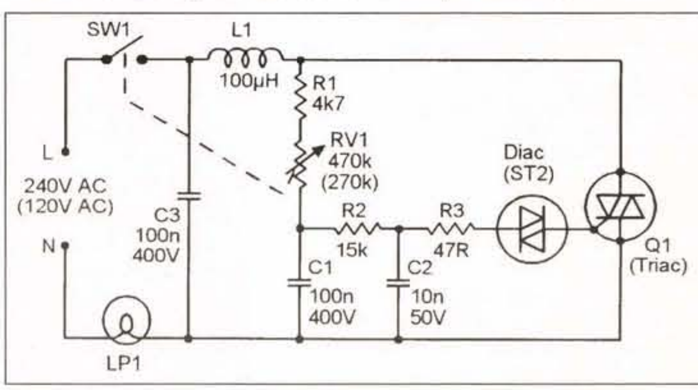


Figure 13. Minimum-backlash diac-type lamp dimmer.

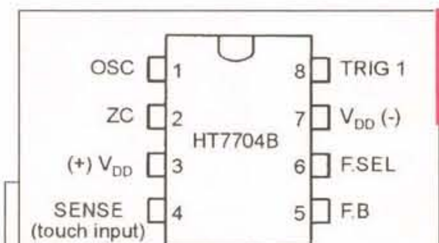
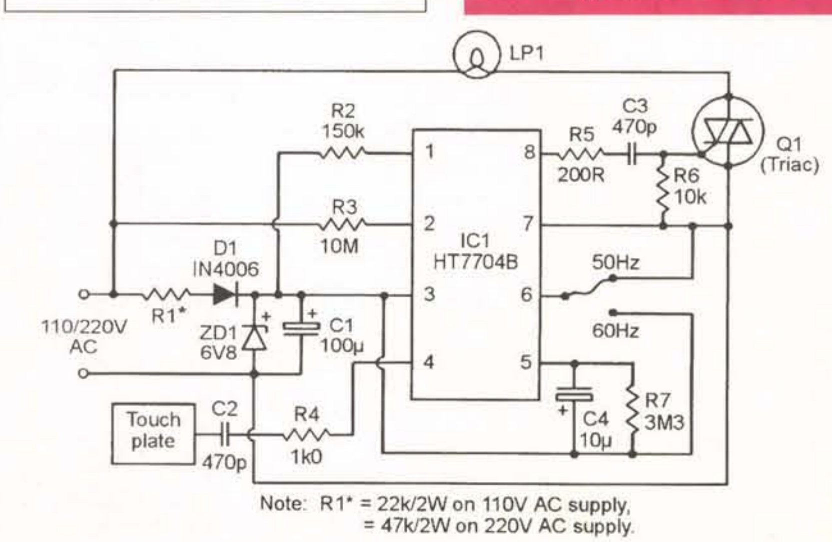


Figure 14. HT7704B outline and pin notations.

Figure 15. Basic HT7704B lamp dimmer application circuit.



minimize RFI problems.

The two most popular ways of obtaining variable phase-delay triac triggering are to use either a diac plus C-R phase delay network, or to use a special-purpose IC as the triac trigger. Figure 11 shows a practical diac-triggered lamp dimmer, in which R1-RV1-C1 provide the variable phase-delay. This circuit is really a simple variant of the basic lamp dimmer circuit shown in last month's Figure 6, with the addition of the L1-C2 RFI suppressor and with RV1 and SW1 ganged together to easily enable the lamp to be turned fully off.

A weakness of the simple Figure 11 design is that it has considerable control hysteresis or backlash, e.g., if the lamp is dimmed off by increasing the RV1 value to (say) 470k, it will not go on again until RV1 is reduced to about 400k, and then burns at a fairly high brightness level. This backlash is caused by the diac partially discharging C1 each time the triac fires. Backlash can be greatly reduced by using the 'gate slaving' technique in Figure 12, in which the diac is triggered from C2, which 'follows' the C1 phase-delay voltage but protects C1 from discharging when the diac fires. If desired, the backlash can be reduced to virtually zero by wiring a current-limiting resistor in series with the diac, to reduce the magnitude of the C2 discharge voltage, as shown in Figure 13.

A 'smart' lamp dimmer IC

Many modern lamp dimmers have their triac driven via a dedicated 'smart' IC that can turn the lamp on or off or control its brilliance, the IC taking its action commands via a touch-sensitive pad or push-button input switch. For many years, Siemens was the leading producer of this type of IC, first with the IC known as the S566B, and then (starting in 1990) with the SLB0586, which remained in full production until 1995 (but was still widely available in early 2000). Today (in 2002), the most popular lamp dimmer IC is a low-cost Holtek product known as the HT7704B 'touch' dimmer.

The HT7704B is an eight-pin DIL IC with the outline and pin notations shown in Figure 14, and provides four levels of brightness plus switch-off control, all sequentially selectable via a simple metal 'touch' pad or plate that is AC coupled to pin 4 of the IC. In use, the first 'touch' turns the lamp on at its lowest brighness level; the next three touches bring the brightness up to maximum level in successive stages; the fifth touch turns the lamp full off, and so on.

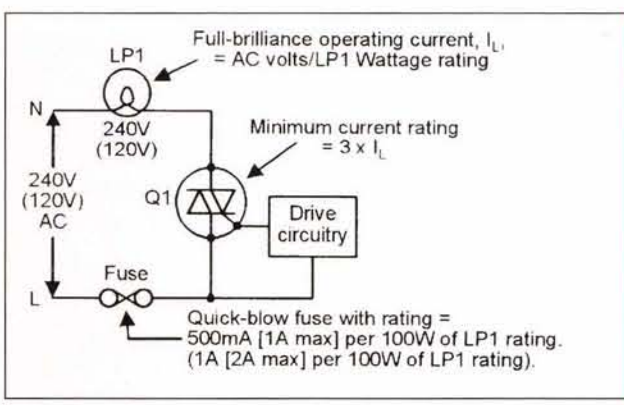


Figure 16. Basic triac and fuse selection data for use in simple on/off lamp switching and lamp dimmer types of application.

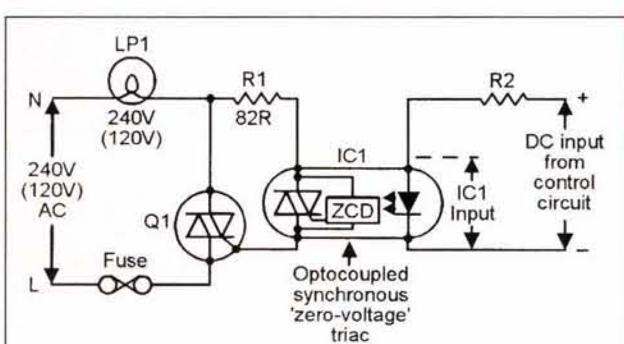


Figure 17. Ideally, all on/off-type lamp switching circuits should be gated via an opto-coupled synchronous 'zero-voltage' triac, to eliminate all switch-on surge current problems.

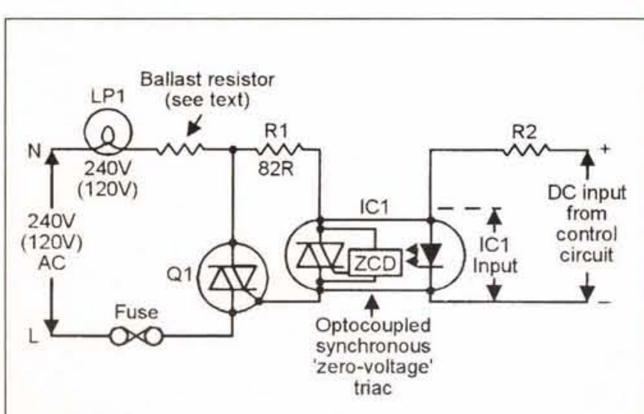


Figure 18. In extreme cases, such as in flashing-lamp disco displays, the main triac (Q1) can be protected against damage from a 'catastrophic' lamp failure by a ballast resistor, wired as shown.

Figure 15 shows the basic application circuit of the HT7704B (without fused overload protection or RFI-suppression circuitry), with alternative component values and pin connections shown for use with 50Hz or 60Hz AC supplies with nominal values of 110V or 220V. Note that R1 is a 2W type and needs a value of 22K on 110V AC supplies or 47K on 220V AC supples, that pin 6 must be tied to pin 7 on 50Hz supplies or pin 3 on 60Hz supplies, and that the ratings of triac Q1 must be chosen to suit the lamp power and supply-voltage rating of the individual system.

Triac protection techniques

In use, triacs must always have an RMS current rating greater than that of the load that they are driving and must always be protected against catastrophic damage from current surges or malfunctions in their loads. Adequate protection can usually be obtained via a suitably-rated quick-blow fuse that is effectively connected (either directly or via a supply-connection plug) in series with the load and the triac's main terminals, but in a few special applications, additional protection may also be needed. Note that the fuse value must always be chosen with great care, and should be of the minimum practicable rating; a fuse with too high a rating provides no useful protection.

When a triac is used in an electric-heater driving circuit, a quick-blow fuse with a current rating greater than that of the heater but less than the maximum current rating of the triac provides adequate protection. When a triac is used in an electric-motor driving circuit, a quick-blow fuse with a current rating greater than the stalled current rating of the motor but less than the maximum current rating of the triac should be used.

In most filament-lamp driving triac circuits, the triac needs a current rating at least three times greater than the normal running current of the lamp, and should be protected by a quick-blow fuse with a rating of 500mA (1A absolute maximum) per 100W of lamp rating in 240V AC systems, or 1A (2A absolute maximum) per 100W of lamp rating in 120V AC systems; in some special filament-lamp driving circuits, however, additional protection may also be needed, as described later in this article. To understand the principles of triac protection in filament-lamp driving circuits, it is necessary to understand certain characteristics of fuses, filament lamps, and triacs as follows.

FUSE BASICS. An ordinary 'quick-blow' fuse consists of a short length of wire, which burns out ('blows') if the current passing through it exceeds a limit determined by the wire's diameter. Most quick-blow fuses use a copper wire, which has a melting temperature of 1083°C and a resistance that — when referenced to 20°C — increases by about 0.4% per °C increase in temperature. Thus, when the current passed through the fuse exceeds roughly 40% of its rating, its resistance and power dissipation and temperature all increase exponentially with further increases in current, until a point is reached where the ability of the fuse to dissipate power is exceeded by the prevailing input power level; under this condition,the fuse eventually blows at its weakest point; when a fuse blows, its wire first melts at the failure point, which is then widened as current briefly arcs across the gap and vaporizes the adjacent metal.

