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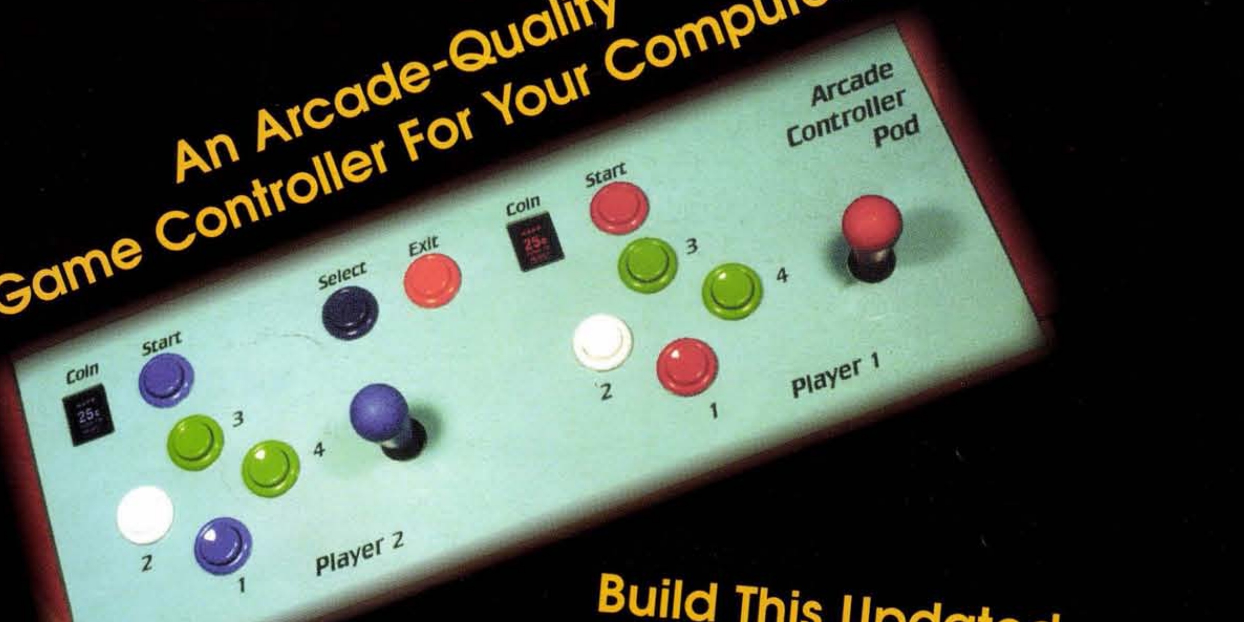
October 2000
Vol. 21 No. 10

Exploring Electronics And Technology For A New Millennium

An Arcade-Quality Game Controller For Your Computer



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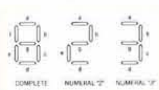

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... articles

by Phil Combs

An Arcade-Quality Game Controller For Your Computer

Photo 1. My arcade controller.

How many hours of your time, and quarters, were spent on video games in the 1980's? Although most of those games are long gone, many people worldwide still want to play them. It's now possible with your PC, Macintosh, Unix, or Linux box, Amiga, and even a certain digital camera! This is done using a software program called an emulator that uses data from the original game ROM (read-only memory) chips.

Playing those old arcade games can be enjoyable, but using a computer keyboard as a controller takes away from the experience. I built my own arcade-quality input device to solve that problem. This is not a step-by-step article on how to exactly duplicate my controller. Like all input devices, a gamer's interface to the machine is a highly personal choice. I will give you enough information to see how mine went together, and will point you to the sources of the components you'll need to construct your own controller.

Background

There are many fine arcade game emulators available on the Internet today, with names like MAME, MESS, Raine, and Impact. I consider MAME — or the Multiple Arcade Machine Emulator — the granddaddy of them all. MAME supports over 2,000 games and has dozens of people worldwide contributing to its ongoing development.

This emulator program was born in 1997, under the hands of Nicola Salmoria. He had written several arcade emulators that played specific games. Nicola decided to combine them using a common emulation engine, with drivers for different types of arcade hardware. As the number of supported games became too large for one person to maintain, other people stepped in to assist.

These programmers, known as the MAME Team, support what is now officially called a 'documentation project.' The project's aim is to preserve the games and assist people who repair and maintain the original arcade game cabinets. A side benefit of these preservation efforts is a freely distributable program that allows game fans to play those classic games again.

What do you need to play the games in your home? I won't go into the details of copyright law here, as this info is clearly spelled out on the many Internet sites supplying ROM images. However, you should own the original arcade hardware, usually just the main processor board, of the games you wish to emulate before downloading their ROM images. Each

Photo 2. The front-panel layout is clean and uncluttered.

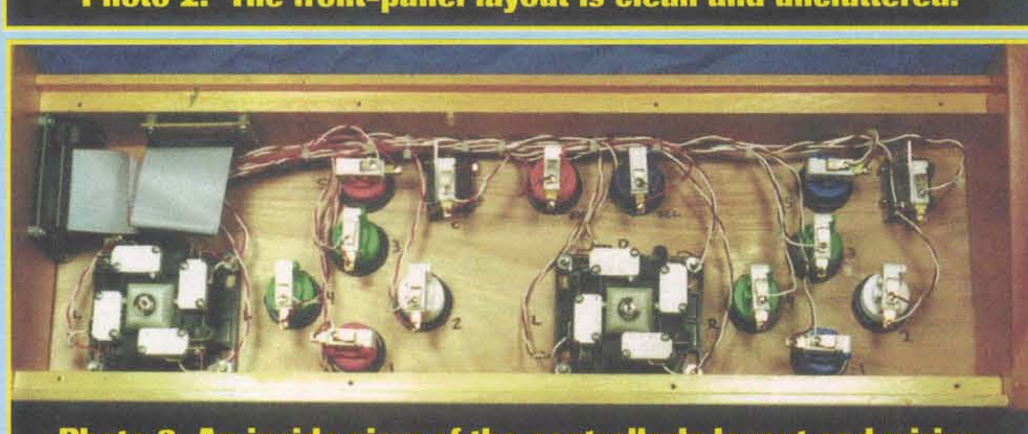


Photo 3. An inside view of the controller's layout and wiring.

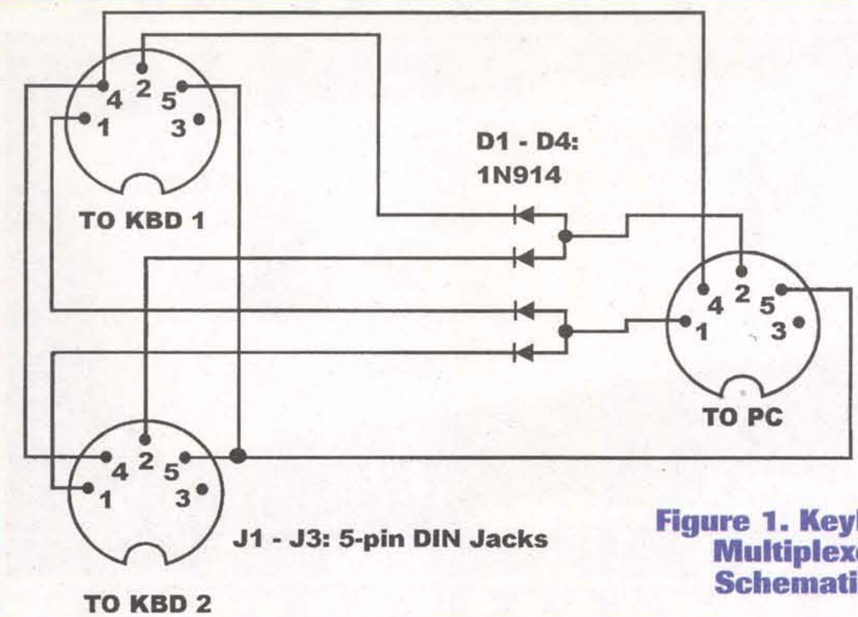


Figure 1. Keyboard Multiplexer Schematic.

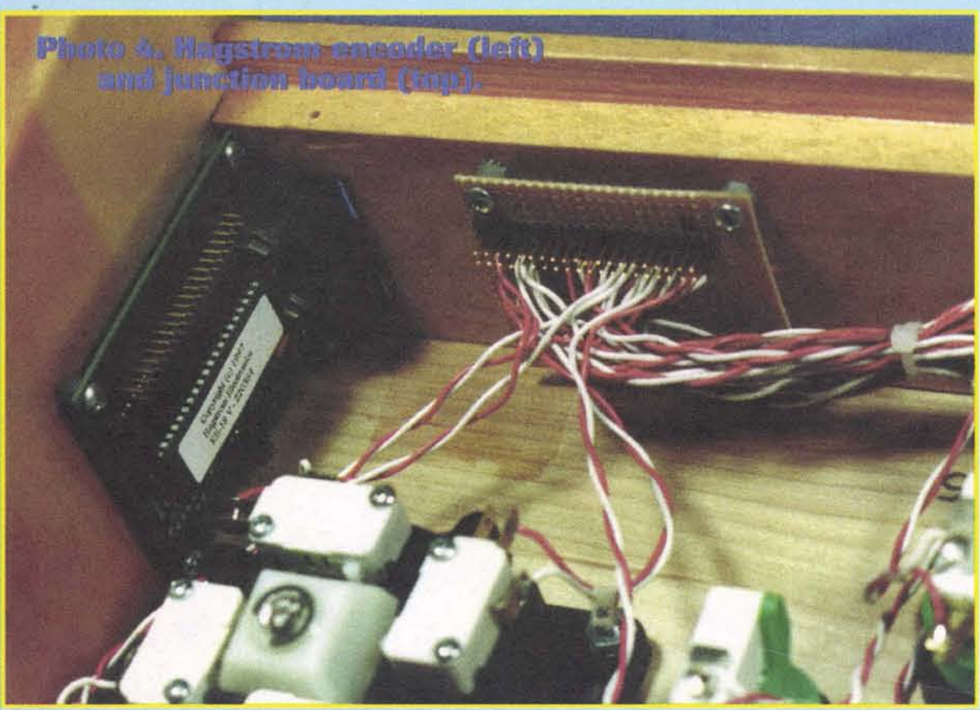


Photo 4. Hagstrom encoder (left) and junction board (top).

emulator's hardware requirements are usually spelled out in the documentation.

For PC users, a Pentium 200MMX with 64 MB of RAM and a fast video card are sufficient for most of the older arcade games. You can use less-capable hardware with DOS-based MAME, which is reputed to play games faster than other versions. Under Windows 95 and 98, you can use MAME DOS by booting the PC into DOS mode, or with a front-end like Arcade @ Home. The Windows version — MAME32 — sacrifices some speed but integrates better with the operating system.

A Simple Controller

Most arcade games are controlled with joysticks, buttons, steering wheels, foot pedals, levers, trackballs, and spinner knobs. Emulators support a limited number of joystick types, but most all of them can use the computer's keyboard. The user customizes the emulator to define keystrokes for certain actions. For example, to go up, you might press the up-arrow key; to fire, you might press the 'F' key. Keyboards are not ideal controllers because of their fragility, but using the keyboard's interface circuitry allows for the creation of a custom controller.

Photos 1 through 3 are pictures of my project. It is built around a Hagstrom Electronics KE18 PC keyboard encoder module. This under-$50.00 part emulates a PC keyboard and receives its power from the host PC. It provides two modes of operation. In one mode, a maximum of 18 different predefined key closures are defined, while matrix mode allows 81 different PC keys to be used.

Table 1 is a list of the keys I used and what functions they control. The KE18 also has a keyboard passthrough, allowing the controller to remain plugged in while you use the keyboard. Hagstrom also makes a version called the KE24, which is completely programmable using your PC's COM port. This makes the controller more usable with emulators that do not allow keyboard remapping, but cost twice as much. The joysticks and switches are genuine arcade-quality units from Happ Controls, a major arcade game parts supplier.

Interfacing the switches and joysticks to the KE18 required a junction board. This simple 2.5" x 2.5" piece of RadioShack solder-ringed hole perfboard duplicates the KE18's 40-pin header connector, and allows simple wire connection and troubleshooting. Photo 4 shows the KE18 and the junction board. The two boards connect with a short length of 40-pin ribbon cable.

Wiring the junction board is straightforward, and begins with the creation of a chart showing the keys you will use with your emulator. You may wish to use my example in Table 1 as-is or create your own. The KE18 supports Control, Shift, and Alt-keypresses like a PC keyboard, but you'll want to use "straight" key assignments for your controller's functions. Next, solder a pair of wires for each key you've defined in the chart across the proper header pins. Label each wire pair with either "Player 1" or "Player 2" and the key name.

Parts List

- **Hagstrom KE18 Interface with keyboard cable**
- **Happ Ultimate Joystick (2)**
- **Happ Push Buttons and Horizontal Switches (14, various colors)**
- **Happ Coin Reject Buttons (2)**
- **Happ/Cherry Microswitches for Coin Reject Buttons (2)**
- **RadioShack #276-158 perfboard (1)**
- **RadioShack #RSU11323813 40-pin header strip (1)**
- **40-conductor IDE PC hard drive cable (1)**
- **Scrap 18-gauge aluminum for Coin Button brackets**
- **6/32 x 1-1/4" screws with nuts (4)**
- **6/32 x 3/4" screws with nuts (4)**
- **22-gauge stranded hookup wire**
- **Suitable case**

Table 1. Key Function Definitions

Player 1 Controls			Player 2 Controls		
Function	Key	Pins	Function	Key	Pins
Start	1	I - K	Start	2	I - L
Coin	3	I - M	Coin	4	H - J
Up	R	B - R	Up	U	C - L
Down	C	A - L	Down	N	B - N
Left	D	A - M	Left	H	A - Q
Right	F	A - O	Right	J	B - J
Button 1	E	A - N	Button 1	Y	C - P
Button 2	T	C - K	Button 2	I	A - R
Button 3	X	C - O	Button 3	B	A - K
Button 4	V	C - M	Button 4	M	B - M

Common To Both Players

Function	Key	Pins
Exit Game	ESCape	C - R
Select	Enter	G - M

Where do I find game ROMs?

ROM download sites can be found all over the Web. Enter any search engine, such as Altavista or Yahoo, and use terms like MAME, emulator, arcade, ROMS, or ROMZ. Add computer-specific names like Amiga and Mac or Macintosh to find emulators for those platforms. Be careful! Some sites may have explicit pornographic banners, and may open multiple instances of your browser that display these sites. It's an unfortunate fact of Internet life that these sites exist, and you're bound to encounter them sooner or later.

Make sure to visit the "Links" section of the sites you visit, as you will find many other resources there that won't appear in the search engines. Bookmark liberally. You'll set up a trail you can retrace later if you find something that catches your eye.

Be prepared to spend a lot of time downloading and updating ROMs. MAME supports over 2,000 different games and, as the program evolves, you may be required to re-download updated ROM sets, as well as new ones. Most classic arcade games are well under one megabyte, while most Neo-Geo games are larger than four megabytes. Some of these games are 30 to 40 megabytes each.

If you don't have an Internet Service Provider (ISP) and can't connect to the Web, stop whining and join the digital age! ISPs typically charge between \$15-\$30 a month for their service, and allow you to have email, as well as access another great resource called newsgroups. These are similar to the computer BBSes of years past. Groups such as alt.binaries.emulators.misc and comp.sys.emulators have ROM files available for downloading. If you can tolerate an on-screen ad banner, services like Free Altavista provide local, FREE dial-up access to the Internet (Web only, no newsgroups). The no-cost software can be found at altavista.com. Find a net-connected friend and have them download this single-floppy program for you.

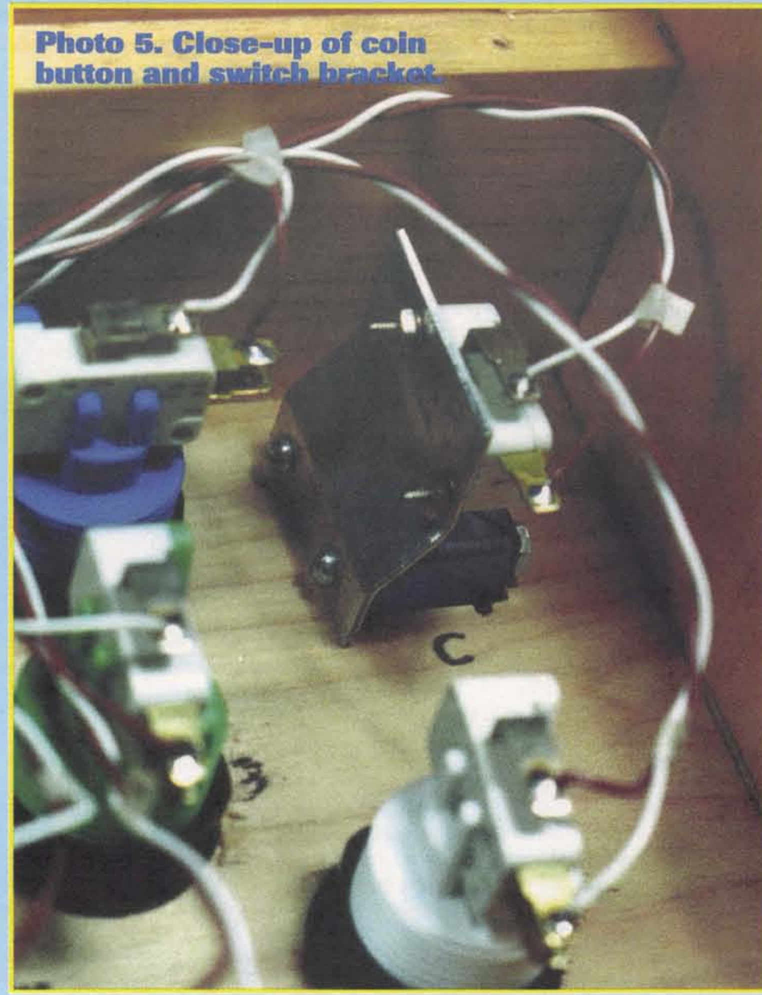


Photo 5. Close-up of coin button and switch bracket.

Be mindful of the joystick's switch orientation when connecting wires, because directions are reversed when operating the joystick. When the stick is pushed up, or away from you, the switch closest to you is actually triggered. When the stick is pushed left, the right-hand switch is pressed. If your joystick does not take you in the proper on-screen direction, double-check your wiring. To help keep my wiring straight, I marked the switch functions on the case's inside. This is visible in Photo 3.

One whimsical detail of my controller is shown in Photos 1 and 2. Rather than use standard push-button switches for the 'Coin' functions, I installed two Happ coin-reject buttons. These buttons do not have switches, as they trigger mechanical coin-reject mechanisms. I fabricated simple switch brackets using sturdy pieces of aluminum, and attached a Cherry microswitch to each bracket. Two holes were drilled completely through each bracket and button, and long screws were then used to fasten the two pieces together. This is shown in Photo 5. The bracket also serves to hold the coin-reject button against the front panel. These buttons are not backlit, as the PC's keyboard port doesn't supply enough current for light bulbs.

The controller cabinet measures 23-1/2" wide by 9" deep. It stands 5-1/4" high in the

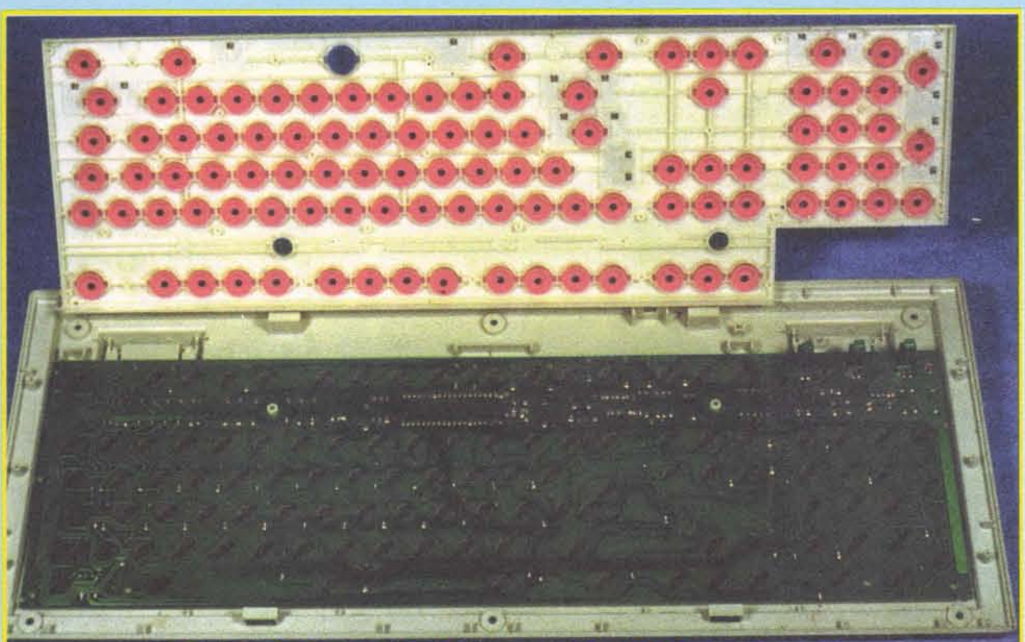


Photo 6. Typical disassembled PC keyboard.

back and slopes to 4-1/4" at the front edge. The slope is accomplished by cutting the bottom edges of the controller's end pieces on an angle, with the short side toward the player. The case was built from ¼" scrap plywood and ½" pine boards, and finished with a honey oak stain/polyurethane. The front panel was sized to allow printing of the front panel legends on two 8.5" by 11" pieces of blue card stock, then taping them together.

The front panel and legends are protected by a sheet of 1/8" Plexiglas, with switch holes cut by a machinist friend using a Bridgeport mill. This is why it pays to have contacts with skilled people who can help you with the more difficult areas of your projects. You might also use dry-transfer lettering with several coats of clear enamel over your work.

Controller Alternatives

If you want to keep costs down, it is possible to gut an existing keyboard and use its controller instead of buying a dedicated controller. PC keyboards can be found at most swap meets for $5.00 or less, or in special sales at your local computer store. Interfacing them to the necessary switches can be accomplished in several ways.

If you disassemble a typical keyboard, you'll see that the key mechanisms are mounted onto a frame that fits over a PC board. Photo 6 shows a disassembled keyboard. This PC board contains many pairs of etched-on contacts, which are shown more clearly in Photo 7. One of the rubber key domes is also shown. When a key is pressed, a conductive pad inside the key dome shorts a pair of contacts on the PC board and makes a key closure.

If you have ample room in your controller case, you can keep the PC board intact and simply solder wires from each switch to each pair of key contacts that you will use. It will be necessary to remove the protective black coating on each set of pads by rubbing them gently with steel wool. After the wires are connected at both ends, you then mount the entire PC board into your controller case. Small-footprint, space saving keyboards work best for this approach.

If you wish to have a neater project, you can use a volt-ohmmeter to trace each key's contacts back to the keyboard encoder IC. Make a list of which pins are shorted when each key is pressed. Then use a bandsaw or jigsaw to carefully separate the keyboard encoder section from the rest of the PC board. Construct a junction board similar to mine, then make an umbilical cord that attaches the junction board to the encoder board.

This approach prevents the simultaneous hookup of a real keyboard; however, adding the simple circuit in Figure 1 should address that shortcoming for PC-based controllers. Gutting a keyboard is the only viable approach for the owners of Amigas and some pre-USB Macintoshes. Other owners of older Macs have another option that I'll discuss in the next section.

My controller works with most arcade games, but some games demand a trackball. For those occasions you can attach a PC trackball to your COM port. By carefully choosing the case style of your trackball, you can mount it directly inside your controller's case. Happ offers a genuine arcade trackball with serial and USB interfaces. While this option is more

Photo 7. Close-up of PC board and key dome.

Companies Referenced

Hagstrom Electronics
Keyboard and USB encoders
2 Green Lantern Blvd.
Endicott, NY 13760
(607) 786-7523
www.hagstromelectronics.com

Wico
Arcade game parts and controllers.
7847 North Caldwell Ave., Building C
Niles, IL 60714-4508
1-800-367-9426 or (847) 583-1320
www.wicothesource.com

Happ Controls
Arcade game parts and controllers
106 Garlisch Drive
Elk Grove, IL 60007
1-888-289-4277 or 1-847-593-6130
www.happcontrols.com

Fultra
This site offers arcade spinners
www.fultra.com/arcade/

MCM Electronics
Arcade game parts and other items to finish your project
650 Congress Park Drive
Centerville, Ohio 45459
1-800-543-4330
www.i-mcm.com

expensive, it will be easier to install in a custom case and will hold up well under hard use.

Some games like Tempest and Asteroids are best played with spinner knobs. Until recently, these were not easily obtained. A new company, Fultra, is making them available at a reasonable cost. These units are available with serial interfaces. If you want a USB version, I recommend buying just the mechanism from Fultra, then gutting a cheap USB mouse for its interface.

For games requiring light guns, you can use a console's game gun (such as a Super Nintendo) by constructing a simple parallel-port interface and installing a special DirectX Windows driver called DirectPad Pro.

Cross-Platform Controller Options

Did you know that you can use a Macintosh keyboard on your PC, and that a Windows-style keyboard can be used on a Macintosh? It's true – if you have a USB port in your computer and a USB keyboard. Using these keyboards to construct your custom controller will allow their use on either platform. There are some caveats.

The PC must have an option in its BIOS to allow "USB Legacy Support" (or other similarly worded phrase). This is necessary because operating systems older than Windows 98 don't recognize that USB keyboards or mice are connected. The USB support in Windows 95 was half-baked and didn't work reliably. Windows 98 is rock-solid in this area and other aspects of its performance. The best thing you can do for your system is to buy a copy of Windows 98 SE, wipe your hard drive, and perform a fresh installation.

You could gut a USB-based keyboard and use its controller. However, a stand-alone USB controller similar to the Hagstrom unit is available from a British web site. The I-PAC (Interface for PC to Arcade Controls) allows switch interfacing to your computer using the PC-AT (five-pin DIN), PS/2, or USB ports on your PC. Newer Mac users would use the USB port. Owners of older Macs may be able to add a USB controller card and software to use this type of controller. Check with a knowledgeable Mac dealer.

Who Says You Can't Live In The Past?

Emulators open up a world of fun previously unattainable on your computer. I can now run games from the arcades on my PC, as well as for popular consoles like the Super Nintendo, Sega Genesis, Atari 2600/5200/7800, Intellivision, Playstation, and even the Nintendo 64! The uses for game emulators are limited only by your imagination and wallet.

Have you always wanted an arcade console for your rec room, but didn't want to be stuck with one game forever? Buy a dead arcade machine, gut it, and install a PC with an arcade controller interface. Better yet, buy one of the "cocktail" cabinets that allow two players to sit face to face and use it as a living room coffee table. Have fun with your project! **NV**

Phil Combs is a Computer Systems Administrator for Wright State University in Dayton, OH.
You can send any comments or questions to him directly at prc1@ix.netcom.com.

Web Emulation Resources (or, Where Do I Begin?)

The Vintage Gaming Network
www.vintagegaming.com
A great source for gaming and computer emulation.

Arcade @ Home
www.arcadeathome.com
This site offers gaming resources and the best Windows-based GUI for DOS MAME called Arcade @ Home.

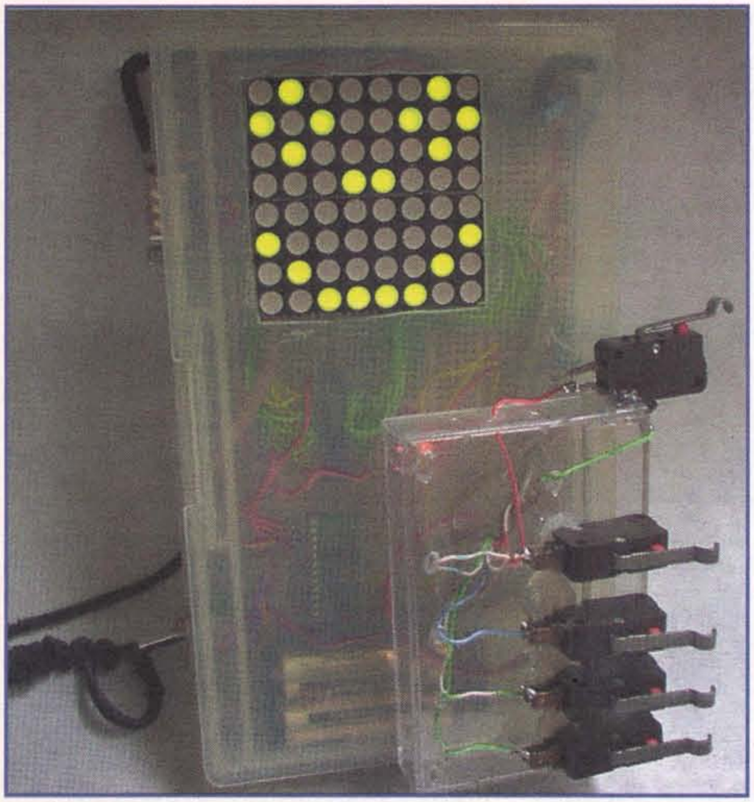
RomCenter
www.emuhq.com/romcenter/
The home of the best ROM management utility I know of. You need this program to maintain your ROM collection.

Build Your Own Arcade Controller FAQ
www.arcadecontrols.speedhost.com/arcade.htm
This site offers lots of info on building your own controller and retrofitting old arcade cabinets.

Andy's Arcade Site
www.spaceinvaders.uk.com
This site features the IPAC interface, as well as instructions for integrating it into your project.

DirectPad Pro
www.ziplabel.com/dpadpro/index.html
You can download the DirectX console controller driver and interface details here. Look around — they may have some other software you never knew you needed!

by Tim Deagan



A front view of the Iconizer.

PROSTHETIC SARCASM WITH EMOTICONS FOR SPEECH

How many times has a smiley face :-) in computer text kept you from taking offense at some statement? These emoticons provide important cues within digital communications. Yet, the same problems crop up in face-to-face communication, as well.

What's a clever microcontroller enthusiast supposed to do, live with it? Not any more.

Enter the Iconizer, a prosthetic for those of us who don't manage to pull off sarcasm, irony, and other non-verbal communications.

The Iconizer uses a BASIC Stamp II (BS2) and MAX7219 to display animated 8x8 icons on an LED grid. A simple chord keyboard allows the wearer an easy one-handed means for sending graphic or text messages to recipients standing nearby or across a nightclub. A serial port accepts system reprogramming and provides project expansion capabilities. In the spirit of simplicity, the whole project can be assembled in two hours. Let's take a look at what makes this gadget work.

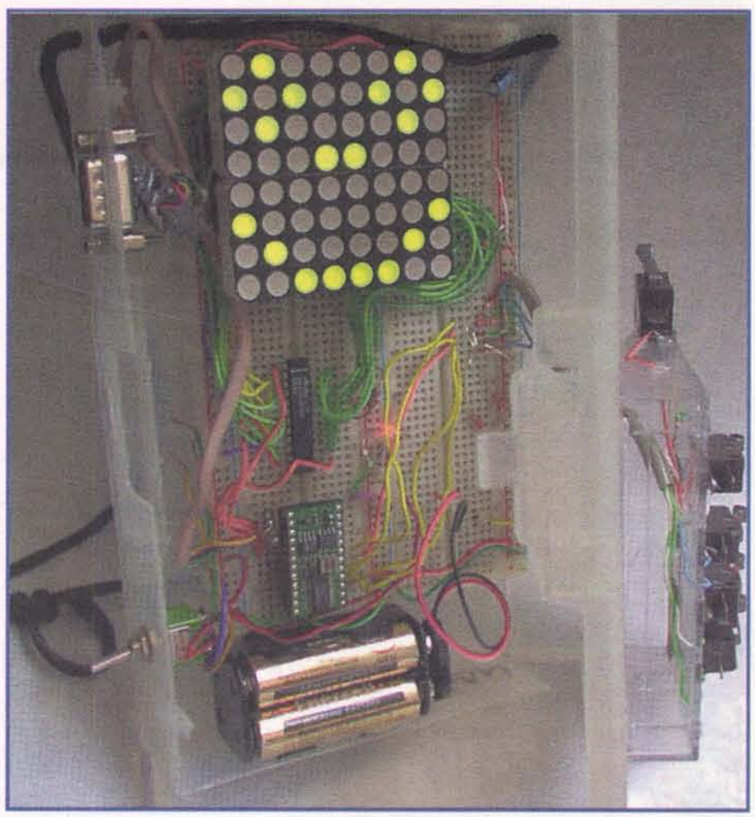
The Hardware

The display is the most obvious part of the project. Two 4x8 LED grid arrays are mounted side by side to provide an 8x8 pixel 'screen.' This may seem a tad overboard in the direction of 'low-res,' but you'll be surprised what can be accomplished in this small an area. Before there were True-Type Fonts, amazing things were being done in the tiny space allotted to characters in DOS. The challenge of expressing yourself with icons in this small mode can be a lot of the fun in this project.

I'm using two LTP-23458AA-NB displays from Lite-On. They measure 8x8 as a pair, providing a large display surface. These displays use bi-color LEDs (Red/Green, together producing Orange.) As the project is currently set up, I'm only using the green LEDs. Together, these displays provide 16 pins — eight cathode and eight anode — as the means to control the 64 LEDs. Other LED matrix displays will work fine, though a single MAX7219 is only capable of driving a total of 64 LEDs.

I have to confess that in many respects, this project is an excuse to work with the MAX7219 chip from Maxim. This chip is a real boon to microcontroller developers. Originally designed to drive eight seven-segment LED displays from a serial input, it has a host of other uses, as well. Since the MAX7219 is designed to handle the decimal point present on most seven-segment LED displays, its full capacity is 8x8 or 64 LEDs. It drives these LEDs without the need for biasing resistors. This makes for easy hookup and simple designs. Special internal functions provide for dimming and selective update.

The data sheet also makes clear how to use this chip with 8x8 grid arrays instead of LED numeric displays. This makes the chip immediately useful for easily controlling 64 outputs with a simple serial connection. These chips can even be cascaded for controlling bigger displays.



A view of the Iconizer internals.

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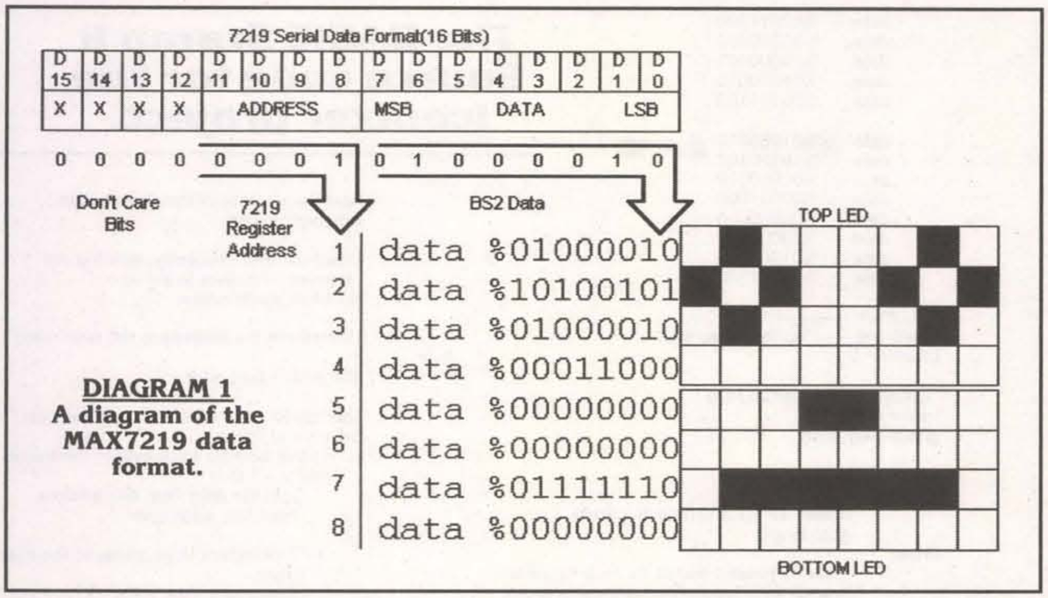


DIAGRAM 1
A diagram of the MAX7219 data format.

PARTS

1 - BASIC Stamp II
1 - MAX7219CNG (Digi-Key MAX7219CNG-ND)
2 - 4x8 LED arrays (See note below)
5 - momentary contact switches
1 - SPST switch (RS# 275-634)
1 - 9-pin D-sub male serial connector (RS# 276-1537)
1 - 4-AA battery holder w/ snap connection (RS# 270-383)
1 - 9V snap connector (RS# 270-324)
2 - 6" modular breadboard sockets (RS# 276-174)
4 - 8-pin wire-wrap SIP sockets
1 - 4-pin wire-wrap SIP socket
1 - 24-pin wire-wrap DIP socket
1 - 1uF capacitor
6 - 2.2K ohm resistors
1 - VHS cassette case
1 - 8mm or VHS-C cassette case
4 - AA batteries
hookup wire
Some kind of light neck strap

Note: As of the printing of this article, 4x8 LED matrix arrays have become very difficult to find. Digi-Key carries a 5x8 matrix array from Lite-On (MFG Part# LTP-2158AHR, Digi-Key Part# 160-1014-ND). With a little care in the hookup, this is a workable replacement for the 4x8 matrix. You could even drive the extra LEDs directly from the BASIC Stamp II for extra fun!

Tim Deagan KC5QFG is an Information Ecologist and Python Advocate in Austin, TX. He loves to take things apart. He can be reached via email at tdeagan@fc.net.

The BS2 from Parallax is a great workhorse of a project micro-controller. As many new alternatives as I try, I keep coming back to the BS2. It's powerful, easy, and fun. Programmed in a surprisingly powerful BASIC variant, all the commands and memory space I need are a breeze to use. Using the BS2's serial port to connect to the PC for programming is a snap. There is a sizable amount of free code on the Internet for the BS2 and an avid developer community. All in all, I find that using the BS2 is a fast and enjoyable way to prototype projects. I often intend to later redo the project on a different architecture and never find a need (other than cost.)

Input to the system is through one of my favorite peripherals, the chord keyboard. Five momentary contact switches are arranged for thumb and fingers. Using the thumb switch as 'ON' and using all four fingers up (0000) as 'BLANK,' 15 icons are possible as combinations of the finger switches. Simply press the desired arrangement of finger switches and then hit the thumb switch to display the chosen icon. Simple pull-up resistors assure clean operation with the BS2. I mounted the five switches onto a plastic 8mm cassette case using hot melt glue.

This project uses a breadboard for circuit assembly. Two modular sections are joined together, providing an ample working area. These two sections fit nicely into a VHS cassette tape case, leaving room at the bottom for batteries. Choose a VHS case that either has no bumps for positioning the spools of the cassette itself, or use a hobby knife to trim them off.

Additional cuts can easily be made in the case to provide mounting for the power switch, serial port, and chord keyboard wires. Small holes can easily be made by heating a piece of coathanger or other wire and plunging it through the case; be careful to do this in a well ventilated environment.

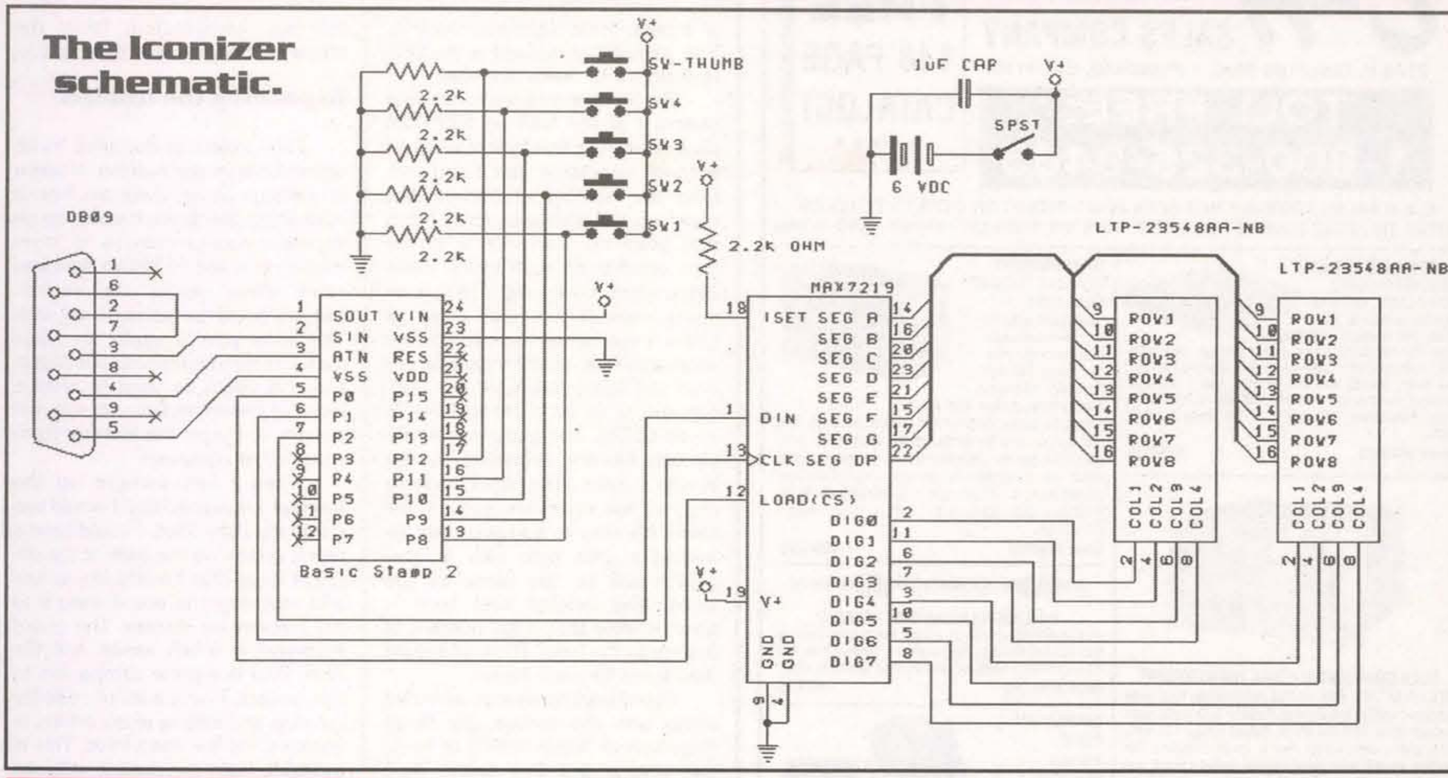
The power supply is a set of four AA batteries providing 6VDC. This is within the operating parameters of the MAX7219 and the BASIC Stamp's unregulated input voltage, so the project manages to work without any additional voltage regulation. A simple 1uF decoupling capacitor between the positive and negative rails of the power bus helps keep the noise low on the power supply bus. Increased noise suppression could be gained by adding a .1uF cap across power and ground, as well.

It's easy to assemble this project on the breadboard before putting it into the case. There is plenty of spare room even with the space requirements of the LEDs. It's really worth the time and effort to solder a couple of simple reusable parts. The SPST power switch and the nine-pin serial port are incredibly useful if you solder some wires to them in advance. Almost any solid core wire will do (as long as it will fit into the breadboard holes when stripped.)

I like to use six-conductor telephone wire; you can either remove

The BASIC Stamp II Source code for the Iconizer project.

```
' Time between each frame of the icon
frm_pause     con     75

' Time icon should wait after last frame
icon_pause    con     1000

' 7219 setup register values
decode_reg    con     $0900
intensity     con     $0a0a
scan_limit    con     $0b07
shutdown_on   con     $0c01
shutdown_off  con     $0c00
test_off      con     $0f00
test_on       con     $0f01

' Pin alias's
load          con     0
clk           con     1
dout          con     2

' Application variables
frm_addr      var     word
x             var     byte
x_val         var     byte
y             var     byte
frames        var     byte
frm           var     word
icon          var     word
btnwrk        var     byte

'—— SETUP FRAMES ——
blank  data   1

       data   %00000000
       data   %00000000
       data   %00000000
       data   %00000000
       data   %00000000
       data   %00000000
       data   %00000000
       data   %00000000

smile  data   7

       data   %01000010
       data   %10100101
       data   %01000010
       data   %00011000
       data   %00000000
       data   %00000000
       data   %01111110
       data   %00000000

       data   %01000010
       data   %10100101
       data   %01000010
       data   %00011000
       data   %00000000
       data   %00000000
       data   %01111110
       data   %00000000

       data   %01000010
       data   %10100101
       data   %01000010
       data   %00011000
       data   %00000000
       data   %01000010
       data   %00111100
       data   %00000000

       data   %01000010
       data   %10100101
       data   %01000010
       data   %00011000
       data   %00000000
       data   %10000001
       data   %01000010
       data   %00111100

       data   %01000000
       data   %10100111
       data   %01000000
       data   %00011000
       data   %00000000
       data   %10000001
       data   %01000010
       data   %00111100

       data   %01000000
       data   %10100111
       data   %01000000
       data   %00011000
       data   %00000000
       data   %10000001
       data   %01000010
       data   %00111100

       data   %01000010
       data   %10100101
       data   %01000010
       data   %00011000
       data   %00000000
       data   %10000001
       data   %01000010
       data   %00111100

'— Main ———
gosub init        'do the setup stuff
btnwrk = 0

' Launch initial startup icon
icon = smile
gosub play_icon

' Main loop
looper:
        button 12,1,1,250,btnwrk,1,Press
        goto looper
Press:
        ' this command should be on a single line
        branch INC, [oooo,xooo,oxoo,xxoo,ooxo,
        xoxo,oxxo,xxxo,ooox,xoox,oxox, xxox,ooxx,
        xoxx,oxxx,xxxx]

' easy map of button presses to icon displayed
' o - switch open
' x - switch closed
' replace the word "blank" with the name of the icon
' that you want displayed for that button combination
oooo:
        icon = blank
        goto play_icon
xooo:
        icon = smile
        goto play_icon
oxoo:
        icon = blank
        goto play_icon
xxoo:
        icon = blank
        goto play_icon
ooxo:
        icon = blank
        goto play_icon
xoxo:
        icon = blank
        goto play_icon
oxxo:
        icon = blank
        goto play_icon
xxxo:
        icon = blank
        goto play_icon
ooox:
        icon = blank
        goto play_icon
xoox:
        icon = blank
        goto play_icon
oxox:
        icon = blank
        goto play_icon
xxox:
        icon = blank
        goto play_icon
ooxx:
        icon = blank
        goto play_icon
xoxx:
        icon = blank
        goto play_icon
oxxx:
        icon = blank
        goto play_icon
xxxx:
        icon = blank
        goto play_icon

end

'— play icon ———
play_icon:

        ' get the address of the chosen icon
        frm_addr = icon

        ' read the first icon entry, which is the
        ' number of frames in the icon
        read frm_addr,frames

        ' increment the address to the first frame
byte
        frm_addr = frm_addr + 1

        ' do this loop for each frame of the icon
        for x = 1 to frames
          ' do this loop for each byte in the frame
            for y = 1 to 8
              ' get the data from this address
              read frm_addr,x_val

              ' increment the address to the next
             ' byte
              frm_addr = frm_addr + 1

              ' get the 7219 call setup with the
              ' address (y * 256) and the data
(x_val)
              frm = y*256+x_val
              gosub load_reg    ' go load the
7219
            next
            pause frm_pause       ' pause after
                                  ' frame
        next
        pause icon_pause          ' pause after
                                  ' icon

        ' return to the main loop
        goto looper

'— Load 7219 register ———
load_reg:

        low load
        ' push out the 7219 data a bit at a time,
        ' msb first
        shiftout dout,clk,1,[frm\16]
        high load

return

'——— Initialize  BS2 & 7219 ———
Init:
        ' setup input/output pins
        DIRS = %0000000000000111
        x_val = 0

        ' pass the 7219 all it's setup values
        for x = 1 to 8
              frm = x*256
              gosub load_reg
        next

        frm = decode_reg          ' set to bits not
                                  ' characters
        gosub load_reg

        frm = intensity           ' set the
                                  ' brightness
        gosub load_reg

        frm = scan_limit          ' set number of
                                  ' data registers
        gosub load_reg

        frm = test_off            ' set display test
                                  ' to off
        gosub load_reg

        frm = shutdown_on         ' set to all LEDs
                                  ' off
        gosub load_reg

return
```



The Iconizer schematic.

RESOURCES

7219 Data sheet location:
http://209.1.238.250/arpdf/1339.pdf

BASIC Stamp 2 manual and info location:
http://www.parallaxinc.com

A great BASIC Stamp II info site:
http://www.phanderson.com/stamp/

Project source code location:
http://www.fc.net/~tdeagan/inconizer

the wires from the sheath or you can leave them bundled within it. I also find that the BS2 will survive many breadboard projects if you stick it in a 24-pin wire-wrap socket. I mounted the LED arrays on wire-wrap SIP sockets so that I could route wires underneath them. This also assures that the displays will stand up at the level of the case cover.

I really like my projects to look like technology from a Mad Max movie. I don't go out of my way to trim the breadboard leads or route them extra carefully. I'm not shy about stringy hot melt glue or pieces of duct tape. Since the tolerances on this project are pretty loose, it's a matter of preference. On many projects, the assembly style can make the difference between working and failing, so use judgment on how sloppy you can afford to be.

The Software

This project is so simple because of the built-in functionality of the MAX7219. As with any new chip you want to explore, don't hesitate about getting the data sheet (see resource sidebar.) A simple three-wire interface makes it easy to communicate with the BS2. First the Chip Select (pin 12) is pulled low, and then each rising edge of the Clock (pin 13) reads in a bit on Data In (pin 1.) Data is sent to the MAX7219 in 16-bit blocks which include a register address and a value (see Diagram 1.)

The software sends a few setup values to the chip, then sends it address/data words (two bytes) to define which LEDs to light. These values are sent to the 7219 one bit

:) ;) :(:) ;) :(:) ;) :(

at a time, most significant bit first. The 'shiftout' command of the BS2 is designed to make this easy.

