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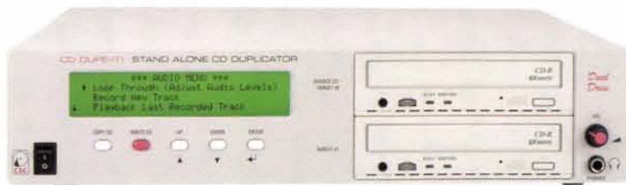

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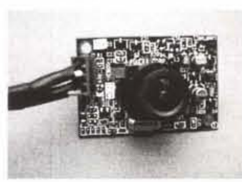

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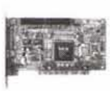

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- Color camera is digital output only (not NTSC as was previously believed)
- Note: HP and Logitech will provide no information on these items!
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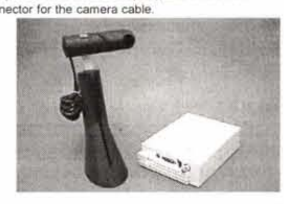

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Patent No. 5,471,402

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Reaction Tune	•	•
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Nuts & Volts (ISSN 1528-9885) is published monthly for $19.00 per year by T & L Publications, Inc., 430 Princeland Court, Corona, CA 92879. PERIODICALS POSTAGE PAID AT CORONA, CA ND AT ADDITIONAL MAILING OFFICES. POSTMASTER: Send address changes to Nuts & Volts, 430 princeland Court, Corona, CA 92879-1300.

CNC Retrofit: *Affordable* Servo Control For Your Desktop Milling Machine

by Jeffrey Kerr

Figure 1: Table top milling machine with servo motor retrofit.

If you have a desktop milling machine or mill-drill machine, you have probably thought about retrofitting it with CNC controls. Perhaps you want to machine contoured parts from a CAD model. Maybe you need to machine repetitive patterns. Or maybe, like me, it simply takes you two or three times to get something right. Whatever your reasons, CNC — even for the hobbyist — is the way of the future.

But, if you thought adding CNC (Computer Numerically Controlled) capabilities to your desktop milling machine was way out of your price range, you should think again. Or, if you thought that stepper motors and a clunky DOS interface were the only way to get affordable CNC capabilities, you should think again.

We'll be guiding you through the process of putting together a high-performance servo motor-based CNC controller using low-cost servo motor controllers and Windows based freeware, all for a little over $1,000.00.

What You Need

We're assuming you already have a small desktop milling machine such as those made by Sherline or MAXNC. These usually have an X-Y table and a Z-axis headstock driven by 16 or 20 thread per inch drive screws. If you are lucky, your machine will already have brackets for mounting motors, very often for NEMA size 23 stepper motors. We'll leave the mechanical mounting details up to you, and here, we'll concentrate on the motors, controllers, and software.

The complete parts list for the CNC retrofit is shown in Table 1, along with vendors and approximate prices. Figure 2 shows the collection of major components. A few of these items, however, warrant a bit more discussion.

Motors

For servo motors, we are using Pittman 14204 motors equipped with 500 line optical encoders (yielding 2,000 counts per rev.). They have a continuous torque rating of 26 oz-in and a no-load speed of about 5,000 RPM. More critical than the torque rating, however, is the torque constant of 10.0 oz-in per amp. Because the motor amplifiers we will be using can supply up to three amps, we can get up to 30 oz-in out of the motor for up to a minute or so at a time without fear of overheating the motor.

Note that the servos require an encoder resolution of about 10 to 20 times higher than the required positioning accuracy. The encoders specified here will provide an position accuracy of about 0.0005 inches, depending on your operating conditions. (At very low speeds, however, accuracy can be as high as 0.00001 inches.) The motors can be purchased new from Pittman, although they can also sometimes be found in surplus catalogs like MECI or Herbach and Rademan for much less.

Motor Controllers

We will be using PIC-SERVO CMC motor control boards, one per motor. Each board includes an integrated amplifier which can source up to three amps continuously and six amps peak (although for only a few milliseconds). It is also possible to use these controllers with external amplifiers if more current is needed for larger motors. These controllers continuously read the position of the motor's encoder and use a PID servo control algorithm to control the position of the motor. A special feature of these controllers is an internal path-point buffer which allows multiple controllers to be synchronized without real-time control from your PC.

The PIC-SERVO CMC controllers are sent commands over an RS485 communications interface. Included in the parts list is an RS232-RS485 converter for connecting to your PC's RS232 COM port.

Control Computer

The control software runs on a PC running Windows 95/98. The control software has been tested on 166MHz and faster Pentium systems, although with some reconfiguring of the control software parameters, you should be able to run on slower systems as well.

Control Software

The control software is a program called PIC-SERVO CNC (PSCNC.EXE), which is available at no cost for use with PIC-SERVO motor controllers. It runs under Windows 95 or 98 (and probably also under Windows NT and 2000, although this has not been fully tested). The software provides a user interface for manually moving the motors, and for loading and executing the G-Code programs. It provides a digital readout of the tool position, multi-segment contouring and real-time feed-rate override.

Construction: Wiring

The first step in constructing your system is to wire up your motors and controllers and test them on your bench. This will greatly simplify any debugging you may have to do, and give you confidence in the system's operation should you encounter difficulties further on.

Cabling the motors should be done first. All signals to the motor/encoder and limit switches for each axis appear on the DB15 con-

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Figure 2: Motors and controllers for the CNC retrofit.

nector on the PIC-SERVO CMC controller boards. Table 2 is a wiring description. The total of six limit switches (two per axis) should be normally closed switches that are placed so that they will be activated at each end of the range of motion for each axis. The control software actually only uses one limit switch at the forward end of motion for each axis, but having a second switch at the reverse end of motion is not a bad idea.

The motor and encoder cables should be no longer than 10 feet to avoid picking up noise on the encoder lines. The motor wires should be at least 22 gauge wire twisted together and shielded separately from the encoder and limit switch signals. The encoder wires should be 24 or 26 gauge with Channel A twisted with GND and Channel B twisted with +5V. The Index signal should be twisted with another GND wire which is connected only at the PIC-SERVO CMC board. The limit switch wires should also be twisted. The entire bundle of encoder and limit switch wires should be shielded separately from the motor wires. Usually, it is easiest to have the encoder and motor wires in separate jacketed cables.

Make sure to use end-shells on the DB15 connectors with strain relief. You should also strain-relieve the cable at the motor with wire ties. Cabling integrity is probably the single most important issue in overall system reliability.

After cabling up the motors, you should interconnect the PIC-SERVO CMC motor controllers and the Z232-485 converter board according to the PIC-SERVO board documentation. The boards are interconnected using 10 wire flat ribbon cables and IDC type connectors. For this project, with all the boards going into a single enclosure, standard flat ribbon cable will be fine.

The 24V motor power supply should be wired up with a power cord and fuse for the AC input, and the output with 18 gauge wire to the screw terminals on each of the PIC-SERVO CMC boards. Make sure to get the polarity correct, or you will damage the amplifiers on the boards.

When everything is wired together, you can test the hardware using the program NMCTEST.EXE. Following the instructions in the PIC-SERVO board documentation, you should test that each of the motors and encoders are working properly.

Assembling the Enclosure

A metal enclosure, preferably aluminum, with interior dimensions of approximately 10 x 10 x 4 inches should be sufficient for mounting the PIC-SERVO CMC controllers, the Z232-485 converter board, the motor power supply, and the logic power supply. The PIC-SERVO CMC boards should be mounted with the tab of the LMD18201 power amplifier chip screwed directly to the case as a heatsink.

The heatsink tab is isolated internally so you do not have to use an insulator. These DMOS servo amplifiers do generate a great deal of heat, so simply connecting them to the case as a heatsink should eliminate the need for any fans or other cooling.

The motor power supply and logic power supply can be connected to a single AC power line with a two-amp fuse. A neat way to do this is with a panel mount computer-style power receptacle with an integrated power switch. You can even get these with an integrated fuse holder.

You may also want to use some intermediate bayonet-style bulkhead connectors for the motor cables. They have better strain relief, and are easier to connect and disconnect with positive locking. Using intermediate connectors can also simplify mounting the boards inside the enclosure.

Obviously, the enclosure should not have any openings through which metal chips could get in. Ideally, the enclosure should be mounted above the level of your

Item	Qty.	Part Number	Vendor	Cost (approx.)
24V Servo motors with 500 line encoders	3	14204S006	Pittman Motors (215) 256-6601	$145.00
PIC-SERVO CNC motor control boards	3	128862	HdB Electronics (800) 287-9432	$190.00
Z232-485 converter board	1	108939	HdB Electronics (800) 287-9432	$60.00
Logic power supply (9V, 500mA)	1	123964	HdB Electronics (800) 287-9432	$14.00
24V, 10 amp motor power supply (an unregulated 24V, 10 amp supply could be used as well)	1	137656	Jameco (800) 831-4242	$110.00
Miscellaneous Items				
PC (166 MHz Pentium or better) running Windows 95/98	1			
Mechanical microswitches	6			
Motor cable - 1 twisted pair, 22 ga., shielded	30'			
Encoder cable - 5 twisted pair, 24 ga., shielded	30'			
10 wire flat cable	18"			
10 pin flat ribbon cable connectors	6			
DB15 male connectors	3			
RS232 Cable - DB9 male/DB9 female wired straight through	1			
AC Power cord	1			
18 ga. interconnect wire	20'			
2 amp fuse and fuse holder	1			
Enclosure - approx. 10" x 10" x 4"	1			
Documentation & Software				
PSCNC.ZIP - Windows-based three-axis CNC control program			www.jrkerr.com	no charge
NMCTEST.ZIP - Test utility program for PIC-SERVO controller boards			www.jrkerr.com	no charge
PSBOARD.PDF - PIC-SERVO controller board data sheet			www.jrkerr.com	no charge
PSDATA.PDF - Data sheet for the PIC-SERVO controller chip			www.jrkerr.com	no charge
DESKTOP.PDF - More information on CNC retrofitting			www.jrkerr.com	no charge

Table 1: Parts List for CNC retrofit.

What is CNC?

CNC stands for Computer Numerically Controlled — or more simply put — the ability to drive your machine tool from a computer. As you can imagine, this involves strapping some sort of motors onto a machine's drive screws, and then controlling the motors by a computer. The basic elements of the system are: motors, motor control hardware, control computer, and control software.

Motors

Two different types of motors can be used: stepper motors and servo motors. Stepper motors are special motors which can run "open loop" with step and direction pulses dictating the position of the motor. Servo motors are usually conventional DC motors with a feedback device or encoder which measures the position of the motor and is used for controlling the motor position using "closed loop" control. Servo motors are generally of higher performance than steppers.

Motor Control Hardware

All types of motors need, at a minimum, some sort of power amplifier to convert signals from the control computer into power signals. For stepper motors, this is sometimes all that is needed. Servo motors, however, typically also have some dedicated control electronics which perform the time critical chore of reading the feedback device and then adjusting the motor drive signal accordingly to ultimately control the motor's position.

Control Computer and Software

The control software running on the control computer has two functions: 1) interpret user written text programs describing the machine motions, and 2) sending commands to, and monitoring the state of, the motor control hardware. Most of the available CNC software for PCs is DOS-based because the real-time job of keeping all of the motors moving in a coordinated fashion is very difficult to do under Windows. If the real-time coordination is performed by the motor control hardware, however, Windows can be used quite effectively for the control software.

How is CAM different from CNC?

CNC software usually takes as a starting point a text program written in what is known as G-Codes. G-Codes — for the most part — are very simple commands to move from one set of X-Y-Z coordinates to another. Writing raw G-Code programs to machine a complex part can be very tedious and time consuming. This is where CAM, or Computer Aided Manufacturing, comes in. CAM software will take a geometric description of your part (made with Autocad or the like) and convert it into a G-Code program to move a cutter around to carve out the part.

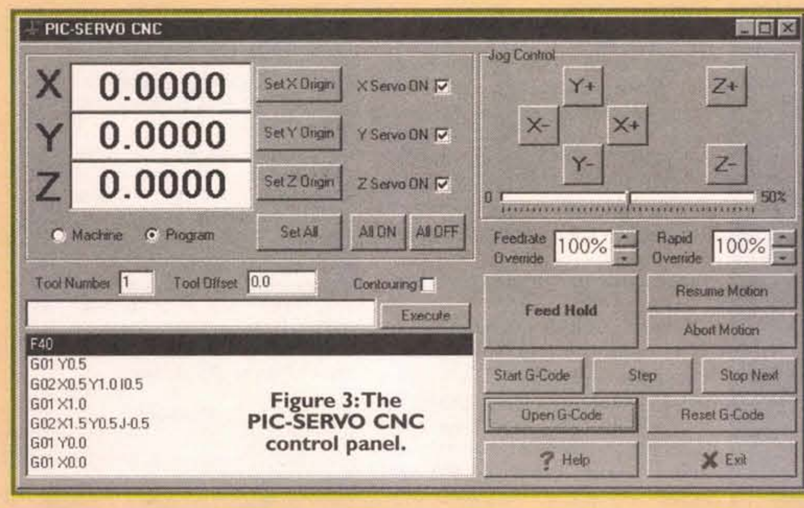

Figure 3: The PIC-SERVO CNC control panel.

adjusted to accurately align the motor shaft to the drive screw shaft. Misalignments will damage your bearings. The use of a flexible coupling (bellows or helical type) is not a bad idea. If your milling machine already has mounting provisions for a size 23 motor, you can easily make an adapter plate to make the Pittman motors look like size 23 motors. The Pittman motors also have a 0.250 diameter shaft like most size 23 motors.

The second option for mounting your motors is to use a toothed belt drive with the motor mounted offset from the drive screw. This has two advantages: 1) it eliminates precise alignment of the motor and drive screw, and 2) it allows you to introduce a gear reduction in the drive train.

This second point is important when you consider the operating speed of the motor. Under load, the motor can go up to 4,000 RPM, but you really don't want the drive screw spinning any faster than 1,000 RPM. By using a 2:1 or 3:1 belt drive reduction, you will utilize more of the available motor power, provide yourself with more torque, and increase your position resolution and positioning accuracy.

An 80 pitch, ¼ inch wide toothed belt is a good choice for a small milling machine, and the motor mount should be adjustable to take out any slack in the belt. If you are retrofitting a larger machine like a mill-drill machine, a belt drive reduction will definitely be needed to maximize the power output of the motors.

No matter which way you mount your motors, you should make sure that the motor leads and encoder connectors are shrouded and oriented downward to prevent chips and cutting fluids from getting inside.

milling machine and far enough away to keep it out of the stream of chips.

Once everything is assembled, you should again test it all with the NMCTEST.EXE program before proceeding with mounting your motors. In addition to testing your motors, you should also test your limit switches — they should be displayed as OFF by the test program until they are activated.

Mounting the Motors

There are two ways to mount your motors to your milling machine. The first is to directly couple the motor shaft to your drive screw. This is the arrangement shown in Figure 1. You should make sure that your motor mounting bracket can be

Software Setup

With your controller box assembled and your motors mounted on your milling machine, you can now test everything using the PSCNC.EXE control program. The documentation which comes with

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2225A, Thinkjet Printer, HPIB $150
3314A, Arbitrary/Function Generator $900
339A, Distortion Analyzer $700
3456A, 6.5 digit Multimeter, HPIB, cal'd with cert $450
3468B, 5.5 digit Multimeter, HP-IL $300
3852A, Data Acq/Control Unit $800
435B, Power Meter w/11730A sensor cable, HPIB $300
436A, Power Meter w/11730A sensor cable, HPIB $550
5004A, Signature Analyzer $200
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5180A, Waveform Digitizing Recorder, 20MHz $500
5315B-04, 100 MHz Counter $200
5328A-011-020-030, 512 MHz Counter w/DVM, HPIB $225
5334A-060, 100 MHz Counter, front & rear input, HPIB $300
5335A, 200 MHz Counter, HPIB $525
5335A-10-40, 200 MHz Counter, Oven Oscillator, HPIB $675
5335A-10-20-30-40, 1.3GHz Counter, Oven/DVM/HPIB .. $900
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6034L, Autoranging Pwr Sup, 60V/10A/200W HPIB $575
6038A, Autoranging Pwr Sup, 60V/10A/200W HPIB $1250
6253A, Dual Pwr. Sup, 0-20V@3A $250
6255A, Dual Pwr Sup, 0-40V@1.5A $300
6267B, Pwr Sup, 0-40V@10A $450
6268B, Pwr Sup, 0-40V@30A $600
6271B, Pwr Sup, 0-60V@3A $175
6274B, Pwr Sup, 0-60V@15A $650
6284A, Pwr Sup, 0-20V@3A $100
6289A, Pwr Sup, 0-40V@1.5A $100
6294A, Pwr Sup, 0-60V@1A $100
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8112A, 50MHz Programmable Pulse Generator, HPIB $2200
8340A, Synthesized Sweep Generator, 0.01-26.5GHz $14000
8350B, Sweep Generator Mainframe $1200
83522A, RF Plug-in, .01-2.4 GHz RF Plug-in $2400
83592B, RF Plug-in, .01-20 GHz RF Plug-in $7000
8481A, Power Sensor, DC-18GHz, -30 to +20dBm $450
8494G, Prog Attenuator, DC-4GHz, 0-11dB, SMA $300
8496G, Prog Attenuator, DC-4GHz, 0-110dB, SMA $300
8496H, Prog Attenuator, DC-18GHz, 0-110dB, SMA type $400
8498A, High Pwr Atten, 25W, DC-18GHz, 30dB $400
8501A, Storage Normalizer w/cable (use w/8505A) $750
8502A, Transmission Reflection Test Set, 0.5-1300MHz $700
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8566B, Spectrum Analyzer, 100Hz-22GHz, HPIB $18000
8569B, Spectrun Analyzer, 0.01-22GHz, HPIB $4500
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P6460, Data Aquisition Probe (for 1240/1241 Analyzer) $125
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SG504, Leveled Sine Wave Generator $1850
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TM501, 500-series Power Module $100
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MISCELLANEOUS

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Cablescan 256, Programmable Cable Assembly Tester $475
Cablescan 512, Programmable Cable Assembly Tester $750
EIP 548A, Microwave Counter, 10 Hz-26.5 GHz $1800
EMI TCR160T30, Pwr Sup, 0-160V@30A $650
ENI 3200L, RF Power Amp, 0.25-150MHz, 200W $7000
ESI SR1030 Resistance Transfer System, 0.1Ω-1MΩ, includes 6 resistor banks, PC101, SPC102, and 2 SB103 .... $6500
ESI SR1030-1K, Resistance Standard, 1KΩ/step $875
Fluke 5200A, AC Voltage Calibrator $1000
Fluke 5440B, DC Calibrator, calibration verified $2800
Fluke 6080A/AN, Synth Signal Gen, 0.5-1024MHz, AM-, FM-, Phase-, and Pulse-Mod, High Spectral Purity $3200
Fluke 752A, Reference Divider $1750
Fluke 845AB, High Impedance Null Detector $300
Fluke 87, 4.5-digit RMS Handheld DMM $225
Fluke 8922A, Digital RMS Voltmeter, 2 Hz-11 MHz $400
Heise 711B, Digital Pressure Gauge, 0 to 30 PSI, .05% $250
Heise CC (18inch), Pressure Gage, 0.1%, 0-1500psi $250
Heise CC (18inch), Pressure Gage, 0.1%, 0-2000psi $250
Hughes 1177H04F000, TWT Amp, 12.4-18GHz, 10W $800
Krohn-Hite 3550, Filter, Hi/Lo Pass, Band Pass & Reject .. $275
Lambda LQ530, Digital Pwr Sup, 0-10V@14A $125
Lambda LQ531, Digital Pwr Sup, 0-20V@8.6A $125
Lambda LQD421, Dual Dig Pwr Sup, 0-20v@1.7A $125
L&N 4223B, Standard Resistor, 0.001Ω $1800
L&N 4385, Shunt Box, 8 ranges (.075A to 15A), 0.02% $250
Racal-Dana 1996, Counter, 1.3GHz, Oven Osc, GPIB $275
RF Power Labs M102L, RF Amp, 30Hz-100MHz, 2W $400
Rockland 852, Dual Hi/Lo Pass Filter $450
Solartron 7061, DMM, 7-1/2 Digit $800
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HEWLETT PACKARD, Model 4328A. Designed to measure very low resistances. Measurement range 1m ohm to 100 ohms. Resolution 20 u ohms. Analog meter readout. Ideal for measuring contact resistance of switches or relays. This unit is also useful for measuring the resistivity of semiconductor devices. (Requires special 4 terminal probes which are not supplied, but probably are available from Hewlett Packard.) Power input: 115–230 VAC 48–66 Hz, 5 VA max. Dimensions: 5-1/8" wide x 11-1/2" deep x 6-1/2" high.
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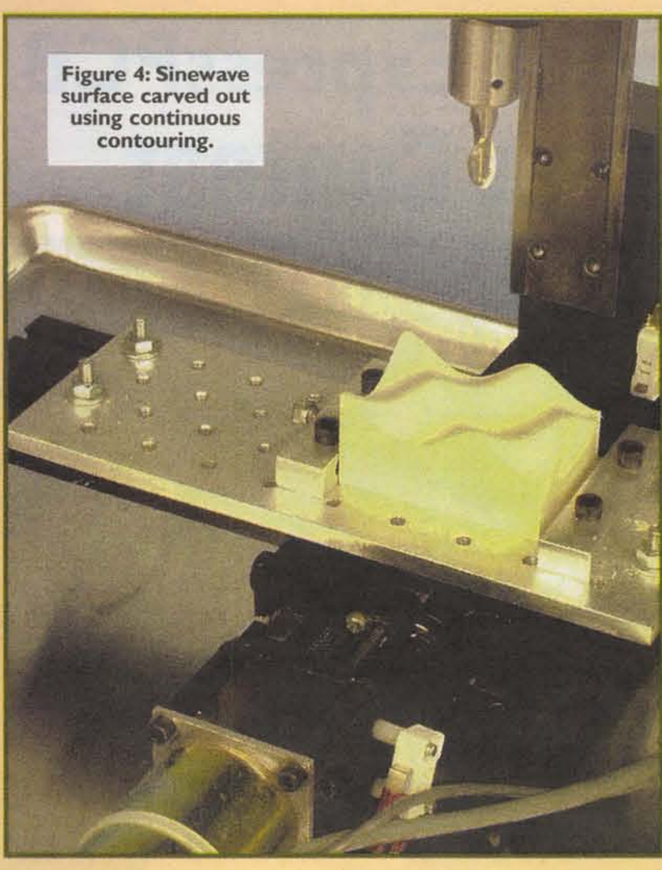

Figure 4: Sinewave surface carved out using continuous contouring.

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SILRX — $26.00 ea.
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The TXM and SILRX modules are a transmitter and receiver pair which can achieve a one-way radio data link-up to a distance of 200m over open ground.

Both units are supplied in space-saving single-in-line packages and offer SAW controlled, wide band FM transmission/reception.

The modules are particularly suited to battery-powered, portable applications where low power and small size are critical design criteria.

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TX2 — $19.50 ea.
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Write in 108 on Reader Service Card.

PSCNC.EXE describes how to set up the program for use with your particular milling machine. The program uses an initialization file which has an assortment of geometric and servo control parameters. The documentation will walk you through the process of determining and verifying these parameters.

Briefly, the process starts with setting up the basic scale factors and servo parameters for your motors and machine. Once these are set up, you can use the PSCNC.EXE program to move the mill around and determine the working envelope parameters. Lastly, you will verify that your limit switches and the automatic homing procedure are working properly.

Working with PSCNC.EXE

The Windows program PSCNC.EXE gives you most everything you need to do serious CNC machining. As shown in Figure 3, it has a digital readout display, jogging controls, a G-Code display window, and controls for loading and executing G-Code programs. The documentation that comes with this program will give you complete details on using it, as well as its peculiarities and limitations. However, it is worth going over some of the highlights here.

Table 2: Motor/encoder wiring specification.

DB15 Pin Number	Description	Connect To (color coding is for Pittman motors only)
1	M+ motor drive signal	Motor's RED terminal
2	M+ motor drive signal	*leave unconnected*
3	LED Drive (for optical limit switches)	*leave unconnected*
4	Forward limit switch	Fwd switch's "normally closed" terminal (twist with wire from pin 12)
5	Encoder Channel A	Encoder's YELLOW wire (twist with wire from pin 13)
6	Encoder Channel B	Encoder's BLUE wire (twist with wire from pin 14)
7	Reverse limit switch	Rev. switch's "normally closed" terminal (twist with wire from pin 15)
8	Encoder Index	Encoder's GREEN wire (twist with wire from pin 11)
9	M+ motor drive signal	Motor's BLACK terminal
10	M+ motor drive signal	leave unconnected
11	Ground	twist with wire from pin 8, but leave unconnected at the motor end
12	Forward limit switch return (GND)	Fwd switch's "common" terminal (twist with wire from pin 4)
13	Encoder ground	Encoder's BLACK wire (twist with wire from pin 5)
14	Encoder +5V	Encoder's RED wire (twist with wire from pin 6)
15	Reverse limit switch return (GND)	Rev. switch's "common" terminal (twist with wire from pin 7)

Digital Readout (DRO) Display

The upper left corner of the control panel displays the current machine position, even when the servos are turned off. The origins for each axis can be set individually or set altogether. Positions are displayed in either raw machine coordinates (relative to the home position) or in program coordinates relative to the current origin.

Jogging Controls

The jogging controls are displayed in the upper right corner of the control panel, and allow you to move each axis manually in the positive or negative direction. A slider bar beneath the jog buttons is used to set the jog speed.

G-Code Display Window

The G-Code display window shows the current line of G-Code program along with a few lines ahead and behind. You cannot edit the G-Code from this window; you should use a regular text editor for creating and modifying programs. Just above the G-Code display, however, is an immediate execution window where you can enter in a single line of G-Code and execute it immediately.

G-Code Execution Controls

Controls for loading and executing G-Code programs appear in the lower right corner of the control panel. These include a dynamic feed-rate override (feed-rates can be adjusted while moving) and a non-dynamic rapid speed override. The feed-hold and resume buttons allow you to stop and start motions in the middle of execution, and the single step button lets you execute just one line of G-Code at a time.

G-Code programs can also be run with a contouring feature which will execute multiple tool-path segments as a smooth, continuous motion. Figure 4 shows a sinewave pattern cut out using this feature.

Perhaps the best feature of this program is that the C source code is provided. This will allow you to add or modify features to suit your needs.

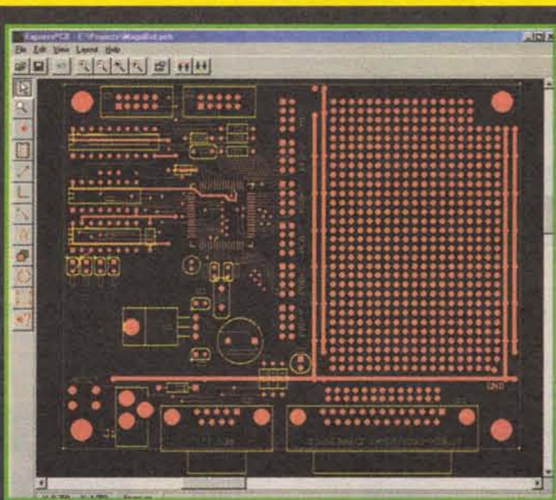
Ultimately, your imagination will be the only real limitation on the capabilities you can build into your CNC system. **NV**

Jeffrey Kerr is the founder of J.R. Kerr Automation Engineering (**www.jrkerr.com**), producer of PIC-SERVO motion control products. He has designed products for and consulted in the areas of robotics, automation, and motion control for many years, as well as occasionally writing articles for *Nuts & Volts*. Please send any inquires or comments to **jeff@jrkerr.com**.

Enter the **Nuts & Volts** and **ExpressPCB**
Electronics Design Contest

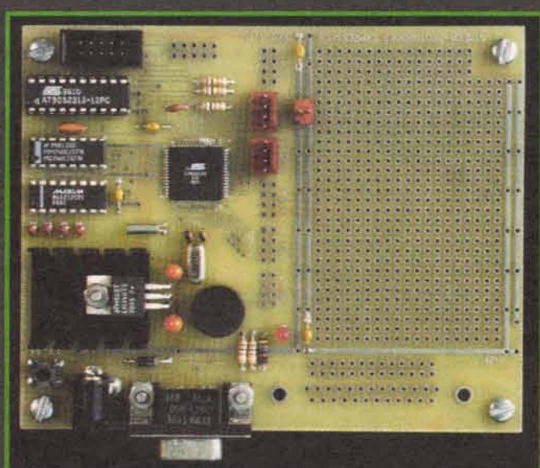
CONTEST ENTRY DEADLINE: JULY 19, 2000

1. **Go from this:**



This is a sample project for our design contest. The first step is to lay out a circuit board using the ExpressPCB editor. Your project could be robotic like this one, or related to telecommunications, ham radios, PC computer devices, microcontrollers, scientific equipment, data logging, or almost anything else using an electronic circuit.

2. **To this:**



This circuit board controls three RC-servos. The heart of the electronics is a surface-mount Atmel ATMega microcontroller.

3. **To this:**

This robotic leg and foot was originally designed for movie special effects. It is a prototype mechanism used to animate small creatures.

1st Prize
Tektronix TDS-210 Digital Oscilloscope

2nd Prize
Palm Pilot V Organizer

3rd Prize
Palm Pilot V Organizer

Contest Rules:

- Enter the contest by submitting a written description and photographs of a working electronic project that you have designed.
- Each project must be built using an ExpressPCB circuit board.
- The circuit board must have been designed by you using the ExpressPCB layout program.
- One grand prize and two second prizes will be awarded to the most interesting projects.
- The winning projects will be announced in the September 2000 issue of *Nuts & Volts* and on the ExpressPCB website. Project photographs and descriptions will be published for each of the winners.
- All entries must be received on or before July 19th, 2000.
- Please note: The materials submitted with each contest entry will become the property of *Nuts & Volts Magazine* and will not be returned.

How to enter:

Each contest entry must include:

- Your name, address, phone number, and E-Mail address.
- A written description of your project, about 250 to 500 words.
- A close-up photograph showing your assembled circuit board.
- One or two photographs of your completed project shown in use.
- The confirmation number given when your ExpressPCB circuit boards were ordered.

To enter by mail, send a hardcopy of your contest entry to:

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Design Contest
430 Princeland Court
Corona, CA 92879

To enter by E-Mail, send a single PKZip attachment to: designcontest@nutsvolts.com. *PLEASE DIRECT ANY QUESTIONS TO:* support@expresspcb.com.

Note: Project descriptions must be Microsoft Word documents or text files and photographs must be high resolution .TIF or .JPG files (.TIF preferred).


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Open Channel

by Joseph J. Carr

Telephones and EMI

Interference to telephone receivers is almost always the fault of the receiver or its wiring. That means the users or owners of the telephone system are at fault, and will have to bear the expense and effort to clear up the EMI problem.

Federal Communications Commission

Basically, the Federal Communications Commission (FCC) has no responsibility in the matter of EMI to telephones. Ever since deregulation, there has been no reason why the FCC is interested. The FCC regards this as a matter between the parties involved, and does not get involved. The FCC does, however, receive a large number of complaints about EMI to phone systems. As a result, their Compliance & Information Bureau publishes a booklet that may be of some help: *What To Do If You Hear Radio Communications On Your Telephone* (Bulletin CIB-10). It can be downloaded at **http://www.fcc.gov**.

Telephone Company

The local telephone company may view EMI problems as a matter of interest to those involved, and of no particular interest to themselves. Their responsibility ends with the "drop" at the service entrance to the business or home.

Ever since deregulation, the local phone companies have not had any interest beyond the drop. However, some do offer wiring contracts where the user pays a monthly fee on their telephone bill to have the phone company be responsible for the wiring.

Most such contracts will exempt the telephone receiver itself. Nonetheless, these contracts are worth exploring if there is an EMI problem on the telephone lines. Most such EMI problems are line problems, especially in the 500 KHz to 40 MHz region. Otherwise, if you are going to involve the telephone company discuss who is going to pay them.

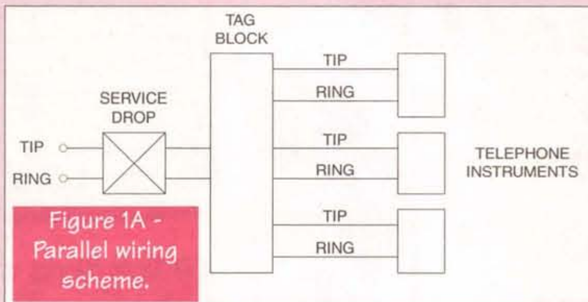

Figure 1A - Parallel wiring scheme.

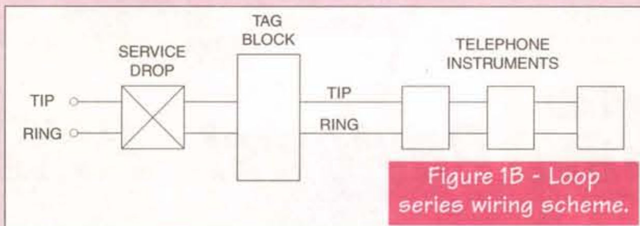

Figure 1B - Loop series wiring scheme.

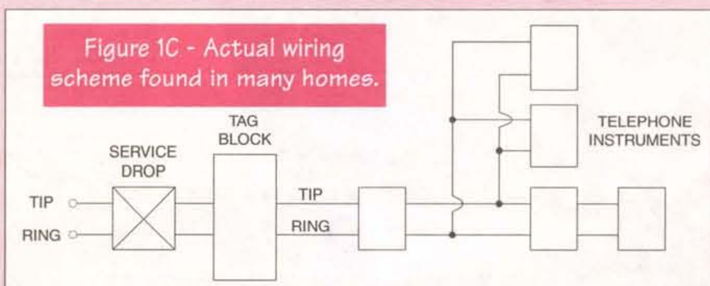

Figure 1C - Actual wiring scheme found in many homes.

Radio Owner

FCC regulations state that radio signals must be free of those characteristics that interfere with other services. That means radio and television services, not telephones. The radio owner and operator have no responsibility towards the telephone owner. That said, it is incumbent on the responsible operator of the equipment to try to provide the solution to the interference problem. But what that means is open to discussion.

It may mean, for example, handing out filters. Or it may mean handing out good advice. The issue of personal diplomacy is of primary concern here because the person being interfered with feels aggrieved.

Telephone Manufacturer

Ever since the deregulation of the telephone industry, there has been a tremendous number of firms providing telephones to the US marketplace. Some of them deal with EMI complaints effectively, others do not. You would think that manufacturers and importers of telephone equipment would be interested in the interference free use of that equipment. Such is not always the case.

In fact, several importers do not have the technical capacity to be of much use to the user. Some manufacturers, however, are a little better and will even supply filters for those customers who experience interference.

Telephone Owner

The responsibility for EMI proofing telephone equipment falls squarely on the end user of the equipment. Regardless of whether the interference is due to conducted pick-up in the wiring, or due to direct pick-up in the instrument itself, there is nothing the radio operator can do to eliminate the problem.

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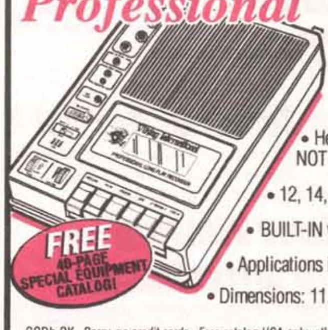

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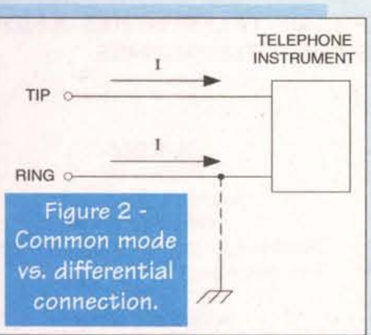

Figure 2 - Common mode vs. differential connection.

The problem is due to poor design of the telephone equipment selected by the consumer. The use of a filter should be explored. Failing that, a consumer may opt for one of the EMI-proof telephones that are offered.

A problem is that the interfering station appears to be doing something to the telephone. That sometimes produces a bitter consumer who demands that the problem be cleared up on the transmitter end. A little "personal diplomacy" will go a long way towards settling that issue, I suspect.

Technical Issues

All that has gone before in this article assumes that someone will get the job of defining a solution to the EMI problem. In this section, we will discuss the telephone wiring system and what can be done about it.

Figure 1 shows two forms of wiring that may be present in a home or business. Figure 1A shows the parallel wiring scheme, and Figure 1B shows the loop series wiring scheme. In the parallel scheme, there are as many wires from the junction block where the phone company's interest terminates as there are telephones. In the loop series wiring scheme, there is one pair of wires leaving the junction block, and the telephone instruments are daisy-chain wired from them. In truth, there might be a situation where both methods are used (which would reflect a user wiring scheme) ... as shown in Figure 1C!

There will be a fused lightning arrestor present at the drop. This lightning arrestor might be corroded, or it may be non-linear. In the case of corrosion, the non-linearity may be due to oxides or bimetallism causing the device to act like a diode. In either case, the non-linearity will act like a diode and cause rectification of RF energy. This, in turn, causes the EMI.

Twisted Pair, Flat (Parallel), and Shielded Wiring

Twisted pair wiring is superior to flat wire where EMI is concerned. It gets this attribute because of the fact that twisted pairs are self-shielding where flat wire is not. Twisted pair wiring can pass through noisy environments and be EMI free.

Unfortunately, most telephone wiring in the United States appears to be flat wire, eliminating the self-shielding aspects of twisted pair wiring. If you have a situation where there is a lot of flat wire involved, then it would be prudent to change it. For really difficult cases, use telephone company Category 3 or Category 5 wiring, even if the cost is high. Alternatively, you can use shielded wire yourself. The shield will protect against the EMI, but is terribly expensive.

It is good practice to ground unused wires or pairs of wires in a bundle. If the unused wires are grounded at the service entrance to the house, then there will be a decrease in susceptibility to EMI.

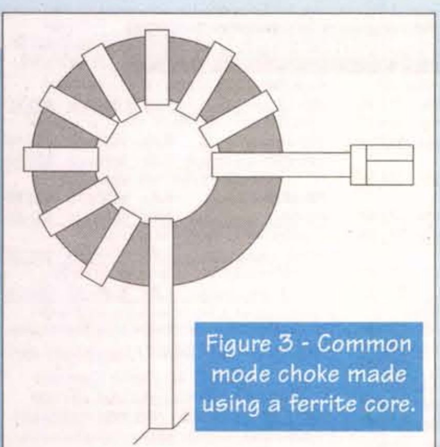
Figure 3 - Common mode choke made using a ferrite core.

Common Mode vs. Differential Mode

The telephone system is normally common mode, which is to say that it is balanced with respect to ground. Figure 2 shows this condition. When common mode integrity is maintained, the currents (I) flowing due to RF will be equal, nulling out at the instrument. It is not guaranteed that common mode lines will be EMI-free, but there is a higher probability of that condition existing.

Occasionally, a differential mode condition exists. This is an unbalanced condition. This is illustrated by the grounded condition in Figure 2. This mode can exist because of staples used to mount the wire breaking one insulator but not the other, by insulation breaking down, and by wiring errors. When the differential mode exists, the telephone will still operate as before, but the susceptibility to EMI will be tremendously increased.

Resonances

The telephone wiring in a home or business acts like a random length or even long-wire antenna to signals in the 500 KHz to approximately 200 MHz region. In that case, there will be resonance effects, i.e., those lengths that are integer multiples of quarter wavelength. The effect appears to peak in the 1.6 to 15 MHz region, but is present throughout the region of the spectrum cited above. At these resonant points, there is an increased probability of EMI problems.

Telephone Ground

The telephone system is grounded at the service entrance and no other point. If grounds exist elsewhere, they must be dealt with appropriately ... remove them. A properly installed telephone ground will either use a separate ground rod or be tied to the power company's ground. But there is a kind of ground where the telephone ground is tied to a cold water pipe at one end of a house, and the cold water pipe is, in turn, grounded to the AC power mains ground at the service entrance. This is a bad practice, and should be eliminated.