All fuses carry a 'rating' figure (such as 500mA, 1A, 2A, 5A, etc.) which indicates the maximum current that the fuse can safely carry without blowing or suffering a reduction in its working life. The fuse will only blow if its rating figure is exceeded ('overloaded') for a significant period of time; thus, a 2A quick-blow fuse may take absolute maximum times of several days to blow at 2.2A, 2.5 hours at 3A, 1 second at 4A, 40mS at 6A, 8mS at 10A, 2mS at 20A, 500µ S at 40A, and so on. All quick-blow fuses can thus safely handle large-amplitude current transients or surges, provided that they do not exceed a certain critical duration.

FILAMENT LAMP BASICS. An ordinary filament lamp consists of a tightly coiled Tungsten wire filament that is supported on insulated struts, has its two ends made externally available, and is enclosed in a sealed glass envelope or bulb. In use, an electric current passed through the resistive filament raises its temperature to a white heat, causing it to emit white light; the glass bulb that encloses it is normally filled by a non-reactive gas such as argon, to stop the filament burning up under this condition.

The Tungsten filament's wire has a melting temperature of 3370°C and a resistance that — when referenced to 20°C — increases by about 0.45% per °C increase in temperature, making the resistance value rise sharply with filament temperature. The resistance of a 240V 100W lamp is typically 40R at 20°C but is 576R under normal 'white heat' running conditions (the lamp thus shows about a 14:1 resistance variation over its full usage range). Note from this data that this 100W lamp consumes a normal RMS running current of 417mA from the 240V AC supply but — if it is initially switched on at a moment when the AC voltage happens to be at the peak point in a half-cycle — may pass an initial switch-on surge current of up to 8.46A, thus generating a 2030W switch-on power surge in the lamp. By comparison, a 120V 100W lamp consumes a normal RMS running current of 833mA and may pass an absolute peak switch-on surge current of

16.5A. In practice, the lamp's initial switch-on power surge makes its filament resistance rise very rapidly (in a few milliseconds) to a value reasonably near to the filament's normal operating value; the lamp-driving triac (and its protective fuse) must be able to handle this surge current without suffering damage.

Tungsten filament lamps have a typical operating life of about 2,000 hours. The outer surfaces of the coiled Tungsten filament slowly 'boil off' with continued use, until the weakened filament eventually blows at its most vulnerable (thinnest) point, in the same basic manner as in a fuse, i.e., the failure point first melts and is then partly vaporized by arcing; usually, the vaporized metal blackens part of the glass bulb's inside surface. Filament lamp failures occur in three basic types, which can be classified as 'simple,' 'recursive,' or 'catastrophic;' these failure types have the following characteristics. Most lamp failures are of the 'simple' type, in which the filament simply burns through and then arcs at its weakest point, vaporizing the local metal; the lamp emits an audible 'ting' as the two halves of the ruined filament spring apart; usually, the arcing debris blackens only the end of the bulb. This type of failure often occurs at the moment of initial switch-on and is usually harmless to triac drivers.

The 'recursive' type of lamp failure can be regarded as a small number of 'simple' failures occurring in quick succession. At the end of the first failure, the broken but still hot and vibrating ends of the filament briefly make contact and weld together, passing a surge of current through the remaining (but shortened) length of filament, which quickly suffers another failure at another weak point, and so on. In this type of failure, the lamp usually flickers on and off a few times before finally dying; the inside of the bulb normally becomes widely blackened as a result of the multiple arcing that occurs in this process. This type of failure may be accompanied by very heavy current surging, which may damage a driving triac that is not adequately rated or fuse-protected.

The 'catastrophic' type of lamp failure is a rare and very savage type of recursive failure, in which the internal arcing is so severe that the entire inner surface of the lamp and the filament's supports becomes coated in conductive vaporized metal, thus shorting out much of the filament and causing a very low resistance to appear across the lamp's terminals. This type of failure sometimes occurs in crude flashing-lamp disco displays in which the triac-driven lamps are switched on and off in response to the filtered amplitudes of the music, often going through thousands of on/off switching sequences (and their associated heavy surge currents) per hour; triacs need special protection in this type of application. In extreme cases of this type of failure, the triac may develop an internal short-circuit, and the fuse may then blow as the lamp filament self-destructs, thus destroying all three components during the 'failure' process.

TRIAC BASICS. From the 'current overload protection' point of view, the two most important parameters of a triac are its basic 'RMS on-state current rating,' $I_{T(RMS)}$, and its non-repetitive peak surge on-state current rating over a period of one full cycle duration, I_{TSM}. Typically, I_{TSM} is 10 times greater than $I_{T(RMS)}$ in 60Hz systems, and eight times greater than $I_{T(RMS)}$ in 50Hz systems. Thus, a 4A triac can typically handle I_{TSM} surge current of up to 32A in a 50Hz system, or 40A in a 60Hz system.

TRIAC PROTECTION CIRCUITS. When all of the above data is put together, it transpires that the simplest on/off-switching or 'dimmer' type of lamp-driving triac circuit should take the basic form shown in Figure 16. The lamp's normal 'fully on' running current, I_L, equals the AC supply voltage divided by the lamp's power rating, the triac needs a minimum current rating of 3 x I_L, and the fuse must be a quick-blow type with a current rating of 500mA (1A absolute maximum) per 100W of lamp rating in 240V AC system, or 1A (2A maximum) per 100W of lamp rating in 120V AC systems. Ideally, all modern lamp-driving 'on-off' types of triac circuit (including those used in flashing-lamp disco displays) should take the basic form shown in Figure 17, in which the main triac is gated via an optocoupled synchronous 'zero-voltage' triac (as described earlier in this article), thus completely eliminating all switch-on surge current problems.

In very extreme cases, particularly in flashing-lamp disco displays, the above circuit can be modified to give the main triac additional protection against damage from the 'catastrophic' type of lamp failure by wiring a ballast resistor is series with the load, as shown in Figure 18; this resistor must be a wire-wound type with a resistance equal to at least 5% of the lamp's hot resistance and with a power rating equal to at least the same percentage of the lamp's power rating. If the lamp suffers a near-short-circuit during a catastrophic failure, this ballast resistor limits the surge current to a value that blows the fuse but does not damage the triac; the ballast resistor gives a slight reduction in lamp brilliance under normal running conditions. **NV**

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Ham Radio Extra Class Test Changes

By Gordon West

A few issues back, the article "Hams in Hog Heaven" prompted correspondence from our readers that now is a great time to get into ham radio. The dreaded Morse Code tests were eliminated for the entry-level Technician class license. Technician class operators have full access and ALL privileges above 50 MHz.

The 50 MHz six-meter ham band, all by itself, can take the no-code Technician class operator into major voice worldwide skywave DXing. "DXing" means working on a radio band and having your signals come in a whole lot further than you ever dreamed possible.

A Long Island mobile six-meter DXer hooks up with another mobile operator in Spain, and they talk for over half an hour before the band conditions begin to fade in and out. Midwest six-meter hams enjoyed crystal-clear conversations with AL7BJ Rex toasting his footsies by the fireplace in Alaska where the outside temperature was 30 below. And along the West Coast, our six-meter single-sideband contacts with skywaves coming in from Hawaii were suddenly, and pleasantly, interrupted by more powerful Japanese six-meter signals that pounded in for hours.

All this excitement without having to pass a code test, and we still have another good year of hot six-meter activity for Technician no-code operators before we begin to slide down the back side of solar cycle 23. But learning the code at a simple 5 wpm and taking one more theory test puts you into the General class license. This opens up almost 4,000 additional kilohertz of worldwide ham bands below 30 MHz. The General class ticket is the big one — there is always one of the worldwide bands that continues to have daytime and nighttime propagation over thousands of miles with ease.

EXTRA CLASS

The Extra class is at the top of the ham radio pyramid. Less than 20 percent of hams have the Extra, but this is changing rapidly. Now that the Extra class license does not require a 20 wpm code test, hams are easily picking up the Extra class book, spending about 20 days going over the 665 Q & As in the pool, and taking the 50-question Extra class multiple-choice test. And you don't need to get 100 percent — a passing score is 70 percent. Most everyone gets the Extra on the first try now that there is no further Morse Code requirement beyond 5 wpm.

But things will change come July 1 of this year. The VEC (Volunteer Examiner Coordinator) Question Pool Committee (QPC) has just released a "new" question bank for the Element 4 Extra class test administered after July 1, 2002. The pool increases by a whopping 20 percent, going from the present 665 Extra class question pool to the huge new 807 question pool. Fifty percent of those 807 questions cover electrical principles, circuits, signals, and emissions. Bound to be a brain-buster, right?

Certainly, 100 additional questions beyond 665 will take increased study time. However, rumors that the new 807 July 1 Extra class test question pool contains "new" test questions is absolutely bunk! The "brand new pool" actually contains only about 50 brand new questions, most dealing with rules and regulations, pulled together by former FCC Chief Johnny Johnston, now retired and having a ball on his ranch playing ham radio. He did a nice job with some of the new rules and regs questions.

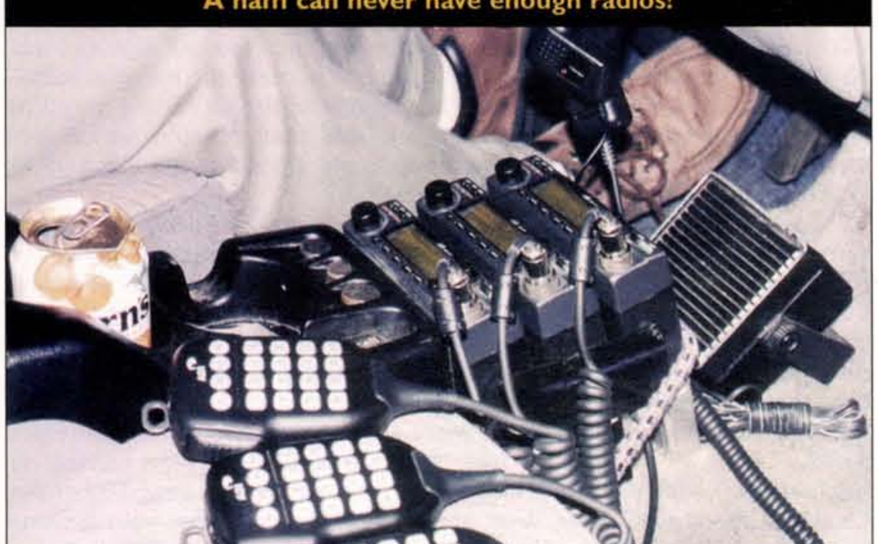
So where did those 142 additional Extra class questions come from? A few are REALLY new from electrical principles, circuits, signals, and emissions, and the remaining questions are actually resurrected shelved Extra class questions prior to April 2000.