The icons are stored in the data memory of the BS2 as EEPROM data bytes. The first byte stored has a name associated with it and contains the number of frames that make up the animated icon. From that point on, each frame in the icon consists of eight bytes. Eight bytes, each having eight bits, is an exact map of our 8x8 array of LEDs. I use binary notation in the source code so that it's easy to see what the frame will look like (picture the 1s as on LEDs and the 0s as off LEDs). The code in this article only has one animated icon for brevity's sake. The downloadable copy of the code has quite a few more. It's easy to add your own by adding a data byte with a label (which will be the name of the icon). The labeled data byte is given a value that is the number of frames in the icon. Then add eight data bytes for each frame.

Chord keyboards were invented along with the mouse (by Doug Engelbart at Xerox PARC) to facilitate one-handed text entry. We'll use our chord keyboard to input which icon to display. The BS2 'button' command will test to see if the thumb key is pressed. If it is, then we test the value of the third nibble (four bits) of the input pins, referred to as 'INC' by the BS2. The value of these four pins redirects us to one of 16 locations. I have given the labels associated with these locations names made up to represent the key combination from the chord keyboard (oxoo, oxxo, etc.).

Expanding the Iconizer

This project is designed to be expandable in any number of ways. In software alone, there are lots of interesting directions. It would be an excellent coding exercise to store messages in the EEPROM data and scroll them across the screen. Images could be scrolled, as well. The serial port is useful for more than just reprogramming the BS2 in place, it could be used to receive icons or messages from an external source, or trigger the Iconizer from some other computer.

When I first thought up the Iconizer, I imagined that I would use it with my Palm Pilot. I would have a touch screen on the pilot of the different icons that I might like to use and touching one would send it to the Iconizer for display. The chord keyboard is much easier, but the Palm Pilot is a great companion to this project. I have a lot of code for creating and editing icons written in Pocket C for the Palm Pilot. This is available from the project web site as well.

Adding a second MAX7219 creates a lot of neat opportunities. More LED arrays could be added. Or, somewhat more interesting is the idea of taking advantage of the fact that many LED displays (at least the ones I bought), are dual color. There is a red and green LED in each location, combined they even make yellow! A second MAX7219 could be used to drive the red LEDs and create some really exciting icons.

The MAX7219 deserves an additional minute to cover some of its other uses. This chip was initially intended to drive seven-segment LED numeric displays and has an internal setting which will allow it to accept numbers as seven-segment LED display data. The MAX7219 will then do the decoding to light up the correct LED segments to display the passed number. In the straight binary mode the Iconizer uses, the MAX7219 can drive small relays, or with the addition of transistors or other drivers, it could control almost anything with a digital input. It's a quick and easy 64-bit digital out expansion for a microcontroller. All of this and more is covered in the data sheet. It takes a little while to get used to wading through the information in data sheets, but it's worth the effort.

Whether you're giving a digital wink to someone across a crowded bar, or an LED thumbs down to someone speaking on stage, the Iconizer lends you all the incredible power of ASCII graphics and more. ;-) **NV**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> Sound & Mic > 8.25" Display-64 Shade Monochrome REFLECTIVE
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> 2gig Drive $109 / 3 gig $149
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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:

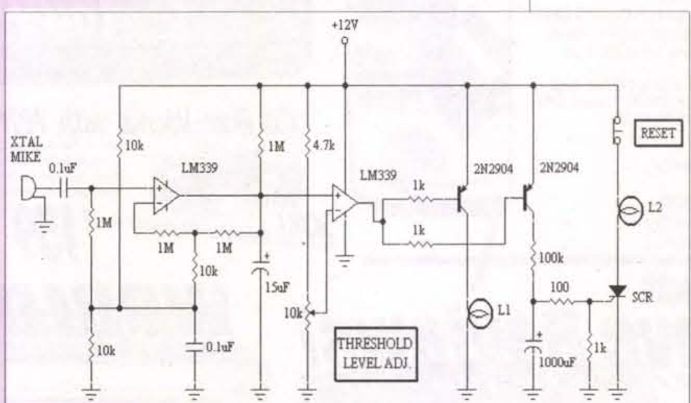
Plans for a sound level alarm and a unique volume limiter for a 20-meter receiver. Where to find manuals, teaching aids, and schematics for all sorts of devices and technologies.

Q - I'm a teacher in Santa Clara, CA with a very basic knowledge of electronics and I need some help with a device I want to build. I hear that the design is pretty straightforward, but after asking around, no one can tell me exactly how to do it. Perhaps you can help.

Basically, I want a device that will turn a light on at a certain noise level. When the noise level drops below the trigger point, the light goes off. If the light stays on for a certain amount of time (approximately 10 sec.), a buzzer sounds and stays on until it is reset. Any input would be greatly appreciated.

Carl Erickson
via Internet

A - Yes, it's a simple circuit, but not one most people with just a basic knowledge of electronics would



want to attack unassisted. My solution is shown above.

The circuit is built around a pair of comparators. The first comparator functions as an amplifier with a gain of 100 and detector. The output of the amplifier is an open-collector, which the circuit takes advantage of by feeding the output to a negative-peak-rectifier with a decay time determined by the 15uF capacitor; more capacitance equals a longer decay time. The detector provides rectification, and a time delay that prevents loud, short-lived pops from triggering the alarm. The DC output is then compared to the reference voltage level established by the Threshold Level Adj. — the amount of noise you can tolerate before L1 lights. If the din wanes before your time-out period, L1 turns off and stands guard again for a noise outburst. If, however, the clatter continues, the SCR will trigger and turn on L2, which remains lighted until the Reset normally-closed push-button is depressed. This time can be adjusted via the 1,000uF capacitor; the larger the value of the cap, the longer the alarm waits before triggering the SCR.

Q - I have a few monitors (two from Hewlett Packard) which are "dead" — no picture, no raster, no nothing. I don't want to just toss them before trying to fix them first. I attended a technical electronic school for 1,200 hours, and since then I have built everything from small robots to digital multimeter kits. So, I can humbly say that I have a good knowledge of electronics, which I really love, and feel that I can repair them with some basic instruction. In other words, where do I start?

Gill Nascimento
via Internet

A - Given your electronic background training, the quickest route would be to study a book on the subject. Here is a list of the best books for basic monitor repair.

Computer Monitor Troubleshooting & Repair
by Joseph Desposito, Kevin Garabedian

Troubleshooting and Repairing Computer Monitors
(TAB Electronics Technician Library)
by Stephen J. Bigelow

1999 Computer Monitor Troubleshooting Tips
by M. I. Technologies, edited by Robert Yount

Q - Would you happen to know where I can get a user's manual for a Tektronix 5113 Dual Beam Storage Oscilloscope?

Peter Stratigos
via Internet

A - This is a frequently asked question that I've answered in the past. But it has been more than two years since I updated my list. So, here is a current version.

Manuals Plus
130 North Cutler Drive
North Salt Lake, UT 84054
Tel: **801-936-7000**
www.manualsplus.com

Deane E. Kidd W7TYR
27270 S.W. Ladd Hill Road
Sherwood, OR 97140
Tel: **503-625-7363**

Ed Matsuda
Test Equipment Manuals
P.O. Box 390613
San Diego, CA 92149
Tel: **619-479-0225**

Linda Perkins
Manual Merchant
Email: **linda_p@ix.netcom.com**

Bob Lee
R5-D3 Electronic Surplus
Milwaukee, OR
Tel: **503-513-0410**

Q - About a year ago, I obtained an old RCA CRM-P2B-5 CB Radio. Due to the lack of information about these old tube-type CBs, it has basically just sat in a corner all this time. I thought you or maybe a reader could help me get the information I need to get it working. The only way I could identify it was through Retrocom's CB Virtual museum, because the only identification on the unit is a plastic Dynamo label reading "KDB 8894." Just a schematic would be helpful, but I'd prefer a manual.

Matt Pease
via Internet

A - You can obtain a schematic for this transceiver from Sams Photofact **(www.samswebsite.com /index.html)**; it's located in volume CB-1. The CRM-P2B-5 "chapter" also includes parts location and troubleshooting hints in addition to the schematic.

Often, though, you can troubleshoot a radio by simply knowing where the stages are and what they do. You can find this information from the Radio web site at **www.oldtuberadio.com**. However, the site is currently under reconstruction and not totally up to speed, so here is a tube function chart for the CRM-P2B-5.

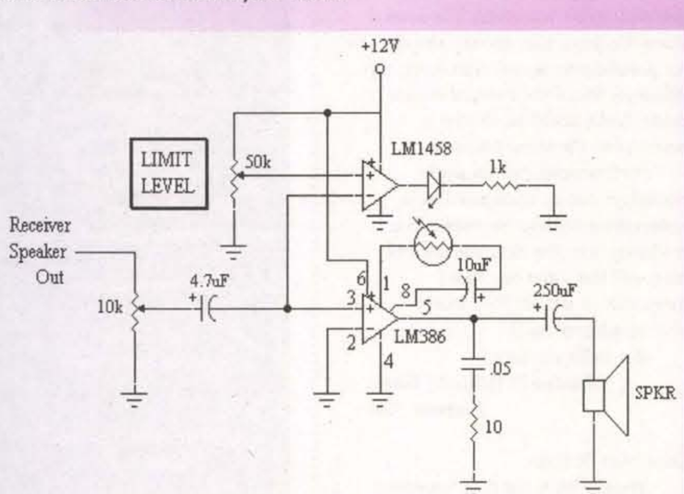
Tube Number	Function	Tube Type
1	RF Amplifier	6BA6
2	Converter	6BE6
3	1st IF Amplifier	6BA6

4	2nd IF Amplifier	6BA6
5	Det./Squelch/AF Amplifier/ Noise Limiter	6T8A
6	Receiver Output/Modulator	6AQ5A
7	Transmitter Oscillator/ Final Amplifier	6AQ5A

Q. Could you publish the plans for an automatic volume control that would go between a ham radio receiver and the speaker? When I'm listening to a two-way conversation on my 20-meter receiver and turn up the gain for a distant contact, the closer contact blasts me. The automatic volume control would ease the strong transmission and amplify the distant one.

John R Thibadeaux
Big Island, HI

A. Automatic Volume Control (AVC) circuits are often found in receivers. In fact, your receiver already has one in the RF amplifier section called an Automatic Gain Control (AGC). This circuit prevents the RF input from overwhelming the RF amplifier. While it adjusts the gain of the RF amp, it has little effect on the loudness of the speaker, which is what you're asking for. Here's a novel circuit that should fill your needs.



This circuit works on a tight optical coupling between the output of the LM1458 op amp and the LM386 audio power amp. You see, the gain of the LM386 is determined by the value of the resistor/capacitor combination between pins 1 and 8. When these pins are unconnected, the gain of the amplifier is 20. When shorted with a 10uF capacitor, the gain is 200. By inserting a resistance in this gain loop, the gain can be accurately set between these extremes. For example, a 1.2K resistor in series with a 10uF capacitor produces a gain of 50. By replacing a variable resistor in this loop, you can control the gain of the amp. For this application, a CdS photocell serves as the gain resistor, whose resistance is controlled by the amount of light falling on the cell. The brighter the light, the lower resistance — and the lower gain of the amplifier. The louder the audio signal, the less brighter the LED glows and the lower is the resistance of the CdS photocell. Hence, an automatic volume control — of sorts. It's by no means linear, but it gets the job done for what you want.

reader FeedBack

Dear Nuts & Volts:

I submitted an answer to Question #8003 Aug. 2000 which was a follow-up of #10011 Jan. 2000.

The gist was someone was looking for the location of a program called Plotgpib.zip.

I'm pretty good at finding things :^) and offered **www.fangorn.demon.co.uk/projects/plotgpib/plotgpib.html**

The #8003 answer with my name attached was the above page text and it looks like I wrote the text whereas all I did was point to the author's site where he has the program for download. I'd hate to be accused of stealing the author's words, etc.

Oh, and the location of the file was not in the resultant text, so the question remains unanswered .

Dontcha hate it when THAT happens? :^)

Ed
via Internet

Editors Note — Yeah we do. And just so we can be done with this once and for all, we have posted the file on our FTP site in the August index. Sorry for the mix up.

Dear Nuts & Volts:

What a surprise to see an old skeleton of mine!

Question #8003 dealt with a software file called plotgpib.zip. This file has an interesting history, indeed.

Back in 1984 or 1985, when I was living in Sunnyvale, CA, a friend, Dave Dillon, showed up with an HP five-pen plotter that he had purchased at a "fire sale" of the inventory at a Control Data sales office. He had a beta copy of Sorcim's SuperCalc 2.0 to draw charts, but no way to connect his PC-XT clone to the GPIB plotter.

I remembered that a pre-IBM PC computer, the Victor 9000, used a special parallel port cable to connect to GPIB (HPIB) devices. Why not do the same thing with my PC XT clone?

So, using a borrowed HP voltmeter and manual as an HPIB reference, I wrote a small test program (running under PC DOS 2.1) to emulate the interface.

Since I needed a bidirectional port to test with, I found that by making a small change on a monochrome/printer PC Board (or printer card), I could use bit 5 of the printer control port to change the data direction of the port.

Interestingly, it turned out that this bit was used in exactly the same way by the much later PS/2 bidirectional port. Some good ideas are timeless, I guess.

To make a long story short, the idea worked and a small terminate-and-stay resident which "hooked" the BIOS printer interface and provided just enough functionality to drive the plotter from SuperCalc resulted.

I returned the plotter and voltmeter to Dave with the program; he used it to generate some presentations and the project was forgotten.

Some years later in 1990, a friend from Minnesota, Greg Mansfield called and suggested that I bundle the code up and put it out for general distribution. I rewrote the code for MASM 5.0, added some documentation, and shipped it. Keep in mind that I did not have access to any GPIB devices, so the rewrite was "flying blind." I guess some errors got left in but were later corrected.

I still don't have any GPIB devices, but it certainly is amazing to see my old code come to the surface after all these years!

For what it's worth, the code was originally written for an XT clone running DOS at 8 MHz. It contains some timing loops that are far too short if run on a Pentium-class machine (easily remedied, however).

The biggest problem is that it probably won't run under Windows, since Windows uses its own drivers for parallel port access. However, for Windows 95 or 98 a virtual device driver (VxD) could be written to accomplish the same purpose.

Furthermore, printer ports nowadays can be configured to be bidirectional without resorting to a soldering iron (the direction control bit is still the same one that I jumpered on my old IBM monochrone adapter card).

But that's my baby!

Charles P. (Chuck) Guzis
Eugene, OR

Dear Nuts & Volts:

Yowch! Who put that frequency table together?

TV channels 2,3, & 4 are 54-72 MHz. TV channels 5 & 6 are 76-88 MHz. (Not too bad, only one channel off in each band.)

UHF channels 14-88! Wow! Imagine channel 88.

From its inception in 1952, the maximum the UHF dial ever covered was 14-83 (470-890 MHz).

The FCC did away with channels 70-83 in the late 60's. (Although there were and are a very few remaining translators.) So since then, the UHF band has been channels 14-69 (470-806 MHz).

The new DTV (including HDTV) band is channels 14-51 (470-698 MHz). During the transition, however, there will be a limited number of stations using channels 52-69.

And now Ladies and Gentlemen, here's the real whopper: Direct Broadcast satellite at 1500 MHz. I don't think so.

Let's try 11,700-12,200 MHz or more commonly known as 11.7-12.2 GHz (the Ku band).

Really, you should be ashamed of yourselves for such gross inaccuracies.

Craig Fox
Syracuse, NY

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Newsbytes

ZENITH LCD TV COMBINES HD DISPLAY AND SLEEK INDUSTRIAL DESIGN

The industry's first TFT-LCD combining high-definition display, NTSC TV, and computer monitor capability is being introduced by Zenith Electronics Corporation.

Marrying an HD-capable display with a slim industrial design, the new 15.1-inch set features 1024 x 768 XGA resolution for television and computer display. Both NTSC signals (received with the set's built-in analog tuner) and ATSC signals (provided by a separate digital receiver) are converted to a 1024 x 768 display.

Model ZLD151A1 is built around advanced TFT-LCD (thin film transistor-liquid crystal display) technology developed by Zenith's parent company, LG Electronics, Inc. This display doubles the contrast ratio of other LCD TVs to 200:1 and offers viewing angles of 120 degrees horizontal and 90 degrees vertical.

Designed for flexible connection of digital receivers, DVD players, VCRs, and personal computers, the set provides a 15-pin RGB connector, Y/Pb/Pr Component Video, S-Video, Baseband Video/Audio, and RF inputs, as well as a stereo headphone connector.

The 15.1-inch set features a built-in NTSC tuner with 181-channel capability, comb filter, V-chip parental control, trilingual (English, Spanish, and French) onscreen menus, stereo TV sound, and an ergonomic remote control. Zenith's EZ Features include sleep timer, closed caption capability, and automatic channel programming.

Available now, Model ZLD151A1 is expected to sell for around $2,000.00.

• • • • • • • • • • •

New OEM Module Allows Design Engineers to Easily Integrate GPS Time and Frequency

TrueTime, Inc. announced the introduction of its new GPS Synchronized Time and Frequency Module, the GPS-TFM. The new module is an ideal solution for applications such as video synchronization, cellular frequency references, E911 Time of Arrival position determination systems, telecom synchronization systems, network quality of service measurement systems, and other applications requiring precise time and frequency. The GPS-TFM can be custom tailored to meet specific OEM requirements. Modules can be supplied delivering a broad range of reference frequencies and timing outputs. The GPS-TFM is specifically designed for OEM applications that require a precise source of time and frequency with a simple interface, small size and low cost. Field upgrades can be quickly programmed by sending data through the RS-232 port to the GPS-TFM's flash memory. Integration into host systems is simplified by a single +12VDC power input.

The evaluation module acquires precise time and frequency from atomic clocks aboard (GPS) satellites with 40 nanosecond time accuracy and 1×10^{-12} frequency accuracy referenced to the world's international time standard — Universal Coordinated Time (UTC). During satellite tracking there is no long term frequency drift.

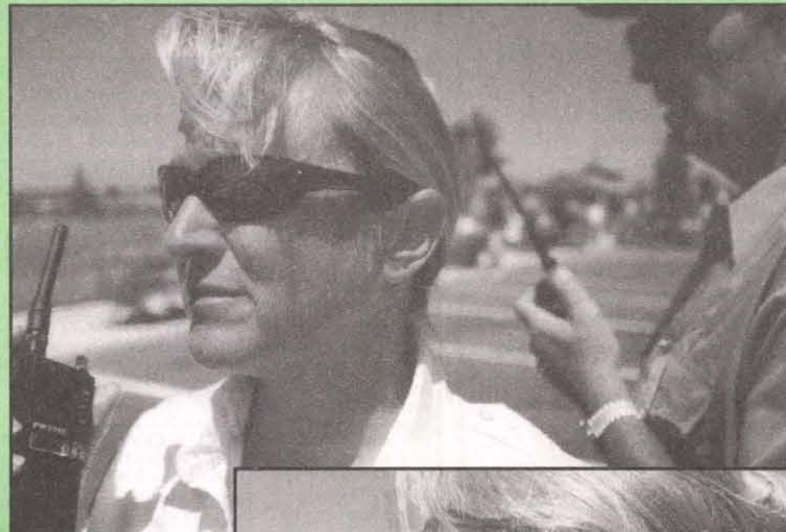
The time module delivers time over an RS-232 serial bus and utilizes the bus to accept a time comparison programming value. This value, with a resolution of one millisecond, triggers an output pulse when the UTC time equals this time value. The programmable time comparison pulse and a one Pulse Per Second (PPS) output signal are the high accuracy time outputs. In addition, the module features a 10MHz frequency reference which is cycle-locked to the one PPS output signal.

The GPS-TMF joins TrueTime's family of time and frequency solutions for today's complex computer, network, communications, and instrumentation systems. Evaluation GPS-TMF modules are available now with pricing starting at $ 1,500.00.

TrueTime's web site is **www.truetime.com**.

by Gordon West

FAMILY RADIO SERVICE MORE THAN TOY WALKIE-TALKIES



Fire Prevention Specialist Teri Durnall uses a five-watt GMRS radio on FRS Channel 4 (GMRS licensed).

The Kenwood FRS radio has input jacks for a speaker/mike or slow scan TV.

The one-half watt UHF FRS radios work up to two miles in the city.

Five years ago, Robert Miller K2RM, of RadioShack asked for my support to a petition he had sent to the Federal Communications Commission (FCC) for a low-power UHF, unlicensed radio service. He asked me my frank opinion on whether or not the two-way radio industry might try and wage a land-mobile radio industry war of negative comments to his petition.

After reading the petition for a low-power, no-license, UHF radio service, I felt that any land-mobile, two-way radio manufacturer opposing his position would ultimately be shooting themselves in both feet if they couldn't see the big picture of introducing low-cost, license-free radios for casual and business radio use, and then watching these operators upgrade to a more powerful land-mobile radio system, or trunking radio systems, and a variety of step-up, two-way radios to expand their communications range.

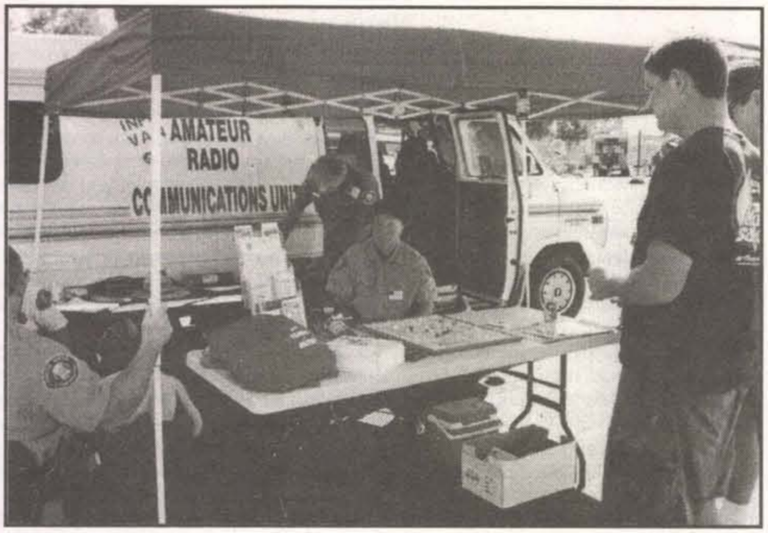
Sure enough, one land-mobile radio manufacturer voiced negative comments on FRS, yet today they are one of the biggest suppliers of inexpensive FRS sets and acknowledge these little two-way radios may ultimately lead to a more professional step-up radio system for the future of their clients.

"We love FRS because we are regularly developing new customers and, they many times, switch up to a more professional radio system," comments a Motorola dealer at a recent land-mobile trade show.

"I consider FRS radios a convenient stepping stone from no radios to a complete professional, licensed, two-way radio system," adds the Motorola salesman.

In the Jan. '97 issue of *Nuts & Volts*, my feature article on Family Radio Service was reprinted by most FRS equipment manufacturers (totally only about eight) so they might better inform the public what FRS was all about. In the Oct. '98 issue of *Nuts & Volts*, a follow-up article went into greater technical detail about those splinter-channel FRS frequencies, and some of the most bizarre uses of the equipment that have far exceeded what Robert Miller ever envisioned. These little half-watt, narrow-band, FM communicators were far from being just 49 MHz toy radios for the kids. The Family Radio Service is now a part of many local radio systems, and has earned the respect of even seasoned radio amateurs who originally thought the 14 license-free channels would become another Class D Citizen's Band bungle.

"All of the major ham radio manufacturers offer FRS transceivers," comments William Alber WA6CAX, a ham radio instructor in the San Francisco Bay area. "ICOM, Kenwood, Yaesu, Alinco, ADI — all of these radios offer a natural stepping stone from no license to ham license," adds Alber, showing off his "class loaner" plan where his registered students all use a tiny FRS to



A mobile amateur radio communications unit stages to act as a relay for FRS low-power radios.

communicate to him on an evening "net" where he continues his classroom discussion of radio etiquette actually on the air.

Hams also use FRS as a way of introducing two-way radio to their kids; and, if the kids really get into operating these tiny little radio sets, they could very well "signal" that they are good candidates for the amateur radio code-free Technician class license. And, if the kids show no interest in the two-way radio, this is a sure indication that sending them through a ham radio class for the code-free Technician class license will probably be a waste of time. "Either they like the lure of talking over airwaves, or they don't — FRS will let hams check their kid's interest in airwaves long before the decision is made to send them through an evening or weekend class," adds Alber.

The FRS is governed by the FCC under the Code of Federal Regulations, Title 47, Part 95 — PERSONAL RADIO SERVICES. The FRS's general provisions are found in Subpart B, specifically Rules 95.191, 95.192, 95.193, and 95.194. The simple rules say that you can use these little radios as long as you are not a representative of a foreign government. You must also share the 14 channels with other users.

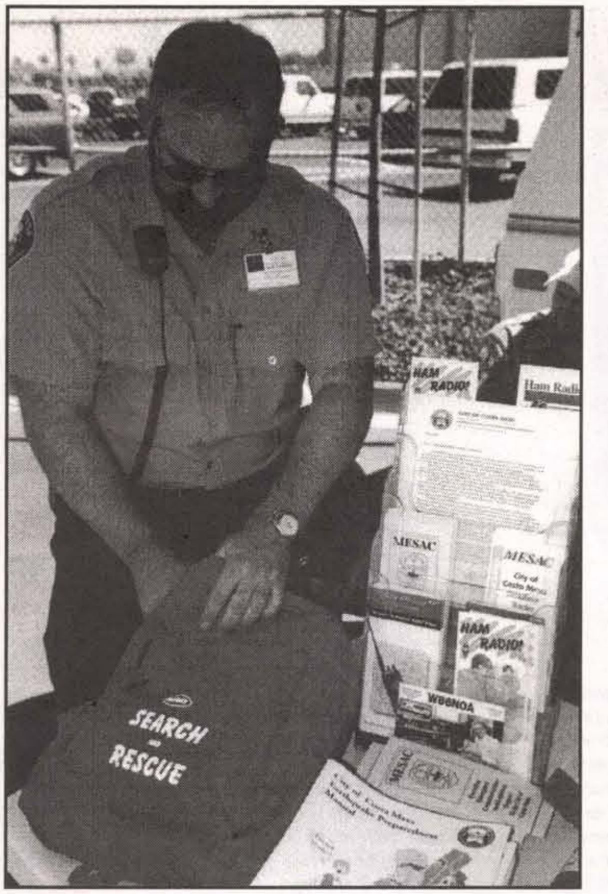
MORE THAN TOY WALKIE-TALKIES

Channel 1	462.5625 MHz
Channel 2	462.5875 MHz
Channel 3	462.6125 MHz
Channel 4	462.6375 MHz
Channel 5	462.6625 MHz
Channel 6	462.6875 MHz
Channel 7	462.7125 MHz
Channel 8	467.5625 MHz
Channel 9	467.5875 MHz
Channel 10	467.6125 MHz
Channel 11	467.6375 MHz
Channel 12	467.6625 MHz
Channel 13	467.6875 MHz
Channel 14	467.7125 MHz

- Power output one-half watt maximum
- Deviation ±2.5 kHz maximum
- Audio frequency response 3.125 kHz maximum
- No external antenna connector
- Frequency tolerance .00025%

The FRS equipment operates on interstitial frequencies to the more powerful General Mobile Radio Service. FRS Channels 1 through 7 fall between powerful GMRS output frequencies. FRS Channels 8 through 14 fall between sensitive GMRS repeater input frequencies.

"Yes, we *are* concerned about interstitial



CERT members use little FRS radios to report area incidents to a command station.

MORE THAN TOY WALKIE-TALKIES

channel interference on FRS Channels 8 through 14 that fall between sensitive GMRS repeater input frequencies," comments Bob Leef (949-770-9501) with REACT International, Inc. "REACT (Radio Emergency Associated Communications Teams) is suggesting the adoption of FRS Channel 1, 462.5625 MHz, as the official call channel, without tone," adds Leef. "We seek the support of agencies such as the National Park Service, and other recreational areas, to publicize the 'call channel' as a common frequency to use for communicating with others when needed," adds Leef.

REACT, well known for its dedicated team of thousands of radio volunteers to Class D CB Channel 9, and their tireless monitoring of GMRS emergency and assistance frequency 462.675 receive, 467.675 transmit, sees the emergency capabilities of these little FRS transceivers.

Most recently, two young Oregon brothers, ages seven and five, of McMinnville intercepted a plea for help by some injured mountaineers on Mount Hood, more than 80 miles away. The brothers — Fletcher and Parker Wold — alerted their dad who contacted authorities and triggered a full-scale mountain rescue. It was quite by accident that the kids just happened to be on the right FRS channel to hear the call for help.

In Southern California, a couple of lost hikers spent 40 minutes calling on 14 different FRS channels using 38 different tones per channel to seek assistance, and again it was kids who were just playing around with these radios that were finally able to establish communications with the lost hikers and talk them down to their heavily wooded campsite. Thank goodness for an extra set of AAA batteries that most FRS transceivers run on.

The city of Costa Mesa, CA, also recognizes the importance of these one-half watt, narrow-band, FM communicators in connection with their ongoing Citizen's Emergency Response Team (CERT) disaster preparedness communications. Costa Mesa fire prevention specialist Teri Durnall, amateur call sign KF6VVC, explains:

Our city's amateur radio 60-member emergency group, MESAC (Mesa Emergency Service Amateur Communications), developed a plan where they would hold weekly radio 'nets' on FRS Channel 4 with the city's trained CERT members who owned their own FRS transceivers. CERT-trained city employees with city-owned FRS transceivers would also take part in this evening net, and the whole idea was the amateur operators staging at their local school yard in a disaster or disaster prep and having contact with local citizen and city employees over FRS Channel 4. These local FRS neighborhood damage reports would then be relayed back to our city's EOC over our amateur radio repeater.

And, once the word began to spread about this city-wide plan for CERT members to come up on Channel 4 during a potential widespread power failure, earthquake, or nearby fire, other cities began to tune in and found out how important the small FRS walkie-talkie was in the overall CERT communications plan.

"This has been one of the best investments we have made in our CERT program," comments Durnall, pointing out that the city of Costa Mesa now has one of the best emergency communication systems around when it comes to getting block-area reports directly from their trained CERT members plus other residents in the city who might also possess FRS equipment. In fact, the FRS capability is now a great selling tool for the city's ongoing CERT program.

Kenwood FRS equipment also takes the Kenwood-specific speaker/earphone headset that also doubles for the jacks for the Kenwood VCH1 video communicator. Instead of tying up a wide area amateur radio repeater with 15 seconds of a color video image, why not send the image over an FRS channel? A little interpretation of the rules is due, here.

FRS Rule 3, 95.193, talks about FRS to conduct two-way voice communications with another person. But the rule (b) also allows for the transmitting of tones (video image by altering tones) "to make contact or to continue communications with a particular FRS unit ... if the tone lasts no longer than 15 seconds at one time." During a recent test, the FRS equipment from Kenwood at both ends of the circuit gave us a crystal-clear color image in exactly 15 seconds of total transmit time. This could allow a CERT member with a Kenwood FRS transceiver and a Kenwood VCH1 video communicator add-on device to send a picture across town to the city of Costa Mesa EOC to be viewed on the big screen television as a high-resolution snapshot of any damage within their block.

Family Radio Service Channels 1 through 7 are in between GMRS repeater outputs, and the FCC now allows licensed GMRS users to run up to five watts on these interstitial channels, too. FCC Rule 95.29(f) gives GMRS-licensed users full access to these same FRS interstitial channels to talk simplex. This *could* allow a licensed GMRS operator in the city of Costa Mesa to transmit to another GMRS family member with five watts of

MORE THAN TOY WALKIE-TALKIES

power on GMRS Channel 4, easily received by one-half watt handhelds where disaster instructions might be "overheard" by all units on FRS Channel 4. In an emergency, FCC rules specifically allow different radio services to exchange communications, and this could allow a 10 times more powerful GMRS user to legally communicate with FRS CERT members on their appropriate city FRS-adopted channel.

"This could allow a base station five-watt signal to be heard all over town, just as long as the GMRS operator speaks well away from the base station microphone," observes Hal Puritz KF6WQS, with the city of Costa Mesa MESAC group. "This is a serious modulation consideration when a little FRS radio is receiving interstitial GMRS calls," adds Puritz. Most FRS handhelds will chop-out any deviation more than approximately 3.5 kHz. The properly adjusted GMRS transceiver could have as much as 5 kHz of deviation.

When I recently spoke with FRS founder Robert Miller, he seemed quite pleased that his 14 suggested FRS channels worked in nicely with the present eight duplex GMRS frequency allocations.

GMRS CHANNELS REQUIRE FCC LICENSING!

The operation of GMRS equipment on the seven interstitial FRS channels is only allowed after FCC licensing. The GMRS is a radio service intended primarily for use by people communicating with their family and friends during recreational activities, such as fishing, camping, and boating. It may also be used by family and friends as part of disaster preparedness and CERT activities. Your GMRS license will authorize you and all other members of your immediate family to communicate with each other using type-accepted GMRS equipment. You file for a GMRS license on FCC Form 605 electronically. This is accomplished using the FCC's new universal licensing system (ULS). Just point your web browser to http://www.fcc.gov/wtb/uls. I am told that this ULS process is running smoothly, and within hours you may obtain your official GMRS license that then opens up the seven channels shared with FRS equipment.

"Get your XYL on the air — no test required," reads the ad from Pryme Radio Products. "Channels 1 through 7 in both our Pryme Clear Connect™ and Sport Connect™ are the same as FRS Channels 1 through 7, so you can still talk with any FRS radio in your group," the ad goes on to say — but with a bold heading that operation in the general mobile radio service requires an FCC-issued GMRS license. I have operated the Pryme UHF transceivers, and they work well in both GMRS, as well as FRS frequencies at a full five watts of power output.

Last year, the FCC amended GMRS rules lifting the restriction on base-to-base communications. Secondly, another FCC rule change last Feb. '99 allows any GMRS licensee to operate on any GMRS repeater with that repeater owner's permission. The FCC ultimately rescinded their initial decision of making 462/467.675 as a repeater pair only for emergency and traveler's assistance — it now remains available for users like REACT to conduct normal traffic-watch comms.

Costa Mesa hams work a drill over FRS frequencies.

A good insight on GMRS may be seen at the personal radio steering group website at www.provide.net/~prsg.

"The recent news articles about people being saved points out the ability to talk to others is not only desirable, but can save lives," finalizes Bob Leef of REACT International. "REACT is suggesting to radio manufacturers, magazines, and other news media and the public that FRS Channel 1, 462.5625 MHz, be used as a call channel, open squelch," adds Leef. You can visit the website for REACT at www.reactintl.org, or contact Robert Leef directly at 949-770-9501. Mr. Leef also has details on a personal project to develop two-way communications specifically for motorists, sharing some of the same FRS and GMRS frequencies. He envisions it as a "driver's radio service," and he seeks comments from those of you that might be interested in working with him to bring this service on the air.

So, next time you see one of those inexpensive, one-half watt, UHF FRS transceivers, do consider them more than just a toy. In fact, if you have kids using them now, the FRS equipment is a good starting ground for teaching good operating techniques over the airwaves.

We encourage other cities who may want to learn more about how the city of Costa Mesa CERT program is set up using both FRS, as well as ham radio to contact Ms. Teri Durnall, Fire Protection Specialist/CERT Coordinator, City of Costa Mesa, P.O. Box 1200, Costa Mesa, CA 92628-1200. **NV**

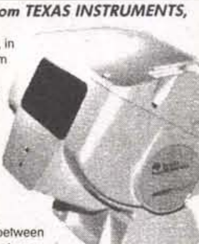
Base Station, Mobile Relay Station, Fixed Station, or Mobile Station		**Mobile Station, Control Station, or Fixed Station in the Duplex Mode**	
GMRS	Ch. 1 - 462.550 MHz	GMRS	Ch. 1 - 467.550 MHz
	Ch. 2 - 462.575 MHz		Ch. 2 - 467.575 MHz
	Ch. 3 - 462.600 MHz		Ch. 3 - 467.600 MHz
	Ch. 4 - 462.625 MHz		Ch. 4 - 467.625 MHz
	Ch. 5 - 462.650 MHz		Ch. 5 - 467.650 MHz
	Ch. 6 - 462.675 MHz		Ch. 6 - 467.675 MHz
	Ch. 7 - 462.700 MHz		Ch. 7 - 467.700 MHz
	Ch. 8 - 462.725 MHz		Ch. 8 - 467.725 MHz

SUPER POWERFUL, SHARP, NIMH BATTERY, Type BT-H42U, an amazing 3.6v @8.1Amp Hours in a 2.2" Cube!

This is a Brand New, Factory sealed, original equipment battery. This is THE SHARP battery not an off brand lower capacity replacement. These are very hard to find and sell for over $100. They provide over twice the power of replacement units. This is a Nickel-Metal, Hydride chemistry for NO MEMORY EFFECT. Design this puppy into your next robot. That's no typo 8100mAH or 8.1 AH! Unbelievable..... but true....true....

SPECIAL.............$24ea.

WOW! THERMAL IMAGER from TEXAS INSTRUMENTS, NIGHTSIGHT 100.



Detects a human sized image at up to 800ft., in complete darkness. Yes,it is tough to hide from a thermal imager. (You have seen them in action on "COPS" This like new unit generates a real time, black and white video output, compatible with any standard monitor or VCR. Unlike "Night Vision" systems which require some available light or added external illumination, the thermal imager will operate in TOTAL darkness. Also ambient lighting such as street lights or bright auto headlamps have no blinding affect. Thermal imagers function by detecting the difference between the background ambient temperature and the temperature of the objects being observed. Completely self contained, apply 12VDC and it works. Specifications: Temperature stabilization via internal thermo-electric cooler. FOV 27H x 18V degrees, Power required: 12VDC @2Amps max., Video output standard NTSC/Composite, Auto brightness and contrast, Selectable image polarity, <30 seconds from turn on to operation. Operating temp. range: -40 to +122F. Waterproof package is only 8"H x 7.4"W x 8"D. Weight: 6.5 lbs. FANTASTIC don't miss out.

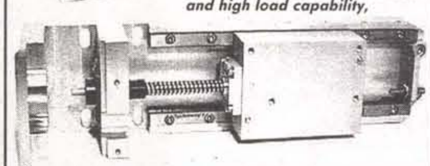
Regular Price >$8500, SPECIAL, NIGHTSIGHT 100.............$5549ea.

WORLDS SMALLEST ••• 100mW ••• VIDEO TRANSMITTER, ON SALE

Incredibly only 0.9" x 0.8" x 0.37" Transmits crystal controlled hi-res. images with 100mW output! The transmitter you've been waiting for. Shown actual size. Much smaller than the 9V battery which powers it. Draws only 35mA! Factory tuned. Receive on cable channel 59. Will work with color or B&W cameras. UHF Bow tie antenna with balun and 3" F cable for TV Included. Perfect with our GM1000A. **SPECIAL TVX-100..$159 with GM1000A CAMERA..$209**

FABULOUS LINEAR SLIDE from Star Linear Systems,

Roller bearing slide with lead screw provides ultra precision and high load capability,



BRAND NEW. Built for accuracy and strength. Each beautifully machined unit weighs in at a hefty 3.5 pounds. The travel is up to 3.4 inches. The dual Tychoway type 'P' roller ways are six inches long and mounted on the 2.6"H x 0.8H x 10.3"L solid, machined aluminum base. The massive 3"L x 2.25"W x 1.1"H carriage block is mounted to dual, low profile, roller bearing carriages. Size: 0.75"W x 2.8"L x 0.3"H. The carriage is moti-vated with a precision 10TPI x 0.3" diam. lead screw. Each end of which is ball bearing mounted and pre loaded for a completely zero backlash, zero play system. The end plate is pre drilled for a standard size 23 motor. The lead screw drive end is reduced to a 0.185" diameter. The overall finish is superb and protected with clear anodizing. Linear accy is 0.0001" per inch off travel, max. Bi directional repeatability is 0.0004" per inch. Vertical and horizontal straightness is 0.0004" This is one of the best looking and performing units we have seen in a long time. Limited qty available. **STAR106...$99ea.**

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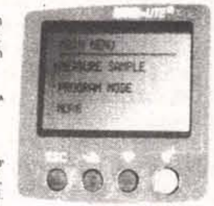
Brand New, solid state thermoelectric modules. Silent, compact & reliable. Thermoelectrics require no maintenance & can heat by reversing the input. No load cooling to - 42°F with the hot side at 77°F. No vibration or noise operates in any orientation. Specs.: Max^T=66°C @ 27°C, Max current, 3 Amps, Max voltage, 15.4V. For best efficiency and smaller heat sink, derate voltage and current to 75% Size: 1.18" L x 1.18"W x 0.142"H **SPECIAL.....$8ea. or 4 for $29**

HYGIENE ANALYSIS SYSTEM, A VERY UNIQUE DEVICE. Biotrace, Uni-Lite®XCEL,

The Most Advanced, State Of The Art, Luminometer Available! Utilizing advanced photon counting techniques and state of the art electronics immediate field determination of contamination levels. This award winning, PC-compatible (RS232 cable and software not included) system enables hygiene analysis with test results to identify emerging trends. Developed by Biotrace's team of engineers and microbiologists, Uni-Lite®XCEL, used in conjunction with the Clean-Trace™ and Aqua-Trace™ (not supplied), is considered the most advanced rapid cleanliness testing system in the world. How Does The Uni-Lite®XCEL Work? Reagents are based on the measurement of adenosine triphosphate (ATP) - the energy molecule of all animal, vegetable, bacteria, yeast and mould cells. Food residues are also rich in ATP and provide nutrients for microorganisms to grow. When ATP is brought into contact with the firefly reagent luciferin/luciferase, a reaction takes place, which results in the production of light. This light is then measured in a Biotrace luminometer. Biotrace instruments simply measure this light output. The higher the hygiene risk present the more light is produced! Simply insert the sample, close the chamber and measure! Applications include: Determine the cleanliness of surfaces in food and beverage plants, supermarkets, restaurants etc. Monitor efficiency of biocides. Detect contamination in water samples in the paper and pulp industry, water treatment industry and other water applications. Detect contamination in filterable beverages. Carry out research projects. System can be used with all Biotrace reagents such as the Clean-Trace™ rapid cleanliness test, the Aqua-Trace™ rapid water test, the Bev-Trace™ filterable beverage test and any of the Multi-Trace™ kits. All available from Biotrace. Uni-Lite® XCEL's Main Features: • Simple operation • Data Management and Trend Analysis • Multilingual • Lightweight • Windows® connectivity • Easy to follow scroll screens. Display via an internal, 128 x 64 LCD, Hard copy via an internal thermal printer. (Uses std. 2.2" wide rolls) Easy menu driven operation via only four buttons. Power required: external 5VDC. System able to use snap in, NICAD pack not supplied. Size: 6.25"W x 8.25"H x 4.4"D All accessories available from Biotrace. Units are slightly used. Guaranteed to power up and initialize only. We cannot warrant their biological performance. **LTD. QTY. SPECIAL......$229EA.**



lcd screen view

TEKTRONIX 2465, 4 Chan., 300MHz, O'Scope, With on screen waveform stats

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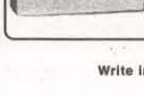

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BUILD AN ELECTRONIC SOLAR-POWERED DIGITAL BAROMETER

by Anthony J. Caristi

We all watch weather reports on TV, and are aware that the current barometric reading is usually specified. To some of us, this weather-related parameter might be a mystery, but it need not be if you build this electronic barometer which will easily outperform even the most expensive aneroid barometer you are likely to buy.

Additionally, this instrument requires no external power source. It is powered by solar energy, and will operate very nicely under artificial light, as well. The resolution of the digital display is 0.01 inches of mercury, which is far greater than what could be obtained from an analog barometer.

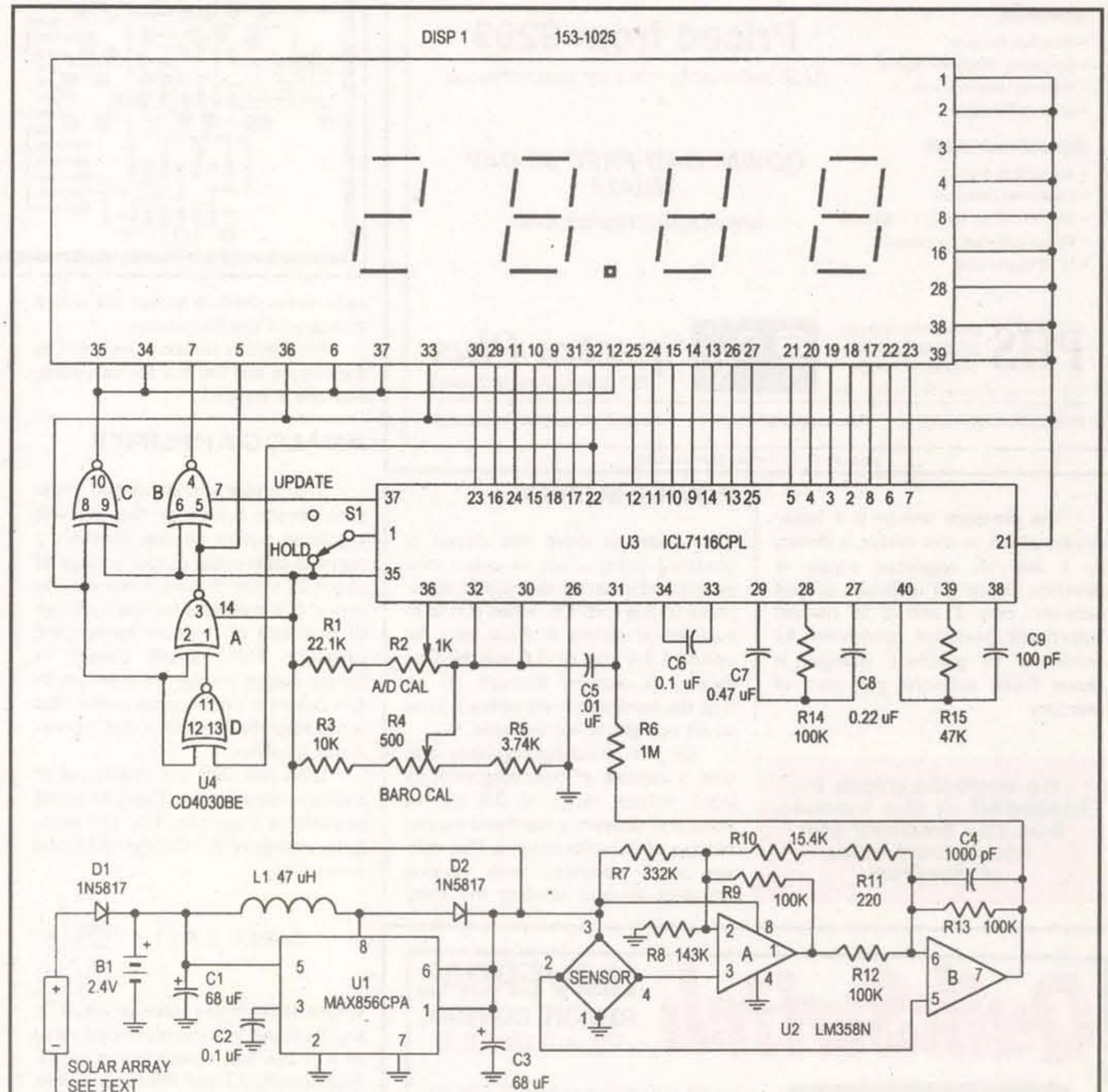
A barometer measures absolute ambient air pressure, usually specified in inches of mercury. At sea level, under standard conditions set by the World Meteorological Organization, the accepted absolute air pressure is equal to 29.91216 inches of mercury.

This translates to 14.696 pounds per square inch absolute (PSIA). The actual level of air pressure is always changing, and such movements provide an excellent method of predicting the weather.

One important aspect of the barometric reading is the direction of change: rising or falling.

For example, if the barometric reading is rising or at high levels, good weather is generally ahead. Conversely, if the reading is falling or low, one can expect stormy conditions. Normal pressure readings fall within the range of 29 to 31 inches of mercury.

One important aspect of the barometric reading is the direction of change: rising or falling. The electronic barometer described here has a "hold" feature, which allows the present reading to be frozen. Then, at a later time, a new reading may be taken. The change of direction will therefore signify if there is a rising or falling condition. The new reading may then be frozen until another check of the pressure is made.



SOLAR-POWERED ELECTRONIC BAROMETER

ABOUT THE CIRCUIT

Refer to the schematic diagram. The heart of the electronic barometer is an absolute pressure sensor that has a detection range of zero to 15 PSIA. This piezo-electric device is composed of four resistors implanted on a silicon substrate, which acts as a diaphragm. One side of the substrate is exposed to a chamber that has been totally evacuated to an almost perfect vacuum. The other side is exposed to ambient air pressure.

The four resistors, normally equal in value, are connected in a Wheatstone bridge configuration. The substrate is physically stressed by the action of ambient air pressure on one side pushing against the zero pressure chamber on the other. As a result, two of the resistors have increased resistance, while the other two are lower than normal. This produces an unbalanced bridge and the output voltage — taken between pins 2 and 4 of the sensor — represents the actual absolute value of air pressure (and barometric reading).

The pressure sensor is a linear device which, in this circuit, is driven by a five-volt regulated supply. It develops about 20 millivolts output between pins 2 and 4 at normal barometric pressure conditions. Its sensitivity to pressure changes is about 0.678 millivolts per inch of mercury.

POWER SUPPLY

Power to drive the circuit is obtained from a set of solar cells connected in series to provide about three to five volts DC when placed in sunlight or strong artificial light. An optional 2.4 volt or 3.6 volt Ni-Cad battery is charged through D1 so that the barometer will operate even when sunlight is not available.

U1 is a switching regulator chip that is capable of operating with an input voltage range of 0.8 to five volts, and delivers a regulated output voltage of 5.0 volts at pin 6. This voltage stays constant with varying amounts of light striking the solar cells, and is used to power the entire circuitry of the barometer.

No On/Off switch is included in the circuit, but the builder can easily add one, if desired.

No On/Off switch is included in the circuit, but the builder can easily add one, if desired.