Corrosion on the Connections

Corrosion can occur on wires in the telephone system. This occurs because of years of exposure in damp spaces. Corrosion can cause noise on the line (hissing and frying, or pops), as well as making the line more susceptible to EMI. The susceptibility to EMI occurs because corrosion makes a decent diode, especially when two metals are involved in the junction (e.g., tinned vs. copper). Wiring that is corroded should be replaced, or at least the corroded

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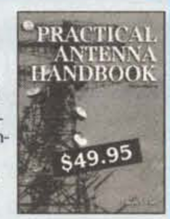

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Telephones and EMI

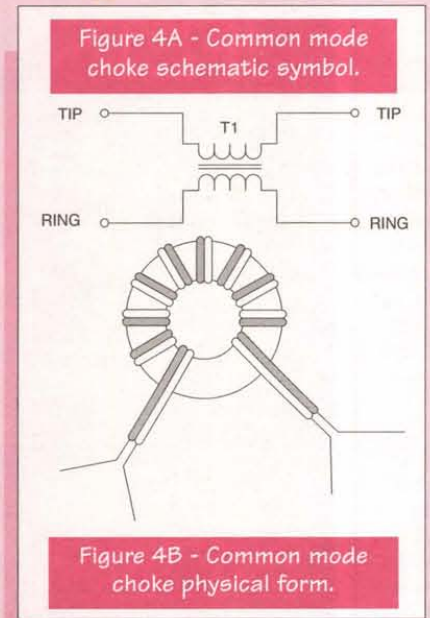

Figure 4A - Common mode choke schematic symbol.

Figure 4B - Common mode choke physical form.

portions eliminated and soldered.

Substandard Wiring

There is a substantial possibility of encountering substandard wiring in troubleshooting EMI to telephone problems. This is made especially likely now that consumers are doing their own wiring. Whenever substandard wiring is encountered, it should be replaced before any attempts — other than simple filtering — are made to eliminate the EMI. This is especially true if one of the wires is shorted to ground or there is corrosion present.

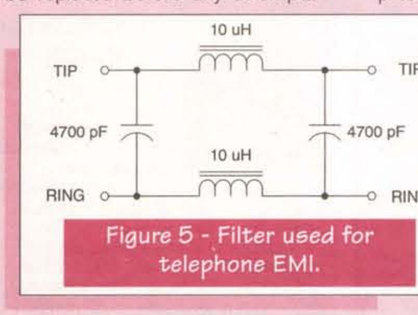

Figure 5 - Filter used for telephone EMI.

Telephone Classification

Telephones are classified according to type: plain old telephones or multi-featured. The plain old telephone is relatively free of EMI, but not entirely. This is due to the fact that the features of the other type require electronic circuitry in which there may be semiconductor junctions that can rectify RF. Generally speaking, the plain old telephone EMI can be dealt with using simple filtering (discussed later). Filtering alone may or may not help the multi-function EMI problem. In those cases, shielding may be in order.

Telephone Registration Numbers

Many telephones are sold in the United States with no importer or manufacturer listed. There will be a manufacturer's registration number present. In case you want to contact the manufacturer, the registration number can be interpreted for you by the FCC (Manager Part 68 Rules, 2000 M Street N.W., Washington, DC 20554). Once it is determined that the telephone itself is at fault, contact the manufacturer for information on fixes.

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Telephones and EMI

Capacitors

The capacitor is a differential mode filter of sorts, and can be used to eliminate EMI. Use a 0.001 mF to 0.01 mF, 1000 WVDC disk ceramic unit (the voltage rating is needed because the ring voltage can exceed 100 volts).

Unfortunately, this simple fix won't always work. At 3,000 Hz (the maximum frequency response of a telephone), the impedance of a 0.01 mF capacitor is about 5,300 ohms. Several capacitors will produce a value of impedance that may disrupt service, making it low volume.

The capacitor will not work in the case of EMI to a high speed MODEM. Even low value capacitors will exhibit enough phase shift to interrupt the operation of these devices.

Common Mode RF Chokes

If the telephone is responding to common mode signals, then a common mode choke may do wonders for the EMI problem. The simplest form of choke is the ferrite, such as shown in Figure 3.

Use the type 73, 75, or 77 ferrite material for the lower HF range, and type 43 ferrite for the VHF range. This type of choke is placed as close as possible to the instrument.

Figure 4 shows a common mode choke that is useful for EMI up to about 30 MHz or so. Figure 4A shows the schematic symbol, where Figure 4B shows the physical form of an actual choke.

The turns of the common mode choke are wound in the bifilar manner, i.e., they are wound together. This is done either by paralleling the wires, or by twisting them together prior to winding. If you plan to build your own, use about 28 turns of No. 30 AWG wire on a 0.50-inch form.

Filtering

There is a basic fact of life in telephone EMI problems: filtering eliminates a tremendous amount of it! The instrument can't respond to EMI if the RF that causes EMI can't get to the instrument. It's as simple as that!

A sample telephone filter is shown in Figure 5, although you will probably want to buy a filter rather than make one. It is most useful when the filter is placed as close to the affected instrument as possible.

When dealing with commercial filters, it may be necessary to work with several products, especially if the frequency of the offending station is not well established. The filters are made for different bands, and that factor alone makes them useful for different types of EMI.

Conclusion

Electromagnetic interference to telephone receivers is often difficult to nail down. Nonetheless, the EMI problem can be dealt with using the methods discussed in this article. **NV**

Connections ...

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Newsbytes

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It has also been announced that Avis Rent A Car will offer XM Satellite Radio to its US customers.

XMs first satellite is scheduled to launch in November 2000. Commercial XM service is scheduled to begin during the first half of 2001 for a monthly subscription fee of $9.95.

XM-Ready radios will be manufactured by such household names as Sony, Alpine, Pioneer, Delphi Delco Electronics Systems, Audiovox, Clarion, Mitsubishi, Motorola, and Sharp.

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XMs owners include Motient, which holds controlling interest in the company, General Motors, Clear Channel Communications, and DIRECTV, respectively, the leading car, radio, and satellite TV companies in the US.

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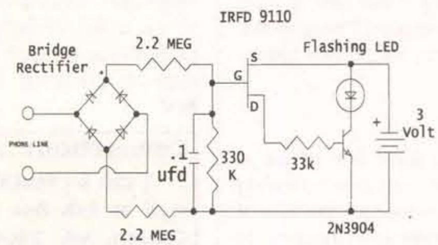
reader FeedBack

Telephone Busy Light

Dear Nuts & Volts:

Reference Fred Blechman's March '00 article on a telephone busy lite and subsequent feedback in the April '00 issue.

Since the first time someone picked up an extension phone while I was downloading a long file (25 Kbyte) on a high-speed modem (1200 baud) from a BBS, phone line busy indicators have been of special interest to me. Mr. Blechman's circuit is fine, but needlessly expensive (nine-volt battery, zener diode) and provides no polarity protection for the phone line. Mr. Roger Flaten's comment in the April issue is very apropos — a flashing LED is the way to go.

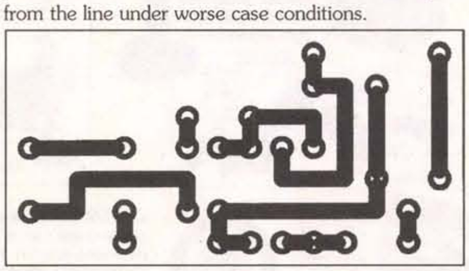


My solution is shown in the above schematic. This circuit has been in use for more than eight months without fail. The AA alkaline batteries are holding up well and should last at least a year depending on the long windiness of your family.

The 10 MM flashing LED is available from BG Micro for $.79. Almost any P-channel power FET will work — I just had the IRF 9110s on hand (Digi-Key is a good source).

The bridge rectifier (400 PIV) solves the polarity problem and no expensive nine-volt battery is required.

The circuit provides very low loading on the phone line and draws no more than 10 micro amps from the line under worse case conditions.



Here is a PC board layout if anyone is interested, however, a small piece of perf board will work just fine

Robert M. Harkey
Charlotte, NC

Telephone Busy Light

Dear Nuts & Volts:

Fred Blechman's article in the March '00 *Nuts & Volts*, "Build a Telephone-Busy Lite," was interesting, as was Gerald Roylance's letter in the Apr. '00 Reader Feedback. (I have built several telephone projects.)

I agree with Mr. Roylance that there are problems with Telephone Busy Lite, however, I also find problems with some of Mr. Roylance's statements.

Mr. Roylance says: "The DC resistance of a telephone must be greater than 10 megohms." This would be when the phone is "on-hook." This can't be measured with a DMM on most telephone-line equipment, as there is usually a diode (or diodes) in series, and the voltage of the ohms-range of DMMs is too low to turn on the diode. It can be measured by using a higher voltage source and measuring the current.

The reason for this high-resistance requirement is that, for preventive maintenance, the phone company measures the line current when the line is not in use to check for leakage.

When I first read Mr. Roylance's "10 megohm," I thought it was too high. However, I measured the current drawn by a RadioShack No. 43-443 Telephone Busy Light. With a 51.7 volt input, the current was 4.9 microamps, Ohm's Law gives a load resistance of 10.2 megohms.

The REN (Ringer Equivalence Number) has nothing to do with the DC load the phone places on the line. It is a measure of the AC impedance of the ringer circuit at the ring frequency of 20 Hz. Typical phones, modems, etc., have RENs of 0.1 to 1.0.

On some rural lines, according to the instructions with the RadioShack 43-443, it should not be over 3. (The REN of the RadioShack 43-443 is 0.0, and the REN of the Electronic Rainbow Busy Lite would also be very low.)

Since the input impedance of an FET, such as Q1 in the Busy Lite, is high, it should be possible to increase the resistances of R1 and R2 by at least a factor of 10, giving an input impedance of over 1

Published Monthly By
T & L Publications, Inc.
430 Princeland Court
Corona, CA 92879-1300
(909) 371-8497
FAX (909) 371-3052

E-Mail — editor@nutsvolts.com
URL — http://www.nutsvolts.com

Subscription Order ONLY Line
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megohm. (I also note that *Poptronics* published a Line-In-Use circuit, Feb. '00 page 21, which has an input resistance lower than that of the original Electronic Rainbow circuit described by Fred.)

I agree with Mr. Roylance that D2 should be replaced with a resistor. With a nine-volt supply, two volts will be across D1, leaving seven volts across the resistor, for a current of 7 mA with a 1K resistor.

Another way to reduce the off-hook current is to use a 2 mA LED (RadioShack 276-310 or 276-303) with a 3,300-ohm resistor.

In addition to the CarterPhone decision mentioned by Fred Blechman in his reply, the decision to break up AT&T from the operating companies eventually resulted in customer ownership of all equipment and lines inside the building. (Before the breakup, all equipment and the lines inside the building were phone company property, and the monthly phone bill included a lease charge for them.)

Although the interface requirements may still be on the books, they don't seem to be enforced unless the customer equipment causes a problem.

In conclusion, I would recommend the RadioShack 43-443 unit. It is powered only from the phone line, uses two LEDs, is bright, and the current drawn from the phone line when a phone is off-hook varies from 1.9 to 3 mA, depending on the phone used. All with an on-hook current of less than five microamps. RadioShack also sells another unit 43-108, which uses a nine-volt battery, but I haven't tried it.

Bill Stiles, Hillsboro, MO

Telephone Busy Light

Dear Nuts & Volts:

In my previous letter regarding the Telephone Busy Lite, I recommended a similar RadioShack unit, the No. 43-443 Single Line-Status Indicator. Last week, our phones wouldn't work. The problem was a short in the 43-443. RadioShack replaced it, and the new one is okay so far. The RadioShack store personnel said they had sold several, and this was the first one returned. Fred Blechman told me by E-Mail that he bought one of the RadioShack units before I did, and it has worked quite well. In fact, Fred's recommendation was one reason I bought one.

Second, the problem of load on the phone line when it is not in use. I mentioned in my letter that *Poptronics*, Feb. 2000, published a unit which loads the line even more than the Electronic Rainbow unit described by Fred. In the June 2000 issue, *Poptronics* published in "Q & A" a letter from "D. B." which says that FCC Reg. 47 CFR 68.312 specifies that the DC resistance of a telephone not in use, or of a device connected to a not-in-use line, should be greater that 5 megohms. In his reply, Michael Covington says that the old value was 1 megohm. In Mr. Roylances' letter in the April '00 Reader Feedback, he gave a value of 10 megohms. This is probably a desirable value,

Continued on page 85

Honda Motor Co., Inc., and XM Satellite Radio are also negotiating to provide digital satellite radio service to Honda and Acura customers in the United States.

"Acura and Honda have helped pioneer the application of satellite navigation systems in the auto industry. OnStar and XM Satellite Radio provide us with an opportunity to offer state-of-the-art, mobile communications services that will enhance the driving experience for our customers," said Tom Elliott, executive vice president of American Honda Motor Co., Inc.

"We are delighted to deliver OnStar's safety, security, and information services to Honda and Acura drivers," said Chet Huber, president of OnStar."

"XM's satellite connection to the vehicle provides the potential for additional in-vehicle services," said Hugh Panero, XM's president and CEO."

About OnStar

OnStar, a wholly owned subsidiary of General Motors, is the nation's leading provider of in-vehicle safety, security, and information services. Using the Global Positioning System (GPS) satellite network and wireless technology, OnStar links the driver and vehicle to the OnStar Center, where advisors are available to offer real-time, personalized service 24 hours a day, 365 days a year. OnStar services include automatic notification of air bag deployment, stolen vehicle tracking, emergency services, roadside assistance with location, remote door unlock, remote diagnostics, route support, OnStar Concierge, and convenience services locator. New services include: Personal Calling, which allows drivers to make and receive hands-free, voice-activated personal calls from their vehicles without an additional cellular contract; and OnStar Virtual Advisor, which will deliver to the vehicle personalized Internet-based information such as news headlines, sports scores, stock quotes, weather conditions, and E-Mail through a hands-free, voice-activated, audio interface.

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POWERLINE NETWORKING STANDARD TO BE SET BY JANUARY 1, 2001

The Consumer Electronics Association (CEA) announced that it is working to establish a single standard for high data-rate home networking using the powerlines already installed in every home.

Through a formal evaluation process that is already underway, CEA's Data Networking Subcommittee is selecting a single standard that capitalizes on the consumer benefits associated with powerline networking. This open process will result in a standard for a high data-rate powerline networking technology with the ability to handle isochronous data (including audio, video, and voice telephony) and asynchronous data (shared Internet access and file transfer). The selected technology will be forward-compatible as higher data-rate technologies are developed and will not interfere with existing home control and automation standards.

"CEA is working toward the goal of a single standard, that supports the needs of the audio, video, PC, and telephony industries. The home networking industry is looking to avoid conflicting standards on the powerline that could lead to confusion in the market and a delay in the availability of the powerlines for networking appliances in the home," says Bill Rose, vice president of Electronic Engineering at the Leviton Manufacturing Company and Chair of the R7 Home Networking Committee.

Networking over the powerlines offers consumers many advantages. Power outlets are conveniently located throughout the home, the technology is cost-effective and they provide a simple way to install a network without new wiring. The convenience of connecting devices through power outlets promises to provide a boost to networks in homes and will foster many new products and applications delivering entertainment, information access, and telephony services to consumers.

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COURT UPHOLDS FCC DECISION TO PRECLUDE CABLE TV OPERATORS FROM OFFERING "INTEGRATED" CONVERTER BOXES.

On June 6, 2000, the U.S. Court of Appeals denied General Instrument Corp's petition to reverse a decision by the FCC that would preclude cable TV operators from offering "integrated" set-top converter boxes that perform both security and ancillary functions.

Converter boxes have traditionally been available to consumers only by lease from cable operators, as part of a cable service package. As part of the Telecommunications Act of 1996, the FCC was directed to take steps to make converter boxes (and other navigation devices) commercially available from sources other than cable operators.

To this end, the FCC has required cable operators to cease providing new integrated cable boxes by January 1, 2005. The commission suggested a separation of the converter box into two parts. A device providing ancillary functions to be sold at retail and a security module, which would allow cable operators to maintain control over program access through an interface between the two devices.

Due to the current transition to digital programming, analog-only boxes were exempt from the ruling, as they will soon become obsolete.

When cable signals become digital, a set-top or other device will be necessary to view signals sent to present TVs. Since the same digital circuitry is used in many TVs, DVDs, digital VCRs, computers, etc., many of these items could be used in place of digital "converter boxes."

If a standard connection interface between the navigation device and security module were required by the FCC, any of these devices could be programmed to receive digital premium programming, eliminating the need for a separate set-top box.

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WILL WIRELESS PHONES MAKE TRADITIONAL HOME TELEPHONES OBSOLETE?

Wireless phones have quickly become one of the most obvious demonstrations of technology's effect on consumers' lifestyles. In the past three years alone, the household penetration rate of wireless phones jumped from just over one-third to more than half of all households. But does the emergence of this incredibly well-received technology mean the end of the traditional home tele

Continued on page 85

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HP 11650A Network Analyzer Accessory Kit, APC7 ... $600.00

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HP 8502A Transmission/ Reflection ... $675.00
Test Set, 0.5-1300 MHz

HP 85054A Type N Calibration ... $1,800.00
Kit, for HP 8510 series

HP R85026A WR28 Detector, ... $1,200.00
26.5-40 GHz, for HP 8757 series

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FLUKE 6060A Synthesized Signal Gen., ... $1,650.00
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FLUKE 6060A/AN Synthesized ... $950.00
Signal Generator, 10 kHz-520 MHz, 10 Hz res

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GIGATRONICS 600/6-12 ... $2,500.00
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Multiplier, x4, 50.0-75.0 GHz output, -3 dBm

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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, ... $450.00
2-18 GHz, 80 dB on/off ratio

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 Synth. ... $2,500.00
Sig. Gen., 1-1300 MHz, AM / FM

HP 8660C/86603A/86632B ... $3,250.00
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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

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HP 8340B Synthesized Sweep ... $20,000.00
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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 ... $3,900.00
Oscillator, 5.9-12.4 GHz, 70 dB step attenuator

HP 8601A Generator/Sweeper, ... $400.00
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HP 8620C Sweep Oscillator Frame ... $550.00

HP 86222B-E69/8620C Sweep ... $1,500.00
Oscillator, 0.01-2 GHz & 2-4 GHz, +10 dBm

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

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BOONTON 42B/41-4E Analog ... $450.00
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HP 436A-022/8484A Power Meter, ... $1,200.00
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HP 437B/8481D Power Meter, ... $2,200.00
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HP Q8486A Power Sensor, ... $1,200.00
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HP R8486A WR28 Power ... $1,500.00
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HP 415E SWR Meter ... $200.00

HP 8406A Comb Generator, ... $500.00
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HP 8447A Amplifier, 20 dB, ... $375.00
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HP 8447E Amplifier, 22 dB, 0.1-1300 MHz, +13 dBm output ... $750.00

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HP 8901B-1,2,3 Modulation An., ... $2,000.00
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ROHDE & SCHWARTZ ESH2 ... $3,750.00
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HP 777D Dual Directional Coupler, 20 dB, 1.9-4.1 GHz ... $275.00

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HP 8495H-001 Programmable ... $400.00
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HP R422A WR28 Crystal Detector, 26.5-40 GHz ... $400.00

HP R752D WR28 Directional Coupler, 20 dB, 26.5-40 GHz ... $450.00

HP R914B WR28 Moving Load, 26.5-40 GHz ... $250.00

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HP V752D WR15 Directional Coupler, 20 dB, 50-75 GHz ... $650.00

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Detector, 1-20 GHz, SMA(f/f)/SMC

KRYTAR 2616S Directional ... $200.00
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TEK 1411R PAL Test Gen., ... $1,100.00
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FET PRINCIPLES AND CIRCUITS Part 3

Field-Effect Transistors

by Ray Marston

Ray Marston looks at practical MOSFET and CMOS circuits in this penultimate episode of this four-part series.

Part 1 of this series explained (among other things) the basic operating principles of the MOSFET (or IGFET), and pointed out that complementary enhancement-mode pairs of these devices form the basis of the digital technology known as CMOS.

The present episode of the series looks at practical applications of MOSFETs and CMOS-based MOSFET devices.

A MOSFET INTRODUCTION

MOSFETs are available in both depletion-mode and enhancement-mode versions. Depletion-mode types give a performance similar to a JFET, but with a far higher input resistance (i.e., with a far higher low-frequency input impedance).

Some depletion-mode MOSFETs are equipped with two independent gates, enabling the drain-to-source currents to be controlled via either one or both of the gates; these devices (which are often used as signal mixers in VHF tuners) are known as dual-gate or tetrode MOSFETs, and use the symbol shown in *Figure 1*.

Figure 1. **Symbol of the dual-gate or tetrode MOSFET.**

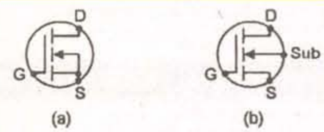

Figure 2. **Standard symbols of (a) three-pin and (b) four-pin n-channel enhancement-mode MOSFETs.**

Most modern MOSFETs are enhancement-mode devices, in which the drain-to-source conduction channel is closed when the gate bias is zero, but can be opened by applying a forward gate bias. This 'normally open-circuit' action is implied by the gaps between source and drain in the device's standard symbol, shown in *Figure 2(a)*, which depicts an n-channel MOSFET (the arrow head is reversed in a p-channel device). In some devices, the semiconductor substrate is made externally available, creating a 'four-terminal' MOSFET, as shown in *Figure 2(b)*.

Figure 3 shows typical transfer characteristics of an n-channel enhancement-mode MOSFET, and *Figure 4* shows the V_{GS}/I_D curves of the same device when powered from a 15V supply. Note that no significant I_D current flows until the gate voltage rises to a threshold (V_{TH}) value of a few volts but that, beyond this value, the drain current rises in a non-linear fashion.

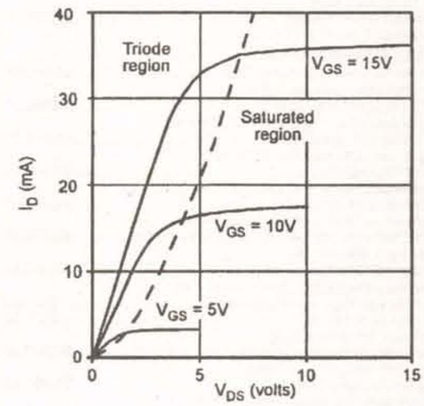

Figure 3. **Typical transfer characteristics of 4007UB n-channel enhancement-mode MOSFETs.**

Also note that the *Figure 3* graph is divided into two characteristic regions, as indicated by the dotted line; these being the 'triode' region, in which the MOSFET acts like a voltage-controlled resistor, and the 'saturated' region,' in which it acts like a voltage-controlled constant-current generator.

Because of their very high input resistances, MOSFETs are vulnerable to damage via electrostatic discharges; for this reason, MOSFETs are sometimes provided with integral protection via diodes or zeners.

THE 4007UB

The easiest and cheapest practical way of learning about enhancement-mode MOSFETs is via a 4007UB IC, which is the simplest member of the popular CMOS '4000-series' digital IC range, and actually houses six useful MOSFETs in a single 14-pin DIL package.

Figure 5 shows the functional diagram and pin numbers of the 4007UB, which houses two complementary pairs of independently-accessible MOSFETs and a third complementary MOSFET pair that

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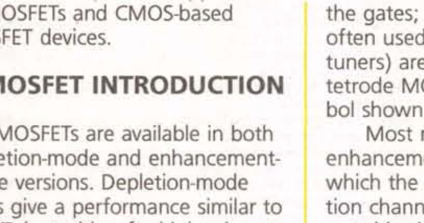

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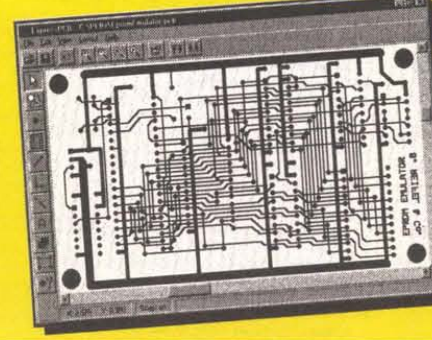

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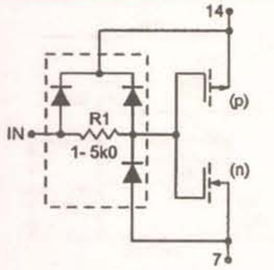

***Figure 6.* Internal-protection network (within dotted lines) on each input of the 4007UB.**

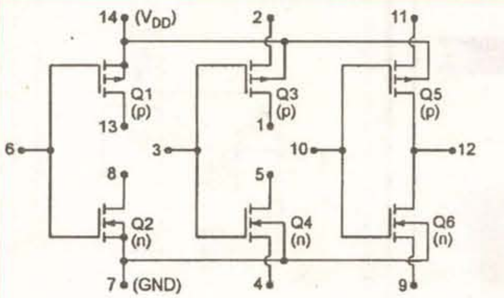

***Figure 5.* Functional diagram of the 4007UB dual CMOS pair plus inverter.**

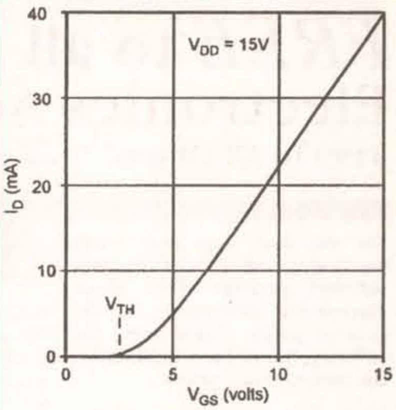

***Figure 4.* Typical V_{GS}/I_D characteristics of 4007UB n-channel enhancement-mode MOSFET.**

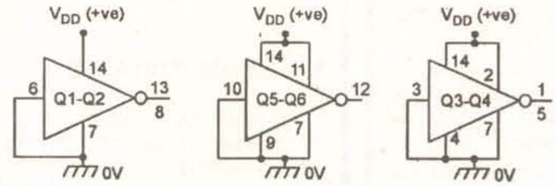

***Figure 7.* Individual 4007UB complementary pairs can be disabled by connecting them as CMOS inverters and grounding their inputs.**

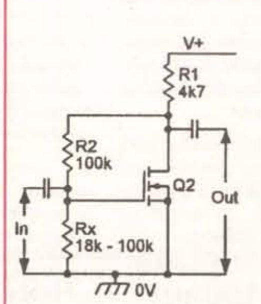

***Figure 8.* Method of biasing n-channel 4007UB MOSFETs for use as a linear inverting amplifier (with medium input impedance).**

is connected as a standard CMOS inverter stage.

Each of the IC's three independent input terminals is internally connected to the standard CMOS protection network shown in *Figure 6*.

Within the IC, Q1, Q3, and Q5 are p-channel MOSFETs, and Q2, Q4, and Q6 are n-channel types. Note that the performance graphs of *Figures 3* and *4* actually apply to the individual n-channel devices within this CMOS IC.

The 4007UB usage rules are simple. In any given application, all unused IC elements must be disabled. Complementary pairs of MOSFETs can be disabled by connecting them as standard CMOS inverters (i.e., gate-to-gate and source-to-source) and tying their inputs to ground, as shown in *Figure 7*.

Individual MOSFETs can be disabled by tying their source to their substrate and leaving the drain open circuit. In use, the IC's input terminal must not be allowed to rise above V_{DD} (the supply voltage) or fall below V_{SS} (zero volts).

To use an n-channel MOSFET, the source must be tied to V_{SS}, either directly or via a current-limiting resistor. To use a p-channel MOSFET, the source must be tied to V_{DD}, either directly or via a current-limiting resistor.

LINEAR OPERATION

To fully understand the operation and vagaries of CMOS circuitry, it is necessary to understand the linear characteristics of basic MOSFETs, as shown in the graph of *Figure 4*.

Note that negligible drain current flows until the gate rises to a 'threshold' value of about 1.5 to 2.5 volts, but that the drain current then increases almost linearly with further increases in gate voltage.

Figure 8 shows how to use an n-channel 4007UB MOSFET as a linear inverting amplifier. R1 acts as Q2's drain load, and R2-Rx bias the gate so that Q2 operates in the linear mode.

The Rx value is selected to give the desired quiescent drain voltage, and is normally in the 18k to 100k range.

The amplifier can be made to give a very high input impedance by wiring a 10M isolating resistor between the R2-Rx junction and Q2 gate, as shown in *Figure 9*.

Figure 10 shows how to use an n-channel MOSFET as a unity-gain non-inverting common-drain amplifier or source follower.

The MOSFET gate is biased at half-supply volts by the R2-R3 divider, and the source terminal automatically takes up a quiescent value that is slightly more than V_{TH} below the gate value.

The basic circuit has an input impedance equal to the paralleled values of R2 and R3 (=50k), but can be increased to greater than 10M by wiring R4 as shown.

Alternatively, the input impedance can be raised to several hundred megohms by bootstrapping R4 via C1 as shown in *Figure 11*.

Note from the above description that the enhancement-mode MOSFET performs like a conventional bipolar transistor, except that it has an ultra-high input impedance and has a substantially larger input-offset voltage (the base-to-emitter offset of a bipolar is typically 600mV, while the gate-to-source offset voltage of a MOSFET is typically two volts).

Allowing for these differences, the enhancement-mode MOSFET can thus be used as a direct replacement in many small-signal bipolar transistor circuits.

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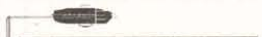

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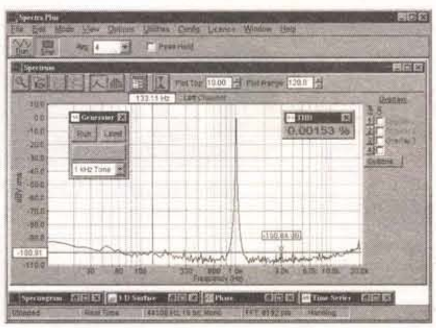

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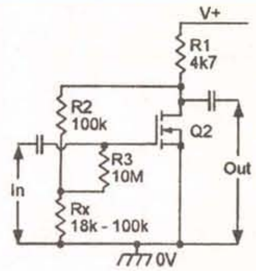


Figure 9. **High impedance version of the inverting amplifier.**

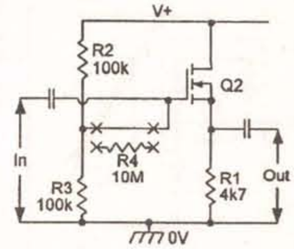


Figure 10. **Methods of biasing n-channel 4007UB MOSFET as a unity-gain non-inverting amplifier or source follower.**

THE CMOS INVERTER

A major application of enhancement-mode MOSFETs is in the basic CMOS inverting stage of *Figure 12(a)*, in which an n-channel and a p-channel pair of MOSFETs are wired in series but share common input and output terminals.

This basic CMOS circuit is primarily meant for use in digital applications (as described towards the end of Part 1 of this series), in which it consumes negligible quiescent current but can source or sink substantial output currents.

Figures 12(b) and *12(c)* show the inverter's digital truth table and its circuit symbol. Note that Q5 and Q6 of the 4007UB IC are fixed-wired in the CMOS inverter configuration.

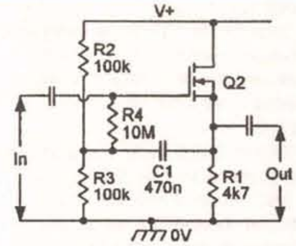
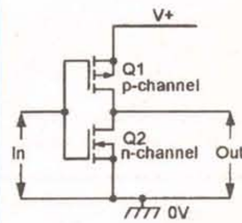


Figure 11. **Bootstrapped source follower has ultra-high input impedance.**

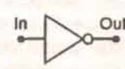
Although intended primarily for digital use, the basic CMOS inverter can be used as a linear



(a)

In	Out
0	1
1	0

(b)



(c)

Figure 12. **Circuit (a), truth table (b), and symbol (c) of the basic CMOS digital inverter.**

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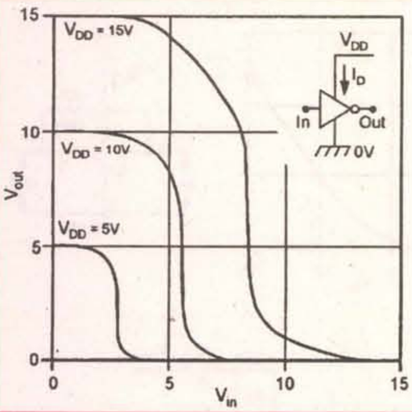


***Figure 14.* Typical input-to-output voltage transfer characteristics of the 4007UB simple CMOS inverter.**

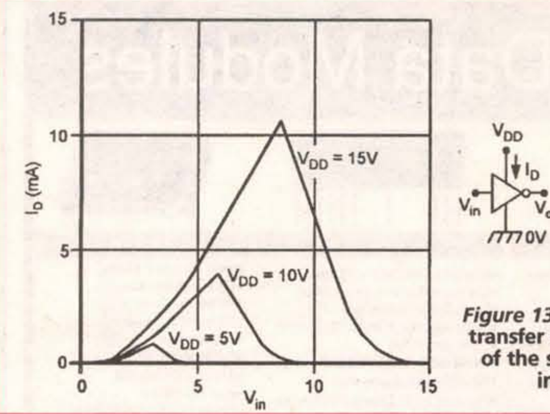
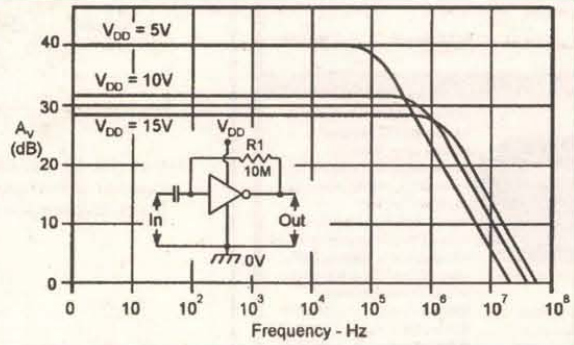


***Figure 13.* Drain-current transfer characteristics of the simple CMOS inverter.**

amplifier by biasing its input to a value between the logic-0 and logic-1 levels; under this condition Q1 and Q2 are both biased partly on, and the inverter thus passes significant quiescent current.

Figure 13 shows the typical drain-current (I_D) transfer characteristics of the circuit under this condition; I_D is zero when the input is at zero or full supply volts, but rises to a maximum value (typically 0.5mA at 5V, or 10.5mA at 15V) when the input is at roughly half-supply volts, under which condition both MOSFETs of the inverter are biased equally.

***Figure 16.* Typical A_V and frequency characteristics of the linear-mode basic CMOS amplifier.**



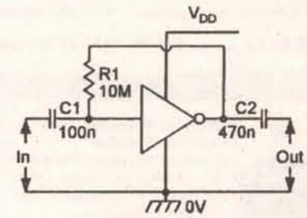


***Figure 15.* Method of biasing the simple CMOS inverter for linear operation.**

Figure 14 shows the typical input-to-output voltage-transfer characteristics of the simple CMOS inverter at different supply voltage values. Note that the output voltage changes by only a small amount when the input voltage is shifted around the V_{DD} and 0V levels, but that when V_{in} is biased at roughly half-supply volts, a small change of input voltage causes a large change of output voltage.

Typically, the inverter gives a voltage gain of about 30dB when used with a 15V supply, or 40dB at 5V.

Figure 15 shows a practical linear CMOS inverting amplifier stage. It is biased by wiring 10M resistor R1 between the input and output terminals, so that the output self-biases at approximately half-supply volts.

Figure 16 shows the typical voltage gain and frequency characteristics of this circuit when operated at three alternative supply rail values; this graph assumes that the amplifier output is feeding into the high impedance of a 10M/15pF oscilloscope probe and, under this condition, the circuit has a bandwidth of 2.5MHz when operating from a 15V supply.

As would be expected from the voltage transfer graph of *Figure 14*, the distortion characteristics of the CMOS linear amplifier are quite good with small-amplitude signals (output amplitudes up to 3V peak-to-peak with a 15V supply), but the distortion then increases as the output approaches the upper and lower supply limits.

Unlike a bipolar transistor circuit, the CMOS amplifier does not 'clip' excessive sinewave signals, but progressively rounds off their peaks.

Figure 17 shows the typical drain-current versus supply-voltage

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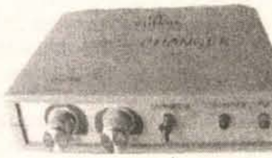

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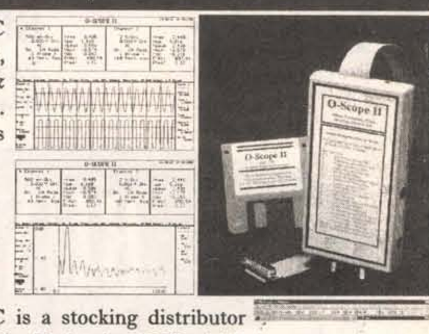

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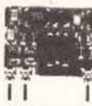

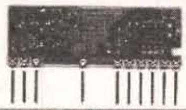

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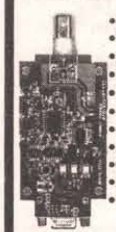

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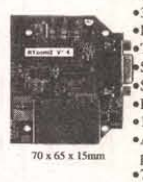

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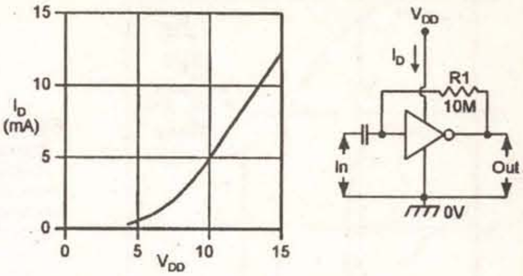
Figure 17. **Typical I_D/V_{DD} characteristics of the linear-mode CMOS amplifier.**



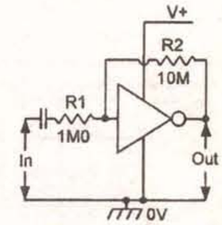
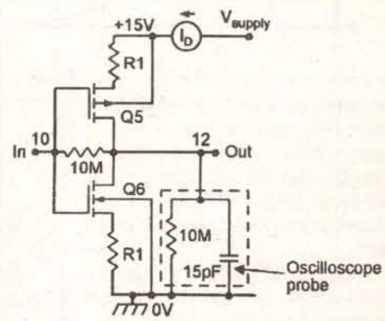


Figure 19. **Linear CMOS amplifier wired as x10 inverting amplifier.**



R1	I_D	A_V (V_{out}/V_{in})	Upper 3dB Bandwidth
0	12.5mA	20	2.7MHz
100R	8.2mA	20	1.5MHz
560R	3.9mA	25	300kHz
1k0	2.5mA	30	150kHz
5k6	600µA	40	25kHz
10k	370µA	40	15kHz
100k	40µA	30	2kHz
1M0	4µA	10	1kHz

Figure 18. **Micropower 4007UB CMOS linear amplifier, showing method of reducing I_D, with performance details.**

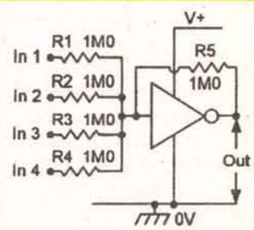
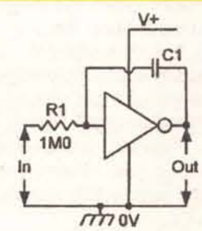


Figure 20. **Linear CMOS amplifier wired as unity-gain four-input audio mixer.**

Figure 21. **Linear CMOS amplifier wired as an integrator.**



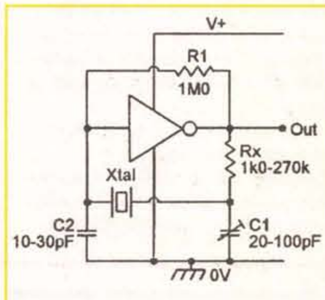


Figure 22. **Linear CMOS amplifier wired as a crystal oscillator.**

characteristics of the CMOS linear amplifier. The current typically varies from 0.5mA at 5V, to 12.5mA at 15V.

In many applications, the quiescent supply current of the 4007UB CMOS amplifier can be usefully reduced — at the cost of reduced amplifier bandwidth — by wiring external resistors in series with the source terminals of the two MOSFETs of the CMOS stage, as shown in the 'micropower' circuit of *Figure 18*.

This diagram also lists the effects that different resistor values have on the drain current, voltage gain, and bandwidth of the amplifier when operated from a 15V supply and with its output loaded by a 10M/15pF oscilloscope probe.

Note that the additional resistors of the *Figure 18* circuit increase the output impedance of the amplifier (the output impedance is roughly equal to the R1-A_V product), and this impedance and the external load resistance/capacitance has a great effect on the overall gain and bandwidth of the circuit.