Back in April of 2000, the Question Pool Committee had to hastily combine the now extinct amateur Advanced class test with the present Extra class test back then and, in doing so, they ended up with over 100 questions that were simply set aside when the two pools were merged. The old Advanced class license exam was eliminated in April of 2000, but many of the Advanced class questions would live on when merged into the present Extra class pool.

So as not to have the present Extra class pool explode by combining two pools into one, specific topic areas that might have 10 specific questions on a certain subject were scaled down to three or four questions, and the remaining questions were set aside. Guess what? Beginning July 1 of this year, those "set aside" questions are returning to the new Extra class pool. So don't let anyone tell you that the "new" Extra class test question pool is all that different than what has been already seen in prior Advanced and Extra class textbooks in the past. But here is what is actually new:

- Fifty fresh and timely rules and regulation questions
- Four satellite questions reworked into plain language modes
- A couple new questions on slow-scan television
- Three questions on contest etiquette
- Eight good questions on automatic position/packet reporting system (APRS)
- A couple new questions on PSK digital modes
- A couple new questions on second-order and third-order intermodulation dBm levels
- Elimination of the multiple questions on Thevian theorem voltage dividers

A ham can never have enough radios!



Hams send GPS data bursts to track one another over the radio.

Plenty of "deals" with new and used ham radio equipment.

We need more kids to obtain their ham license for our service to remain viable.

- Five new questions on monolithic microwave integrated circuits
- A few new questions on the isotropic radiation
- A couple questions on Yagi angle of radiation
- A handful of questions on basic stuff like velocity of radio waves in space, Zener diodes, and one on a load resistor

It was fun to compare how the "all new" pool was put together – long runs of identical questions, supplemented by runs of past shelved questions, and then two or three genuine new questions at the end of each topic area if they lacked a couple of spots to be filled up. I suppose you could call it a patch job, but you can't blame the Question Pool Committee for not coming up with more new and technologically updated Q & As. Three out of the four QPC men are doing this on their own time yet working or retired as their primary job. One QPC member works a regular job in this testing business, and probably didn't get an official assignment to take him out of VEC duties and put him into brainstorming new Extra class questions.

The Question Pool Committee pleaded with the ham community to come up with ALL NEW questions, but only a few trickled in. It would take a very technical ham volunteer probably three months, eight hours a day, five days a week to do nothing but create new Extra class questions and take just as much time in coming up with the new questions as documenting exacting where they came from in engineering or radio communication handbooks. I know that I had only enough time to send in a few suggested Extra class questions, and it looks like the QPC adopted many of my suggestions.

So the bottom line is, if you're a General class ham operator now, or soon to get your General class, prepare for Extra class right now with the question pool 20 percent smaller. Come July 1, 2002, the Extra class pool goes from 665 present questions to 807 questions. You can buy the present Extra class test preparation book with explanations to each and every question by calling 800-669-9594. You can view the NEW Extra class test at http://www.arrl.org/arrlvec/pools.html. You can try your test-taking online with either the old or the new pool at www.qrz.com/testing.html.

NEXT IS TECHNICIAN CLASS

So what will happen a year from now when the QPC releases the entry-level Technician class test question pool? A lot depends on what ham operators and ham instructors throughout the country come up with as suggestions to the present Tech pool, due for a change next year. If the ham community does nothing, just like it did for Extra, the pool will probably remain unchanged. Children by the thousands will take one look at the book, and tell mom and dad they would rather get into computers. Many of us will look at the entry-level Technician class question pool and scratch our heads wondering why there are not more questions on ham radio operating as opposed to internal radio circuits like the inductive reactance of a coil – something that we don't really come in contact with as a new operator.

But who has the time at the end of this year to create close to 400 brand new questions for the beginning operator? One person alone would take months to pull off the job. I suggest the QPC and everybody in the ham radio industry send out a call, LOUD AND CLEAR, that every ham should send it at least one single question and four possible answers, dealing with 10 sub-element areas ranging from rules and regulations to safety around transmitting antennas. JUST ONE QUESTION!

Let the ham community create a brand new entry-level test question pool that has relevance to the beginning operator setting up their first two-meter base, mobile, or handheld station. When your brand new license arrives, and a buddy has preprogrammed your brand new handheld to the local repeater, what's a good way to make that first contact? Do you call CQ? Do you say the letters QRZ? Do you send out your call sign and say, "Gotta copy, good buddy?" Or maybe you just squeeze the transmit button and say your call sign, announce that you are on the air for the very first time, ask if anyone is receiving your signal, and again repeat your call sign phonetically? That would be a great way to go. Seems to me like a good, logical question for the test for beginners, huh?

So yes, hams are in hog heaven with equipment prices staying the same or actually dropping, plenty of elbow room out there on the airwaves, ARRL-sponsored ham programs for schools, and thousands of volunteer hams who spend days and weeks teaching classes for free, giving tests for free, helping submit test questions for free, and becoming "Ham Ambassadors" to friends down the street wanting to get into this "secret handshake" hobby.

If you're interested in learning more about ham radio as an electronics techno – guy or girl – call 800-326-3942, or send email to newham@arrl.org. You may also send your suggested new Technician Class questions to Gordon West at swmeow@aol.com. Get your training material at 800-669-9594. We need more technical types like YOU! **NV**

DUSTMEISTER

The Search for an Intelligent Vacuum Controller — Part I

By Robert Lang and Thomas Ober

The circuitry described in this article can be used to control any large or small motor application.

For over 20 years, I have been a slave to my workshop dust collector. It is always off when I need it on and on when I want it off. I have to stop whatever I am doing and go over and turn the dust collector on or off. I am sure other woodworkers sometimes feel like slaves to their dust collectors, as well. And, if you are not a woodworker, read on. The circuitry described in this article can be used to control any large or small motor application.

In the process of machining wood, it is good practice to remove wood chips and sawdust with some sort of dust collection or vacuum system as they are produced. The inconvenience of manual dust collector controls may lead the woodworker into not using the dust collector and thereby not getting the improved safety or air quality benefits. On the other hand, continuously running a dust collector leads to a distracting, noisy shop and the wasting of electricity and air conditioning.

What I needed was a way to automate a shop-wide vacuum/dust collector system — such as the one shown in Figure 1 — to turn on whenever a woodworking tool is turned on and shut off after the tool is turned off. I searched for such a ready-made device, but could not find one.

I decided it was time to design and build an intelligent dust collector/vacuum controller that I call the DUSTMEISTER. In DUSTMEISTER Part 1, I will cover some basics of current sensing, the design and building of the hardware, and the circuit theory. In Part 2, I will cover the building of a tool sensor from scratch, and the programming and testing of the DUSTMEISTER.

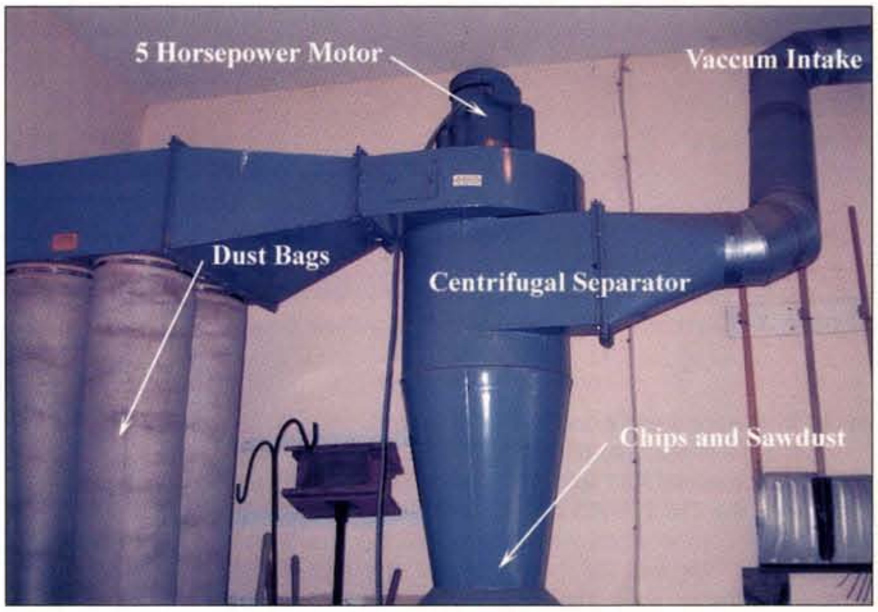


Figure 1 Shopwide Vacuum (dust collector) System

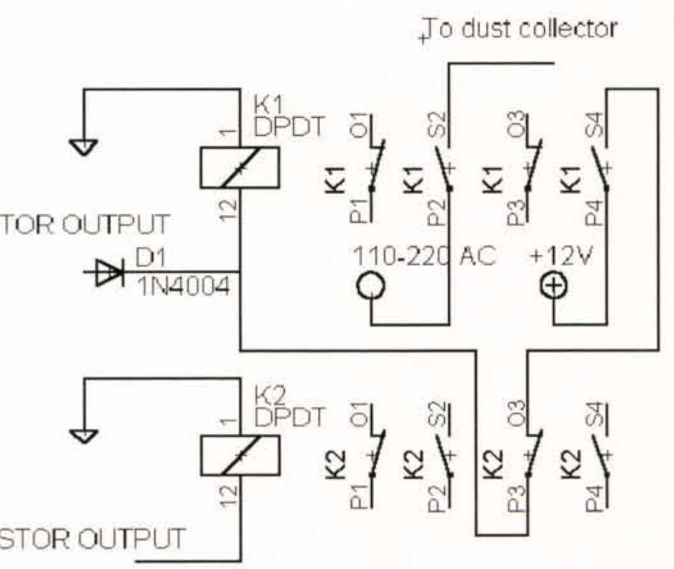


Figure 2 Alternate Wiring of Relays for Dust Collector without Motor Controller

DESIGNING THE SYSTEM

I looked at several approaches to the problem, but I eventually decided to detect the current flowing in the power wires to the tools. I wanted the system to have some intelligence, so I decided upon a microprocessor-based digital approach. I wanted the completed DUSTMEISTER system to:

1. Sense when woodworking tools are turned on or off.

2. Have a user-controlled delay after a tool starts before the dust collector system starts to minimize starting currents.