ANALOG AMPLIFIER

The bridge circuit of the pressure sensor, driven by the five-volt regulated power source, provides a nominal differential output voltage of about 20 millivolts which will vary by only 0.678 millivolts for each change of one inch of mercury barometric pressure. This minute change in bridge output voltage must be amplified before it can become useful. This is accomplished by U2, a dual operational amplifier.

U2A and U2B are connected as a differential amplifier. The gain of the amplifier is determined by the resistance values of R7 through R13, and is equal to

$$\text{GAIN} = 2 \times \left\{ 1 + \frac{100\text{K}}{\text{R}} \right\}$$

where 100K is the value of R9, R12, and R13, and R is the combined value of R10 and R11 connected in series. Additionally, R7 and R8 form a voltage divider that provides a 1.5 volt DC offset to the amplifier, and this resistance pair has a Thevinin equivalent of 100K to match R9, R12, and R13.

Using the voltage gain expression shown above with the resistor values shown in the schematic diagram, the gain of the amplifier is 14.8. With a sensor output voltage swing of 0.678 millivolts for each one inch of mercury change in air pressure, it can be seen that the output voltage of the amplifier will change 10 millivolts for each inch of mercury. The actual output voltage of the amplifier will be 1.5 volts as provided by offset resistors R7 and R8, plus the bridge differential output voltage multiplied by the gain of the amplifier. Normal output is about 1.8 volts at pin 7 of U2.

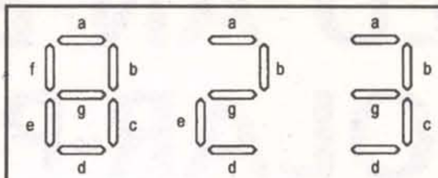
ANALOG-TO-DIGITAL CONVERTER

U3 and its associated components form a complete 3-1/2 digit voltage measurement system that drives a liquid crystal display (LCD). Only the three least significant digits are used. The half digit, "1," is not required since the barometer must display either a "2" or "3" as its most significant digit. A special driver circuit (U4) is used to accomplish this.

The analog voltage input to U3 is applied to positive input terminal 31 through isolation resistor R6. The negative analog input of U3, terminal 30, is driven by potentiometer R4 which acts as a calibrating adjustment. This takes into account variations in pressure sensors, and allows the display to be set to the correct barometric pressure reading as determined from a known, accurate source.

The sensitivity of the A/D converter is determined by the reference voltage appearing between pins 32 and 36. In this circuit, it is necessary that the A/D converter has a full scale (1999) sensitivity of 199.9 (200) millivolts. This is accomplished by using potentiometer R2 to set the reference voltage to 100 millivolts (0.100 volts).

With a reference voltage of 100 millivolts, U3 will generate a display of 1,000 when its differential analog input voltage is equal to 100 milli-



COMPLETE DIGIT NUMERAL "2" NUMERAL "3"

FIGURE 1

ILLUSTRATION OF SEGMENT IDENTIFICATION OF THE DISPLAY DIGITS. U4 IS USED TO PROVIDE PROPER LOGIC LEVELS TO THE SEGMENTS OF THE MOST SIGNIFICANT DIGIT WHICH MUST BE A 2 OR A 3.

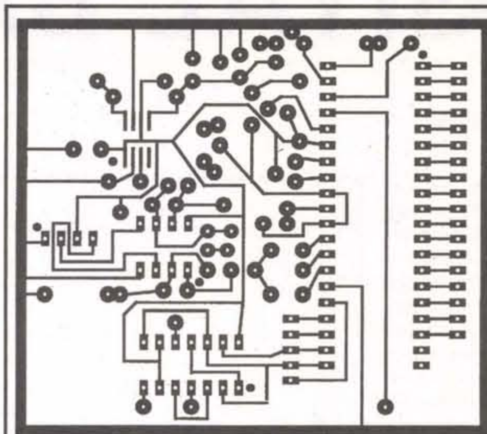


FIGURE 2

PRINTED LAYOUT OF THE ANALOG BOARD SHOWN FULL SIZE AS SEEN FROM THE COPPER SIDE.

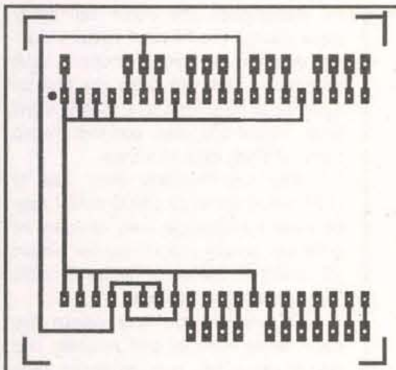


FIGURE 3

PRINTED LAYOUT OF THE DISPLAY BOARD SHOWN FULL SIZE AS SEEN FROM THE COPPER SIDE.

volts. Moreover, a positive or negative change of 10 millivolts as caused by a change of one inch in the barometric pressure will cause the generated display to be either 1,100 or 900, respectively.

Thus, it can be seen that for barometric pressure levels ranging from 28.00 to 31.00 inches in one-inch increments, the three least significant digits of the display will be 8.00, 9.00, 0.00, and 1.00 when the decimal annunciator (pin 12) is hard-wired for a display resolution of 0.01 inches of mercury.

MOST SIGNIFICANT DIGIT GENERATION

Since it is necessary that the range of the barometer display cover the range of 28.00 inches to 31.99 inches, the most significant digit is required to be either a 2 or a 3. A clever one-chip quad exclusive OR circuit (U4) is used to generate the proper digit. An exclusive OR gate produces a logic 1 output only when its inputs are at opposite logic levels.

Each of the digits of the display are composed of seven segments, identified by the letters a through g. See Figure 1. The key to generating a 2 or a 3 is by examination of the "g" segment of the second most significant digit. If that segment is active because the digit is 8 or 9, the most significant digit must therefore be a 2. If the second most significant digit is a 0 or 1, its g segment is inactive and the most significant digit must therefore be a 3.

The LCD is operated by a squarewave backplane signal generated at U3 pin 21 that is applied to the common terminal, pin 1, of the display. Any segment of the display will be extinguished when it is driven by the backplane waveform, and activated when it is driven by the same waveform that has been inverted 180 degrees.

U4C is used as an inverter that activates the most significant digit segments that are common to a 2 or a 3. These are a, b, d, and g. The inverted backplane signal at pin 10 of U4C is hard-wired to pins 35, 34, 6, 37, and 12 of the LCD to permanently illuminate those segments, plus the decimal point.

Segment f of the most significant digit is never activated; therefore, pin 36 of the LCD is connected directly to backplane.

U4D simultaneously examines the g segment of the second most significant digit of the display, and the backplane waveform. When the g segment is active (for digit 8 or digit 9), the output of U4D pin 11 is high. Otherwise, it is low for digits 0 and 1.

U4A is used as a conditional inverter so that its output is identical to backplane when the secondmost significant digit is 0 or 1, and inverted when the digit is an 8 or 9. U4A feeds the "e" segment of the most significant digit of the display (pin 5) to illuminate part of the 2 digit, and it also feeds one input of inverter U4B. The "c" segment of the most significant digit is driven by U4B so that it will

SOURCES OF SUPPLY

Display & other components: **Digi-Key, 800-344-4539**

Solar cells: **Edmund Scientific Co., Barrington, NJ, 609-573-6250**

Solar cells: **Herbach & Rademan, Moorestown, NJ, 1 800-802-0422**

Pressure sensor: **Newark Electronics, 1 800-4-NEWARK**

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

Set of two etched and drilled PC boards @ $19.50, pressure sensor @ $29.75, U1 @ $6.75, U2 @ $4.75, U3 @ $3.00, U4 @ $13.75, set of 10 metal film resistors @ $4.50.
Please add $5.00 postage/handling.

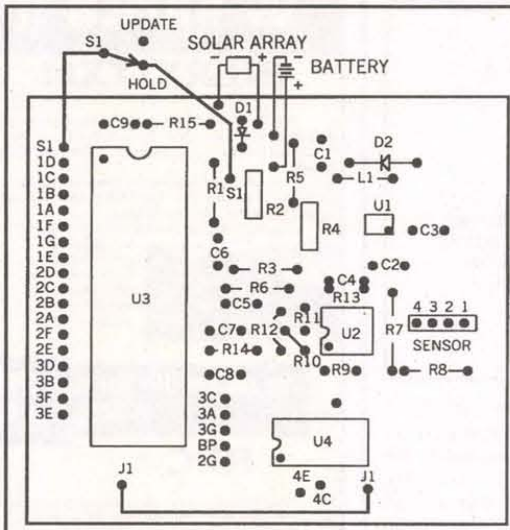


FIGURE 4

PARTS PLACEMENT OF THE ANALOG BOARD AS SEEN FROM THE COMPONENT SIDE. NOTE: U1 IS PLACED ON THE COPPER SIDE OF THE BOARD. ONE JUMPER WIRE, J1, IS REQUIRED.

always be opposite to the "e" segment.

The logic circuit of U4 always generates the correct most significant digit of the barometric reading, but cannot produce any digit other than a 2 or a 3.

MEMORY FEATURE OF THE BAROMETER

U3 normally updates its reading about three times a second in response to changes in the differential analog input voltage fed to pin 31. However, it is designed with a hold feature that allows the display reading to be frozen. This allows the user to store the current reading and update it at any time to provide information as to the trend of the barometric pressure: rising, steady, or falling. This is accomplished by operating S1, the Hold/Update switch.

SOLAR CELL SELECTION

Before constructing the barometer, it would be prudent to determine the size of the desired solar cell array, which will determine the size of a suitable enclosure. Single solar cells and arrays are available from many electronics parts houses, two of which are listed in the sidebar.

A solar cell typically generates just under 1/2 volt in full sunlight, and one measuring 5 mm x 20 mm is capable of supplying 25 milliamperes. This is more than enough capacity for the circuit. Current capability of a solar cell is directly proportional to its area.

The barometer circuit is operational over an input voltage range of about 1 to 5 volts, with the input current inversely proportional to the voltage. At 2.4 volts, the circuit will draw about 13 milliamperes. More current is required at lower voltages; less at higher input voltages. Note that the switching regulator chip may require up to 2.4 volts to start, but once activated, it will regulate with an input voltage down to less than one volt.

Additionally, the Ni-Cad battery will need a source voltage of at least three volts to ensure some charging current under bright light conditions. Thus, the minimum requirement for a solar cell array is six cells connected in series when using a 2.4 volt battery.

Depending upon the lighting conditions of the desired location of the barometer, the builder may choose more solar capacity by connecting additional cells in series and/or parallel. Remember, the solar cell array must charge the Ni-Cad battery during daylight or strong artificial light conditions. This will allow the unit to operate at zero light level during night time hours. Do not connect more than 10 solar cells in series.

Any size Ni-Cads from size N (150 mAh) up to D (4000 mAh) may be used for storage. Fully charged N cells can power the circuit for about 10 hours in darkness, while D cells will operate for 11 days.

Of course, you may delete the solar array entirely, and operate the circuit using any two batteries (dry cell or Ni-Cad) connected in series to provide at least 2.4 volts. Alternatively, a common wall adapter transformer, with a well filtered output voltage of 2.4 to 4.5 volts DC, can also be used to power the circuit.

CONSTRUCTION

The circuitry of the barometer is contained on two single sided printed circuit assemblies called the analog board and display board. The analog board contains the pressure sensor, amplifier, A/D converter, and power supply. The display board contains the LCD module.

The two boards are mounted inside a suitable enclosure which has been cut out with a rectangular opening for the display module. The Ni-Cads are secured inside the enclosure and the solar array is placed on top for maximum exposure to light. The only operating control is the Hold/Update switch.

Full size layouts of the printed wiring of the two boards are illustrated in Figures 2 and 3. The circuit is not critical and, if desired, it may be hard-wired on a perfboard, using good construction techniques. If you do not wish to etch your own boards, a source of supply is specified in the Parts List.

Before constructing the barometer, it would be prudent to determine the size of the desired solar cell array.

Figure 4 illustrates the parts placement of the analog board as seen from the top or component side. When placing polarized components into the board, be sure they are properly oriented as shown. Just one part placed backwards in the circuit will render the barometer inoperative, and may cause damage to one or more components.

Sockets may be used for U2, U3, and U4, and the display module. To make a socket for the display, cut a 40-pin DIP socket in half. The use of sockets permits ease of service should it ever be necessary.

The location of U1 is depicted in Figure 4, but note that this component must be soldered to the copper side of the board. To do this, first locate pin 1 of the chip, which is usually identified by a small dot. Pin 1 of the chip will be located at the lower left hand corner when viewing the IC from the top side with the legend facing you so you can read it. Then locate pin 1 of the copper foil, which is also indicated by a small dot. Use the following procedure:

1. Place the chip in position so that it is centered on the foil pattern with all terminals directly over the copper foil pads.

2. Gently solder just one corner pin with a small, pointed soldering iron tip. Do not use too much heat or too much solder; to do so may cause the foil pattern to lift off the board.

3. Examine each terminal of the chip and verify that all are located directly over the foil pads. Make any adjustments, if necessary, or remove the chip and repeat step 1.

4. When all terminals are properly positioned, solder them in place. Examine the chip for short circuits between terminals. Correct if necessary.

The analog circuitry contains several 1% precision metal film resistors to ensure accuracy and stability. Ordinary carbon resistors are not temperature stable and should not be substituted for metal film types where specified.

Be very careful when handling the pressure sensor. Note that pin 1 is identified by a notch on the terminal, and be sure to follow Figure 4 when placing it into the board.

Handle the glass LCD module carefully. Refer to Figure 5 which shows how this component is placed into the display PC board. Proper orientation is indicated by a small boss at one end of the module.

When both printed circuit boards are completed, examine each of them very carefully for opens, short circuits, and bad solder connections which may appear as dull blobs of solder. Any solder joint which is suspect should be redone by removing the old solder with desoldering braid, cleaning the joint, and carefully applying new solder. It is far easier to correct problems at this stage rather than later on if you discover that your barometer does not work.

BATTERY

The builder has the option of deleting the battery and D1 if sufficient light — such as from florescent or incandescent lamps — is available at all times to operate the instrument. When deleting the battery, be sure that no greater than 10 solar cells connected in series are used to power the barometer. Maximum allowable input voltage to the switching regulator chip is five volts.

When a built-in battery is not used, the memory feature of the instrument will be temporarily lost if illumination falls below the minimum required to power the unit.

BOARD INTERCONNECTIONS

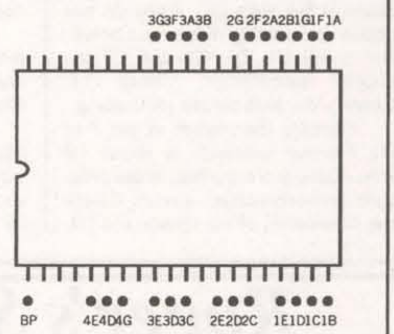
Note that Figures 4 and 5 serve to identify the location of the various connections between the two boards. Use insulated stranded #22 or #24 gauge wire. Do not use solid wire — it will break.

Make the interconnections carefully as you follow the schematic diagram. A wiring error here will result in a completely blank display, or one with deformed digits.

ENCLOSURE

Obtain an enclosure that is large enough to hold all the required components, including the solar array. Cut a rectangular opening for the display, and secure the boards with suitable screws, nuts, and spacers.

FIGURE 5



TOP VIEW OF THE DISPLAY BOARD SHOWING LOCATION OF HARD-WIRE CONNECTIONS TO THE ANALOG BOARD.

The Hold/Update switch may be mounted at any convenient location on the enclosure. Refer to the schematic diagram, and Figure 4, when wiring this component to the circuit. A power On/Off switch is optional and, if included, should be connected in series with the positive side of the battery.

Secure the solar cell array to the top of the enclosure, which has been drilled for the positive and negative leads of the array. Using RTV silicone adhesive is a good method for installation.

Do not wire or assemble the Ni-Cad cells into the enclosure at this time. This will be done later during the preliminary checkout procedure. When the barometer is fully assembled except for the battery, examine the wiring very carefully for proper connections. Do not attempt the checkout procedure unless you are satisfied that the assembly and wiring are 100% correct.

PRELIMINARY TEST

CAUTION: If the Ni-Cad cells have any charge, you must be extremely careful not to cause an accidental short circuit. Ni-Cads can deliver very heavy currents into a short circuit. Should this occur, board traces can vaporize and connecting wires can get extremely hot.

A DVM is required to test and calibrate the unit. Before installing the battery, measure the resistance between the power input terminals of the analog board, +2.4 volts, and ground, to be sure there is no short circuit. Normal indication, with the positive lead of the DVM connected to the positive side of C1, is essentially high resistance (about 10K). If zero or low resistance is measured, examine the circuit assembly very carefully to locate and correct the fault.

Connect the two Ni-Cads in series (positive to negative), then wire the two-cell battery to the circuit being very careful to observe proper polarity as indicated in the schematic diagram. If the battery is totally discharged, you may place the barometer in direct sunlight for a while to store sufficient energy to operate the circuit. Alternatively, the Ni-Cads may be charged from a DC power supply, by passing a current through them, equal to 1/10 the ampere hour capacity. This may be done for a period of one or two hours for a partial charge.

Measure the terminal voltage of the battery. Normal indication is 2.4 volts or more. Measure the voltage —

PARTS LIST

B1 Two Ni-Cad cells connected in series (see text)

C1, C3 68 uFd 25-volt radial electrolytic capacitor

C2, C6 0.1 uFd 50-volt ceramic disc capacitor

C4 1000 pF 50-volt ceramic disc capacitor

C5 0.01 uFd 50-volt ceramic disc capacitor

C7 0.47 uFd 50-volt ceramic or metallized film capacitor

C8 0.22 uFd 50-volt ceramic or metallized film capacitor

D1, D2 1N5817 Schottky diode

Display Digi-Key 153-1025

L1 47 microhenry inductor, Digi-Key M7833-ND or similar

R1 22.1K 1/4 watt 1% metal film resistor

R2 1K cermet potentiometer, PC mount

R3 10K 1/4 watt 1% metal film resistor

R4 500 ohm cermet pot, PC mount

R5 3.74K 1/4 watt 1% metal film resistor

R6 1 Megohm 1/4 watt carbon resistor

R7 332K 1/4 watt 1% metal film resistor

R8 143K 1/4 watt 1% metal film resistor

R9, R11, R12, R13 100K 1/4 watt 1% metal film resistor

R10 15.4K 1/4 watt 1% metal film resistor

R11 220 ohm 1/4 watt carbon resistor

R14 100K 1/4 watt carbon resistor

S1 SPST toggle or slide switch

S2 SPST toggle or slide switch (optional, see text)

Sensor Motorola MPX2100A, 15 PSI Absolute

U1 Switching regulator, Maxim MAX856CSA

U2 Dual operational amplifier, LM358N

U3 Quad 2 input exclusive OR gate, CD4030BE

U4 A/D converter/LCD driver Maxim ICL7116CPL

Misc. Solar cell array (see text), enclosure

PARTS LIST

with respect to circuit common — at the positive side of C3. Normal indication is five volts DC. If you do not obtain this reading, disconnect power and check U1, D2, C1, and C3 for proper orientation. Check L1. Correct the fault before proceeding.

Measure the voltage at pin 7 of U2. Normal indication is about 1.8 volts. If not, there is a fault in the pressure sensor/amplifier circuit. Check the orientation of the sensor, and U2. Check the values of resistors R7 through R13. Look for bad solder connections, and try a new chip.

Measure the voltage between pins 32 and 36 of U3. Adjust R2 for a reading of 100 millivolts (0.1 volts). Once set, do not readjust R2 again.

The display should show a four-digit reading with a decimal point. By slowly adjusting R4 over its range, you should be able to see a display of digits that vary from about 29.00 to 31.00 inches of mercury with the decimal point properly illuminated. Set R4 for the proper barometric reading as obtained from a weather report or another barometer that is known to be extremely accurate. If an airport is located nearby, the control tower can provide you with an accurate current barometric pressure reading.

Check the operation of the Hold/Update switch. In the Update position, the display will change with barometric pressure. Allow sufficient time for the reading to change. Note: It is normal for the digital display to sometimes switch back and forth 0.01 or 0.02 inches. With S1 set to the Hold position, the reading should remain constant, despite changes in the barometric pressure.

Should the display ever go blank, recharge the battery by placing the barometer in bright sunlight for a few hours.

Once R4 is properly set and S1 checked, the barometer test and calibration procedure is completed.

If the display has deformed digits, it may be caused by a wiring error between the display and analog board or a short or open in the wiring. The location of the deformed digit(s) will tell you where to look for the problem. Refer to the schematic diagram and Figure 1, and check each interconnecting wire with an ohmmeter after disconnecting power to the circuit.

If the display is totally blank, check the orientation of U3, and check all components associated with it. If possible, check pin 21 of U3 and pin 1 of the display with an oscilloscope to verify the presence of the squarewave backplane signal.

Verify the reference voltage of U3 by measuring the voltage between pins 36 (positive) and 32 (negative). Normal indication is 0.1 volt. If incorrect, check R1 and R2.

If the most significant digit is not a 2 or a 3 as it should be, check the orientation of U4. Check the circuit for shorts or opens, and try a new chip.

FINAL ASSEMBLY

The Ni-Cads may be fastened at a convenient location in the enclosure using RTV silicone rubber, or any other appropriate method. The boards are similarly secured in the desired location. Once the assembly is completed, the barometer may be placed in full sunlight for a couple of hours to charge the battery.

USING THE BAROMETER

S1 is normally left in the Update position so that the barometer will show the existing pressure level. However, the Hold position may be selected at any time to freeze the reading until a new reading is taken, by switching to the Update position of the switch. This way, the trend of the barometric reading, rising or falling, may be determined.

Remember, the barometer should be placed at a location of bright light during daytime hours to keep a trickle charge on the battery. Should the display ever go blank, recharge the battery by placing the barometer in bright sunlight for a few hours. **NV**

Write in 99 on Reader Service Card.

AMATEUR ROBOTICS NOTEBOOK

by Robert Nansel

This month, I begin a design dialog on what goes into building robots to meet specific requirements. I'm still assimilating the lessons I've learned from my Jiffy robot, so I'm not going to show a 4WD design based on Jiffy just yet. Instead, I'll lead off with what it takes to build an elementary two-wheel drive system for a sumo robot.

Other than two equations, I'm going to keep the discussion mostly qualitative. I find my design cycle tends to alternate between getting a literal hands-on feel for the problem and calculating performance from first principles. If you are a gut-level designer and hate equations, or if you are a math whiz with hundreds of unrealized paper designs, bear with me. You need both approaches to build good robots, if only as a way to check your work. Next month, I'll lean more on the theoretical side.

Finally, I've got a great book on motors to recommend. Let's get started on the sumo design.

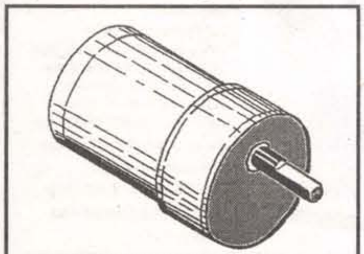


Figure 1: Barber-Colman Gearmotor

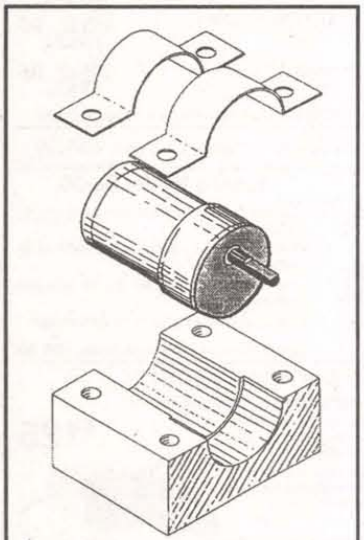


Figure 2: Pillow Block Motor Mount

Applying a Little Muscle

Barber-Colman gearhead motors are plentiful in the surplus market. C & H Sales (www.candhsale.com; see their ad on page 14) sells Barber-Colman #FYQF-63310-9 gearmotors for $17.50 each, new surplus. They are 12 VDC permanent magnet 300 RPM gearheads with 25 in-oz of torque, continuous duty.

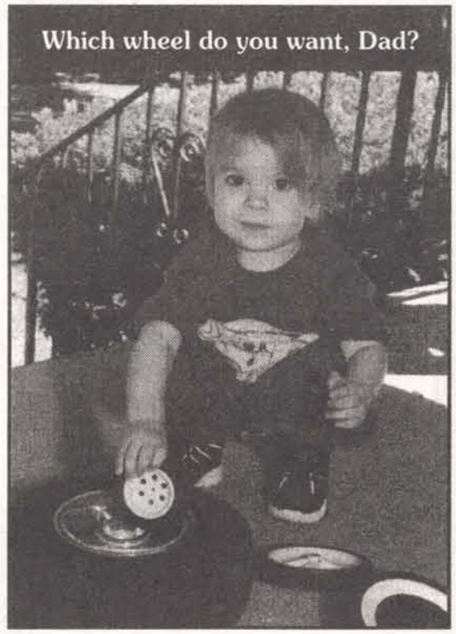
Two of these gearheads make a fine start on a sumo 'bot drive system, but they're too fast, and the torque isn't as high as I would like for a sumobot. For a practical sumo wrestler, the wheel RPM should be about 75 RPM for a 3" wheel. A 4:1 speed reducer would give this, with the added bonus of multiplying the torque output by four.

Speed reducers come in hundreds of styles, but most fit within three groups: gear, belt, and worm. I'll dismiss worm drives right away for efficiency sake (worm drives are lucky if they get to be 50% efficient). Gears are very efficient, usually around 99%, but they are expensive, noisy, and hard to adjust.

V-belt drives, on the other hand, are cheap, quiet, and easy to adjust. Also in their favor is the natural shock absorbing elasticity belts give a drive system, something important for drives intended for high-shock sumo wrestling.

They are less efficient than equivalent gear reducers (that shock absorbing elasticity doesn't come for free), but the main problem with ordinary belt drives is that belts can slip, and this could be disastrous for a sumo robot.

The answer is to use a *timing belt* reducer, which combines the best features of V-belts and geartrains. Timing belts are nearly as efficient as gears, have zero backlash, and still offer the ease of adjustment and shock absorbing qualities of belt drives. And they cost less than gears.



Time for Reduction

Okay, to get a 4:1 reduction I have to put a small pulley on the output shaft of my gearhead, and a four-times larger diameter pulley on the shaft that drives the robot's wheel. As a rule, the smaller of the two pulleys must have at least six teeth in mesh at any one time to carry its full-rated torque, and since only about half of the teeth of the pulley can ever be in mesh with the belt at one time, that means a 12-groove pulley, minimum. To be on the safe side, I would choose a 15-groove pulley.

The large pulley then must have 4 x 15 = 60 grooves.

But what size belt should I use? For that matter, what pitch (tooth spacing) should the belt and pulleys have?

The wheels of my robot are 3.2 inches (8.13 cm) in diameter, so the 60-groove pulley must be smaller than that.

Oh, and my wheel drive shaft is 0.25 inch (6.35 mm) diameter and the output shaft of the Barber-Colman gearhead measures 0.185 inch (4.7 mm) in diameter.

A quick look through my "Seitz Standard and Special Drive Components" catalog shows that a 60-groove, 0.080 (MXL) pitch pulley has a 1.7 inch (43.19 mm) flange diameter, about right for the wheel I intend to use. It is an "engineered plastic" component made of 10% glass filled polycarbonate, so it should be plenty strong. It's available with an aluminum hub insert bored for my 0.25 inch shaft and it comes in both single and double flange versions.

Flanges keep the timing belt from wandering off the pulleys, a problem for smaller pulleys, so I'll use the double flange versions for both the 60- and 15-groove pulleys (part nos. 0002429 and 000416, $4.74 and $3.48, respectively when I bought them; check Seitz at www.seitzcorp.com for current pricing).

The distance between the gearhead output shaft and the wheel drive shaft will be 2.84" (7.22 cm). With this distance and the pulleys I'm using, I'll need a 110 tooth MXL pitch belt (part no. 0013818, $4.25). How did I know what belt size to use? It's an iterative process.

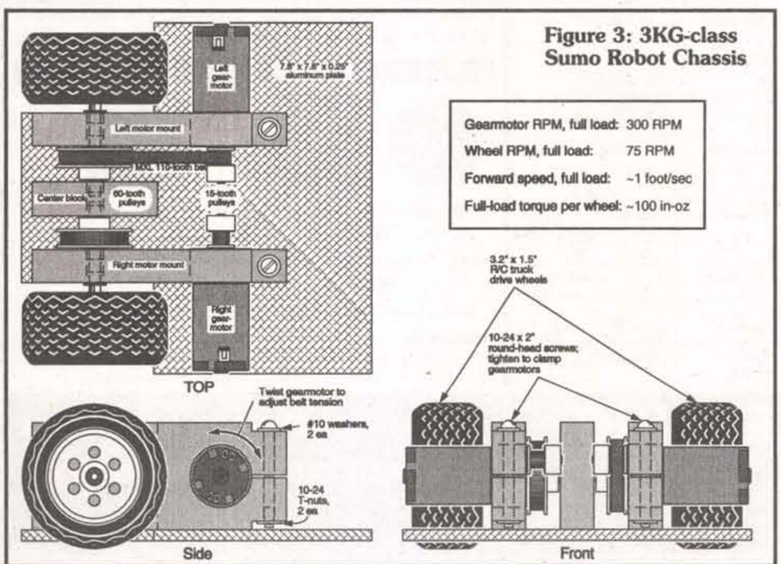


Figure 3: 3KG-class Sumo Robot Chassis

Get Your Calculator

First, I figured the belt size knowing **C**, a first best-guess center-to-center distance between the two pulleys; **D** is the large pulley diameter, and **d** is the small pulley diameter. The formulae for belt length and center-to-center distance are:

(1) $\mathbf{L = 2C + 1.57 * (D+d) + (D - d)^2 / (4C)}$

(2) $\mathbf{C = SQRT\ [\ ((2L-3.14 * (D-d)) / 4)^2 - (\ (D - d) / 2\ ))^2\ ]}$

In this case:

C = 2.85" (my first guess)
D = 1.528"
d = 0.382"

Plug-n-chug with the above numbers, and you get **L** = 8.8" (approx.). The 112-tooth belt (#0013822) has an **L** equal to 8.960", and the 110-tooth belt (#0013818) is equal to 8.800".

Next, plugging these numbers back into Equation (2) gives a center-to-center spacing of **C** = 2.9243" for the 112-tooth belt, and **C** = 2.8427" for the 110-tooth belt. I chose the 110-tooth belt, though note that this configuration leaves about 0.65" clearance between the tire and the gearmotor.

This distance could be safely reduced to about 0.15", with a corresponding **C** equal to 2.35" if you want to make a more compact assembly. In that case, you would need to substitute 2.35" for **C** in Equation (1) to solve for the new **L**. You would then locate the nearest corresponding belt size and plug that size into Equation (2) to make sure that the new center-to-center distance is still acceptable.

This works out to **L** = 7.8384", with 8.000" (the 100-tooth belt) being the closest larger size. In turn, this implies **C** = 2.43", which means the actual clearance between tire and motor would be about 0.23". The next belt size down — 97-tooth — has a length of 7.760", which gives a final center spacing of 2.31" and a wheel clearance of about 0.11"... isn't this fun?

Anyway, once I've selected the gearmotors, the wheels, pulleys, and toothed belts, I'm done, right?

Well, these parts can't just float in space. They have to be mounted to the robot.

Motor Mounts

A *pillow block* is one idea to mount the motor. A pillow block is a cradle with straps designed to hold a motor or bearing rigidly in position (Figure 2). As an experiment, I made pillow blocks for my gearmotors by boring two concentric holes the proper depth in the side of a 2.7" square wood block. The larger bore is 1.375" diameter and .75" deep for the gearhead casing; the smaller bore is 1.25" diameter through the rest of the block for the motor body.

Four transverse holes form the mounts. Sawing down the middle gives two identical pillow blocks, left and right. Secure the gearmotor with sheet metal straps and bolts. Since the output shaft of the gearmotor is off-center, simply twisting the gearmotor tensions the belt.

That works fine for the gearmotor, but what about the wheel drive pulleys? I could have made similar bearing blocks for the wheel shafts, but I might have had some trouble getting — and keeping — the separate blocks in alignment with each other.

I settled on a different design that uses a single block to clamp each gearmotor and mount its wheel shaft bearings, with a third center bearing block (Figures 3 and 4). Now instead of sheet metal straps, I use machine screws and tee-nuts to provide the clamping force to hold the gearmotors in place. The bearings (flange-type, sintered bronze) for the 1/4" drive shafts press fit into 3/8" holes. Notice that the center block is shared by both drive shafts. This gives the wheel shafts much greater stability than just bearings in the motor mount blocks alone could afford.

When the 60-groove pulleys are tightened on their respective shafts, they keep them from sliding in or out, though there should be about 1/32" of play. Accordingly, the ends of the shafts inside the center bearing block must have about 1/16" minimum clearance from each other.

All blocks are made of 3/4" thick, straight-grained rock maple. I secured the motor mount blocks and the center bearing block with countersunk woodscrews through the 1/4" aluminum chassis plate (Figure 4). Those blocks aren't going anywhere.

One tip about mounting the blocks: Before you drill the mounting holes in the blocks, insert the bearings and run a single straight section of 1/4" drive shaft through all three blocks to make sure they are aligned. I pre-drilled and countersunk the holes in the aluminum plate beforehand and clamped the blocks to the plate, making sure that the shaft was still free to turn. Then I used the holes in the aluminum plate as my drilling guide.

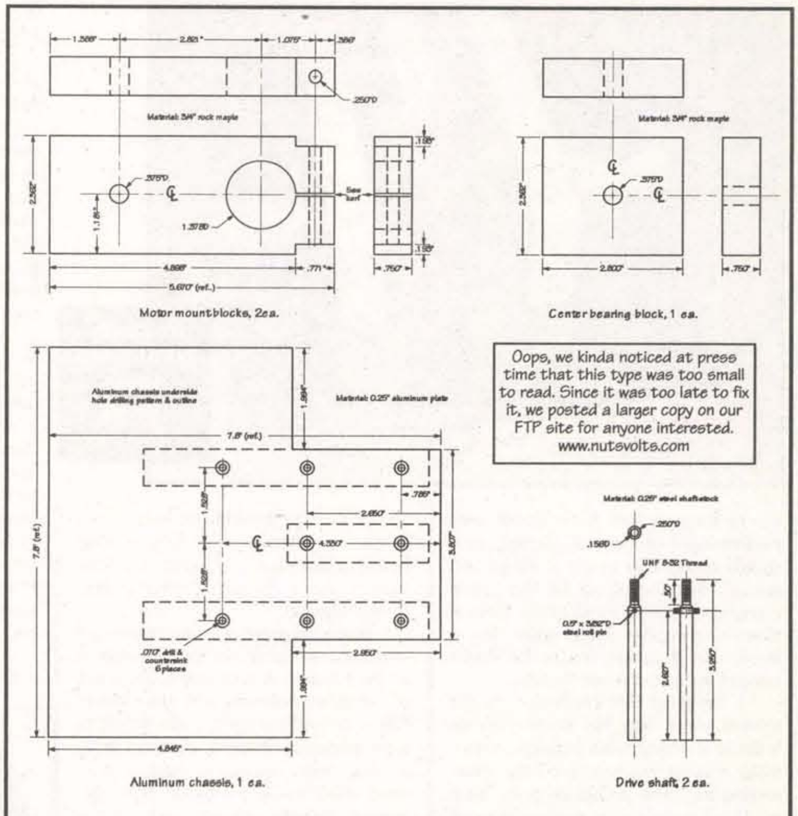


Figure 4: Sumo Chassis Components

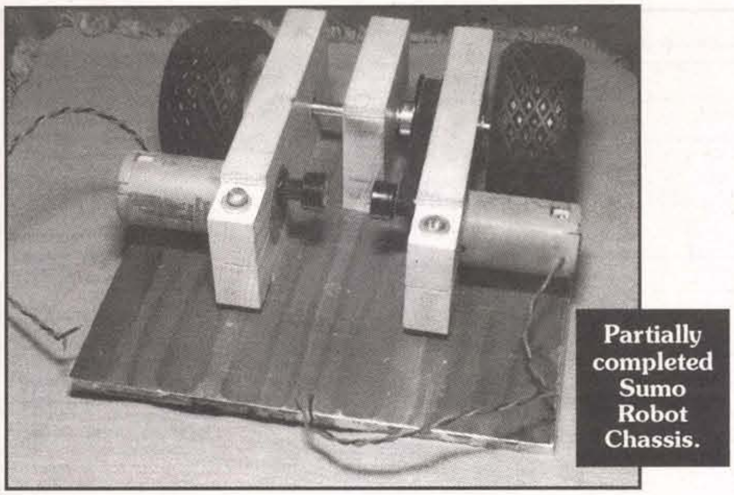
Once you screw the blocks in place, there's a chance that the blocks might deform or shift slightly under the tension, and the alignment shaft might not slide out easily. Don't panic. Take a section of 1/4" steel shaft with a flat milled on one side and use it as a reamer to shave away enough of the bearing surfaces until a plain shaft doesn't bind. Pull the flatted section out frequently and wipe away the metal particles.

Once you've got the flatted shaft to turn smoothly by hand, you can chuck it up in a hand drill and perform the same operation at increasing speeds with the hand drill.

A little WD-40 will help in this operation. Don't overdo it, though. If the bearings are enough out of alignment that you need a hammer to get the shaft out, you're better off starting over and remounting the blocks, perhaps with shims of aluminum foil.

Enough Power Yet?

Without actually competing with other sumobots, there is no easy way to know whether the chassis as presented could overpower another robot sumo opponent. And there's a lot still missing — a caster or skid for the front, a body, a battery, and control electron-



Partially completed Sumo Robot Chassis.

ics, to name a few. It's a good, solid mechanical arrangement, though, so it should be enough to get some of you started. See the photo for the nearly completed chassis. Incidentally, there is blue color on the chassis plate that is layout die; it makes the scribe marks needed for layout easier to see.

I designed this particular chassis several years ago but never finished building it. Many robot projects, regrettably, end up this way, but I am resurrecting the more promising ones, such as this. I came across the box with all my sumo parts as I was gathering material for this month's column. I went back through my project notebook where I had recorded all the detailed design steps, but not everything wound up in my notes. This robot, like most I build, came about because I had a particular wheel/motor combination I wanted to try.

What isn't recorded in my notebook are the hours I spent just sitting at my bench hefting those motors, holding them up next to the wheels, and imagining various drive arrangements. To the uninitiated, this would look like "playing," and I suppose it is, in a sense. By spending those hours playing, my hands become intimately familiar with the components and their possibilities. If you don't already have a well-developed mechanical intuition, playing with the parts before you start to build — or even design — your robot can help you strengthen your intuition.

Roboschlepper

In my rummaging through boxes, I came up with lots of other wheels I've used in past robots. In the photo, my son Yonatan is shown holding the sumobot wheel, and at his feet are some of those other wheels. Yes, the big one really is a wheel to a robot. It's an 11-inch pneumatic go-kart wheel from Azusa Engineering (www.azusaeng.com), one of four wheels for a monster robot called Roboschlepper.

Roboschlepper is for toting around groceries and what not for a person in a wheelchair. It is supposed to be a sort of semi-autonomous cart that would follow behind a person's wheelchair at a programmed distance, perhaps using a color video camera to track a standard slow-moving-vehicle sign (an orange triangle) on the back of the wheelchair. It doesn't need to be particularly bright, but it does need to be able to cope with wheelchair ramps, gravel, uneven pavement, and curb cuts — hence the large wheel size.

The other photo shows the drive motors that would be used for Roboschlepper (on the left) and the sumo 'bot (on the right). The large gearmotor is rated at 1/8 horsepower, with a full-load speed of 167 RPM and torque of 43 in-lbs. A further external 2:1 miter gear reduction brings the F/L RPM down to 83.5 and boosts the torque to 86 in-lb. The robot sumo's performance is naturally much more modest; its motors are only rated at about 7.4 watts mechanical power, a little less than 1/100 horsepower. Roboschlepper's motors give the 230-lb. robot the ability to go up fairly steep wheelchair ramps (1-in-12 slope) at about 2.5 MPH, or 3.7 ft/sec.

How do I know this? Neither of these robots has been completed, so it's not by experimental observation. No, I did some calculations, a handy tool especially for beefy robots. I'll talk in detail next month about the analysis behind all that.

Electric Motor Handbook

Speaking of beefy robots, do you ever get the urge to build a *really* powerful robot? Something with *muscle*? How about a robot that can climb cliffs or zoom to 2,000 feet on 200 burning amps of raw electric power, yeah, that's what I'm talking about!

Well, if you've ever entertained such notions, here's the book you'll need to make them come true: *Electric Motor Handbook* by Robert J. Boucher (AstroFlight, Inc., Marina Del Ray, 1994, ISBN 0-9644065). It is billed as "The Complete Handbook of High Performance DC Motors," and it is by far the best practical reference on PMDC motors I've seen.

Robert Boucher is the president, co-founder, and chief engineer of AstroFlight. For those of you not familiar with the company, AstroFlight has been a well-known name in the electric-powered modelling business for over 30 years. They sell powerful permanent magnet DC motors for everything from model boats to model airplanes, so their motors are designed to operate efficiently from NiCd battery packs consisting of 6 to 36 cells.

When I say AstroFlight makes *powerful* motors, I mean motors drawing, say, 30 amps at peak efficiency (280 at stall!) and producing about 37 in-oz torque at 12,500 RPM. For the curious, that's over 340 watts of mechanical power, almost 1/2 horsepower, putting even Roboschlepper to shame. (In comparison, the hobbyist servos I used on Jiffy each produce about 42 in-oz torque at about 45 RPM, which works out to less than 1.5 watts, a weensy two thousandths of one horsepower.)

Anyway, the point is that Boucher knows his motors, and in this book he shares that knowledge in no-nonsense language. You'll find over 80 pages packed with equations, charts of motor torque, power, and efficiency curves, and practical methods for calculating or measuring all the important parameters of a given motor.

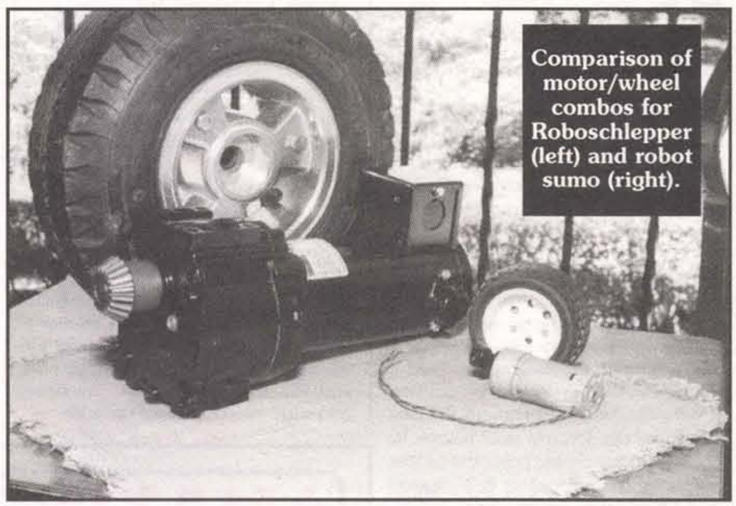
Don't panic at my mention of equations, because they are all simple algebraic equations, where you plug in the values and get your results ("plug and chug" as we used to call it in college). Boucher doesn't show you how his equations are derived (there are plenty of college texts with all the grisly details). What he does give you is the stuff you really need to know to get the most out of a motor — equations, charts, and graphs along with plenty of worked examples — and you won't need a PhD to understand it.

The Ideal Motor

Chapter one introduces the Ideal Motor, then walks you through the various loss mechanisms that every motor has — the so-called copper and iron losses are the main ones — then he shows how to calculate motor efficiency. Chapter two is a short rundown of how to measure three critical values used in calculating motor performance — no-load current, motor resistance, and motor voltage constant. Chapter three covers the arcana of commutation timing, how to adjust the brushes of a high-performance motor to minimize brush sparking and wear. Most robots amateurs build use neutrally-timed motors because we want the motors to run equally well forward and backward, so we have to put up with a little sparking. For applications where a motor will always turn the same direction, though, you can get more speed and power by advancing the brush timing a bit.

Chapter four covers airplane propellers, five explains PWM speed control, and chapter six talks about NiCd batteries. The rest of the book, chapters seven through ten, are all about AstroFlight's various motor offerings, including motor constants, performance curves, and mechanical drawings.

If all you ever plan to build are bitty little table-top robots, then you don't really need this book. But, if you have plans for making ozone and burning rubber in Robot Sumo competition — or if you want to build a flying robot — this is definitely the book to get. At $14.95, it'll pay for itself many times over if it prevents you from burning up just one motor. I bought my copy through Fatbrain.com, but you can also find copies in hobby shops that specialize in RC aircraft and boats. If you can find it in the hobby shop, buy it because both Fatbrain and Amazon take four to six weeks to fill orders for this book.



Comparison of motor/wheel combos for Roboschlepper (left) and robot sumo (right).

Wrapping Up

You'll be seeing lots of partial designs in this column in coming months, as well as some complete projects. The partial designs are my attempt to address areas that cause even experienced robot builders to stumble. It's my hope by giving you a lot of partial designs, the more experienced among you will be able to take one or more and run with them. And they serve to illustrate the process for beginners. This month's sumo chassis is one example. I'll also continue with more complete designs that take you all the way through a project. **NV**

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

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TEK WM782V WR15 Harmonic Mixer, 50-75 GHz $1,500.00

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HP 11650A Network Analyzer Accessory Kit, APC7 ..... $600.00
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HP 85054A Type N Calibration Kit, for HP 8510 series $1,800.00
HP R85026A WR28 Detector, ... $1,200.00
26.5-40 GHz, for HP 8757 series

SIGNAL GENERATORS

FLUKE 6060A Synthesized Signal $1,650.00
Gen., 0.1-1050 MHz, 10 Hz res., GPIB
FLUKE 6060A/AN Synthesized Signal $950.00
Generator, 10 kHz-520 MHz, 10 Hz res
FLUKE 6060B/AK Synthesized $1,900.00
Signal Gen., 0.1-1050 MHz, 10 Hz res.
GIGATRONICS 600/6-12 Synthesized $2,500.00
Source, 6-12 GHz, 1 kHz res., GPIB
GIGATRONICS 875/50 Levelled Multiplier, ... $2,500.00
x4, 50.0-75.0 GHz output, -3 dBm
GIGATRONICS 900/2-8 Synthesized $2,500.00
Signal/Sweep Gen., 2-8 GHz, 1 MHz res.,GPIB
GIGATRONICS GT9000-opt.26A $6,000.00
Synthesized Signal Gen., 0.01-20 GHz, 1 kHz res.
HP 11707A Test Plug-in for HP 8660 series $500.00
HP 11720A Pulse Modulator, 2-18 GHz, 80 dB on/off ratio $450.00
HP 3335A-001 Synthesizer/ Level Gen., ... $3,500.00
200 Hz-81 MHz, -87 to +13 dBm
HP 8656A-001 Signal Generator, ... $1,600.00
0.1-990 MHz, 100 Hz res., HPIB, OCXO
HP 8657A-002 Signal Generator, ... $2,750.00
0.1-1040 MHz, 10 Hz res., HPIB
HP 8660C/86602A/86632B $2,500.00
Synth. Sig. Gen., 1-1300 MHz, AM / FM
HP 8660C/86603A/86632B Synthesizer, ... $3,250.00
1-2600 MHz, 1 Hz res., AM / FM
HP 8672A Synthesized Signal $4,500.00
Generator, 2-18 GHz, +3 dBm output
HP 8684B Signal Generator, ... $3,000.00
5.4-12.5 GHz, AM/ WBFM/ Pulse

SWEEP GENERATORS

HP 8350B/83522A Sweep Oscillator, ... $3,900.00
10-2400 MHz, +13 dBm levelled
HP 8350B/83540A-002,004 Sweep $3,900.00
Oscillator, 2.0-8.4 GHz, 70 dB step attenuator
HP 8350B/83545A-002 Sweep Oscillator, ... $3,900.00
5.9-12.4 GHz, 70 dB step attenuator
HP 83570A RF Plug-in, ... $6,000.00
18.0-26.5 GHz, +10 dBm levelled
HP 83592B RF Plug-in, ... $8,000.00
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HP 8601A Generator/Sweeper, ... $400.00
0.1-110 MHz, +20 dBm levelled
HP 8620C Sweep Oscillator Frame $550.00
HP 86222A RF Plug-in, ... $1,000.00
10-2400 MHz, +13 dBm levelled
HP 86222B RF Plug-in, 10-2400 MHz, ... $1,200.00
+13 dBm lvld., crystal markers
HP 86222B-002 RF Plug-in, ... $1,350.00
10-2400 MHz, +13 dBm lvld., 70 dB step att.
HP 86222B-E69/8620C Sweep Oscillator, ... $1,500.00
0.01-2 GHz & 2-4 GHz, +10 dBm, w/frame
HP 86230B RF Plug-in, 1.8-4.2 GHz, +10 dBm unlevelled $375.00
HP 86241A-001 RF Plug-in, 3.2-6.5 GHz, +8 dBm levelled $300.00
HP 86260A-H04 RF Plug-in, ... $500.00
10.0-15.0 GHz, +10 dBm unlevelled
HP 86290C RF Plug-in, 2.0-18.6 GHz, ... $1,850.00
+13 dBm levelled output
WAVETEK 962 Sweep Generator, ... $950.00
1.0-4.0 GHz, markers, +12 dBm unlvld.