When using a 10k value for R1, for example, if the load capacitance is increased (from 15pF) to 50pF, the bandwidth falls to about 4kHz, but if the capacitance is reduced to 5pF, the bandwidth increases to 45kHz. Similarly, if the resistive load is reduced from 10M to 10k, the voltage gain falls to unity; for significant gain, the load resistance must be large relative to the output impedance of the amplifier.

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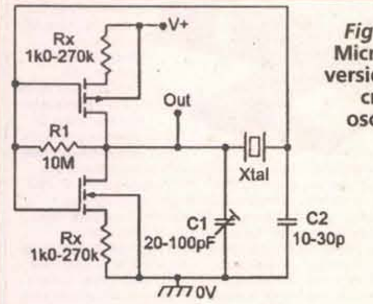

Figure 23. **Micropower version of the crystal oscillator.**

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The basic (unbiased) CMOS inverter stage has an input capacitance of about 5pF and an input resistance of near-infinity. Thus, if the output of the *Figure 18* circuit is fed directly to such a load, it shows a voltage gain of x30 and a bandwidth of 3kHz when R1 has a value of 1M0; it even gives a useful gain and bandwidth when R1 has a value of 10M, but consumes a quiescent current of only 0.4µA.

PRACTICAL CMOS

The CMOS linear amplifier can easily be used in either its standard or micropower forms to make a variety of fixed-gain amplifiers, mixers, integrators, active filters, and oscillators, etc. A selection of such circuits is shown in *Figures 19* to *23*.

Figure 19 shows the practical circuit of an x10 inverting amplifier. The CMOS stage is biased by feedback resistor R2, and the voltage gain is set at x10 by the R1/R2 ratio. The input impedance of the circuit is 1M0, and equals the R1 value.

Figure 20 shows the above circuit modified for use as an audio 'mixer' or analog voltage adder. The circuit has four input terminals, and the voltage gain between each input and the output is fixed at unity by the relative values of the 1M0 input resistor and the 1M0 feedback resistor.

Figure 21 shows the basic CMOS amplifier used as a simple integrator.

Figure 22 shows the linear CMOS amplifier used as a crystal oscillator. The amplifier is linearly biased via R1 and provides 180° of phase shift at the crystal resonant frequency, thus enabling the circuit to oscillate. If the user wants the crystal to provide a frequency accuracy within 0.1% or so, Rx can be replaced by a short and C1-C2 can be omitted. For ultra-high accuracy, the correct values of Rx-C1-C2 must be individually determined (the diagram shows the typical range of values).

Finally, *Figure 23* shows a 'micropower' version of the CMOS crystal oscillator. In this case, Rx is actually incorporated in the amplifier. If desired, the output of this oscillator can be fed directly to the input of an additional CMOS inverter stage, for improved waveform shape/amplitude. **NV**

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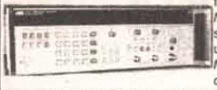

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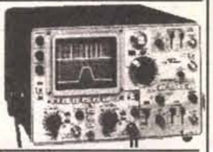

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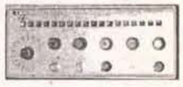

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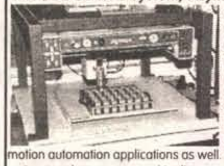

The Automove® 403G is a highly configurable, automatic fluid dispensing system capable of handling a full range of dispensing applications. Wherever hand-held dispensers are currently used, automating with the 403G system will increase both accuracy and throughput. Of course the system can be configured for many other motion automation applications as well. Your imagination is the key. The system can be programmed to dispense dots or continuous lines precisely and consistently using a wide variety of fluids. This flexibility makes it ideal for applications ranging from surface mount electronics to form-in-place gasketing. The system offers several standard features: At speeds of up to 508 mm/sec (20 in./s), it provides 0.025 mm (0.001 in.) resolution with a teach accuracy of 0.025 mm (0.001 in.). It is a gantry configuration with a 457 x 457 mm (18 x 18 in.) work area. Overall size: 36"W x 28"D x 20"H. Once programmed with a personal computer, the 403G stores up to 10 separate programs in onboard memory. Features: • Programmable speeds up to 508 mm/s (20 in./s) perfect for fast, short, repetitive moves required in automated applications. • Semiautomatic part skew alignment corrects for workpiece misalignment. • Easy-to use, flexible, Fluidmove® software for quick program creation is available from the manufacturer. (Not supplied). • Eight extra inputs and outputs provide interface to I/O-triggered devices for further automation. • Multiple programs can be stored in onboard memory allowing computer-free operation in a production environment. Unit is used and in excellent condition. Ships via truck. See www.asymtek.com for info.
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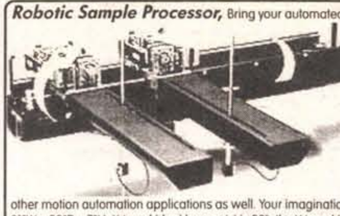
Vin	InL	RPM
6V	128mA	373RPM
12V	158mA	768RPM
18V	160mA	1160RPM
24V	170mA	1563RPM

New, super quality. **SPECIAL....$39ea. or 2 for $69**

Robotic Sample Processor,



Bring your automated system up to speed with this Robotic Sample Processor. It is an XYZ module that is fast and flexible with user friendly software available. (NOT SUPPLIED) Install the RSP XYZ as the nucleus for your new system. Of course the system can be configured for many other motion automation applications as well. Your imagination is the key. Overall size: 31"W x 22"D x 7"H, X travel (dual long axis) is 22", the Y travel (dual short axis) is 12", the Z axis is limited only by the length of the rod inserted into the linear bearing unit. (user supplied) The module is supplied with dual arms as pictured, variable sensitivity liquid level sensing and encoders. The electronics support a number of auxiliary devices including diluters, valves, peristaltic pumps, sample racks and single, multichannel or cap piercing probes. Mix and match from different Cavro modules and build the system that fits your needs. The RSP can be controlled using a simple user interface (We do not have the info). Software controls the arm movements and its accessories as well as performing diagnostics and data handing functions. For more information please see www.cavro.com
Robotic Sample Processor, RSP-XYZ..........$695ea.

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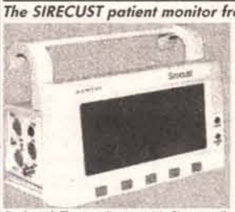
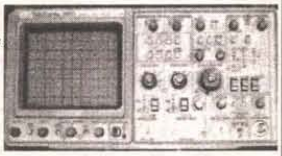


a compact, portable patient monitoring system offers data acquisition, signal processing, display & trending. Features include: • Multichannel, multiparameter monitoring capabilities • Small, lightweight (2.6 kg - 5.7 LB), durable & water resistant • AC or battery powered • NIBP: Fast recycling "continuous" mode and artifact rejection • Automatic alarm limits & preset mode Blood Pressure labeling / auto zero Parameter Features: Monitor can measure the patient's EKG, non-invasive blood pressure & temp. & two invasive pressures. Up to five parameters can be displayed. The monitor accepts Siemens three or five-lead EKG patient cables. (no input cables supplied) Display is 6.5" diag., easy-to-read numeric values & up to three waveforms. Alphanumerics, grids & graphics are presented on a mono, high-contrast, LCD. The EKG waveform auto centers & can be easily interpreted with the on screen mV scale. Lead I, II, or III is selectable, for best signal processing & waveform display. Systolic, diastolic & mean values are displayed. User assignable labels for all invasive pressures. Menu driven keys activate on screen labels which change according to the function selected. Used, each checked for self test and display. Offered as an experimenters item only. Not intended for medical or life support. No manuals. **Patient monitor, Sirecust............$99ea.**

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



One of the most popular & powerful scopes available at a reasonable cost. Features: 500ps/Div sweep, 2mV/Div. vertical sensitivity, 1Mohm / 50-ohm input, 500Mhz trigger bandwidth, four channels. On-screen waveform cursors provide vert. & horiz. scale factors, trigger level, voltage, time, freq., phase, ratio values and mode indication. Complete with 2 probes, and manual. Excellent condition. 90 day warranty. **Very Ltd. Qty.....$2195.**

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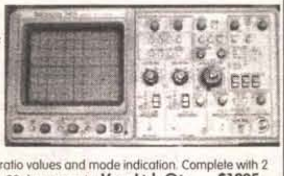

One of the most popular & powerful scopes available at a reasonable cost. Features: 500ps/Div sweep, 2mV/Div. vertical sensitivity, 1Mohm / 50-ohm input, 500Mhz trigger bandwidth, four channels. On-screen waveform cursors provide vert. & horiz. scale factors, trigger level, voltage, time, freq., phase, ratio values and mode indication. Complete with 2 probes, and manual. Excellent condition. 90 day warranty. **Very Ltd. Qty......$1295.**

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Cavro Scientific, XM Series Multi-Channel Pump,

The industry standard, Cavro's XM Series Multi-Channel pump. Now available with three channels. These brand new units were intended to use the slide to activate the plunger of a metering syringe (not supplied) to meter out and pump precision uL volumes of fluid. Each channel has an independently operated valve & can accommodate syringes ranging from 500 uL to 2.5 mL. The can automate multichannel pipetting, diluting & dispensing with independently operated solenoid valves. The pump can aspirate & dispense the same or different fluids. Inaccuracy is less than or equal to 1% at full stroke and imprecision is less than or equal to 0.05% at full stroke. Motion is supplied via a Pacific Scientific, P21NRXS-LNS-NS-03, 5.4V @1.63A unipolar stepper. This is coupled via a toothed belt to the 5.5"L lead screw with slotted optical position sensor. A slide with bronze bearings rides on a polished steel rod & provides 3" of very smooth travel. Construction is of cast and machined aluminum. Can be disassembled and modified to suit. (Software and interface info not supplied). **Multi-Channel Pump, Cavro-3XM......$89ea.**

NEW! LCD COLOR, TFT, ACTIVE MATRIX DISPLAY Offers a super 5.6" VIEWABLE AREA, Pro System with Custom Case, BUILT-IN 12V GEL CELL, all A/V cables and charger. Super Deal.

Pro System with Custom Case, BUILT-IN 12V GEL CELL, all A/V cables and charger. Super Deal. You asked for it. Finally we found a unit with exceptional quality at an affordable price. Perfect as a portable, general purpose color monitor for standard NTSC color or B&W video systems. Fully compatible with all our cameras as well as Camcorder, VCR's etc. Perfect as a rear view system with any video camera by virtue of its built in, mirror image function. Completely enclosed unit has adjustments for color, contrast and brightness and volume, for it's internal stereo speakers! A std. 1/4 x 20 Tripod socket and a tilt down stand for table top viewing. Inputs include: audio (L&R) and video on std. 1/8" mini jacks. External 12VDC on std. barrel connector. Specifications: 5.6", TFT active matrix LCD with 76.8K Pixels, CCFL backlight with 270cd/m Luminance, 500mW audio output available on std. 1/8" jack. 12V@600mA powered, 50mV min. or std. line level audio input. Overall size: 6.4"W x 5.25"H x 2.2D" New first quality. An optional accessory kit is available which includes: A luggage quality, custom made, padded case with dual removable straps for shoulder and/or holding at waist level for portable, hands free viewing. Built into the case is a 12V Gel Cell, rechargeable battery. Also supplied is a complete set of A/V cables. AC power adapter, power switch and battery charger. **GMTFT56-PRO...$344ea. GMTFT56 Display only..$299ea**

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More PIC Macros

by Tom Lyons Fisher and
Mayeul Marie Rigo

Karl Lunt's article "A High-Power PIC Macro Library" (*Nuts & Volts*, July '99) presented a collection of routines which make life more convenient for those of us who insist on programming in PIC assembler. But he left some out! We have developed some additional utilities which we hope PIC programmers will find useful.

IF STATEMENTS:

By combining conditional statement notation stolen from FORTRAN:

GT = Greater Than
GE = Greater than or Equal to
EQ = EQual to
NE = Not Equal to
LE = Less than or Equal to
LT = Less Than

with PIC working register (W), file (F), or a literal (L) notation, 12 easy-to-remember If statements can be formed. For example:

```
IfWGTF Zook,Place3
```

will branch to Place3 if the value in W is greater than the value in Zook.

CAUTION: Because these If macros have embedded goto's, the destination of the branch must be on the same memory page as the If. This shouldn't be a problem because subroutines should never straddle page boundaries and goto's shouldn't jump between subroutines.

Whatever is in W before the If is executed will be preserved, so you can do a series of tests without reloading W:

```
IfWEQL A'E',Pinch5
IfWEQL A'H',Pinch6
```

All of these macros are composed of multiple lines of code. Is this inefficient? Sure, but the improvement in clarity may prevent days of debugging. Whose time is more valuable, yours or the processor's?

INITIALIZATION

In PIC programming, to a large extent "initialization" means assigning pins to the peripherals. It's difficult to treat this logically because of all the special cases: ADCON1 affects all of the PORTA pins, PORTB is the only one with optional pull-up resistors, PORTC has specific pins for the SPI interface ... Also, a particular port (or even a particular pin!) may be shared by several peripherals. Here are some suggestions for keeping everything somewhat straight.

When possible, initialize on a pin-by-pin basis (bcf rather than movlw B'11001011'). This clarifies the initialization code by enabling you to organize by function rather than by peripheral port.

Define a descriptive name for each pin and then immediately use that name to set the data direction (DirIn or DirOut). Notice that you're acting like TRIS and PORT are equivalent; you can get away with this because DirIn and DirOut automatically switch to Bank1 and the low byte of the two addresses is identical. So, to make pin 4 of Port B an output for a Voice Activated Radar switch and pin 1 of Port B a sense line:

```
#DEFINE VARPort PORTB
#DEFINE VARsw 4
DirOut      VARPort,VARsw
#DEFINE SensLn 1
DirIn       VARPort,SensLn
```

Again, this is very inefficient because there is needless bank switching if consecutive Dir's occur. But, during initialization, speed is generally not as important as clarity.

Use only the descriptive name (VARPort,VARsw rather than PORTB,4) in your subroutines so that only the initialization file needs to be altered if you decide to reassign pins.

By the way, it's very helpful to incorporate a pinout diagram in your initialization file. Figure 1 shows an example for a 12C671.

Microchip warns about a subtlety that plagues the use of I/O ports, namely, that most operations are read-then-write. When you're fiddling with a peripheral port, this makes a difference because the operation reads the input port, but writes to the output latch. These are two different registers and they can, under certain conditions, have corresponding bits in opposite states. To avoid trouble, it's best to establish a "port mirror" in RAM which reflects the status of the port latch. Then when you want to change the state of a particular pin, you first change the mirror and then copy that change to the real port. This is a lot of rigmarole to go through each time you want to output something, but the following macros make it more convenient. If you follow the convention of placing the mirrors at the very beginning of available RAM, memory allocation will look like this:

```
05h     PORTA
06h     PORTB
07h     PORTC
.
.
20h     ATROP*
21h     BTROP
22h     CTROP
```

(*Well, what else are you going to name the PORTA mirror?)

This puts every mirror exactly 27d locations higher than its corresponding port so that this macro works correctly:

```
ClrPin      MACRO  PortNum,PinNum

bcf PortNum+D'27',PinNum
movfw       PortNum+D'27'
movwf       PortNum

ENDM
```

SetPin is the converse routine.

TABLES

The format for utilizing a table is:

GoTab *table name*

The offset into the table must be in W when GoTab is called. The value the offset points to is returned in W. You don't have to worry about "paragraph crossing" (a paragraph is 256 bytes of memory starting at an integer multiple of 256), GoTab takes care of everything. There's nothing special you have to do to create your own tables either, just follow the Microchip format, which is:

```
table name  addwf   PCL,F
            retlw   D'79'
            retlw   D'32'
             ...etc.
```

There are some limitations to GoTab: The table can only contain 256 items or less and it must not straddle a page boundary.

SUBROUTINES

Use GoSub rather than call for fully universal subroutine utilization.

The format for GoSub is:

GoSub *subroutine name*

What's so great about GoSub? It automati-

FIGURE 1

+5V -> (1)	Vdd	Vss	(8) -> Gnd
CPUClk <- (2)	GP5	GP0/AN0	(7) <- A2DCh0
CPUDat <- (3)	GP4/AN3	GP1/Vref	(6) <- Switch
Acquire -> (4)	GP3	GP2/Tmr0	(5) <> InpOut

cally updates PCLATH (and PCH) to reflect the context of the current subroutine so that you can use goto and call freely within any of your subroutines. Thus, one of the greatest sources of PIC bugs is eliminated.

If just one variable is needed for the input or the output of the subroutine, it's most often passed to or from the subroutine through W, the working register. For input, be sure you place the required value into W just before you GoSub; for output, the value will be in W upon return.

You can place your subroutine anywhere in memory; just don't allow it to straddle a page boundary!

LOCAL VARIABLES

It's desirable to have subroutines as isolated ("encapsulated") from each other as much as possible. One of the techniques used to do this in high-level languages is the use of local variables. Local variables disappear when the subroutine they're in is not being used. In high-level languages, local variables are pushed onto a stack as one subroutine calls another, and popped from the stack as the program "backs out" of a trail of subroutines. Since only one routine can be active at any instant, only those variables belonging to that routine need to be accessible at that instant.

You can have local subroutine variables (MPLAB already provides LOCAL MACRO variables) by using Push and Pull. All you need to do to take advantage of this feature when you write a subroutine is decide how many local variables you'll need for its operation. Then clear space for that number using the Pushn command. For example, if you're going to use two local variables, put:

```
Push2
```

at the very beginning of your subroutine and:

```
Pull2
```

at the very end. This gives you the right to use two built-in local variables called Temp1 and Temp2 any way you like within your routine. (A Push3...Pull3 combination would give you rights to Temp1, Temp2, and Temp3.) It is absolutely essential that you always pair the Push and the Pull! Otherwise the stack will get out of kilter and you'll get some really bewildering errors.

Of course, you'd probably prefer variable names which are a bit more descriptive than "Temp3." You can #DEFINE alternate names for these built-in variables. Be sure to #UNDEFINE them at the end of the routine so that you can reuse popular local variable names like "Index" and "Count." Your subroutines should have the format of this example:

```
#DEFINE Count Temp1
#DEFINE Index Temp2
Push2
body of your subroutine
Pull2
return
#UNDEFINE Index
#UNDEFINE Count
```

One additional wrinkle: Savvy programmers like to use W whenever possible to pass values to and from subroutines because it's "The Variable Which Leaves No Trace" and thus enhances encapsulation. GoSub, Pulln, and Pushn preserve whatever is in W (in TempW) and restore it transparently. (Thus, GoSub acts just like a call.)

So whatever was in W just before a GoSub or Pushn will also be in W just after, as well. If you utilize W as input in your subroutine, you must grab it right away (immediately after Push, if there is one) within your subroutine and put it someplace safe:

```
#DEFINE Wreg Temp1
Push1
movwf Wreg
body of your subroutine
movfw Wreg
Pull1
return
#UNDEFINE Wreg
```


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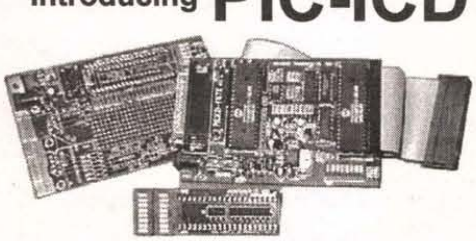

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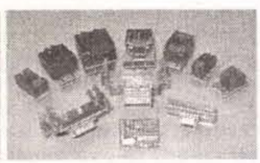


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Pulln works the same as Pushn, so whatever was in W just before return will be in W when you arrive at the calling program.

Of course, if you need W only as input, or only as output, you can eliminate some of the above code and just ignore the contents of W.

Aside from the speed penalty inherent in Push and Pull, there's another inconvenience. Push and Pull utilize FSR, the indirect addressing register, and depend upon its pointing to the correct byte whenever they are used. This means that if you "borrow" the FSR, you need to preserve and then restore the stack pointer which resides in FSR by default. Use SavStak to preserve the pointer and free the FSR for your use, and GetStak to restore the pointer so that Push and Pull can be invoked. You MUST restore the User Stack Pointer before the program encounters another Push or Pull!

Sometimes you'll need to provide your subroutine with more than one byte of input. To keep the routine general, you'll need to communicate through bankless RAM. Pass and Catch allow you to do this. In the following example, the two-byte number called Flex in the main program is made available in the subroutine called Flexer as the two-byte variable named Use:

```
    Pass        Flex0,Flex1
    GoSub       Flexer
    .
    .
    Flexer
    CBLOCK
    Use0
    Use1
    ENDC
    .
    Catch       Use0,Use1
```

The advantages of utilizing Pass/Catch are Bank independence and variable-name hiding. That is, you can change the name of Flex in the main program without re-editing subroutine Flexer.

All of the preceding encapsulation techniques depend upon the availability of "bankless" (common) RAM. All of Microchip's newer controllers have 16 bytes (70h to 7Fh) of this special RAM. Data stored here can be accessed directly regardless of the current bank status. See Table 1 for how we assign these special locations.

All of these utilities can be compiled with Microchip's MPLAB and have been tested on the 12C671, 12C672, 16C76, and 16C77. They will run on the older 16C73 and 16C74 if you make sure never to call a subroutine unless Bank 0 RAM is selected.

Be sure to #INCLUDE the appropriate processor-specific file provided by Microchip. The source code can be found at: http://www.juniata.edu/~fisher/picstuff/macros2.htm

Since the source code is provided, it's easy to determine the number of machine cycles required for these macros. Then you can decide whether you can afford to trade time for convenience in a particular case. In general, using macros everywhere in the first rough draft of a program and then simplifying only where speed is a consideration will get your program out the door faster than trying to write "tight" code for every portion of your program. These macros were designed to make removing them as easy as possible. **NV**

TABLE 1

070h	TempW	;utility working register storage
071h	Temp1	;currently accessible local variables
072h	Temp2	
073h	Temp3	
074h	Stack	;pointer to stored local variables
075h	Flags	;general-purpose bit flags
076h	Pass0	;subroutine argument storage
077h	Pass1	

(We reserve the remainder of bankless RAM for interrupt usage.)

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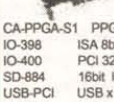

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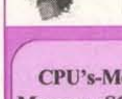

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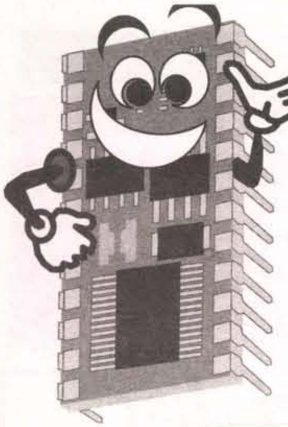


by Jon Williams

Stamp Applications

STAMPS IN THE LAB

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

When Parallax introduced the BS2, I can remember thinking about what a great lab interface it would be. It's got 16 I/O lines, all kinds of neat functions, and a serial interface to the PC that doesn't take away any of the I/O structure. Well, aside from a few experiments, I didn't do much in this regard. Thankfully, the clever guys at SelmaWare Solutions did. These guys have developed a really neat little program called Stamp Plot Lite that you can freely download from their site or from Parallax.

Stamp Plot Lite is a fully configurable, general-purpose graphing and datalogging utility. Stamp Plot Lite takes advantage of the BS2's DEBUG command, which is, in fact, the same as SEROUT at 9600 baud on pin 16. Stamp Plot Lite takes the information sent by DEBUG and deals with it accordingly:

- If the data is a decimal number, it is graphed as the analog value.
- If the data is prefixed by "%" (by using the IBIN modifier), it is assumed to be binary data and the individual channels (up to 9) are graphed as digital (ON or OFF) values.
- If the data is prefixed by "!", it is processed as one of the various Stamp Plot Lite commands.
- If the data doesn't fit any of the above categories, it is considered a general message and placed in a text box on the bottom of the screen.

The really neat part of the program is that it requires no set-up. The Stamp sends all of the set-up information for the graph after Stamp Plot Lite is connected. Since Stamp Plot Lite is so amazingly easy to use, I won't go into a great deal of detail here. There are a couple of notes that I do want to cover, though, before we get into a Stamp program that uses it.

First, Stamp Plot Lite will only graph one analog value. (Note: By the time you read this article, a "pro" version that graphs multiple analog channels will be available.) The second note is on the "X" (horizontal) axis of the scale. This axis always represents seconds as Stamp Plot Lite will time stamp information as it arrives (the time stamp is relative to the start of the graph). If you want to graph for a specific period, you'll need to express the period in seconds to keep things straight.

Since Stamp Plot is easier to explain by putting it through its paces, let's assemble some simple hardware and give it a run.

Project Hardware

If you have a Parallax BASIC Stamp Activity Board (BSAC) and a Dallas Semiconductor DS1620 temperature sensor, you're ready to rock-and-roll. If you don't, the schematics in Figures 1, 2, and 3 will get you there.

Figure 1 is the programming port and DEBUG interface. The capacitors on the ATN line allow the Stamp to be reset by the PC but will block a steady state on the serial DSR line. This will be important later when we connect the Stamp to a terminal program. Note that if you have an older BSAC that only has one capacitor, you'll want to replace it with a two-pin header and removable jumper. The jumper will be installed for programming and removed for general serial communications.

Figure 2 is the button inputs and LED outputs (that will be used a little later). In case you're wondering why we've split the resistor on each I/O line into two ... this configuration protects the I/O pin if it is in a HIGH (five volts) state and the button gets pressed. The 330-ohm resistor limits the current to about 14 milliamps — a safe level for the pin.

Figure 3 is the interface to the Dallas DS1620 temperature sensor. Since we've covered the DS1620 on several occasions, we won't go into any detail about its workings. Refer to past articles by Scott Edwards and me for operational details of the DS1620.

How Well Is That A/C Working? ...

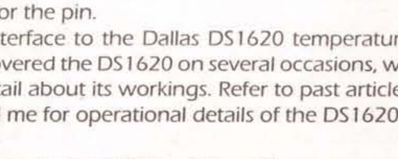
For reasons I can't explain, I'm nutty about knowing the temperature. That's probably why we're using the DS1620 again. It also gives me an opportunity to see the accuracy of my air conditioner's thermostat and I suppose how well the insulation in my apartment is working.

Take a look at Listing 1 (TEMPPLOT.BS2). The purpose of this program is to measure the temperature every second for an hour and send it to Stamp Plot Lite for graphing.

Let's talk specifically about the interface to Stamp Plot Lite. We'll start in the section labeled Init_Graph. The first thing we do is issue the reset command, !RSET. This will clear the contents of the Stamp Plot Lite screen. Notice that the DEBUG command is terminated with CR (carriage return character — same as 13). This is very important. The CR character lets Stamp Plot Lite know that the string has been entered and can be processed.

The next several commands are used to set up the graph. We'll start with the "Y" (vertical) axis. The !SPAN command sets the lower and upper limits of the graph. Since we're interested in monitoring the temperature in my living room, we've used "!SPAN 70,80" to set the lower limit of the graph to 70 degrees and the

Figure 1



STAMPS IN THE LAB

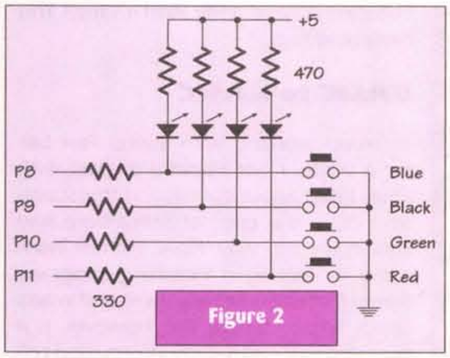


Figure 2

upper limit of the graph to 80 degrees.

The next command — !AMUL — is very clever. This command stands for "Analog Multiplier." What Stamp Plot Lite does is multiply the analog value by this multiplier before sending it to the graph. This is great for converting raw sensor data to values that are meaningful. In our case, temperature is going to be sent to Stamp Plot Lite in tenths of degrees (if the air temperature is 73.5 degrees, the Stamp will send 735 to the PC). By using the multiplier, we will correctly display our temperature data.

Finally, we'll use !CLMM to clear any previously stored minimum and maximum values.

Now it's time to set up the "X" (horizontal) axis. !TMAX tells Stamp Plot Lite how wide the graph should be. Remember that this value is in seconds. In our case, we want to watch the temperature for an hour — 3600 seconds. !PNTS tells Stamp Plot Lite how many data points we want to collect. Since we want to fill the screen with data, well set the number of points to 3600; one data point per second for an hour. !MAXS causes the graph to stop when the maximum number of data points is reached.

The command !TSMP ON enables time stamping. The time stamp is relative to the start of the graph and is expressed in seconds.

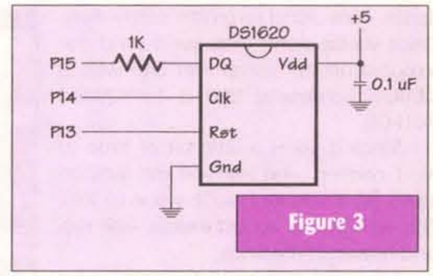


Figure 3

The next few commands are designed to give information to the user about what's being monitored, graphed, and (possibly) logged. !TITL sets the Stamp Plot Lite window title. !USRS puts a message in the user status box. This is the narrow box located just above the graph. !CLRM clears the general message box (located below the graph). The last DEBUG command has no specific formatting character and is assumed to be a general message. It is written to the general message box and stamped with the time-of-day and offset from reset.

The last thing we need to do is tell the graph to start plotting. This is accomplished with the !PLOT ON command.

Okay, we've set up the graph so let's start sending some data. The first thing we do is grab the current air temperature from the DS1620. Remember that the data returned is expressed in half degrees using the Celsius scale. Bit8 of the temperature is the negative indicator. Since we're measuring indoor temperatures, we're probably not ever going to see this bit set — but we'll check it, just to be safe (and if it is set, my goldfish is going to be really angry ...).

The conversion to Fahrenheit probably looks familiar, if not a bit funky. The reason that there is no divisor (usually 5) in the equation is that the raw temperature reading is in half-degree increments. This

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

' ========================================================================
' Program... TEMPPLOT.BS2
' Author.... Jon Williams
' Started... 29 MAY 2000
' Updated... 29 MAY 2000
' ========================================================================


' —-[ Program Description ]———————————————
'
' Plot temperatures measured by a DS1620 using Stamp Plot Lite from
' SelmaWare Solutions (www.selmaware.com)


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


' —-[ I/O Definitions ]———————————————
'
Rst     CON     13                              ' DS1620.3
Clk     CON     14                              ' DS1620.2
DQ      CON     15                              ' DS1620.1


' —-[ Constants ]———————————————
'

' DS1620 commands
'
RTmp    CON     $AA                             ' read temperature
WTHi    CON     $01                             ' write TH (high temp)
WTLo    CON     $02                             ' write TL (low temp)
RTHi    CON     $A1                             ' read TH
RTLo    CON     $A2                             ' read TL
StartC  CON     $EE                             ' start conversion
StopC   CON     $22                             ' stop conversion
WCfg    CON     $0C                             ' write config register
RCfg    CON     $AC                             ' read config register


' —-[ Variables ]———————————————
'
tmpIn   VAR     Word                            ' raw data from DS1620
halfBit VAR     tmpIn.Bit0                      ' 0.5 degree C indicator
sign    VAR     tmpIn.Bit8                      ' 1 = negative temperature
tempF   VAR     Word                            ' degrees F in tenths


' —-[ EEPROM Data ]———————————————
'

' —-[ Initialization ]———————————————
'
Init_DS1620:
        HIGH Rst                        ' alert the DS1620
        ' use with CPU; free run mode
        SHIFTOUT DQ,Clk,LSBFIRST,[WCfg, %10]
        LOW Rst
        PAUSE 10                        ' allow DS1620 EE write
        HIGH Rst
        ' start temp conversion
        SHIFTOUT DQ,Clk,LSBFIRST,[StartC]
        LOW Rst

Init_Graph:
        DEBUG "!RSET", CR                               ' clear graph
        DEBUG "!SPAN 70,80", CR                         ' disply 70 - 80 degrees
        DEBUG "!AMUL 0.1", CR                           ' convert from tenths
        DEBUG "!CLMM"                                   ' clear min/max values
        DEBUG "!TMAX 3600", CR                          ' 1 hour scale
        DEBUG "!PNTS 3600", CR                          ' graph every second
        DEBUG "!MAXS", CR                               ' stop when graph full
        DEBUG "!TSMP ON", CR                            ' enable time stamping

        DEBUG "!TITL Jon's Home Temp", CR                       ' set window
title
        DEBUG "!USRS Temperature in Fahrenheit", CR     ' graph legend
        DEBUG "!CLRM", CR                               ' clear messages
        DEBUG "Reset and monitoring temperature", CR    ' message box

        DEBUG "!PLOT ON", CR                            ' enable plotting


' —-[ Main ]———————————————
'
Main:   GOSUB GetTemp                           ' get the raw temperature
        IF sign = 0 THEN NotNeg                 ' if positive, okay
        tmpIn = 0                               '  - otherwise make zero
NotNeg: tempF = (tmpIn * 9) + 320               ' convert to 10ths F
        DEBUG DEC tempF, CR                     ' send to Stamp Plot Lite

        PAUSE 990                               ' wait about 1 second

        GOTO Main                               ' do it again


' —-[ Subroutines ]———————————————
'

GetTemp:
        HIGH Rst                        ' alert the DS1620
        SHIFTOUT DQ,Clk,LSBFIRST,[RTmp]         ' read temperature
        SHIFTIN DQ,Clk,LSBPRE,[tmpIn\9]         ' get the temperature
        LOW Rst
        RETURN
```

makes converting to tenths pretty easy. Once we've done that, we'll send the temperature to Stamp Plot Lite with a DEBUG command that is terminated with CR.

Since it takes a little bit of time to read, convert, and transmit the temperature, we'll set our PAUSE value to 990. This will give us almost exactly one second between readings.

Now we just need to start Stamp Plot Lite, click on the Connect check box, and start our Stamp program (or restart it by pressing the reset button on the BSAC). Take a look at the screen shot in Figure 4. This shows the result of measuring the temperature in my living room for one hour. What we can see is that with a thermostat setting of 74, the temperature fluctuated between 72.5 and 76.1 degrees. It was a warm morning when I took the readings; almost 85 degrees outside.

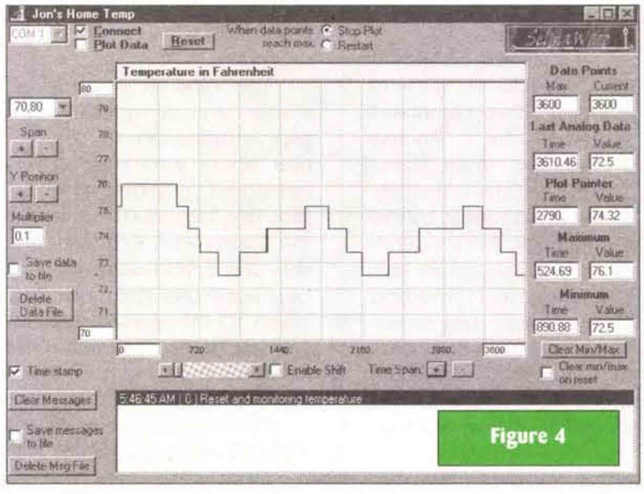


Figure 4

Pretty neat, isn't it? Even with a very simple program. Stamp Plot Lite offers a lot of other cool features, including the ability to save the collected data to a file. And it's free! You can't beat that.

BASIC to BASIC

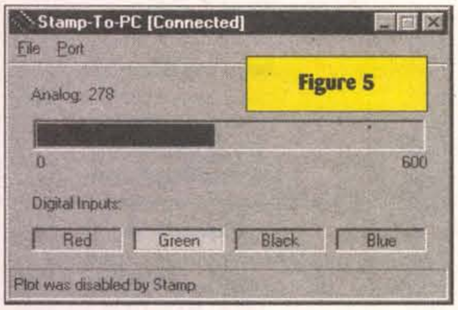
After working with Stamp Plot Lite for a while, I got inspired to play with ideas I had about connecting the Stamp to a PC — the guys at SelmaWare had shown me the way. Now, I'm not interested in writing a graphing program, Stamp Plot Lite is already there and works great. What I would like, however, is a program that can display information collected by the Stamp and perhaps even do more advanced processing with raw sensor data.

As a starter, we'll write a Visual Basic program that will be compatible with most of the Stamp Plot Lite commands. Once we get that working, we can move on to bigger things.

Listing 2 is the Visual Basic code for the project. Keep in mind that this project — and any VB project that does serial communications — will

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

' ========================================================================
' Program... StampToPC.vbp
' Author.... Jon Williams
' Started... 26 MAY 2000
' Updated... 26 MAY 2000
' ========================================================================

Option Explicit

Dim showData As Boolean                 ' okay to show incoming data
Dim rxBuffer As String                  ' buffer for incoming characters
Dim multiplier As Single                ' analog multiplier

Private Sub Form_Load()

  ' center form
  Me.Left = (Screen.Width - Me.Width) / 2
  Me.Top = (Screen.Height - Me.Height) / 2
  Me.Caption = App.Title

  ' setup comm object
  With MSComm1
     .CommPort = 1
     .Settings = "9600,N,8,1"           ' setup for DEBUG
     .DTREnable = mnuPortResetStamp.Checked
     .RThreshold = 1                    ' process one char at a time
     .InputLen = 1
     .InputMode = comInputModeText      ' input will be strings
  End With

  multiplier = 1#                       ' analog multiplier
  SetSpan ("0,100")                     ' set span of progress bar
  ClearForm
  showData = False                      ' wait for reset

End Sub

Private Sub Form_Unload(Cancel As Integer)

  If MSComm1.PortOpen Then MSComm1.PortOpen = False

End Sub

Private Sub mnuFileExt_Click()

  Unload Me

End Sub

Private Sub mnuPortComX_Click(Index As Integer)

  ' deselect last port
  mnuPortComX(MSComm1.CommPort).Checked = False
  ' select new
  MSComm1.CommPort = Index
  mnuPortComX(Index).Checked = True

End Sub

Private Sub mnuPortConnect_Click()

  Dim x As Byte

  If Not (MSComm1.PortOpen) Then
     ' open the port
     On Error GoTo PortError
     MSComm1.PortOpen = True
     ' update the title bar
     Me.Caption = App.Title & " [Connected]"
     ' update port menu
     For x = 1 To 4
       mnuPortComX(x).Enabled = False
     Next
     mnuPortConnect.Caption = "&Disconnect"
  Else
     ' close the port
     MSComm1.PortOpen = False
     ' update the title bar
     Me.Caption = App.Title
     ' update port menu
     For x = 1 To 4
       mnuPortComX(x).Enabled = True
     Next
     mnuPortConnect.Caption = "&Connect"
  End If
  Exit Sub

PortError:
  MsgBox "Could not open Com" & Trim(Str(MSComm1.CommPort)) & ". " & _
         vbCr & "Please select another port.", _
         vbExclamation + vbOKOnly, App.Title

  On Error GoTo 0

End Sub

Private Sub mnuPortResetStamp_Click()

  mnuPortResetStamp.Checked = Not (mnuPortResetStamp.Checked)
  MSComm1.DTREnable = mnuPortResetStamp.Checked

End Sub

Private Sub MSComm1_OnComm()

  Dim newChar As String

  Select Case MSComm1.CommEvent
    Case comEvReceive
      newChar = MSComm1.Input
      If newChar = Chr(13) Then
        ProcessBuffer (rxBuffer)
        rxBuffer = ""
      Else
        rxBuffer = rxBuffer & newChar
      End If

    ' process other events here

  End Select

End Sub
```

STAMPS IN THE LAB



require the MSComm control, which is found in only the Professional and Enterprise editions. Since our focus here is on receiving and processing the Stamp Plot Lite commands, that's where we'll keep our focus.

The first thing we need to do is set up the MSComm control. The code to do this is found in the Form_Load event handler so that it gets set up when the program is started. The Settings parameter is set to "9600,N,8,1" to make it compatible with the DEBUG output from the Stamp. Other key parameters that we pay attention to are RThreshold and InputLen. We set both of these to 1 so that we can process each character as it arrives. Finally, we need to set the InputMode to text (comInputModeText) since we're sending text strings from the Stamp.

Okay, now that we're set up, here's how our program works. With the comm port selected and opened, the program waits for a character to come in. When it does, the MSComm1_OnComm event gets fired. We grab the character from the serial port and check to see if it's a carriage return (character 13). If it's not, we'll add it to our own buffer. When a carriage return is received, we send our buffer to the subroutine called ProcessBuffer.