3. Have a user-controlled delay after a tool stops before the dust collector system stops to clear remaining wood chips.

4. Have no effect on the original dust collector manual control system when the DUSTMEISTER is powered off.

5. Be independent of amperage of the woodworking tools or dust collector system.

6. Avoid cycling the dust collector system unnecessarily when one tool is turned off and another is turned on after a short time.

7. Keep the woodworker informed of system status with simple, easy-to-understand English messages.

8. Be expandable for future improvements.

DUST COLLECTOR MOTOR CONTROLLER

The dust collector motor controller — also known as a magnetic starter — consists of a contactor with the addition of protective control. The controller depends on the magnetic pull of an electromagnet to close and hold its line and auxiliary contacts and offers unlimited flexibility of control. It is dependable and has a long life expectancy. The controller is a standard device for starting and stopping large motors such as those used in woodworking tools or shop-wide dust collector systems. In my case, the dust collector uses a five-horsepower electric motor. A manual ON and OFF switch actuates the motor controller electromagnet which closes and opens the contacts that supply power to the motor. The motor controller electromagnet provides automatic motor shutoff on temporary power loss.

I used a SQUARE-D motor controller, but the description below should apply to most brands of motor controllers. I made no modifications to the SQUARE-D motor controller, but developed a way to control the momentary contact manual ON and OFF switches. Thus, the DUSTMEISTER is independent of the size of the dust collector motor being controlled.

Two 12-volt relays were used to automate the manual ON and OFF switches. The ON switch is a normally open switch used to supply 110-volts AC to the motor controller electromagnet.

I used a double pole, double throw relay in parallel with the manual ON switch. When the relay was energized for a short time, the normally open contacts would close which emulated the manual ON switch.

The OFF switch is a normally closed switch. A similar relay to the one used for the ON switch was connected in series with the OFF switch. When the OFF relay was energized, the normally closed relay contacts would

Tom Ober is an engineer and a member of the Society of American Period Furniture Makers and has built and restored 18th century American furniture and room surroundings as an avocation since 1975. His interest in classic woodworking began by assisting his wife in their antique business in Connecticut. **Robert Lang** is a professional electrical engineer who has written numerous articles for both electronic hobbyist and music magazines. His interests include electronics and building and restoring musical instruments. He has collaborated with Tom on the restoration of pianos from 1840 and 1790. He can be reached at rlang@netdoor.com.

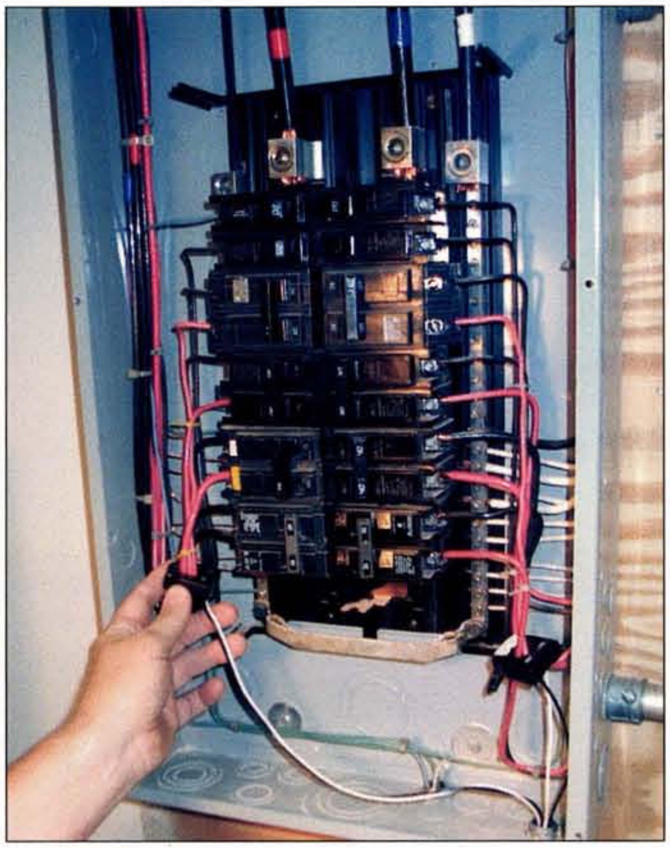


Figure 3 Current Transformer placement in Fuse Box

open. This action emulated the OFF switch.

Because of the way the DUSTMEISTER simply automates the manual ON and OFF switches of the motor controller, the DUSTMEISTER is completely invisible to the manual control when it is powered off. In other words, the manual ON and OFF switches of the SQUARE-D motor controller work the same as always when the DUSTMEISTER is off.

While the DUSTMEISTER circuit board uses only +5 volts and +12 volts, the relays are used to switch 110 volts on and off. Caution must be used when connecting the relays.

Work should never be done on a live circuit.

If your dust collector motor is not large enough to require a motor controller, do not worry. The DUSTMEISTER works just as well without a motor controller on small motors. For the case without a motor controller, the small dust collector motor is connected directly to the ON relay. The ON and OFF relays are connected together as shown in Figure 2 to create a latching relay. As an additional bonus, this set-up gives you one of the benefits of the motor controller. If there is a momentary power outage, the dust collector motor will be disconnected from the power source.

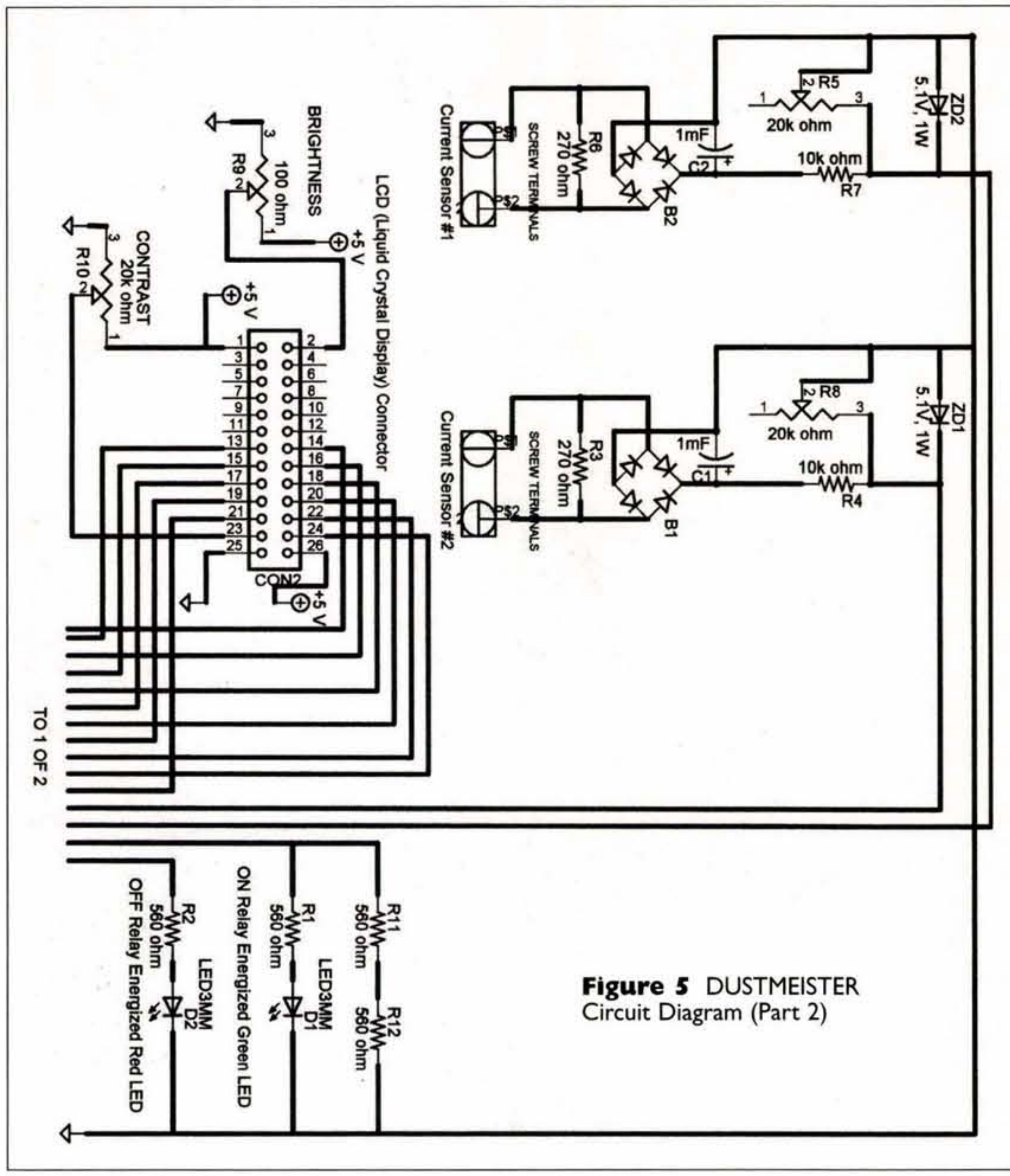


Figure 5 DUSTMEISTER Circuit Diagram (Part 2)