POWER METERS

BOONTON 42B/41-4E Analog Power $450.00
Meter, with 1 MHz-18 GHz sensor
HP 432A/478A Power Meter, ... $300.00
-30 to +10 dBm, 10 MHz-10 GHz
HP 435B/8481A Power Meter, ... $900.00
-30 to +20 dBm, 10 MHz-18 GHz
HP 435B/8482B Power Meter, ... $1,500.00
0 to +43 dBm, 100 kHz-4.2 GHz
HP 435B/8482H Power Meter, ... $900.00
-10 to +34 dBm, 100 kHz-4.2 GHz
HP 436A-022/8481A Power Meter, ... $1,200.00
-30 to +20 dBm, 10 MHz-18 GHz, HPIB
HP 436A-022/8484A Power Meter, ... $1,200.00
-70 to -20 dBm, 10 MHz-18 GHz, HPIB
HP 437B/8481D Power Meter, ... $2,200.00
-70 to -20 dBm, 10 MHz-18 GHz, HPIB
HP Q8486A Power Sensor, ... $1,200.00
33.0-50.0 GHz, WR22, for 435/6/7/8
HP R8486A WR28 Power Sensor, ... $1,500.00
26.5-40 GHz, for HP 435/6/7/8

RF MILLIVOLTMETERS

BOONTON 92C RF Millivoltmeter, ... $500.00
3 mV-3 V f.s., 10 kHz-1.2 GHz
RACAL-DANA 9303 RF Millivoltmeter, ... $750.00
10 kHz-2 GHz, -70 to +20 dBm

AMPLIFIERS, MISCELLANEOUS

AMPLIFIER RESEARCH 4W1000 ..... $950.00
Amplifier, 40 dB gain, 4 Watts, 1-1000 MHz
HP 11729B-003 Carrier Noise Test Set, 5 MHz-3.2 GHz $2,250.00
HP 415E SWR Meter $200.00
HP 8406A Comb Generator, ... $500.00
1/ 10/ 100 MHz increments, to 5 GHz
HP 8447A Amplifier, 20 dB, ... $375.00
0.1-400 MHz, 5 dB NF, +6 dBm output
HP 8447E Amplifier, 22 dB, 0.1-1300 MHz, +13 dBm output $750.00
HP 8901A Modulation Analyzer, 150 kHz-1300 MHz $1,500.00
HP 8901B-1,2,3 Modulation An., ... $2,000.00
0.15-1300 MHz, rear input, OCXO, ext.LO
HUGHES 1177H01F000 TWT Amplifier, ... $1,750.00
>30 dB gain, 2-4 GHz, 10 Watts output
HUGHES 1177H10F000 TWT Amplifier, ... $2,500.00
>30 dB gain, 1.4-2.4 GHz, 20 Watts
HUGHES 8010H13F000 TWT Amplifier, ... $2,500.00
>30 dB gain, 3-8 GHz, 10 Watts
RF POWER LABS ML50 Amplifier, ... $275.00
2-30 MHz, 47 dB gain, 50 Watts, metered, 28V
ROHDE & SCHWARTZ ESH2 Test Receiver, 9 kHz-30 MHz $3,750.00

COAXIAL & WAVEGUIDE

AEROWAVE 28-3000/10 WR28 Directional $300.00
Coupler, 10 dB, 26.5-40 GHz
AMERICAN NUCLEONICS AM-432 ..... $95.00
Cavity Backed Spiral Antenna,LHC, 2-18 GHz,TNC(f) *NEW*
AVANTEK AMT-400X2 WR28 Active Doubler, ... $450.00
+10 dBm in/ +10 dBm out 26-40 GHz
BIRD 6735-300 1 kW Load, ... $650.00
25-1000 MHz, LC(f), with wattmeter
BIRD 8201 500 Watt Oil Dielectric Load, DC-2.5 GHz, N(f) $350.00
FXR/MICROLAB S3-02N Triple $125.00
Stub Tuner, 200-1000 MHz, 100 Watts max., N(m/f)
FXR/MICROLAB SL-03N Stub Stretcher, ... $75.00
0.3-6.0 GHz, 100 Watts max., N(m/f)
GR 874-LTL Constant Impedance $400.00
Trombone Line, 0-44 cm, DC-2 GHz
HP 11590A-001 Bias Network, 1.0-18.0 GHz, APC7 ..... $450.00
HP 11636A 2-Way Power Divider, DC-18 GHz, N(m/f/f) $300.00
HP 11691D-001 Directional Coupler, ... $450.00
22 dB, 2-18 GHz, N(f)-all ports
HP 11692D Dual Directional Coupler, 22 dB, 2-18 GHz $800.00
HP 33321K Programmable Step $475.00
Atten., 0-70 dB, DC-26.5 GHz, 3.5mm
HP 33327L-006 Programmable Step $1,000.00
Attenuator, 0-70 dB, DC-40 GHz, 2.9mm
HP 774D Dual Directional Coupler, 20 dB, 215-450 MHz $275.00
HP 776D Dual Directional Coupler, 20 dB, 940-1900 MHz $275.00
HP 777D Dual Directional Coupler, 20 dB, 1.9-4.1 GHz $275.00
HP 778D-011 Dual Dir. Coupler, ... $450.00
20 dB, 100-2000 MHz, APC7 test port
HP 8431A 2-4 GHz Band Pass Filter, N(m/f) $150.00
HP 8494G-002 Programmable Step $350.00
Attenuator, 0-11 dB, DC-4 GHz, SMA
HP 8496A-002 Step Attenuator, ... $375.00
0-110 dB, DC-4 GHz, SMA
HP 8497K-004 Programmable Step $750.00
Attenuator, 0-90 dB, DC-26.5 GHz
HP K422A WR42 Flat Broadband $350.00
Detector, 18.0-26.5 GHz
HP K532A WR42 Frequency Meter, 18.0-26.5 GHz $450.00
HP K752D WR42 Directional Coupler, ... $450.00
20 dB, 18.0-26.5 GHz
HP K870A WR42 Slide $275.00
Screw Tuner, 18.0-26.5 GHz
HP K914B WR42 Moving Load, 18.0-26.5 GHz $300.00
HP Q752D WR22 Directional $650.00
Coupler, 20 dB, 33-50 GHz
HP R382A WR28 Direct Reading $2,250.00
Attenuator, 0-50 dB, 26.5-40 GHz
HP R422A WR28 Crystal Detector, 26.5-40 GHz $400.00
HP R752D WR28 Directional Coupler, ... $450.00
20 dB, 26.5-40 GHz
HP R914B WR28 Moving Load, 26.5-40 GHz $250.00
HP V365A WR15 Isolator, 25 dB, 50-75 GHz $750.00
HP V752D WR15 Directional $650.00
Coupler, 20 dB, 50-75 GHz
HP X870A WR90 Slide Screw Tuner $150.00
HUGHES 45322H-1110/1120 ..... $350.00
WR22 Directional Couplers, 10 or 20 dB, 33-50 GHz
HUGHES 45712H-1000 WR22 ..... $750.00
Frequency Meter, 33-50 GHz
HUGHES 45714H-1000 WR15 ..... $900.00
Frequency Meter, 50-75 GHz
HUGHES 45721H-2000 WR28 ..... $1,000.00
Direct Reading Attenuator, 0-50 dB, 26.5-40 GHz
HUGHES 45722H-1000 WR22 ..... $1,000.00
Direct Reading Attenuator, 0-50 dB, 33-50 GHz
HUGHES 45724H-1000 WR15 ..... $1,000.00
Direct Reading Attenuator, 0-50 dB, 50-75 GHz
HUGHES 45732H-1200 WR22 Level Set $250.00
Attenuator, 0-25 dB, 33-50 GHz
HUGHES 45752H-1000 WR22 ..... $1,400.00
Direct Reading Phase Shifter, 0-360 deg.,33-50 GHz
HUGHES 45772H-1100 WR22 Thermistor $400.00
Mount, -20 to +10 dBm, 33-50 GHz
HUGHES 45773H-1100 WR19 Thermistor $650.00
Mount, -20 to +10 dBm, 40-60 GHz
HUGHES 45774H-1100 WR15 Thermistor $750.00
Mount, -20 to +10 dBm, 50-75 GHz
HUGHES 47316H-1111 WR10 Tuneable $600.00
Detector, 75-110 GHz, positive polarity
HUGHES 47741H-2310 WR28 Phase $2,000.00
Locked Gunn Osc., 32.000 GHz, +18 dBm
HUGHES 47742H-1210 WR22 Phase $2,750.00
Locked Gunn Osc., 42.000 GHz, +18 dBm
KRYTAR 201020010 Directional Detector, ... $200.00
1-20 GHz, SMA(f/f)/SMC
KRYTAR 2616S Directional Detector, ... $200.00
1.7-26.5 GHz, K(f/m)/SMC
M/A-COM 3-19-300/10 WR19 ..... $450.00
Directional Coupler, 10 dB, 40-60 GHz
MICA C-121S06 Circulator, ... $75.00
17.5-24.5 GHz, SMA(f/m/m)
MINI-CIRCUITS ZFDC-20-4 ..... $25.00
Directional Coupler, 19.5 dB, 1-1000 MHz, SMA(f)
NARDA 3000-SERIES Directional Couplers $150.00
NARDA 3020A Bi-Directional Coupler, 50-1000 MHz, N $475.00
NARDA 3024 Bi-Directional Coupler, 20 dB, 4-8 GHz $375.00
NARDA 3090-SERIES $225.00
Precision High Directivity Couplers
NARDA 368BNM Coaxial High Power Load, ... $500.00
500 Watts, 2.0-18 GHz, N(m)
NARDA 3752 Coaxial Phase Shifter, ... $1,000.00
0-180 deg./GHz, 1-5 GHz
NARDA 3753B Coaxial Phase Shifter, ... $1,000.00
0-55 deg./GHz, 3.5-12.4 GHz
NARDA 4000-SERIES $75.00
SMA Miniature Directional Couplers
NARDA 4226-10 Directional Coupler, ... $275.00
10 dB, 0.5-18.0 GHz, SMA(f)
NARDA 4227-16 Directional Coupler, ... $325.00
16 dB, 1.7-26.5 GHz, 3.5mm(f)
NARDA 4242-20 Directional Coupler, ... $100.00
20 dB, 0.5-2.0 GHz, SMA(f)
NARDA 4247-20 Directional Coupler, ... $200.00
20 dB, 6.0-26.5 GHz, 3.5mm(f)
NARDA 4247B-10 Directional Coupler, ... $200.00
10 dB, 6.0-26.5 GHz, 3.5mm(f)
NARDA 5070-SERIES Precision $300.00
Reflectometer Couplers
NARDA 562 DC Block, 10 MHz-12.4 GHz, ... $65.00
100 V max., N(m/f)
NARDA 765-10 10 dB Attenuator, ... $165.00
50 Watts, DC-5 GHz, N(m/f)
NARDA 791FM Variable Attenuator, ... $600.00
0-37 dB, 2.0-12.4 GHz
NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz $375.00
NARDA 794FM Direct Reading Variable $375.00
Attenuator, 0-40 dB, 4-8 GHz
OMNI-SPECTRA 2085-6010-00 ..... $50.00
Crystal Detector, 1-18 GHz, negative polarity, SMA(m/f)
PAMTECH KYG1014 WR42 Junction $250.00
Circulator, 18.0-26.5 GHz
SONOMA SCIENTIFIC 21A3 WR42 ..... $75.00
Circulator, 20 dB, 20.6-24.8 GHz
TEKTRONIX 2701 Step Attenuator, ... $175.00
0-79 dB, DC-1 GHz, AC or DC coupled
TRG B510 WR22 Direct Reading Attenuator, ... $900.00
0-50 dB, 33-50 GHz
TRG V510 WR15 Direct Reading $900.00
Attenuator, 0-50 dB, 50-75 GHz
TRG V551 WR15 Frequency Meter, 50-75 GHz $600.00
TRG W510 WR10 Direct Reading $1,000.00
Attenuator, 0-50 dB, 75-110 GHz
TRG W551 WR10 Frequency Meter, 75-110 GHz $750.00
WAVELINE 100080 WR28 ..... $200.00
Terminated Crossguide Coupler, 30 dB
WEINSCHEL 150-110 Programmable $450.00
Step Attenuator, 0-110 dB, DC-18 GHz, SMA
WEINSCHEL DS109 Double $150.00
Stub Tuner, 1-13 GHz, N(m/f)
WEINSCHEL DS109LL Double $150.00
Stub Tuner, 0.2-2.0 GHz, N(m/f)
HP 3780A Pattern Generator / $850.00
Error Detector, 1 kb/s - 50 Mb/s

COMMUNICATIONS

HP 4935A Transmission Impairment Measuring Set $600.00
HP 59401A HPIB Bus Analyzer $375.00
MICRODYNE 1200MR 215-320 MHz $450.00
Telemetry Receiver, PSK demodulation
TEK 1410R NTSC Gen., w/SPG2 sync. $800.00
generator, TSG7 color bars
TEK 1411R PAL Gen.,w/SPG12 sync; $750.00
TSG11 color bars;TSG13 linearity
TEK 1411R PAL Test Gen., ... $1,000.00
w/SPG12,TSG11,TSG13,TSG15,TSG16
TEK 1411R PAL Test Gen., ... $1,100.00
w/SPG12,TSG11,TSG12,TSG13,TSG15,TSG16
TEK 1411R-opt.04 PAL Test Gen.,w/
SPG12,TSG11,TSP11,TSG13,TSG15,TSG16 ..... $1,400.00
TEK 147A NTSC Test Signal Generator, ... $800.00
with noise test signal
TEK 148 PAL Insertion Test Signal Generator $700.00
TEK 520A NTSC Vectorscope $750.00
TEK 521A PAL Vectorscope $750.00

MISCELLANEOUS

EG&G / P.A.R. 5302 / 5316 ..... $2,250.00
Lock-in Amplifier, 100 mHz-1 MHz, GPIB / RS232C
FLUKE 2180A RTD Digital Thermometer $500.00
P.A.R. 5206-95,98 Two-Phase $1,500.00
Lock-in Amp., 2 Hz-100 kHz, GPIB
TEK TM5006 5000-series 6-slot $500.00
Programmable Power Module
TEK TM504 500-series 4-slot Power Module $175.00
TEK TM506 500-series 6-slot Power Module $250.00
TEK TM515 500-series 5-slot Traveller Power Module $250.00

Write in 96 on Reader Service Card.

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.

Complimentary issues are available upon request for distribution to your attendees. A street address for UPS is required.

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.

All listing information should be sent to:
Nuts & Volts Magazine
Events Calendar
430 Princeland Court
Corona, CA 92879
Phone 909-371-8497
Fax 909-371-3052
E-mail events@nutsvolts.com

OCTOBER 2000

October 1

IA - WEST LIBERTY - Hamfest. Muscatine County Fairgrounds. VE Exams. Talk-in: 146.31/91, 146.25/85, 146.52 local. Muscatine ARC & IA City ARC, Steve Fowler KA9AQR, 309-537-3678. Email: sfowler@winco.net Web: http://www.qsl.net/kc0aqs/hamfest.html
IL - DECATUR - Hamfest. Cenois ARC, Spencer Carter N9LVW, 217-692-2460. Email: n9lvw@msn.com Web: http://members.tripod.com/btdad/hamfest_y2k.html
IN - BEDFORD - Hamfest. Lawrence County 4-H Fairgrounds. Hoosier Hills Ham Club, John Scheiwe KB9LTI, 812-279-0050. Email: chairman@hoosierhillshamfest.org Web: http://www.hoosierhillshamfest.org
PA - WRIGHTSTOWN - Hamfest. Middletown Grange Fairgrounds, Penns Park Rd. Pack Rats, Joe Keer KU3T, Email: ku3t@amsat.org Web: http://www.ij.net/packrats
WA - CHEHALIS - Hamfest. The Southwest Washington Fairgrounds. Talk-in: 147.06+ PL 110.9, 146.46 simplex. Chehalis Valley ARS, James Kruger KK7AB, 360-748-1930. Email: teaser@localaccess.com Web: http://www2.localaccess.com/teaser/cvars/

October 6-7

NH - ROCHESTER - Hamfest. Fairgrounds. Hoss Traders, Joe Demaso K1RQG, 207-469-3492. Email: k1rqg@aol.com Web: http://www.qsl.net/k1rqg

October 6-7-8

AZ - SCOTTSDALE - Southwestern Div. Convention. Ramada Inn Valley Ho, 6850 Main St. Scottsdale ARC, Walt Schuknecht N7IZM, 480-947-0338. Email: n7izm@arrl.net Web: http://www.w7asc.org/swdc2000
OK - BROKEN ARROW - Hamfest. Broken Arrow ARC, Joe Horn KC5VPO, 918-451-0028. Web: http://www.qsl.net/w5bbs/hamfest

October 7

FL - ORLANDO - Hamfest. Bahia Temple, 2300 Prembrook Dr. Talk-in: 147.390. Ed KY4E, 407-660-0936. Email: y4e@excite.com
MO - WARRENSBURG - Hamfest. Warrensburg Area ARC, Denise Haye N0PVS, 816-697-3426. Email: we0g@microlink.net Web: http://www.call.to/waarci
NJ - TEANECK - Hamfest. Fairleigh Dickinson University. 8am-2pm. FCC Exams. Talk-in: 146.19/79 and 146.52 simplex. Bergen ARA, Jim Joyce K2ZO, 201-664-6725. Email: jjjoyce@cybernex.net Web: http://www.bara.org
PA - LANCASTER COUNTY - Hamfest. West Earl Community Park, Rt. 772. 8am-2pm. Talk-in: 147.015 PL 118.8. Red Rose Repeater Assn., Pat Bouder KA3FGH, 717-626-7539. Email: rbouder-pat@redrose.net
SC - ROCK HILL - Hamfest. York County ARS, Bob Good K4BG, 803-327-9855. Email: k4bg@cetlink.net
TN - SEVIERVILLE - Hamfest. Ten-Tec, Inc., Scott Robbins W4PA, 865-453-7172. Email: sales@tentec.com
TX - BELTON - Hamfest. Bell County Expo Center. Talk-in: 146.820-, PL 123.0. Temple ARC, Mike LeFan WA5EQQ, 254-773-3590. Email: hamexpo@tarc.org Web: http://www.tarc.org

October 8

CT - WALLINGFORD - State Convention. Mountainside Special Event Facility. 9am-3pm. Talk-in: 147.36/96. Nutmeg Hamfest Alliance, Gordon Barker K1BIY, 860-342-3258. Email: k1biy@juno.com Web: http://www.qsl.net/nutmeghamfest
IL - OAKBROOK TERRACE- Hamfest. Entrance at Park View Dr. 8am-1pm. Chicago ARC, George 773-545-3622. Dean 708-331-7764
MD - WEST FRIENDSHIP - Hamfest. Howard County Fairgrounds, Rt. 144. 8am-3:30pm. Talk-in: 147.135/R+. Columbia ARA, Randy Krenz N3HFK, 410-796-2587. Email: n3hfk@arrl.net Web: http://www.qsl.net/cara
MI - DIMONDALE - Hamfest. The Summit, 9410 Davis Hwy. 8am-2pm. VE testing. Talk-in: 145.390 (-600) and 146.520. Central MI ARC & Lansing Civil Defense Repeater Assn., J. Ervin Bates W8ERV, 517-676-2710. Email: w8erv@arrl.net Web: http://www.qsl.net/CMARC/hamfair.html
OH - MEDINA - Hamfest. National Guard Armory, 920 Lafayette Rd. 8am-2pm. Medina Two Meter Group, Michael Rubaszewski N8TZY, 330-273-1519. Email: n8tzy@webcombo.net Web: http://www.qsl.net/m2m

October 13-14

AR - SPRINGDALE - Hamfest. Northwest AR ARC, Richard Naylor K5LRS, 501-442-8932. Email: k5lrs@aol.com
FL - WALDO - Hamfest. Dixieland Music Park. Talk-in: 145.150-. Bradford Area ARC, John Bradley KU4AY, 904-782-1185. Email: jbradley@techcomm.net Web: http://www.angelfire.com/fl/arcba/index.html

October 14

CA - FONTANA - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves
FL - TAMPA - Hamfest. Egypt Temple Complex, 4050 Dana Shores Dr. 8am-5pm. Talk-in: 146.940. Egypt Shrine Temple AR, Jay Strom K9BSL, 727-822-9107. Email: k9bsl@juno.com
GA - AUGUSTA - Hamfest. Westside High School. 9am-3pm. Talk-in: 145.490. ARC of Augusta, Henry KN4AV, 706-793-1625. Email: kn4av@bellsouth.net or w4dv@arrl.net
ME - ELLSWORTH - Symposium. Phil Duggan N1EP, 207-546-7028. Email: n1ep@yahoo.com
MT - BOZEMAN - Hamfest. Gallatin Ham RC, Don Wilson KC7EWZ, 406-586-6659. Email: nandon@mcn.net
ND - GRAND FORKS - Hamfest. Forks ARC, Steve DuFault KB0QQE, 218-281-7875. Email: kb0qqe@rrv.net
NJ - LEONARDO - Hamfest. Croydon Hall. VE testing. Talk-in: 145.485 -6, 151.4. Garden State ARA, Mario Sellitti N2PVP, 732-787-7184. Email: gsara@arrl.net Web: http://www.monmouth.com/~gsara
TX - DENTON - North Texas Section Convention. Denton Civic Center, 321 E. McKinney St. 7am-3pm. Talk-in: 146.92 (PL 110.9). Denton County ARA, William Spradling WA5I, 817-441-1170. Email: wa5i@aol.com Web: http://www.dmathis@lsic.net
VA - STAFFORD - Hamfest. Mt. Ararat Baptist Church parking lot. 8am-3pm. Talk-in: 145.27. Stafford ARA, Richard Diddams KF6UTH, 540-657-8322. Email: rldiddams@earthlink.net Web: http://www.n4nw.org
WA - BREMERTON - Hamfest. County Fairgrounds, President's Hall, NW corner of Fairgrounds Rd. at Nels Nelson Rd. 9am-2pm. Talk-in: 146.620- 103.5, 146.520 simplex. North Kitsap ARC, Susan Johnson AB7MD, 360-697-9379. Email: nkarc@yahoo.com Web: http://www.silverlink.net/nkarc

October 15

MA - CAMBRIDGE - Flea at MIT. Albany and Main Sts. 9am-2pm. Talk-in: 146.52 & 449.725/444.725 W1XM/R PL 114.8 (2A). Nick Altenbernd KA1MQX, 617-253-3776 (9-5). Web: http://web.mit.edu/w1mx/www/swapfest.html
MI - KALAMAZOO - Hamfest. Kalamazoo County Fairgrounds. VE Testing. Talk-in: 147.040. Kalamazoo ARC & Southwest Michigan AR Team, Charlie Burgstahler K8BLO. Email: charlieb@net-link.net Web: http://www.qsl.net/k8blo/hamfest.htm
NY - QUEENS - Hamfest. NY Hall of Science parking lot, Flushing Meadow Corona Park, 47-01 111th St. VE exams. Talk-in: 444.200 repeat, PL 136.5, 146.52 simplex. The Hall of Science ARC, Stephen Greenbaum WB2KDG, 718-898-5599, eves only. Email: WB2KDG@Bigfoot.com or Andy Borrok N2TZX, 718-291-2561. Email: N2TZX@webspan.net
OH - ASHLAND - Hamfest. Ashland Area ARC, David Fike N8UCA, 419-289-1082. Email: aaarc@neo.rr.com
OH - LIMA - Hamfest. Northwest Ohio ARC, Greg Schwark N8WBD, 419-647-6321 or 419-647-5127. Email: gas1950@aol.com

October 19

NC - BURLINGTON - Swapmeet. 2058 Carolina Mill Rd. 9am-4pm. Email: info@gosam.com Web: www.gosam.com

October 20-21-22

CA - CONCORD - Pacific Division Convention. Sheraton Concord (Airport) Hotel. Mt. Diablo ARC, Terry Matzkin KE6WRE, 925-820-5848. Web: http://www.pacificon.org

October 21

CT - WATERFORD - Auction. Senior Citizens Center, Waterford Municipal Complex, Rt. 85. Talk-in: 146.97. Tri-City ARC, Austin J. Wolfe AA1SV, 860-443-2459. Email: aa1sv@downcity.net
FL - PALM BEACH GARDENS - Hamfest. Palm Beach Repeater Assn., Ken Summerell KD4CTG, 561-640-9447. Email: kd4ctg@freewwweb.com
IL - GODFREY - Hamfest. Lewis & Clark RC, Larry Roberts W9MXC, 314-233-3499. Email: lhrob@home.com
LA - LAKE CHARLES - Hamfest. Lake Charles SW LA ARC, Joe Czejkowski WE5V, 337-855-9202. Email: joeczejk@juno.com
MO - GRANDVIEW - Hamfest. South Side ARC, Donna Quick KB0YJN, 816-537-7464. Email: kb0yjn@juno.com Web: http://www.qsl.net/southsidearc/
NH - NASHUA - Hamfest. Res Ctr Church. NE Antique RC 617-923-2665
OR - RICKREALL - Convention. Polk County Fairgrounds. 9am-3:30pm. Talk-in: 146.86. Mid-Valley ARES, Bud Smith WA7FJF 503-838-0266. Email: wa7fjf@arrl.net Web: http://www.teleport.com/~n7ifj/swaptobe.htm
PA - SUNBURY - Hamfest. Sunbury

COMPUTER SHOWS

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

Blue Star Productions
612-788-1901.
http://www.supercomputersale.com

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

Computer Central Shows
847-412-1900 & 1-888-296-6066.
E-Mail: compcent@megsinet.net
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

Georgia Mountain Productions
706-838-4827.
E-Mail: gamtnpro@blrg.tds.net
georgiamountain.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

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

Armory, Catawissa Ave. 8am-3pm. Talk-in: 147.270 and 146.250 simplex. Susquehanna Valley ARC, David Welker K3SI, 570-286-0787. Email: k3si@hot mail.com Web: http://avs.epix.net/svarc/
TN - GRAY - Hamfest. Appalachian Fairgrounds, off I-181. Kingsport, Bristol, and Johnson City Radio Clubs, Wendell Messimer K4ZHK, POB 3682 CRS, Johnson City, TN 37602

October 22

MD - WESTMINSTER - Hamfest. Carroll County Agricultural Center. Talk-in: 145.410(-). The Carroll County ARC, Inc., Email: w3jjh@arrl.net
Web: http://www.qis.net/~k3pzn
MI - WARREN - Hamfest. Italian American Cultural Center, 28111 Imperial Dr. 8am-1pm. VE Testing. Talk-in: 147.180+/ PL 100 Hz. Utica Shelby Emergency Communications Assn., Dave Cunningham KC8IAQ, 810-263-0227.
Email: kc8iaq@att.net Web: http://mem bers.home.net/dougk/useca.htm
NY - FARMINGDALE - Hamfest. Radio Central ARC, Neil Heft KC2KY, 631-737-0019. Email: nheft@attglobal.net
Web: http://www.rcarc.org/expo.htm
PA - SELLERSVILLE - Hamfest. Sellersville Fire House, Rt. 152. VE Session. Talk-in: 145.31. RF Hill ARC, Linda Erdman KA3TJZ, 215-679-5764.
Web: http://www.rfhill.ampr.org

October 27-28

OK - KINGSTON - Hamfest. Lake Texoma Lodge, Hwy. 70. Texoma Hamarama Assn., Herb Sleeper WB5PHM, 940-855-5820.
Email: retmarine@cst.net

October 28

CANADA - QUEBEC - MONTREAL - Hamfest. Montreal South ARC, Micheline Simard VE2XW, 450-446-0477.
Email: ve2xw@amsat.org
FL - JACKSONVILLE - Hamfest. Morocco Shrine Auditorium, 3800 S. St. Johns Bluff Rd. 9am-9pm. Talk-in: 146.76 and 146.88. Greater Jacksonville Hamfest Assn., Jeff Greer WD4ET, 904-613-7427 or Deborah Lusk KG4ADZ, 904-739-9713.
Web: http://www.se.mediaone.net/~lric h/JAXHAMFEST.html
MN - ST. PAUL - Hamfest. RiverCentre. 8am-4pm. VE exams. Twin Cities FM Club, Amanda Roberts KG0AY, 612-535-0637.
Email: kg0ay@pclink.com
Web: http://www.hamfestmn.org
MO - ST. LOUIS - Hamfest. Kirkwood Community Center, 111 N. Geyer Rd. 8am-2pm. VE exams. Talk-in: 146.91-. St. Louis ARC & Gateway to Ham RC, Steve Welton WB0IUN, 314-638-4959.
Email: slw@partyline.net
SC - SUMTER - Hamfest. Sumter ARA, Thomas D'Anella KC4ZTC, 803-499-4806.
Email: dstoy@sumter.net Web: http://www.geocities.com/capecanave ral/2695/sara.htm
TN - EAST RIDGE - Hamfest. Camp Jordan Arena. 8am-4pm. VE exams. Talk-in: 146.79- & 444.1+. Chattanooga ARC, David Hoffman KE4FGW, 423-877-7398. Email: ke4fgw@vol.com Web: http://www.qsl.ne t/w4am/carc_index.html

October 28-29

FL - UMATILLA - Hamfest. Olde Mill Stream RV Resort, 1000 N. Central Ave. VE Exams. Talk-in: 147.255. Lake ARA, Chuck Crittenden KE4EXM, 352-669-2075.
Email: capias@gate.net
TX - EL PASO - Int'l Hamfiesta. Clay Emert K5TRW, 915-859-5502

October 29

IA - DES MOINES - Hamfest. Tikva Tracers ARC & Iowa Assn., of ARCs, Rod Ivers KI0BW, 515-276-0500 or 515-278-9945.
Email: ki0bw@arrl.net
NY - LINDENHURST - Hamfest. Knights of Columbus Hall, 400 S. Broadway. 9am-2pm. GSBARC & SCRC, Lenore Dunlop N2KYP, 516-785-0826.
Email: info@gsbarc.org
Web: http://www.gsbarc.org
OH - CANTON - Hamfest. Stark County Fairgrounds. Talk-in: 147.18+. The Massillon ARC.
Email: marc.hamclub@juno.com
Web: www.qsl.net/w8np
OH - MARION - Hamfest. Marion ARC, Karen Eckard N8KE, 740-499-3565.
Email: meeker@gte.net
PA - CARLISLE - Hamfest. Carlisle Fairgrounds. 8am-3pm. Talk-in: 145.430. South Mountain Repeater Assn., Bill Smyser, 717-532-9870.
Email: smraham@aol.com
Web: www.qsl.net/kb3cvo

NOVEMBER 2000

November 4

FL - SORRENTO - Hamfest. Lake ARA, John Gable W8KCE, 352-394-2723.
Email: w8kce@aol.com
NH - LONDONDERRY - Hamfest. Londonderry Lions Club, Mammoth Rd. Talk-in: 146.850. The Interstate Repeater Society ARC, Paul 603-883-3308.
Email: Harold@neainc.com
NJ - LAWRENCEVILLE - Hamfest. Lawrence High School, 2525 Princeton Pike. 8am-1pm. VE exams. Talk-in: 146.670, PL 131.8. Delaware Valley RA, 609-882-2240. Email: w2zq@arrl.net Web: www.slac.com/w2zq
NM - SOCORRO - Hamfest. Socorro ARA, Tech ARA, & City of Socorro, Al Braun AC5BX, 505-835-3370.
Email: ac5bx@juno.com
Web: http://www.ees.nmt.edu/sara/
OK - ALTUS - Hamfest. Altus Area ARA, MK Schenkel W5VXU, 580-846-5578.
Email: w5vxu@juno.com
OK - ENID - Hamfest. Garfield County Fairgrounds, Hoover Bldg. 8am-5pm. Talk-in: 147.15+, 444.40+. Enid ARC, Tom Worth N5LWT, 580-233-8473; email: n5lwt@hotmail.com or Fred Selfridge WA5OU, 580-242-3551
WA - FERNDALE - Hamfest. Mount Baker

ARC, Al Norton K7IEY,
email: k7iey@netscape.net

November 4-5

GA - LAWRENCEVILLE - Hamfest. Gwinnett County Fairgrounds. Sat: 9am-5pm, Sun: 9am-3pm. Talk-in: 145.45-(PL107.2), 444.25+ (PL131.8), 146.76-(PL107.2). Alford Memorial RC, 770-410-3989. Email: KR4NQ@bigfoot.com
Web: www.totr.radio.org

TX - ODESSA - Hamfest. Ector County Coliseum, Bldg. D, 42nd & Andrews Hwy. 8am-5pm. VE Testing. Talk-in: 145.470/444.425/HF 3.922. West TX ARC, Craig Martindale W5BU, 915-366-4521.
Email: w5bu@hotmail.com

November 5

IA - DAVENPORT - Hamfest. IA National Guard Hangar, Mt. Joy Airport. Davenport RAC, Dave Mayfield W9WRL, 309-762-6010 or 309-757-1880.
Email: hamfest@gwltd.com
Web: http://www.gwltd.com/hamfest

MA - FRAMINGHAM - Hamfest. Framingham ARA, Beverly Lees N1LOO, 508-626-2012

MI - ST. JOSEPH - Hamfest. Playland Hall. 8am-12pm. VE Testing. Talk-in: 146.82-146.72 (if 82 is down). Blossomland ARA, Duane Durflinger KX8D, 616-982-0404.
Email: comdac@comdac.com

PA - LINGLESTOWN - Hamfest. Firehall, 5901 Linglestown Rd. VE session. Talk-in: 145.47. Central PA Repeater Assn., Harold Baer KE3TM, 717-566-8895

WI - APPLETON (KAUKAUNA) - Hamfest. Starlite Club, Corner Hwy. 55 & CR JJ. VE sessions. Talk-in: 146.52. Fox Cities ARC, John Ensley N9RJZ, 920-830-3194.
Email: n9rjz@arrl.net
Web: http://www.w9zl.ampr.net

November 11

AL - MONTGOMERY - Hamfest. S. AL State Fairgrounds, Garrett Coliseum, Federal Dr. 9am-3pm. FCC Exams. Talk-in: 146.24/84. Montgomery ARC, Phil C. Salley K4OZN, 334-272-7980. Email: k4ozn@arrl.net
Web: http://jschool.troyst.edu/~w4ap/

CA - FONTANA - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves

CO - GOLDEN - Hamfest. Jefferson County Fairgrounds, 15200 W. 6th Ave. 8am-2pm. VE Testing. Talk-in: 144.62/145.22 MHz. Rocky Mountain Radio League, Inc., Ron Rose N0MQJ, 303-985-8692.
Email: n0mqj@arrl.net

FL - PORT ST. LUCIE - Hamfest. Port St. Lucie ARA, Roy Cox KT4PA, 561-340-4319.
Email: roycox@ecqual.net
Web: http://www.qsl.net/pslara

TX - AZLE - Hamfest. Tri County ARC of North TX, Jerry Buxton N0JY, 817-523-4426. Email: n0jy@arrl.net Web: http://www.qsl.net/tcarc-ntx/nctech.html

November 17-18

MS - OCEAN SPRINGS - Hamfest. West Jackson County ARC, Phil Hunsberger W9NZ, 228-872-1499.
Email: w9nzl@juno.com

November 18

FL - CORAL GABLES - Hamfest. University of Miami, Physics Parking Lot. Talk-in: 146.865. U of M ARC, Bill Moore WA4TEJ, 305-264-4465 (day).
Email: WA4TEJ@beethoven.com

LA - WEST MONROE - Hamfest. The Barak Shrine Temple. Talk-in: 146.85. Twin City Ham Club, Jim Ragsdale W5LA, 318-396-9529. Email: W5LA@hamtutor.com Web: http://www.tchams.org/users/hamfest

MA - NEWTONVILLE - Auction. Newton Masonic Hall, 460 Newtonville Ave. 11am-4pm. Talk-in: 146.64-. Waltham ARA & 1200 RC, Eliot Mayer W1MJ, 617-484-1089. Email: w1mj@amsat.org Web: http://www.wara64.org/wara/auction.htm

OH - GEORGETOWN - Hamfest. Grant ARC, Dot Silman KB8TQU, 937-446-2234.
Email: huggee@bright.net
Web: http://www.qsl.net/~n1djs

November 18-19

IN - FORT WAYNE - State Convention. Allen County War Memorial Coliseum and Exposition Center, 4000 Parnell Ave. Sat: 9am-4pm, Sun: 9am-3pm. ACARTS, James Boyer KB9IH, 219-489-6700. Email: jboyer@ail.com Web: http://www.acarts.com

November 19

NC - BENSON - Hamfest. Johnston ARS, Paul Dunn KD4BJD, 919-894-3100

November 25

FL - OCALA - Hamfest. Booster Stadium, N.E. 36th Ave. 8am-2pm. Talk-in: 146.97 or 146.61. Marion County Repeater Owners Assn. & Silver Springs RC, Mario N4TSV, 352-472-2240.
Email: n4tsv@amsat.org

IN - EVANSVILLE - Hamfest. Vanderburgh County 4-H Center Fairgrounds Auditorium. 8am-2pm. Talk-in: 145.150-Evansville 146.925- and 443.925+ Vincennes. EARS, Neil Rapp WB9VPG, 812-479-5741. Email: earsham@aol.com Web: http://members.aol.com/earsham/hamfest.htm

DECEMBER 2000

December 2

GA - CLAXTON - Hamfest. Claxton AR Emergency Service (CARES), Ellie Waters W4CJB, 912-653-4939.
Email: ellie@premierweb.net

December 2-3

FL - PALMETTO - Hamfest. Manatee County Convention and Civic Center, 1 Haben Blvd. Talk-in: 146.730. FGCARC, Jean Endicott KC4KZU, 727-525-5178.
Email: kr4yl@arrl.net
Web: http://www.fgcarc.org

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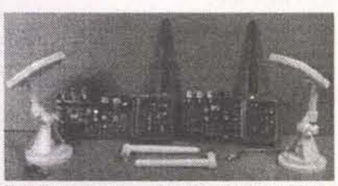

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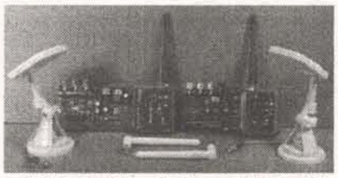

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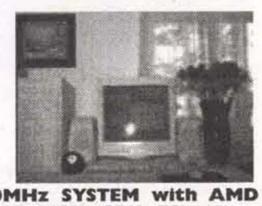

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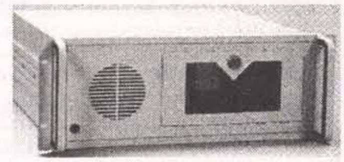

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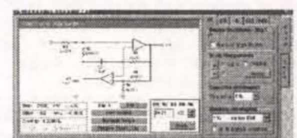

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Continued on page 56

by Fernando Garcia

Build A Model Rocket Launcher

Model rocketry is a fascinating hobby. Like many enthusiasts, I was introduced to it by a starter kit from Estes Industries. Since then, I have purchased, built, and lost literally dozens of models of all sizes. Those models come in all sizes and shapes, with all sorts of rocket motors and different impulses.

One thing has remained constant: the control launcher, shown in Photo 1, which has served me well over all these years. This is a very simple electrical device, powered by four "AA" batteries. The batteries provide the current to light up an igniter, which is basically a nichrome wire coated with a flammable mixture.

The igniter is placed inside the rocket motor, and as the battery current heats the wire and ignites the

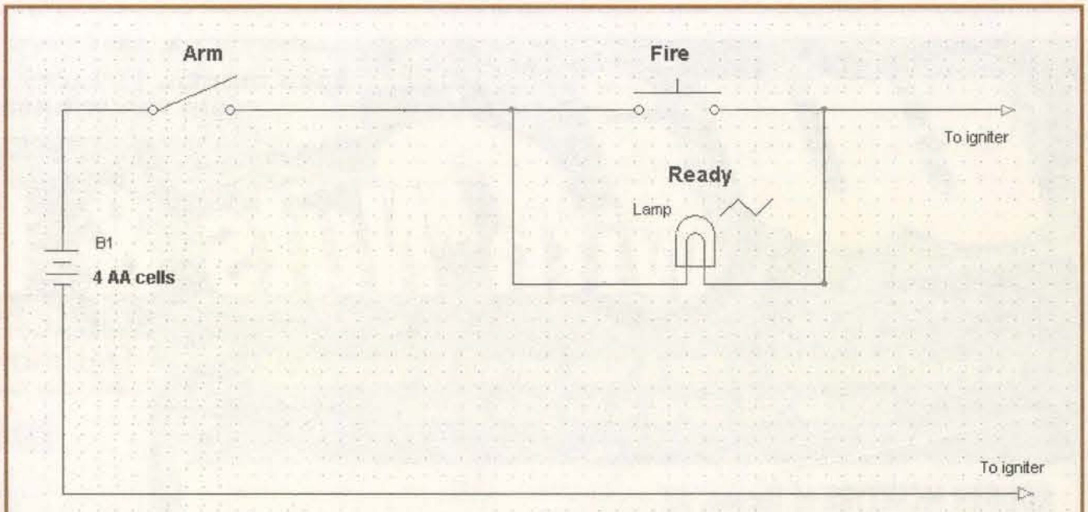


FIGURE 1: OLD CONTROLLER SCHEMATIC.

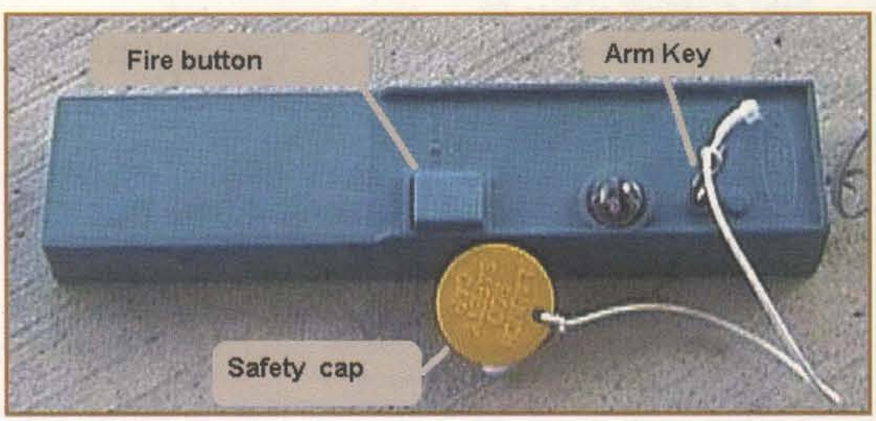


PHOTO 1: THE TRUSTY OLD ESTES CONTROLLER.

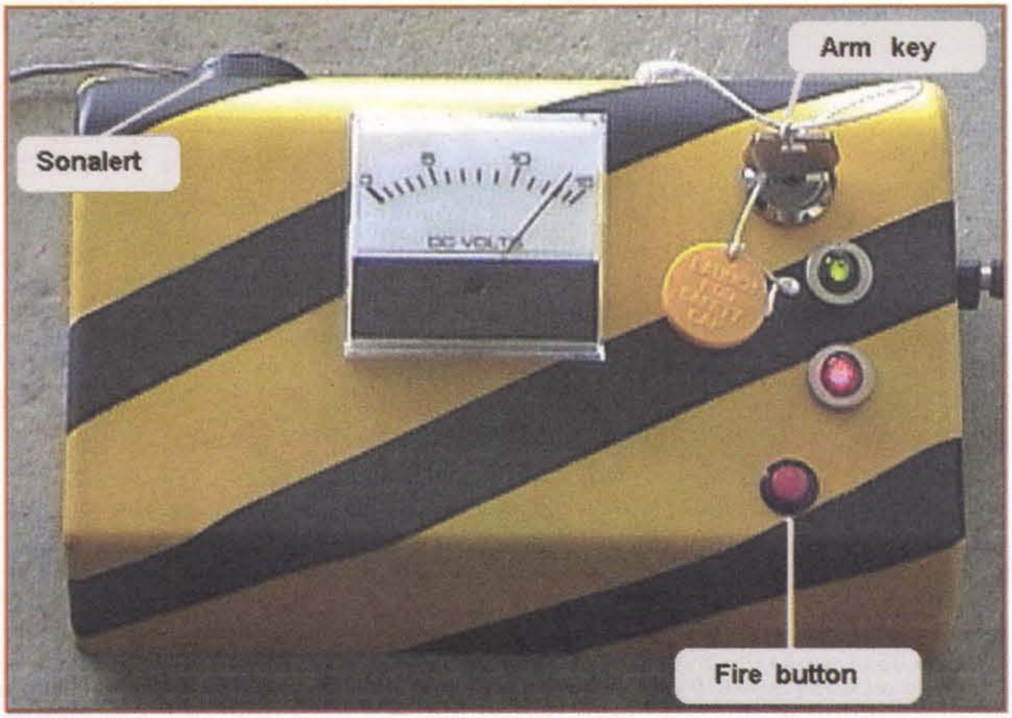


PHOTO 2: THE NEW CONTROLLER MAINTAINS THE SAFETY FEATURES.

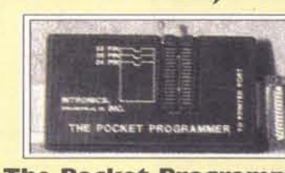
flammable mixture it, in turn, will start the solid fuel inside the motor. The rocket will then fly under the motor's impulse until its fuel is depleted.

A crucial feature of the controller is safety, and it is taken care of by the controller's "arm key" shown in the photo.

Although the motors themselves are small, they can still produce serious burns and create a fire hazard should they ignite at the wrong time. Estes solved this problem in a simple but elegant way, which can be understood by looking at the launcher schematic in Figure 1.

The key (actually a pin) removes electrical continuity, thus preventing a premature engine start as the igniter is being placed. It also has attached to it a safety cap, which is used to cover the launching rod (thus avoiding an eye accident as you work around the launch pad).

Once the rocket pyrotechnics are set, the cap is removed from the rod and everybody goes back to the launch controller, set safely a couple dozen feet away. The key is then inserted in the appropriate position,



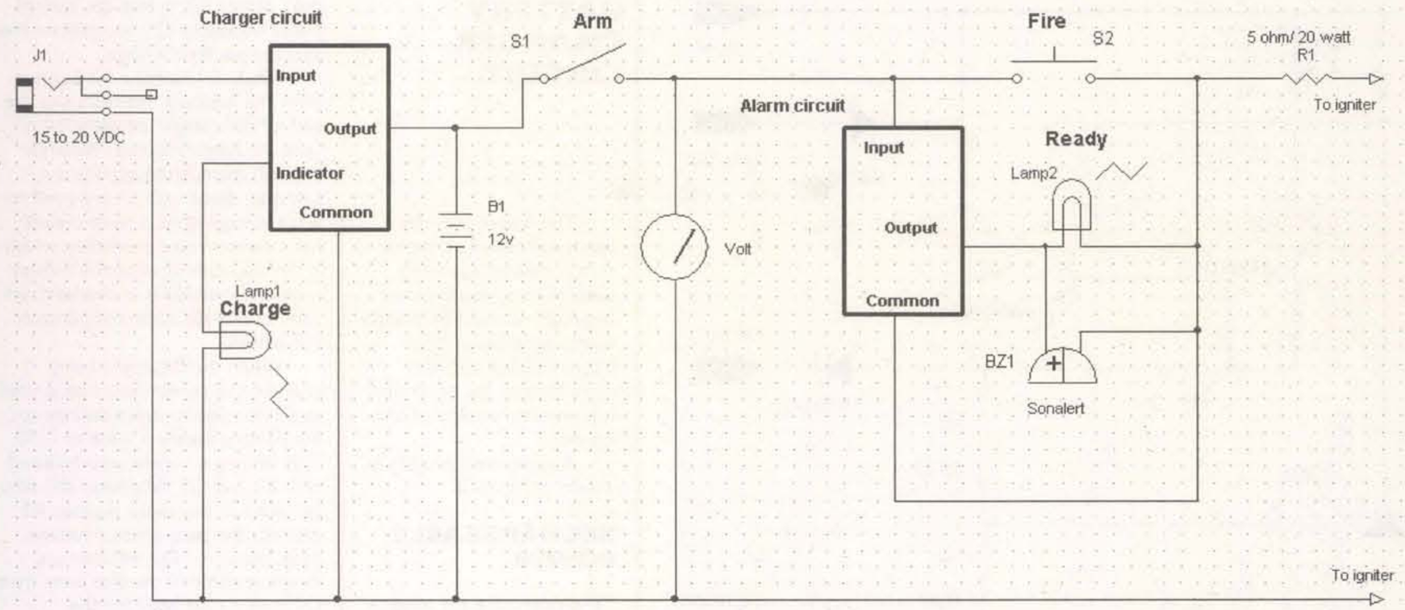


FIGURE 2: NEW CONTROLLER SCHEMATIC.

and although electrical continuity is now established, the current will still be limited by a miniature light bulb.

If the bulb fails to light up, an improper connection has been made and you have to remove the key and go back to the rocket to fix it. If the bulb is brightly lit, all systems are go. As you press the push button, the bulb is bypassed which allows the full battery current to light up the igniter, and hopefully you'll enjoy a successful launch.

Simplicity means ruggedness, but over many years of usage, the original launcher has become intermittent and a replacement has become necessary. Trusty and reliable as it is, I believe the original launcher can be improved upon.

The first aspect has to do with the limited energy available from the AA cells. This may not be an issue for a couple of launches, but the batteries become rapidly depleted afterwards. This means carrying a dozen batteries if several launches are attempted. Worse, you are never really sure when the batteries will not have enough juice left to fire the igniter, and many duds result as a consequence.

The second aspect has to deal with safety. The Estes controller is intrinsically safe, but with a crowded gathering of onlookers, it would be an added safety feature if an audible alarm sounded whenever the controller is armed and the rocket ready to be launched.

A third aspect was to employ a higher voltage than six volts, since the alligator clips that attach to the igniter become inevitably dirty from the combustion gases and thus intermittent connections are common. Thus the idea for this project, whose schematic is shown in Figure 2.

THE CIRCUIT

The basic function of the launcher remains unchanged: to safely provide a means to fire the igniter. This is, of course, achieved with the gel-cell battery. Since this battery can provide much more short circuit current than AA cells, a limiting resistor R1 provides the appropriate current level. This resistor allows the current to be set more consistently as the battery discharges. With the AA cells, the batteries' internal resistance limited the current, but this impedance varies widely as the battery is depleted.

Also seen in the circuit is the safety key. Rather than rely on a simple pin, I employed a real key operated switch. To maintain the safety feature of the original controller, it is mandatory that the key be removable only in the OFF position.