The first thing that ProcessBuffer does is check the first character for "!" or "%" since these characters have special meaning from Stamp Plot Lite. Let's assume that the first character was an exclamation point. This indicates a Stamp Plot Lite command so we'll handle it separately with a subroutine called DoCommand.

```
Private Sub ProcessBuffer(ByVal strBuffer As String)

  Dim leadChar As String
  Dim param As String

  ' get leading character
  leadChar = Mid(strBuffer, 1, 1)

  Select Case leadChar
    Case "!"
      ' command string
      DoCommand (strBuffer)
    Case "%"
      ' binary data
      param = Trim(Mid(strBuffer, 2))
      If showData Then ShowDigital (Bin2Dec(param))
    Case Else
      If IsNumeric(strBuffer) Then
        ' buffer has analog data
        If showData Then ShowAnalog (CLng(strBuffer))
      Else
        ' buffer contains message
        sbarMessage.SimpleText = Trim(strBuffer)
      End If
  End Select

End Sub

Private Function DoCommand(ByVal theCommand As String)

  Dim delimPos As Integer
  Dim cmd As String
  Dim param As String

  ' remove any leading or trailing spaces
  theCommand = Trim(theCommand)

  delimPos = InStr(1, theCommand, " ")
  If delimPos = 0 Then
    ' no parameter(s)
    cmd = UCase(theCommand)
  Else
    ' command has parameter(s)
    ' - get command
    cmd = UCase(Mid(theCommand, 1, delimPos - 1))
    ' extract parameters from command string
    param = Mid(theCommand, delimPos + 1)
  End If

  ' process the command
  Select Case cmd
    Case "!RSET"
      ClearForm
      showData = True
    Case "!CLRM"
      If showData Then sbarMessage.SimpleText = ""
    Case "!USRS"
      If showData Then sbarMessage.SimpleText = param
    Case "!AMIN"
      pbarAnalog.Min = CLng(param)
    Case "!AMAX"
      pbarAnalog.Max = CLng(param)
    Case "!AMUL"
      multiplier = CSng(param)
    Case "!SPAN"
      SetSpan (param)
  End Select

End Function

Private Function Bin2Dec(ByVal binValue As String) As Long

  Dim temp As Long
  Dim binLen As Integer
  Dim x As Integer

  temp = 0
  binLen = Len(binValue)
  For x = 1 To binLen
    ' add bit value if "1"
    If Mid(binValue, x, 1) = "1" Then
      temp = temp + 2 ^ (binLen - x)
    End If
  Next

  Bin2Dec = temp

End Function

Private Sub SetSpan(ByVal span As String)

  Dim comma As Integer

  comma = InStr(1, span, ",")
  If comma = 0 Then Exit Sub                    ' improper format - exit

  ' update progress bar
  pbarAnalog.Min = CLng(Mid(span, 1, comma - 1))
  pbarAnalog.Max = CLng(Mid(span, comma + 1))

  ' update legends
  lblSpanMin.Caption = Str(pbarAnalog.Min)
  lblSpanMax.Caption = Str(pbarAnalog.Max)

End Sub

Private Sub ShowAnalog(ByVal aValue As Long)

  aValue = CLng(CSng(aValue) * multiplier)

  ' show value
  lblAnalogValue.Caption = Trim(Str(aValue))

  ' check limits and show on progress bar
  If aValue > pbarAnalog.Max Then aValue = pbarAnalog.Max
  If aValue < pbarAnalog.Min Then aValue = pbarAnalog.Min
  pbarAnalog.Value = aValue

End Sub

Private Sub ShowDigital(ByVal digValue As Long)

  Dim mask As Long
  Dim led As Byte

  For led = 0 To 3
    If (digValue And (2 ^ led)) > 0 Then
      ' channel off - extinguish
      lblDigitalInput(led).BackColor = &H8000000F
    Else
      ' channel on - light
      lblDigitalInput(led).BackColor = vbGreen
    End If
  Next

End Sub

Private Sub ClearForm()

  ShowAnalog (0)
  ShowDigital (&HFFFF)                          ' all off (active low)
  sbarMessage.SimpleText = ""

End Sub
```

STAMPS IN THE LAB

DoCommand starts by looking for a space character in the buffer. A space is used to separate the command from any parameters. Experienced programmers might suggest that we could have just grabbed the first five characters from the buffer since the Stamp Plot Lite commands have a fixed length. Yes, we could have, but then we'd have had to gone back and grab the parameters for each command that uses them. It seemed easier to look for the delimiter (space) and extract the parameter string at the beginning. If a command uses parameters, we already have them.

Now that we have our command (and sometimes a parameter string) we can process our compatible list with Select Case structure. When a command sends a single numeric parameter (like !AMUL), the parameter is converted with the CLng function. We have to keep in mind that Visual Basic Integers are signed, so Longs are used in our program to deal with PBASIC's unsigned Integers.

What VB doesn't offer, however, is a binary to decimal conversion function. This is no surprise, since binary numbers are rarely necessary in PC applications. We need this function though, since our Stamp programs designed for Stamp Plot Lite will probably send binary data.

If we go back to ProcessBuffer we see that if the first character of our buffer is "%", then the data is extracted and converted to a numeric value with the function Bin2Dec. For this program, we could probably get away without the conversion, but by doing it, we give ourselves the opportunity to process and manipulate the data before sending it to the display.

To see the VB program in action, we need to load our Stamp with the demo program that comes with Stamp Plot Lite (you'll find it in the Help file). Run the Stamp, then start the VB program. If you have a newer BSAC or used the circuit in Figure 1, the VB program can reset the Stamp when the comm port is opened. To do this, we need to leave the "Reset Stamp on Connection" option of the Port menu checked.

If the Stamp's ATN is opened after programming (by removing a jumper), then we'll have to manually reset the Stamp after the VB program is started and the comm port opened. Once this happens, we'll see the analog graph parameters set up (span is set from 0 to 600) and data will start coming in. Figure 5 shows the VB program in action.

This Is Cool — Let's Do More!

Okay, we will. Next month, we'll extend our Stamp program by allowing it to receive requests for information. This will allow us to "ask" for the information with a simple terminal program or a custom program that we'll write in VB, which will give us more precise control over when we get information and what we actually get. Finally, we'll update our Stamp program to receive data with a command. Again, this program will be compatible with a text terminal or a custom program and opens up all kinds of possibilities.

Until then, happy Stamping. **NV**

Resources:

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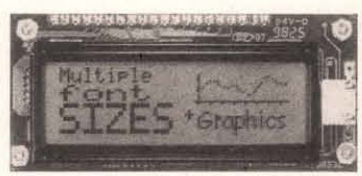

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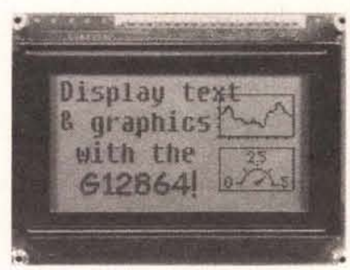

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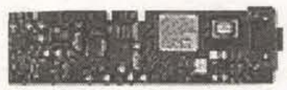

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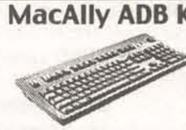

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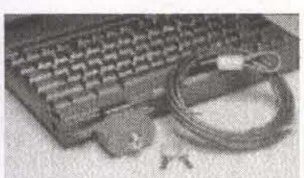

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QUESTIONS

I have a Presto dual-element, floor standing quartz heater about 18 years old. There's no model number on the unit. It has worked great all these years, but this past winter the bi-metallic on/off/temp control switch went defective and the unit is either off or on all the time, no temp control. The numbers on the switch are INF-120-887B, 34-191, 15A 120VAC. I think the INF is short for Infitec, so I E-Mailed them, but they replied that they don't make such a switch. Can you help with a source of this switch or a replacement, or even a timing circuit using a 555 timer and power relay?

7001 **Greg Weiler**
via Internet

I have several Icom M80 marine VHF radios with a failed microprocessor. Icom tells me this chip is no longer available. It's a Motorola MC146805G2. I'd like to have some info on finding a supplier for this chip or a substitute.

7002 **Earl Walton**
via Internet

I am in the computer field and many times after moving a monitor, it has purple splotches on the screen. The built-in degausser just doesn't do the trick. I spoke with an "old timer" in the TV business and he said you can make a degausser.

Does anyone know how to do this as it appears to be a coil of lamp cord and a switch.

7003 **Paul Stafford**
Flower Mound, TX

I have one of the old Atari calculators designed to be used without need of batteries. But under room light, it does not work very well. I would like to replace the cell with a battery (even if it has to be outside the case), but I'm not sure where to start. The model is the CC1200 folding calculator.

7004 **Michael Reese**
via Internet

Years ago, I had a tiny microphone that was perfect for recording phone interviews. It looked like one-half of a pair of an "ear bud" headset. The "bud" went into my ear and the jack went into the "mic" input of my tape recorder. This way, I could both record and listen when I put the phone to my ear.

I've lost the thing and can't find a replacement. Most stores have never heard of such a thing, and I would be greatly helped if readers could steer me to a source.

7005 **Bill Marsano**
via Internet

I recently bought a cable converter for my TV, but now I can not get closed caption on the set. The converter brand is called Storm made in Taiwan. Any Suggestions?

7006 **Anonymous**
via Internet

I have a video transmitter that's operating on a 12 VDC at 300 mA wall adaptor, and a CCD camera, working on a 9V battery. I would like to operate both devices from a portable and compact (12 VDC) battery pack (the smaller the better), for at least an hour.

Any suggestions and/or ideas on how to split the power supply for both devices, each having different power requirements?

7007 **Dan Gherge**
Saint John, IN

What I want to do is add an RS-485 network to the 68HC11. I am looking at SPI communication on the MCU and either a MAX483 or a SN75176A bus driver. What I need is a schematic of how to connect them and some sample software.

7008 **Ralph Irwin**
Yorba Linda, CA

I am trying to hook up some Motorola Speaker Mics (NMN6168A) to a (Yaesu) Vertex VX 500 Handheld. The Motorolas have five wires labled ptt, mic, gnd, com, and ext. The Vertex is a four-wire system. I can get the ptt to work and the speaker, but not the Electret cond mic in the Motorola mics.

7009 **Jerry Valentine**
Kirkland, WA

I have been advised that Motorola Part "MC145453FN" is becoming obsolete. It is an LCD driver.

We are currently looking for a suitable replacement part. Preferably something that is a pin for pin substitute. We have our product that uses this chip certified by CSA and CENELEC and would prefer not to change our circuit board package.

Can someone assist in locating a replacement?

70010 **Carl Mitchell**
via Internet

I am interested in putting strobe lights in my rear turn signals on my truck so that when I stop on the side of the road to aid someone, they will flash very brightly.

I would like to build a circuit that will flash a strobe alternately in a back and forth motion.

It is a '98 Nissan Frontier with yellow turn/hazard lights.

I would like to drill a hole in the housing and install the strobes as secondary flashers so that the turn and original lights still operate normally. I stop to help stranded motorists many times and would like better safety flashers like the courtesy vehicles have.

70011 **Paul Stafford**
Flower Mound, TX

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.
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- The question number and a short summary of the original question will be printed above the answer.
- Unanswered questions from a past issue may still be responded to.
- Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

QUESTION INFO

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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

INFORMATION/RESTRICTIONS

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

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- 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

ANSWER TO #50013 - MAY 2000

I need a schematic for a broadband UHF impedance matching circuit that will match the high impedance of a random long-wire antennna to the low impedance whip antennas used on small radios, using an alligator clip to connect to the short whip on portable radios.

Although you could make a broadband antenna amplifier that would help pull in some weak stations, that same amplfier will also introduce some distortion products that interfere or mask other stations.

Many subtle problems conspire against you. If you need a better performance, then use a receiver that can take an external antenna and connect it to a better antenna with a good transmission line. Good antennas need to worry about directivity and polarization; the random wire antenna is a haphazard affair.

The notion that random long wire antennas are high impedance and whip antennas are low impedance isn't quite right. The impedance of a long wire antenna can vary all over the map. When the wavelength is short (as in this case), the long wire antenna will resonate at many frequencies.The impedance might be high or it might be low. At UHF, the wire and other losses might be high enough that the long wire antenna looks like a lossy transmission line with a constant impedance of a few hundred ohms.

Whip antenna impedances also vary. If the whip is much shorter than a quarter wavelength, then the real part of the antenna impedance is small, but the reactive (imaginary) part can be large. If the whip is a quarter wavelength over a perfect ground plane, then it might look like 40 ohms.

The whip antenna impedance can vary a lot, and the issue is compounded by the receiver design. Attaching something to the antenna might increase distortion or it might detune the front end.

Consequently, we don't know the impedance of the long wire antenna or the impedance of the receiver. It's tough to make an impedance matching circuit when the impedances are unknown.

The linkage to the receiver is also an issue. Generally, you need two connections to complete a circuit. If the receiver is just a whip, then we don't have access to the receiver's ground. The alligator clip access to the antenna input then relies on the stray capacitance between the amplifier/matcher and the receiver. The results would be variable — like adjusting the rabbit ears on a TV receiver. Sometimes it works well, and other times it doesn't work at all.

Sadly, there is no free lunch. The goal here is to use an inferior antenna and some cheap electronics to make a superior broadband antenna system. If that were possible, then many antenna companies would be out of business.

Gerald Roylance
Mountain View, CA

ANSWER TO #60010 - JUNE 2000

I recently purchased a Sony color monitor, #CPD 9000, with an EIAJ-8 connector marked "RGB IN" What is it, and can I use it for video?

Information on the Sony CPD 9000 can be found at **http://www.ita.sel.sony.com/support/techspecs/support.cgi/cpd9000**. It is a 15.75 KHz fixed-frequency monitor.

Your question is "can I use it for video?" It depends on what you mean by video. If you are thinking NTSC composite video, like you get out of a camcorder, then no. This monitor does not have a composite video input. If you mean video as generated by a computer, then the answer is yes.

Unfortunately, this monitor is intended to connect to a CGA video source. CGA is extremely low resolution (640 x 200), and it hasn't been used for over 10 years. Also, CGA video is a TTL digital signal, meaning that it can only display 16 colors. I searched for a pin connection specification on the EIAJ-8 connector, but I didn't find anything.

Tim Godfrey
via Internet

ANSWER TO #6003 - JUNE 2000

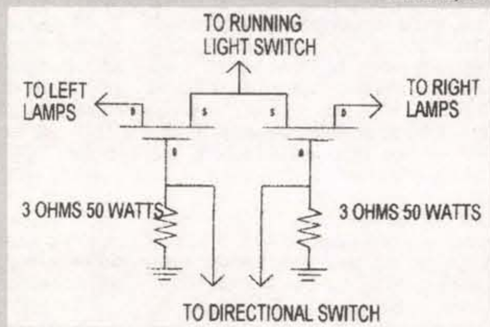
I need a simple, reliable circuit to change motorcycle front turn signals into turn/running lights (using existing switch and lamps).

The simplest way to get running lights on your motorcycle is to change the lamp socket from single contact to double contact. You can then wire the low brightness filament for running lights and the brighter filament to the directional wire.

If you want to use the single contact lamp, this circuit should work. The flasher is a bimetallic thermal switch which depends on the lamp load for timing. The three-ohm resistors simulate a two lamp load. Larger resistance values will give a slower flash rate. The flasher will be turning the lamps off instead of on as formally.

The parts are available from Digi-Key. PMOS transistors: IRF9Z24N-ND, three-ohm resistors: TMC503R0-ND.

Russell Kincaid
Milford, NH



ANSWER TO #6002 JUNE 2000

My ICOM IC-RIO receiver works okay on alkaline batteries. But, not at all with NiCads. The one-volt difference in battery voltage is very critical. Does anyone know of a cure for this problem?

You forgot to mention what battery size you are using in this device.

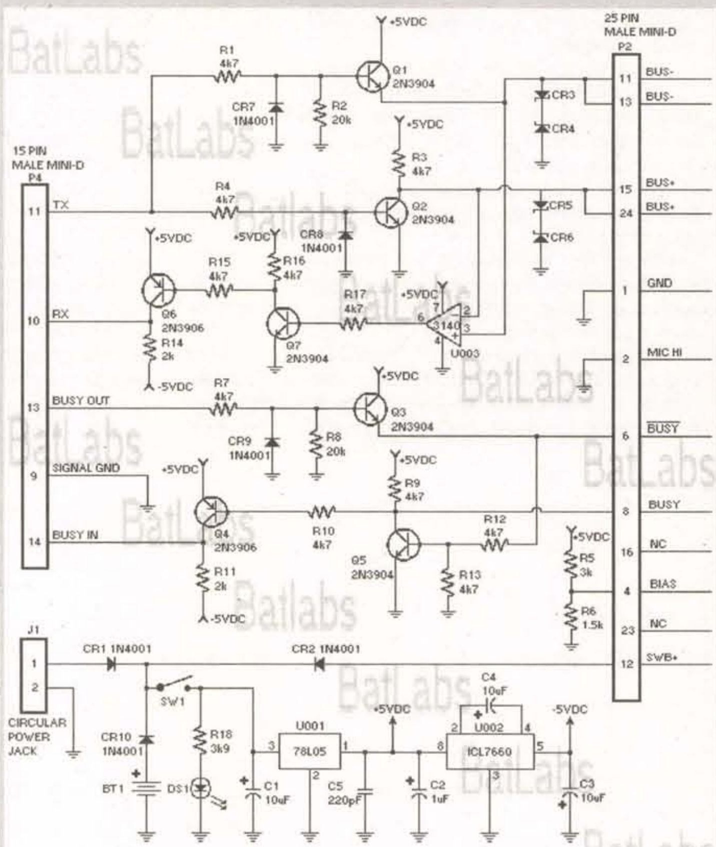
Continued on pages 38 & 86

ANSWER TO #5001 - MAY 2000

I am need a schematic for a Motorola GP300 radio interface box.

Assuming you want the RIB for programming the radio not making two radios into a repeater or some other type of control scheme. Try **http://www.batlabs.com** They have some neat information about Motorola Products.

Dave H.
Buffalo, NY



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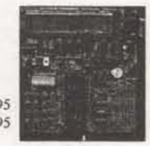

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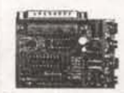

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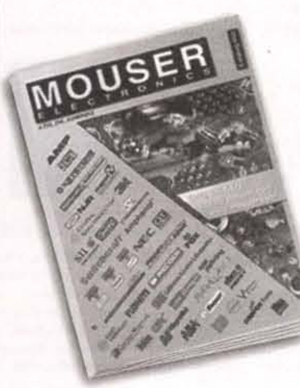

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ANSWERS TO #6006 - JUNE 2000

I would like to add an electric motor to give my race car a 15 to 20 HP boost.

A typical race is 20 laps with lap times of about 20 seconds per lap.

#1 Steven's idea about using an electric motor to boost the effective horsepower of his race car has some interesting implications, physics-wise.

It doesn't take much math to figure out that a 20-HP electric motor will need a power input of about 15.4KW (770 watts/HP 20). Actually more than that will be needed since electric motors aren't 100% efficient.

If he is planning on sucking that power out of a 12V battery, the motor will draw 1,283.3 amps. If the battery stores 750 amp-hours, the battery will last about 35 seconds! Of course, that's longer than the 20 seconds per lap, so it could provide a significant boost for one lap. He would have to choose which lap to use it on, and after that it would just be dead weight (along with the electric motor).

Mark Kimball
Lake Oswego, OR

#2 All HP has to be created from somewhere and, in your case, it will either come from batteries or from a generator running off your motor. If you attempt to draw HP from your existing motor, you will produce 15 HP at a loss of at least 33% in friction and other normal losses according to the laws of physics.

This means that you have to spend 20 HP from your motor in order to get back only 15 and, in your case, it will be 15 electric HP at a cost of 20 gas HP. This approach doesn't make sense.

If you choose batteries as your source, consider the weight factors and what you will need to produce 15 HP, for the 400 seconds that you are racing.

First, start with the electric motor. They weigh in at around 100 pounds, give or take a few pounds. Then for each HP that you need to drive that motor, it takes a conservative 746 watts, or 62 amps per HP at 12 volts and this doesn't account for any power loss in wiring or switching.

Translated into math, you need 11,000 watts to drive 15 HP or almost 15,000 watts to drive a 20 HP motor! 62 amps times 15 HP = approx. 1,000 amps and 20 HP = approx. 1,200 amps.

A deep-cycle battery rated at 400 amps, similar to the type used in diesel trucks and cars, conservatively weighs in at 50+ pounds and this translates into three batteries at 20 HP, or 2-½ batteries at 15 HP, and each weighs 50+ pounds.

At 20 HP, the weight of your vehicle has just jumped 250 extra pounds? Even if you could achieve all of the extra HP at ½ of these figures, it wouldn't be worth the trade off. If you check your existing power-to-weight ratio, you will find that this approach isn't a feasible way to increase your HP.

Your solution is to "Go Turbo." If you add a turbo charger to your motor, you can increase your existing HP by a factor of as much as 50% easily, and the added weight of the turbo will add less than 20 pounds to the overall design.

If you are producing 40 HP now, you can achieve the extra 20 HP easily without adding hundreds of pounds and, unlike storing the 15,000 watts in a battery that weighs 150 pounds, all of this extra HP will be stored in the form of a extra quart of gas or two. One-half gallon of gas only weighs about three or four pounds! Anyway, you do the math, battery-operated cars are very heavy.

Chris
Bieber, CA

ANSWER TO #6008 - JUNE 2000

The LED chaser/sequencer article in the April issue got me going on a sequencer project. I can't figure out how to cascade one 4017 to another for a larger continuous count.

Multiplexing is one way to increase the count, but I want to add a Darlington array to the output of each count to operate a relay. This works fine on a single 4017 with 10 counts. How do I get it up to 18 or 19 using two 4017s?

Here is a circuit that should do the trick.

You can only go as high as 17 with two 4017s, but you'll need three 4017s and a 4081 quad AND gate to reach 18 or 19 outputs. That same circuit can also take you all the way to 25.

The IC power connections aren't shown, so they should be connected to the appropriate voltages for your circuit.

When first powered up, the output of the 4017s may be random, so a power-on reset pulse should be applied to "Reset In." Once the counters are reset to zero, it works like this:

All the counters are at "0." Counter U1 is allowed to count because its clock enable (-CE) is held low by its connection to output Q9. U2 and U3 are not allowed to count due to the 4081 AND gates controlling the clock pulses from the previous stage.

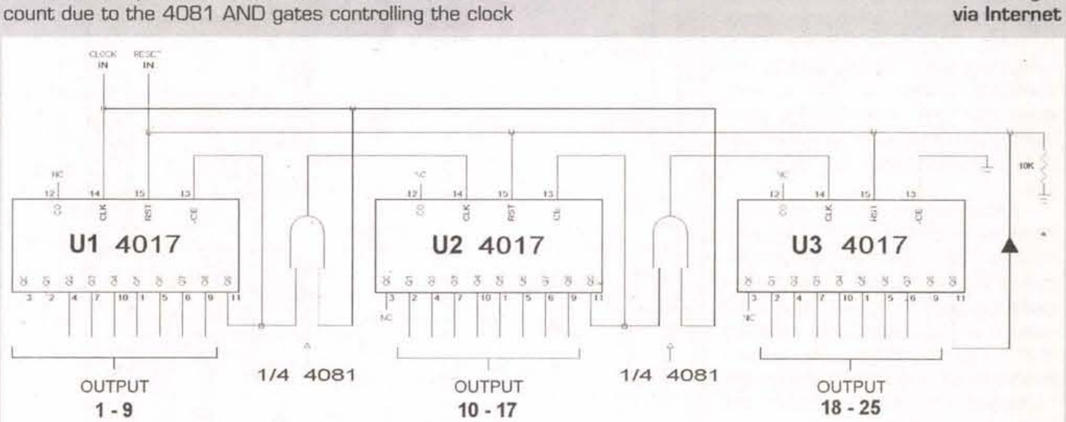
When pulses are applied to "Clock In," U1 steps through its outputs until its Q9 goes high, disabling U1. When U1 disables itself, it simultaneously enables the clock pulse to reach U2 through the 4081, basically doing a "handoff."

U2 is enabled to count by the connection between its Q9 and its own lock enable (-CE). U2 then steps through its outputs until its Q9 goes high, disabling U2.

When U2 disables itself, it enables the clock pulse to reach U3 through the 4081, once again handing off. U3 steps through until the output with the reset connection (the diode) goes high. In the schematic, it is wired to Q9 giving 25 steps total, but you can simply move it to another output to change how high it can count.

The diode is a general-purpose switching diode, 1N4148 or equivalent. If you need more outputs, just add more stages to the chain. You should be able to add as many stages as you like, provided the last stage resembles the U3 stage (with its -CE grounded) and all others in between resemble the U2 stage (with their -CE connected to its own Q9 output) with an AND gate between each stage.

Jeff Burger
via Internet



SEQUENCER SCHEMATIC

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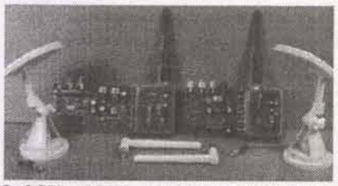

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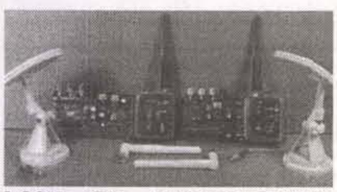

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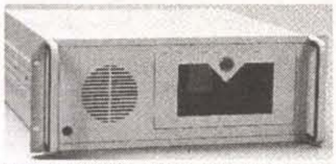

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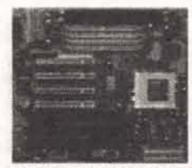

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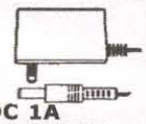
3.375" sq. x 2.75" deep. Mounts in 3" hole, 0.438: deep. Mounting holes: 2.75" spacing. Freq. response: 2KHz-20KHz. Sensitivity: 92dB (1W/1M) Max. power: RMS -75W. Impedance: 4-8 Ohms.
99V015 $4.95 each

TV IF MODULE
Zenith part 9-1320 has AGC and video pots and audio, AFC and osc coils.
99V012 $6.95

MINIATURE C-BAND LNB
Low-noise block converter. Better than 40°K noise temperature. Spec sheet included.
94G001 $29.95 each

14-Day Programmable Timer
Originally used to control a satellite receiver through its IR port. Time on/off for eight distinct events. Modify it for your needs or dismantle it for its parts. Programmable with a 2732 EPROM in a removable "personality" module, the unit may be modified to control any IR device through its IR port. Contains Z80 CPU, clock display and associated parts. Operates from 9VDC 500 mA wall transformer which is included.
92V014 $9.95 each

NIFTY LITTLE BOX
Two-piece, textured-finish, black plastic box, 3.25" x 4.625" x 1.5".
97U016 $2.95 each



9VDC 1A WALL WART
Input 120VAC, 60Hz, 16W. Class 2. Center negative coaxial connector.
98E004 $5.95 each

C-10 CASSETTE TAPES
92V024 20 for $4.95

MINI PIEZO SIREN
Dimensions: 43 x 39 x 58 mm. Voltage: 6-12VDC @ 150mA. Sound level @ 1m: 107dB. F(KHz): 1.5-3.5.
20U001 $7.95 each

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8-12V @ 1mA. 2.625"L x 1.5"W x 0.625"D. With spec sheet.
20L001 $14.95 each

BLUE LED
T1¾ blue water clear.
SE5064N $4.95

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99V020 $9.95

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Small (3.75"L x 1.5"W x 0.625"D), bright and long-lasting operation. No bulb to replace. White LED life is 100,000 hours. Weighs only 1.1 oz. Uses Energizer A23 battery. Made in USA.
99L004 $12.95 each

STEPPER MOTOR
400 step/rev. (0.9°/step). NEMA 17 size, 2.5 cm deep, ball bearing, 5mm dia. shaft front and rear. Front shaft has a sleeve pinned to it to make it 7mm dia. by 1.5cm long. Bipolar 70 Ohm coils. Menebea (Japan) P/N 16PY-Q203-01.
96M005 $4.95 each

GEAR MOTOR WITH MAGNETIC BRAKE
25RPM nom. Torque 11 inch pounds start, 13 inch pounds run. Shaded pole 115VAC induction @ 0.75A. Size 2.75" x 3" sq. with 5/16" x 13/16" shaft and 3/16" x 9/16" motor shaft. Compare at $35.00.
95M001 $26.00 each

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PC-6R $4.95 each

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Closeout Price!
99V006S $49.95

5V WALLWART
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99E006 $7.95

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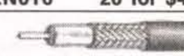

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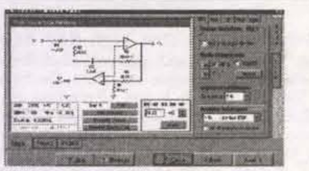

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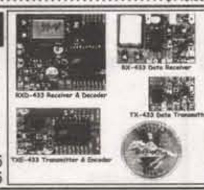
Doppler Direction Finder

Track down jammers and hidden transmitters with ease! This is the famous WA2EBY DF'er featured in April 99 QST. Shows direct bearing to transmitter on compass style LED display, easy to hook up to any FM receiver. The transmitter - the object of your DF'ing - need not be FM, it can be AM, FM or CW. Easily connects to receiver's speaker jack and antenna, unit runs on 12 VDC. We even include 4 handy home-brew "mag mount" antennas and cable for quick set up and operation! Whips can be cut and optimized for any frequency from 130-1000 MHz. Track down that jammer, win that fox hunt, zero in on that downed Cessna - this is an easy to build, reliable kit that compares most favorably to commercial units costing upwards of $1000.00! This is a neat kit!!

DDF-1, Doppler Direction Finder Kit $149.95

Wireless RF Data Link Modules



RF link boards are perfect for any wireless control application; alarms, data transmission, electronic monitoring...you name it. Very stable SAW resonator transmitter, crystal controlled receiver - no frequency drift! Range up to 600 feet, license free 433 MHz band. Encoder/decoder units have 12 bit Holtek HT-12 series chips allowing multiple units all individually addressable, see web site for full details. Super small size - that's a quarter in the picture! Run on 3-12 VDC. Fully wired and tested, ready to go and easy to use!

RX-433 Data Receiver........ $16.95 TX-433 Data Transmitter........ $14.95
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World's Smallest TV Transmitters

We call them the 'Cubes'.... Perfect video transmission from a transmitter you can hide under a quarter and only as thick as a stack of four pennies - that's a nickel in the picture! Transmits color or B&W with fantastic quality - almost like a direct wired connection to any TV tuned to cable channel 59. Crystal controlled for no frequency drift with performance that equals models that cost hundreds more! Basic 20 mW model transmits up to 300' while the high power 100 mW unit goes up to 1/4 mile. Their very light weight and size make them ideal for balloon and rocket launches, R/C models, robots - you name it! Units run on 9 volts and hook-up to most any CCD camera or standard video source. In fact, all of our cameras have been tested to mate perfectly with our Cubes and work great. Fully assembled - just hook-up power and you're on the air! One customer even put one on his dog!

C-2000, Basic Video Transmitter........ $89.95 C-2001, High Power Video Transmitter...$179.95

CCD Video Cameras

Top quality Japanese Class 'A' CCD array, over 440 line line resolution, not the off-spec arrays that are found on many other cameras. Don't be fooled by the cheap CMOS single chip cameras which have 1/2 the resolution, 1/4 the light sensitivity and draw over twice the current! The black & white models are also super IR (Infra-Red) sensitive. Add our invisible to the eye, IR-1 illuminator kit to see in the dark! Color camera has Auto gain, white balance, Back Light Compensation and DSP! Available with Wide-angle (80°) or super slim Pin-hole style lens. Run on 9 VDC, standard 1 volt p-p video. Use our transmitters for wireless transmission to TV set, or add our IB-1 Interface board kit for super easy direct wire hook-up to any Video monitor, VCR or TV with A/V input. Fully assembled, with pre-wired connector.

CCDWA-2, B&W CCD Camera, wide-angle lens $69.95
CCDPH-2, B&W CCD Camera, slim fit pin-hole lens.. $69.95
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IR-1, IR Illuminator Kit for B&W cameras $24.95
IB-1, Interface Board Kit $14.95

AM Radio Transmitter

Operates in standard AM broadcast band. Pro version, AM-25, is synthesized for stable, no-drift frequency and is setable for high power output where regulations allow, typical range of 1-2 miles. Entry-level AM-1 is tunable, runs FCC maximum 100 mW, range 1/4 mile. Both accept line-level inputs from tape decks, CD players or mike mixers, run on 12 volts DC. Pro AM-25 includes AC power adapter, matching case and bottom loaded wire antenna. Entry-level AM-1 has an available matching case and knob set that dresses up the unit. Great sound, easy to build - you can be on the air in an evening!

AM-25, Professional AM Transmitter Kit..... $129.95
AM-1, Entry level AM Radio Transmitter Kit... $29.95
CAM, Matching Case Set for AM-1.......... $14.95

Mini Radio Receivers

Imagine the fun of tuning into aircraft a hundred miles away, the local police/fire department, ham operators, or how about Radio Moscow or the BBC in London? Now imagine doing this on a little radio you built yourself - in just an evening! These popular little receivers are the nuts for catching all the action on the local ham, aircraft, standard FM broadcast radio, shortwave or WWV National Time Standard radio bands. Pick the receiver of your choice, each easy to build, sensitive receiver has plenty of crystal clear audio to drive any speaker or earphone. Easy one evening assembly, run on 9 volt battery, all have squelch except for shortwave and FM broadcast receiver which has subcarrier output for hook-up to our SCA adapter. The SCA-1 will tune in commercial-free music and other 'hidden' special services when connected to FM receiver. Add our snazzy matching case and knob set for that smart finished look!

AR-1, Airband 108-136 MHz Kit........ $29.95
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SCA-1 SCA Subcarrier Adapter kit for FM radio.... $27.95
FR-6, 6 Meter FM Ham Band Kit $34.95
FR-10, 10 Meter FM Ham Band Kit.......... $34.95
FR-146, 2 Meter FM Ham Band Kit.......... $34.95
FR-220, 220 MHz FM Ham Band Kit.......... $34.95
Matching Case Set (specify for which kit) $14.95

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PIC-1, PICPRO PIC Chip Programmer Kit $59.95

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RSG-1000B RF Signal Generator $1995.00

Super Pro FM Stereo Transmitter

Professional synthesized FM Stereo station in easy to use, handsome cabinet. Most radio stations require a whole equipment rack to hold all the features we've packed into the FM-100. Set freq with Up/Down buttons, big LED display. Input low pass filter gives great sound (no more squeals or swishing from cheap CD inputs!) Limiters for max 'punch' in audio - without over mod, LED meters to easily set audio levels, built-in mixer with mike, line level inputs. Churches, drive-ins, schools, colleges find the FM-100 the answer to their transmitting needs, you will too. Great features, great price! Kit includes cabinet, whip antenna, 120 VAC supply. *We also offer a high power export version of the FM-100 fully assembled with one watt of RF power, for miles of program coverage. The export version can only be shipped if accompanied by a signed statement that the unit will be exported.*

FM-100, Pro FM Stereo Transmitter Kit $249.95
FM-100WT, Fully Wired High Power FM-100........ $399.95

FM Stereo Radio Transmitters

No drift, microprocessor synthesized! Great audio quality, connect to CD player, tape deck or mike mixer and you're on-the-air. Strapable for high or low power! Runs on 12 VDC or 120 VAC. Kit includes snazzy case, whip antenna, 120 VAC power adapter - easy one evening assembly.

FM-25, Synthesized Stereo Transmitter Kit $129.95

Lower cost alternative to our high performance transmitters. Great value, easily tunable, fun to build. Manual goes into great detail about antennas, range and FCC rules. Handy for sending music thru house and yard, ideal for school projects too - you'll be amazed at the exceptional audio quality! Runs on 9V battery or 5 to 15 VDC. Add matching case and whip antenna set for nice 'pro' look.

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RF Power Booster

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LPA-1, Power Booster Amplifier Kit........ $39.95
CLPA, Matching Case Set for LPA-1 Kit........ $14.95
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For maximum performance, a good antenna is needed. Choose our very popular dipole kit or the Comet, a factory made 5/8 wave colinear model with 3.4 dB gain. Both work great with any FM receiver or transmitter.

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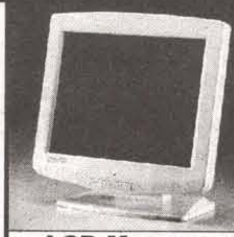

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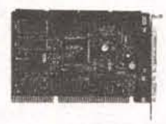

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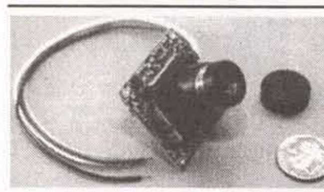

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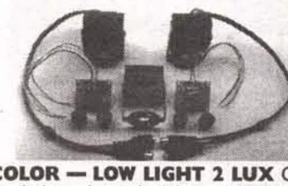

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Continued on page 56

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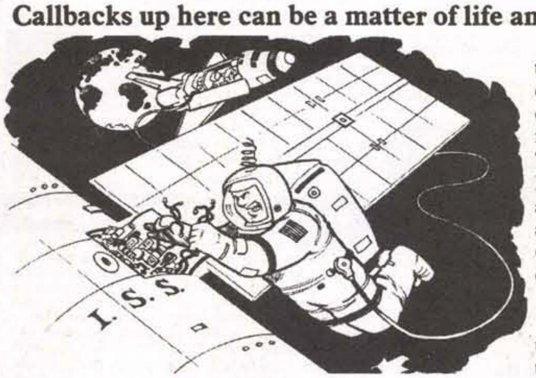

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HAM OPERATORS ENJOYING THE NEW LICENSE STRUCTURE

by Gordon West

As of April 15, 2000, getting into ham radio and upgrading to the highest level of ham license just got infinitely easier.

It is estimated that there have been over 10,000 Technician class operators who upgraded to General class and are now enjoying worldwide band privileges. It is also estimated that there may be as many as 10,000 General class and Advanced class amateurs who have now upgraded to the top license — Extra class — just by completing one more written exam.

As of April 15, 2000, there is now testing for just Technician class with or without code, General class requiring 5 wpm code, and Extra class with no additional code test. The entry-level Technician class examination is just 35 multiple-choice questions, General with 35 more questions to pass, and Extra class with just 50 questions to pass.

But probably the best news to most aspiring radio enthusiasts thinking of becoming a licensed amateur operator is the fact that there is only one simple 5 wpm code test to pass, as opposed to earlier requirements for passing a 13 wpm code test for General, and a 20 wpm code test for Extra. Now there is just a single 5 wpm code test for Technician with the code, General class, and Extra class.

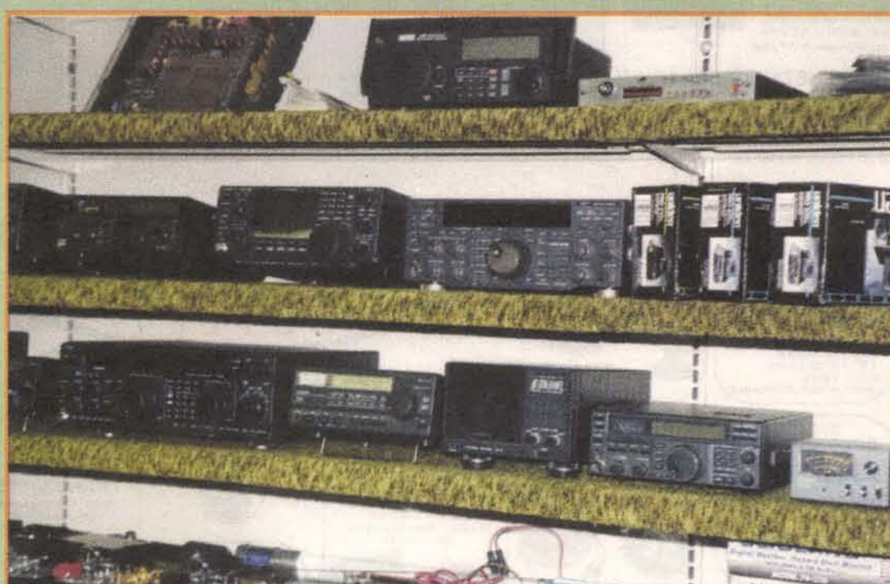
In fact, the Element 1 5-wpm Morse Code examination IS NOT REQUIRED for the entry-level Technician class test for all VHF and UHF band privileges. The 5 wpm code test is only required for those operators wishing to work the frequencies from 30 MHz on down for worldwide communications.