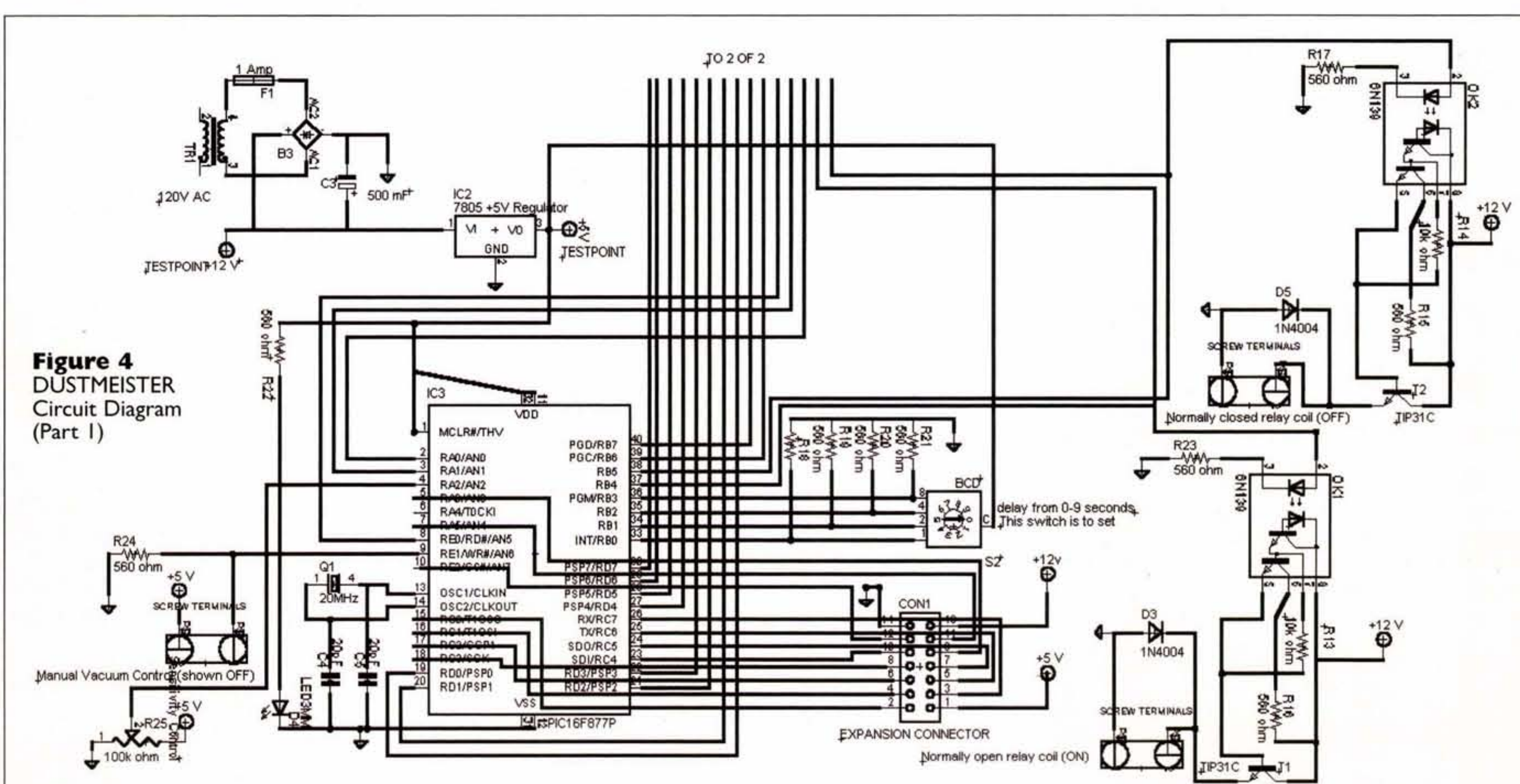


Figure 4 DUSTMEISTER Circuit Diagram (Part 1)

CURRENT SENSING BASICS

Detecting current in wires has traditionally been approached in one of three ways:

1. Resistance measurements
2. Hall-Effect measurements
3. Current transformer measurements

Resistive sensing is very widely used, low-cost, and easily understood. Two shortcomings of resistance measurements are the insertion loss (heating and wasted power) and the lack of isolation. Signal amplification is usually required with resistive current sensing techniques.

Hall-Effect sensor integrated circuits represent the next approach to current sensing. Hall-Effect sensors develop an output signal that is proportional to the applied magnetic field. The magnetic field is usually generated by wrapping the current-carrying wire around a gapped toroid. The sensor is placed in the gap. Disadvantages of the Hall-Effect approach include cost, a non-zero output when there is zero current, and external power requirements.

Current transformers are the last of the low-cost current sensing methods. A current transformer is an instrument transformer in which the secondary current is substantially proportional to the primary current and differs in phase from it by an angle which is approximately zero.

As the term transformer implies, current transformers are only useful with alternating currents. While current transformers may be more expensive than the first two options, current transformers avoid insertion loss, offer electrical isolation, and do not require external power. They also exhibit zero output when there is zero current. For these reasons, I chose the current transformer approach using current sensors from Source 1. The most expensive components in the DUSTMEISTER circuit are the current transformers which cost about $22.00 each. While most woodworkers may feel more comfortable using manufactured current transformers, it is also possible to make your own current sensors from scrap transformers as described in Part 2 of this article.

Figure 7 Prototype DUSTMEISTER on Breadboard

Figure 6 Current Transformer

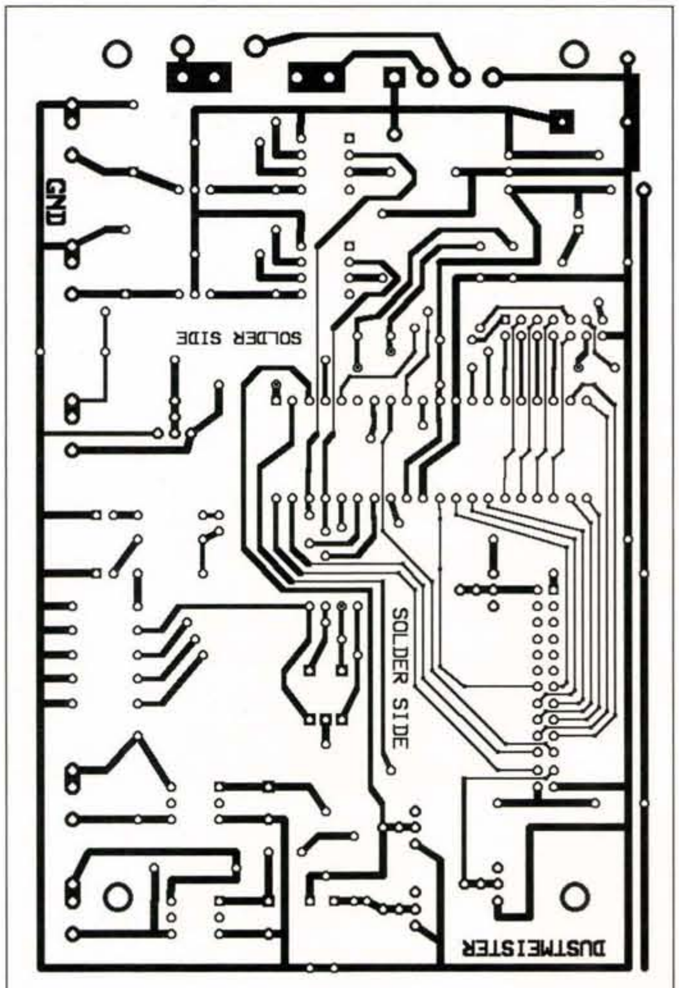


Figure 9 Bottom View of Circuit Board

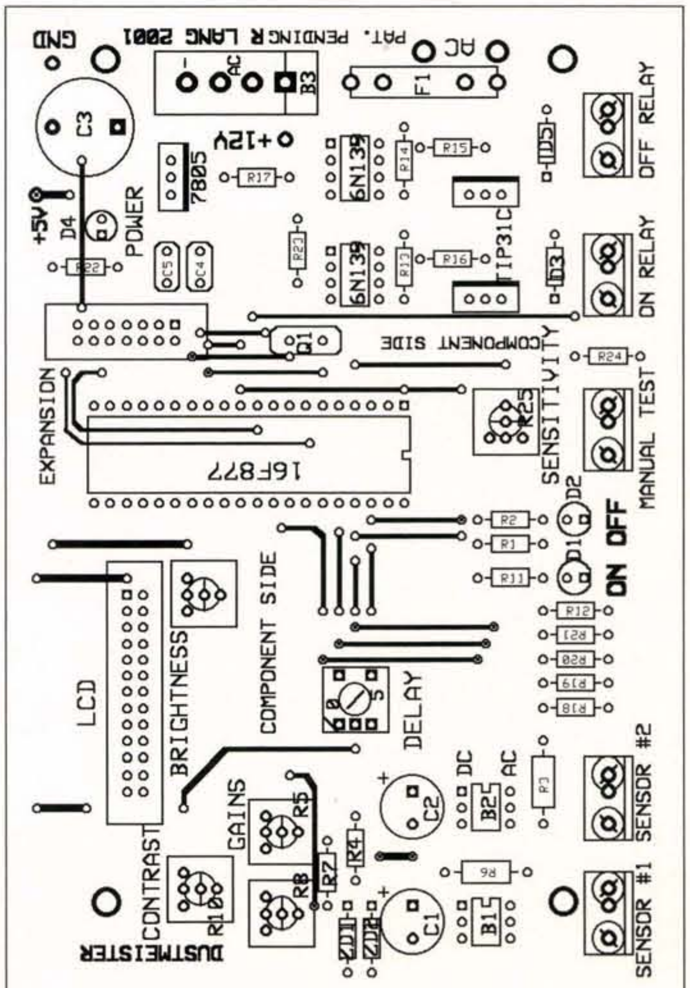


Figure 8 Top View of the Circuit Board

Source 1 CR Magnetics, Inc., for current transformers at http://www.crmagnetics.com/.
Source 2 DUSTMEISTER Homepage for preprogrammed PIC16F877 chips circuit boards at www2.netdoor.com/~rlang.
Source 3 Peter Anderson for blank PIC16F877 and ceramic resonators at http://www.phanderson.com.
Source 4 Electronix Express for printed circuit making supplies and miscellaneous electronic parts at http://www.elexp.com.
Source 5 Marlin P. Jones & Associates, Inc., for electronic parts at http://www.mpja.com.
Source 6 Jameco, Inc., at for optical isolators http://www.jameco.com.

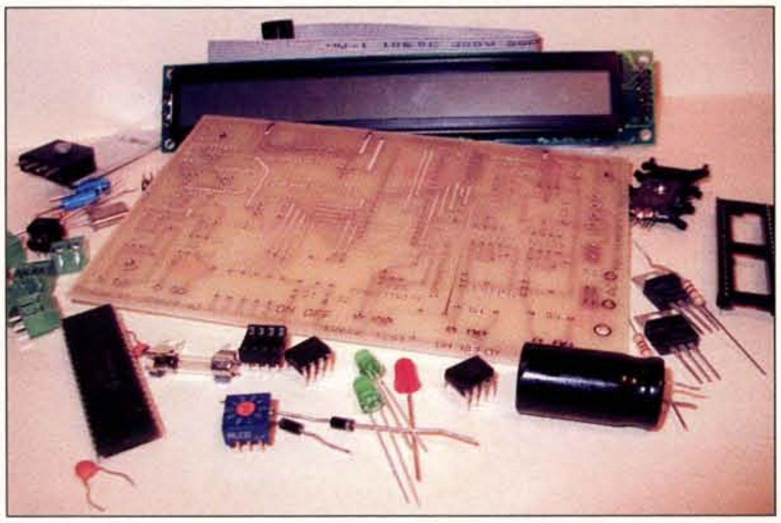


Figure 10 DUSTMEISTER Parts and Etched Circuit Board

One phase of the current-carrying wire to each tool must be run through the hole in the current transformer sensor. The most convenient place to do this is in the fuse or electrical service box. Figure 3 shows two current sensors placed in the electrical service box. The two sensors used in the DUSTMEISTER can easily sense three tools each which means that the dust collector system can be controlled by any of the six sensed tools.