The firing switch is a normally open, momentary type push button. As in the original controller, upon firing, it bypasses the READY lamp and alarm circuit, which is described below. Being in series with the igniter, these will provide a visual and audible indication of a properly

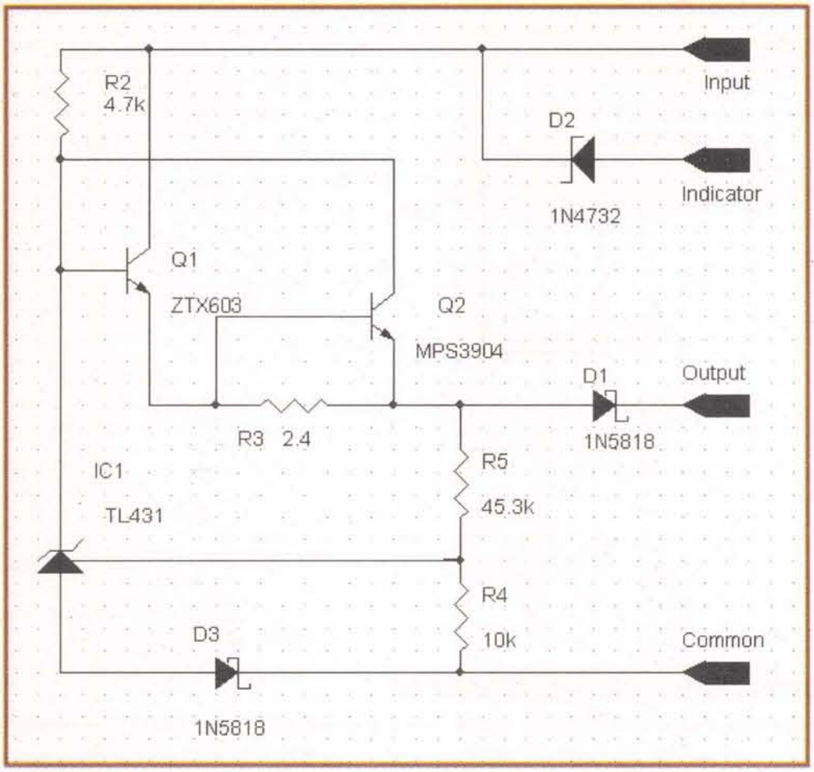


FIGURE 3: THE BATTERY CHARGER CIRCUIT.

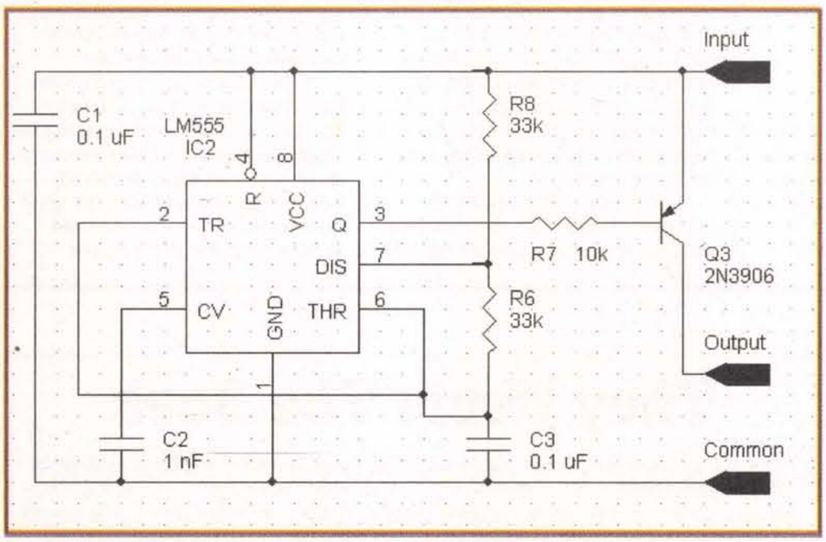


FIGURE 4: THE ALARM CIRCUIT USES A SIMPLE 555 TIMER.

armed rocket. The small current draw of the circuitry is not enough to fire the rocket.

Completing the controller circuit are two functions not included in the original controller: the charging circuit, also described below, and an optional meter.

The meter provides a handy indication of the battery condition, especially useful if many launches are expected. It could be a dedicated digital panel meter, but in keeping with the retro look of the controller, I decided to employ an analog one.

A completed project is shown in Photo 2.

RECHARGEABLE POWER

To overcome the alkaline cell limitation, a heftier power source is required, and preferably rechargeable. NiCad cells were considered, but like almost everybody else, I have had bad experiences with the memory effect of a cell fouling the capacity of the whole string. Lithium or metal-hydride are expensive, and its associated chargers complicated and usually beyond the reach of hobbyists. Thus, sealed lead gel-cell batteries were determined to be the best option. Lead-gel batteries are very rugged, relatively simple to use, and relatively inexpensive for the energy storage capacity. The only required care is to remember to recharge them if they are to be stored for extended periods of time.

The charger circuit works in constant current and constant voltage modes. The first mode is employed when the battery is fully charged, and maintains a voltage high enough to keep the battery in float mode. As shown in Figure 3, adjustable voltage reference IC1 together with feedback resistors R4 and R5, maintain the proper voltage drop across R2 to bias the base of buffer transistor Q1 to maintain the appropriate float voltage.

Diode D1 isolates the battery from the feedback resistors and the rest of the charger circuitry, otherwise the battery would discharge through them. Although this is a Schottky diode with a very small forward voltage drop, it nevertheless has a temperature coefficient which is the opposite of what the battery requires. Thus, D3 is in the feedback path to provide some temperature correction.

When the battery is being charged, the current must be limited to a safe value to avoid damage to the battery, usually a value of C/10. This limiting is simply accomplished with R3 and Q2. Whenever the voltage drop across sense resistor R3 exceeds the base-emitter voltage drop, transistor Q2 will turn on, diverting some of the bias away from Q1 until it only provides the required current. As the sense resistor is inside the feedback loop, its voltage drop is automatically compensated when the charger is operating in the voltage mode.

As shown previously, an indicator lamp lights up whenever DC power is connected to the external jack and the battery is being charged. Since the lamps are rated at 12 volts and the input voltage is higher than that, zener diode D2 is used to drop about 4.3 volts to provide a longer bulb life.

ALARM CIRCUITRY

As previously explained, an additional safety feature is incorporated in the launcher in the form of an audible alarm. No audible alarm is more attention-gathering (read obnoxious) than the Sonalert™ devices. It is also very efficient and compact.

Thus, the only addition required is a small circuit to pulse it on and off. As shown in Figure 4, this is simply accomplished with a 555 timer IC2 operating in the astable mode at a rate of about 1 Hz. Its output drives PNP transistor Q3, which actually turns on and off the Sonalert and associated lamp.

It is important to note that the alarm circuitry is in series with the igniter. Only if the igniter is connected correctly, will the alarm and "ready" indicator lamp operate, indicating that the circuit is armed and ready to fire.

BUILDING THE CIRCUIT

Before assembling the project, some words of advice: Safety first! It is beyond this short article to outline all the safety precautions when dealing with model rocketry.

PARTS LIST

CHARGER BOARD
- Q1: ZTX603 Darlington NPN transistor
- Q2: MPS3904 NPN transistor
- D1: 1N5818 Schottky diode
- D2: 1N4732 Zener diode
- D3: 1N5818 Schottky diode
- IC1: TL431 Voltage reference
- R2: 4.7K, 1/8W, 5%
- R3: 2.4, 1/2W, 5%
- R4: 10K, 1/8W, 1%
- R5: 45.3K, 1/8W, 1%

ALARM BOARD
- Q3: 2N3906 PNP transistor
- IC2: LM555 timer
- R6: 33K, 1/8W, 5%
- R7: 10K, 1/8W, 5%
- R8: 33K, 1/8W, 5%
- C1: 0.1 uF, 50V ceramic cap
- C2: 1 nF, 50V ceramic cap
- C3: 0.1 uF, 50V ceramic cap

MAIN ASSEMBLY
- J1: Input power jack
- L1: 12-volt green lamp
- L2: 12-volt red lamp
- R1: 5 ohm, 20W, 5%
- B1: 12 volt, 3 AH gel-cell battery
- S1: Key switch (see text)
- S2: Normally Open push switch
- BZ1: Sonalert buzzer
- Volt: 15 VDC voltmeter (optional)

Model rocketry is a fascinating hobby ...

PHOTO 3: THREE ... TWO ... ONE ... BLAST OFF!!

Follow the guidelines in the Estes products.

The second issue is to test the circuit prior to launching a rocket. The easiest is to attach an igniter (without the rocket engine) and see that it will light up. Then you are ready for the real thing.

The circuit is so simple that most of the components may be assembled using point-to-point wiring. The exception is on the two small boards used for the charger and alarm circuits. Here small perfboards may be employed.

It is important that you DO NOT connect the battery until all the circuitry has been wired and thoroughly checked. Due to its low impedance, a short-circuited gel-cell can produce extremely large currents. And when you do connect it, make sure that the key switch is in the off position.

Employ at least 24-gauge wire for all the connections from the battery to the igniter (which should be no less than 25 feet away from the launcher); the other connections may employ a lighter gauge.

Although you may use any type of cabinet for your project, I would recommend one that has a metal bottom cover. The reason is twofold: Current limiting resistor R1 can become pretty warm and to assist the heat dissipation, it may be cemented to the plate.

The second is that the gel-cell battery is relatively heavy, and must be securely attached to a surface that won't break loose.

Have fun! **NV**

And the winner is ...

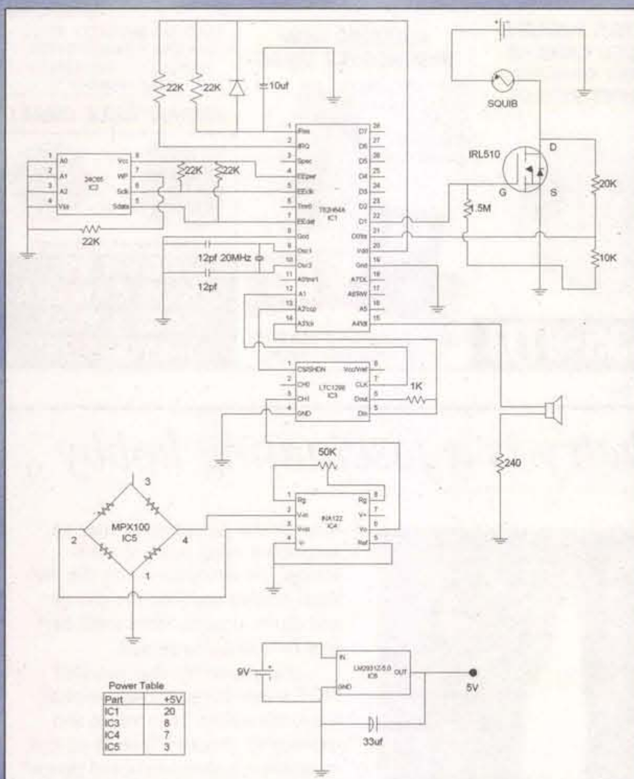
2ND PLACE

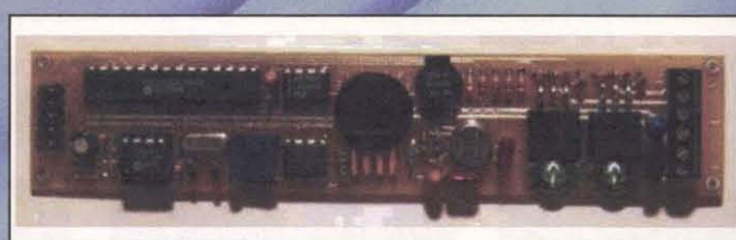
An Electronic Flight Computer

for use in model rocketry

entered by Jeff Karpinski

JUDGES COMMENTS: *"We found this rocket-based project intriguing. The device built by the author both collected data to monitor the rocket's flights, as well as deploy the two recovery parachutes at the appropriate points."*





The purpose of this project was to implement a fully programmable flight computer for a large model rocket. Key features include a BASIC programmable 20MHz microcontroller from Protean Logic, barometric and acceleration sensors with 12-bit resolution, 32K of EEPROM for flight data storage, two HEXFET controlled high current events, serial and LCD interfaces, and audible feedback via piezo beeper. A 7.2V NiCd battery powers the unit. The assembled flight computer is only 1.1" by 5" in size.

During operation of the flight computer, acceleration and pressure data are captured and stored sequentially in the EEPROM. Launch is detected by reading consecutive high-G events from the accelerometer. At this point, high and low pressure values are stored, and then repeatedly compared and updated from subsequent readings. Once the current pressure is higher than the lowest pressure achieved (by approximately 50 feet), event #1 is fired. Generally, this event completes a circuit to an electric match, which ignites a black powder charge to eject a small drogue parachute. The drogue chute brings the rocket down from apogee in a rapid, but controlled descent. As the current pressure approaches the maximum pressure reading (less approximately 1,000 feet), event #2 is fired which deploys the main chute to reduce descent to under 15 fps for a safe recovery. Once event #2 fires, the flight computer begins repeatedly beeping out the difference between maximum and minimum altitude in Morse code fashion. A lookup table incorporated into the code (which is calibrated to the specific pressure sensor and the Army/Navy Equation of State) facilitates this pressure to altitude conversion. Once the rocket is retrieved, the complete flight profile of pressure and acceleration data can be downloaded to a laptop for review and additional analysis. A handheld LCD display can also be attached for in-field data review or for debugging flight code.

The included pictures show the schematic, close-ups of the completed board, assembly into the rocket nose cone (note the vent holes for obtaining accurate pressure readings), and an in-flight shot. From data captured on this launch, the 650ns "J" motor was pushing the 3.5lb rocket over 500mph at the time this picture was snapped!

Rocket details:

The rocket is 4'6" long, 4" in diameter, and weighs approximately five lbs. when loaded and ready for flight. It is built from fiberglass, phenolic tubing, plywood, and balsa. It is a fi scale model of the British ASRAAM, or Advanced Short Range Air to Air Missile. Originally initiated by Germany and the UK in the 1980s as a joint effort to find a replacement for the aging AIM-9 Sidewinder, Germany left the venture over design details. Britain continued with development, and the first ASRAAMs were deployed to the RAF in 1998.

This is one of my favorite rockets because the design is statically stable (most missiles are more neutrally stable for active guidance), and the large 4" diameter payload bay makes testing various electronic payloads easy. Because the rocket is fiber glassed, it can easily take the punishment that larger motors like this J450 (125 lbs. of lift) can dish out. This rocket has seen well over 50 flights in four states and has even crashed once into the Bonneville Salt Flats due to a failed shock cord.

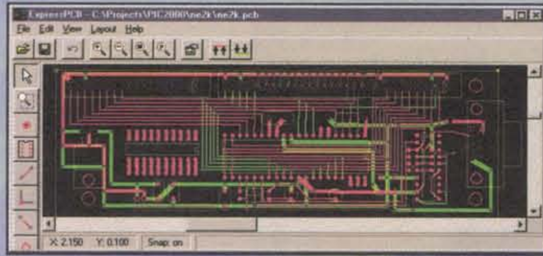


Figure 1. Designing the PIC-ISA Control Board using Express PCB's layout software.

3RD PLACE

A PIC_ISA Control Board

(sample application: a stand-alone web cam)

entered by Dr. Edward Cheung

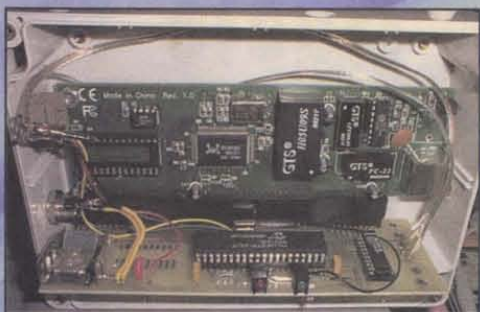
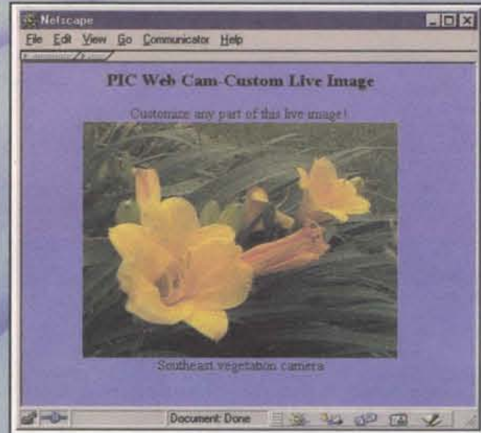


Figure 2. The completed PIC-ISA control board (yellow). Here, an ISA ethernet card (green) has been plugged into it.

Figure 6.



JUDGES COMMENTS: *"This PIC project makes use of the large assortment of I/O devices that are available for the PC. The author built a simple board that interfaces a PIC microprocessor to any standard PC ISA card. His sample application shows a PIC processor connected to an off-the-shelf ethernet card. Also, he has interfaced a digital camera. By combining all three, he has put together a stand-alone web cam using very little custom hardware."*

Figure 3. The completed Web Camera with the digital camera installed.

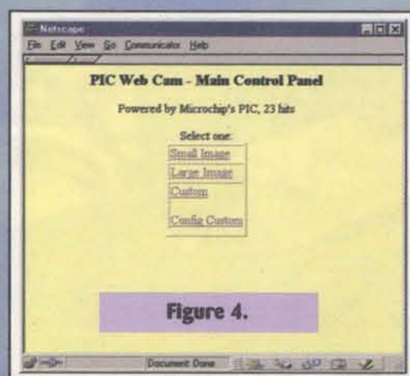


Figure 4.

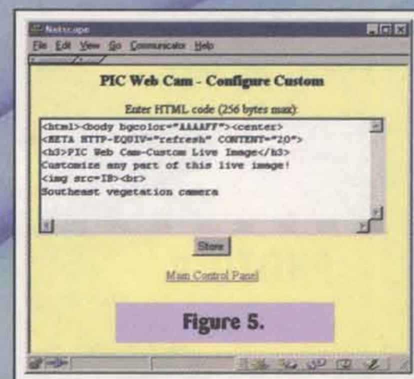


Figure 5.

Over the years, a huge variety of interface boards have been developed for the PC's ISA bus. Examples of these are RS-232 (serial ports), IDE (mass storage), parallel ports, ethernet boards, modems, etc. If it were possible to connect a PIC processor to these interface boards, we would have an enormous amount of choices for real-world input and control. This project describes a circuit board – known as the PIC-ISA control board – that accomplishes that. Once assembled, the PIC processor emulates the PC side of the ISA bus interface allowing it to communicate and control the ISA interface board. As an example, the control board is connected to a standard PC Ethernet card, allowing the PIC to become a full node on the local ethernet network. Software on the PIC not only turns it into a full-fledged web server but, by using a digital camera, the PIC also becomes a complete Web Camera.

The ethernet board plugs into the ISA bus connector soldered into the control board. This connects the 16 bits of the ISA data bus and five bits of the ISA address bus to three ports on the PIC. The remaining bits on the address bus are hard-wired so that the base address of the ISA board is presumed to be at 0x300. The five address lines thus allow the addressing the registers of the ISA board over the address range 0x300 to 0x320. This should be sufficient for most applications. Traces can be cut and soldered to modify the base address and range.

After the PIC Web Camera is connected to the local ethernet network via a 10BaseT (Cat 5) cable, the user can communicate with it by using 'ping' or by requesting the default home page with the URL: http://IP_ADDRESS (198.118.120.3 in this project). The resultant display on the web browser is shown in Figure 4.

Clicking on 'Small Image' will result in the small image (160x120) which is refreshed automatically every 10 seconds, and clicking on the 'Large Image' yields the large image (320x240) which is automatically reloaded every 30 seconds (see Figure 6). Lastly, clicking on 'Custom' brings up the page that is customizable by the user via the 'Config Custom' link. A form stored on the PIC is then brought up where the existing HTML code of the custom page is shown. The user can then edit and then store the code in the PIC's non-volatile memory.

On the custom page, parameters such as text, background color, image size, and refresh interval can be adjusted to the user's liking. Since the file is stored in the PIC's EEPROM, a maximum of 256 bytes can be stored. This feature allows the user to have a completely custom display for the PIC Web Camera as shown in Figure 6.

This project illustrates what is capable of a tiny PIC processor, doing the work of a much larger desktop computer and serving up digital images from a still camera. Other projects that are just as amazing are possible by starting with a different type of ISA board plugged into the Express PCB control board.

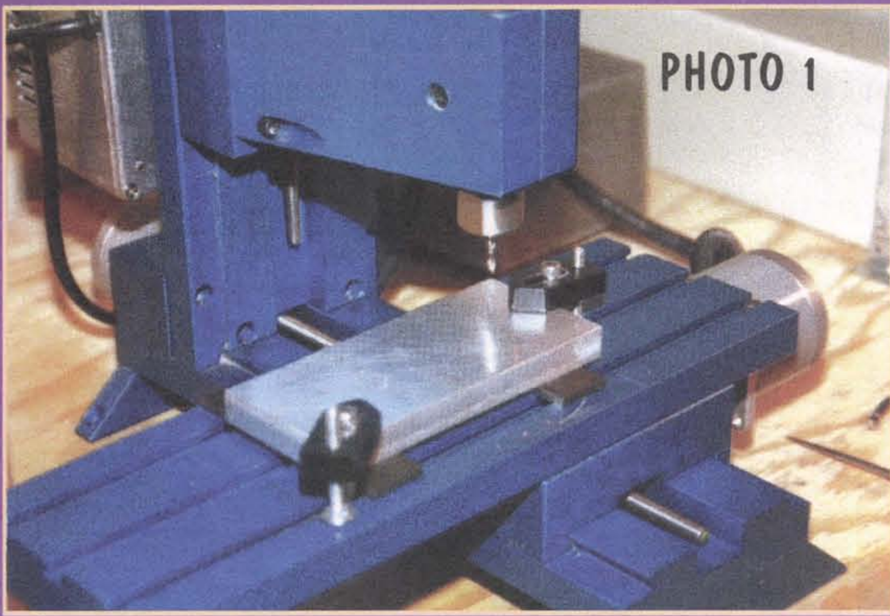
Be sure and check out next month's issue when the Honorable Mentions will be featured.

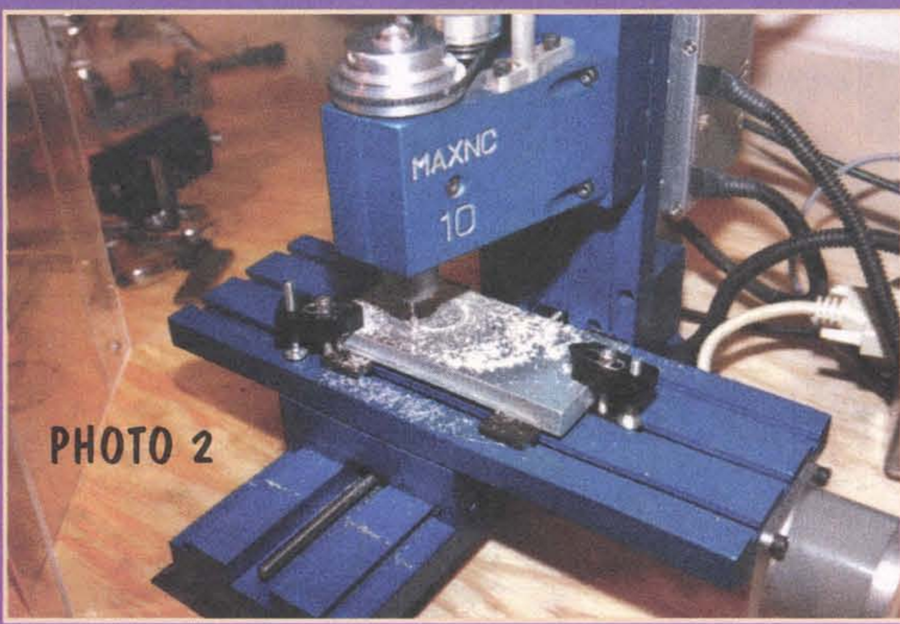
Honorable Mentions

"100 Watt Power Amplifier" entered by Robert E. Friess

"ClipClop" entered by David E. Smith

"WindReader"™ entered by Victor Fraenckel





by Matthew Evans

Using Basic to Generate G-code

Several recent articles in *Nuts & Volts* have given readers instructions on how to build a computer numerically controlled (CNC) milling machine. An industry standard method used to control the milling machine after it's built is to create a G-code file that can be interpreted by the milling machine's computer. A G-code file is comprised of instructions that describe the path the cutting tool will take.

There are many different methods of creating this G-code file. If you have a CAD program which can export a DXF file, there are programs which will convert the DXF file into G-code. If all you have is an idea in your head or a sketch on the back of a napkin, this article will help. It will explore using the Basic programming language to generate the G-code file.

You could write G-code with a text editor. However, on small, low horsepower CNC machines like a converted Sherline (www.sherline.com), a MAXNC10 (www.maxnc.com), or perhaps one you built yourself from following the *Nuts & Volts* articles, the allowable incremental increase in the amount of material removed per cut is small. You cannot make a .050 x .500 cut with a 1/10 HP milling machine.

Writing G-code with a text editor to remove a relatively large amount of material with a small machine is painfully time consuming. As an example, I milled out a 1.657 diameter by .400 deep bearing pocket (see Figure 1) from some half inch 6061-T6 aluminum with the MAXNC10. Using a radial increase of .020", and a depth increase of .020", the resulting G-code file was over 200 lines created by cutting and pasting the repetitive parts and then editing the lines which control the depth one by one. This task took hours.

There is an advantage when using a small milling cutter: to make two cuts, one just inside the other, so that the amount of material removed on the second or finish cut is small. Now entering the G-code manually takes twice as long!

Instead, it is easy to create a Basic program to write a text file that can be read by a G-code interpreter. A G-code interpreter is a program that converts G-code statements into movement commands for the steppers driving the axis on the milling machine. In my case, the G-code interpreter was included in the MAXNC10 package. (See elsewhere in the article for a table of G-codes supported by the MAXNC10 interpreter.)

Qbasic is a Microsoft product that came with DOS and is still probably somewhere on your computer unless you specifically deleted it. It is on the Windows 98 CD (in the directory 'tools\oldmsdos\', the two files 'qbasic.exe' and 'qbasic.hlp'), on the Windows 95 CD (in the directory 'other\oldmsdos\'), or on the MS-DOS 5 or 6.x disks. So, if you own MS-DOS (version 5 or higher) or Windows 9x, QBasic is completely free for you. Even the older GWbasic can create the text files described here.

These small milling machines do not require a lot of computing horsepower; mine runs in a Windoze95 DOS window on an 80486-DX2/100. It could run on a system with just DOS, but I like the text editor in WIN95.

The large hole in the plate of Figure 1 is a pocket for a 1.655 diameter bearing for the main shaft of a small hand operated plunger type injection molding machine that I am converting to motor drive. The 1.657 pocket is .400 deep. A 1.250 hole goes through the remainder of the material. In this case, the center portion can be removed as a plug for the first cut. Using a .125 end mill, a sample G-code statement would be:

```
G03 X -3.420 Y - .430 I0 J -. 563
```

Using the upper left corner of the plate in Figure 2, this line of G-code creates a small circular groove .125 wide with an outside diameter of 1.251 (.563 + .563 + .125 = 1.251). The G-code statements describe the path that the center of the milling cutter takes, not the finished edges. The G03 header indicates that this will be a clockwise circular arc.

On the MAXNC10 G-code interpreter, G03 can be either an arc or a complete circle. Other G-code interpreters may use different codes for arcs and complete circles. The X and Y values are the start location of the cut. Remember that the values are for the center of the tool. The I value is the distance from the start position of the end mill to the center of the diameter being cut along the X direction. In this case, that distance is 0. The J value is the distance from the start position of the diameter being cut along the Y direction. In this case, it is .563. The negative signs indicate that this cut is below and to the right of the origin. Photo 1 shows the plate mounted on the MAXNC10 before the first cut with the end mill at the origin.

There are several advantages to cutting a smaller diameter right inside the 1.251 one (see Figure 3). First, most of the material is removed on the first cut, which makes a .125 x .020 groove; this leaves only a .020 x .020 increase on one side for the second cut. This small second cut will leave a better finish on the final diameter.

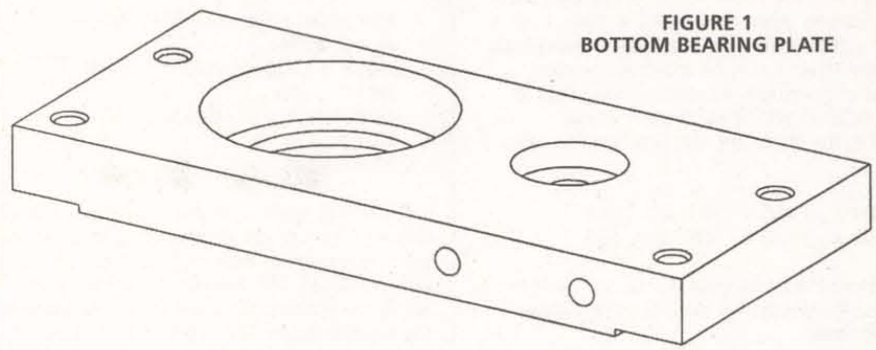


FIGURE 1
BOTTOM BEARING PLATE

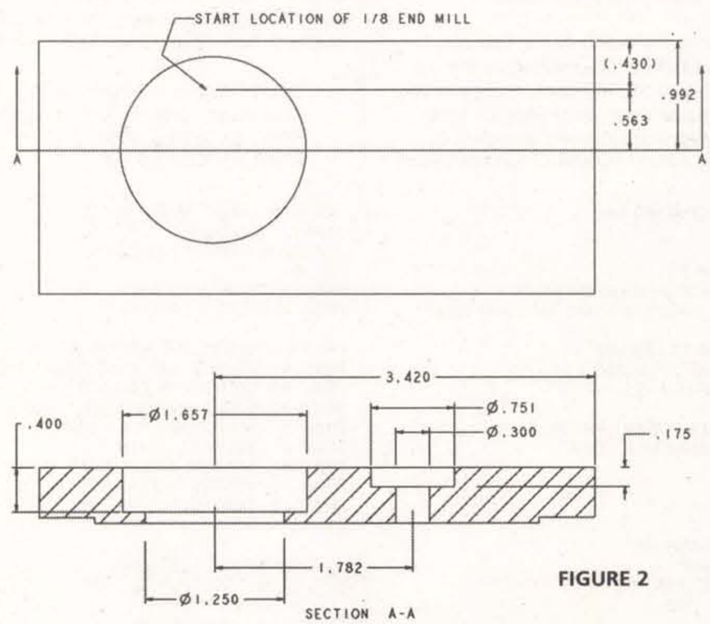


FIGURE 2

Other advantages are that the cut is wider than the end mill, giving some of the chips an easier way out, and the end mill runs cooler because it is not rubbing against two sides at once. I use a can of compressed air with a tube to periodically blow the chips out. If the material was steel instead of aluminum, I'd use a cutting fluid to lubricate and cool the cutter as it works.

With the inside cut, the first two lines are now:

```
G03 X -3.420 Y -. 410 I0 J -. 543
G03 X -3.420 Y -. 430 I0 J -. 563
```

Before the groove can be cut, we need to increase the depth and then increase it again after each cut.

```
G01 Z -. 02
G03 X -3.420 Y -. 410 I0 J -. 543
G03 X -3.420 Y -. 430 I0 J -. 563
```

The Z value is the depth of the first cut. This is the value that will be incremented as the cut gets deeper. This cut is .500 deep, therefore you could cut and paste these three lines 25 times (.500 total depth/.020 incremental depth) or imagine writing a short FOR-NEXT loop program that increments the depth for you and writes the file. The concept for this program is below

```
FOR depth = 0 to .500 STEP .02
G01 Z depth
G03 X -3.420 Y -. 410 I0 J -. 543
G01 Y -. 390
G03 X -3.420 Y -. 430 I0 J -. 563
G01 Y -.410
NEXT depth
```

The FOR statement sets the initial and final values of the variable depth. The STEP value tells the FOR statement how much to increment the value of depth. The G-codes are the same as above, except that the value for Z is replaced by the variable depth. The NEXT line tells the computer to return to the FOR statement. The FOR statement increments the value of depth and then checks to see if that value is greater than the final value and either allows the loop to continue or terminates when the final depth is reached. Real Qbasic code looks like this,

```
OPEN "1stgruv.txt" FOR OUTPUT AS #1
REM move cutter to X=0, Y=0, Z=.050
PRINT #1 "G00 Z .050"
PRINT #1 "G00 X0 Y0"
REM move cutter to start position
PRINT#1 "G01 X -3.420 Y -.410"
FOR depth = .02 to .500 STEP .02
PRINT #1, "G01 Z -";
PRINT #1, USING "#.###"; depth
PRINT #1, "G03 X -3.420 Y -.410 I0 J -.543"
PRINT #1, "G01 Y -.390"
PRINT #1, "G03 X -3.420 Y -.430 I0 J -.563"
PRINT #1, "G01 Y-.410
NEXT depth
CLOSE
END
```

The OPEN statement opens a new file named "1stgruv.txt" in the current directory. The filename must be in DOS readable (i.e., 8.3) for the G-code interpreter that drives the MAXNC10. The REM statement is for a REMark; you can add anything after it and Qbasic will ignore it. The PRINT statement adds lines to the open file.

The first two PRINT statements move the tool to a known position from wherever it might be when the program starts. Note the space after the Z and the semicolon after the last quotation mark in the fourth PRINT statement. This formats the line properly and allows the following PRINT statement to be appended to the same line.

The USING statement formats the variable

Here is the listing of gcg.bas

```
CLS
REM gcg.bas ver 1.0
REM released as freeware to the public
REM domain in conjunction with "Nuts and Volts"
REM article.
REM last update on 25-jul-00
INPUT "FILENAME"; FILENAME$
FILENAME$ = FILENAME$ + ".TXT"
NUMLINE = 0
OPEN FILENAME$ FOR OUTPUT AS #1
PRINT #1, "("; FILENAME$; ")"
CLOSE

MENU:
PRINT "0 QUIT"
PRINT "1 CUT DIAMETER"
PRINT "2 whatever"
INPUT "CHOOSE"; FEATURE
IF FEATURE = 1 THEN
  GOSUB HOLE
  GOTO MENU
ELSEIF FEATURE = 2 THEN
  PRINT "SORRY CHARLIE"
  GOTO MENU

ELSEIF FEATURE = 0 THEN
  OPEN FILENAME$ FOR APPEND AS #1
  PRINT #1, "G01 Z .1"
  PRINT #1, "G01 X0 Y0"
  PRINT #1, "M5"
  PRINT #1, "M30"
  CLOSE
  END
END IF

HOLE:
INPUT "CENTER OF HOLE X,Y "; X, Y
INPUT "START DIAMETER "; SDIA
INPUT "END DIAMETER "; EDIA
INPUT "START DEPTH "; SDEPTH
INPUT "FINISH DEPTH "; DEPTH
INPUT "RADIAL INCREMENT "; RI
INPUT "DEPTH INCREMENT "; DI
INPUT "MILL DIAMETER "; MD

REM SET INITIAL CUTDIA
IF SDIA = 0 THEN
  CUTDIA = MD + RI
  DIA$ = " INSIDE "
  LASTDIA = EDIA - MD / 2
ELSEIF SDIA > 0 AND SDIA < EDIA THEN
  CUTDIA = SDIA
  DIA$ = " INSIDE "
  LASTDIA = EDIA - MD / 2
ELSEIF SDIA > EDIA THEN
  RI = -RI
  CUTDIA = SDIA + MD + RI * 2
  DIA$ = " OUTSIDE "
  LASTDIA = EDIA + MD / 2
END IF
PRINT "CUTDIA "; CUTDIA
PRINT "LASTDIA "; LASTDIA

OPEN FILENAME$ FOR APPEND AS #1
PRINT #1, "(THIS IS AN "; DIA$; " DIAMETER"
PRINT #1, "(CENTER OF DIAMETER X,Y "; X; " "; Y; ")"
PRINT #1, "(CUTTING DIAMETER "; SDIA; ")"
PRINT #1, "(END DIAMETER "; EDIA; ")"
PRINT #1, "(DEPTH "; DEPTH; ")"
PRINT #1, "(RADIAL INCREMENT "; RI; ")"
PRINT #1, "(DEPTH INCREMENT"; DI; ")"
PRINT #1, "(MILL DIAMETER "; MD; ")"
CLOSE

REM SET INITIAL CUT DEPTH
CUTDEPTH = SDEPTH + DI


REM MOVE TO INITIAL START LOCATION
OPEN FILENAME$ FOR APPEND AS #1
PRINT #1, "G01 Z .05"
PRINT #1, "G01 X"; X; " Y "; CUTDIA / 2 + Y
PRINT #1, "M3"
IF SDEPTH > 0 THEN PRINT #1, "G01 Z -"; SDEPTH
CLOSE

DEPTH:
IF CUTDEPTH < DEPTH THEN
  REM WRITE A LINE TO FILE
  OPEN FILENAME$ FOR APPEND AS #1
  PRINT #1, "G01 Z ";
  PRINT #1, USING "#.###"; -CUTDEPTH
  CLOSE
  GOSUB DIAMETERCUT
  REM INCREMENT CUTDEPTH
  CUTDEPTH = CUTDEPTH + DI
ELSEIF CUTDEPTH > DEPTH OR CUTDEPTH = DEPTH
THEN
  CUTDEPTH = DEPTH
  REM WRITE A LINE TO FILE
  OPEN FILENAME$ FOR APPEND AS #1
  PRINT #1, "G01 Z ";
  PRINT #1, USING "#.###"; -CUTDEPTH
  CLOSE
  GOSUB DIAMETERCUT
  GOTO MENU
END IF
GOTO DEPTH

DIAMETERCUT:
 IF SDIA < EDIA THEN
  IF CUTDIA < LASTDIA THEN
   CUTRADIUS = CUTDIA / 2
   GOSUB CUTME

  ELSEIF CUTDIA > LASTDIA OR CUTDIA = LASTDIA
THEN
   CUTDIA = LASTDIA
   CUTRADIUS = CUTDIA / 2
   GOSUB CUTME
   REM RETURN TO START DIAMETER SDIA
   REM RESET CUTDIA
   IF SDIA = 0 THEN
    CUTDIA = MD + RI
    ELSE
    CUTDIA = SDIA
   END IF
   OPEN FILENAME$ FOR APPEND AS #1
   PRINT #1, "G01 Y ";
   PRINT #1, USING "#.###"; CUTDIA / 2 + Y
   CLOSE
   RETURN
  END IF
 ELSE
  IF CUTDIA > LASTDIA THEN
   CUTRADIUS = CUTDIA / 2
   GOSUB CUTME

  ELSEIF CUTDIA < LASTDIA OR CUTDIA = LASTDIA
THEN
   CUTDIA = LASTDIA
   CUTRADIUS = CUTDIA / 2
   GOSUB CUTME
   REM RETURN TO START DIAMETER SDIA
   CUTDIA = SDIA + MD + RI * 2
   OPEN FILENAME$ FOR APPEND AS #1
   PRINT #1, "G01 Y ";
   PRINT #1, USING "#.###"; CUTDIA / 2 + Y
   CLOSE
   RETURN
  END IF
  END IF

REM INCREMENT CUTDIA
CUTDIA = CUTDIA + 2 * RI
GOTO DIAMETERCUT

CUTME:

REM WRITE A LINE TO FILE
OPEN FILENAME$ FOR APPEND AS #1
PRINT #1, "G01 Y ";
PRINT #1, USING "#.###"; CUTDIA / 2 + Y
PRINT #1, "G03 X"; X; " Y ";
PRINT #1, USING "#.###"; CUTDIA / 2 + Y;
PRINT #1, " I 0 J ";
PRINT #1, USING "##.###"; -CUTRADIUS
CLOSE
RETURN

REM Program written by Matthew Evans
REM klmevans@warwick.net
```

depth to X.XXX. If the value is not formatted before printing, the computer might add some insignificant digits that might confuse the interpreter. Qbasic interprets each line as you type it, and will question typing errors and alert you to most programming errors.

Here are the first 15 lines of the code created by the above program:

```
G00 Z .050
G00 X0 Y0
G01 X -3.420 Y -.410
G01 Z -0.020
G03 X -3.420 Y -.410 I0 J -.543
G01 Y -.430
G03 X -3.420 Y -.430 I0 J -.563
G01 Z -0.040
G03 X -3.420 Y -.410 I0 J -.543
G01 Y -.430
G03 X -3.420 Y -.430 I0 J -.563
G01 Z -0.060
G03 X -3.420 Y -.410 I0 J -.543
G01 Y -.430
G03 X -3.420 Y -.430 I0 J -.563
```

Photo 2 shows the MAXNC10 running this code.

Notice how several print statements are used

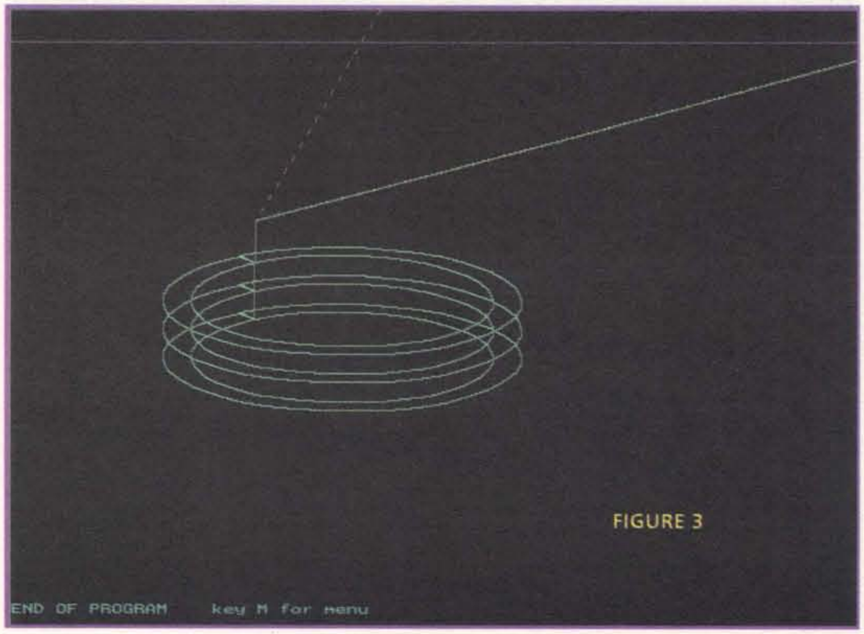


FIGURE 3

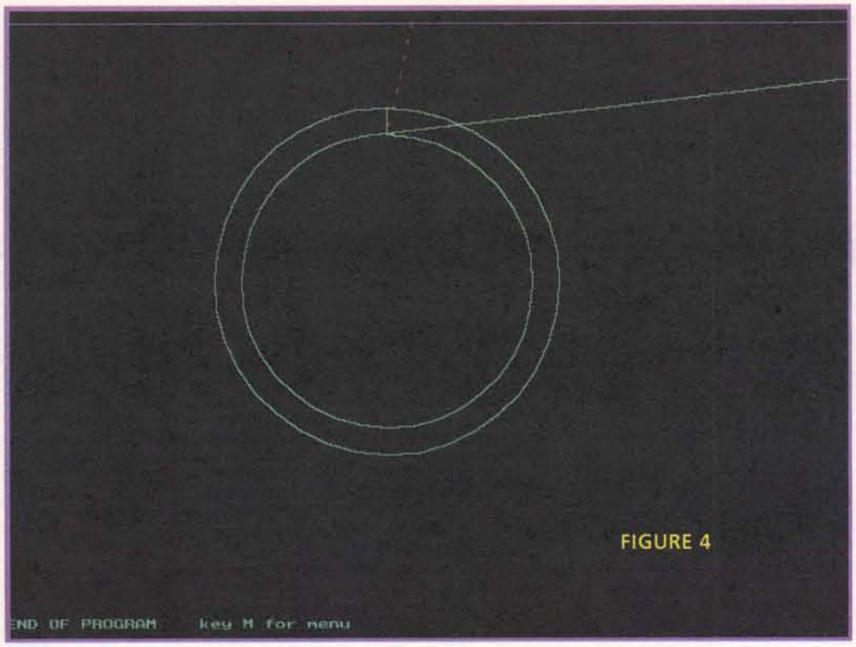


FIGURE 4

```
G03 X -3.420 Y -.410 I0 J -.543
G01 Y -.310
G03 X -3.420 Y -.430 I0 J -.643
G01 Y -.410
G01 Z -0.200
G03 X -3.420 Y -.410 I0 J -.543
G01 Y -.310
G03 X -3.420 Y -.430 I0 J -.643
G01 Y -.410
G01 Z -0.300
G03 X -3.420 Y -.410 I0 J -.543
G01 Y -.310
G03 X -3.420 Y -.430 I0 J -.643
G01 Y -.410
```

See Figure 3 for the screen capture of the above G-code. In this figure, the magenta line near the top is the X axis. As this is a zoomed in view, the Y axis is not visible. You can see the different values of the variable depth as it increments. Figure 4 is the plane or top view, showing the output as it appears on the X-Y plane of the milling machine table. You can clearly see that one tool path is nested inside the other.

If you start this cut at the top surface of the part, the last cut will break through the bottom surface, probably breaking the end mill and flinging the plug across the garage. You might also cut into the mill's working surface. If you set your Z=0 to be .005 or .010 above the top surface, there will be a thin web left and you could push the plug out with your fingers after the program ends. You could also run the program from 0 to .495 and achieve the same thing.

Clamping a piece of thin waste material under the part is another good method if you remember to zero the Z-axis before running. In a pinch, several pieces of paper can be used; a piece of generic copier paper is about .004" thick. See Photo 3 for the finished cut (from 1stgruv.txt, not the picture-friendly T3.txt!) with the plug removed.

Different milling machines will have different rates of removing material, determined by the power of the motor and other factors. You'll have to experiment with motor speeds and tool feed rates on your machine.

On the MAXNC10, I am comfortable with a .040 x .040 cut with a .250" end mill in aluminum alloy 6061-T6 at the highest motor speed and approximate feed rate of four inches per minute.

On a more sophisticated CNC machine, you

to assemble a single line of G-code. There are always three or four viable ways of getting a Qbasic program to do something. This method is easy to debug because the Qbasic interpreter runs the program line by line and stops at any error. The more Qbasic lines you have to describe a G-code instruction, the easier it is to debug your program.

It is nice to run the file output by this code (1stgruv.txt) on a graphical interpreter before trusting it to your mill. The MAXNC10 came with a graphical interpreter that reads the file and plots it on the screen instead of driving the steppers. The output from the graphical interpreter from 1stgruv.txt is too close together to see any detail, so to create a better picture, let's change the STEP (depth) value to .100 and decrease the final depth to .300. The second circular cut will also increment by .100 each time. This would make the final diameter of the circle .663 x 2 = 1.326.

```
OPEN "T3.txt" FOR OUTPUT AS #1
REM move cutter to X=0, Y=0, Z=.050
PRINT #1 "G00 Z .050"
PRINT #1 "G00 X0 Y0"
REM move cutter to start position
PRINT#1 "G01 X –3.420 Y -.410"
FOR depth = .100 to .300 STEP .100
PRINT #1, "G01 Z -";
PRINT #1, USING "#.###"; depth
PRINT #1, "G03 X –3.420 Y -.410 I0 J -.543"
PRINT #1, "G01 Y -.310"
PRINT #1, "G03 X –3.420 Y -.530 I0 J -.643"
PRINT #1, "G01 Y-.410
NEXT depth
CLOSE
END
```

Here is the output from this figure friendly program.

```
G00 Z .050
G00 X0 Y0
G01 X -3.420 Y -.410
G01 Z -0.100
```

can program the speeds and feeds more accurately. On the MAX, if the motor loses significant RPM during a cut, then it's too big. If AL-6061 gets hot and gums up the tool, then the speed is too high for the feed rate. Experiment on your machine with and without cutting fluids.

The next step in making the bearing pocket is to mill out the stepped volume of the pocket. In this case, we need to cut several different diameters at each depth before incrementing to the next depth. This requires nesting another FOR-NEXT loop nested inside the one that controls the depth. The constant values for Y and J from the previous code example will be replaced by variables and the new FOR-NEXT loop will control them.

For this hole, the start diameter is equal to the finish diameter of the previous hole plus the radial increase or 1.250 + .020 = 1.270. The step size of the MAXNC10 is .0008, which is small enough that programming out to three decimal places makes sense. The start position for the center of the end mill is the start diameter minus the radius of the end mill or 1.270 - .063 = 1.207. The finish diameter is 1.657. Therefore, the finish position for the end mill is 1.657-.063 = 1.594.

So now, the nested FOR-NEXT loops will increment the cutting diameter from 1.207 to 1.594, increase the depth by .020, and then loop back until all the diameters at all the depths have been cut.

In order to make things a little easier to program, we'll cut from 1.194 to 1.594. This makes the first cut smaller than all of the rest, but makes the total cut evenly divisible by .040. Since each cut starts and stops at the same X coordinate, the values for X and I remain constant. The start position for X is –3.420 The start position for Y is .992-1.194/2 = .395. The end position for Y is .992 – 1.594/2 = .195.