And more good news for those of you who may have held an amateur license many years ago, but let it expire — an expired original Technician class license that you may have held before March 21, 1997, receives full 5 wpm Morse Code credit. That means that old Technician class license that you may have held in the 60s, 70s, or 80s gets you out of taking the 5 wpm code test over again! Also, that old expired Tech license issued prior to March 21, 1997, gives you additional General class written credit, and all you need to do to get back into amateur radio is take the relatively simple Element 2 35-question Technician class exam.

If you once held an old Novice class license, back in the 50s, 60s, 70s, 80s, or 90s, you continue to get credit for the Element 1 Morse Code exam. If you have an old expired Technician class license after February 14, 1991, you also get 5 wpm code credit.

And if you have a current Technician class license, and it was issued on or before March 21, 1987, you will soon be a General class operator without ANY tests just as soon as you can get copies of your old license or verification from the FCC that you once held a Tech license prior to March of 1987, and take this information down to an upcoming amateur radio volunteer examination session. You will be given your General class CSCE right on the spot, and you can begin operating as soon as you leave the test room. But keep in mind that this is only

Kids having fun in Gordo's ham class.



Ham equipment for worldwide General bands costs as little as $649.00 new!

Hams stand ready for emergency communications.

HAPPY HAMS

available to presently licensed Technician class operators who can prove that they held a Tech license prior to March of 1987.

It's now far easier than ever before for newcomers to get into our hobby — especially kids. The entry-level, no-code Technician class license test is no longer 65 questions (Novice and Technician) taken from a huge question pool of almost 700 questions. It's now less than half as long and twice as easy to pass — 35 questions from a new question pool of only 384 total questions — and most of the questions are asked twice but in slightly different wording.

It's now possible to encourage kids to enter the amateur radio hobby by showing them what amateur radio and computers can do for them. Where else can a newcomer with a brand new Technician class license stand outside with a dual-band handheld and talk for a few minutes through an orbiting satellite using frequency modulation? The Space Station will also be an easy "hit" for kids to stay tuned into science projects aloft. Imagine their excitement talking to an astronaut.

The new rules may have caught old-time hams who feel Morse Code is extremely important off guard — they thought the code would be watered down and become less important to beginners. To the contrary, never before in the history of amateur radio is the 5 wpm code test as important to earning worldwide ham privileges than under the new April 15 rules. Now *everyone* licensed or not is learning the code, and many who pass the 5 wpm code test are continuing to sharpen their skills by operating CW with some of the oldtimers who are encouraging them to up their speed. So, oldtimers *for* the code, get busy with your enthusiasm and start teaching code classes, rather than sitting back and worrying about whether or not code is ultimately going away.

Soon more amateur satellites will be opening up the UHF and SHF bands with "armchair copy" relay capabilities. Frequencies as high as 10,000 MHz will be aboard Phase 3D, and this is expected to draw more new hams into the microwave region. The international Space Station will also take advantage of those higher microwave bands, and the more hams who start using equipment on these bands, the less likelihood there will be of bands being "taken away" due to inactivity. We need to use the bands, or more than likely we will *lose* the bands above 1270 MHz.

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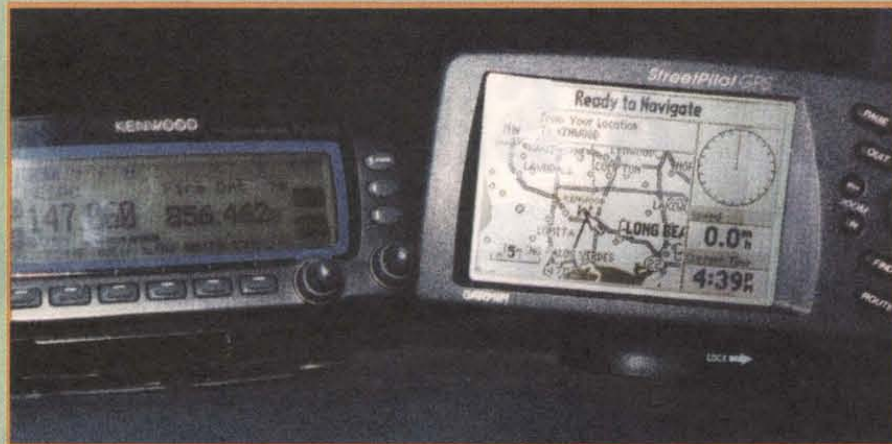

Ham GPS locators are now 10 times more accurate.

The small worldwide ham set will be of interest to all General class operators.

The much shorter path to Technician class licensing without any code test at all makes ham radio instruction a great deal easier for a once-a-week, three-hour, evening course for nine weeks. This works well into community colleges, high schools, and elementary schools. Famed grade school instructor, Ms. Carol Perry W2MGP, proves that amateur radio is a powerful teaching tool in the classroom by offering her students everything from geology, anthropology, and social studies while tuning in her radio equipment in Staten Island. Ham radio clubs could easily find their own instructional niche by offering an early evening ham class for kids and adults.

But there is one problem with the overall ham radio recruitment picture — and that is the first contact and the first impression. If you were to walk into a ham radio club meeting as a visitor, you have a 50 percent chance of being embraced or totally ignored. Unless clubs are setting up their own "greeter," the likelihood of getting somewhat ignored is half a chance.

"I walked into the ham store, and told them I was an absolute beginner in radio, and they just about treated me like a leper," comments a prospective ham who holds an EE degree and was an instructor at the local city college.

"And while I was in the ham store, the two guys behind the counter were bellyaching about how the ham service is going to XXXX in a handbasket because the code and theory requirements were being watered down," adds our professor. "And when I asked them where a local ham class was being offered, the response was to go over to the bulletin board, and look for myself," as if they thought I couldn't read or understand the English language.

And this is not the first time that would-be hams have made contact with me, voicing their frustration that trying to break into our hobby with a friendly soul to coach them was next to impossible.

Unfortunately, I must agree. During a recent industry meeting in conjunction with Amateur Electronics Supply, Milwaukee, Superfest, most were in agreement that we all (as an industry) needed to do a much better job in helping sell our hobby.

My solution was to develop "ham ambassadors" which would be motivated ham "greeters" who would receive "selling territories" and be able to accrue "bonuses" from equipment manufacturers through participating dealers for all of the newcomers they attract to our hobby. The ham ambassadors would develop a pyramid of "agents" that they could turn over prospective new hams to begin classroom study, home study, or at least a warm invitation to a local club meeting. Manufacturers of amateur equipment all agreed they would get behind this program if someone can indeed break through the invisible barrier of what it takes to score the ham ticket.

ICOM America pledged radio equipment to any group making the biggest impact in showing off amateur radio at the popular movie "Frequency." The American Radio Relay League (ARRL) was solidly behind the idea and would help spread the word throughout their membership. The ARRL is amateur radio's only non-profit membership service who regularly lobbies Washington to help protect our amateur bands. (American Radio Relay League, 225 Main Street, Newington, CT 06111; 860-594-0200; Jim Haynie W5JBP, President; David Sumner K1ZZ, Executive Vice-President.)

While I doubt we will see any major change in amateur dealer counter personnel jumping over the display cases to greet "newbies," I do think that ham ambassadors and clubs with a ham ambassador program *can* make a difference when many of you reading *Nuts & Volts* go out and try to find a friend to help you enter our amateur radio hobby and service. Try the ARRL phone number, too — you may be pleasantly surprised that there is a local ham club just down the street.

And what will ham radio do for you as a hobby and a service to your community? Plenty!

Just ask any outgoing "ham ambassador" ham for details. Join us soon — I'll look forward to working you over the airwaves. **NV**

A Simple Tunable Low Pass Active Filter

A fifth order Butterworth filter in an eight-pin chip.

by James Lyman

In experimenting with electronic systems, we often need filters to condition signals we are using. Usually a low pass filter is required to eliminate higher frequency noise, so an active low pass filter is needed having a cutoff frequency the same as the frequency we are trying to work with.

Commercially-tunable filters are an expensive piece of laboratory equipment which most home electronic experimentalists cannot afford — even from the used equipment market.

Consequently, the experimenter needs to design and build a custom low pass active filter for each task. This means a filter is not used unless it's absolutely necessary. But now, a single eight-pin chip gives the experimenter a very effective tunable low pass filter to use over and over.

This chip is Linear Technology's LTC1063 which is a DC Accurate, Clock-Tunable Fifth Order Butterworth Low Pass Filter.

Using a simple input and output buffer, this chip forms the complete filter circuit, including the tuning circuit for cutoff frequency.

As used in this circuit, the tunable filter has a range of 7 to 8,500 Hz which is continuously variable over three switch selected ranges. It accurately passes the DC component of a signal and has wide band noise in the micro volt levels. The distortion plus noise is rated at -80 dB and, being a fifth order filter, its frequency rejection curve is very steep so, if set for a cutoff frequency of say 25 Hz, a 60 Hz signal would be

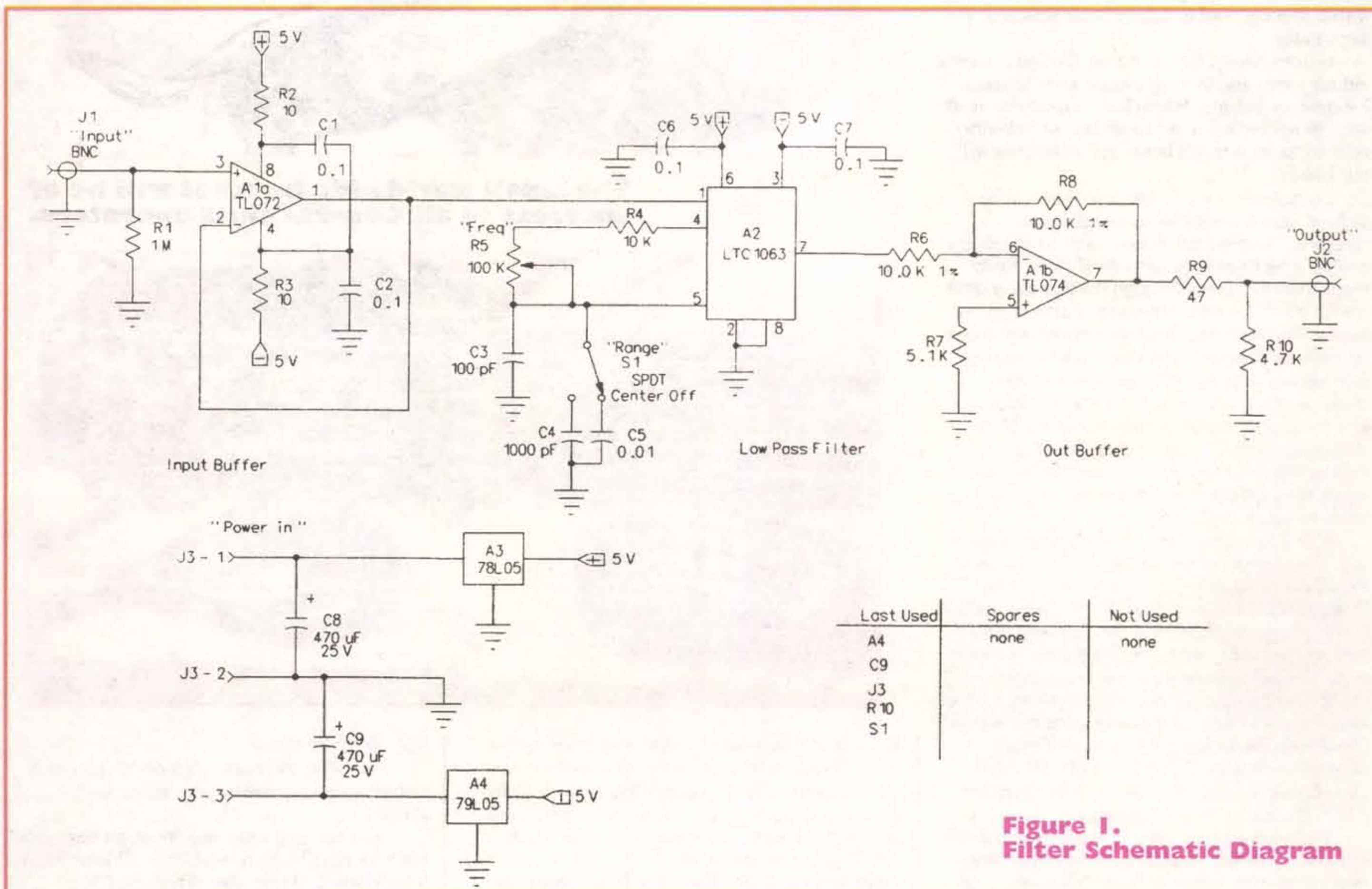

Figure 1.
Filter Schematic Diagram

attenuated 40 dB.

The LTC1063 Chip

Linear Technology's LTC1063 is a wonder in a small package. It is a clock tunable filter whose simplicity defies words for allowing the experimenter to easily and quickly design, then build a low pass filter. This monolithic filter is a fifth order filter using switch capacitance technology which, in a very rough and crude way, means it's equivalent to five filters in series. That's what gives this filter such sharp rejection of out of band frequencies.

Being a switch capacitance filter, the designer needs only to provide a digital clock signal which is 100 times the desired cutoff frequency, and this clock signal may be provided externally from another circuit or internally with the RC oscillator built into the chip.

Other than two decoupling capacitors on its power supply, there are no other components required — how can it get any simpler? If the internal oscillator is used, then a resistor and capacitor are selected which gives a clock frequency defined by the product of the resistor and capacitor values. The clock frequency is 100 times the filter's desired cutoff frequency which equals 1/R*C, where R is in ohms and C is in farads. The resistor goes between pins 4 and 5, while the capacitor goes from pin 5 to ground.

So, if you want a low pass filter with a cutoff frequency of, say 120 Hz, then a digital clock of 12 KHz (120 x 100) into pin 5 will give that cutoff frequency without any other components or adjustments. To use the internal oscillator, the frequency of the clock is set by a resistor-capacitor combination equaling approximately 1/RC, so start by selecting either a resistor or capacitor value.

The resistor value should be greater than 10 Kohms and the capacitor greater than 100 pF. Calculate the other component's value with Fclock = 1/RC. So, for a resistor of, say 100 Kohms, the required capacitor value should be:

$$C = 1/(R * Fclock)$$
$$C = 1/(100{,}000 * 12000)$$
$$C = 833.3E\text{-}12$$

Use the nearest standard capacitor value of 820 pF for a calculated cutoff frequency of 122 Hz. If a capacitor is selected, then find the resistor by:

$$R = 1/(C * Fclock)$$

Connect the resistor, capacitor, and a split power supply with 0.1 uF decoupling capacitors and the filter is ready to go. The power requirements are between ±2.375 and ±8 volts, but the clock signal is unipolar so, when ±5 volts is used, a standard TTL signal can be used to drive the filter.

The data sheet isn't very clear about input signals greater than the filter's power supply voltages but, if it's just a little over, the chip will instantly be destroyed. The LTC1063 is available from Digi-Key (part number LTC1063CN8-ND) and costs only $10.00 in single quantities. It is usable over a 50 KHz bandwidth and is cascadable for sharper frequency rejection. For a two-volt RMS signal, it has 0.01% THD making it ideal for use with audio circuits.

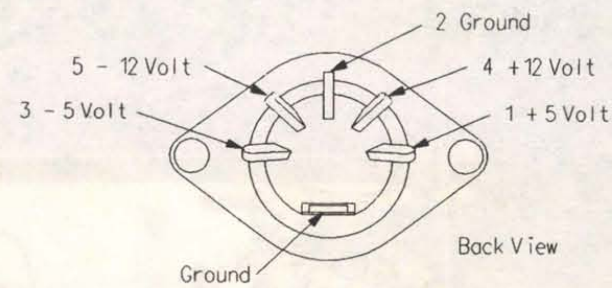

Figure 2. Power Connector Pin Outs

Figure 3. Instrument Setup

The Filter

To use the TLC1063 as a tunable filter, I used its internal oscillator and added a variable resistor with sufficient value to cover one decade of frequency. To further expand the filter's tuning range, I added switch selectable capacitors for overlapping decades of frequency. With three capacitors, the filter is tunable from 7 to 110 Hz, 90 to 1,200 Hz, and 1,000 to 8,500 Hz. Since capacitors often have a wide tolerance, it's best to select capacitors with a capacitor meter or by tack soldering the capacitor in circuit and testing the sweep range.

If you select the "capacitors in circuit" method, start with the lowest value (highest frequency range) and work up in capacitors making sure the next capacitor overlaps the previous one.

You can add additional capacitors — and hence ranges — using a multi-pole rotary switch. Increasing the range entails using smaller values of capacitance, making the circuit more susceptible to influences of parasitic capacitance — a real prob-

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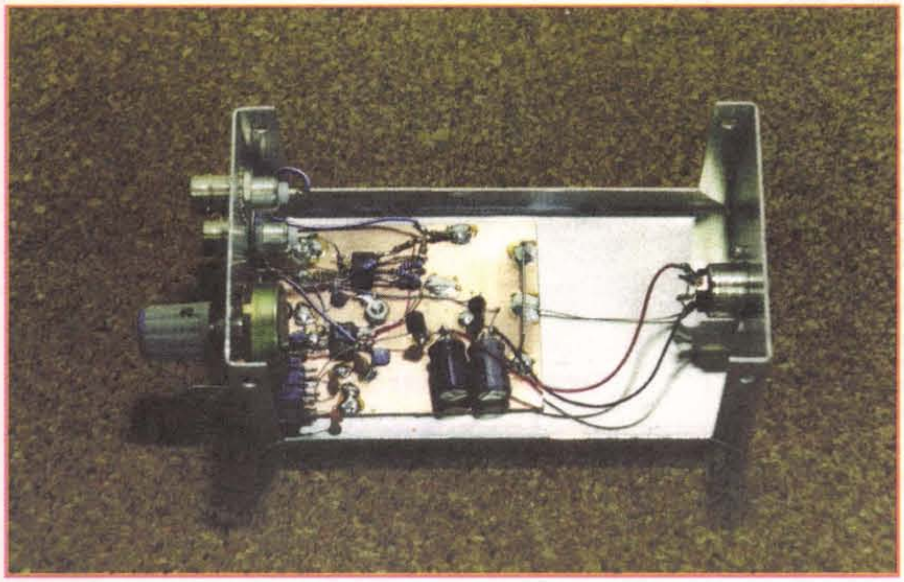

Figure 4. Instrument Interior

lem when a switch is part of the circuit. The data sheet is vague about the minimum resistor value from pins 4 to 5, so you may lose a chip or two in trying to push the frequency too high.

Circuit Description

Both the input and output of the filter is buffered by opamps. The input buffer A1a is a source follower opamp configuration with a very high input impedance and a unity voltage gain.

Resistor R1 (refer to Figure 1, Filter Schematic Diagram) with a value of one megohm serves two functions. This first is to set the filter's input impedance to a standard and constant value. The second is to connect the opamp's input to ground, so if a signal is coupled in by a capacitor, no DC voltage will build up until the amplifier is driven into cutoff.

Resistors R2-R3 and capacitors C1-C2 form a filter network for amplifier A1's power supply. Each resistor-capacitor forms a low pass RC filter for each voltage rail, with C1 between the positive and negative rails for rejection of differential mode noise, and C2 for common mode noise.

This decouple network is commonly used for opamp applications and is recommended over using just capacitors to ground to give superior protection against noise on the power supply.

Tunable Low Pass Active Filter

Ref. Desg.	Qty.	Nomenclature	Part No.
A1	1	TL072 Dual Bi-FET opamp, eight pin DIP	Note 1
A2	1	LTC1063 Clock-Tunable Fifth Order Butterworth LP Filter	Note 2
A3	1	78L05 +5V, 100 mA, three terminal voltage regulator, TO92	Note 3
A4	1	79L05 -5V, 100 mA, three terminal voltage regulator, TO9	Note 4
C1,2,6,7	4	0.1 uF Monolithic Bypass Capacitor, 25V	
C3	1	100 pF Ceramic Disk Capacitor, 25V	
C4	1	1,000 pF Ceramic Disk Capacitor, 25V	
C5	1	0.01 uF Monolithic Capacitor, 25V	
C8,9	2	470 uF Electrolytic Capacitor, 25V	
J1,2	2	BNC Panel Mount Bulkhead Recept, Solderable	Note 5
J3	1	Five-position DIN Receptacle, panel mount	Note 6
R1	1	1 Mohm Resistor, 5%, 1/4 Watt	
R2,3	2	10 ohm Resistor, 5%, 1/4 Watt	
R4	1	10 Kohm Resistor, 5%, 1/4 Watt	
R5	1	100 Kohm Potentiometer, Linear, Panel Mount	Note 7
R6,8	2	10 Kohm Resistor, 1%, 1/4 Watt	
R7	1	5.1 Kohm Resistor, 5%, 1/4 Watt	
R9	1	47 ohm Resistor, 5%, 1/4 Watt	
R10	1	4.7 Kohm Resistor, 5%, 1/4 Watt	
S1	1	SPDT Miniature Toggle Switch, Panel Mount	Note 8

Note 1 - Jameco part number 33195
Note 2 - Digi-Key part number LTC1063CN8-ND
Note 3 - Digi-Key part number NJM78LO5A-ND
Note 4 - Digi-Key part number NJM79LO5A-ND
Note 5 - Digi-Key part number ARFX1064-ND
Note 6 - Digi-Key part number 275-1014-ND
Note 7 - RadioShack part number 271-092
Note 8 - RadioShack part number 275-620

PARTS LIST

The output of input buffer A1a goes directly into the filter's input at pin 1. The filter A2 is very sensitive to input over voltages and is easily damaged if it exceeds the power supply's voltage rails. The input buffer serves as protection for over voltage input to the filter since the opamp is very tolerant to over voltage, but its output cannot exceed the power supply rails.

A2 forms the complete fifth order low pass filter whose cutoff frequency is determined solely by a digital squarewave whose frequency is 100 times the filter's cutoff frequency. The internal clock is used in this design so a resistor and capacitor are used between pin 4 (Clock Output) and pin 5 (Clock Input).

To make the filter tunable, a variable resistor R5 is used in series with a fixed resistor R4 that provides the minimum resistance value of 10 Kohms. This resistor combination is between pins 4 and 5 of A2 and the capacitors C3-5 complete the RC timing circuit. To give a wider range of operation, different values of capacitance are switched in by a toggle switch.

The capacitor for the highest range C3 (1 to 10 KHz) is permanently in the circuit with the other two frequency range capacitors C4 and C5 switched in by the SPDT center off switch S1. For the lowest frequency range (10-100 Hz), C5 is switched into the circuit parallel with C3, for the mid range (100 Hz to 1 KHz) C4 is switched in, and for the highest range S1 is in its center off position, so only C3 is in the timing circuit. Varying resistor R5 allows the cutoff frequency to be continuously varied across the range set by the capacitors.

The filter's input is pin 1 of A2 and its output is pin 7. This filter is a true low pass so it will accurately pass the DC component. The filter uses a split rail power supply of five volts and has decoupling capacitors C6 and C7 to ground as recommended by the manufacturer's data sheets.

To isolate the output of filter chip A2, a unity gain buffer amplifier is provided using the second half of opamp A1. The buffer amplifier is an inverting amplifier because — in my application — the filter's output is approaching -180 degrees in phase shift and I wanted to correct this. According to the manufacturer's data sheet, the filter has a constant phase shift of about -20 degrees in the pass band but decreases rapidly as the frequency approaches the cutoff. This is the region I intended to use my filter in, but for applications using the whole pass band a non-inverting buffer may be used. This would be a source follower configuration the same as the input buffer with its input to pin 5 of A1b and pin 6 connected to output pin 7.

So the output of an opamp buffer can drive coax cables, a DC decoupling network is used on the output of the buffer amplifier. Resistors R9 and R10 provide a DC path for opamp A1b's output other than through a coax cable and some unknown load which may be highly reactive, such as a capacitor. Such loads can make an opamp to be unstable creating numerous problems in the opamp's performance, which changes as the load is changed.

Resistors R9 and R10 provide a voltage divider ratio of 0.99 which decreases the output and gives a one percent error but provides the essential DC path to ground. This error is usually sufficiently small to ignore, but for applications requiring higher accuracy, the gain of the buffer amplifier can be adjusted by using a 200 ohm trimmer resistor in series with feedback resistor R8, but remember, a one percent error is usually less than the accuracy of your instruments.

The power supply for the circuit is regulated using two small three-terminal regulators at each rail to give ±5 volts. Since the current requirements for the complete filter circuit are so small, the 100 mA TO-92 style regulators are used with each input having a 470 uF input capacitor to filter out any unwanted noise.

In doing research, I often need small special instruments or circuit modules to try out concepts or make test measurements. This involves building up simple circuits such as amplifiers or filters to use with conventional instruments — circuits that are general enough to be used again. But providing power for such circuits becomes unwieldy if lab supplies are used and expensive if power supplies are included. My solution is an unregulated power supply having four output voltages: two positive and two negative. (Refer to "Modular Instrument System," June 2000 issue of *Nuts & Volts*.)

To connect this power supply to an instrument module, I use five pin DIN audio connectors with standardized pinouts so any instrument module can be quickly connected to power (Figure 2, Power Connector Pin Outs). Therefore, an instrument module only requires filter capacitors and voltage regulators for its power supply. After regulation, ±12 volts and ±5 volts are available. This power supply has multiple outputs, so several modular instruments can be used at once (Figure 3, Instrument Setup). Using short BNC cables, I can do a "lash up" of instrument modules to do an experiment.

Since only ±5 volts is required for this instrument, only two regulators are installed: A3 for the +5 volts and A4 for the -5 volts.

Building the Filter

As seen by the schematic (Figure 1), this circuit is simple and requires only a few connections. Working at low frequencies, the component layout is not critical, but lowest noise is achieved with a good ground plane. This circuit can be built on a blank copper circuit board or on a perf board prototyping board such as RadioShack's "General-Purpose IC PC Board" part number 275-150.

I chose the blank copper circuit board for my filter to gain the best noise performance (Figure 4, Instrument Interior). The manufacturer's data sheet recommends a good ground to achieve the lowest feed through noise level from the filter's clock. Although this method of construction is not very ecstatic, many electronic hobbyists don't realize how electrically sound this construction method is. If you want really quiet circuits, then use lots of ground plane.

Like most of my modular instruments, I use aluminum enclosures such as RadioShack's "Aluminum Project Enclosure" part number 270-238 and install the circuit board upside down on the inside of the box's top. Controls and connections go on the ends of the box with the power connector on the back end (Figure 5, Instrument Face).

No parts should be mounted on the bottom section (the part that forms the sides and goes "into" the top), thus avoiding connections which must be disconnected every time the instrument is taken apart. When a copper circuit board is used, it can be mounted with a single 4-40 screw and nut. Position the circuit board where you want to mount it, select a empty spot near the center of the board, then drill a 1/8 inch hole through both the box top and circuit board.

The controls and connectors — such as the input and output BNC connections — can be labeled with a home label machine. I use the silver colored tape with the outlined text mode which blends in well with the box's natural aluminum color. Since the bottom has no electrical connections, you can test the instrument with it removed, make any adjustments, then install the bottom using the four screws. Make sure the points of these screws do not contact any electrical part of the instrument as they make a great short to ground.

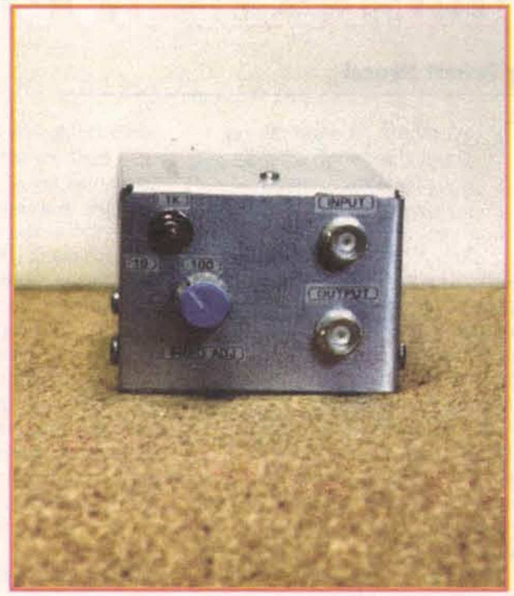

Figure 5. Instrument Face

Using the Filter

Other than setting the filter's cutoff frequency, there is little to using this instrument. The easiest way to set the frequency is to connect a function generator — set at the desired cutoff frequency — to the filter's input while monitoring its output with an oscilloscope or AC voltmeter.

There is no power switch on the instrument module, instead the power supply itself is turned on. Adjust the frequency range via switch S1 and the frequency via variable resistor R5 until the signal is at maximum voltage, then adjust R5 until the signal is one-half its original level. The filter's cutoff frequency is now set and the filter is ready to use.

Disconnect the filter's input and output and connect the filter into your test setup. This may be done with the instrument's power still on.

The input impedance of the filter is one megohm so there should be no loading of the signal source, but the output is NOT a 50 ohm source even though there is a 47 ohm resistor in series. The opamp for the buffer cannot drive such a low impedance so the output load should be at least one Kohm and preferably more.

Although the input buffer amplifier will clip waveforms greater than ±4 volts, it is advisable not to try and use this instrument with inputs that exceed this limit. An external resistive voltage divider should be used to reduce the input below the over voltage condition.

Excessive voltage for a long period may damage the input buffer amplifier so it's always advisable to check the input level before applying it to the filter. Better safe than sorry.

Your tunable filter is now ready for your next test setup. I have found mine to be a great addition to my lab and I'm sure you will find the same. Additionally, you will find the LTC1063 useful in your circuit designs. **NV**

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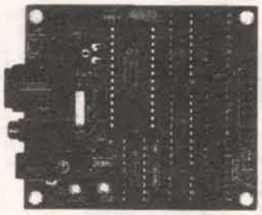

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AMATEUR ROBOTICS NOTEBOOK

by Robert Nansel

Last month, I began talking about the design considerations for a robot able to compete, with modifications, in either Robot Sumo or Robot Fire Fighting contests. I want a four-wheel-drive design, but there are a bunch of unknowns (to me anyway) in this, so I decided to build a test-bed robot using cheaper parts to try out some of my ideas.

The resulting robot is called Jiffy, and I'll show you how to build Jiffy's chassis and drive system this month. Next month, I'll show you how to do the electronics.

Before I get into Jiffy, though, I must make an apology. I was supposed to name a winner of the Second Lonely Gearhead contest last month, and I just flat forgot, so now I'll correct that oversight: the winner is Bryan DeWeese of Boise, ID. Congratulations Bryan, you'll have a copy of Karl Lunt's *Build Your Own Robot!* by the time this issue is out.

Okay. Onward.

As a first guiding principle, Jiffy was designed to be built with a minimum of tools and using only parts readily available at RadioShack, hobby shops, and grocery stores. Indeed, it's designed to be built on a shaded picnic table in the company of like-minded friends while sipping beer, so no power tools whatsoever are allowed — after all, there might not be AC power available at the picnic table, and who would enjoy trying to talk with friends over the whine of a Dremel tool? Jiffy is a summer vacation robot, if you will, and everything needed to build it — parts, tools, and beer — must fit comfortably in a knapsack.

I built my first version using mostly just the tools available in a Leatherman Wave tool — the saw, knife, file, and pliers. The only other tools I used were an extra screw driver, a hand reamer, and a hand-cranked drill, though I proved to my own satisfaction that I could have dispensed with these and done all of the work with the Leatherman alone. Using a Leatherman isn't the easiest way to do things, but it forced me to keep the design simple.


PHOTO 1

All-Terrain Drive

The second guiding principle was to build a four-wheel-drive robot that has a simple steering and suspension able to negotiate uneven terrain — say, the area around a campfire.

The simplest four-wheel-drive system uses no suspension (as such) at all; the wheels are driven by motors rigidly mounted to the chassis; squishy tires handle the bumps and dips. Bobcat earthmovers are built this way, and they steer by what the Bobcat Company calls the "skid-steer" method. Check out their main website (www.bobcat.com) for pictures and descriptions.

As applied to Bobcats, skid-steer is more than just another name for tank-style steering. Bobcats are built so most of the weight is on the rear wheels when the loader scoop is empty, and on the front wheels when the scoop is full.

If you watch a Bobcat loader in action, you'll see that the front wheels skid during turns when the scoop is empty, but the rear wheels skid during turns when the scoop is full. If the weight were distributed so all the wheels shared the load equally then, theoretically, all four wheels would skid and the Bobcat would pivot about its center.

Skid-steer works only when the front and rear wheels are reasonably close together. For good maneuverability, the shorter the wheelbase the better; but for stability, longer is better. The limit for how close you can place front and rear wheels is when the wheels nearly touch. Some Bobcats are built this way, and if you watch one working, you'll notice it rocks back and forth quite a bit. They are very maneuverable, but the drivers always walk away a little dazed after a couple hours at the controls.

The limit for how far apart the wheels can be is more complicated. For a given tracking width, the longer the wheelbase, the less effective skid-steer steering becomes, while at the same time the more stable the Bobcat will be. The best compromise seems to be when the wheelbase is about 3R, that is, three wheel radii from axle to axle, and Jiffy is designed with this geometry.

Kinematic Suspension

Jiffy uses fairly rigid plastic wheels which aren't very squishy at all, so a simple rigid suspension just won't work. Any minor bump or dip encountered would cause one or more of the wheels to lose

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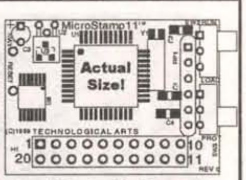

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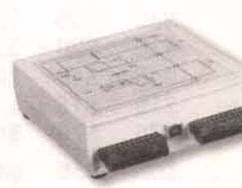

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traction.

RC cars solve this problem (even though they have squishy tires) with elaborate independent wish-bone suspension systems, complete with shock absorbers and wheel alignment adjustments. I decided to see what I could accomplish with a simple articulated design whereby the front and rear sets of wheels pivot relative to one another about the midline of the robot. Under most circumstances, this should guarantee that all wheels remain in contact with the ground. The exceptions are when the terrain is so rough that the robot can get high-centered or tumble over a precipice, and even the best suspensions can't deal with that.

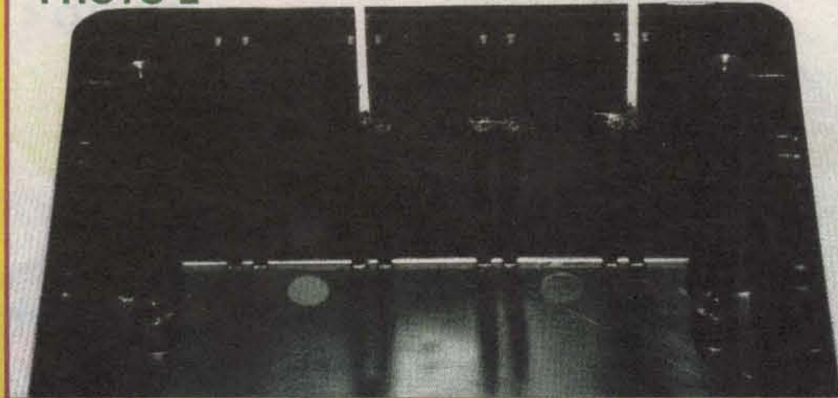
Anyway, this is an example of a kinematic suspension — that is, a suspension using only pivots and rigid links. Mars Sojourner used a more complicated kinematic suspension. It was more complex not just because it used six-wheel drive, but also because its "rocker-bogie" suspension not only assured that all six wheels would always be in contact with the ground, but that they would all have the same traction. This is not true of the suspension Jiffy uses; traction decreases the farther from neutral the wheels tilt.

Rocker-bogie suspensions also have the nifty property that the robot's body tends to stay more or less level. The Jiffy suspension can't manage this feat, but it still does a pretty good job of coping with small bumps and dips.

Peanut Butter and Jelly

The final guiding principle is that it should be cheap to build. Since Jiffy is supposed to be a testbed for ideas that may or may not make their way into a Sumo/Firefighter, I didn't want to make a big deal out of it. Quick, dirty, and cheap was my mantra. As is so often the case with robot projects, I started with the wheels.

PHOTO 2



At first I thought I would have to resort to something really ugly, like tuna cans, but I came up with a much better solution: plastic peanut butter jar lids. Peanut butter jar lids (or "closures" as they call them in the industry) are very round — an excellent property for a wheel. Moreover, the tops are flat, which makes it a snap to attach servo control horns. Finally, they have a perfect little dimple marking the exact center, a byproduct of the injection molding process (this dimple will be put to good use).

With a toddler around, we go through a lot of peanut butter and jelly sandwiches here at the Robot Ranch. We buy store-brand peanut butter in the 28 ounce jars, and these jars have 3.4" O.D. lids with a 0.8" rim (see Photo 3). Jif, Skippy, and other brands all have pretty much the same lids (just different colors), and there are both larger and smaller lid sizes. All of them are made of nigh-on indestructible polypropylene, and all of them have some kind of edge fluting, great for traction.

PHOTO 3

Four Jars?!

Now, if you happen to have saved your last four peanut butter jars (or least the lids), then you are set. I had only one on hand, though, and that one I had to dig out of the kitchen trash (the things I do to further the Arts Robotic ...). I made a late-night run to the supermarket. A 28-ounce jar of store-brand peanut butter goes for about $3.50 in our area, and even if I just threw away the full jars and kept the lids, each wheel would still be cheaper than the same size model airplane wheel from a hobby shop. But if you cannot countenance throwing away four perfectly good jars of peanut butter when there are starving people in Africa, here's a simple trick: buy five jars.

Alright, I'm not crazy. Peanut butter jars come with a foil-lined cardboard seal, so you don't really need a lid for a jar which still has an intact seal. Buy five jars, liberate four lids for use as robot wheels, and leave one lid for its original purpose. Each time you break the seal on a new jar, simply wash the lid and transfer it to that jar. The expiration dates on the jars I bought were all a year away, and we'll surely go through all of the jars in that time (Yonatan loves peanut butter).

Here's another way buying so much peanut butter can be helpful to your robotics projects: consider how much money you'll save eating good old PB&J sandwiches for lunch instead of, say, buying a cheeseburger. You get about 25 sandwiches from a 28-ounce jar. Combined with the

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PHOTO 4

For fun and inspiration be sure to look over the Bobcat company's companion page – www.bobcatstore.com – for nifty scale models of Bobcats. You'll find 1/25 and 1/50 scale Bobcat loaders and excavators to keep the kids happy while you're building Jiffy and working 1/10 scale RC models of those same Bobcats if you have the desire to do a robot conversion. Price is between $110.00 and $130.00 for the RC models. I haven't actually played ... er ... worked with these models, so I don't know what quality they are. I'd love to hear any reports from folks who have them.

cost of bread and jelly, this works out to about 50¢ a sandwich. If you eat a hundred PB&J sandwiches this year – four jars – instead of the burgers, you'll save about $300.00, enough to build several Jiffy robots ...

In Search of a Body

Since Jiffy is supposed to be run at least occasionally outdoors, it can't have the open chassis of a robot like Breadbot. In fact, it would be nice if everything were perfectly waterproof.

The current design is by no means waterproof, but it will withstand a few raindrops since all the electronic components are enclosed inside two plastic boxes. The boxes I chose are 6 x 4 x 2" project boxes (RadioShack #270-1806).

These boxes are quite roomy, even after the drive servos, battery holders, and electronics are installed. There is plenty of space left over for extra goodies such as sensors (and servos to pan and/or tilt the sensors). The boxes are used upside down with the drive servos mounted with screws.

By coincidence, it turns out that the spacing of the card slots on the short sides of this particular project box is just about equal to the length of a Futaba S148 servo. Further, it also turns out that if you make cutouts between the first and third card slots, the servo output shafts wind up just about on the centerline of the box. Jiffy makes use of this fact to accurately position the drive servos without complex measurements (remember, this is designed to be built on a picnic table with a pocket knife).

Building Jiffy

Mark the locations of the centerlines of the first and third card slots on the outside of the project box. The pencil lines on the outside of the box needn't be too precise since they won't be used as guide lines; instead, they will mark the ends of a horizontal scribe line.

As a further aid, cut a piece of card stock to the inside height of the project box. I used the card backing of the servo package since it was already the right width to fit between the box lid's screw bosses. Just slide the card into the end of the project box and cut it flush with the top edge.