DUSTMEISTER CIRCUIT OPERATION

The circuit for the DUSTMEISTER is fairly simple. All voltages on the circuit board are 12 volts or less. The major electronic component is the PIC16F877 microprocessor. The circuit is shown in Figure 4 and Figure 5 and works as follows.

Current flowing to a woodworking tool is sensed by using a CR Magnetics remote current transformer connected to the Sensor #1 or Sensor #2 terminal strips. This device — shown in Figure 6 — can detect current flowing through a wire threaded through its circular opening.

The secondary of the current transformer should never be allowed to become open circuited when current is flowing through the primary (the wire supplying power to the tool). When open-circuited, the voltage across

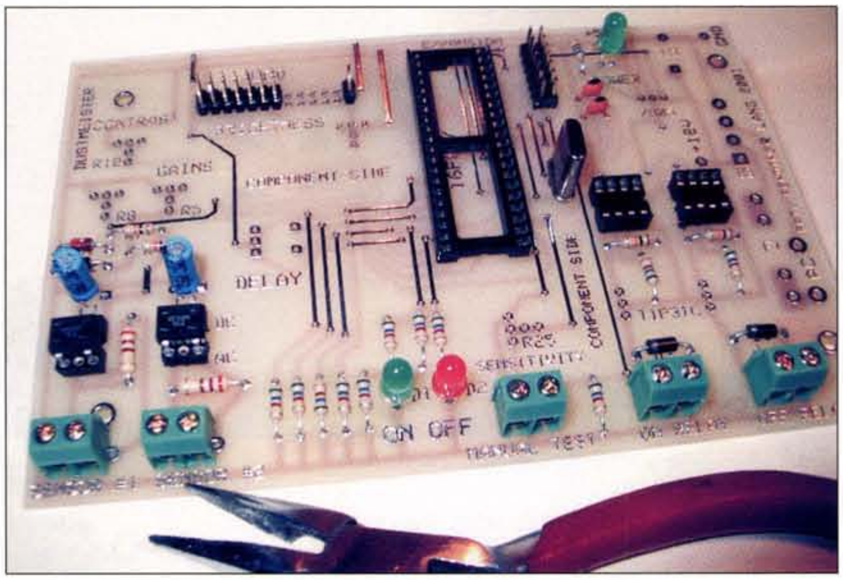


Figure 11 DUSTMEISTER Circuit Board with Diodes, LEDs, Crystal, Capacitors, and Connectors Added

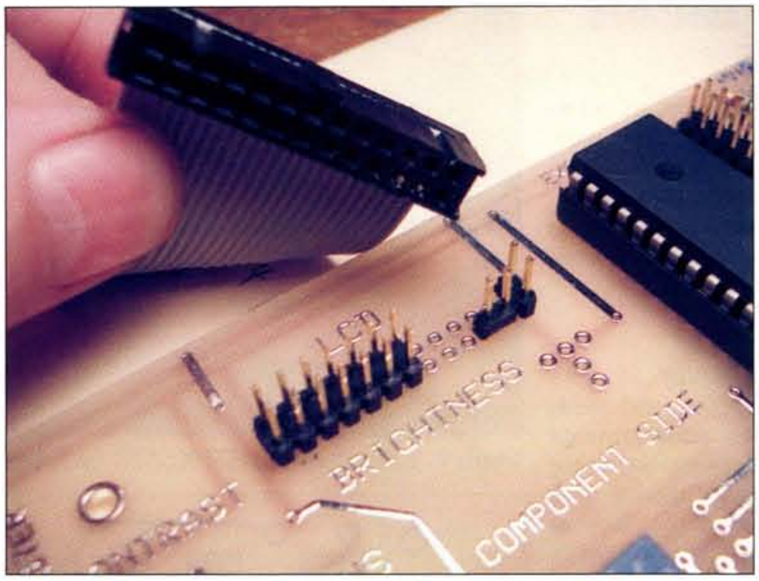


Figure 12 LCD Display Connection

CHECK OUT THE ANIMATION VIDEO OF THE DUSTMEISTER IN ACTION ON THE WEB AT www.nutsvolts.com

Figure 13 DUSTMEISTER Completed Circuit Board

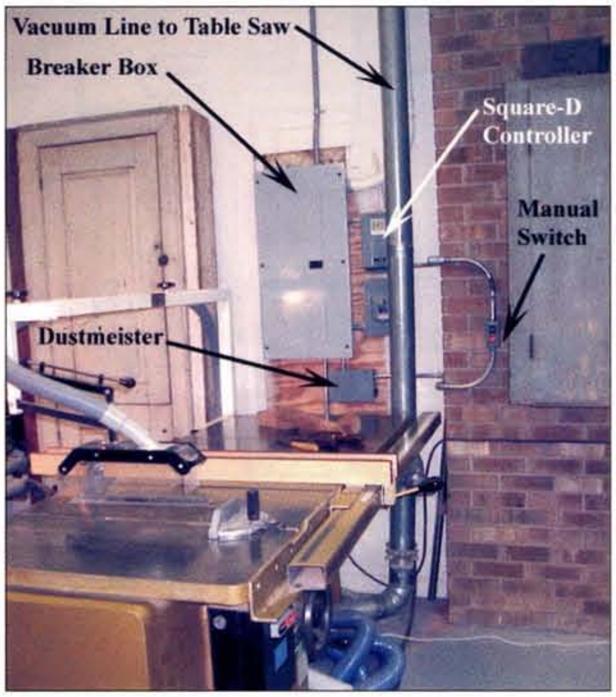


Figure 14 Placement of DUSTMEISTER in Workshop

the secondary becomes so high as to be dangerous and the flux becomes so large in magnitude that the transformer may overheat.

With this caution in mind, each current transformer is connected to a 270-ohm resistor and bridge rectifier. The DC output is filtered by a 1mF capacitor and limited to a maximum of 5.1 volts by the Zener diode. The Zener diode is important because otherwise the voltage across the capacitor can easily exceed the microprocessor analog-to-digital (A/D) input limits. There is also a 20k ohm potentiometer for each sensor to control the voltage to the A/D converter. The voltage is applied to one of the A/D converter pins on the microprocessor. Up to two sensor circuits can be used.

There are several other controls. A 100k ohm potentiometer acts as a sensitivity control to set the current which will turn on the dust collector. A 100 ohm and a 20k ohm potentiometer act as the brightness and contrast controls for the LCD display.

Microprocessor pins 33-36 are inputs for the number of seconds of delay. Microprocessor pins 19-22, 27-30, 8, and 39-40 are outputs used to drive the Liquid Crystal Display (LCD).

The LCD displays English messages to the woodworker to inform him of the state of the system.

Microprocessor pins 37 and 38 are outputs used to control the two relays. The ON relay closes the normally open switch and supplies voltage to the SQUARE-D automatic motor controller as if the manual ON switch had been pressed. The OFF relay opens the normally closed circuit as if the manual OFF switch had been pressed. The output of the microprocessor is too feeble to control a 12-volt relay.

The output of the microprocessor is used to control the 6N139 optical isolator. The output of the optical isolator is used to control a 40-watt transistor. The transistor supplies more than adequate current at 12 volts to energize the relay coil. Components TR1, B3, C3, and F1 in the circuit diagram make up a 12-volt DC power supply. IC2 is a 7805 voltage regulator that supplies +5 volts to the microprocessor.

Table 1 PIC 16F877 and LCD DUSTMEISTER Data Connections

REGISTER/ BIT	INPUT OR OUTPUT	DESCRIPTION	PIC16F877 PIN	CONNECTOR
RA0	I	Current Sensor #1 (analog)	2	NC
RA1	I	Current Sensor #2 (analog)	3	NC
RA2	I	Minimum Turn-on Setting (analog)	4	NC
RA3	I	UNUSED	5	E9
RA4	O	Open drain don't use		
RA5	I	UNUSED	7	E11
RD0	O	Output to LCD	19	L19
RD1	O	Output to LCD	20	L20
RD2	O	Output to LCD	21	L17
RD3	O	Output to LCD	22	L18
RD4	O	Output to LCD	27	L15
RD5	O	Output to LCD	28	L16
RD6	O	Output to LCD	29	L13
RD7	I/O	Input/Output to LCD (LCD BUSY BIT)	30	L14
RB0	I	BCD SWITCH BIT 0	33	NC
RB1	I	BCD SWITCH BIT 1	34	NC
RB2	I	BCD SWITCH BIT 2	35	NC
RB3	I	BCD SWITCH BIT 3	36	NC
RB4	O	ON Relay	37	NC
RB5	O	OFF Relay	38	NC
RB6	O	LCD ENABLE PULSE	39	L22
RB7	O	LCD MODE: 0=COMMAND, 1=DATA	40	L24
		CLOCK	9,10	
GND			12,31	L25,E14
+5V			1,11,32	L26,L1,E1
+12				E13
		LCD CONTRAST		L23
		LCD BACKLIGHT		L2
RC0	O	UNUSED	15	E2
RC1	O	UNUSED	16	E4
RC2	O	UNUSED	17	E6
RC3	O	UNUSED	18	E8
RC4	O	UNUSED	23	E10
RC5	O	UNUSED	24	E7
RC6	O	UNUSED	25	E5
RC7	O	UNUSED	26	E3
RE0	O	LCD READ/WRITE 0=WRITE, 1=READ	8	L21
RE1	I	MANUAL SWITCH	9	NC
RE2	O	UNUSED	10	E12

BUILDING THE DUSTMEISTER HARDWARE

Initially, I built the vacuum controller circuit on a breadboard, as shown in Figure 7. After I completed the initial design and testing of the hardware and software, I designed and built a printed circuit board. Figure 8 shows the pattern for the component and foil pattern for the circuit board as viewed from the top. The correct size for the circuit board is 3.9" x 5.9".