In order to eliminate any confusion between the value for Y and the text Y printed to the G-code file, the program will use a variable named "wye." The value for J, which is the distance from the start position to the center of the cut, starts at 1.194/2 = .597 and finishes at 1.594/2 = .797. To eliminate any confusion between the value for J and the text J printed to the G-code file, the program will use a variable named "jay." You can name a variable anything you want, but using a descriptive name will make the program easier to understand. The program now looks like this:

```
OPEN "2ndgruv.txt" FOR OUTPUT AS #1
REM move cutter to X=0, Y=0, Z=.050
PRINT #1, "G00 Z .050"
PRINT #1, "G00 X0 Y0"
REM move cutter to start position
PRINT #1, "G00 X –3.420 Y -.395"
FOR depth = .02 to .400 STEP .02
jay = .597
PRINT #1, "G01 Z -";
PRINT #1, USING "#.###"; depth
     FOR wye = .395 to .195 STEP -.04
     PRINT #1, "G01 Y –";
     PRINT #1, USING "#.###"; wye
     PRINT #1, "G03 X –3.420 Y –";
     PRINT #1, USING "#.###"; wye;
     PRINT #1, " I0 J –";
     PRINT #1, USING "#.###"; jay
     jay = jay +.04
     NEXT wye
NEXT depth
CLOSE
END
```

Here are the first 27 lines of G-code generated by the above program:

```
G00 X 0 Y 0 z .05
G00 X -3.42 Y -.395
G01 Z -0.020
G01 Y -0.395
G03 X -3.420 Y -0.395 I0 J -0.597
G01 Y -0.355
G03 X -3.420 Y -0.355 I0 J -0.637
G01 Y -0.315
G03 X -3.420 Y -0.315 I0 J -0.677
G01 Y -0.275
G03 X -3.420 Y -0.275 I0 J -0.717
G01 Y -0.235
G03 X -3.420 Y -0.235 I0 J -0.757
G01 Y -0.195
G03 X -3.420 Y -0.195 I0 J -0.797
G01 Z -0.040
G01 Y -0.395
G03 X -3.420 Y -0.395 I0 J -0.597
G01 Y -0.355
G03 X -3.420 Y -0.355 I0 J -0.637
G01 Y -0.315
G03 X -3.420 Y -0.315 I0 J -0.677
G01 Y -0.275
G03 X -3.420 Y -0.275 I0 J -0.717
G01 Y -0.235
G03 X -3.420 Y -0.235 I0 J -0.757
G01 Y -0.195
```

The entire G-code file had 225 lines. Imagine typing that! Now while we're programming, wouldn't it be nice if the program would ask some questions and do the math by itself? How about letting you add more than one hole to the G-code file? Maybe it could automatically add lines to start and stop the milling machine's spindle motor, add some comments to the text file indicating which end mill to use, and a whole slew of other things. Now think of how nice it would be if you could download that program from the *Nuts & Volts* website (www.nutsvolts.com) and not do any programming at all! Go for it!

As is, it probably won't work for anything but the MAXNC 10 G-code interpreter, but with a few modifications, it would probably work for any machine's interpreter.

It is not an example of "How To Program Right" (the author is not a programmer), or even "How To Machine Right" (he is not even a machinist), but an example of how easy it is to program a solution to the problem of endless hours of typinfg code and korecting misteaks (he can't even type!). **NV**

G-codes:

G0 Rapid Travel
G1 Linear Interpolation
G2 Circular Interpolation CW
G3 Circular Interpolation CW
G4 Dwell
G12 Full Circle Cycle CW
G13 Full Circle Cycle CCW
G17 XY Plane for Arcs
G40 Radius Offset Cancel
G41 Radius Offset Left
G42 Radius Offset Right
G43 Height Offset Activation
G49 Height Offset Cancel
G61 Input Signal Sensing
G80 Drill Cycle Cancel
G81 Drill Cycle
G82 Drill Cycle with Dwell
G83 Pecking Drill Cycle
G85 Boring Cycle
G90 Absolute Input
G91 Incremental Input
G92 Position Preset

M-codes:

M0 Program Stop
M1 Optional Stop
M2 End of Program
M3 Spindle Start CW
M4 Spindle Start CCW *
M5 Spindle Stop
M6 Tool Change
M7 Coolant On
M8 Coolant On
M9 Coolant Off
M30 Program Reset
M99 Repeat program

Continued from page 42

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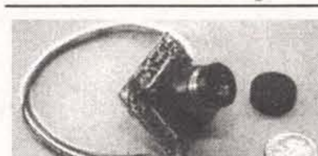

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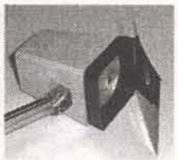

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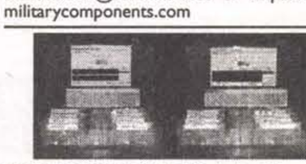

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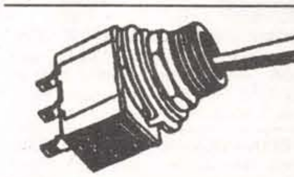

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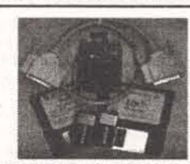

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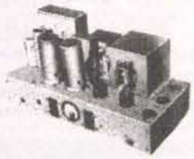

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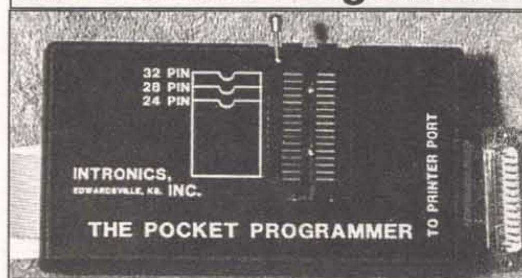

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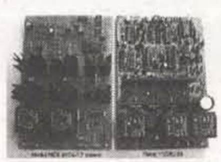

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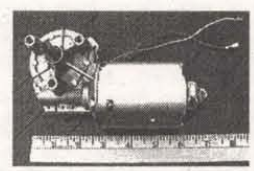

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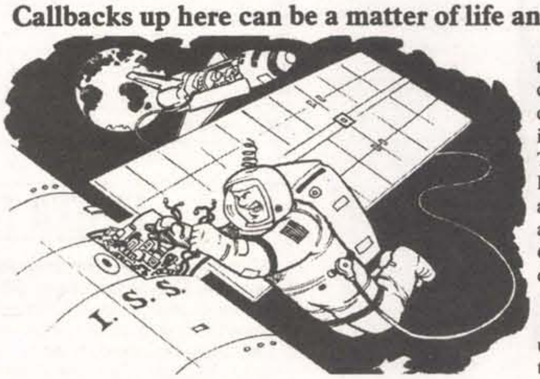

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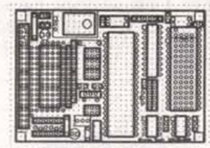

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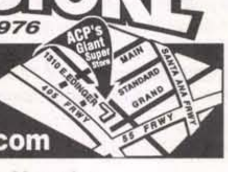

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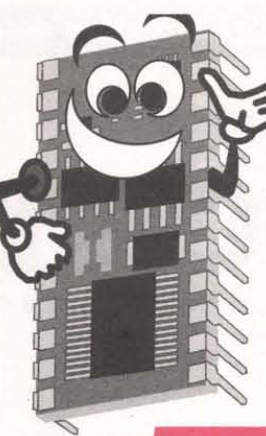


by Jon Williams

Stamp Applications

A STAMP-II ISD SOUND LAB

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

I love "talking" projects. I really do. While I still wish that a semiconductor company would come along and resurrect the SP0256-AL2 allophone synthesizer, I'm not holding my breath. So, last month I used the ISD2560 ChipCorder® to create a talking-pet trainer. The ISD25xx chips are incredibly popular and they can be found in a very wide range of industrial and consumer products.

"Well ..." I thought, after playing with the pet trainer, "I guess I'd better crack open the docs and really dig in."

The pet trainer used the ISD in its simplest mode, called "Push-Button." This mode is generally intended for stand-alone applications. We used the Stamp to push the buttons and make the device train our pet.

With a little more work and some more connections, we can make the ISD25xx do all sorts of neat things. Let's give it a try.

ISD2560 Basics

For this month's project, we'll use the ISD2560. This is the most popular of the series because it has the best overall sound quality. The ISD2560 can store up to 60 seconds of sound in a unique type of patented, non-volatile memory. This means you can remove power from the device without losing your recordings. The chip's PD pin puts it into a very low power state (when not operating), making battery-operation viable.

After a sound segment is recorded in the ISD2560, an End-Of-Message (EOM) marker is left in memory. When recording multiple messages, the next recording starts at the address following the EOM. Addressing individual recordings stored in the ISD can be accomplished two ways: indirectly (message cueing) by knowing the message number and directly by knowing the starting address of the message. Once the device starts playing, all we have to do is watch for a low-going pulse on the EOM line to know when the message is complete.

... which is easier said than done in message cueing mode. When we set up for message cueing (details later), the chip actually scans through memory (looking for EOM markers so it can skip messages) at 800 times its normal speed. What this means is that the EOM pulse could be as short as 11 microseconds! That's not much of a pulse. Thankfully, we can use a little PBASIC trick to catch it. We'll get into more ISD details as we analyze the lab code.

Our Lab And The Software That Drives It

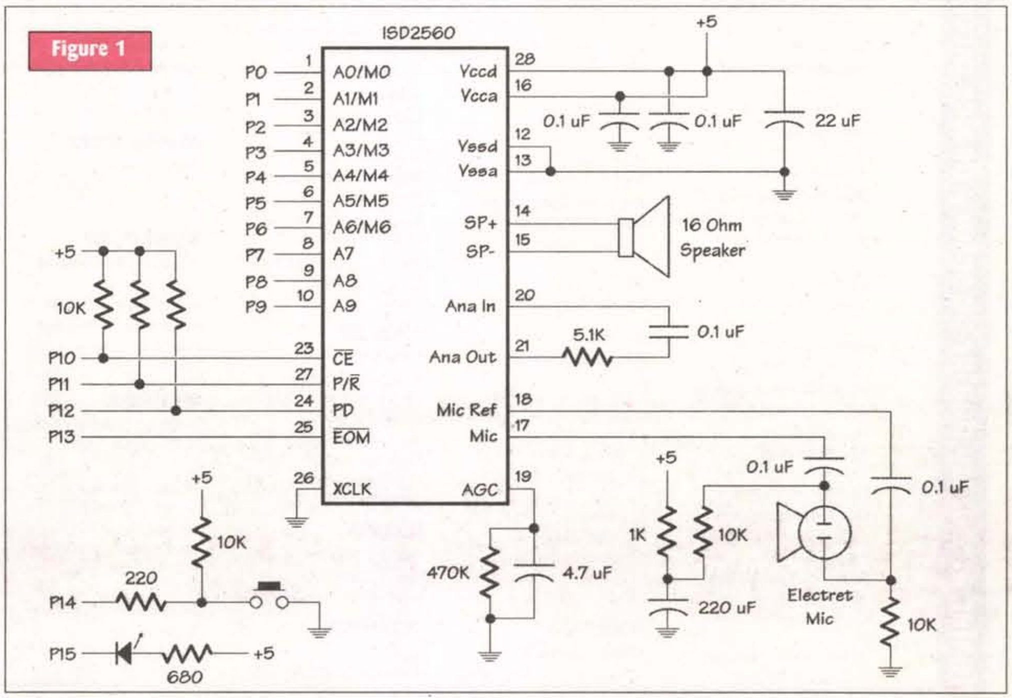
Since the idea behind this project is experimenting, I assembled mine on a solderless breadboard. What you'll immediately notice about this project is that it uses all of the Stamp's I/O lines. Don't fear, we're only doing this now to make experimenting easy. If you find you want a more permanent solution, you can tie address lines together (i.e., Push-Button mode) or use shift registers to set the ISD's address lines. More on that later.

The software for our lab is called ISD_LAB.BS2. Since this program is designed to be interactive (modified and re-run), you should make a back-up copy to recover from a potential accident.

There are five modes to the program: record, sequential playback, play a message using cueing, play a message at a specific address, and play a message at an address for a specified number of milliseconds (something less than the recorded message length). You control the program's behavior by changing the Mode constant.

Initialization of the Stamp is pretty straightforward and yet, I want to make an important point about the order in which things are done. You'll notice in the code that the Stamp's output lines are

Figure 1



A STAMP-II ISD SOUND LAB

set up before they're actually defined as outputs. There is a reason.

The Stamp initializes all variables to zero, including outputs and direction registers (defaulting them to inputs). Since the CE pin of the ISD wants a high-to-low transition, we put a 10K pull-up on it — that way we have to force it to go low. During the initialization sequence, the CE control pin is set to 1 so that it will go high when that pin is defined as an output.

Don't change this sequence. If you set the CE pin as an output before making its value 1, you'll get a glitch recording at the beginning of your ISD's memory. Go ahead; ask me how I know this. Yes, I chased that bug for a day. It's a good lesson. Always define the value of your output pins before setting them to outputs.

Moving on, the program resets the ISD by pulling the PD line high for 13 milliseconds. After the PD line goes low, you must wait for 25 milliseconds before initiating any record or play cycle. You'll see that sprinkled through the code.

After basic initialization and checking to see that the button is not stuck, the program BRANCHes to the section dictated by Mode. Since the first thing we need to do is record some messages, let's go there first. We set the Mode constant to MRec (0).

To record messages into the ISD, we'll use Push-Button mode, just like the pet trainer did. The difference is that we won't reset the ISD address after each recording. This way we can record any number of messages, one after the other, up to the limit of memory.

To go into Push-Button mode, we need to set the ISD's A6, A8, and A9 lines high. On the ISD, address lines zero through six are also defined as operational mode inputs. The mode inputs are active when both A8 and A9 are high. If either A8 or A9 is low, the mode inputs are treated as part of a message address.

We start by clearing any old mode bits, setting opMode to six, and calling the SetModeBit subroutine. This routine uses the DCD operator to set the correct bit. It also takes care of A8 and A9. Notice too, that it adds the new opMode bit (old bits aren't cleared). The reason for this is that some of the ISD operational modes can work together. By changing opMode and calling SetModeBit again, we can set multiple bits.

With Push-Button mode set p, we set the PR (play/record) control line to record mode by bringing it low and then waiting for the button to be pressed. When the button is pressed, the program waits 250 milliseconds (so we can get our voice ready), then starts the recording by pulsing the CE line low.

In Push-Button mode, the ISD's EOM line becomes a recording indicator. The program watches for this line to go high and then turns on the LED to indicate it's time to start talking. Recording continues until the button is released. Once the button is released, pulsing the CE line again terminates recording. This causes the ISD to put an End-Of-Message marker after our recording and advance its memory pointer to the next available address.

With this message recorded, our program puts the ISD into Play mode (just to be safe), turns off the LED, and loops back to wait for another button press. Note that the ISD is not reset after the recording. This would cause the address pointer to be set to zero and we could only record one message (this is how the pet trainer works).

Now it's time to check our messages. To do this, change the Mode constant to MPSeq (1). The section of code called P_Seq works identically to the Record section. Where it differs is that it puts the ISD into Play (PR high) mode, pulses the CE line, then waits for the EOM line to go low at the end of the message. As in recording, the EOM line acts as an activity

Listing 1

```
' Nuts & Volts - Stamp Applications
' October 2000 (Listing 1)

' -----[ Title ]-------------------------------------------------------
-
'
' File...... ISD_LAB.BS2
' Purpose... ISD2560 ChipCorder Lab
' Author.... Jon Williams
' E-mail.... jonwms@aol.com
' Started... 04 SEP 2000
' Updated... 08 SEP 2000


' -----[ Program Description ]-----------------------------------------
-
'
' This program facilitates experimenting with the ISD2560 ChipCorder.
'
' Program Modes:
'
' 0 - Record one or more messages to the ISD
' 1 - Play messages, one at a time, in order
' 2 - Play a specific message
' 3 - Play sound clip from specific address - auto stop at EOM
' 4 - Play sound from address for number of milliseconds


' -----[ I/O Definitions ]---------------------------------------------
-
'
AddrL   VAR     OutL                    ' low bits of ISD address (0..7)
AddrH   VAR     OutC                    ' high bits of ISD address
(8..9)

CE_     CON     10                      ' ISD chip enable
PR      CON     11                      ' ISD play/record (play = 1)
PD      CON     12                      ' ISD power down (reset = 1)
EOM_    VAR     In13                    ' ISD end of message indicator
EOMpin  CON     13                      ' EOM pin number

BtnIn   VAR     In14                    ' button input
LED_    CON     15                      ' LED output (active low)


' -----[ Constants ]---------------------------------------------------
'

MaxAddr CON     599                     ' last address in ISD25xx

MRec    CON     0                       ' record
MPSeq   CON     1                       ' play back messages in order
MPMsg   CON     2                       ' play specific message
MPAddr  CON     3                       ' play sound from address
MPTime  CON     4                       ' play for n milliseconds

Mode    CON      MPSeq                  ' default to sequential play


' -----[ Variables ]---------------------------------------------------
-
'
btn     VAR     Bit                     ' pushbutton input
x       VAR     Byte                    ' loop counter
msgNum  VAR     Byte                    ' message number
msgAddr VAR     Word                    ' clip segment address (0 - 599)
msgLen  VAR     Word                    ' clip length in milliseconds
waste   VAR     Word                    ' workspace for PULSIN
opMode  VAR     Nib                     ' for use with SetModeBit
cntr    VAR     Byte                    ' loop counter


' -----[ Initialization ]----------------------------------------------
-
'
Init_IO_Pins:
  AddrL = %00000000                     ' clear message address bus
  AddrH = %1100                         ' play, CE_ high, clear A9 & A8

  DirL = %11111111                      ' low bits of address
  DirC = %1111                          ' PR, CE_, A9, A8
  DirD = %1001                          ' LED_, Btn, EOM_, PD

ISD_Setup:
  GOSUB ResetISD
  PAUSE 25                              ' let ISD settle (Tpud)

LED_Off:
  HIGH LED_


' -----[ Main Code ]---------------------------------------------------
-
'
Main:
  GOSUB GetBtn
  IF btn = 1 THEN Main                  ' wait for release

CheckMode:
  BRANCH Mode,[Record,P_Seq,P_Msg,P_Addr,P_Time]
  GOTO Main
```

indicator when the ISD is in Push-Button mode. Each press of the button will cause another message to play until the end of memory is reached.

Playing messages in order is fun, but not always useful. Wouldn't it be nice if we could play any message or a sequence of messages in any order? We can. The ISD has an operational mode called message cueing (M0). What this mode does is fast forward through its memory to the desired message.

To test message cueing, you need to set the Mode constant to MPMsg (2) and re-run the program. The demo code at P_Msg will take the first five messages in the ISD and play them backward. Cueing messages in the ISD is a bit tricky, so I put together a subroutine to handle the details.

Take a look at the subroutine called PlayMessage — this is the code that does the fast forwarding for us. This code resets the ISD then puts it into cueing mode by setting A0 and A4. This allows cueing and consecutive messaging. To enable the mode bits, we must also set A8 and A9. With everything set up, we have to wait 25 milliseconds before proceeding.

The first thing the routine does is check to see if the message number is zero or one. (I decided that the first message in memory is message number 1 — you could modify the code to make the first message number 0 without any difficulty.) If the message number is zero or one, the cueing operation is skipped and the first message in the ISD is played.

Let's assume it's not message one and see how the cueing operation works. Remember that with cueing set, the ISD scans through its memory at 800 times its normal rate. What this means is that the EOM pulse could be as short as 11 microseconds. That's too short for our normal polling loop to catch.

Luckily, PBASIC provides a work-around. What we do is use PULSIN to watch for the EOM pulse. Since PULSIN can measure a pulse down to two microseconds, we're in luck. To skip to a message, we're going to pulse the CE line and watch for the EOM one less time than the value of our message number. Once we've done all this skipping, the ISD address pointer is set to the desired message. To play the message, we must clear the cueing bit (A0) and then proceed as we have before. Once the EOM line pulses low, we know the message is done playing and we can return to the program.

You can create complex phrases playing messages in the order you choose. The only thing you need to know is the message number.

The last two modes of the demo start playback of a sound segment from a specific address in the ISD. These modes are similar in that they reset the ISD, set up the message address, wait for the device to settle (25 ms delay), then pulse the CE line low to start playback. Since the ISD25xx chips have 600 memory cells, addresses are limited to 599.

With Mode set to MPAddr (3), playback is automatically terminated when the EOM marker is reached. When Mode is set to MPTime (4), playback is manually terminated after waiting a specified number of milliseconds (set in msgLen) by taking the PD line high, resetting the ISD. The neat thing about MPTime mode is that we can actually parse individual sound segments out of one long recorded message. It takes some work though; we have to find the address and the length of our clip. We'll give that a try in the next program.

Resources:

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3718 Valley View Lane, #3040
Irving, TX 75062
(972) 659-9090
jonwms@aol.com

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

ISD25xxx Documentation
www.isd.com

Quadravox
www.quadravox.com

Talking Numbers

Listing 2 is the code for a program that demonstrates a couple of the routines we just developed. What this program does is generate random numbers, then says them aloud. The number is also displayed on a DEBUG terminal. There are two elements of this program: one that calls out the

```
' ===============
' Record messages
' ===============

Record:
  AddrL = 0                     ' clear old mode bits
  opMode = 6
  GOSUB SetModeBit              ' record in pushbutton mode
  LOW PR                        ' record mode

R_Hold:
  GOSUB GetBtn
  IF btn = 0 THEN R_Hold        ' wait for button

  PAUSE 250                     ' time to get voice ready
  PULSOUT CE_,50                ' initiate recording

R_Wait:
  IF EOM_ = 0 THEN R_Wait       ' wait for recording indicator
  LOW LED_                      ' record LED on

R_Loop:
  GOSUB GetBtn
  IF btn = 1 THEN R_Loop        ' record until button release
  PULSOUT CE_,50                ' mark end of message
  HIGH PR                       ' back to play (for safety)
  GOTO LED_off                  ' clear LED

' ======================
' Play messages in order
' ======================

P_Seq:
  AddrL = 0                     ' clear old mode bits
  opMode = 6
  GOSUB SetModeBit              ' play with pushbutton mode

PS_Hold:
  GOSUB GetBtn
  IF btn = 0 THEN PS_Hold       ' wait for button

  PULSOUT CE_,50                ' start message
  PAUSE 50                      ' let EOM go HIGH

PS_Wait:
  IF EOM_ = 1 THEN PS_Wait      ' wait for message to end

  GOTO PS_Hold                  ' get ready for next

' ======================
' Play specified message
' ======================

P_Msg:
  GOSUB GetBtn
  IF btn = 0 THEN P_Msg         ' wait for button

  FOR cntr = 5 TO 1             ' say 5 messages backward
    msgNum = cntr
    GOSUB PlayMessage
  NEXT

  GOTO P_Msg

' ==================================
' Play message at specified address
' ==================================

P_Addr:
  GOSUB GetBtn
  IF btn = 0 THEN P_Addr        ' wait for button

  msgAddr = 107                 ' set address
  GOSUB PlayClip                ' play to EOM marker

  GOTO P_Addr

' ===================================
' Play message for specified duration
' ===================================

P_Time:
  GOSUB GetBtn
  IF btn = 0 THEN P_Time        ' wait for button

  msgAddr = 95                  ' set address
  msgLen = 850                  ' set length (milliseconds)
  GOSUB PlayLength              ' play for specific length

  GOTO P_Time

' -----[ Subroutines ]-------------------------------------------------------
-
'
ResetISD:
  HIGH PD                       ' reset the ISD
  PAUSE 13
  LOW PD
```

digits of the number and one that says the number as we humans would.

There are a couple of requirements for this program to work, however. First, you have to record the list of digits and numbers into the device using ISD_LAB.BS2 set to Record mode. What you're going to do is press the button, wait for the LED to come on, say a number, then release the button. You want each number in the list stored as an individual message in the ISD.

Here's the complete list:

0, 1, 2, 3, 4, 5, 6, 7, 8, 9
10, 11, 12, 13, 14, 15, 16, 17, 18, 19
20, 30, 40, 50, 60, 70, 80, 90
"hundred"
"thousand"

You need to record the numbers very carefully, making sure not to create any blank messages in between. You can do a quick test by setting the Mode constant in ISD_LAB.BS2 to MPMsg (2), set the msgNum to 30, then running the program. If all went well, you should hear "thousand" come out of the speaker. If you get something else, you need to go back to Record mode and do it all again. Once it's done, it's done — and you'll probably get it on the first go.

Before you load up SAYNUMBR.BS2 though, you have to find the addresses and message lengths of the first 10 digits (0-9). Change the Mode constant to MPTime (4). What you're going to do is experiment with addresses and message lengths, listening for the best results.

The way to do this is to find the address first. I found that "sneaking up" on the address was the easiest way to go. Once you've found the best starting address, work on the message length. Again, I started shorter than I thought I'd need and extended out until the message sounded good.

My numbers won't be exact, but if you speak at an "average" speed, they can get you in the ballpark.

Clip	Addr	Length
"zero"	2	550
"one"	13	660
"two"	25	570
"three"	33	680
"four"	42	690
"five"	52	700
"six"	62	750
"seven"	73	830
"eight"	84	780
"nine"	95	850

Start at zero and work your way through the list. Don't forget to write down your own addresses and clip lengths!

Okay ... now you can load up SAYNMBR.BS2. Don't run it yet though, you need to edit the DATA statements, substituting your clip addresses and lengths for mine. Notice that the clip lengths are stored in 10 millisecond increments. I did this because the PBASIC READ command will only read bytes from EEPROM. By using a resolution of 10 ms, we could have clip lengths of up to 2.55 seconds. This is fine for our single-digit recordings.

Now run the program. Once it's downloaded, you should get a DEBUG screen that tells you to press the button. Go ahead and do it. While the Stamp is waiting for you to press the button, it's continuously calling the RANDOM function to generate a new number. This brings a "human" factor into the randomness. If we didn't do this, the program would give us the same pseudo-random list every time it was run.

When you do press the button, the DEBUG screen will clear and you'll see the message "Saying digits:" followed by five digits. Then, in your own voice, you'll hear the digits called out. Pretty neat, huh?

What I noticed — and you might too — is that I was a little stingy on addresses and clip lengths when I did my earlier analysis. This caused the digit list demo to sound a bit choppy and unnatural. Since the addresses and lengths are stored in DATA statements, you can fine-tune them to get a really great sounding demo. Even though it's not particularly practical in and of itself, I like this demo because it shows how cleanly sound clips can be concatenated with the ISD using the PlayLength subroutine. Yes, it takes some work, but I think it's worth it.

And keep in mind that PlayLength (with proper analysis, of course) can be used to break a single long clip into shorter fragments, reducing redundant recordings. Perhaps you want to be able to play one long segment, but also a single word or phrase from it. By locating the address and length of the word or phrase, you don't have to record it separately. This will save ISD memory space, allowing you to store a greater vocabulary. I'll bet you're already thinking about adding speech to one of your favorite projects, aren't you?

Okay, let's check out the next demo. The DEBUG screen will have cleared by now and prompted you for another button press. This time, you'll get the message: "Saying number:" followed by a number. Then, you hear the number spoken, just like you would if someone asked you to.

This segment of the program demonstrates the strengths and the weaknesses of using the ISD's message cueing mode. The strength of this mode is that we don't have to know the address or length of the message; we only need to know which message to play (starting with 1). The weakness is that clips often have "dead air" (silence) before and after the actual sound. Those silences and the occasional EOM pop become apparent when concatenating messages with cueing mode.

```
  RETURN


' scan and debounce button input
' - button must stay pushed for 25 ms and not change during routine
'
GetBtn:
  btn = 1                          ' assume pressed
  FOR x = 1 TO 5
    btn = btn & ~BtnIn             ' test input
    PAUSE 5                        ' delay between tests
  NEXT
  RETURN


PlayMessage:                    ' skip to specific message
  GOSUB ResetISD
  AddrL = %00010001             ' consecutive messages with cueing
  AddrH = %1111                 ' play, CE_ high, enable mode bits
  PAUSE 25                      ' wait Tpud

  IF (msgNum < 2) THEN PM_Play_It     ' play first if 0 or 1

PM_Fast_Forward:
  msgNum = msgNum - 1              ' don't skip selected message
  FOR x = 1 TO msgNum              ' fast forward to it
    PULSOUT CE_,3                  ' start FF
    PULSIN EOMpin,0,waste       ' wait for EOM of current message
  NEXT

PM_Play_It:
  AddrL = %00010000             ' remove cueing bit
  PULSOUT CE_,50                ' start the message
  PAUSE 50                      ' let EOM set

PM_Wait:
  IF EOM_ = 1 THEN PM_Wait      ' wait for EOM to pulse low
```

```
  RETURN


PlayClip:                                     ' play until EOM hit
  GOSUB ResetISD
  GOSUB SetAddress                            ' set address of message
  PAUSE 25
  PULSOUT CE_,50                              ' start play
  PAUSE 50                                    ' allow EOM to get set

PC_Wait:
  IF EOM_ = 1 THEN PC_Wait                    ' wait for EOM to pulse low
  RETURN


PlayLength:                                   ' play for msgLen milliseconds
  GOSUB ResetISD
  GOSUB SetAddress                            ' set address of message
  PAUSE 25                                    ' wat Tpud
  PULSOUT CE_,50                              ' start play
  PAUSE msgLen                                ' wait for message to end
  HIGH PD                                     ' stop
  RETURN


SetAddress:
  msgAddr = msgAddr MAX MaxAddr               ' limit address to chip
  AddrL = msgAddr.LowByte                     ' set A0..A7
  AddrH = %1100 | (msgAddr >> 8) ' set play, CE_ high, A8..A9
  RETURN


SetModeBit:
  AddrL = AddrL | (DCD opMode)                ' add operational mode bit
  AddrH = %1111                               ' set play, CE_ high, enable
mode
  RETURN
```

A STAMP-II ISD SOUND LAB

Let's take a look at the SayNumber code to see how this segment works. First, it checks to see if the number is zero. If it is, we set msgNum to 1 ("zero") and play it. If the number is greater than zero, it is broken down into three sections: thousands, hundreds, and tens/ones. We do this because it's the way we say numbers: "X thousand, Y hundred, Z."

A word-sized variable has 16 bits, so the largest number that will be returned by RANDOM is 65,535. Since the thousands portion and the tens/ones portion will be 99 or less, it makes sense to create a common subroutine to say a number from one to 99. Jump down to the subroutine called SayValueXX.

The first thing that this routine does is make sure that its target variable, tmpVal, is within the range of one to 99. If not, the routine is skipped, "saying" nothing. While this sort of range checking is not strictly necessary, it will save us headaches when we start copying this code to other programs.

Assuming the value is good, it's checked to see if it's less than 20. If this is the case, the code jumps down to the label SV_1TO19. At this point, we simply need to add one to the value (since "zero" is message 1) to get the message number and say it. After that we can return to the caller.

If the target value is greater than 19, we calculate the first message number by dividing the value by 10, then adding 19. This will cause the ISD to say "20," "30," and so on. Now we take tmpVal // 10 to see if there

Listing 2

```
' Nuts & Volts - Stamp Applications
' October 2000 (Listing 2)

' -----[ Title ]-----------------------------------------------------------
-
'
' File...... SAYNUMBR.BS2
' Purpose... Uses an ISD2560 to "say" and number
' Author.... Jon Williams
' E-mail.... jonwms@aol.com
' Started... 07 SEP 2000
' Updated... 08 SEP 2000


' -----[ Program Description ]---------------------------------------------
-
'
' This program demonstrates ISD message concatenation.  The program has
' two modes:
'
' MSDig (say digits)
' ==================
' In this mode, the individual digits of the random number are played.
' This code demonstrates playing sounds from a specific address for a
' specifiedlength of time.  Digit addresses and durations are stored in
' DATA statements (duration stored in 10 ms increments to fit into Byte).
'
' MSNum (say number)
' ==================
' In this mode, the number is spoken like we would.  This code
' demonstrates cueing.
'
' Requirements
' ============
' For this program to work, you need to use ISD_LAB.BS2 to record the
' list of digits (below) and determine clip timing (in 10 ms units) of
' the digits 0 through 9.
'
' Record this list (as individual clips) to the ISD:
'
'        0, 1, 2, 3, 4, 5, 6, 7, 8, 9
'        10, 11, 12, 13, 14, 15, 16, 17, 18, 19
'        20, 30, 40, 50, 60, 70, 80, 90,
'        "hundred", "thousand"


' -----[ I/O Definitions ]-------------------------------------------------
-
'
AddrL    VAR     OutL                    ' low bits of ISD address (0..7)
AddrH    VAR     OutC                    ' high bits of ISD address
(8..9)

CE_      CON     10                      ' ISD chip enable
PR       CON     11                      ' ISD play/record (play = 1)
PD       CON     12                      ' ISD power down (reset = 1)
EOM_     VAR     In13                    ' ISD end of message indicator
EOMpin   CON     13

BtnIn    VAR     In14                    ' button input
LED_     CON     15                      ' LED output (active low)


' -----[ Constants ]-------------------------------------------------------
-
'
MaxAddr CON      599                     ' last address in ISD25xx

MSDig    CON     0                       ' say digits
MSNum    CON     1                       ' say number


' -----[ Variables ]-------------------------------------------------------
-
'
btn      VAR     Bit                     ' pushbutton input
x        VAR     Byte                    ' loop counter
mode     VAR     Bit                     ' demo mode
msgNum   VAR     Byte                    ' message number
msgAddr  VAR     Word                    ' clip segment address (0 - 599)
msgLen   VAR     Word                    ' clip length in milliseconds
waste    VAR     Word                    ' workspace for PULSIN
opMode   VAR     Nib                     ' for use with SetModeBit
randW    VAR     Word                    ' random number
digit    VAR     Byte                    ' work value for saying digits
tmpVal   VAR     Byte                    ' work value for number to
speech


' -----[ EEPROM Data ]-----------------------------------------------------
-
'
DAddr    DATA    2,13,25,33,42,52,62,73,84,95     ' ISD address ("0" -
"9")
DTime    DATA    55,66,57,68,69,70,75,83,78,85    ' time (10 ms units)


' -----[ Initialization ]--------------------------------------------------
-
'
Init_IO_Pins:
  AddrL = %00000000                      ' clear message address bus
  AddrH = %1100                          ' play, CE_ high, clear A9 & A8

  DirL = %11111111                       ' low bits of address
  DirC = %1111                           ' PR, CE_, A9, A8
  DirD = %1001                           ' LED_, Btn, EOM_, PD

ISD_Setup:
  GOSUB ResetISD
  PAUSE 25                               ' let ISD settle (Tpud)

LED_Off:
  HIGH LED_


' -----[ Main Code ]-------------------------------------------------------
-
'
Main:
  GOSUB GetBtn
  IF btn = 1 THEN Main                   ' wait for release

  DEBUG CLS, "Press the button..."

BWait:
  RANDOM randW                           ' generate new random number
  GOSUB GetBtn
  IF btn = 0 THEN BWait                  ' wait for press

  BRANCH Mode, [SayDigits,SayNumber]     ' branch to selected demo
  GOTO Main


' =============================
' Say individual digits
' - use clip address and length
' =============================

SayDigits:
  DEBUG CLS, "Saying digits: ", DEC5 randW, CR

  FOR x = 4 TO 0                         ' say all 5 digits
    digit = randW DIG x                  ' get the digit
    READ (DAddr + digit),msgAddr ' set the ISD digit address
    READ (DTime + digit),msgLen          ' read the length
    msgLen = msgLen * 10         ' set to milliseconds
    GOSUB PlayLength                     ' say the digit
  NEXT

  mode = ~mode                           ' flip mode
  GOTO Main                              ' do it all again


' ==============================
' Say number as we would speak it
' ==============================

SayNumber:

  DEBUG CLS, "Saying number: ", DEC randW, CR
```

are any ones in our value (remember that // returns the remainder of a division). If there is a ones value, the code at SV_1TO19 handles it as I described above. If the result is zero, we're done.

Back to saying our number. The first thing we're going to do is divide our random number, randW, by 1,000. If the result is greater than zero, we'll use SayValueXX to say it and then we'll say "thousand" by playing message 30. Saying the hundreds value works the same except the "hundreds" message is number 29. Finally, we're down to less than 100 and we can just say it. It's really very easy once the process has been broken into parts.

So once again, we've concatenated discrete sound clips into a single message. If you're careful not to leave too much dead space at the beginning and end of your messages, this technique is easy to use and can be quite effective.

Making It Permanent

You may get the itch — as I have — to build a permanent version of the ISD Lab. The problem is all the Stamp I/O lines that get eaten up. My suggestion is that you use two 74HC595 shift registers — connected in series — to handle all of the address lines (A0..A9), PD (pin 24), and PR (pin 27). The CE and EOM pins should be connected directly to the Stamp.

Of course, the software will need updating, too. If I get enough requests, I'll post my schematic and updated code.

Oops ...

For those of you that did attempt to build last month's project, you may have run into a little bit of trouble — unless you downloaded the ISD documentation and caught my error. My schematic (Sept. 2000 issue, page 28) shows all of the ISD's address lines tied to ground. This is not correct. For Push-Button mode, pins 7 (A6), 9 (A8), and 10 (A9) should be tied to Vdd (+5). I'm sorry for the error and any headaches it may have caused you.

Next Time

I seem to be on a sound wave, as it were, and we'll continue with that theme next month. My friend and fellow DPRG member, Robert Jordan, has shown me some really neat tricks with the Stamp's FREQOUT and DTMFOUT commands. I'll be passing them on to you.

Until then, Happy Stamping. **NV**

```
  IF randW = 0 THEN SN_Zero                 ' if zero, just say it

  tmpVal = randW / 1000                     ' get 1000s
  IF tmpVal = 0 THEN SN_100s                ' if zero, skip to 100s
  GOSUB SayValueXX                          ' say thousands value
  msgNum = 30
  GOSUB PlayMessage                         ' say "thousand"

SN_100s:
  tmpVal = (randW // 1000) / 100 ' get 100s
  IF tmpVal = 0 THEN SN_10                  ' if zero, skip to 10s
  GOSUB SayValueXX                          ' say 100s value
  msgNum = 29
  GOSUB PlayMessage                         ' say "hundred"

SN_10:
  tmpVal = randW // 100                     ' get 10s and 1s
  GOSUB SayValueXX                          ' say value
  GOTO SN_Done

SN_Zero:
  msgNum = 1
  GOSUB PlayMessage                         ' say "zero"

SN_Done:
  mode = ~mode                              ' flip mode
  GOTO Main


' -----[ Subroutines ]-----------------------------------------------------
-
'

ResetISD:
  HIGH PD                                   ' reset the ISD
  PAUSE 13
  LOW PD
  RETURN


' scan and debounce button input
' - button must stay pushed for 25 ms and not change during routine
'
GetBtn:
  btn = 1                                   ' assume pressed
  FOR x = 1 TO 5
    btn = btn & ~BtnIn                      ' test input
    PAUSE 5                                 ' delay between tests
  NEXT
  RETURN


PlayMessage:                                ' skip to specific message
  GOSUB ResetISD
  AddrL = %00010001                         ' consecutive messages with cue-
ing
  AddrH = %1111                             ' play, CE_ high, enable mode
bits
  PAUSE 25                                  ' wait Tpud

  IF (msgNum < 2) THEN PM_Play_It           ' play first if 0 or 1

PM_Fast_Forward:
  msgNum = msgNum - 1                       ' don't skip selected message
  FOR x = 1 TO msgNum                       ' fast forward to it
    PULSOUT CE_,3                           ' start FF
    PULSIN EOMpin,0,waste                   ' wait for EOM of current mes-
sage
  NEXT

PM_Play_It:
  AddrL = %00010000                         ' remove cueing bit
  PULSOUT CE_,50                    ' start the message
  PAUSE 50                                  ' let EOM set

PM_Wait:
  IF EOM_ = 1 THEN PM_Wait                  ' wait for EOM to pulse low
  RETURN


PlayClip:                                   ' play until EOM hit
  GOSUB ResetISD
  GOSUB SetAddress                          ' set address of message
  PAUSE 25
  PULSOUT CE_,50                    ' start play
  PAUSE 50                                  ' allow EOM to get set

PC_Wait:
  IF EOM_ = 1 THEN PC_Wait                  ' wait for EOM to pulse low
  RETURN


PlayLength:                                 ' play for msgLen milliseconds
  GOSUB ResetISD
  GOSUB SetAddress                          ' set address of message
  PAUSE 25                                  ' wat Tpud
  PULSOUT CE_,50                    ' start play
  PAUSE msgLen                              ' wait for message to end
  HIGH PD                                   ' stop
  RETURN


SetAddress:
  msgAddr = msgAddr MAX MaxAddr             ' limit address to chip
  AddrL = msgAddr.LowByte                   ' set A0..A7
  AddrH = %1100 | (msgAddr >> 8) ' set play, CE_ high, A8..A9
  RETURN


SetModeBit:
  AddrL = AddrL | (DCD opMode)              ' add operational mode bit
  AddrH = %1111                             ' set play, CE_ high, enable
mode
  RETURN


' ===============
' Talking Numbers
' ===============
'
' say a value between 1 and 99
'
SayValueXX:
  IF (tmpVal < 1) | (tmpVal > 99) THEN SV_Done

  IF tmpVal < 20 THEN SV_1TO19              ' skip if less than 20

  msgNum = (tmpVal / 10) + 19               ' calculate 10s message #
  GOSUB PlayMessage                         ' say 10s
  tmpVal = tmpVal // 10                     ' calculate 1s message #
  IF tmpVal = 0 THEN SV_Done                ' skip if zero

SV_1TO19:
  msgNum = tmpVal + 1                       ' correct 0-offset
  GOSUB PlayMessage                         ' say 1s

SV_Done:
  RETURN                                    ' all done
```

by Ray Marston

MISCELLANEOUS '555' CIRCUITS

In this '555 timer IC' application article, Ray Marston shows a variety of unusual ways of using the IC in applications such as Schmitt triggers, astable gadgets, alarms, and long-period timers.

The '555' timer is a popular bipolar IC that is specifically designed to generate accurate and stable C-R – defined timing periods, for use in various monostable 'one-shot' pulse generator and astable squarewave generator applications. The '555' IC is, however, very versatile, and this article shows a variety of ways of using it in 'special' or unusual applications.

SCHMITT TRIGGERS

The 555 can be used as a Schmitt trigger by shorting pins 2 (trigger) and 6 (threshold) together and applying the input signals directly to these points, as shown in the functional diagram and circuit in *Figure 1*. The IC's action is such that (as illustrated by the *Figure 1* input and output waveforms) when the input voltage rises above 2/3 V_{cc}, the IC output switches low, and remains there until the input falls below 1/3 V_{cc}, at which point, the output switches high and remains there until the input rises above 2/3 V_{cc} again. The difference between these two trigger levels is called the hysteresis value, and equals 1/3 V_{cc} in this case; this large hysteresis value makes the circuit useful in noise/ripple-rejecting signal conditioning applications.

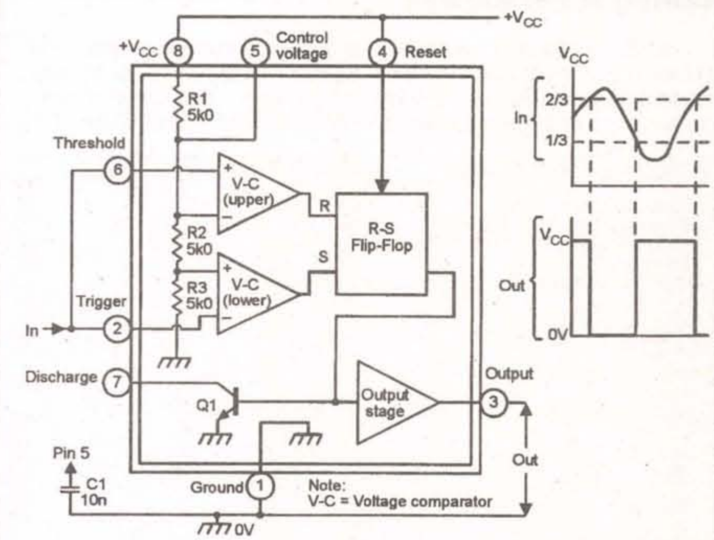


Figure 1. **Functional block diagram (within the double lines) of the 555 timer IC, with external connections for use as a simple but useful Schmitt trigger.**

Figure 2 shows the basic Schmitt circuit modified for use as a high-performance sine/square converter that can be used at input frequencies up to about 150kHz. Potential divider R1-R2 biases pins 2 and 6 to a quiescent value of 1/2 V_{cc} (i.e., mid-way between the upper and lower trigger values),

CIRCUIT APPLICATIONS:

- SCHMITT TRIGGERS
- MORSE CODE PRACTICE OSCILLATORS
- ELECTRONIC DOOR BUZZER
- CONTINUITY TESTER
- SIGNAL INJECTOR
- METRONOME
- LED FLASHERS and ALARMS
- LONG-PERIOD TIMERS

and the sinewave input is superimposed on this point via C1; squarewave outputs are taken from pin 3. R3 isolates the input signal from the effects of the 555's switching actions. The diagram shows how optional RFI suppression can be obtained via C3.

Figure 3 shows the 555 used as a minimum-backlash (zero hysteresis) dark-activated relay switch, with light-dependent potential divider RV1-LDR wired to its input terminal. The RV1 and LDR values are roughly equal at the median switching light level. This circuit acts as a fast comparator rather than as a true Schmitt trigger, since pin 6 is tied high via R1, and the light-sensing RV1-LDR potential divider is applied to pin 2 only. Note that this circuit needs good supply decoupling, which is provided via C2.

The above circuit can be made to act as a light (rather than dark) activated switch by transposing the RV1 and LDR positions, as shown in *Figure 4(a)*, or can be made to act as a temperature-activated switch by using an NTC thermistor in place of the LDR, as shown in *Figures 4(b)* and *4(c)*; in all cases, the LDR or thermistor must present a resistance in the range 470R to 10K at the required turn-on level.

ASTABLE GADGETS

The 555 astable multivibrator is very versatile and can be used in many applications of interest to both the amateur and professional user. *Figures 5* to *11* show examples of typical 555 astable gadgets. *Figure 5* shows a Morse-code practice oscillator, with frequency variable from 300Hz to 3kHz via TONE control RV1. The 'phone volume is variable via RV2, and the 'phones can have any impedance from a few ohms upwards. The circuit draws zero quiescent current when the Morse key is open.

Figure 6 shows a simple electronic 'door-buzzer' that feeds a monotone signal to a small speaker (25R to 80R) when SW1 is closed; C1 has a low supply-line impedance and ensures adequate output drive capacity.

Figure 7 shows a continuity tester that generates an audible tone only if the resistance between the test probes is less than a few ohms. The astable operates only if pin 4 is biased above 700mV; normally this pin is grounded via R2, so the astable is off; to operate the astable, the two probes must be shorted together, connecting R2 to the output of the R3-ZD1 voltage-reference generator via RV2. In use, RV2 is trimmed so that astable operation is barely obtained under this condition, and ceases if the inter-probe resistance exceeds a few ohms. Note that the circuit consumes several mA whenever SW1 is closed, even if the probes are open circuit.

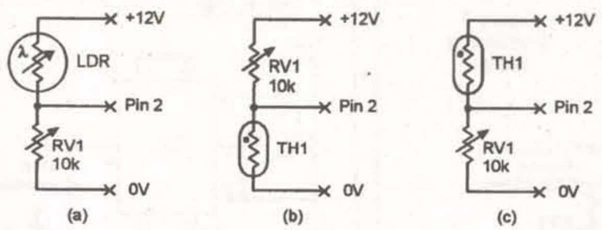


Figure 4. **Alternative input circuits for *Figure 3*, to give activation by (a) light, (b) under-temperature, and (c) over-temperature.**

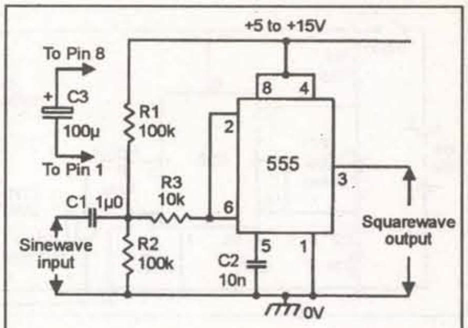
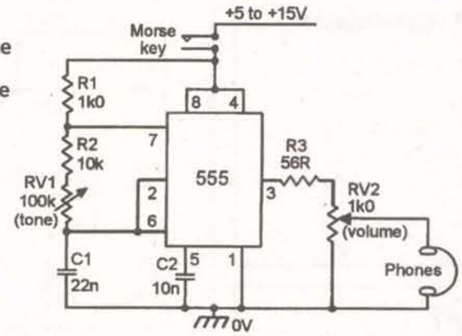


Figure 2. **555 Schmitt sine/square converter, with optional RFI suppression via C3.**

Figure 5. **Code-practice oscillator with variable tone and volume.**



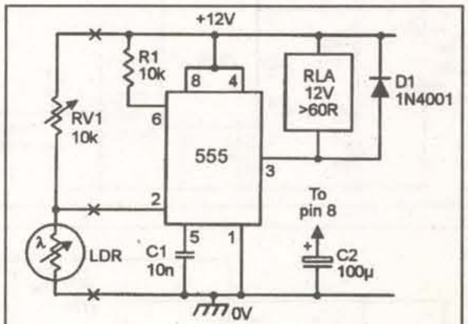


Figure 3. **Minimum-backlash dark-activated relay switch.**

Figure 6. **Electronic 'door-buzzer.'**

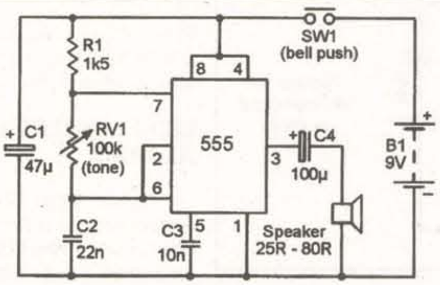


Figure 8 shows a signal injector that is useful for testing both AF and RF circuits. The astable operates at a basic frequency of a few hundred Hz when PB1 is closed; the square output waveform is very rich in harmonics, however, and these can be detected at frequencies up to 10s of MHz on a radio receiver. The signal injection level is variable via RV1.