Remove the card and place the box upside down without its lid on a smooth surface, and lay one of the servos on its side with its bottom pressed against the project box; place it between the two pencil lines. Lightly scribe a line with a pocket or hobby knife using the body of the servo as a guide.

Try to get the scribe line as even and parallel with the servo as you can. Scribe a matching line on the above guide card, too, and cut the card into two strips. Use the wider strip (the strip above the servo) to mark the inside distance from the inside bottom of the box down even with the scribe line on the outside.

Next, cut through the card slots as shown in Photos 2 and 4, with the guide card strip inside the box to show you approximately when to stop. I used the saw blade from my Leatherman tool, which turned out to be ideal because it has the right kerf width and it's designed to cut on the pull stroke rather than on the push stroke.

I placed the box on end and used the outer ribs of the card slots to guide the blade. A coping saw or a keyhole saw will work fine, too, but whatever you use, be sure to support the plastic with a table edge or a block of wood as you cut. When I got near the end of each cut, I put the box flat so I could see the scribe line and cut down to it.

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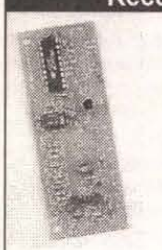

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Score and Snap

Now V-notch the card slot ribs as shown in Photo 2. Use the cardboard strip to guide your knife blade. The notches make it easier to snap out the plastic rectangle. Use a pair of pliers to bend the waste plastic inward part way. Where the plastic turns white, score with your knife a few times more, then bend the tab all the way in until it snaps off cleanly. Trim the rough edges of the opening with the knife and sand or file until the servo fits snugly in the cutout with its mounting ears on the outside of the box. Be sure that the servo case is flush with the top edge of the box.

Turn the box upside down again with the servo in place and mark the mounting hole locations. Alternatively, you can simply use the holes in the mounting ears to guide a 9/64" drill bit. Once you've made the holes, set the servo aside and use a knife to shave away the ribs remaining on the sides of the cutout (this is so the hex nuts and lock washers will sit flat on the plastic walls of the project box).


PHOTO 5

Place the plastic lid on the box and scribe marks at the sides of the new cutouts on the lid lip. The lip protrudes down into the box so it must be notched to clear the servo body and its mounting hardware. Notch the lip a quarter-inch wider on each side than the servo cutout so there will be room inside for 6-32 hex nuts. The best way I found to notch the lip is to make saw cuts on each side of the area to be notched and several more cuts in between. This leaves you with several smaller tabs which you can then remove by the score-and-snap method as above. File the bottom of the notches smooth, test fitting the lid on the box with the servos in place.

An Articulated Robot

Jiffy's chassis is made of two boxes joined through a pivot. To make the pivot, I chose a potentiometer because it's easy to mount and because it may prove useful in the future to be able to measure the angle between the front and rear segments. With an eye toward this possibility, I chose a 100K-ohm, linear-taper potentiometer (RadioShack #271-092). It's cheap, it has low rotating friction, and it's untrimmed shaft is long enough to give the proper wheelbase (see Photos 5 through 7).

The body of the pot mounts in the rear box, and the free end of its shaft is locked to the front box by means of a modified control knob (RadioShack #274-424) secured with three screws to the inside of the front box.

PHOTO 6

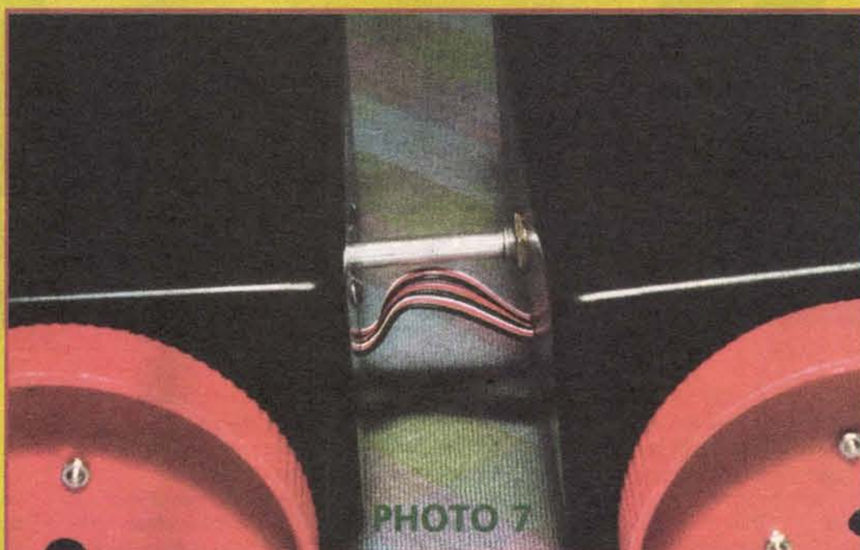

PHOTO 7

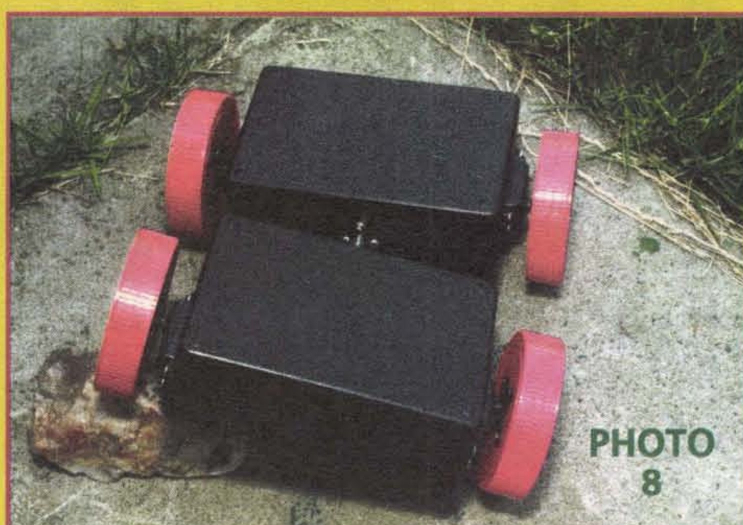

PHOTO 8

Install the pot in the rear box by carving or drilling a 5/16" hole about 7/8" from the top of the box (which is the bottom of the robot). You'll have to shave the center card slot ribs flush with the surrounding plastic so the pot will seat properly.

Temporarily insert the pot from the outside of the box and position its little metal registration tab so the solder lugs face down. Twist the body of the pot a little so the tab leaves a mark in the plastic, then remove the pot and drill a 9/64" hole centered on the mark. Set the pot aside.

Hold the two boxes together and transfer the location of the potentiometer hole to the front box by scribing the outline of the hole. Make a small hole in the center of the outline to start with (9/64" will do fine) and enlarge it after the following steps are completed.

First, shave away the card slot ribs so the control knob will sit flat against the inside of the box. Set the box aside. The knob is molded from bakelite in the form of an inner and outer shell joined by three ribs. The inner shell has a brass insert with a setscrew; this is what will take the pot shaft. Next, drill three 9/64" holes through the body of the control knob as shown in Photo 5. I held the knob insert-side up and centered my drill bit by eye in the arc slots between the ribs and drilled straight down. The bakelite is fairly thin, about 1/8", so it's not hard to drill these holes by hand.

Once the knob is ready, enlarge the shaft hole in the front box to about 1/4". Mount the pot with its shaft protruding out of the rear box, insert the shaft through the 1/4" hole in the front box, and place the knob on the end of the shaft. Turn the knob so the setscrew is up, then tighten the setscrew. Hold the knob against the side of the front box and temporarily insert the three 1"x6-32 mounting screws from the front side of the knob. Press the screws against the box side and twist them a bit to mark the plastic. Remove the knob, set aside the rear box, and drill 9/64" holes where the screws marked the plastic. Secure the knob to the inside of the front box with screws, washers, and nuts as shown in Photos 5 and 6. Enlarge the shaft hole, if needed, to give the shaft clearance.

The finishing touch for the boxes is notching the lids and sides of the each box to allow an umbilical of six wires (two thee-wire servo cables plus two wires for battery power) to pass between the front and rear segments (see Photo 7).

A Set of Wheels

As mentioned previously, the peanut butter jar lids have two dimples, a small concave dimple on the top, and a larger, convex dimple on the inside of the lid. Use the small dimple to guide your drill or carving knife, and use the outline of the larger dimple to keep your hole centered.

Just ream or trim away plastic until the dimple is gone and the hole will be the right size to accommodate the hub of a Futaba control horn (this applies only to lids made by Sun Coast Closures; if your lids are made by a different manufacturer, you'll have to adjust according to the actual size of the dimple).

In my first attempt to attach a control horn to the wheel, I tried to epoxy a Futaba "D" control horn (the little round one that comes mounted on the servo) directly to the top of the lid. Even though I allowed the epoxy (Devcon Five-minute Thick Gel) to cure more than 24 hours, it never really grabbed onto the material of either the polypropylene lid or the servo horn (whatever kind of plastic they are made of).

I'm sure there's some way to bond these two plastics, but I didn't have the patience to figure out what kind of primer and adhesive to use. I settled for the direct approach and just bolted four-armed Futaba "A" horns to the wheels with four 1/4" x 2-56 screws. You have to enlarge the outermost holes of the control horn with a 3/32" bit, then drill a matching set of holes in the wheel disks (Photos 1, 3, and 7).

Next Time

I'll have more details on building Jiffy, I'll have some robotics-related books to review, and a few surprises.

Also, don't forget High GEAR, Great Escape And Retreat, is coming up the last weekend of this month (July 28-30), at South Whidbey Island State Park in Washington State.

There are at least four camping sites reserved for Gearheads to get together and talk robots (and build Jiffys!).

If you plan to come, drop me a note so I can make sure there will be room. I'll be there and lots of folks from the Seattle Robotics Society will be on hand, too.

Even if you can't camp, come by and say, "Howdy! **NV**

Write in 165 on Reader Service Card.

Continued from page 42

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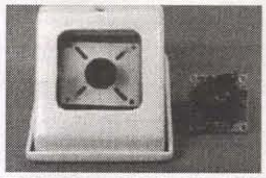

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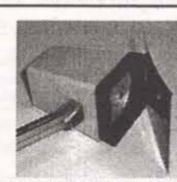

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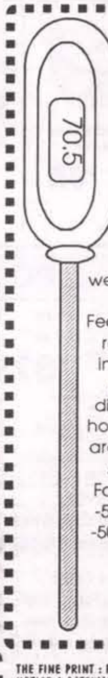

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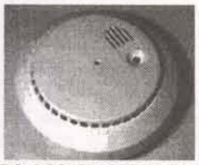

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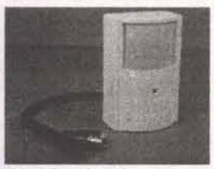

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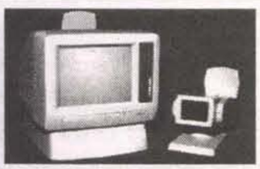

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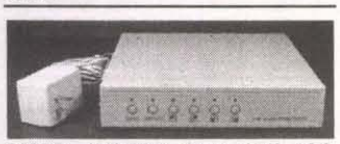

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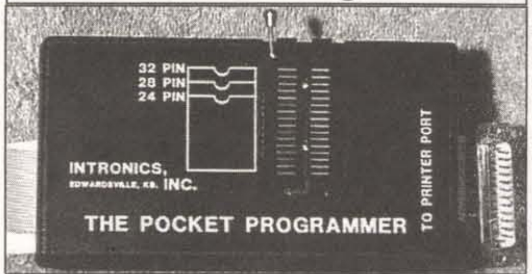

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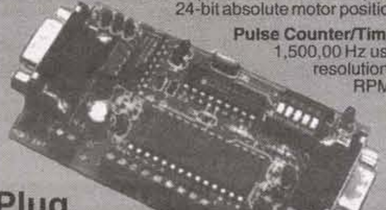

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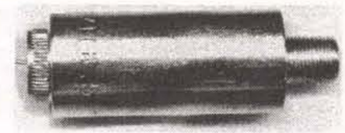

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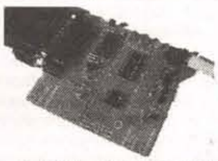

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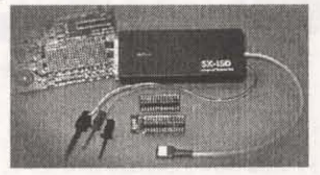

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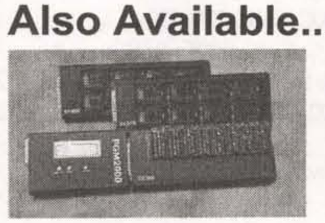

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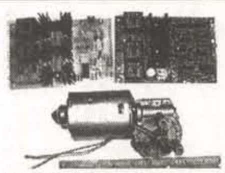

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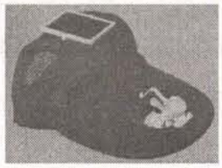

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Continued on page 84

by
Anthony
Caristi

FUNCTION GENERATOR SCHEMATIC

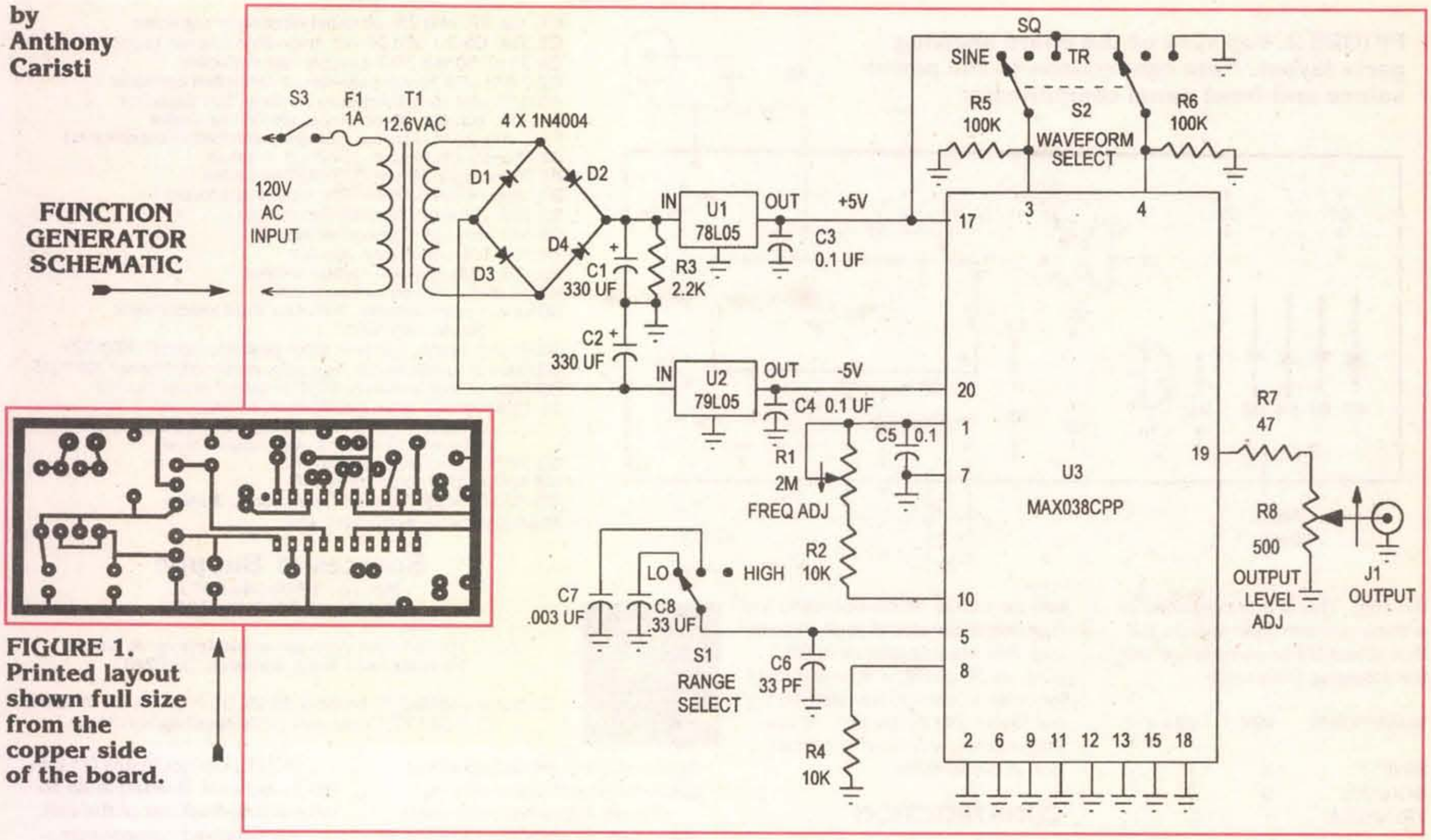


FIGURE 1. Printed layout shown full size from the copper side of the board.

BUILD THIS LOW-COST FUNCTION GENERATOR

Anyone who likes to tinker with electronic circuits needs from time to time a generator that will provide a signal, of some desired frequency, that can be used to drive a circuit or component such as an amplifier or speaker. Commercially manufactured test equipment is readily available, but many people will hesitate to invest a large sum of money for a signal generator. The answer to this is to build *this* simple but versatile quality function generator that can provide sine, square, and triangular waveshapes from 10 Hz (or less) to 10 MHz.

The function generator itself is a one chip circuit that was developed by Maxim Integrated Products, Inc. The IC contains all the necessary circuitry to provide three waveshapes over a very wide frequency range, and can drive signals into a load impedance of 50 ohms or more. Very few external components are required. The chip is capable of producing frequencies from 0.1 Hertz to 20 MHz.

HOW IT WORKS

Refer to the schematic diagram. Power to operate the circuit is provided by a common and readily available 12.6 volt step-down transformer. The AC voltage is rectified by a full wave bridge circuit composed of D1 through D4. Two filter capacitors, C1 and C2, are connected in series across the output of the bridge so that both a positive and negative DC power source is available to operate the function generator chip. An extra resistor, R3, is placed across C1 to help balance the load on the bridge.

The positive and negative DC voltages appearing across C1 and C2 are each fed to an appropriate voltage regulator chip — U1 and U2 — to provide a positive and negative five-volt regulated supply. The use of regulators ensures stable circuit operation regardless of possible variations in AC line voltage.

U3 is the heart of the function generator. Its output frequency is determined by two parameters: the value of capacitance that is connected from pin 5 to circuit common, and the amount of current fed into pin 10 of the chip.

In this circuit, three values of discrete capacitance are possible, depending upon the setting of a three position rotary switch. These values are chosen so that the total range of the function generator covers 10 Hz to 10 MHz. C6, the high frequency range capacitor, is permanently connected into the circuit. C7 and C8 are switched into the circuit by S1 to provide the lower frequency bands.

The current fed into pin 10 is provided by potentiometer R1 and fixed resistor R2. Internal circuitry within U3 generates a 2.5 volt reference voltage at pin 1, and pin 10 sits at -2.5 volts. Total adjustment of R1 allows a total frequency change of more that 100:1. For the values shown in the schematic diagram, the three frequency bands are:

LOW	10 Hz to 1,000 Hz
MED	1 KHz to 100 KHz
HIGH	100 KHz to 10 MHz

There is significant overlap of the three ranges. The formula that determines the frequency of operation is shown in Equation 1.

The builder has the option of adding more positions to S1 (with additional appropriate capacitor values) — and using a lower value for R1 — to provide greater resolution of the frequency adjust potentiometer.

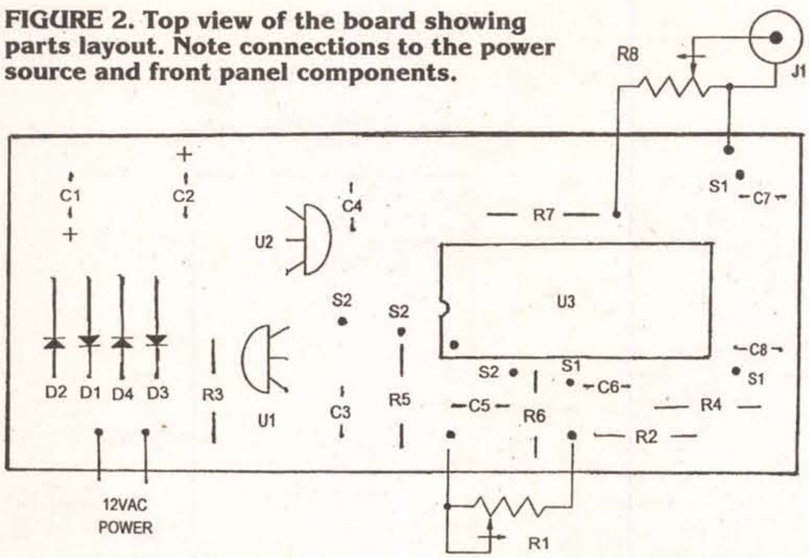
WAVEFORM SELECTION

The waveform output of U3 is determined by a logic two-bit address fed into pins 3 and 4 of

Equation 1

$$\text{Frequency in MHz} = \frac{\text{current in microamperes}}{\text{capacitance in picoFarads}} = \frac{\text{current in milliamperes}}{\text{capacitance in nanoFarads}}$$

FIGURE 2. Top view of the board showing parts layout. Note connections to the power source and front panel components.



PARTS LIST

C1, C2 330 uFd 25-volt radial electrolytic capacitor
C3, C4, C5 0.1 uFd 50-volt monolithic ceramic capacitor
C6 33 pF 50-volt NPO ceramic disc capacitor
C7 0.003 uFd 50-volt polyester or metal film capacitor
C8 0.33 uFd 50-volt polyester or metal film capacitor
D1, D2, D3, D4 Silicon diode, 1N4004 or similar
F1 1 ampere slo-blo fuse (for units with built-in transformer)
J1 Phono jack, Mouser 161-2003 or similar
P1 Phono plug, Mouser 17PP058 or similar
R1 Linear potentiometer. 2M, front panel mount
R2 10K 1/4 watt 1% metal film resistor
R3 680 ohm 1/4 watt carbon resistor
R4 10K 1/4 watt carbon resistor
R5, R6 100K 1/4 watt carbon resistor
R7 47 ohm 1/4 watt carbon resistor
R8 Linear potentiometer, 500 ohm, front panel mount Mouser 31VA205
S1 Rotary switch, one pole three position, Mouser 10YX025
S2 Slide or toggle switch, two pole, center off, Mouser 108P016
S3 Slide or toggle switch, SPST (optional power switch)
T1 12.6-volt step-down transformer, 10 VA Mouser 553-VPP12800 (built-in construction) or Mouser 412-212053 (wall adapter type)
U1 AN78L05 +5 volt regulator IC
U2 AN79L05 -5 volt regulator IC
U3 MAX038CPP Function Generator IC, Maxim
Misc: Enclosure, fuseholder, wire

Sources of Supply:
Mouser: 1-800-346-6873
Digi-Key: 1-800-344-4539

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

Etched and drilled PC board @ $9.95, U1 @ $2.00. U2 @ $2.00, U3 @ $21.75. Please add $5.00 shipping/handling.

the chip. This is accomplished by a three position slide switch, S2, that drives U3 in accordance with the following truth table:

WAVEFORM	PIN 3	PIN 4
SINE	X	1
SQUARE	0	0
TRIANGLE	1	0

(X = don't care)

OUTPUT CIRCUIT

The function generator will deliver about two volts peak-to-peak maximum. The output of U3 is fed to R7 and potentiometer R8 so that the amplitude of the signal appearing across the output jack can be varied. When operating the function generator at high frequencies into low impedance loads such as 50 ohms, it is best if coaxial cable is used to transfer the signal to the unit under test. At low frequencies, any type of connection is permissible.

CONSTRUCTION

The function generator circuit is mostly contained on a single sided printed circuit board measuring about 1-1/4 by 3 inches. Figure 1 illustrates the printed layout in full size as seen from the copper side of the board. A drilled and etched board is available from the source given in the parts list if you do not wish to etch your own. Alternatively, the circuit may be hardwired on a perfboard using good construction techniques.

Figure 2 illustrates the parts placement as seen from the top or component side of the board. Be sure to refer to Figure 3 to identify the leads of U1 and U2 so that they each are placed properly into the board.

Before starting assembly, clean the copper side of the PC board gently with steel wool to remove any dirt, oxidation, etc. Wash it with detergent and water and dry thoroughly.

NOTE: Do not install U3 into the board until directed to do so later during final test of the unit.

All polarized components — such as semiconductor devices and electrolytic capacitors (C1 & C2) — must be properly oriented as depicted in Figure 2. Just one part placed backwards in the board will render the circuit inoperative and may cause damage to one or more of the components.

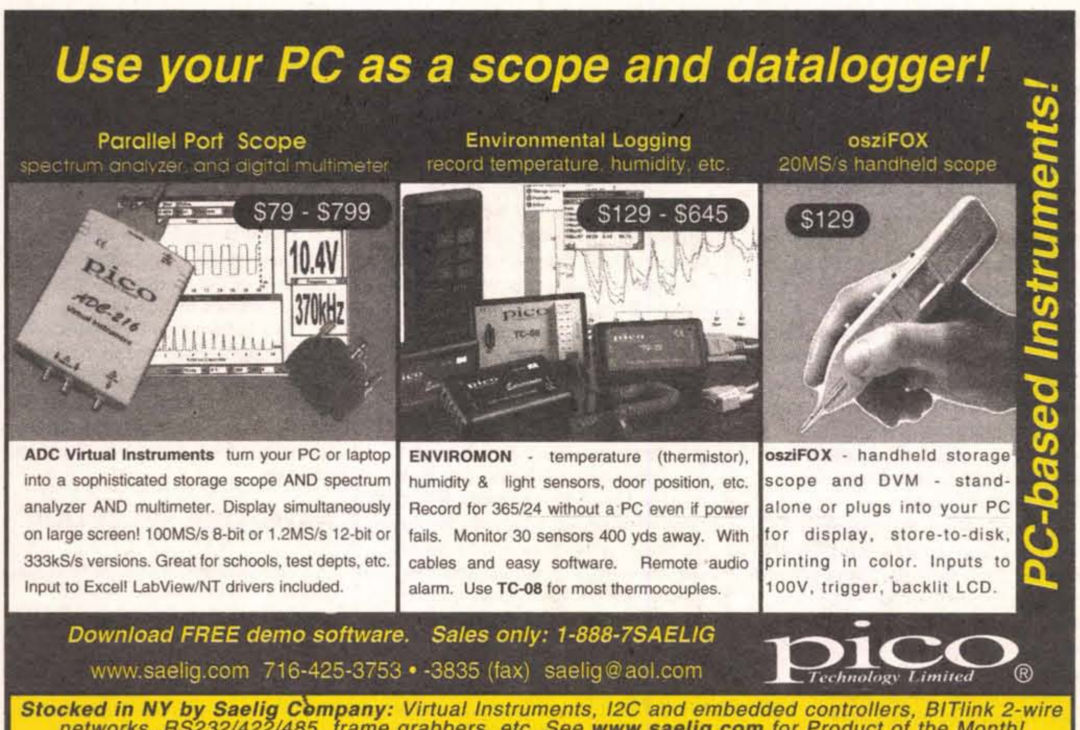
Be sure to use a metal film resistor for R2, and a cermet potentiometer for R1. This will help ensure stability of the operating frequency with changes in ambient temperature. Carbon resistors are not temperature-stable and should not be used where metal film or cermet types have been specified.

When the printed circuit board is completely stuffed and soldered, examine the assembly 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 function generator does not work. When finished with the PC board, place it aside to work on the enclosure.

ENCLOSURE

The small size of the PC board allows just about any type of enclosure to be used. Choose one that can accommodate S1, S2, R1, R8, and J1 on the front panel. A typical assembly is illus-



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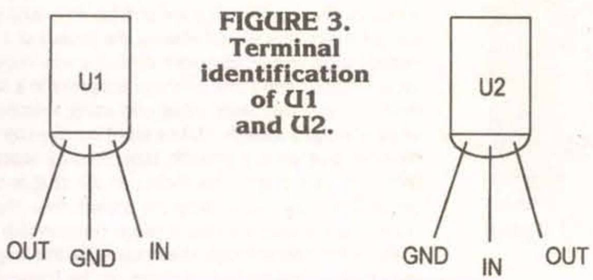

FIGURE 3. Terminal identification of U1 and U2.

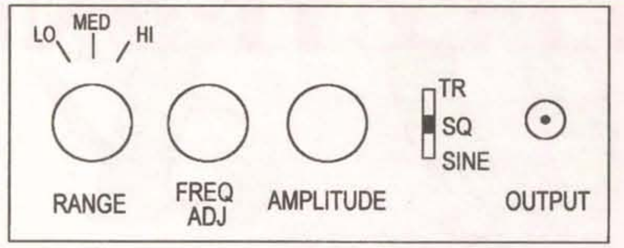

FIGURE 4. Typical front panel layout of the function generator.

trated in Figure 4. S3, a power On/Off switch, is optional.

For the selected enclosure front panel, take a piece of paper and draw a rectangle that represents the panel in full size. Then take the front panel components and lay them on the rectangle in the desired location. When you are satisfied with the layout, mark the paper at the location of each component. You may then drill the front panel of the enclosure, using the drawing as a template, to accommodate the parts.

Mount the components to the front panel and wire them to the PC board as illustrated in Figure 2 and the schematic diagram. It is important to use flexible wire (solid wire will break), and the length should be as short as practical.

Be sure to review the schematic diagram when wiring the two potentiometers. Clockwise rotation is indicated by the arrow shown vertically on the wiper connection. When finished with the front panel assembly, examine the wiring very carefully. A mistake here will result in an inoperable unit.

POWER SOURCE

The circuit will be powered by 12 volts AC, derived from a step-down transformer. The builder has the option of using a readily-available AC wall adapter transformer, or obtaining a step-down transformer and mounting it directly inside the enclosure. Representatives of both types are specified in the parts list.

If the built-in transformer version is chosen, be sure to mount a fuseholder in the cabinet and use a one ampere slo-blo fuse wired in accordance with the schematic diagram. This will protect the circuit in the event of a malfunction. If the wall adapter transformer is used, a fuse is not essential.

PRELIMINARY TEST

The preliminary test is divided into two parts. First, the two regulated DC supplies are checked for proper operation. Then U3 is placed into the board and the remainder of the test is performed.

CAUTION: If the built-in power transformer version has been selected, be careful not to touch any part of the primary circuit, including the line cord, S3, fuse, and transformer primary wires. High voltage exists at these points, which could cause dangerous shock if inadvertently touched.

Apply power to the circuit and use a DC voltmeter to measure the voltage, with respect to circuit common, at the positive side of C1. Normal indication is about +10 volts or more. Measure the voltage at the negative side of C2. Normal indication is -10 volts or more.

Measure the regulated voltages at pins 17 and 20 of U3's circuit pads. Normal indication is +5 volts and -5 volts, respectively, within a tolerance of 0.25 volts.

If you do not obtain the correct readings as specified above, disconnect power and troubleshoot the board until the fault is located and corrected. Use a visual check first, verifying that the diodes, electrolytic capacitors, and regulator chips are properly inserted into the board. Refer to Figures 2, 3, and the schematic diagram. Check the board for shorts, opens, and bad solder joints. Measure the voltage at the secondary of the transformer to verify that at least 12 volts AC is present. Do not proceed with the checkout until both regulated supplies are operating properly and delivering ±5 volts.

FINAL TEST

Remove power from the circuit. At this time, U3 may be directly soldered into the board using Figure 2 as a guide for orientation. Alternatively, the use of a socket allows ease of service should it ever be necessary. It is difficult to remove a multi-pin IC that has been soldered into a board without damaging either the chip or copper pads. When finished Pplacing U3 into the circuit, examine carefully all solder joints.

The best way to test the function generator is to use an oscilloscope to view waveforms present at the output jack of the unit. The time scale of the scope also allows fairly accurate frequency measurements if a counter is not available.

Set the frequency range switch to mid-position, and the output level control midway. Apply power to the circuit and adjust the vertical gain and sweep speed of the scope so that the waveform may be viewed. Rotate the amplitude control of the function generator and verify that maximum output occurs at the maximum clockwise position.

Throw the waveform switch to each position and verify that sine, square, and triangular waveforms are present. Rotate the frequency adjustment and verify that the frequency increases with clockwise adjustment of the knob.

Try the other two settings of the frequency range switch and verify that all bands are operational. This completes the final test of the function generator.

If any of the potentiometer controls work backwards, it is a simple matter to correct by reviewing the schematic diagram which illustrates clockwise adjustment of the pot.

If the waveform switch does not operate properly, check carefully the wiring to S2 in accordance with the schematic diagram. Be certain the correct switch is being used. **NV**

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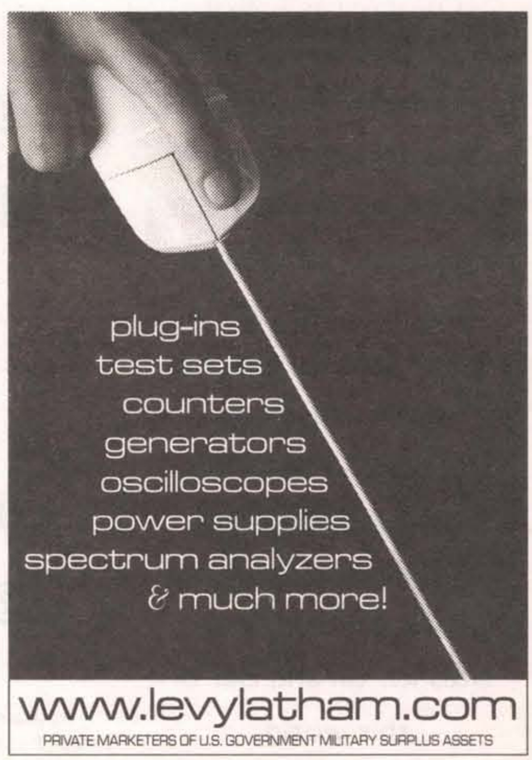

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ELECTRONICS Q&A

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:
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What's Up:

The definitive answer on converting multi-line telephones. AC and DC lamp dimmers, alarm clock relay, and an RV water tank gauge. Solutions to some perplexing component replacement part problems, and cool web sites for on and out of this world.

Jurassic-Park-Tube Conversion

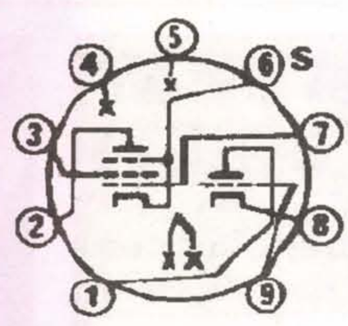
Q. Being a guitarist and an EE, I've acquired quite a few tube amplifiers. The problem is that a number of them use the 7199 tube. I was told that the socket for the 7199 could be rewired to accommodate a 12AX7, but I'm having a hard time finding documentation for this. Even though I have training in electronics, vacuum tubes were just a brief footnote in my studies and not my strong suit. Do you know how this is done?

Al Lovecky
via Internet

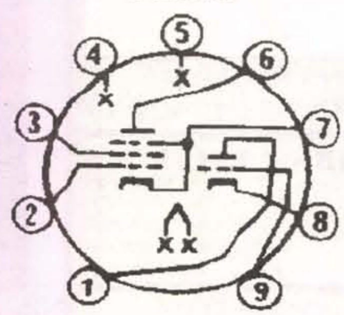
A. No, but I can tell you how to rewire the 7199 socket for a 6GH8 tube. You see, the 7199 is a small triode-pentode, used in the old Dynaco Stereo-70 amplifier and many others. The 12AX7 is a dual triode. The two have as much in common as apples and oranges in that they are both tubes, but not the same fruit. The 6GH8, on the other hand, is a small triode-pentode that will substitute for the 7199 if the socket is rewired. Here's a chart showing the pin conversion

Tube Element	7199	6GH8
G(1)	1	9
P1	2	6
G2	3	3
H	4	4
H	5	5
K1	6	7
G1	7	2
K2	8	8
P2	9	1

7199



6GH8



As you can see, five of the nine pins have to be swapped — not an easy chore if there's more than one 7199 socket to modify. Back in the Cenozoic period of tubes, as they rapidly died off and became extinct, we had adapters that would change the pinout of an extinct-tube socket to match that of a still-living tube type. I haven't seen one of these adapters in a long time, but you can easily make one using a nine-pin socket (the winged, chassis-mount type) on the top and a nine-pin plug on the bottom, separated by spacers. What you do is wire the socket to the plug in the new order. Plug the adapter into the socket, then plug the tube into the adapter. This is much simpler and cleaner than hacking away inside the chassis. By the way, an excellent tube substitution chart can be found at **http://www.nostalgiaair.org/otcr.htm**.

AC Lamp Dimmer Primer

Q. I have a Torchiere standing halogen lamp that quit working. I replaced the bulb to no avail, so it seems that the driver circuit might be at fault. Do you know where I can get a circuit diagram for this? Do you know of common faults with these popular lamps?

Graham Oberem
San Diego

A. Before I begin, let me say that you can buy these lamps everyday for less than $10.00, and generally they aren't worth repairing (more on that later). But I think the question deserves an answer, if only for the sake of knowledge, and as a good primer for a later question.

Like all lamp dimmers, the brightness of the Torchiere's halogen lamp is controlled by duty cycle. For this discussion, refer to Figure 1 below.

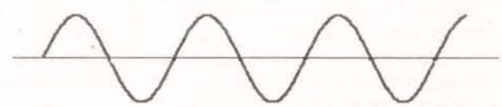


Fig. 1. Sinewave.

This is a sinewave, and it powers the lamp to full brilliance. In other words, this is the brightest the lamp will ever get and is called 100% duty cycle. The average voltage that the lamp sees is equal to the area under the sine curve, and is equal to 0.707 volts of the peak voltage. Now, if we remove a portion of that wave, as shown in Figure 2, there will be less power and therefore less average voltage under the modified curve. With half the waveform gone, the average voltage drops by 50%.

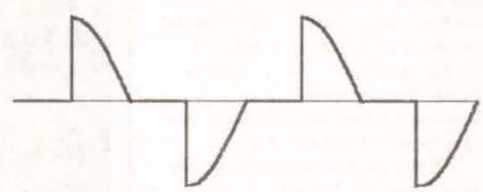


Fig. 2. 50% duty-cycle, pulse-width modulated sinewave.

What a dimmer does is adjust the area of the waveform that's clipped from the full sinewave. At its extreme, barely any of the sinewave is left, as shown in Figure 3, meaning there's very little — if any — light emitted.

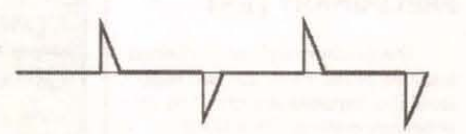
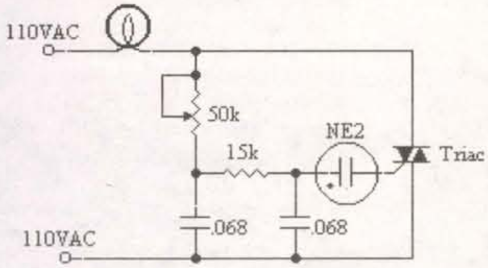


Fig. 3. 10% duty cycle, pulse-width modulated sinewave.

Most AC lamp dimmers are built around a triac: a switching device that's very similar to a relay, only faster. When the triac is on current flows. A triac controller circuit determines at what point the triac turns on which, in turn, determines how much of the sinewave is removed. Here's a simple triac dimmer circuit.



In this dimmer circuit, the triac won't trigger until the neon lamp turns on. The point at which the lamp turns on is determined by the 50k variable resistor.

As for popular faults for Torchiere lamps, the most common is lamp failure. While dimming a halogen lamp is neat, it shortens the life of the bulb considerably because the gas never reaches full temperature. Hence, the filament burns out prematurely. Next is the switch/dimmer. Although it's not economical to repair the dimmer itself, it can be replaced with a simple on/off switch that they sell at any hardware store. Not only is it a cheap fix, it extends the life of the bulb.

Notebook LCD Screen Replacement

Q. I have a HyperData 5033 laptop computer with a broken screen. I've only found one company who sells a replacement for it and it's very expensive. Do you know of an alternative screen or aftermarket dealer that might have it cheaper? The screen number is Hyundai-HT12S11. It's a 12.1-inch TFT.