Figure 9 shows the foil pattern for the bottom side of the circuit board. Table 1 is a wiring list for the microprocessor and the external connectors. You can build your own vacuum controller using the foil pattern and the parts shown in Table 2 for about $100.00. If you don't want to program your

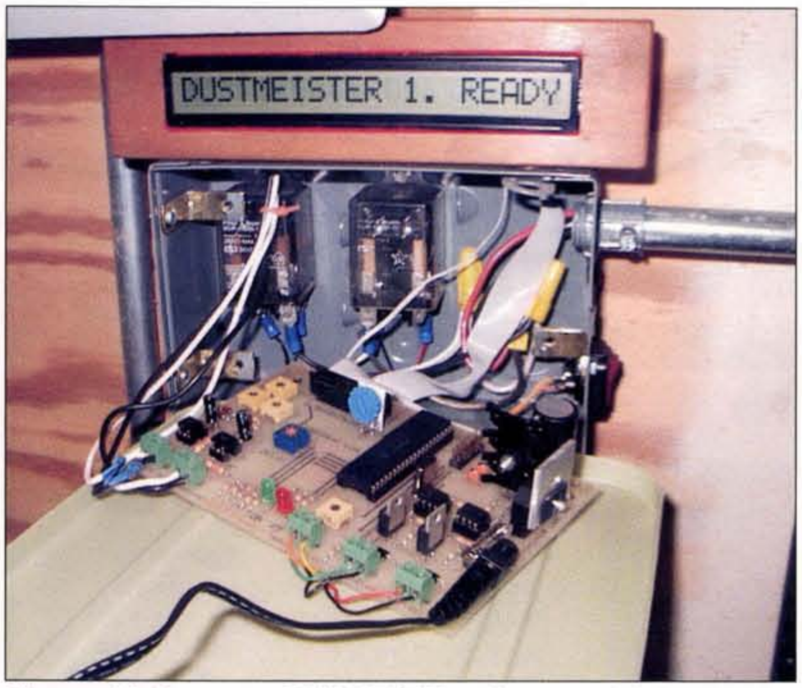


Figure 16 Connecting DUSTMEISTER to Sensors and Relays

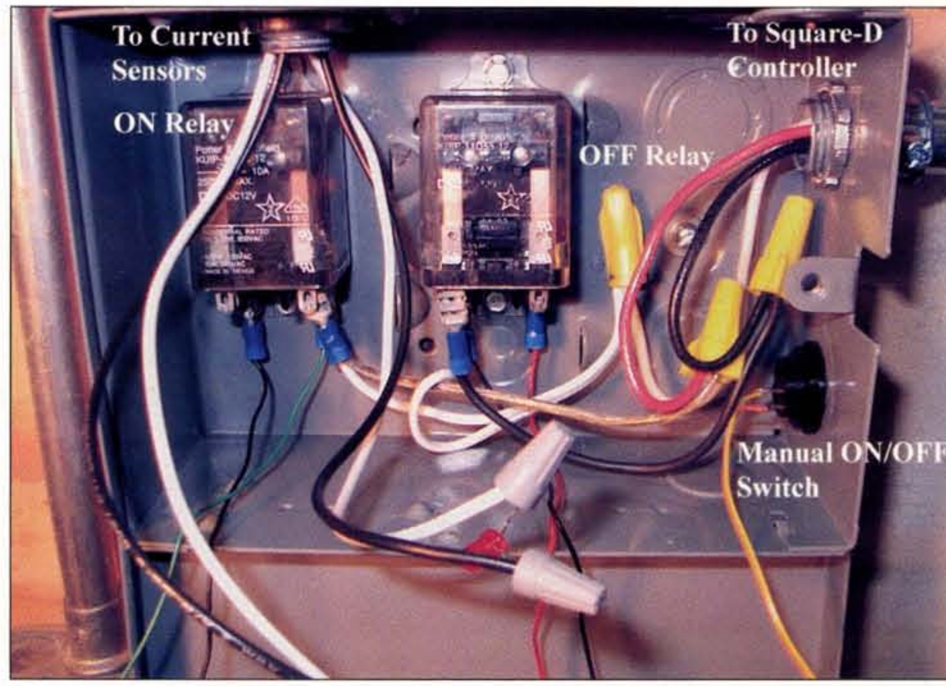


Figure 15 DUSTMEISTER Control Box with Relays

Qty	Value	Device	Parts	Vendor and Part #
1		20 Character LCD Display	LCD1	Source 5 8087-OP
2	1 Amp	100 Piv Bridge Rectifiers		Source 4 11DB01
1		26 Pin Connector	CON2	Source 6 53495
1		+12 Switching Power Supply	PS1	Source 5 12815PS
2	1N4004	Diode	D3, D5	Source 4 111N4004
2	1 mF	Electrolytic Capacitor	C1,C2	Source 4 14ER0501U
2	5.1 V	Zener Diode	ZD1,ZD2	Source 4 1114N4733
2	6N139	Optical Isolator	OK1, OK2	Source 6 42489
4	10k ohm	1/4 Watt Resistor	R4, R7, R14, R13	Source 4 13005100K
1	16F877	Preprogrammed Microchip Microprocessor		IC1 Source 2
1		40 Pin IC socket	For IC1	Source 4 191CM40
3	20k ohm	Potentiometer	R5,R8,R10	Source 4 18CSP20KH
1	100 ohm	Potentiometer	R9	Source 4 18CSP100H
1	100k ohm	Potentiometer	R25	Source 4 18CSP100KH
2	270 ohm	1/2 Watt Resistor	R3,R6	Source 4 13.55270
12	560 ohm, 1/4 watt	Resistors	R1, R2, R11, R12, R15,R16, R17, R18, R19, R20, R21, R22, R23, R24	Source 4 13005560
1	7805	+5V Voltage Regulator, TO-220	IC2	Source 4 107805T
1		0-9 BCD Compliment Out Switch	S2	Source 5 5323SW
1	20MHz	Crystal	Q1	Source 3
2	20pF	Capacitor	C4,C5	Source 3
2		Green LED	D1, D4	Source 4 08I53GD
1		Red LED	D2	Source 4 08I53RD
5		Two Position Screw Terminal Strip	ST1, ST2, ST3, ST4, ST5	Source 5 7398TS
2	TIP31C	3 Amp NPN Transistor ,TO-220	T1, T2	Source 4 11TIP31
2		12V DPDT Relay	K1,K2	Source 5 8787RL
2	Model 18	Remote Current Indicator		Source 1
1		Test Switch		Source 4 1700LKR
1		3.9" x 5.9" Circuit Board		Blank board from Source 4, 03PSPb1 or pre-etched and drilled circuit board from Source 2
1	4 Amp	Bridge Rectifier	B3	Source 4 11RS402
1	500 mF	Electrolytic Capacitor	C3	Source 4 19ER035500U
1		110V/9V, 1.5 Amp Transformer	TR1	Source 6 112336
1	1 Amp	5mmx20mm Fuse and Fuse Holder	F1	Source 6 102859, 103907

Table 2 DUSTMEISTER Parts List

Figure 17 Completed/ Installed DUSTMEISTER (Access door open)

own microprocessor or etch your own circuit board, a pre-programmed PIC16F877 microprocessor chip and a double-sided etched/drilled printed circuit board are available from Source 2. To build the DUSTMEISTER, gather the parts and purchase or etch a printed circuit board.

Figure 10 shows most of the parts and the etched circuit board necessary to build the DUSTMEISTER. If you have etched your own single-sided circuit board, begin by examining the circuit board for any copper bridges or open circuits. Place jumpers on the top of the board as shown in Figure 8. If you purchased a board, the jumpers are etched on the top side of the board.

To assemble the board, begin by soldering the IC sockets, resistors, and the five screw terminals to the circuit board. Verify the orientation of all IC sockets before soldering. Be careful when soldering the socket for IC1. The IC1 socket and the LCD and expansion connectors have copper traces running between pins that are spaced 0.1" apart and can easily be shorted by sloppy soldering. The holes on the circuit board from Source 2 are plated through and require only the smallest amount of solder.

Next, proceed with adding all diodes, LEDs, crystal, capacitors, LCD, and expansion connectors as shown in Figure 11. Add the transistors, potentiometers, and power components to the board. Next, add the BCD switch, S2, being careful to orient it as shown in Figure 8. Complete the assembly by connecting the transformer and plugging the LCD to the LCD connector. Note the orientation of the LCD connector in Figure 12. You may want to add indexing pins at unused pin locations 4 and 6 to avoid incorrectly connecting the plug.

The completed DUSTMEISTER circuit board is shown in Figure 13. The DUSTMEISTER was placed near the workshop electrical service box as shown in Figure 14. I purchased a metal box to protect the relays and TEST switch as shown in Figure 15. I connected the relays, TEST switch, and sensors to the DUSTMEISTER as shown in Figure 16. Figure 17 shows the completed DUSTMEISTER with the LCD readout in a wooden frame. Next time, I will complete the DUSTMEISTER with a discussion of building a tool sensor from scratch, and the programming and testing of the DUSTMEISTER. **NV**

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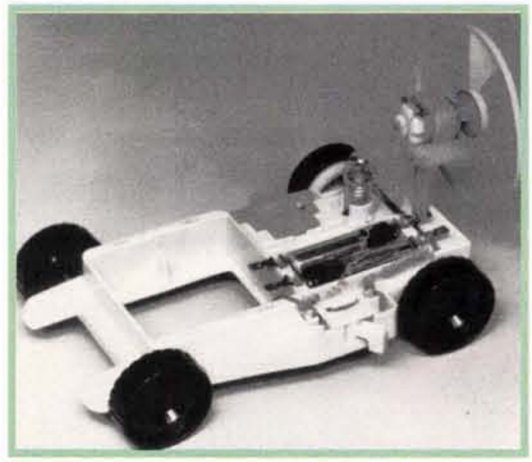

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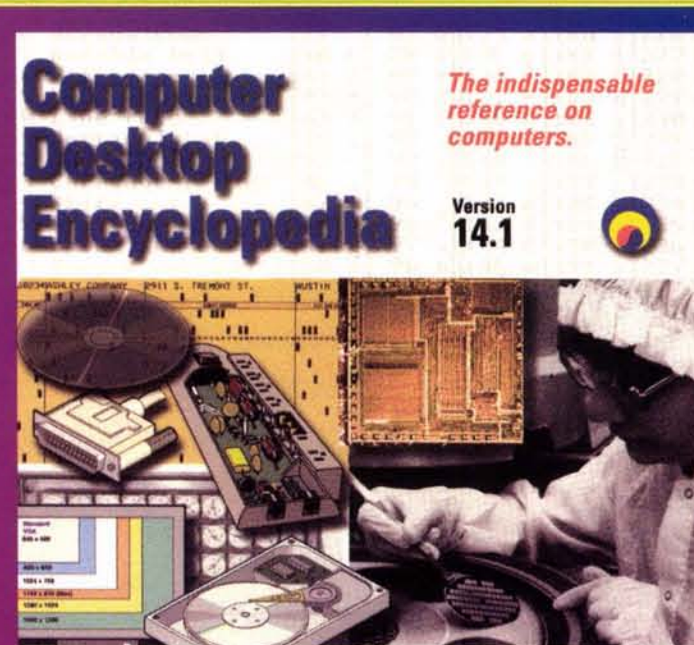

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New Product News

SCOPE + SCOPEALYZER™ = LOGIC ANALYZER

Did you ever wish you could use your existing 20 MHz oscilloscope as a high-performance logic analyzer? Now you can with the highly affordable Barrett Instruments ScopeAlyzer™.