Figure 9 shows a metronome in which the 'tick' rate is variable from 30 to 120 beats per minute via RV1, and the volume is variable via RV2. This circuit is a modified version of the standard astable,

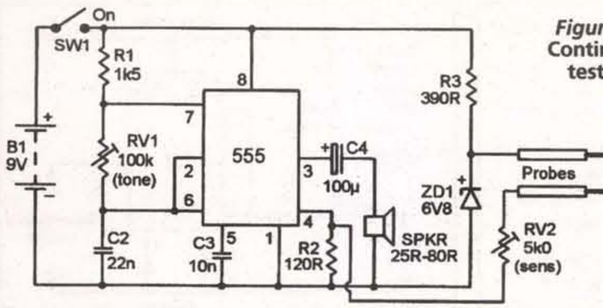


Figure 7. **Continuity tester.**

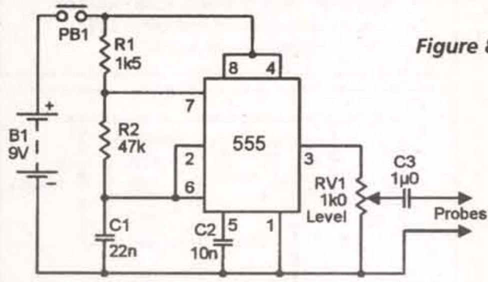


Figure 8. **Signal injector.**

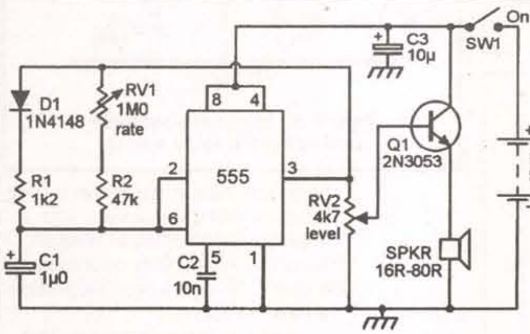


Figure 9. **Metronome circuit.**

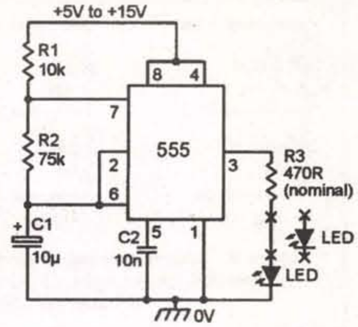


Figure 10. **LED flasher with 'single-ended' output.**

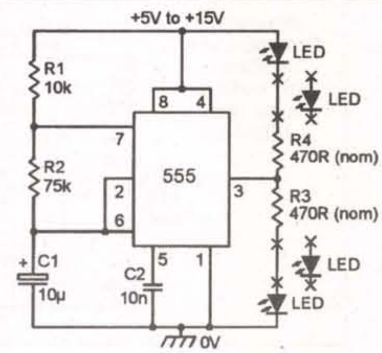


Figure 11. **LED flasher with 'double-ended' output.**

with its main timing network driven from the IC's pin 3 output. When the output switches high, C1 charges rapidly via D1-R1 to generate a brief (a few mS) 'tick' pulse. When the output switches low again, C1 discharges via RV1-R2, producing an 'off' period of up to 2s (= 30 beats/minute). The output pulses are fed to a small speaker via volume control RV2 and buffer Q1.

LED FLASHERS and ALARMS

Figures 10 to *12* show the 555 astable used in LED flasher applications in which the LEDs have equal on and off times. With the component values shown, the circuits each operate at about one flash per second. The *Figure 10* circuit has a 'single ended' output. Either a single LED or a chain of series-wired LEDs can be put between the IC's output and ground, and all LEDs turn on or off together; R3 sets the ON current of the LEDs. Most LEDs drop about 2V when on, so several LEDs can be series-wired in a circuit that is powered from a 15V supply.

Figure 11 is similar to the above, but has a 'double-ended' output connection in which all 'upper' LEDs are on when the 'lower' ones are off, and vice versa. R3 sets the ON currents of the lower LEDs and R4 sets that of the upper ones.

Figure 12 shows the basic *Figure 10* flasher circuit modified to give automatic dark-activated operation. R4-R5-LDR-RV1 are used as a light-sensitive Wheatstone bridge that is used to activate the 555 astable via balance-detector Q1 and the pin 4 RESET pin of the IC. Under bright conditions, the LDR has a low resistance, so the Q1 base-emitter junction is reverse-biased and less than 700mV appear on pin 4, so the astable is off. But under dark conditions, the LDR resistance is high and Q1 is biased on, generating more than 700mV on pin 4 and turning the astable on. The LDR must give a resistance in the range 470R to 10K at the dark turn-on level, and RV1 is adjusted so that the astable just activates under this condition.

The above technique gives precision gating and can be used to auto-activate a variety of other 555 astable circuits, to make various audible alarms and relay pulsers, etc. By transposing the LDR and RV1 positions or replacing the LDR with an NTC thermistor, these circuits can be made to auto-active when light or temperature levels go

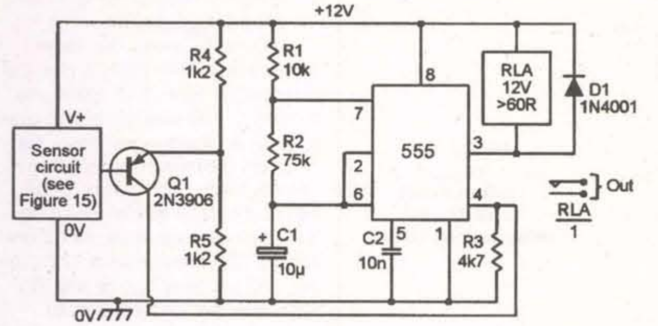


Figure 13. **Heat/light-activated relay pulser.**

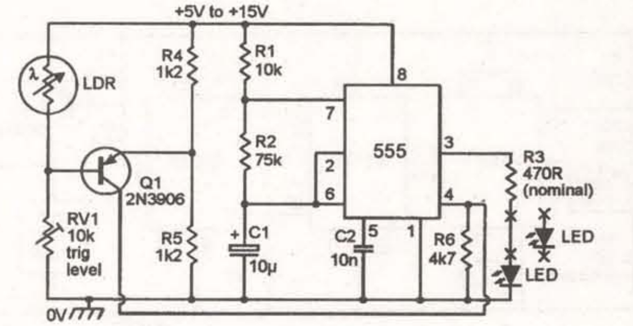


Figure 12. **Automatic (dark-activated) LED flasher.**

beyond pre-set limits. *Figures 13* to *15* show practical examples of such circuits.

The *Figure 13* circuit gives automatic heat or light activation of a relay pulser, which switches on and off at a once-per-second rate when activated. The relay can be any 12V type with a coil resistance greater than 60 ohms, and its contacts can be used to activate external electrically powered devices such as light, sirens, or alarm horns, etc.

Figure 14 gives automatic heat or light activation of a monotone alarm-call generator, which generates an 800Hz alarm tone at several watts in an eight-ohm speaker when activated. Note that the high output current of the circuit may cause modulation of the supply line, so D1 and C3 are used to protect the circuitry from ripple effects, and D2 and D3 clamp the speaker's inductive switching spikes and thus protect output transistor Q2 from damage.

Figure 15 shows the alternative sensor circuitry that can be used to auto-activate the *Figure 13* or *14* circuits. For light-sensitive operation, the sensor must be an LDR; for temperature-sensitive activation, it must be an NTC thermistor; in either case, the sensor element must have a resistance in the 470R to 10K range at the desired trigger level.

Figure 14. **Heat/light-activated medium-power monotone (800Hz) alarm.**

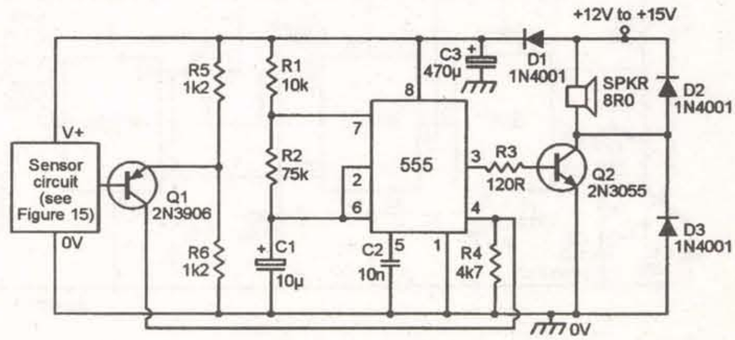
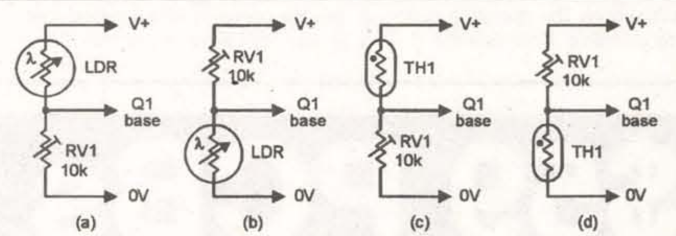


Figure 15. **Alternative sensor circuits for use with *Figure 13* or *14*, to give activation via (a) dark, (b) light, (c) under-temperature, or (d) over-temperature.**



LONG-PERIOD TIMERS

The 555 IC can be used to make an excellent manually-triggered relay-driving timer when connected in the monostable or pulse-generator mode, but cannot give accurate timing periods in excess of a few minutes, since it would have to use a high value electrolytic timing capacitor, and these have very wide tolerance limits (typically -50% to +100%) and large and unpredictable leakage currents.

An excellent way of getting very long but accurate timing periods is shown (in block diagram form) in *Figure 16*, which outlines the design of a 60-minute relay-driving timer. Here, the 555 is wired as a 2.28Hz astable that uses a stable polyester timing capacitor, and its output is fed to the relay driver via a 14-stage binary divider that gives an overall division ratio of 16,384. The divider action is such that (if its output register is set to zero at the start of the input count) its output switches high on the arrival of the 8192nd astable pulse and goes low again on the arrival of the 16,382nd pulse, thus completing the count cycle. Thus, the *Figure 16* circuit operates as follows:

The timing sequence is initiated by pressing push-button switch PB1, thus connecting the circuit's supply, activating the astable, and (via C2-R3) setting the counter to 'zero count' and driving its output low and turning the relay on; as the relay turns on, its RLA/1 contacts close and by-pass PB1, thus maintaining the supply connection once PB1 is released. This state is maintained until the 8192nd astable pulse arrives, at which point the counter's output switches high and turns the relay off, thus opening contacts RLA/1 and breaking the

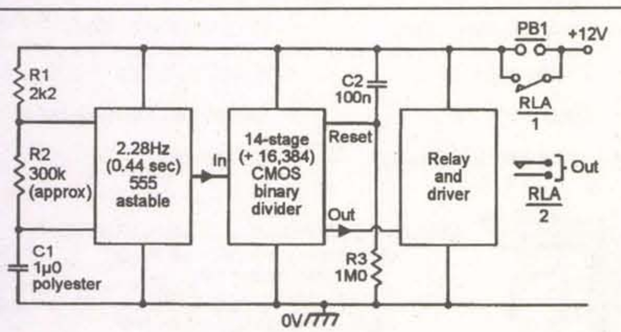


Figure 16. **Method of obtaining 60-minute timing period from the 555 IC.**

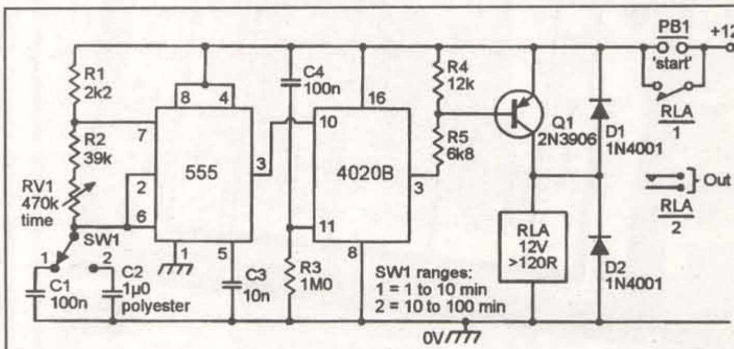


Figure 17. **Two-range (1-10 minute and 10-100 minute) relay-output timer.**

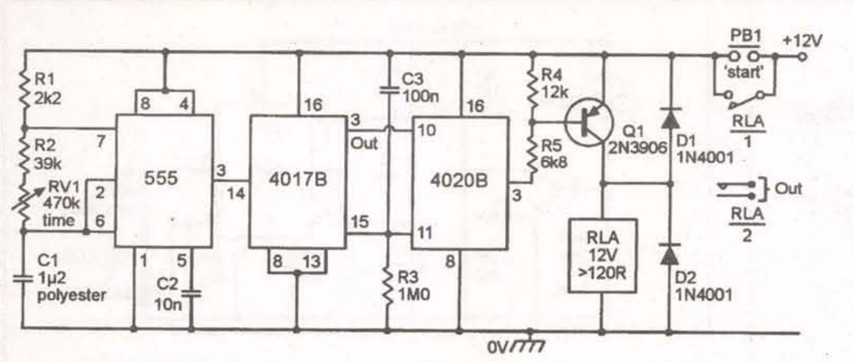


Figure 18. Extra-long-period (100 minutes to 20 hours) relay-output timer.

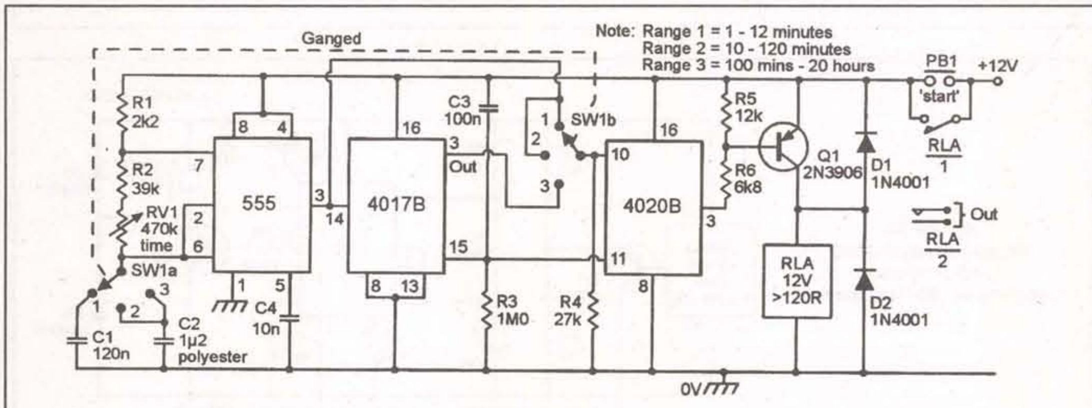


Figure 19. **Wide-range timer that covers one minute to 20 hours in three decade ranges.**

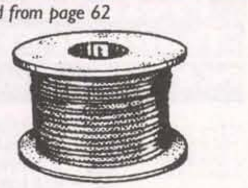
circuit's supply. The operating cycle is then complete. Note that the astable operates with a period that is only 1/8192nd of the final 'timing' period, i.e., 0.44 seconds in this case, and that this period can easily be obtained without using an electrolytic timing capacitor.

Figure 17 shows the above technique used to make a practical relay-output timer that spans one minute to 100 minutes in two overlapping decade ranges. Here, the 555 variable-frequency two-range astable feeds clock pulses to the 4020B 14-stage divider which, in turn, activates the relay via transistor Q1. The circuit uses a 12V supply, and the relay can be any 12V type with two or more sets of change-over contacts and a coil resistance of 120 ohms or greater.

Figure 18 shows how the available time delay of the circuit can be further increased by wiring a 4017B decade divider between the output of the 555 and the input of the 4020B, to give an overall division ratio of 81,920, thus making delays in the range 100 minutes to 20 hours available from this single-range timer. Both divider ICs are automatically reset (via C3-R3) at the moment of switch-on (PB1 closure).

Finally, *Figure 19* shows the above circuit modified to make a wide-range general-purpose timer that spans one minute to 20 hours in three decade-related ranges; the 4017B decade divider stage is used only on range '3.' Range switching is obtained via two-pole three-way switch SW1. **NV**

Continued from page 62



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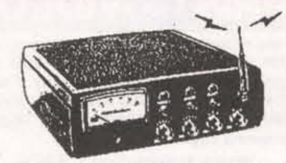

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Open Channel

by Joseph J. Carr

Using the P-I-N Diode

The P-I-N (or "PIN") diode has a number of uses that are unique, and will do some of the same jobs as regular signal diodes better. In this article, we will look at the structure of the PIN diode, and some of its applications.

Consider some of those applications. Most modern radio transceivers (i.e., "transmitter-receiver") use "relayless" switching to go back and forth between the RECEIVE and TRANSMIT states. Relayless switching is usually done with PIN diodes. Receiver IF filters and front-end bandpass filters are selected with a front panel switch that handle only direct current. How? Again, PIN diodes. These interesting little components allow us to do switching at RF, IF, and audio frequencies without routing the signals themselves all over the cabinet. In this month's column, we will see how these circuits work.

The P-I-N or "PIN" diode is different from the standard PN junction diode (see Figure 1A), which consists of P-type and N-type semiconductors mated together at a junction. The PIN diode has an insulating ("Intrinsic," hence the "I" in "PIN") region between the P- and N-type material (Figure 1B). It is therefore a multi-region semiconductor device despite having only two electrodes. The I-region is not really a true semiconductor insulator, but rather is a very lightly doped N-type region. It is called an "intrinsic" region because it has very few charge carriers to support the flow of an electrical current.

When a forward bias potential is applied to the PIN diode, charge carriers are injected into the I-region from both N and P regions. But the lightly-doped design of the intrinsic region is such that the N- and P-type charge carriers don't immediately recombine (as in PN junction diodes). There is always a delay period for recombination. Because of this delay phenomena, there is always a small but finite number of carriers in the I-region that are uncombined. As a result, the resistivity of the I-region is very low.

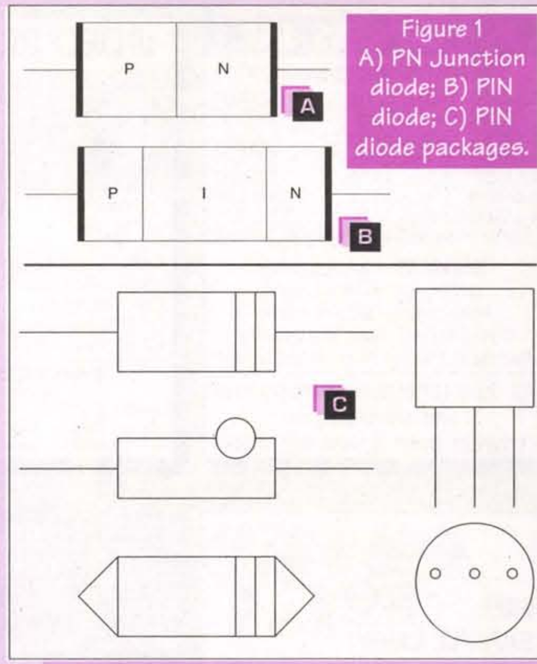


Figure 1
A) PN Junction diode; B) PIN diode; C) PIN diode packages.

One application that results from the delay of signals passing across the intrinsic region is that the PIN diode can be used as an RF phase shifter. In some microwave antennas, phase shifting is accomplished by the use of one or more PIN diodes in series with the signal line. Although there are other forms of RF phase shifters (e.g., phase shifter) usable at those frequencies, the PIN diode remains popular.

Figure 1C shows some of the package styles used for PIN diodes at small signal power levels. All but one of these shapes is familiar to most readers, although the odd-shaped flat package is probably recognized only by people with some experience in UHF and up switching circuits. The NTE-553 and ECG-553 PIN diode will dissipate 200 mW, and uses the standard cylindrical package style. The NTE-555 and ECG-555 device, on the other hand, uses the UHF flat package style and can dissipate 400 mW. I used these diodes for the experiments performed to write this column because they are service shop replacement lines, and both ECG and NTE are widely distributed in local parts stores. An alternative that might be harder

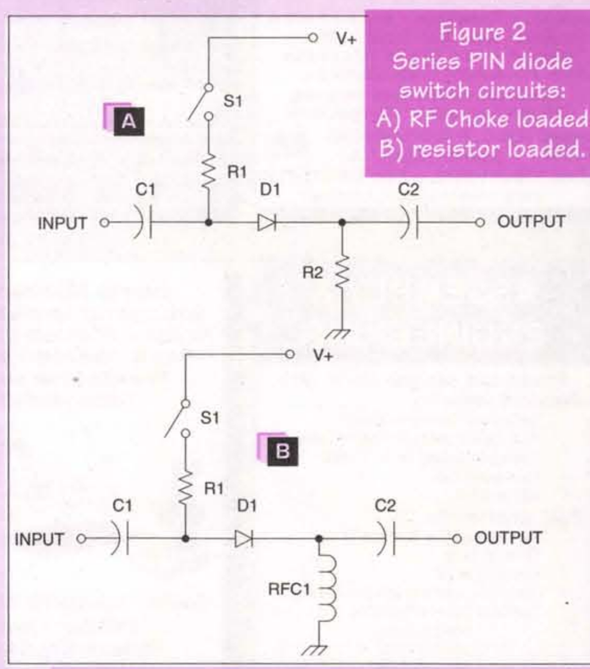


Figure 2
Series PIN diode switch circuits: A) RF Choke loaded B) resistor loaded.

Using the P-I-N Diode

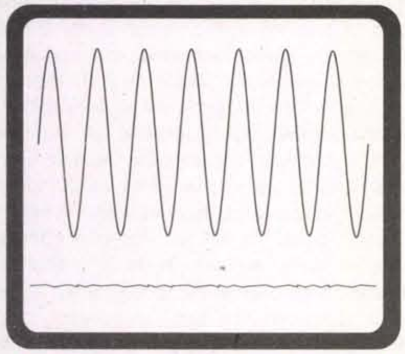


Figure 3
Switched and unswitched input/output waveforms.

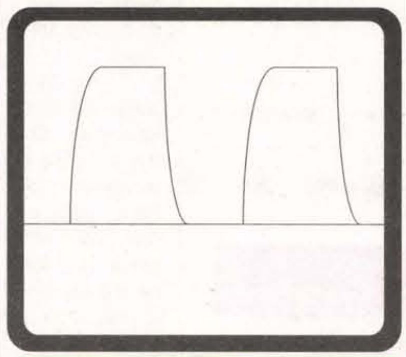


Figure 4
Switching via square wave.

to come by is the MPN3404, which uses the TO-92 plastic package style shown in Figure 1C.

Radio frequency AC signals can pass through the PIN device and, in fact, see it under some circumstances as merely a parallel plate capacitor. We can use PIN diodes as electronic switches for RF signals, as an RF delay line or phase-shifter, or as an amplitude modulator.

PIN Diode Switch Circuits

PIN diodes can be used as switches in either series or parallel modes. Figure 2 shows two similar switch circuits. In the circuit of Figure 2A, the diode (D1) is placed in series with the signal line. When the diode is turned on, the signal path has a low resistance, and when the diode is turned off it has a very high resistance (thus providing the switching action). When switch S1 is open, the diode is unbiased so the circuit is open by virtue of the very high series resistance. But when S1 is closed, the diode is forward biased and the signal path is now a low resistance. The ratio of off/on resistances provides a measure of the isolation provided by the circuit. A pair of radio frequency chokes (RFC1 and RFC2) are used to provide a high impedance to RF signals, while offering low DC resistance. Figure 2B is similar to Figure 2A except that the RF chokes are deleted, and a resistor is added.

Figure 3 shows a test that I performed on the circuit of Figure 2B using a 455 KHz IF signal (the 'scope was set to show only a few cycles of the 455 KHz). The upper oscilloscope trace in Figure 3 shows the "ON" position where +12 VDC was connected through switch S1 to the PIN diode's current limiting resistor. This signal is 1,200 mV peak-to-peak. The lower trace in Figure 3 shows the same signal when the switch was "OFF" (i.e., +12 VDC disconnected), but with the oscilloscope set to the same level. It appears to be a straight line. Increasing the sensitivity of the 'scope showed a level of 12 mV getting through. This means that this simplest circuit provides a 100:1 on/off ratio, which is 40 dB of isolation. [Note: For this experiment, the ECG-555 and NTE-555 hot carrier PIN diodes were used].

Figure 4 shows the same switch when a squarewave is used to drive the PIN diode control voltage line, rather than +12 volts DC. This situation is analogous to a CW keying waveform. The photo represents one on/off cycle. With the resistor and capacitor values shown, there is a pronounced switching transient present.

Figure 5 shows the circuit for a shunt PIN diode switch. In this case, the diode is placed across the signal line, rather than in series with it. When the diode is turned off, the resistance across the signal path is high, so operation of the circuit is unimpeded. But when the diode is turned on (S1 closed), a near-short-circuit is placed across the line. This type of circuit is turned off when the diode is forward biased. This action is in contrast to the series switch in which a forward biased diode is used to turn the circuit on.

A combination series-shunt circuit is shown in Figure 6. In this circuit, D1 and D2 are placed in series with the signal line, while D3 is in parallel with the line. D1 and D2 will turn on with a positive potential applied, while D3 turns on when a negative potential is applied. When switch S1 is in the "ON" position, a positive potential is applied to the junction of the three diodes. As a result, D1 and D2 are forward biased and thus take on a low resistance. At the same time, D3 is hard reverse biased, so has a very high resistance. Signal is passed from input to output essentially unimpeded (most PIN diodes have a very low series resistance).

But when S1 is in the off position, the opposite situation occurs. In this case, the applied potential is negative so D1/D2 are reverse biased (and take on a high series resistance), while D3 is forward biased (and takes on a low series resistance). This circuit action creates a tremendous attenuation of the signal between input and output.

Other PIN Diode Applications

PIN diodes can be used as either a variable resistor or as an electronic switch for RF signals. In the latter case,

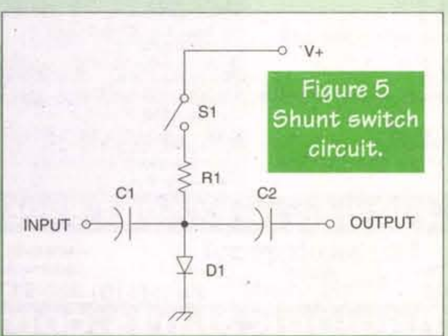


Figure 5
Shunt switch circuit.

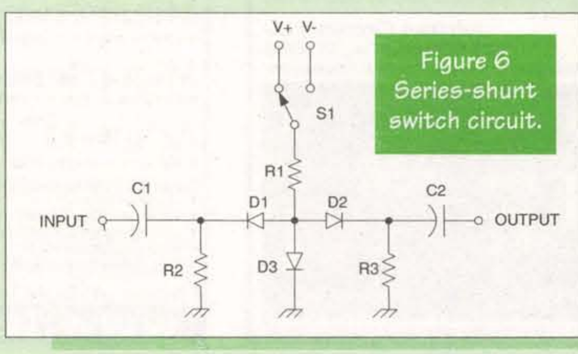


Figure 6
Series-shunt switch circuit.

Using the P-I-N Diode

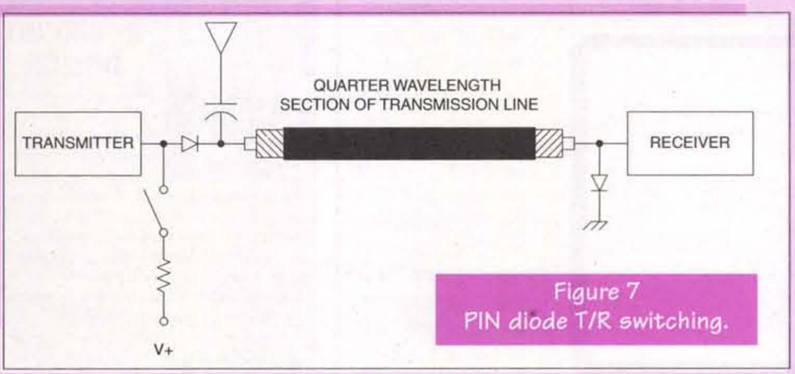


Figure 7
PIN diode T/R switching.

the diode is basically a two-valued resistor with one value being very high and the other being very low. These characteristics open several possible applications.

When used as a switch, PIN diodes can be used to switch devices such as attenuators, filters, and amplifiers in and out of the circuit. It has become standard practice in modern radio equipment to switch DC voltages to bias PIN diodes rather than directly switch RF/IF signals. In some cases, the PIN diode can be used to simply short out the transmission path to bypass the device.

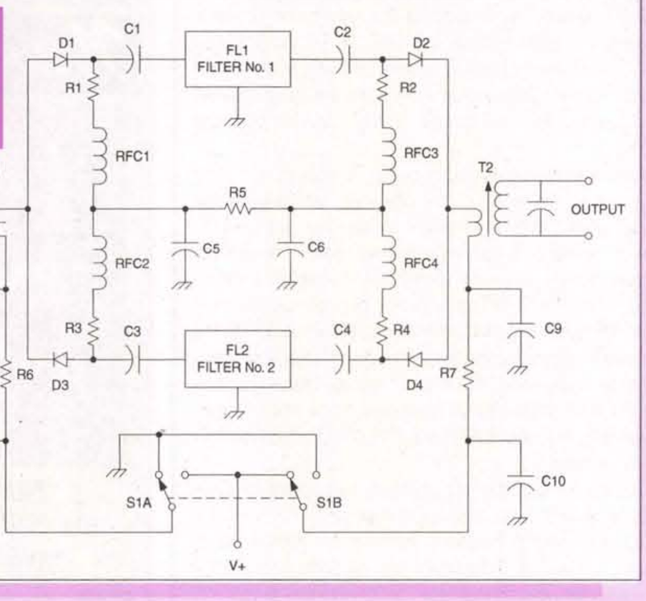
The PIN diode will also work as an amplitude modulator. In this application, a PIN diode is connected across a transmission line, or inserted into one end of a piece of microwave waveguide. The audio modulating voltage is applied through an RF choke to the PIN diode. When a CW signal is applied to the transmission line, the varying resistance of the PIN diode causes the signal to be amplitude modulated.

Another application is shown in Figure 7. Here we have a pair of PIN diodes used as a transmit-receive (TR) switch in a radio transmitter; models from low-HF to microwave use this technique. Where you see a so-called "relayless TR switch," it is almost certain that a PIN diode network such as Figure 7 is in use. When switch S1 is open, diodes D1 and D2 are unbiased, so present a high impedance to the signal. Diode D1 is in series with the transmitter signal, so blocks it from reaching the antenna; diode D2, on the other hand, is across the receiver input so does not attenuate the receiver input signal at all. But when switch S1 is closed, the opposite situation occurs: both D1 and D2 are now forward biased. Diode D1 is now a low resistance in series with the transmitter output signal, so the transmitter is effectively connected to the antenna. Diode D2 is also a low resistance, and is across the receiver input so causes it to short out. The isolation network can be either a quarter wavelength transmission line, microstrip line designed into the printed circuit board, or an LC pi-section filter.

Transmitters up to several kilowatts have been designed using this form of switching, and almost all current VHF/UHF portable "handi-talkies" use PIN diode switching. Higher power circuits require larger diodes than were discussed here, but they are easily available from industrial distributors.

Figure 8A shows how multiple IF bandpass filters are selected with only DC being routed around the cabinet between circuitry and front panel. A set of input and output PIN diode switches are connected as shown, and fed with a switch that selects either 0 VDC or +12 VDC alternately. When

Figure 8A
IF Bandpass filter switching.



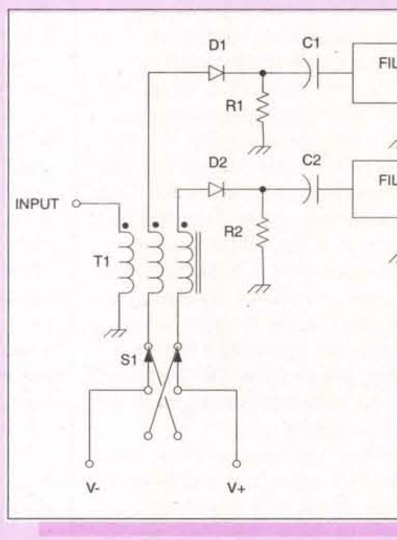


Figure 8B
Alternate RF switch using trifilar transformer.

Using the P-I-N Diode

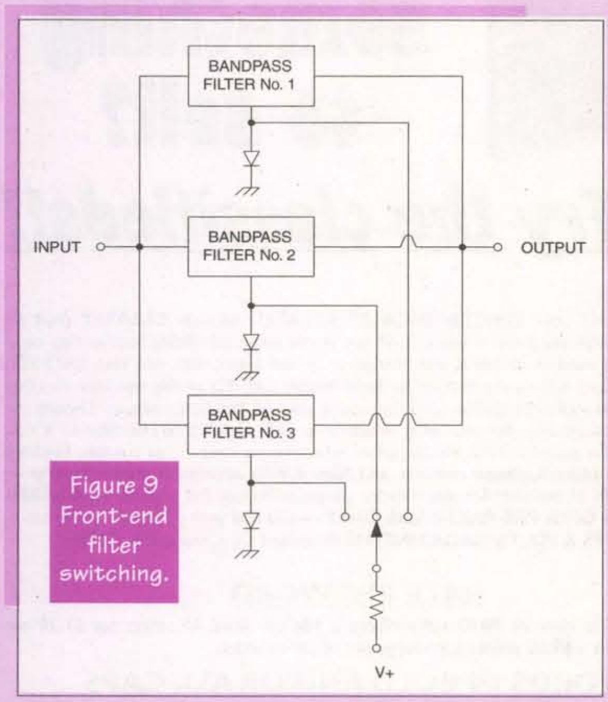


Figure 9
Front-end filter switching.

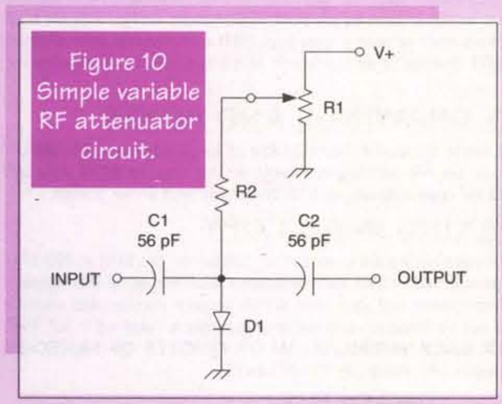


Figure 10
Simple variable RF attenuator circuit.

the switch is in opposite to the position shown, the +12 goes to the filter no. 1 switch, so filter no. 1 is activated. When the switch is in the opposite position, the alternate filter is turned on. This same arrangement can be used in the front-end of the receiver, or the local oscillator, to select L-C components for different bands.

An alternate two-way RF switch is shown in Figure 8B. This circuit uses four PIN diodes and a three-winding, trifilar wound transformer. Several different forms of trifilar wound transformer are on the market, but you can also build your own using a toroid core. To be trifilar wound, one must wind all three lengths of wire together (some actually twist them together). The core material and the number of windings depends on the operating frequency. For frequencies in the HF (3,000 to 30,000 KHz) region, use either T-37-2, T-37-6, T-50-2, or T-50-6 cores. For frequencies less than 2,000 KHz, use the T-37-15 or T-50-15 cores.

Another filter selection method is shown in Figure 9. The entire circuit differs from this variant in that a total of six filter sections are used rather than just three, as shown in Figure 9. In each bandpass filter (BPF1 and BPF2), a network of inductor and capacitor elements are used to set the center and both edge frequencies of the band to be covered.

The circuit of Figure 9 is shown using a switch to apply or remove the +12 VDC bias potential on the diodes, but in the actual receiver, this potential is digitally controlled. The digital logic elements sense which of 30 bands are being used, and selects the input RF filter accordingly.

PIN Diode Attenuators

Another application for PIN diodes is as a voltage-variable attenuator in RF circuits. Because of its variable resistance characteristic, the PIN diode can be used in a variety of attenuator circuits. One of the simplest is the shunt attenuator of Figure 10. The front-end of this circuit is a bank of selectable bandpass filters per Figure 9, so we will not dwell on that topic now. But at the output of the filter bank, there is shunted from the signal line to ground, a series combination of a capacitor (C1) and a PIN diode (D1).

The PIN diode acts like an electronically variable resistor. The resistance across the diode's terminals is a function of the applied bias voltage. This voltage — hence the degree of attenuation of the RF signal — is proportional to the setting of potentiometer R1. The series resistor (R2) is used to limit the current when the diode is forward biased. This step is necessary because the diode becomes a very low resistance when a certain rather low potential is exceeded. This circuit is used as an RF gain control on some modern receivers.

Another PIN diode attenuator circuit is shown in Figure 11. This is the "bridge-Tee" attenuator. It is capable of providing a 10-dB attenuation range over a very wide bandwidth.

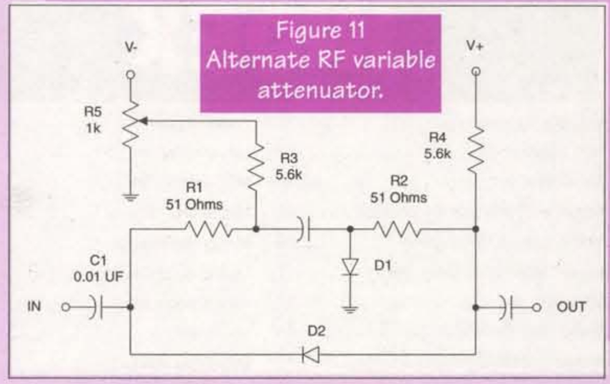


Figure 11
Alternate RF variable attenuator.

Conclusion

PIN diodes are one of those components that are little known, but nonetheless very useful. If you build any RF projects that could involve traditional switching, then you will probably find the PIN diode makes a dandy substitute that avoids the problems associated with routing signal around switching circuits. Try it, you'll like it. **NV**

Connections ...
I can be reached by snail mail at P.O. Box 1587, Annandale, VA 22003 *(NEW ADDRESS!)*, or via E-Mail at CARRJJ@AOL.COM.

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Questions & Answers

TECH FORUM

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!

QUESTIONS

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

I have a SRL model 2581 wide-band amplifier. Should this be put between the pre-amp and receiver, or should it be put before the pre-amp? Am I using the unit correctly or does it have other applications?

10001 **Dennis Roberts**
Buffalo, NY

I have an IR imaging tube with power supply I picked up from a salvage yard. (Power supply wraps around IR tube.) Unfortunately, the wires from the power supply were broken loose from the IR tube.

Several people have looked at this and said it looks to be in good shape, but could not help on the wiring part.

The unit is approximately 1.75" dia. x 1.125" thick complete.

The two-piece power supply is wrapped around the tube like a blanket with a small section open on one side for the wires to connect. The wire colors are i.e., blue, which is already connected, yellow and red on one side, and red, black, and another black. I believe this is from a pair of ANP-7 night-vision goggles.

The unit is marked on the side of the power supply "Galileo" #'s 3555985, 79-23, 58874, 65093.

I do know that on the goggles, a black and red wire goes to the battery, and a black and red wire goes to a light sensor.

10002 **Peter A.**
via Internet

One of *Nuts & Volt's* advertisers (Ramsey Electronics) features a TV transmitter which can be received by "... any TV tuned to cable channel 59."

What are the differences, if any, between cable channel 59 and TV broadcast channel 59?

10003 **J. M. Smith**
via Internet

Does anyone have ideas on how to make a car error code reader, that could maybe interface with the serial port on a laptop? I have a 1996 Chevy Monte Carlo.

10004 **Anonymous**
via Internet

I am interested in a system that would consist of a solar and auto-type battery with a regulator that could be used for running a laptop, small radio, or charging other smaller batteries.

Does somone know of such a system or can someone give me some help in constructing it (i.e., what is needed between the solar panel and battery for charging and between the battery and output)?

This system would be used for outdoor type camping.

10005 **Steve Hock**
via Internet

I have a system that does not have any BIOS settings to allow me to boot without an attached keyboard or to continue boot after errors, etc. I need a way of "fooling" the system into thinking that a keyboard is attached so it will boot. The control app it is running is completely mouse-driven and the keyboard is in the way. This is an ATX system with a PS/2 keyboard port.

10006 **Wayne O. Wilson, Jr.**
via Internet

Okay, how can I use an Optrex DMC 20434 LCD using a Scenix 28-pin microprocessor? I cannot find any data to help me!

10007 **Daniel**
via Internet

Does someone know where I can obtain a stereo IC part number STK2028?

10008 **Bob Brockett**
Harrison Twp., MI

Does anyone have an idea for a circuit to build an inexpensive satellite finder? This device should be able to work on C-band and Direct TV types of equipment.

10009 **Ken Peck**
via Internet

I need a pinout with functions for a TMS 3450 NL TI clock chip.

100010 **Edwin Smith**
via Internet

I would like to equip a model police car with strobe lights like real ones.

My idea is to make a lightbar with superbright LEDs that would flash alternately with a cadence of four rapid flashes for the left and four rapid flashes for the right.

Would it be easier to use recovery flash units? Are any schematics available?

100011 **Patrick Montaron**
via Internet

ANSWERS

ANSWER TO #8001 - AUG. 2000

Is there a way to check components in small power supplies (electronic typewriters) without removing components? Seems like theory discussion doesn't cover troubleshooting.

Components in a power supply or other circuit can usually be checked without removal. If the circuit is able to have power applied, it may be easier to troubleshoot when "live." (Use caution when testing any live supply. Note that even a battery-operated switching power supply may have very high voltages present.)

If the circuit is being tested with power applied, then an oscilloscope could be used to check for the proper voltages and waveforms. A multimeter could also be used very effectively. If power cannot be applied, for example, maybe it is blowing fuses or some part is smoking, then an oscilloscope would be useless.

Different power supply types exist and the troubleshooting points vary with each. A typical transformer/rectifier/filter arrangement would be easier to troubleshoot than a switching power supply. Most work can be performed with a digital multimeter. Although it may make things easier if schematics are available, they are most often not necessary.

When troubleshooting a power supply, it depends upon the defect symptoms as to what makes sense to check. A typical troubleshooting sequence with no power applied, using a multimeter is as follows:

Examine the obvious things. First, visually inspect the circuitry, looking for burnt components, cracked solder joints or components, burnt traces, indications of leaking capacitors, damaged line cords, etc. Of course, check any fuses, sometimes a fuse blows although no circuit defect exists, but it usually is an indication of a shorted component drawing excessive current.

Semiconductors (transistors, diodes, field effect transistors) in power supplies are usually the shorted component, but a shorted transformer winding can also occur. If a fuse in the primary or secondary of a transformer is blowing, an easy way to check the transformer is to isolate (disconnect) the secondary from the rest of the circuit, replace the fuse,

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 E-Mail.
- In most cases, only one answer per question will be printed.
- Your name, city, state, and E-Mail address, (if submitted by E-Mail), will be printed in the magazine, unless you notify us otherwise with your submission.
- 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.

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All questions should relate to one or more of the following:
1) Circuit Design 3) Problem Solving
2) Electronic Theory 4) Other Similar Topics

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- 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 and Phone Number. Only your name will be published with the question, but we may need to contact you.

ANSWERS TO #9005 - SEPT. 2000

Can the small bobbin and cylinder-shaped fixed inductors found in computer monitors and TVs be used as "RF chokes" in radio construction projects?

How do you test the appropriateness of these inductors for radio projects?

Also, what is the purpose of the small disk-shaped permanent magnets attached to one end of some of these inductors?

#1 The inductors used in TV and monitors are designed to work at power line or deflection frequencies (60 Hz to 15 KHz) and would not be suitable at high frequency. The inductance at high frequency would be no better than air core.

The permanent magnet is used to compensate for DC current in the coil. The DC current biases the core, reducing the inductance. The magnet cancels the bias, restoring the zero bias inductance. You can find a lot of information and downloadable software at **www.micrometals.com**

Russell Kincaid
Milford, NH

#2 A good RF choke should have a low impedance at DC and a high reactance at the frequency it is supposed to block. Measuring its resistance at DC and its impedance at the desired RF is the basic test of a suitable choke.

There are some other problems you must consider.

The core material will increase the choke's inductance, but only over a limited range of frequencies and DC bias currents. Too much DC bias current will saturate the core material and drastically reduce the inductance.

This problem appears if there are large DC currents, many turns, or high permeability cores. You can test for this problem by measuring the RF inductance twice. First with no DC bias and then with the DC bias the circuit will use. If the change in measurements is moderate (say less than 2:1), then the choke is probably okay. If the DC biased impedance is much smaller than the no bias measure, then the core has saturated and the choke is not suitable.

The core material usually only works well over a limited range of frequencies. If you measure the Q at several different frequencies, it should hold up well over a band of frequencies. If you operate the choke within that band, then it should give you good performance. It is also possible to operate above that band (ferrite beads do this), but then the choke behaves more like a resistor (dissipating power as heat) than an inductor.

Inductors also have a self-resonant frequency (SRF) where the stray capacitance of the winding resonates with the inductance. Use an inductor as an RF choke at or below its self-resonant frequency. Choke performance decreases above the SRF.

In high-power circuits, power dissipation can be a problem. Calculate the power dissipation (the I^2R loss including the RF losses) and compare it to the power rating of similarly sized resistor. If the choke gets too hot, the core material's properties will change, and it may stop looking like a choke and turn into a piece of wire.

I have never seen a permanent magnet attached to a coil. It might be used to offset the field caused by a DC bias, but I'm suspicious of the effectiveness and the cost. Why not use more ferrite in the core? Maybe the magnet cancels the external field to avoid disturbing the TV deflection system.

Gerald Roylance
Mountain View, CA

and apply power. If the fuse blows, the transformer is bad. Shorted components would be indicated by zero resistance across the component's leads when measured with a digital multimeter.

The most common component failures involve semiconductors. First, suspect high heat producing semiconductors such as large transistors mounted on a heatsink.

Diodes and transistors may be checked while in the circuit using a multimeter with diode test. To do this, check diodes with the test leads in one direction, then reverse the test leads on the diode. There should be conduction in only one direction. Transistors may be checked in the same way. Conduction should exist in only one direction from base to emitter and base to collector. Check from emitter to collector that no conduction exists. Check some known good semiconductors to become familiar with this.

If the device exhibits conduction in an unexpected direction, then it will be necessary to examine the circuitry to find if the device is, in fact, defective or if there is another reason for the conduction.

An example would be a resistor across the base-emitter junction causing conduction in both directions. You may desolder a suspected leg from the board making sure that contact with the trace is removed, then check the junction again (being careful that you are not pushing the leg back into contact with the trace while testing).

Familiarize yourself with the transistors being tested as sometimes a transistor may appear to be shorted when, in fact, you may be measuring an internal resistor or diode. If a switching power supply has power in, but no output voltage, note that switching power supplies have a protection circuit that shuts down the switching action if a short exists in the output. It may also shut down on over-voltage conditions.

Resistors may be measured in the circuit, although usually their values will read much differently from their actual values because of their connection to other circuitry. A resistor's in-circuit measured value should never be greater than it's marked value. In this case, a value that is far from the expected value would be suspect. Maybe a 10-ohm resistor is reading 1,000 ohms. Upon removal, most often a resistor measuring in this manner would be found to be open (no reading on the multimeter).

The question would then be if the resistor failed on its own, or if another component's failure (usually a shorted semiconductor) caused it? The resistors to suspect first are any that are standing up off the board and are of a different body color than a usual resistor (tan).

Examples are light blue, red, or white resistors. Most of these will be a low value, maybe in the range of .3 to 10 ohms. Often these are fusible resistors. If one is found to be open, again, usually it has failed because of a shorted semiconductor.

Capacitors are more difficult to check. If one is bad, most often it will be an aluminum case electrolytic. Other types of capacitors, such as ceramic disc rarely fail.

The first electrolytics to suspect are those located near a heat source such as a transistor mounted on a heatsink or a power resistor. Bad electrolytics can be the cause of improper regulation in a switching power supply or low-voltage output in a linear supply. If an electrolytic has vented (top has split open, or bottom rubber seal has blown), this is an indication that the voltage applied to the capacitor has exceeded its rating. The same thing could happen if the capacitor is installed with reversed polarity. It is difficult to check capacitors with a multimeter. It is possible though, to analyze circuit function to arrive at the defective capacitor.

In general, the hotter a component is and the higher the voltage a component is handling, the more likely it is to fail. These are some ideas to get you started. A good way to learn is to measure components in a known good supply, so you start getting an idea of typical multimeter readings to expect.

David Wolff
San Jose, CA

ANSWER TO #9008 - SEPT. 2000

I need a wiring diagram for a DC power supply for a Hewlett Packard Laserjet series II printer.

The schematics were never widely distributed. Canon kept them as a company secret, and even HP printer designers were forbidden to see them.

Consequently, the HP service manuals did not have schematics.

ANSWER TO #8004 - AUG. 2000

I work with AVR microcontrollers which are being clocked with an external crystal or oscillator. I would like to be able to change the clock rate (slower) via an external circuit triggered either by an outside event or by the micro itself.

There are two sources for the clock signal. One is the 8 MHz clock. The other is from a slower clock.

The 8 MHz can simply be an oscillator module with TTL and CMOS compatible output. The slower clock can be a 555 timer running in astable mode or a CMOS relaxation oscillator made from a hex Schmidt inverter chip.

See **www.WFTelectronics.com** for details of slow oscillators.

The clock select line controls which clock is presented to the microprocessor. Zero means slow and one means the 8 MHz oscillator. A dual D-flop (7474 type) is used to synchronize events on the falling edge of the 8 MHz clock. The value of the clock select line is latched through at Q of D-flop 1 on the falling edge of the * MHz clock. When both the 8 MHz and the slow clock are low, the value of clock select is latched through at Q of D-flop 2.

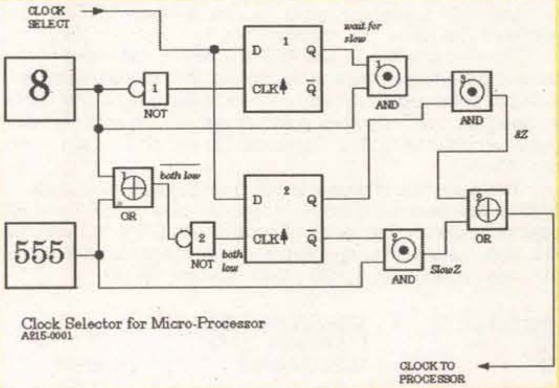
If the 8 MHz clock is being used and we switch to the slow clock, the 8Z signal (see diagram) is held low as soon as the fast clock goes low. This is accomplished by D-flop one (wait for slow signal). As soon as the slow clock goes low as well, slow starts clocking and becomes the clock provided to the microprocessor.

If the slow clock is being used and we switch to the 8 MHz clock, the switch to the fast clock does not occur until both the slow clock and the fast clock are low. This prevents glitches.