Judy Warren
via Internet

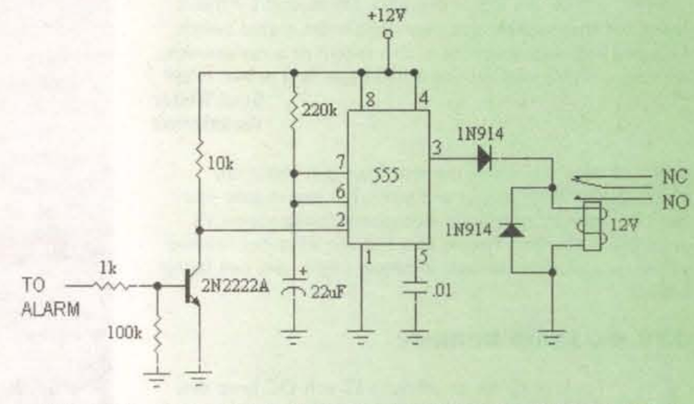
A. The laptop you have comes from a Canadian distributor of notebooks. It appears the original manufacturer of this notebook (Notebook Fujitsu LiteLine 5033) is a German company. Spare parts for this PC can be found at **http://www.eastcomp.de/inserate.htm#laptopnotebook** The manufacturer of the display — **Hyundai Electronics America** — can be found at LCD, 3101 North First Street, San Jose, CA 95134 **(408-232-8000; http://www.hea.com/hean2/lcd/list.htm)**. But what I'd do instead is buy a cheap 14-inch monitor and plug it into the VGA socket on the back of your HyperData laptop. Okay, it's not as portable as it used to be, but it's affordable — less than $100.00. You know the other alternative: a new notebook.

Alarm Clock Relay

Q. I'm trying to tap off a digital alarm clock that I want to use as a trigger for a 12-volt relay. When the alarm goes off, it sends a string of three beeps, pauses, then repeats until you turn it off or hit the snooze button. Nothing I've tried seems to work. I can detect the beeps okay, and drive the relay with a transistor, but the relay cycles with the beeps — you know, click-click-click. I need the relay to pull-in and stay latched until the beeper is reset. Can you please help me with a circuit that will work?

Dave Freeman
via Internet

A. What you need is a timer: one that triggers on the first beep and stays that way for a predetermined amount of time. When the timer times out, it searches for another beep. If there are no further beeps, the relay remains off until the next incident. Such a timer is easily built using a 555 chip.



When voltage is applied to the beeper, it turns on the 2N2222A transistor, which triggers the timer. Once the timer is activated, no amount of input beeps will keep it from its assigned task, holding in the relay for a prescribed amount of time. After the timer times out, it awaits another input. The timer won't trigger again until another beep is emitted. The amount of time delay is determined by the 220k resistor and 22uF capacitor — which is about 10 seconds for the values shown. The delay time can be decreased by reducing the value of the resistor and increased by increasing the resistance.

Embedded Code Woes

Q. I have several Icom M80 marine VHF radios with a failed microprocessor. Icom tells me this chip is no longer available. It's a Motorola MC146805G2. I'd like to have some info on finding a supplier for this chip or a substitute.

Earl Walton
via Internet

A. Embedded systems are great when they work. They are compact, intelligent, and low cost. Unfortunately, when they quit working it's another story. They are expensive to repair, if at all, and finding replacement parts is a hit and miss proposition. That's because the microcontroller — the "brains" of the system — has embedded code that's burned into memory (usually ROM or EPROM). When the controller dies, so does the code — code that was written and installed by the manufacturer of the device, who may be long out of business or has discontinued the product. That's your problem. The MC14608G2 is a discontinued eight-bit microcontroller with factory-coded ROM instructions. In other words, there is no substitute because it's proprietary coded. Your only hope is to find somebody who has some of these chips in a cigar box or a defunct M80 radio with a good chip. I'll post this request in the Tech Forum, too, and let's hope a reader has a small cache of them. Good luck!

Needs Bi-Metal Thermostat

Q. I have a Presto dual-element, floor standing quartz heater about 18 years old. There's no model number on the unit. It has worked great all these years, but this past winter the bi-metallic on/off/temp control switch went defective and the unit is either off or on all the time, no temp control.

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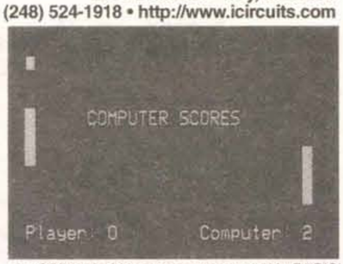

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Write in 37 on Reader Service Card.

The numbers on the switch are INF-120-887B, 34-191, 15A 120VAC. I think the INF is short for Infitec, so I E-Mailed them, but they replied that they don't make such a switch. Can you help with a source of this switch or a replacement, or even a timing circuit using a 555 timer and power relay?

Greg Weiler
via Internet

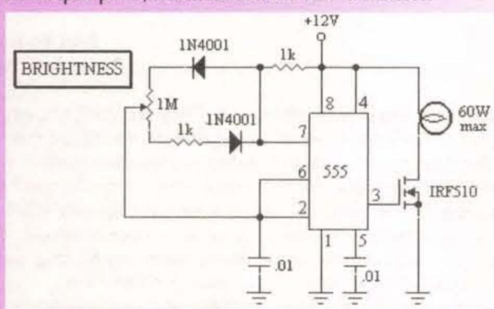
A - I think a bi-metal element from just about any 1500W floor heater will work. But just in case you can't find one that fits your mechanical configuration, I'll post this in the Tech Forum, too, and see what our readers come up with. Who knows, someone might have one laying around.

12V DC Lamp Dimmer

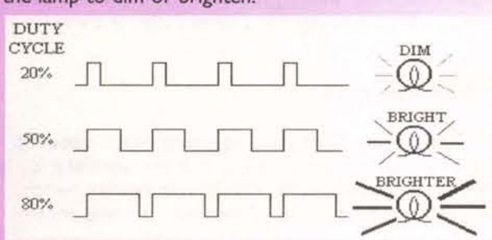
Q - I'm looking for an efficient 12-volt DC lamp dimmer with a capacity of 15W to 50W. Actually, I need three such dimmers, but I assume they can be paralleled. Low noise would be a bonus.

Jan Zumwalt
via Internet

A - Here's a very efficient DC lamp dimmer built around a free-running multivibrator. The frequency of the multivibrator is determined by three resistors, the potentiometer being one, and the .01 capacitor on pin 2. With the values shown, the frequency is about 80 Hz, which is fast enough to prevent the lamp from flickering. Adjusting the Brightness control changes the duty cycle of the pulse on output pin 3, which drives the FET transistor.



When the duty cycle is low (about 3%), the lamp is virtually off; when the duty cycle is high (about 97%), the light is full on. Anything in between causes the lamp to dim or brighten.



A heatsink isn't generally required for loads up to 40 watts.

RV Water Level Gauge

Q - I'd like to find a way to monitor the level of a 20-gallon potable water tank that sits under a seat in my camper. Having to remove the seat to check the water level is ... well, a real pain in the seat. An electronic level gauge would be a godsend if you know of one.

Michael Blaisdell
via Internet

A - It all depends on how handy you are, because you're going to have to stick your head into the tank to install it. My friend has an RV motor home with the kind of gauge you're looking for. Actually, it's a gauge cluster that measures fresh water level, gray water level, and battery condition. His happens to be a meter, but they come in LED versions, too. The water-tank sensor is a four-element monitoring device that tells you whether the tank is all the way full, three-quarters, half, one-quarter, and, of course, empty. They sell for about $72.00 and can be purchased from most RV supplies marts, like Camping World. However, you can make your own using the circuit below.

Cool Web Sites

Want a screensaver that's more interesting than flying toasters and, at the same time, assist in the Search for Extraterrestrial Intelligence (SETI)? Now you can have it by downloading and running the SETI@home screensaver from **setiathome.ssl.berkeley.edu** A volunteer program sponsored by UC Berkeley, SETI@home analyzes data received from space during periods when you're not using your computer. Rather than running in the background (and using resources), the SETI@home program goes into action only when the screen saver comes on. The data is combed for telltale radio signals and the results saved to your hard disk (10MB free space required). This is all done while your computer is "asleep." Moreover, you can see the results of the calculations on the screensaver in real time. When the job is done, you send the file back and download a new one. At no time does this program activate while you're using your PC, and you can upload and download data at your convenience; you're not tied to a schedule.

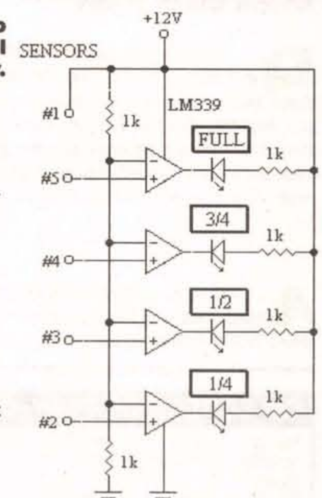
Closer to home are two great web sites that try to improve the world by asking you to simply click on and pledge to look at their sponsor's banners. The first is The Hunger Site, which donates 1-3/4 cups of staples per day when you venture into their den of sponsors — a mere handful of banners. No, you don't get cookied or spammed to death, they just want you to be aware of their presence and products. Sponsors range from Sprint, to coupon hawkers, to free hard disk Internet suppliers, to on-line shopping malls. It's painless, and well worth the effort. Sponsors change from time to time, so there's always something new to explore.

www.thehungersite.com

If saving the rainforests sounds like a worthy cause, check out Adopt An Acre. Like The Hunger Site, clicking on this web site secures 19.2 square feet of rainforest from destruction. Your donation adds to the 200,000 acres of rainforest already protected by The Nature Conservancy's Adopt An Acre program. Again, this is advertiser-sponsored, but I've run into some cool products here.

www.therainforestsite.com/

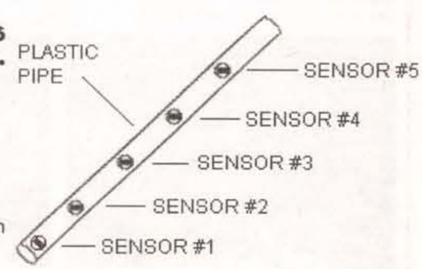
Four comparators make up the heart of this liquid level monitor.



The electronics is a simple quad comparator, like the LM339, with the reference inputs connected to Vcc/2 (one-half Vcc). The comparator inputs are connected to electrodes that are positioned inside the water tank at defined water levels. When the sensor is submerged under water, it creates a current path to Vcc, which triggers the comparator and lights the associated LED.

The level sensor consists of a length of plastic pipe with five #6 panhead screws along its length. The bottom-most screw is the common, and connects to Vcc. Along the length of the pipe are screws that reflect one-quarter, half, three-quarters, and full. The sensor wire is stripped and secured in place under the screw head.

Sensors are #6 panhead screws.



The best way to insert this measuring rod into the water tank is catty-corner from top to bottom, using opposing sides of the tank. This wedges the sensor pipe in place so that it won't shift position and give false readings. Short of that, secure the PVC rod along any side of the tank, with the common screw pointed down and the full screw at the top. Of course, you'll have to adjust the length of the pipe to fit your tank.

MAILBAG

Dear TJ:

Your April '00 column response to Garry Iman didn't mention a couple of the truly great audio do-it-yourself magazines. I don't know how you missed them, but be sure to add these to your list:

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Mike Hardwick
Turner, OR

Dear TJ:

I read your column today in the May '00 issue and would like to help you out on a question from Peter Stratigos about his Western Electric 2565 phone.

The way to modify the phone for a single line is to simply use the white/blue and blue/white wires for the first line in the set. If he ties those two wires to his phone line (the green/red pair), he'll get a dial tone with the first button pushed in. As far as dangerous voltages are concerned, the highest voltage on that phone (not including the 90 volts ringing) was a paltry 10 VAC that lit up the lamps.

Mike Phillips WB6RHW (AT&T retired)
via Internet

Dear TJ:

The white/blue and blue/white wires are the tip and ring for the first phone button. If you want the phone to ring, open the case and back off the screws holding the dial pad. Just to your right of the left hand dial support there is a short row of screw terminals then five rows of longer screw terminals. The first row of long terminals represents line #1. Remove the red and black leads of the ringer and tie them down to the white/blue and blue/white pair. The set will now ring. All manufacturers — AT&T, Stromberg Carlson (Comdial), NT, and ITT — use the identical layout so this will convert them as well.

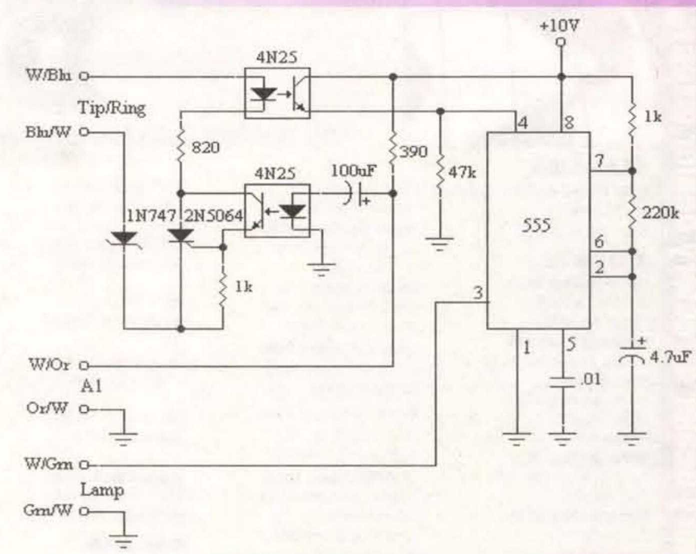
Mike Tewksbury WA8RYG
via Internet

Response:

I'd like to thank both Mikes and other readers who gave me the inside scoop on this telephone. From everything I was told, the 2565 couldn't be converted for residential use. But these pros have put that wives' tale to rest. Here is a chart of the wire assignments for the 2565 and similar multi-line phones.

Line #	Tip	Ring	A	A1	Lamp	Lamp GND
1	white/blue	blue/white	white/orange	orange/white	white/green	green/white
2	white/brown	brown/white	white/gray	gray/white	red/blue	blue/red
3	red/orange	orange/red	red/green	green/red	red/brown	brown/red
4	red/gray	gray/red	black/blue	blue/black	black/orange	orange/black
5	black/green	green/black	black/brown	brown/black	black/gray	gray/black

In order for the hold function to work, you have to place a 20-40 mA load across the line, which is what A and A1 do. Want the light to flash on hold? No problem; it's easily done using a 555 flasher. Here's the completed hook-up with all the bells and whistles.



When A1 is in the hold position, the contacts open and the 100uF cap charges through the lower 4N25 LED, causing it to light momentarily and turn on the transistor. This triggers the SCR, which places the phone line on hold and lights the LED in the upper 4N25 optoisolator. The reset input (pin 4) of the 555 astable oscillator now goes high and activates the flasher circuit, which blinks the lamp on and off once every second. When the handset is picked up, its lower resistance quinces the SCR and places the lamp flasher in a standby mode.

TJ Byers
Q & A Editor

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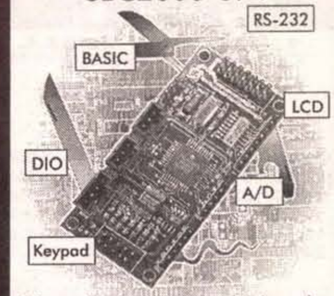

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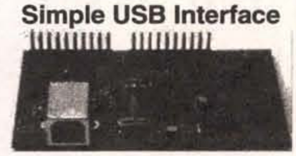

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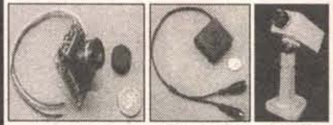

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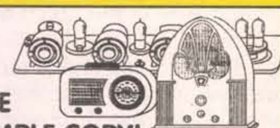

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Troubleshooting an RF Signal Generator

by Fred Blechman

The simple Lafayette LSG-10 Signal Generator sold in the early 1960s for $29.00. Similar ones today cost about $130.00.

At hamfests and swap meets – or in the ads in *Nuts & Volts* magazine – you can often find old used test equipment for sale at very low prices – about 5% of the cost of today's more complex, new equipment. Transmitters, receivers, oscilloscopes, and signal generators are just some of the items. Frequently, however, the item you get doesn't work!

Troubleshooting old equipment is often easier than dealing with the printed circuit boards, integrated circuit chips, and the tiny SMT (surface-mounted technology) components used in modern equipment. Older designs used plug-in vacuum tubes and wiring you could trace from point to point.

This story, though true, uses fictional characters to discuss how signal generators work, and describes the troubleshooting and repair of a "salvaged" RF signal generator.

Steve was excited when he appeared at my electronics service shop. "Hey, Bob, look what I just picked up at a hamfest for only $5.00 – and it even came with the user manual and schematic! I've been wanting one of these for years for my electronics experimenting, but new ones cost almost $200.00!"

Steve handed me the Lafayette LSG-10 RF Signal Generator and said, "... but I'm not sure it works!" Another challenge!

I was familiar with the LSG-10 since I had my own over 40 years ago, when Lafayette Radio – now extinct – sold practical test equipment at low prices. I recalled that mine only cost $29.00 brand new – in 1960 dollars.

"Okay, Steve, let's plug it in and see if it smokes." A few quick checks indicated that one of the six RF bands had no output at all, and the audio modulator section was dead.

"Bob, can it be fixed? And what would I really use it for? The price was so good I couldn't resist it ..."

"Steve, I think I can fix it, but before we go any further, let's first discuss what signal generators can be used for, and basically how they work. The signal generator – as the name implies – is an instrument that generates an electrical signal in either the audio frequency (AF) or radio frequency (RF) range. RF generators, like this Lafayette LSG-10, also include a single audio tone that can be used to modulate the RF. Signal generators are very popular instruments, and will be found in almost all radio-TV shops, labs – and on hobbyist workbenches.

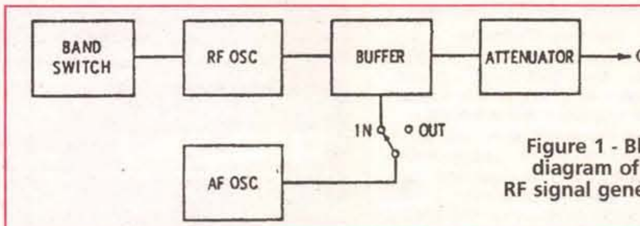

Figure 1 - Block diagram of an RF signal generator.

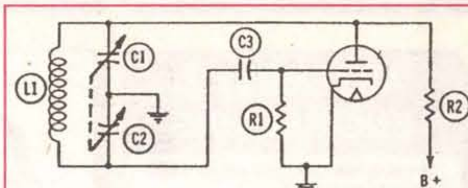

Figure 2 - Colpitts oscillator.

"A signal generator is usually considered to be a limited instrument, useful only for alignment and signal-substitution tests. As a matter of fact, AF and RF signal generators are versatile instruments, with an unexpectedly wide field of use."

I told Steve, how he could use this signal generator to localize

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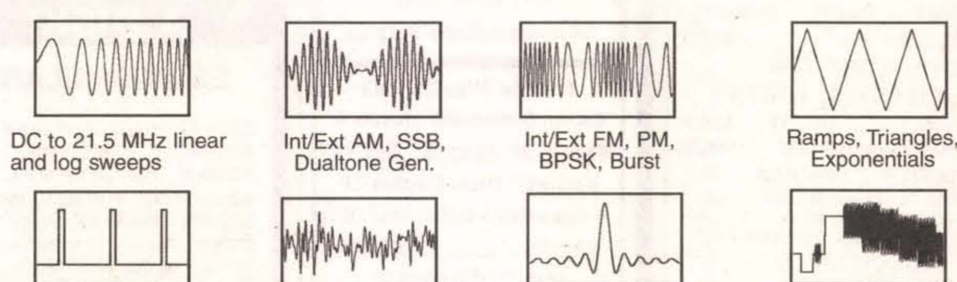

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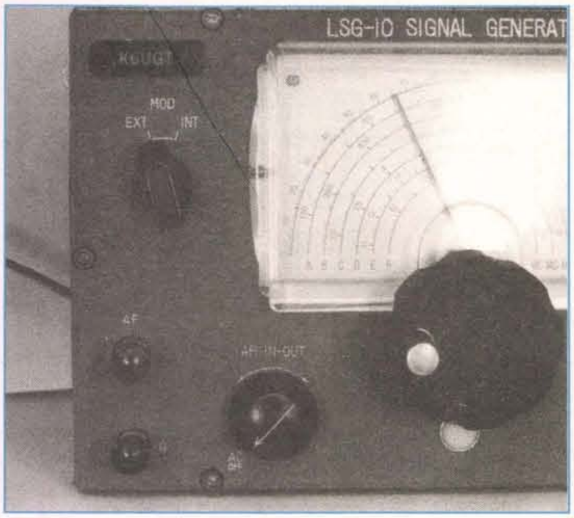
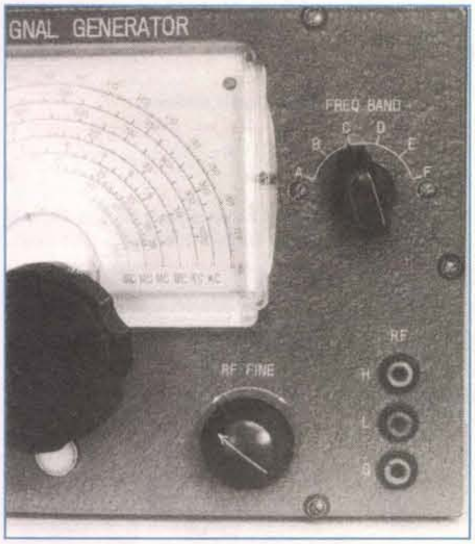


The audio frequency (AF) controls and input/output terminals are on the left side of the LSG-10.



The radio frequency (RF) controls and output terminals are on the right side of the LSG-10.

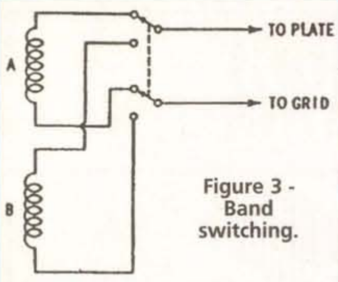


Figure 3 - Band switching.

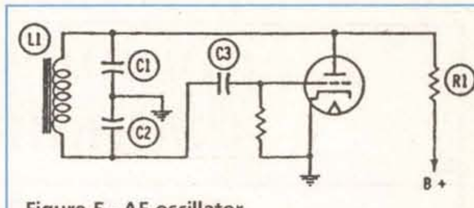


Figure 5 - AF oscillator.

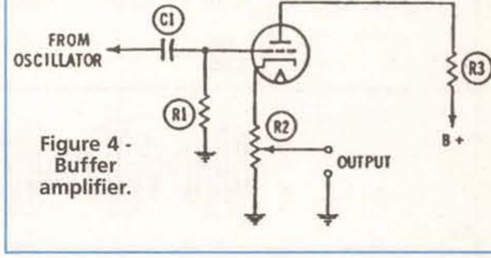


Figure 4 - Buffer amplifier.

intermittents; to check for open bypass capacitors; to check amplifier distortion; to determine the dynamic range of an amplifier; to measure image-rejection ratios; to check high-frequency impedances; to test FM receivers for AM rejection; to modulate broadcast signals, black-and-white TV signals, or color TV signals on another carrier frequency; to localize regeneration; to make over-all audio-fidelity tests; to check for frequency stability of receivers against line-voltage variations; and to make numerous other special tests.

"Wow," offered Steve, "How do I learn how to do all those things?"

"Well," I replied, "there are many test equipment books that describe these uses. For now, Steve, let's look at how the LSG-10 is supposed to work. Here's a block diagram of a typical RF signal generator." I showed him Figure 1.

Signal Generator Block Diagram

"This is just an overview, Steve. Later, I'll get into the explanation of each of these blocks. The BAND SWITCH selects the proper components for the desired range of RF frequencies to be generated by the RF OSCILLATOR. A vernier tuning control (not shown) adjusts the output frequency, which is connected to the BUFFER stage.

"A separate AF oscillator," I continued, "when switched IN, is connected to the BUFFER stage, where it combines with the RF to produce modulated RF output. The ATTENUATOR allows the signal to be controlled so as not to overload the circuit under test."

The RF Oscillator

I continued, "The simplest generator possible must contain an oscillator. The Lafayette LSG-10 uses a vacuum tube Colpitts oscillator for the RF portion. Look at Figure 2. A tuned circuit (inductance L1, with ganged variable air capacitors C1 and C2) is used. B+ voltage is fed to the plate of the tube and the tuned circuit through resistor R2."

I explained that instead of a single capacitor across the inductor, typical of a simple tuned circuit, two capacitors in series are used, with a common ground. This is an easy identification of a Colpitts.

The two capacitors across the coil each have a certain amount of reactance. Therefore, when there is an AC voltage across the tuned circuit, some of it will be across one capacitor and the rest across the other. The amount across each will depend on the capacitive reactance of the two. Generally, different values are used for each one, though not always.

I pointed out that the amount of capacitive reactance desired (and thus the amount of signal voltage developed across it) is determined by the amount of feedback voltage required. The feedback voltage is used to maintain oscillation by using the tube to furnish energy to the tuned circuit. Capacitor C3 is used not only to keep B+ from the grid, but also to pass the oscillatory signal. Resistor R1 establishes a bias for the tube grid.

"Here's what happens, Steve. The signal reaching the control grid appears at the plate (after amplification) only to be connected directly back to the tuned circuit. The amount of voltage across the circuit is divided across C1 and C2. That voltage across C2 (used as the feedback voltage) is in phase with

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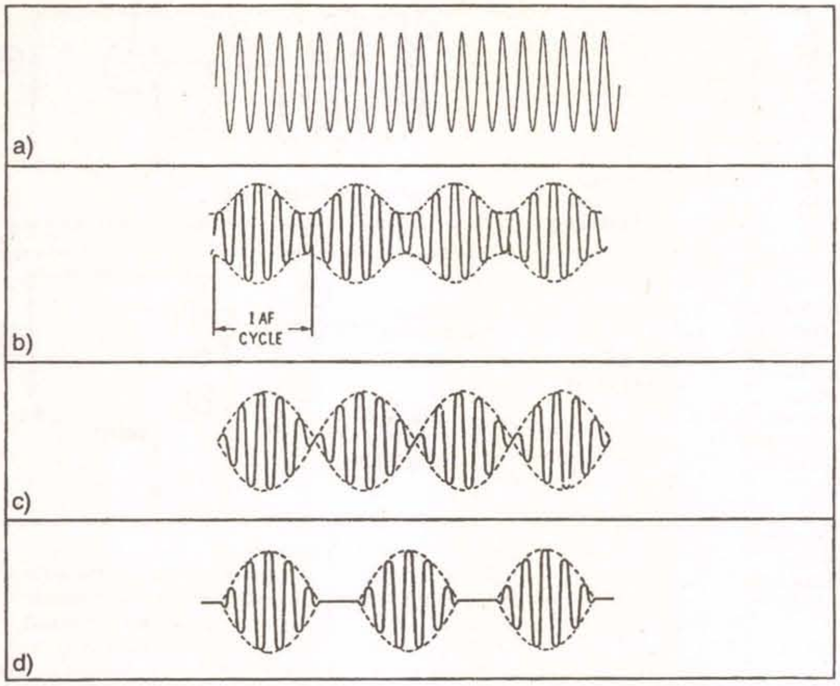


Figure 6 - AF modulation of RF carrier.

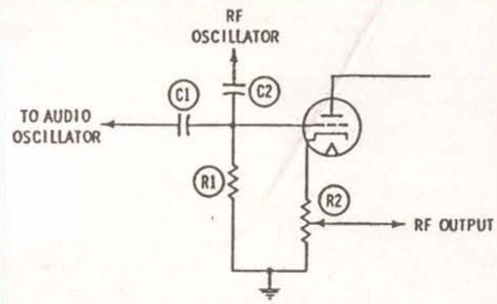


Figure 7 - Grid modulation.

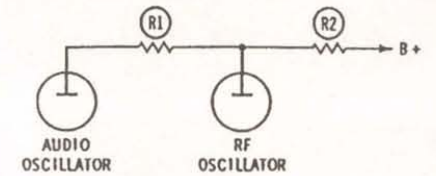
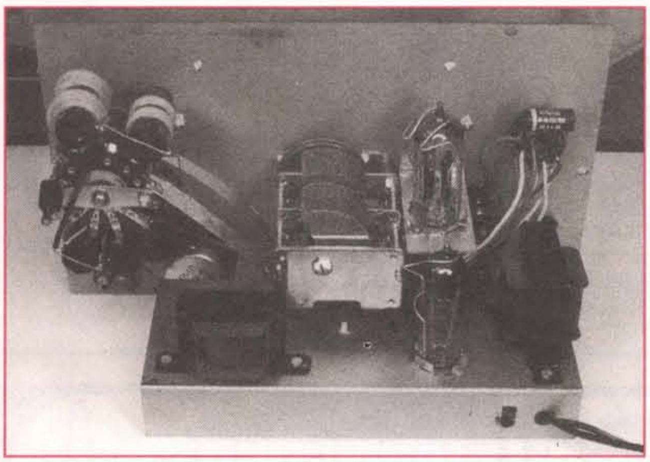
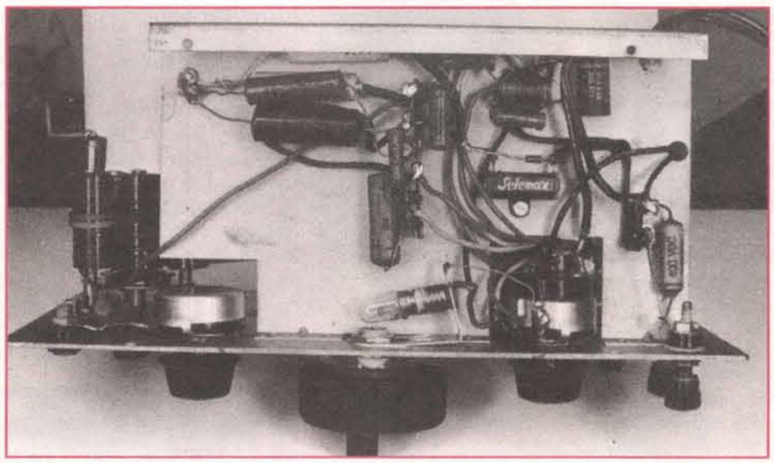


Figure 8 - Plate modulation.



The entire unit, when slipped out of the steel case, consists of a front panel and chassis bolted together. The 6AR5 AF oscillator vacuum tube is mounted on the main chassis, while the 12BH7 RF oscillator/buffer vacuum tube is mounted on a small sub-chassis next to the ganged variable air capacitors.

The underside of the chassis reveals the typical rat's-nest direct wiring of pre-printed-circuit days.



the oscillator signal and therefore aids it – maintaining the oscillation of the tuned circuit. To change frequencies, the capacitance, rather than the inductance, is generally changed."

Band Changing

I took a deep breath. "I know this is getting pretty detailed, but it's all really basic stuff that can be a great help in troubleshooting. For the RF section, the broad range of frequency coverage ordinarily required of a signal generator is much greater than can be accomplished with one coil and capacitor. To permit the oscillator to cover a considerably greater range of frequencies, a number of oscillator coils are generally used. Look at Figure 3. This drawing, Steve, illustrates a method often used to switch these coils in and out of the circuit. The switch used to connect the various coils is called the Band Switch.

"There are other possibilities for the band-changing circuit such as shorting coils out when not used rather than switching them. Also, it is possible to place coils in parallel with each other – lowering the band of frequencies usable with each coil switched in."

Steve's eyes had taken on a glassy stare. I asked, "Are you sure you want this much detail. You seem lost."

"Lost – but learning. Sock it to me!"

The Buffer

Thinking this might help Steve sometime, I went on. "Most signal generators use a buffer stage whose purpose is to act as an isolation stage between the oscillator and output. It is undesirable to load down the oscillator or place low-frequency loads on it. This might easily take place if the oscillator output were connected directly to a radio or other device.

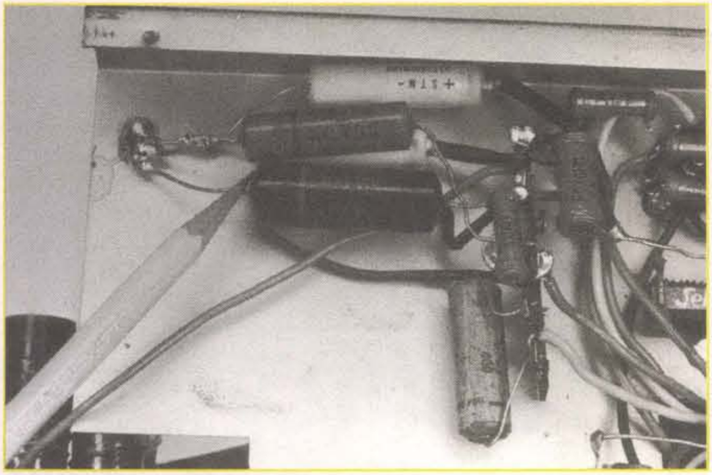
"Look at this sketch (Figure 4) of a typical buffer stage. Notice the cathode-follower output. Using a stage of this type permits the cathode follower to offer a very high impedance to the oscillator (which is very desirable) and a very low impedance to the output circuit. Many times this stage is also used to accomplish the modulating process, as I'll show you later."

The Audio Oscillator

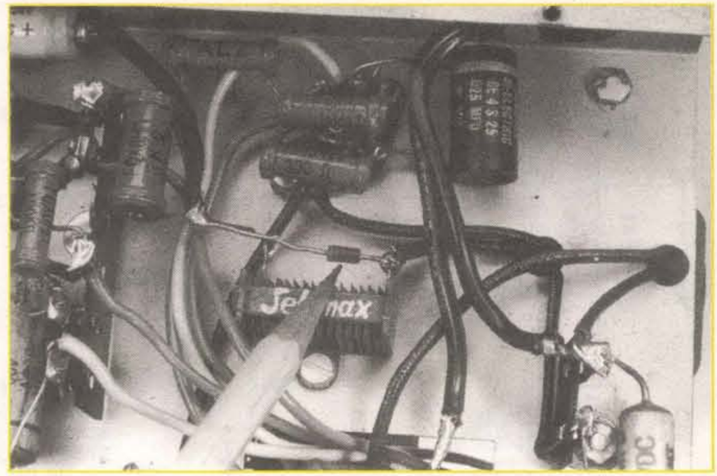
I droned on. "As I mentioned earlier, almost all signal generators contain an audio oscillator, as well as an RF oscillator. Many circuits, such as radio and television sets, have stages which handle audio frequencies; therefore, the signal generator should be capable of producing an AF test signal. Also, modulated RF signals are frequently more useful than unmodulated RF.

"Therefore, an RF signal generator should have an AF oscillator. A typical audio oscillator as used in signal generators is shown here in Figure 5. Notice the similarity to the Colpitts RF oscillator back in Figure 2.

"But there are two major differences between RF and AF oscillators. One is that instead of using an air-core coil, as in RF oscillator coils, an iron core is used for AF. The reason for this is because of the great



Oscillator capacitors C1 and C2 of Figure 9 were replaced.



The defective selenium rectifier was replaced with a common 1N4004 silicon diode. Also, capacitor C4, located by the 6AR5 tube socket, was replaced.

amount of inductance required for a frequency in the audio range. Secondly, the frequency of the audio oscillator is generally not variable. The most common frequency used for the audio oscillator is 400 cycles, though 1,000 cycles is occasionally used."

Steve interrupted. "Bob, when can we fix my signal generator?"

"Well," I replied, "We can dive into it now, but do you know what modulation is all about?"

"Duh. No. Do I need to?"

"Your signal generator is not modulating, so let's discuss that. Okay?"

Steve sat down and listened.

Modulation

I stroked my short made-me-look-like-a-professor beard and continued. "Modulation of an RF signal is the process of putting an audio signal on the RF carrier. In audio modulation (AM), the process is such that the amplitude of the RF carrier is made to vary at the rate of the audio frequency. The more audio amplitude impressed on the carrier, the greater will be the variation of the RF carrier amplitude.

"It must be mentioned, however, that only a certain amount of audio may be impressed on an RF carrier. This maximum amount is referred to as 100% modulation. Various amounts of modulation (from none at all to over 100%) may be seen in this four-part illustration (Figure 6).

"An unmodulated RF carrier is shown in Figure 6a. Notice that the amplitude is even and constant. When audio voltage having an amplitude one-quarter that of the RF is added, 50% modulation takes place, as shown in Figure 6b. Here, the amplitude of the carrier is being varied at the audio frequency rate.

"In Figure 6c, one-half as much audio signal is present as RF. The RF carrier is now 100% modulated; as much audio is present as can be used to modulate the carrier. Notice here that when the amplitude of the RF carrier decreases, the upper and lower parts of the carrier first meet, then increase again. This pattern can be seen on an oscilloscope.

"But," I pointed out, "If more than one-half as much audio as RF voltage is combined, the RF carrier will be overmodulated, as shown in Figure 6d. Here, the rise and fall of the RF carrier amplitude is broken off with a straight line occurring between each audio cycle.

"There are two common methods of modulating an RF signal in signal generators. One

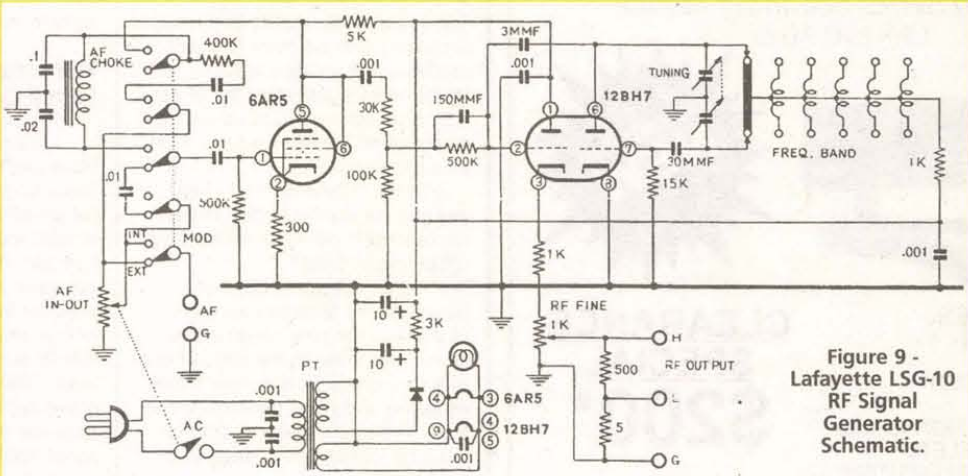


Figure 9 - Lafayette LSG-10 RF Signal Generator Schematic.

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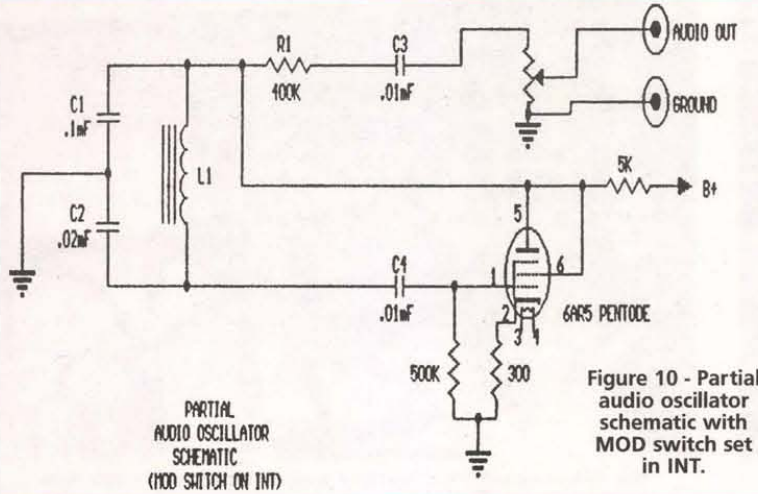
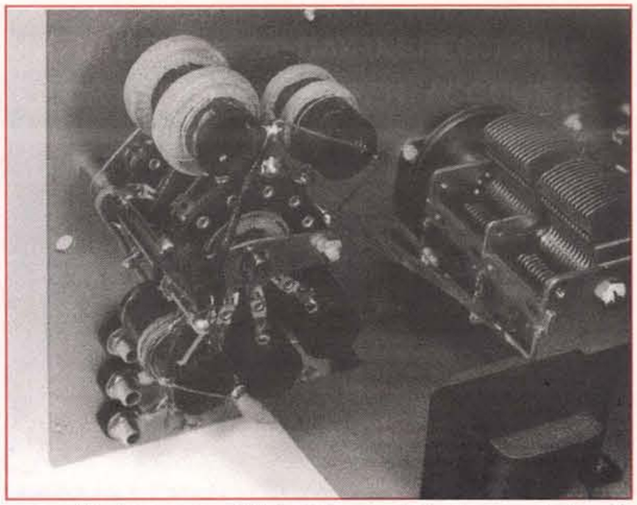


Figure 10 - Partial audio oscillator schematic with MOD switch set in INT.