Just attach one vertical channel and the external trigger to the ScopeAlyzer and you now have a professional-grade logic analyzer with these specs: 16 channels, 100 MHz sample rate (1-2-5 sequence), 128K memory, trigger (0,1,x, edges), and tracepoint.

The ScopeAlyzer emphasizes ease of use since one of the most frustrating aspects of logic analyzers is that they are difficult to use and set up.

Want to take a snapshot of data? With the ScopeAlyzer, you only need to press one key.

The ScopeAlyzer is small — measuring only 3" x 5" - and fits conveniently in the toolkit and on the bench. When you need it add it to the oscilloscope without disturbing the rest of your workbench.

The ScopeAlyzer is offered in two models: Model 61050, eight channels, 50 MHz $395.00; Model 61100, eight channels, 100 MHz $595.00.

For more information, contact:

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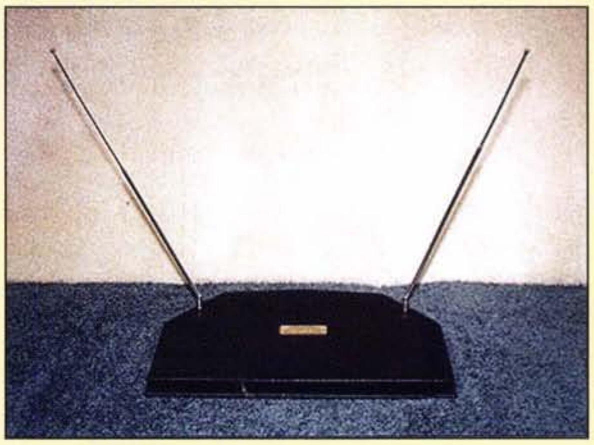
SUPER ANTENNA MODEL 1



Godar Electronics introduces Super Antenna Model 1 for high definition television. This is the world's first compact rabbit ear incorporating rods with a 14 element yagi antenna. This combination gives stable digital HDTV, and standard VHF/UHF reception.

Model 1 is a passive non-amplified broadband antenna requiring no electronic amplifier. In addition, there are no controls or switches. This will add to the product's longevity.

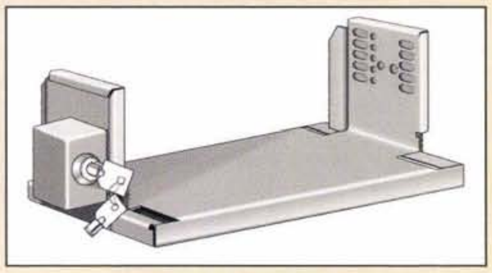
Model 1's sleek flat design affords a better looking antenna over other indoor TV antennas. The base is made of indestructible ABS plastic. A six-foot detachable coax cable is included.

Price is $59.95, made in the USA.

For more information, contact:

GODAR ELECTRONICS
339 N. GILBERT RD., DEPT. NV
GILBERT, AZ 85234
480-892-8207

MOBILE RADIO PROTECTION AGAINST THEFT AND TAMPERING



Availability of the ET-850 Locking Slide Mount for amateur and commercial two-way mobile radios is announced by Hugh Goulding, President of E TIP, Inc.

Designed to help prevent theft and tampering, the ET-850 provides a standardized radio-mounting platform for vehicles and other equipment applications while allowing the operator to remove the radio easily and quickly. The attractive and durable black powder-coat finish makes the ET-850 at home in the work vehicle or the luxury automobile.

Because the radio is mounted to the slide for easy removal and the base stays in the vehicle, blind fumbling with tools to release hidden fasteners is eliminated. Technicians save labor wherever the ET-850 is installed. Transfer of radios between vehicles becomes easy and straightforward.

The ET-850 locking slide mount with an independent tubular key system provides a higher level of security that helps control unauthorized removal and transfers, tampering, and thefts of opportunity.

Many fleet organizations such as fire, law enforcement, utilities, schools, marine operations, trucking, contractors, service, and commercial organizations, etc., encounter expensive and disruptive loss of communications because of crimes aimed at the two-way radio. Fleet communications are an important infrastructure component that is vital to providing superior service. Protecting mobile two-way radios with the ET-850 locking slide mount lessens the potential for disruption of a fleet communications network. Increased awareness of the importance of fleet communications and the vulnerability of radios is especially important now.

The ET-850 locking slide mount fits most of the available mobile two-way radios on the market today including but not limited to: Kenwood, Motorola, Johnson, Uniden, Vertex, Ericcson, M/A Com.

Ask about the new double-stack locking slide mount that secures two mobile radios and the high-security radio cage.

For more information, contact:

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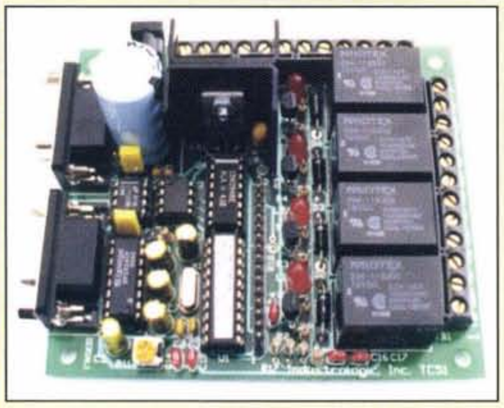

TC51 SINGLE BOARD COMPUTER

Industrologic, Inc., announces the release of their TC51 Single Board Computer.

The Industrologic TC51 is a microcontroller-based single board computer designed to be a complete industrial controller assembly that is easy to program and connect to external signals. It includes a versatile complement of input and output circuitry needed by many common control applications.

The board can be programmed as a stand-alone controller using its on-board Tiny Machine Basic programming language, or it can be used as an RS-232 serial data acquisition board.

The TC51 is based on the Atmel AT89C4051 microcontroller chip with EEPROM program memory, and can be reprogrammed using any number of software development tools and device programmers available for Atmel microcontrollers.

Communication with the TC51 is accomplished via two serial RS-232 ports with true RS-232 drivers and DB9 connectors matching PC compatible serial port pinouts.

Convenient screw terminal block connections are used for all of the digital, analog, and relay connections, which include four 10 amp Form "C" relays, four logic levels signals usable as inputs or outputs, and two 12-bit analog-to-digital inputs.

Its on-board power supply has a wide input range and includes +5 and +12 volt outputs for use by external devices.

The TC51 package is shipped complete with all items necessary to immediately begin application development, including a serial port cable for connection to a PC compatible computer, a wall block power supply, host computer software, and programming examples, and hardware and software reference manuals.

For more information, contact:

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Selected Titles For The Electronic Hobbyist and Technician —

The *NV* Hobbyist Bookstore

Robotics

The Robot Builder's Bonanza
by Gordon McComb

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

Microcontrollers

Handbook Of Microcontrollers
by Myke Predko

This reference is the first guide to cover all the most common types of microcontrollers. With its from-the-bottom-up approach, this book/CD-ROM package gives you all the information you need to simplify the job of selecting the right microcontroller and writing an application for it. ***$54.95***

Programming & Customizing the 8051 Microcontroller
by Myke Predko

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

Programming & Customizing the 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***

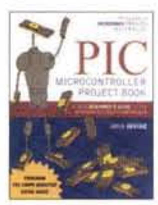
Programming & Customizing PICmicro Microcontrollers
2nd Edition
by Myke Predko

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***

Programming & Customizing the BASIC Stamp Microcontroller
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



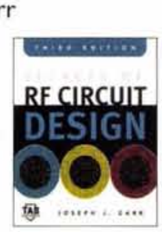
This project-oriented guide gives you 12 complete projects, including: using transistors to control DC and AC motors, DTMF phone number logger and distinct ring detector and router ... home automation using X-10 communications ... digital oscilloscope ... simulations of fuzzy logic and neural networks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

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

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

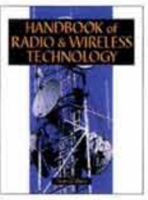


This revised and updated guide gives you the best ways to design, build, and test today's radio frequency circuits. It's filled with projects and experiments that make it easy to apply RF principles to real-life applications. ***$39.95***

Practical Antenna Handbook
4th Edition
by Joe Carr

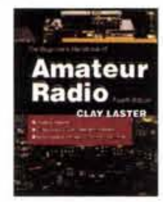
The most popular book on antennas ever written. This edition blends "the theoretical concepts that engineers and others need to design practical antennas, and the hard-learned practical lessons derived from actually building and using antennas." ***$49.95***

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***

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



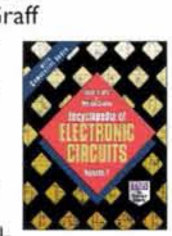
The revised edition of the most trusted guide in ham radio is here. This edition delivers all the guidance you need — from radio and electronics fundamentals needed to set up a transmitter to the newest equipment to revisions to the FCC rules and tests. ***$34.95***

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***

Encyclopedia of Electronic Circuits Vol. 7
by Rudy Graff

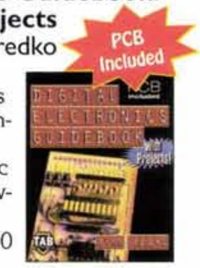


Designed for quick reference and on-the-job use, the *Encyclopedia of Electronic Circuits*, Volume 7, puts over 1,000 state-of-the-art electronic and integrated circuit designs at your fingertips. This collection includes the latest designs from industry giants such as Advanced Micro Devices, Motorola,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

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***

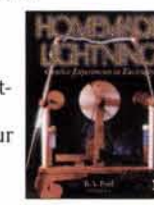
Digital Electronics Guidebook: With Projects
by Myke Predko



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***

High Voltage

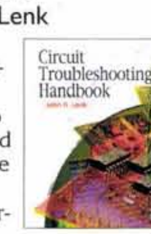
Homemade Lightning: Creative Experiments in Electricity
by R.A. Ford



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***

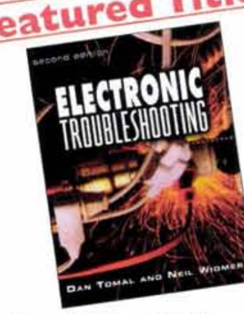
Troubleshooting

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***

This Month's Featured Title



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***

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