OR gate 2 chooses to forward one of the two clocks as long as the other is held low.

You can contact me via **www.WFTelectronics.com** with any questions.

Gus S. Calabrese
Denver, CO



Clock Selector for Micro-Processor
A215-0001

Some intrepid souls have reverse-engineered schematics (I have one for part of the AC power module), but they are hard to find and contain errors. You will also spend a lot of time debugging and chasing parts. There is a simpler option.

The used prices on Canon SX engine laser printers have crashed. Six months ago, they were about $50.00. Two months ago, Halted Specialties was selling them for $25.00. Two weeks ago, I could have picked up four LaserWriter II-NTX for $7.00 each.

Instead of repairing the DC power supply, you might buy a beat-up surplus printer and exchange the power supply. In the bargain, you might get a half-used up printer cartridge worth $30.00 or even a completely working printer. Alternatively, you can buy the DC power supply from The PrinterWorks **www.printerworks.com**. They have an excellent web site.

You should also be aware of why the prices have crashed. The paper feed mechanism on the SX engine relies on a rubber roller that hardens and fails with age. Almost all the printers I see now have this problem, so even if you fix the DC power supply, your paper feed will probably fail soon.

You can buy a Paper Pick-up Roller Ass'y (RG1-0931-060) from The PrinterWorks for about $13.00. Buying just the pick-up roller is even cheaper, but you have to remove the old one from the shaft. It takes about 30 minutes for the renewal, and you must take out the DC power supply to do it.

The repair steps are as follows: Remove the main cover (eight screws) and disconnect the control panel. Remove the front panel bracket (six screws, one ground wire, a cable restraint, and a fiber optic cable). Remove the DC power supply (three screws and the motor connector); use a screwdriver to pry the power supply out — there are some connectors underneath. Remove the pick-up roller assembly (two screws).

Gerald Roylance
Mountain View, CA

ANSWER TO #9004 - SEPT. 2000

I need information on how to build ferrite antennas for the AM broadcast and shortwave bands?

The information about designing ferrite antennas is scattered, sketchy, and full of misinformation. Don't believe everything you read. You also need a good background in transformers, coil winding details, and field strengths.

The *ARRL Antenna Book* (about $30.00), which you might find in your public library, has about two pages of design notes and several practical designs.

The treatment is reasonable, but it confuses voltage and power and makes some faulty conclusions about SNR and the number of turns. The practical designs tend to omit the rod characteristics, the number of turns, and the design impedance levels. It is a place to start, it will help make some workable antennas, but it does not offer a solid engineering base. It does, however, have a good bibliography.

The book *Antennas* (John Kraus, McGraw-Hill) has several pages on ferrite rod antennas. His material is accurate, has good examples, but is very dense. For example, he correctly computes the SNR from the atmospheric noise level (effective temperature = 10 billion degrees Kelvin at 1MHz) rather than the antennas physical temperature (300 degrees Kelvin). Your public library may have this book (several of my local libraries do). The book does a superb job about the antenna performance and electrical models, but offers no advice about practical details or circuit design.

Amidon 714-850-4660 is a good source for ferrites (they even sell Litz wire, which is hard to find now). They stock some inexpensive ferrite rods, and you can special-order ferrite strips (which should make better antennas). Their technical data book ($8.00) describes material properties (such as loss tangents) and part specifications, but you could survive with just their catalog. You probably want material #61. The tech data book has some design advice condensed from DeMaw's *Ferromagnetic Core Design Handbook*, which was also a source for the *ARRL Antenna Book*.

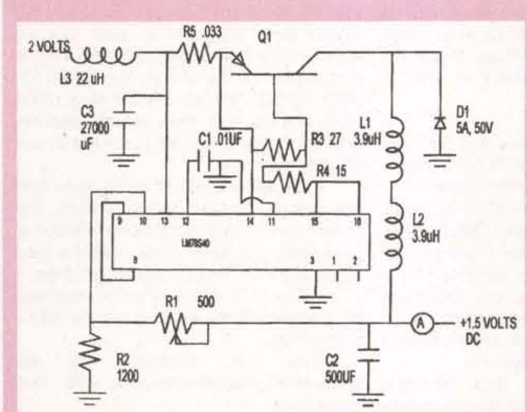
That's a start, but I still have many questions about ferrite loops. By the way, you don't need the ferrite if you are willing to make the antenna a little larger (say a 10-inch diameter wire loop). Even if you need a ferrite antenna, you might build some wire loop antennas first.

Gerald Roylance
Mountain View, CA

ANSWER TO #9006 - SEPT. 2000

I need two circuits to run from a 12VDC gel-cell or car battery for my RC gas powered car. One circuit must be 1.5 volts and provide up to 4-5 amps. I need to be able to adjust the glow plug current due to the change in resistance when hot, and it should have a meter in the circuit to monitor the current flow and adjust as needed.

The second circuit is to charge the AA batteries in the controller and receiver in the car. It needs to run from the same 12VDC.



First, the 1.5 volt supply: The LM78S40 IC is available from Digi-Key. It is a switching regulator which in this design runs at 30 KHz. If you are running from a car battery, you need L2 and C3 to filter out spikes from the automobile system, otherwise you don't need them when using a gel-cell.

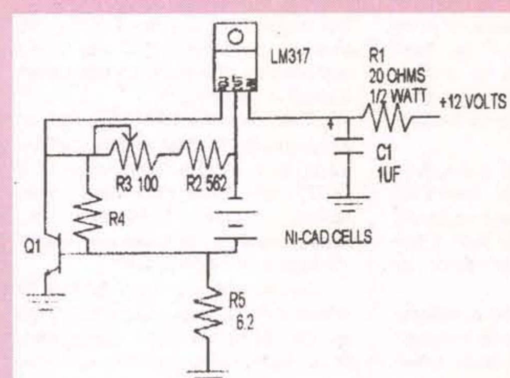
The .033-ohm resistor provides current limiting. You will need 10 0.33- ohm resistors in parallel to get .033 ohms.

The PNP transistor could also be a P-type MOSFET, both Digi-Key part numbers are given. The resistors are 1/4 watt except as otherwise noted.

The way it works is: The PNP transistor switches on, charging the inductor and providing current to the output. When the transistor switches off, the inductor continues to provide current to the output until the transistor switches on again. Two inductors in series are used in order to handle the 10 amps peak current. The 500 uF capacitor, C2 smoothes out the voltage ripple, down to 0.1 volts.

The parts list shows a 27,000 uF capacitor because I could not find a 500 uF that was rated for 10 amps ripple current. R1 and R2 provide voltage control feedback. The range of control with R1 is 1.3 volts to about 1.6 volts. The best place to find an inexpensive ammeter is an auto parts store. Or JC Whitney catalog lists a ±30 amp meter for $5.00.

Parts List	Digi-Key Part No.	
IC	LM78S40CN-ND	
Q1	2SB974A-ND	transistor
Q1	IRF9Z24N-ND	MOSFET
D1	G1820CT-ND	5A, 50V fast recovery
L1,	L2 DN4495-ND	3.9 uH, 9.75A
R1	CT2156-ND	500 ohm pot
C2	P6552-ND	27,000 uF, 16 volts
C1	E2103-ND	.01uF 250 volts
C3	P6552-ND	27,000 uF, 16 volts
L3	DN4504-ND	22 uH, 5.2 amps
R2	1.2KQBK-ND	1200 ohms, 1/4 watt
R3	27QBK-ND	27 ohms, 1/4 watt
R4	15QBK-ND	15 ohms, 1/4 watt
R5 (use 10 in parallel)	0.33W-5-ND	0.33 ohms, 5 watts each



Second, the battery charger for Ni-Cad cells. This circuit will charge two or four cells in series, in a fast charge mode. If you have a bad (shorted) cell, the others can be overcharged. The cells should fully charge in an hour, if not, suspect a bad cell.

The LM317 is a voltage regulator, trimmed for 1.3 volts, and current limited via Q1 to 100 mA. Almost any general-purpose NPN will work for Q1. You can leave the cells on charge indefinitely if the cells are good, the circuit will not overcharge.

Parts List	Digi-Key Part No.	
IC	LM317EMPCT-ND	1.5 amp, TO220 case
R1	20H-ND	20 ohms, 1/2 watt
R2	562XBK-ND	562 ohms, 1/4 watt, 1%
R3	CT94W101-ND	100 ohm pot
R4	619XBK-ND	619 ohms for two cells
R4	1.87KXBK-ND	1870 ohms for four cells
R5	6.2QBK-ND	6.2 ohms, 1/4 watt
C1	P6237-ND	33 uF, 25 volts
Q1	ZTX455-ND	general-purpose NPN

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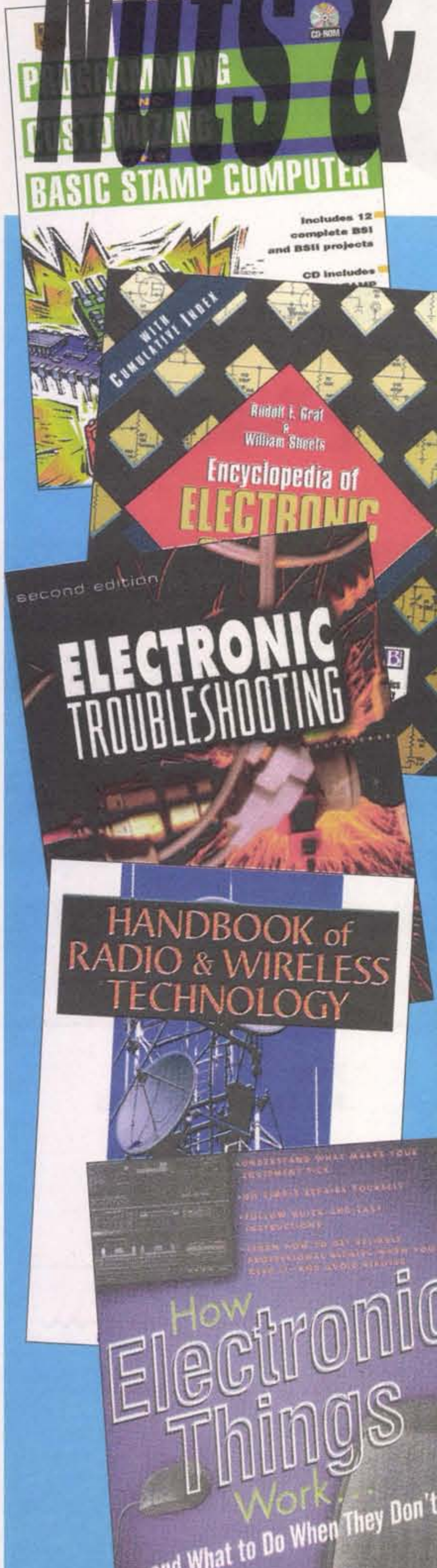

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Axelson, JL — Making Printed Circuit Boards	$22.95	**$20.65**
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McComb, G — The Robot Builder's Bonanza	$18.95	**$17.05**
Predko, M — Handbook of Microcontrollers	$54.95	**$49.45**
Predko, M — Programming and Customizing the PIC Microcontroller	$39.95	**$35.95**
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Sinclair, J — How Radio Signals Work	$24.95	**$22.45**
Tomal, D/Widmer, N — Electronic Troubleshooting	$34.95	**$31.45**
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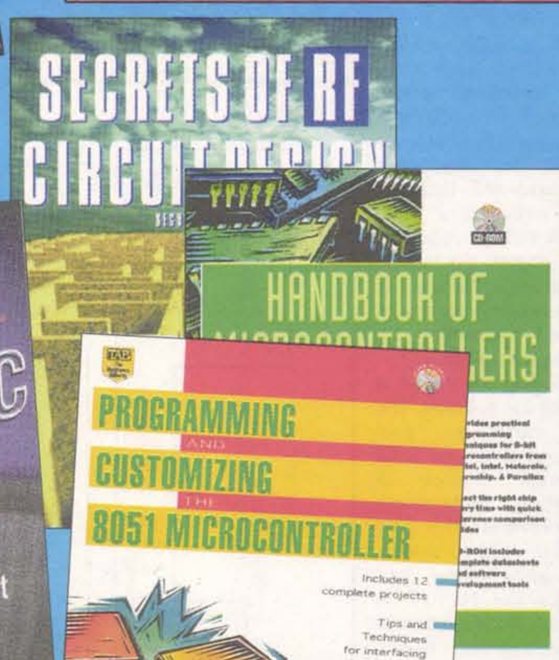

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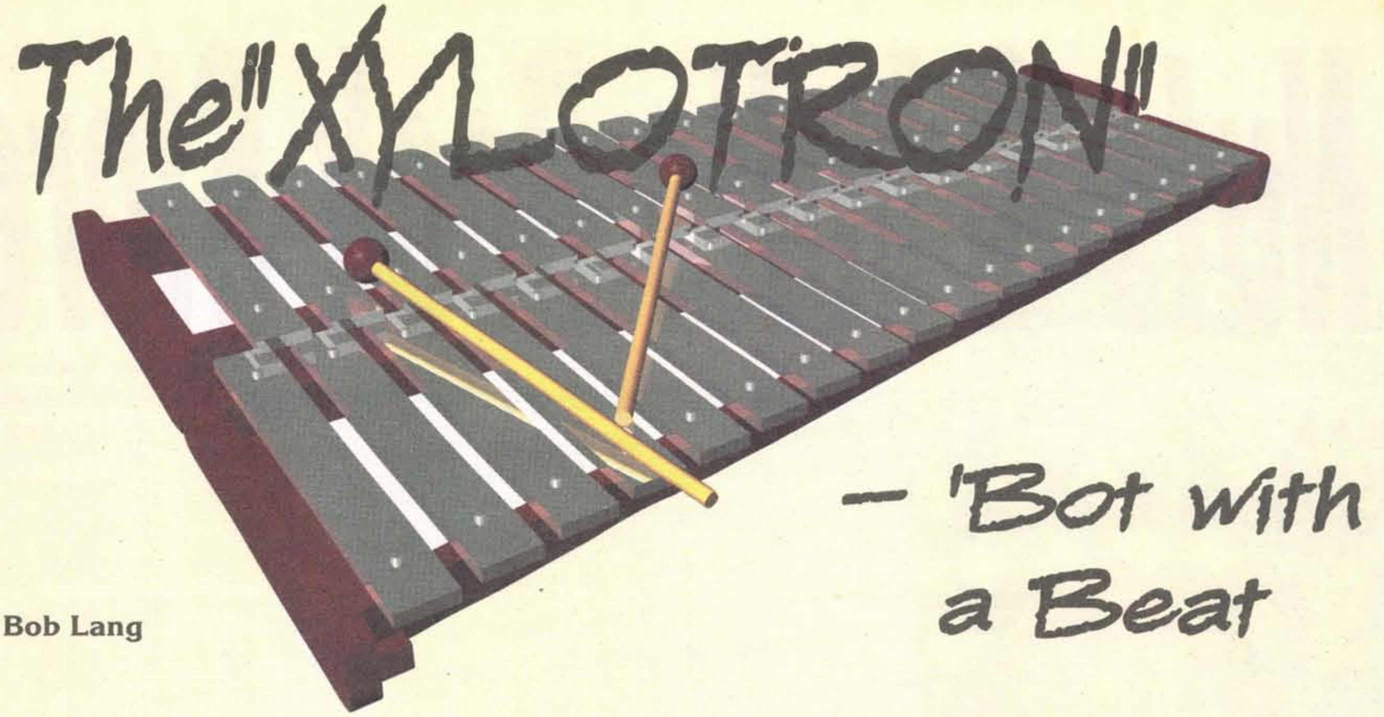
The "XYLOTRON" – 'Bot with a Beat



by Bob Lang

INTRODUCTION

This project begins with the idea of creating a MIDI musical instrument for under $150.00. It was desired that the instrument could be played manually or by a computer via the MIDI interface. The final project turned out to be the conversion of a xylophone to MIDI. This is an instrument anyone can build and play that I call the "XYLOTRON."

MIDI DECODING

Let's briefly review the Musical Instrument Digital Interface (MIDI). In 1982, the primary vendors of keyboard synthesizers hammered out the specifications for MIDI, which was a combined language and transmission protocol that allowed the sending and receiving of information to synthesizers.

MIDI information is sent through the connecting cables serially, that is, one bit at a time, 31,250 bits/second. When an instrument receives a MIDI status byte such as "note on," it must receive the eight bits of information that makes up the "note on" byte, decode it, and act upon it.

MIDI commands are divided into status and data bytes. MIDI status bytes always have the high order bit set equal to one. Data bytes always have the high order bit set equal to zero.

Normally, a "note on" status byte will be followed by two data bytes giving the note and velocity which, at some later time, would be followed by a "note off" status byte with the same two data bytes. Sometimes, however, a "note on" status byte will be followed by more than two data bytes thereby turning on more than one note with a single "note on" status byte. Likewise, a single "note off" status byte can be used to turn off multiple notes. These mode changes also need to be handled.

INTERFACE CONTROLLER

The MICROCHIP 16F877 peripheral interface controller (PIC) is the brain of the system. This is a cool 40-pin chip that runs at 20 MHz, has a built-in serial port, up to 32 usable output pins, in-circuit programming, eight KB of re-programmable flash memory — all for under $10.00. The circuit for the controller is shown in Figure 1. The 6N138 is a high-speed optical isolator that can handle the MIDI baud rate. Included in the circuit is a 7805 five-volt voltage regulator and a 100mF electrolytic capacitor for producing the +5 volts necessary to run the PIC from the +12-18 volt power supply.

Building the circuit is only half the solution. The chip must be programmed to do the MIDI decoding. Source 1 (Microchip Technology, Inc.) provides free software for writing, assembling, and linking software for the 16F877. A programmer that includes a development breadboard can be obtained from Source 2.

The programmer connects to the parallel interface of a computer.

```
0030   1E8C   RECBYTE   BTFSS    PIR1, RCIF  ; LOOP TILL THERE'S
0031   2830             GOTO     RECBYTE     ; SOMETHING TO RECEIVE
0032   0818             MOVF     RCSTA,W     ; GET THE STATUS WORD
0033   00A0             MOVWF    TEMP        ; PUT IN TEMP
0034   18A0             BTFSC    TEMP,1      ; CHECK FOR OVERFLOW
0035   283B             GOTO     RRESET
0036   1920             BTFSC    TEMP,2      ;  CHECK  FOR  FRAMING
ERROR
0037   283B             GOTO     RRESET
0038   081A             MOVF     RCREG, W    ; INPUT THE BYTE THEN
0039   00A0             MOVWF    TEMP        ; MAKE A COPY IN TEMP
003A   0008             RETURN
003B   1786   RRESET    BSF      PORTB,7     ;TURN ON LED ON PIN 40
                        ; TO INDICATE OVERFLOW OR FRAMING ERROR
003C   20C8             CALL PAUSE           ; SHORT WAIT
003D   1218             BCF RCSTA,4          ; DISABLE RECEIVE TO
                        ; CLEAR FRAMING AND OVERFLOW ERROR BITS
003E   1386             BCF      PORTB,7     ; CLEAR ERROR LED
003F 2 0C8              CALL PAUSE           ; SHORT WAIT
0040   1618             BSF RCSTA,4          ; RESTART THE RECEVER
0041   2827             GOTO CMD_START
```

FIGURE 2 — Portion of 16F877 Source Coding

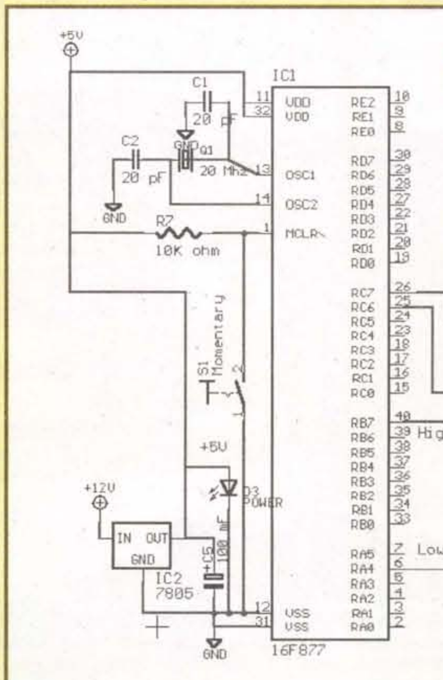


FIGURE 1
PIC Circuit Schematic

Source 1
Microchip Technology, Inc.
Technical information on 16F877 PIC, MPLAB Integrated Development Environment software for PICs at www.microchip.com.

Source 2
Peter Anderson
PIC programmer kit, programmer software, PIC books, 16F877 PIC at www.phanderson.com.

Source 3
XYLOTRON home page
Source coding for XYLOTRON, Preprogrammed 16F877 PIC, additional XYLOTRON information and pictures at www2.netdoor.com/ ~rlang/xylotron/xylotron.htm.

Source 4
Digi-Key
Power transistors, optical isolators, 16F877 PIC at www.digikey.com.

Source 5
Protel Software
EASYTRAX software for designing and printing circuit boards at www.cia.com.au/rcsradio/ibmezcad.htm.

Source 6
Circuit Specialists, Inc.
Photosensitive printed circuit boards, developer, etchant at www.webtronics.com. See their ad on Page 94.

Source 7
Electronix Express
Magnet wire, LEDs, voltage regulator, resistors, diodes at www.elexp.com. See their ad on Page 19.

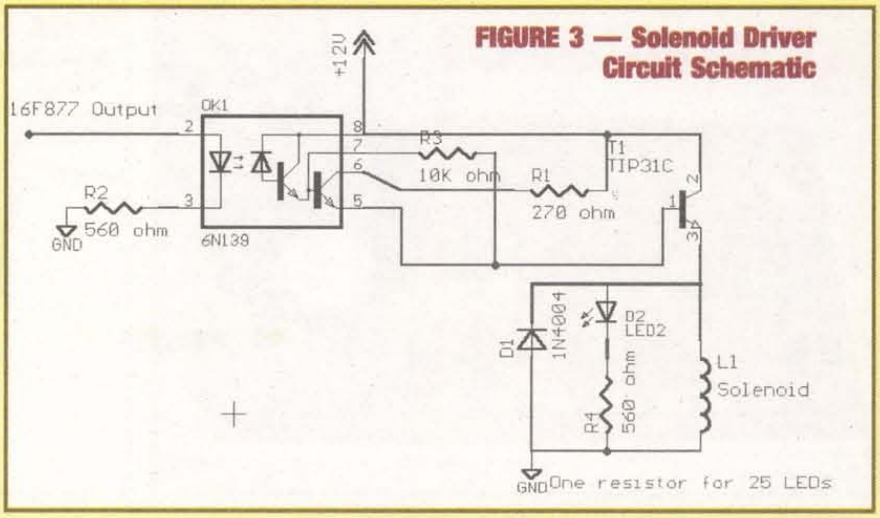


FIGURE 3 — Solenoid Driver Circuit Schematic

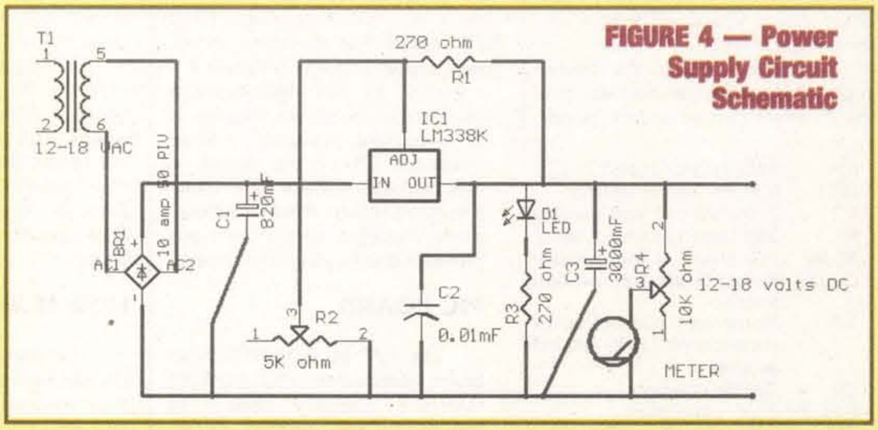


FIGURE 4 — Power Supply Circuit Schematic

The linked program in ".HEX" file format can then be downloaded from the computer to the programmer. Once the chip is programmed, it remembers the program until it is erased or re-written.

The program can be obtained free of charge from Source 3 in either source (XYLOTRON.ASM) or hex (XYLOTRON.HEX) format. A short portion of the coding, written in MICROCHIP assembly language, that reads the MIDI input is given in Figure 2. The program does not use interrupts and features a start-up test section.

When the program starts, each note is played from highest to lowest to verify that the driver circuits are working. The program only reacts to MIDI "note on" and "note off" commands for MIDI notes 48-72 on the lowest MIDI channel (0). All other MIDI commands, MIDI notes, and MIDI channels are ignored.

When the program receives a "note on" status byte, it will decode it and set the mode to "note on." The two data bytes that follow will set the output pin corresponding to that note HIGH. It will remain HIGH until a "note off" status byte is received for that note or another "note on" status byte for that note is received with a zero velocity.

If additional data bytes follow the "note on" they are interpreted as additional notes to be turned on. The receipt of a "note off" status byte will set the mode to "note off" and all subsequent data bytes are interpreted as additional notes to be turned off.

POWER SUPPLY/DRIVER BOARD

The link between the PIC brain and the note actuator muscle is the solenoid driver circuit. Figure 3 shows the driver circuit for one solenoid. There are 25 of these circuits, one for each 16F877 output note. Parts for the driver circuits were from Source 4. An optional LED


FIGURE 5
Power Supply/Driver Circuit Board

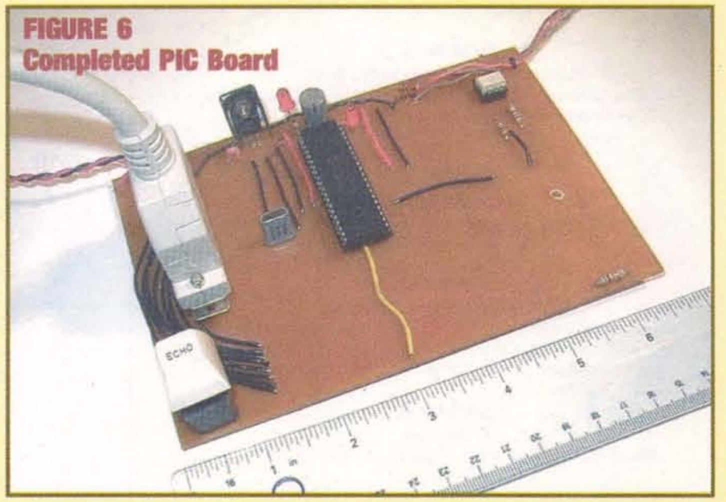


FIGURE 6
Completed PIC Board

and resistor can be placed in each driver circuit which will light when the note is played.

I decided to build the power supply (minus the transformer) and the 25 driver circuits on one board.

IC1	MICROCHIP 16F877 PIC
OK1	6N138 Optical isolator
R2	270 ohm 1/4 watt resistor
R1	560 ohm 1/4 watt resistor
R5,R7	10k ohm 1/4 watt resistor
D1,D2	Red LED with internal limit resistor
S1	Momentary contact switch connects MCLR to ground to reset
Q1	20MHz crystal
C1,C2	20pF capacitors
IC2	7805 +5 volt regulator
C5	100mF electrolytic cap
C4	22mF electrolytic cap

Table 2 – PIC Parts List

The LM338K voltage regulator comes in a TO3 case and is rated for 5.0 amps. The schematic for the power supply is given in Figure 4.

A 5.9" by 9.8" light-sensitive printed circuit board was chosen. It is important to have a large capacitor, C3, on the output to help maintain voltage when multiple solenoids are fired simultaneously. Figure 5 shows the completed power supply/driver board.

PIC BOARD

The 6.5" by 4.5" PIC circuit board contains the PIC and MIDI interface circuitry shown in Figure 1. The printed circuit boards in this project were designed using the free software from Source 5. The full-size circuit board patterns are available at no cost at Source 3. The positive etch process was used. Printed circuit boards and supplies are available from Source 6.

A 25-pin cable was used to connect the PIC board to the driver board. A 25-pin parallel cable was used to connect the driver board to the solenoids. Figure 6 shows the completed PIC board. Table 1 is the parts list for the driver board and Table 2 is the parts list for the PIC board.

T1	TIP 31C NPN transistor
OK1	6N139 Optical isolator
R1 2	70 ohm 1/4 watt resistor
R2,R4[1]	560 ohm 1/4 watt resistor
R3	10K ohm 1/4 watt resistor
D1	1N4004 Diode
D2[1]	LED[1]

Note: There is a common R4 for all of the optional LED driver circuits

Table 1 – Driver Parts List

CHARACTERISTIC	DESIGN
LOW VOLTAGE	12 VOLT
LOW CURRENT	~0.75 AMP
WINDING	160 FT
COIL HEIGHT	1 INCH
WIRE	#30 MAGNET
IRON CORE	1.5 INCH IRON
CORE WINDING TUBE	.25 INCH DIAMETER
STROKE	~.75 INCH

Table 3 – Actuator Description

HOW IT WORKS

The purpose of the electronic circuit is to decode the MIDI signal from the computer/MIDI keyboard and activate/deactivate the proper note actuator solenoid for a "note on"/"note off" MIDI message.

The MIDI serial signal is received by the 6N138 optical isolator on the PIC board. This electrically isolates the MIDI source from the XYLOTRON and provides a 0-5 volt signal to the Microchip 16F877 peripheral interface controller serial input pin.

The PIC software decodes the MIDI messages and turns on or off one of 25 output pins on the 16F877 chip. The outputs are routed to the driver board. If the software detects a DATA FRAMING or DATA OVERFLOW on the serial input line, then an LED tied to pin 40 will be lit. The error will automatically be reset and the LED turned off after a short period of time.

On the driver board, the signal is routed through a 6N139 optical isolator to isolate the five-volt PIC board voltage from the 12-18 volt driver board voltage. The output of the optical isolator is used to turn on and off the TIP31C output transistor which provides power to the note solenoid.

XYLOPHONE

The instrument to be played is not critical in this design. I obtained a xylophone with 25 keys (Chromatic range C4 through C6) from an EBAY auction for $28.00. Since there are five unused output pins on the 16F877 PIC, any sort of xylophone, glockenspiel, or marimba with up to 30 keys can be used. The key instrument characteristic used in the design is that the keys can be hit from the top or the bottom.

ACTUATOR DESIGN AND CONSTRUCTION

If the 16F877 peripheral interface controller is the brain of the system, the note actuator is the muscle. I decided to use a solenoid-type actuator. The first step was to design an actuator. There are some general guidelines for dimensions one can use in designing a solenoid. Two equations are used:

$$\frac{L_{coil} + L_{plunger}}{2} > K_1 * L_{stroke}$$

$$L_{plunger} > K_1 * L_{coil}$$

where L_{coil} is the length of the wire coil, $L_{plunger}$ is the length of the iron plunger, L_{stroke} is the desired stroke, K_1 is the constant between 1.2 and 1.5.

I desired a stroke length of approximately one inch and wound up with the design shown in Table 3. A couple of rules to remember: **1.** Two times more coils of wire = four times more force. **2.** Two times more current = four times more force.

The actual coil was wound around a 1/4-inch styrene plastic tube, 2.25 inches long obtained from a hobby store. The ends of the coils were fabricated from 7/8" square pieces of 0.08" thick sheet styrene. Quarter-inch holes were drilled in the center of the sheet

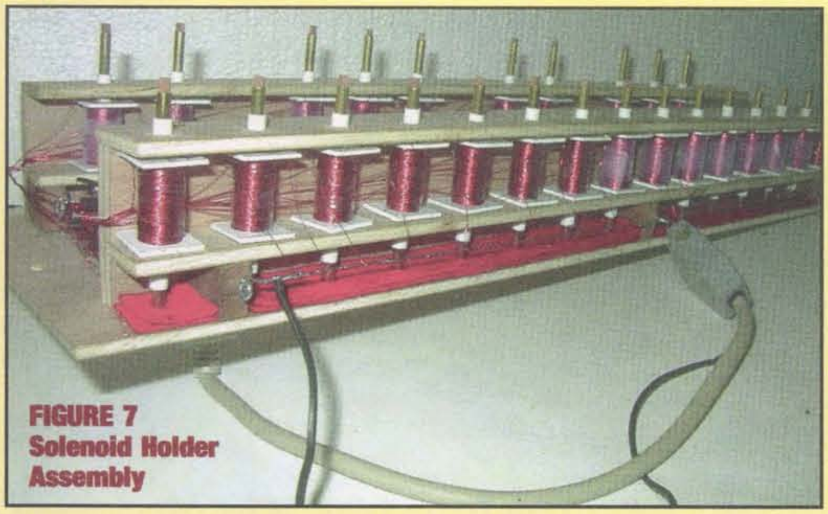


FIGURE 7 Solenoid Holder Assembly

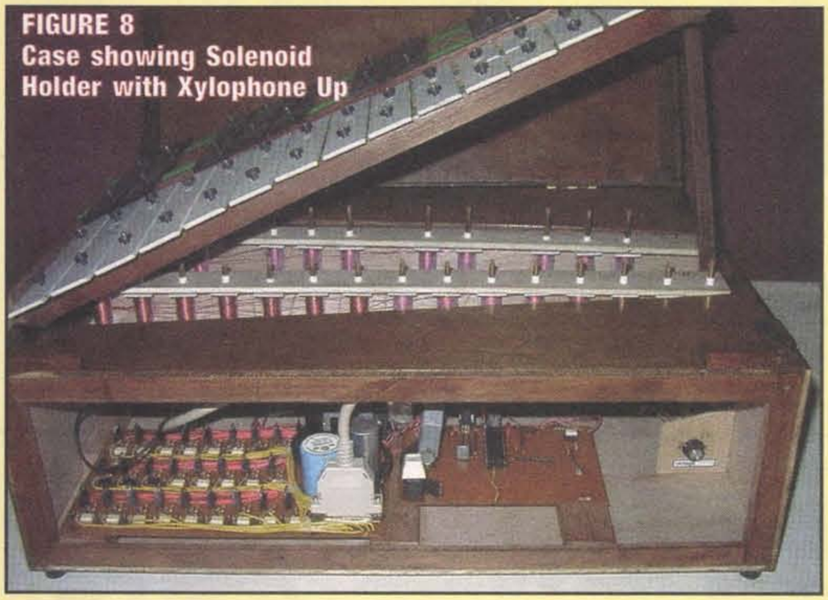


FIGURE 8 Case showing Solenoid Holder with Xylophone Up

styrene square. One square was glued 1/4 inch from the end of the tube and the other was glued 1.0" from the first square with plastic model cement.

Drilling a 1/4 inch hole in styrene plastic can be a bit of a problem; I found that a hand powered drill or just holding the drill bit in your hand and turning it drilled the hole without ripping the soft plastic. After the glue dried, 160 feet of #30 magnet wire obtained from Source 7 was wound onto the one-inch coil. The winding of the coils was the most time-consuming part of the project, but it was automated somewhat with a winding jig powered by an electric screwdriver.

The rest of the actuator consisted of 3/16" brass tubing obtained from a hobby store. The tubing was cut to a length of 3.0 inches for the white keys and 3.375 inches for black keys. The iron core – a 12D nail cut to 1.5 inches – was inserted into one end of the tubing and was held by a drop of glue.

A key design choice for the actuator was what material would actually hit the xylophone. Many xylophones have beaters made of wood or plastic. I tried just using the brass tube to hit the key, but my wife said it was too loud! Eventually, we found a volume we both liked by tipping each brass tube with a piece of wood that actually did the hitting. The wood gave a nice musicbox volume.

CASE LAYOUT

The case was just a box to hold the electronics and the xylophone. The dimensions were not critical. Since the notes are actually played by the solenoid-driven beaters hitting the bottom side of the keys, the solenoids are mounted under the xylophone which sits on the top of the box. The case was constructed of 1/4" hardwood plywood with the dimensions of approximately 22" x 15" x 10".

The first piece of the frame that was built was the solenoid holder. This wooden assembly holds the 25 solenoids at a precise 1-3/8" spacing in two rows of 15 and 10, corresponding to the white and black keys on the xylophone. Connections for all the solenoids are terminated at a DB-25 connector located on the bottom of the assembly.

The dimensions of the solenoid holder assembly are 6" x 21.5" x 2.0" and are shown in Figure 7. The next step in construction was the placement of the solenoid holders in the cabinet. The solenoid holder was positioned in the case so that the brass rods came within 0.5" of the bottom of the xylophone key as shown in Figure 8.

Access to the electronics is through a 8" x 22" removable panel in the front as shown in Figure 9. The solenoid holder assembly can be removed through the top when the xylophone is removed; controls, MIDI connection, and power cable are contained in a 4" x 6" recessed

FIGURE 9 Inside the Xylotron

panel in the back. The finished XYLOTRON and back control panel are shown in Figure 10.

TESTING AND ADJUSTMENT

The testing of the XYLOTRON electronics proceeded from breadboard prototyping to printed circuit board. The PIC board is connected to the +12-18 volt power supply on the power supply/driver board and a MIDI output. The MIDI output can be a MIDI keyboard or a computer with MIDI output.

Check for solder bridges and bad solder joints before turning on the power. The power on test should activate each solenoid and flash each LED in order from highest to lowest. Most of the problems I had were due to bad solder joints or solder bridges.

A five-volt source can be applied to each driver circuit input with the PIC board disconnected to isolate the problem of an individual note to the driver board or the PIC board. If the electronics check out, make sure that the actuator slides freely in the coil and is not binding.

Finally, a note should be played on the MIDI keyboard and the appropriate note's solenoid should fire and note LED should light if the optional driver LEDs were installed. Try playing some chords and multiple solenoids/LEDs should activate/light at the same time.

The last thing to do is to play one of the MIDI songs arranged for XYLOTRON available through Source 3 on the computer and kick back while the XYLOTRON beats out some Bach or Beethoven or Tito Puente. **NV**

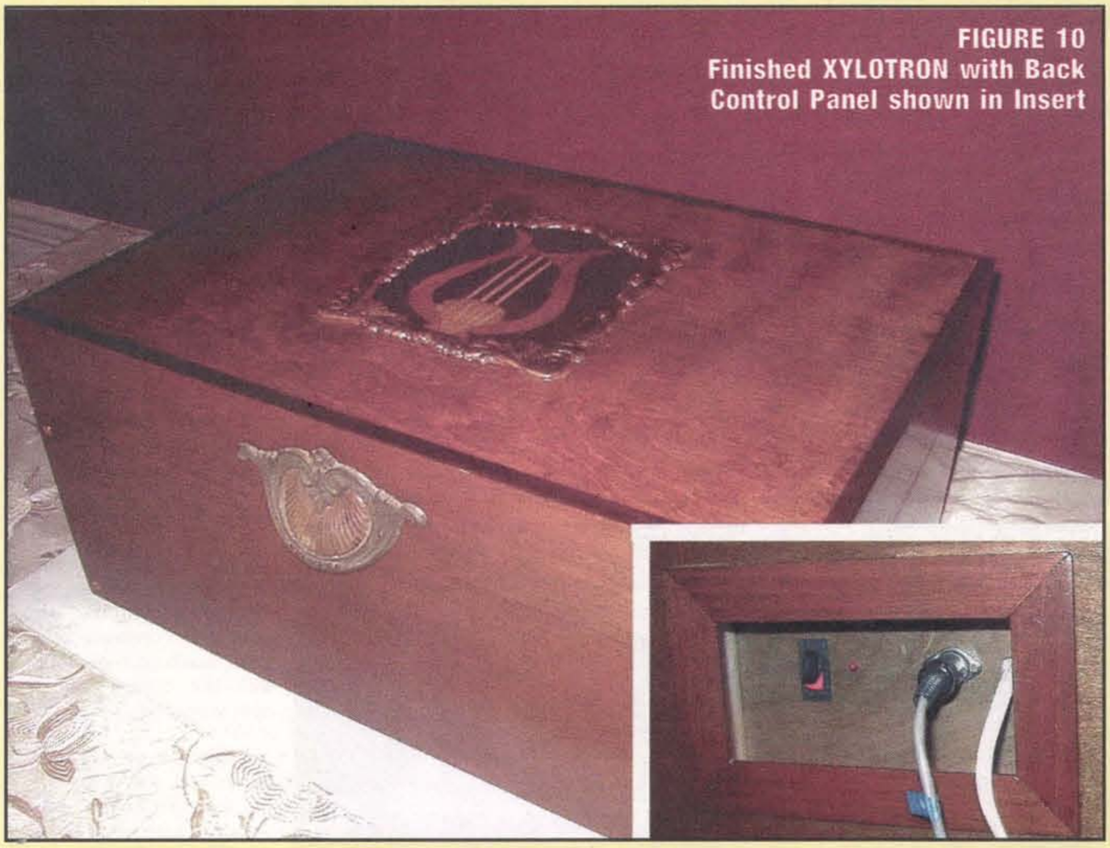


FIGURE 10
Finished XYLOTRON with Back Control Panel shown in Insert

FLAME FLICKER SIMULATOR

by Dennis Eichenberg

The circuits shown provide a simple and inexpensive way to simulate a flame flicker. These circuits are ideal for jack-o-lanterns and other similar applications. The circuits require very low power, and thus are well-suited for battery-powered applications. The circuits start immediately and are not affected by temperature variations. The circuit shown in Figure 1 drives an LED, and the circuit shown in Figure 2 drives an incandescent lamp.

The heart of both circuits is the FRL-4403 red flashing LED (part no. 276-036 at RadioShack). It operates directly from 5V and produces a consistent pulse of light at approximately 1 Hz without a time-constant capacitor. There is a slight variation in frequency from LED to LED. This frequency variation is used to produce the flicker effect.

In Figure 1, two flashing LEDs are connected in parallel and in series with standard LED3. LED3 is on whenever either LED1 or LED2 is on. LED3 is off whenever both LED1 and LED2 are off. Thus, LED3 tends to flicker nicely due to the frequency variation in LED1 and LED2. A yellow LED3 produces a very nice candle effect, but different LEDs can be experimented with to produce the desired result.

Figure 2 is the same basic circuit as Figure 1, with the addition of transistor Q1 and bias resistors R1 and R2 to drive LAMP1. LAMP1 can be any incandescent lamp with a current rating up to 200 mA. Colored lamps work well, and a 12-volt lamp operated from a six-volt source produces a nice candle effect.

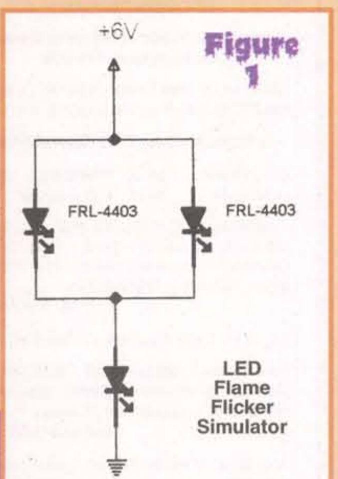


Figure 1

LED Flame Flicker Simulator

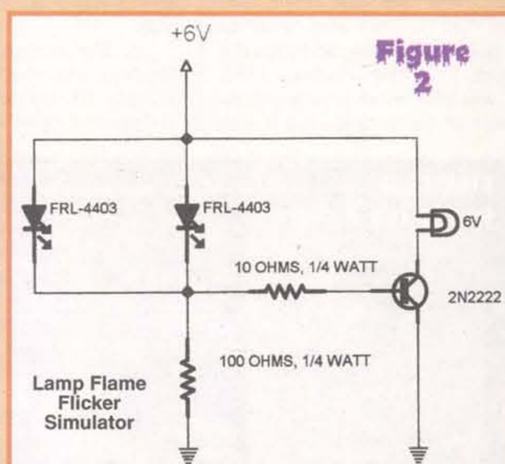


Figure 2

Lamp Flame Flicker Simulator

PARTS LIST

No.	Description
LED1, 2	LED Flashing, Red, RadioShack No. 276-036
LED3	LED, Yellow, RadioShack No. 276-021
LAMP1	Incandescent lamp, 6-volt, RadioShack No. 272-1098
Q1	Transistor, NPN, 2N2222, RadioShack No. RSU 11328499
R1	Resistor, 10 ohms, 1/4 watt, RadioShack No. 271-1301
R2	Resistor, 100 ohms, 1/4 watt, RadioShack No. 271-1311

New Product News

SUPERNOTES CLEARS DESKTOP CLUTTER & ORGANIZES YOUR INFORMATION

Control your clutter in a few clicks. SuperNotes v1.0 is a Windows application that makes it quick and easy to organize notes and other pieces of information that accumulate on home and office desks.

SuperNotes are digital notes which can be displayed on your computer screen. The software, developed by Integratech Software, allows you to organize any type of information – to-do lists, birthdays, anniversaries, telephone numbers, telephone calls, appointments, and other reminders.

SuperNotes lets you create an unlimited number of digital notes that can contain a wealth of information about any subject. Since SuperNotes is OLE-enabled, you can even link or embed related images such as pictures, maps, and documents, as well as sound and video clips into each note. SuperNotes lets the user define custom note templates and tailor the program to meet individual needs. Each note supports fonts, colors, tab settings, paragraph settings, and other word processing standards enabling a note to be created just the way you like it.

SuperNotes is Internet-ready. Send email or launch your web browser and visit favorite Internet web sites with a single click. Email addresses and Internet web sites can be organized by any criteria you desire and can have an unlimited amount of descriptive text to describe information important to you.

SuperNotes has built-in reminders to help you track special dates and events. An alarm can be set on any note enabling you to receive a reminder. Alarms can be defined to activate once, every day, every week day, once a week, once a month, or once a year. This feature offers a great way to keep up with birthdays, anniversaries, and other important events.

All notes are maintained in a database by user-definable note type and can be organized and recalled to the computer desktop at any time.

SuperNotes costs $24.00 and may be ordered from Integratech Software's web site. An unlimited site license is also available for $249.00.

For more information, contact:

INTEGRATECH SOFTWARE
P.O. BOX 293403, LEWISVILLE, TX 75067 Fax: 972-420-7880
EMAIL: rf@integsoft.com
WEB: http://www.integsoft.com

MODEL 555 DIGITAL DELAY/PULSE GENERATOR

Berkeley Nucleonics releases the Model 555 digital delay/pulse generator with one nano-second delay resolution. In addition to independent delay and width selection on each channel, it now includes selectable TTL/CMOS or adjustable amplitudes up to 15V into high impedance.

Available configurations are two, four, or eight channels of output.

The model 555 includes the ability to enable/disable channels, to gate the outputs, to provide bursts from each channel, to divide the triggers by a different N for each channel, and to even add customized timing via software.

The digitally-controlled time delays and widths may be programmed from the front panel or via the GPIB or RS232 interface.

For more information, contact:

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SC100 AUTO-DIALER FOR SECURTY AND CONTROL

LJB Engineering introduces the SC100 auto-dialer. This board connects to standard phone lines and cellular phones (with appropriate interface) and dials two phone numbers when an alarm condition occurs.

Up to 24 digits per number can be programmed into memory. The unit uses EEPROM memory so no battery backup is required.

When an alarm call is made by the SC100, the unit plays error tones and a voice message to alert the operator of the situation.

The SC100 only requires a phone line and 12VDC to operate. The 12VDC alarm input triggers on falling or rising edge input.

The on-board speech chip allows you to record up to a 20-second message.

The SC100 answers after a programmable number of rings and can be called to turn the relay on or off over the phone. The relay programs as either a one shot or latched on/off operation. One shot time delay from one second to 99 minutes.

Uses for the Secure Control 100 include: 1) Home security system auto-dialer. Connect sensors such as motion detectors and door switches and the unit will phone you when the alarm is tripped. 2) Mount on remote machinery and use the alarm input to monitor operation. If the unit shuts down, the SC100 will phone you and notify you. 3) Connect to equipment that must be turned on or off over the phone.

The SC100 is priced at $299.00.

For more information, contact:

LJB ENGINEERING
RR 1 BOX 680, DEPT. NV
DESHLER, NE 68340
402-365-4214
http://ljbengineering.8m.com

HOME THEATER LIGHTING CONTROL KIT

Control two lights and one appliance (expandable to 16 lights/appliances) from a wireless remote. Perfect for dimming the lights before a show in your home theater and for bringing the lights back up afterward.

Appliance module (built into the wireless base unit) can be used to remotely control power to appliances such as coffeemakers, fans, radios, or another light (without dimming).

Remote can also be used to open/close X10 drapery controllers. Works with all X10-compatible products.

The transmitter uses four AAA batteries (not included).

The Home Theater kit includes: one 4000 X10 wireless remote system, and two 2000 lamp modules.

The Home Theater kit is complete for only $59.95.

For more information, contact:

LORD & WYATT COMMUNICATIONS, INC.
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IBM HOME DIRECTOR X10 KIT

Lord & Wyatt Communications, Inc., announces At-Home Technology IBM Home Director Kit. Home Director gives you the power to control and program timed schedules and macros for over 100 lights and appliances throughout your home all from the convenience of your PC.

With the macro capability, a single command either from your PC or from any X10 transmitter can trigger a sequence of X10 commands. One press can turn on a series of lights and appliances.

Programmed events and macros can be downloaded to the memory on the Home Director for stand-alone operation (with the PC turned off). Your PC does not have to be left on to run the schedules or macros once they have been programmed.

The kit includes a 6-in-1 IR remote control that can control most commonly available audio/video components, as well as X10 via RF (using the included X10 RF receiver base). With this one remote you will be able to turn on your TV, dim the lights, and even close your drapes.

The Home Director plugs into the serial port of any PC running Windows 95, 98, or Windows 3.1. with a CD-ROM drive.

The Home Director is functionally identical to the X10 Activehome CM11A unit and will work with all software and accessories designed for the Activehome unit. You may expand the Home Director Kit with virtually any X10 compatible product.

The Home Director starter kit includes: one IBM Home Director PC interface, one software CD-ROM, one 6-in-1 remote control, one X10 16-device RF base, and one X10 lamp module.

The IBM Home Director starter kit is available for only $28.95.

For more information, contact:

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