The RF band switch had five special coils mounted on it.

method – called grid modulation – is shown in this illustration (Figure 7). Both AF and RF signals are capacitively-coupled to the tube control grid, thus varying the plate current.

"However, the RF oscillator goes through a complete cycle many times during only one cycle of audio. As a result, the audio voltage causes the overall gain to be varied slowly while the RF signal causes it to vary rapidly – within the amplitude set by the audio signal. This, then, causes the RF carrier amplitude to be varied by the audio frequency.

"The second method is a type of modulation similar to plate modulation where the output of the audio oscillator is at the oscillator plate, as shown in this illustration (Figure 8). The audio oscillator plate-load resistor is connected to the plate of the RF oscillator. The variation in B+ caused by the audio signal varies the RF oscillator plate voltage which causes the amplitude of the RF signal to vary at an audio rate.

"Is this," Steve asked, "where you give me my electronics degree? I'm overwhelmed. I just want my signal generator fixed."

"Steve, did you notice that I flipped on the recorder over there? I'll give you the tape. Listen a few times, with these illustrations in front of you, and you'll know more about oscillators and signal generators than many electronic engineers. Let's go just a bit further before fixing your generator."

Attenuators

I told Steve that the output of any signal generator must be made variable. In most radio and other similar work, it is desirable to have the amount of RF signal as low as possible since, as the device is aligned or tuned up, the generator output will have to be reduced.

Therefore, a fixed amount of signal from the generator is not suitable. Many methods of controlling the output of the generator are possible, but most often an attenuator pad is used. In addition, a potentiometer and a rotary switch are used. The rotary switch permits the output signal to be varied in fixed steps while the variable control allows the maximum and minimum values of the rotary-switch position to be varied.

Thus, the rotary switch is placed at one of its positions and the fine or variable control is used to set the exact amount of signal. If the variable control cannot raise the signal enough, the rotary switch is turned to the next position and the variable control is again used.

"In your LSG-10," I told Steve, "for RF output, a rotary potentiometer is used with HIGH and LOW terminals; LOW is 1/100 the value of HIGH. For AF, a simple rotary potentiometer control is used.

The Lafayette LSG-10 RF Signal Generator

I stopped, drawing a deep breath, then continued. "It's time, Steve, to get specific about your signal generator. Looking at the user manual and schematic (see Figure 9), I see that the LSG-10 is basically an RF generator with a fixed-frequency AF oscillator that can be used separately or to modulate the RF carrier. The variable RF output of up to .1 volt covers from 120KHz to 260MHz in six slightly overlapping bands. The two- to three-volt AF oscillator is fixed at about 400Hz. The user can also use an external audio source of up to four volts. The power source is 115 volts at 60Hz, using only about 12 watts.

"The RF section uses a 12BH7 dual-triode vacuum tube. One triode section is used as a Colpitts oscillator, and the other triode is used as a buffer to isolate the load from the frequency determining portion. The output portion is continuously variable with High and Low terminals. The Low terminal has 100th the output of the High terminal.

"A 6AR5 pentode vacuum tube is used in a 400Hz Colpitts oscillator circuit, either as an internal modulator or as an audio source for external use. If desired, an external audio source may be used, in which case the tube becomes an amplifier. Notice the close comparison with the circuits previously explained."

LSG-10 Disassembly

I looked closely at the LSG-10.

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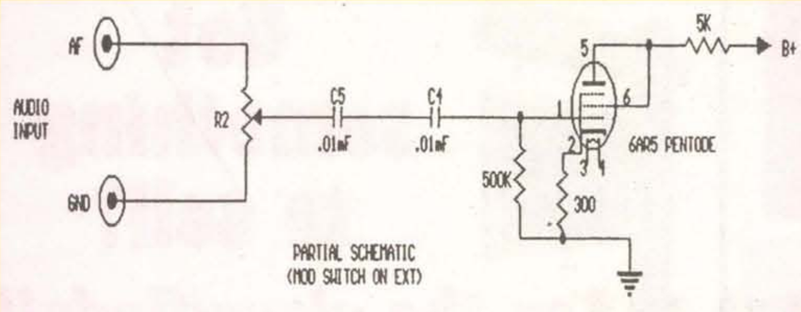
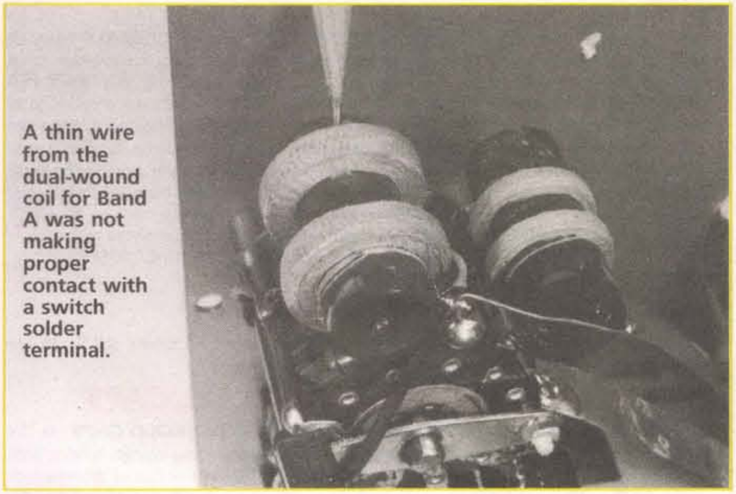


Figure 11 - Partial audio oscillator schematic with MOD switch set to EXT.



A thin wire from the dual-wound coil for Band A was not making proper contact with a switch solder terminal.

"Hmmm. This looks easy. We just remove six screws on the front panel and two screws underneath, and the entire front panel and chassis pulls out of the steel case as one piece. Neat!

"Notice, Steve," I said, "that most resistors and capacitors associated with the power supply and 6AR5 AF sections are mounted under the main chassis in the typical direct wiring of pre-printed-circuit times. Actually, though, this makes troubleshooting the AF section easier. Hmmm. However, the 12BH7 RF oscillator tube and its various circuit components are mounted on a compact subchassis very difficult to get at without removing this subassembly ..."

Troubleshooting the Audio Section

It was time to get to work. I plugged in the LSG-10 and turned it on. The pilot light glowed brightly. Since the pilot light is connected in parallel with the tube filament voltages, that meant the low-voltage section of the transformer was probably okay. However, when I connected a scope to the AF output terminals, and placed the MOD switch in the INT (internal) position, there was no signal. When I connected the scope to the RF H (high) terminal, and advanced the RF FINE control fully clockwise, I got some output when the FREQ BAND switch was on all bands – except Band A!

Although the LSG-10 schematic showed no voltages, I decided to check for B+ voltage at the positive side of the second 10mF power supply filter capacitor. The voltage seemed low, so I disconnected and tested the selenium rectifier, which had a large forward voltage drop. I replaced it with a common 1N4004 silicon diode and the B+ voltage came up considerably. This also greatly increased the RF output – but the audio was still dead.

Now it was time to use some signal injecting and tracing. However, with all the switching going on between INT and EXT at the MOD switch, it was getting confusing trying to follow the signal path – so I drew a simplied circuit showing the components involved when the switch was in the INT position. This is shown in Figure 10.

I injected the external audio signal at the plate (pin 5) of the 6AR5, and it clearly appeared at the AF output jack. This meant R1 and C3 were okay. Injecting the audio signal to the input side of C4, however, produced no output at all. This probably meant either the 6AR5 tube or capacitor C4 was bad.

I tested the 6AR5 in a tube tester and it was fine. I replaced C4, confident this would solve the problem. It did, so long as I injected a signal at C4. But when I switched the MOD to INT, there was still no AF output at the terminals, and no modulation of the RF carrier!

Next, I applied the external audio signal to the AF input with the MOD switch in EXT (as shown simplified in Figure 11) and the RF was modulated, as it should, depending on the setting of rotary potentiometer R2. So capacitor C5 was okay.

Obviously, then, the problem was that the AF oscillator was not working. Back to Figure 10. Either the L1 choke or capacitors C1 or C2 were defective. Since it was easy to change the capacitors, I did that – and the AF portion of the LSG-10 worked perfectly, and modulated the RF signal properly at about 50% (non-adjustable).

Troubleshooting RF Band A

Now, everything was working normally except for Band A of the RF section. I inspected the coils soldered to the band switch. Wires extended from the ends and center of each coil form. Each form actually had two coils on it, with a centertap between them, as shown in Figure 9.

I found that physically moving the coil form for Band A could result in RF output. Since it appeared this was being caused by a poor solder joint, I carefully resoldered the switch terminals to which the three wires from this coil were connected. That did the trick, and Band A now worked as well as the other bands!

Steve was delighted. "You've done it again! Now I can use this LSG-10 with the RCA oscilloscope you fixed for me recently, and, who knows, maybe I can fix an old radio that has been laying in the attic for the last 70 years ...

"Oh, no!" I sighed, as I sat down ...

Summary

Sometimes it's worth the time and trouble to resurrect old electronic equipment, which tends to be very expensive these days. The most common problems, as in this case, are bad capacitors and poor solder joints. Also, selenium rectifiers age badly, and should be replaced.

Keep your fingers crossed that any tubes used are good, because replacing tubes that cost $1.00 in 1960 can now cost you $20.00 each! **NV**

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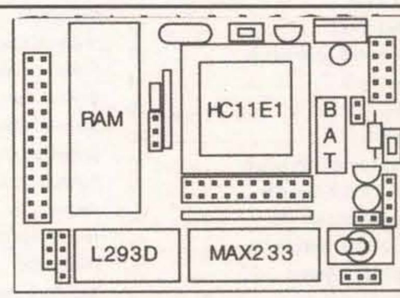

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Events CALENDAR

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.

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Events Calendar
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Phone 909-371-8497
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E-mail events@nutsvolts.com

JULY 2000

JULY 2

PA - LEHMAN - Hamfest. Luzerne County Fairgrounds, Rte. 118. FCC exams. Talk-in: 146.52, 146.61. Murgas ARC, Bob Michael N3FA, 570-288-3532. Frank N3WPG, 570-824-7579. E-Mail: n3wpg@aol.com and wb3faa@aol.com

JULY 4

PA - BRESSLER - Hamfest. Emerick Cibort Park. VE testing. Harrisburg RAC, Tom Hale WU3X, 717-232-6087. E-Mail: thale@state.pa.us Web: http://hrac.tripod.com

JULY 7-8-9

UT - BRYCE CANYON - State Convention. UT Hamfest Committee, Kathy Rudnicki N7JSH, 801-547-9218. Web: http://www.utahhamfest.org

JULY 8

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

CANADA - PE - SUMMERSIDE - Hamfest. Summerside ARC, Ella McCormick VE1PEI, 902-886-2280. E-Mail: mccormick@ns.sympatico.ca

GA - GAINESVILLE - State Convention. Georgia Mountains Center. 8:30am-3pm. VE Testing. Talk-in: 146.67(-). Lanierland ARC, Ken Johnson NZ4Q, 706-335-9658. E-Mail: nz4q@aol.com Web: http://www.mindspring.com/~w4tl/hamfest.htm

IN - INDIANAPOLIS - Central Division Convention. Marion County Fairgrounds. 6am-3pm. Talk-in: -146.76. Indianapolis Hamfest Assn., Rick Ogan N9LRR, 317-257-4050. E-Mail: oganr@in.net Web: http://www.indyhamfest.com

MI - PETOSKEY - Hamfest. 4-H Bldg. Emmet County Fairgrounds. 8am-12pm. VE testing. Talk-in: 146.68-. Straits Area ARC, Tom W8IZS, 231-539-8459 or Dirk KG8JK, 231-348-5043, E-Mail: kg8jk@qsl.net

MO - KANSAS CITY - Hamfest. PHD ARA, Bob Roske WA0CLR, 816-436-0069. E-Mail: wa0clr@worldnet.att.net Web: http://members.tripod.com/~PHDARA/

NC - SALISBURY - Hamfest. Salisbury Civic Center. VE Testing. Talk-in: 146.73 tone 94.8 and 146.52 simplex. Rowan ARS, Jim Morris KA4MPP, 704-278-4960 or Carol Maher W4CLM, 704-633-6603. E-Mail: rbrown@salisbury.net Web: http://homestead.juno.com/w4clm.ham/club2.html

WI - OAK CREEK - Hamfest. The American Legion Post 434, 9327 S. Shepard Ave. 6:30am-4pm. Talk-in: 146.52 simplex. South Milwaukee ARC, Bob Kastelic WB9TIK, 414-762-3235 days & early eves.

JULY 9

IL - PEOTONE - Hamfest. Will County Fairgrounds. Talk-in: 146.94 (-600). Kankakee Area Radio Society, Don Kerouac K9NR, 815-939-7548. E-Mail: k9nr@juno.com Web: http://www.w9az.com

OH - BOWLING GREEN - Hamfest. Wood County Fairgrounds. 8am-1pm. Talk-in: 147.18+ or 444.475+ PL 77.0. Wood County ARC, John Lagger AA8XS, 419-662-9686. E-Mail: aa8xs@arrl.net Web: http://bravais.bgsu.edu/~boughton/hamfest.html

PA - PITTSBURGH - Hamfest. Northland Public Library, 300 Cumberland Rd. 8am-3pm. Talk-in: 147.09. North Hills ARC, Keith Ostrom KB3ANK, 412-821-4135. Bob Ferrey, Jr. N3DOK, 412-367-2393, E-Mail: n3dok@pgh.net Web: www.nharc.pgh.pa.us

JULY 14-15-16

MT - EAST GLACIER - State Convention. Glacier/Waterton Int'l Hamfest Committee, Frank Phillips AC7AY, 406-273-2894. E-Mail: ac7ay@bigsky.net Web: http://www.tlatech.com/hamfest/

JULY 15

CO - LOVELAND - Hamfest. Larimer County Fairgrounds, 700 Railroad Ave. 9am-4pm. VE exams. Talk-in: 145.115 (- offset) or 146.52 simplex. NCARC, Michael Taylor N7RKC, 970-203-0609 eves. E-Mail: mtaylor@hach.com Web: http://www.info2000.com/~ncarc

MD - BRUNSWICK - Hamfest. Mid-Atlantic DX & Repeater Assn., Roy Bates N2CSQ, 301-834-9351. E-Mail: 74163.200@compuserve.com

MI - FAIRVIEW - Hamfest. Au Sable Valley ARC, Gerry Crawford K8GER, 517-848-5996 or 517-826-8131. E-Mail: k8ger@arrl.net

NC - CARY - Hamfest. Cary Community Center, 404 N. Academy St. Cary ARC, Herb Lacey W3HL, 919-467-9608. E-Mail: infomanag@aol.com Web: http://www.ipass.net/~falynch/carc/carc.html

OH - WELLINGTON - Hamfest. Lorain County Fairgrounds. 8am-2pm. VE Exams. Talk-in: 146.10/70. Northern Ohio ARS, John Shaaf KC8AOX, 216-696-5709. E-Mail: kc8aox@qsl.net Web: http://www.apk.net/noars/noarsfe.htm

PA - BERWICK - Hamfest. Jonestown Mountain Repeater Assn., Grace Ann Hovancak N3UMO, 570-759-8628

TX - SHERMAN/DENISON - Hamfest. Silver Wings Club, Grayson County Airport. VE testing. Talk-in: 147.00. Wilmer O. Kinsey WB5DCU, 903-893-5872. E-Mail: wb5dcu@gte.net Web: http://home1.gte.net/wb5dcu/nortex00.html

TX - TEXAS CITY - Hamfest. Tidelands ARS, Joe Wileman AA5OP, 409-945-6794. E-Mail: aa5op@aol.com

JULY 16

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

MO - WASHINGTON - Hamfest. Zero Beaters ARC, Keith Wilson K0ZH, 636-629-2264. E-Mail: jwpubl@fidnet.com Web: http://zbarc.usmo.com/

NJ - AUGUSTA - Hamfest. Sussex County Fairgrounds, Plains Rd. Talk-in: 147.90/30. Sussex County ARC, Dan Carter N2ERH, 973-948-6999. E-Mail: n2erh@email.com Web: http://www.scarcnj.org

NY - BATAVIA - Hamfest. Batavia Downs, 8315 Park Rd. Talk-in: W2RCX, 147.285+. GRAM, Randy Boyle K2RLB, 716-948-9679. E-Mail: racboyle@iinc.com Web: http://www.majordomo@hamgatel.sunyerie.edu/~gram/

OH - VAN WERT - Hamfest. Van Wert County Fairgrounds, US Rt. 127 S. 8am-3pm. Talk-in: 146.85. Van Wert OH ARC, Robert Barnes, 419-238-1877. E-Mail: barnesrl@bright.net Web: http://www.bright.net/~barnesrl/w8fy.html

PA - KIMBERTON - Hamfest. Fire Co. Fairgrounds. Rte. 113. Talk-in: 146.835/- and 443.80/+. MARC, Bill Owen W3KRB, 610-325-3995. E-Mail: hamfest-info@marc-radio.org Web: http://www.marc-radio.org/hamfest.html

JULY 21-22

FL - MILTON - Hamfest. Santa Rosa County Auditorium. Fri: 5pm-9pm, Sat: 8am-2pm. FCC Exams. Talk-in: 146.70. Milton ARC, Bill Couch W4VY, 850-623-0592. E-Mail: billcouch@sprintmail.com Web: http://home.att.net/~k4ozl/marc.htm

JULY 22

NH - NASHUA - Hamfest. Res Ctr Church. NE Antique RC 617-923-2665

NY - FRANKFORT - Hamfest. Utica ARC, Bob Decker AA2CU, 315-797-6614. E-Mail: ktrnd@borg.com

OH - CINCINNATI - Hamfest. Diamond Oaks Development Campus, 6375 Harrison Ave. 7am-2pm. VE Exams. Talk-in: 146.67 and 146.925. OH-KY-IN ARS, Gene McCoy N8KOJ, 513-541-6935. E-Mail: n8koj@arrl.net Web: http://www.qsl.net/k8sch

TN - DAYTON - Hamfest. Rhea County ARS, Bob Jordan KN4VY, 423-775-3225. E-Mail: kn4vy@arrl.net Web: http://webcube.volstate.net/~ko4sy/

JULY 23

IL - SUGAR GROVE - Hamfest. Waubonsee Community College, Rt. 47 Harter Rd. VEC Exams. Talk-in: 147.210 (+600) PL 103.5/107.2. Fox River Radio League, Maurice Schietecatte W9CEO, 815-786-2860. E-Mail: w9ceo@arrl.net Web: http://www.frrl.org/hamfest.html

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Web: www.petertrapp.com

JULY 28-29

OK - OKLAHOMA CITY - State Convention. OK State Fair Park, Made in OK Bldg. Fri: 5-8pm, Sat: 8am-5pm. Talk-in: 146.82. Central OK Radio Amateurs, Harold Miller KB1ZQ, 405-672-7735 or 405-650-9963. E-Mail: n1lpn@swbell.net Web: http://www.geocities.com/heartland/7332

TX - AUSTIN - Convention. Austin ARC, Austin Repeater Group, Texas VHF-FM Society, Joe Makeever W5HS, 512-345-0800. E-Mail: w5hs@arrl.net Web: http://www.repeater.org/summerfest/

JULY 28-29-30

AZ - FLAGSTAFF - State Convention. Ft. Tuthill. Fri: 12pm-5pm, Sat: 9am-5pm, Sun: 9am-2pm. VE Testing. Talk-in: 146.980 MHz with 100.0 Hz PL Tone. ARCA, Norm Martin K7OLD, 520-297-9562. E-Mail: norm@hamsrus.com Web: http://www.hamsrus.com/tuthill.html

CANADA - BC - VANCOUVER - Pacific Northwest DX Convention. BC DX Club & Fraser DX Club, Dave Johnson VE7VR, 604-438-8715. E-Mail: ve7vr@rac.ca Web: http://www.bcdxc.org

JULY 29

NC - WAYNESVILLE - Hamfest. Western Carolina ARS, Pat Kelsey AB5RB, 828-236-0181. E-Mail: ab5rb@bellsouth.net Web: http://www.wcars.org/hamfest2000

NV - RENO - Hamfest. Sierra Nevada ARS, Bill Massie K7NHP, 775-246-3756. E-Mail: k7nhp@arrl.net

OR - BANDON - Hamfest. Coos County RC, Brian Howard W7MLT, 541-572-5623. E-Mail: w7mlt@usa.net

JULY 30

MD - TIMONIUM - Hamfest. Timonium Fairgrounds. Talk-in: 147.03+ and 224.96-. BRATS, Mayer Zimmerman W3GXK, 410-461-0086.E-Mail: w3gxk@arrl.net Web: http://www.smart.net/~brats

OH - RANDOLPH - Hamfest. County Fairgrounds, St. Rt. 44. 8am-4pm. VE exams. Portage ARC, Joanne Solak KJ3O, 330-274-8240. E-Mail: ljsolak@apk.net Web: http://parc.portage.oh.us

AUGUST 2000

AUGUST 4-5-6

IL - ELGIN - Radiofest. Ramada Hotel, 345 River Rd. ARCI, POB 1139, LaGrange Park, IL 60526. E-Mail: arci31280@aol.com

AUGUST 5

IL - CARLINVILLE - Hamfest. Macoupin County Fairgrounds. Talk-in: 146.82- or 443.400+ 103.5PL. Macoupin County ARC, Tim Jones 217-627-2355. E-Mail: KA9VIV at jester25@royell.net

MI - ESCANABA - Hamfest. Delta County ARS, John Anderson WD8RTH, 906-789-6950. E-Mail: wd8rth@arrl.net

MI - TAWAS - Hamfest. Iosco County AR Enthusiasts, John Hanley KA8AIP, 517-756-2845. E-Mail: ka8aip@centurytel.net Web: http://www.oscoda.net/icare/

MO - SPRINGFIELD - Hamfest. Southwest MO ARC, Woodvall Moore W0ODY, 417-833-2248. E-Mail: w0ody@arrl.net Web: http://www.smarc.org

NM - ROSWELL - Hamfest. Pecos Valley ARC, Vernetta Verasso KC5WKA, 505-627-7777. E-Mail: kc5wka@dfn.com Web: http://www.pvarc.com

NY - ITHACA - Hamfest. Tompkins County Airport. 7am-2pm. VE testing. Talk-in: 146.97. Tompkins County ARC, Richard Spingarn AA2UP, 607-387-5251. E-Mail: richard@eagleprint.com Web: http://www.compcenter.com/~tcarc

Events CALENDAR

OH - COLUMBUS - Hamfest. Voice of Aladdin ARC, James Morton KB8KPJ, 614-846-7790. E-Mail: kb8kpj@cs.com

PA - LEWISTOWN - Hamfest. US 522 N. Decatur Township Fire Co. Grounds. Talk-in: 146.91. JVARC and the Decatur Township Fire Co., Richard Yingling, 717-242-1882

TX - SULPHUR SPRINGS - Hamfest. Hopkins County ARC, Steve Heller WA0CPP, 903-945-3659. E-Mail: steve@steveheller.com Web: http://www.qsl.net/hcrc

VA - VINTON - Hamfest. William Byrd High School, Washington Ave. 9am-3pm. VE exams. Talk-in: 146.985 (-600) W4CA. Roanoke Valley ARC, Dave Miller 540-977-3142. E-Mail: dmiller@rev.net or Fponton@worldnet.att.com Web: http://ourworld.compuserve.com/home spages/fcupp/rvarc.htm

AUGUST 5-6

WA - SPOKANE - Eastern WA Section Convention. University High School, 10212 E. 9th Ave. Sat: 9am-5pm, Sun: 8am-12pm. NW Tri-State ARO, Palouse Hills ARC, Inland Empire VHF & Spokane RA, Kamiak Butte Am. Rptr., Betsy Ashleman N7WRQ, 509-448-5821. E-Mail: n7wrq@aol.com Web: http://www.iea.com/~n7utg

AUGUST 6

IN - ANGOLA - Hamfest. Land of Lakes, Bill Brown WD9DSN, 219-475-5897. E-Mail: sharon.l.brown@gte.net

VA - BERRYVILLE - Hamfest. Clarke County Ruritan Fairgrounds. VE Exams. Talk-in: 146.82-. Shenandoah Valley ARC, Irvin Barb W4DHU, 540-955-1745. E-Mail: ibarb@visuallink.com Web: http://www.vvalley.com/svarc/hamfest

WI - MARSHFIELD - HAMNIC. Marshfield Area ARS, Guy Boucher KF9XX, 715-384-4323. E-Mail: guyboucher@tznet.com

AUGUST 12

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

IL - QUINCY - Hamfest. Eagles Alps Grounds, 3737 N. 5th St. 8am-2pm. VEC Testing. Talk-in: 147.63/147.03. Western IL ARC, Jim Funk N9JF, 217-336-4191. E-Mail: jfunk@adams.net Web: http://www.qsl.net/w9awe

ME - ST. ALBANS - Hamfest. Piscataquis ARC, George Dean WA1JMM, 207-965-8864. E-Mail: wa1jmm@midmaine.com

NY - ROME - Hamfest. Rome RC, Russell Schorer KB2MAS, 315-853-8739. E-Mail: w4bny@juno.com

VT - BURLINGTON - Hamfest. Elks Club on North Ave. 8am-3pm. VE session. Burlington ARC, Renee Berteau N1UXK, 802-893-7660. E-Mail: n1uxk@juno.com Web: http://www.together.net/~kd1r/fest00.htm

WV - HUNTINGTON - Hamfest. Veterans Memorial Field House, 2590 5th Ave. 8:30am-2pm. VE testing. Talk-in: 146.76-. Tri-State ARA, Dwight D. Smith, Sr. WB8JPJ, 304-522-7865. E-Mail: wb8jpj@home.com Web: www.qsl.net/tara

AUGUST 13

CA - GOLETA/SANTA BARBARA - Hamfest. Santa Barbara ARC, Alan Soenke WA6VNN, 805-562-2694. E-Mail: wa6vnn@sbarc.org Web: http://www.sbarc.org

IA - AMANA - Hamfest. Amana Outdoor Convention Center. VE Exams. Talk-in: 146.745/.145 and 146.520. Cedar Valley ARC, Chuck Bassett N0UTS, 319-378-0448. E-Mail: n0uts@rf.org Web: http://cvarc.rf.org

IL - PEOTONE - Hamfest. Hamfesters Radio Club, Christine Mack K9RFY, 708-358-1786. E-Mail: christine1@mediaone.net

IN - GREENTOWN - Hamfest. Greentown Lions Club Fairgrounds. Kokomo & Grant County ARCs, L.B. (Nick) Nickerson KA6NQW, 765-668-4814. E-Mail: ka6nqwnick@netusa1.net Web: http://www.netusa1.net/~ka6nqwnick/hamfest.html

MA - ORANGE - Hamfest. Mohawk ARC, John Dould AE1B, 978-249-5905. E-Mail: ae1b@gis.net

MI - JACKSON - Hamfest. Jackson Community College. VE testing. Cascade ARS, Dennis Byrne KC8IJZ, 517-522-4058 or 517-796-6966. E-Mail: byrneda@voyager.net Web: http://www.qsl.net/cars-jxn

MN - ST. JOSEPH - Hamfest. St. Cloud ARC, Linden Scott Hall KA0DAQ, 320-252-4498. E-Mail: lscotth@aol.com Web: http://www.w0sv.org/hamfest.html

NJ - BAYVILLE - Hamfest. Bayville Fire House, Rt. 9. VE Testing. Talk-in: 146.910 out, 146.310 in, PL 127.3. Jersey Shore ARS, Bob Murdock WX2NJ, 732-269-6379. E-Mail: jsarsfest@aol.com Web: http://members.aol.com/jsarsfest/jsa rsfest.html

NY - CHEEKTOWAGO - Hamfest. Leonard Post VFW, Walden Ave. VE Testing. Lancaster ARC, Luke Calianno N2GDU, 716-634-4667 or 716-683-8880. E-Mail: lcalianno@freewwweb.com Web: http://hamgate1.sunyerie.edu/~larc

PA - YORK - Hamfest. VE testing. Talk-in: 146.700. York ARC, Southern PA Comm. Group, & Hilltop Transmitting Assn., Cecil Mundorff K3DCU, 717-927-6662

AUGUST 18-19-20

CANADA - BC - PRINCE GEORGE - Hamfest. Prince George ARC, Brent Lyons E-Mail: lyonsden@saintmail.net Web: http://www.pghamfest.dhs.org/

AUGUST 19

KS - CHANUTE - Hamfest. Chanute Area ARC, Charlie Ward WD0AKU, 316-431-6402

NJ - OAKLAND - Hamfest. Ramapo Mountain ARC, Anthony Cassera N2KDZ, 914-732-2731 or 973-839-3564. E-Mail: acassera@intac.com Web: http://www.intac.com/~hansen/rmarc.htm

WA - LONGVIEW - Hamfest. Cowlitz County Expo Center. 9am-1pm. Talk-in: 147.26+. Lower Columbia ARA, Bob Morehouse KB7ADO, 360-425-6076. E-Mail: kb7ado@aol.com Web: http://www.qsl.net/nc7p/swapmeet.htm

AUGUST 20

CO - GOLDEN - Convention. Denver RC, Ron Taylor K0HRT, 303-989-3978. E-Mail: k0hrt@arrl.net Web: http://www.qsl.net/w0tx

IN - LAFAYETTE - Hamfest. Tippecanoe County Fairgrounds. 8am-2pm. Talk-in: 147.135/443.775. Tippecanoe ARA, Bob Martin W9YE, 765-423-1035. Web: www.w9reg.org

KY - LEXINGTON - Hamfest. National Guard Armory, adjacent to Lexington airport. 8am-4pm. VE sessions. Talk-in 146.760-. Bluegrass ARS, John Barnes KS4GL, 606-253-1178. E-Mail: KS4GL@juno.com Web: http://www.qsl.net/k4kjg

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

OH - WARREN - Hamfest. Trumbull Campus Kent State Univ., Rt. 45 (Mahoning Ave.) and Rts. 5/82 bypass. Talk-in: 146.970, 443.000. Warren ARA, Renee McCaman KB8SVF, 330-755-2433. E-Mail: mccaman@cboss.com Web: http://www.onecom.net/wara

AUGUST 25-26-27

MA - BOXBOROUGH - Convention. Holiday Inn Conference Center. Tony Penta W1ABC, 617-248-6996 or 978-887-8887. E-Mail: w1abc@arrl.net Web: http://www.boxboro.org

AUGUST 26

MO - COLUMBIA - Convention. National Guard Armory, 5151 Roger Wilson Dr. 8am-2pm. VE testing. Talk-in: 146.76-. Central MO Radio Assn., Dewey Bennett WM0H, 573-445-7030. E-Mail: dbenne01@coin.org Web: http://www.qsl.net/~cmra

TX - GAINESVILLE - Hamfest. Cook County ARC, James Floyd N5ZPU, 940-668-7511. E-Mail: jfloyd@cooke.net Web: http://HOME1.GTE.NET/rperkins/ccarc.htm

WV - JACKSONS MILL - State Convention, WV State AR Council, Ann Rinehart KA8ZGY, 304-768-9534. E-Mail: ka8zgy@arrl.net Web: http://www.qsl.net/wvsarc

AUGUST 27

IL - DANVILLE - Hamfest. Vermilion County ARA, Terry England W9CAU, 217-446-6076. E-Mail: w9cau@soltec.net Web: http://members.soltec.net/~wx9ema/VCARA/

IN - LA PORTE - Hamfest. La Porte County Fairgrounds. 7am-1pm. Talk-in: 146.52, 146.61(-) PL 131.8. La Porte ARC, Neil Straub WZ9N, 219-324-7525. E-Mail: nstraub@niia.net Web: www.geocities.com/siliconvalley/byte/1653

KS - SALINA - State Convention. Central KS ARC, Ron Tremblay WA0PSF, 785-827-8149. E-Mail: tremblay@midusa.net Web: http://www.qsl.net/w0cy

MI - LAPEER - Hamfest. Lapeer County Center Bldg. 8am-4pm. VE testing. LCARA, Charles Conley N8RVG, 810-245-0347. E-Mail: cconley@bigfoot.com Web: http://www.lapeer.com/lcara

MO - ST. CHARLES - Hamfest. Blanchette Park. 6:30am-1pm. Talk-in: 146.670-. St. Charles ARC, Ken Fieser KB0VLN, 314-428-4383. E-Mail: kfieser@aol.com Web: http://www.qth.com/wb0hsi/

NY - YONKERS - Hamfest. Saunders High School, 145 Palmer Rd. 8:30am-2pm. VE testing. Talk-in: 146.265/865. Yonkers ARC, John, 914-963-1021; Paul, 914-237-5589; Dan, 914-667-0587. E-Mail: w2yrc@hotmail.com

PA - NEW KENSINGTON - Hamfest. Skyview Radio Society, Robert Livrone N3WAV, 724-339-9607. E-Mail: n3wav@arrl.net

SEPTEMBER 2000

SEPTEMBER 2

CANADA - ONTARIO - CARP - Hamfest. Carp Agricultural Fairgrounds, 3970 Carp Rd. 10am-1pm. Talk-in: VE2CRA 146.940-. The Ottawa ARC, Inc., Greg Danylchenko VE3YTZ, 613-236-9291. E-Mail: fleamarket@oarc.net Web: http://oarc.net/fleamarket

TX - SULPHUR SPRINGS - Hamfest. Hopkins County ARC, Steve Heller WA0CPP, 903-945-3659. E-Mail: steve@steveheller.com Web: http://www.qsl.net/hcrc

SEPTEMBER 2-3

NC - SHELBY - Hamfest. Cleveland County Fairgrounds, US Hwy. 74. Shelby ARC, John Ledford W4JL, 704-482-4507. E-Mail: w4jl@shelby.net Web: http://www.shelby.net/n4fan

SEPTEMBER 8-9

AR - MENA - Hamfest. Queen Wilhelmina Hamfest Assn., Ray Lively W5DLC, 903-764-5599. E-Mail: raysoft@intrastar.net

SEPTEMBER 8-9-10

FL - MELBOURNE - Hamfest. Melbourne Auditorium. Platinum Coast ARS, Tim Madden KI4TG, 407-724-9339. E-Mail: ki4tg@hotmail.com

SEPTEMBER 9

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

IN - SPENCER - Hamfest. Owen County ARA, Kathryn Smith K9INU, 812-829-2140

KY - LOUISVILLE - State Convention. Bullitt County Fairgrounds. 8am-5pm. FCC exams. Greater Louisville Hamfest Assn., Herbert Rowe W4WQD, 812-294-4905. E-Mail: wd4ixl@juno.com Web: http://www.thepoint.net/~glha/

MI - GRAYLING - Hamfest. Hanson Hills Recreation Area, 7601 Old Lake Rd. 8am-12pm. VE Testing. Talk-in: 145.13. ARA of Hansen Hills, John Schultz N8YSS, 517-348-4966. E-Mail: jschultz@i2k.net Web: http://www.arahh.org/swapshop.html

MN - RUSH CITY - Hamfest. East Central MN ARC, Larry Jilek KA0MEN, 320-358-4205. E-Mail: lj@ecenet.com

NY - BALLSTON SPA - Hamfest. Saratoga County Fairgrounds. 7am-3pm. VE Testing. Talk-in: 146.40/147.00 and 147.84/147.24. Saratoga County RACES Assn., Inc., Darlene Lake N2XQG, 518-587-2385. E-Mail: lake@capital.net Web: http://www.capital.net/users/lake

SEPTEMBER 9-10

FL - MELBOURNE - Hamfest. Platinum Coast ARS, Tim Madden KI4TG, 407-724-9339. E-Mail: ki4tg@hotmail.com

SEPTEMBER 10

MA - SOUTH DARTMOUTH - Hamfest. Southeastern MA ARA, Bill Miller K1IBR, 508-996-2969. E-Mail: billmiller@netzero.net

NY - BETHPAGE - Hamfest. Briarcliffe College, 1055 Stewart Ave. 8:30am-2pm. VE testing. Talk-in: W2VL 146.85 repeater (136.5 PL). Long Island Mobile ARC, Ed Muro KC2AYC, 516-520-9311. E-Mail: hamfest@limarc.org Web: http://www.limarc.org

PA - BUTLER - Hamfest. Butler County ARA, Gerald Wetzel, W3DMB, 724-282-6777. E-Mail: w3dmb@arrl.net Web: http://www.cfcorp.com/bcara/

SEPTEMBER 15-16-17

IL - PEORIA - Hamfest. Exposition Gardens. 6am-4pm. FCC Exams. Talk-in: 147.075+, 53.990 (-1.7), and 146.76(-). Peoria Area ARC, Ron Morgan KB9NW, 309-692-3378 or 309-694-2469. E-Mail: kb9nw@juno.com Web: http://www.w9uvi.org

SEPTEMBER 16

AR - LITTLE ROCK - All-Arkansas Hamfest. CAREN, Scott Derden K5SCD, 501-258-1881. E-Mail: k5scd@arrl.net Web: http://carenclub.webjump.com

GA - DALLAS - Hamfest. Paulding Meadows Park. 8am-2pm. Talk-in: 146.895+ 77Hz, 224.700-. Paulding County ARC, Inc., Bill Houston WD4LUQ, 770-445-9191. E-Mail: Bhouston@worldnet.att.net Web: http://www.pauldingarc.com/

IL - ROLLING MEADOWS - Convention. Northern IL DX Assn., Bill Smith W9VA, 847-945-1564. E-Mail: w9va@aol.com Web: http://www.qth.com/w9dxcc

MI - GRAND RAPIDS/CALEDONIA - Hamfest. Caledonia High School. VE exams. Talk-in: 147.26+ ctcss 94.8 or 146.52 simplex. Grand Rapids ARA, Lowell ARC, & MI ARA, Lee Burgess W8MLB, 616-458-9297. E-Mail: hamfest@w8dc.org Web: http://www.w8dc.org

NY - WHITE PLAINS - Hudson Division Convention. Westchester County Center. 8am-2pm. Talk-in: 147.06 PL 114.8. Westchester Emergency Communications Assn., Thomas Raffaelli WB2NHC, 914-741-6606. E-Mail: wb2nhc@weca.org Web: http://www.hudsonconvention.org

PA - SCHNECKSVILLE - Hamfest. Schnecksville Fire Dept. Talk-in: 146.70 (PL151.4)/R, 444.90 (PL151.4)/R. The Delaware Lehigh ARC, Inc., Carl Seier, 610-261-0403. E-Mail: aa3ix@arrl.net Web: http://www.kutztown.edu/faculty/chuk/dlarc/

SEPTEMBER 16-17

PA - YORK - Hamfest. York Hamfest Foundation, John Shaffer W3SST, 717-764-8193 or 717-764-4805. E-Mail: w3sst@yorkhamfest.org Web: http://www.yorkhamfest.org

SEPTEMBER 17

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

OH - CINCINNATI - Hamfest. Kolping Center. 8am-4pm. VE exams. Talk-in: 146.88-. Greater Cincinnati ARA, Jim Weaver K8JE, 513-459-0142. E-Mail: k8je@arrl.net

PA - YORK - Hamfest. York County Vo-Tech School. VEC testing. York Hamfest Foundation, 717-764-8193. E-Mail: w3sst@yorkhamfest.org Web: http://www.yorkhamfest.org

SEPTEMBER 23

NY - HAMBURG - Western NY ARRL Section Convention. Erie County Fairgrounds, Rt. 62. 8:30am-4:30pm. Harold Smith K2HC, 716-424-7184 E-Mail: info@buffalohamfest.org Web: http://www.buffalohamfest.org

NY - MARGARETVILLE - Hamfest. Margaretville ARC, Lester Bourke KB2DCE, 914-586-3186 or 914-586-2324. E-Mail: bourke@catskill.net Web: http://www.catskill.net/marc

TX - WEBSTER - Hamfest. Clear Lake ARC, Kyle Swarts KD5HQD, 713-666-5854. E-Mail: kd5hqd@mindspring.com Web: http://www.clarc.org/swapfest.htm

WA - WALLA WALLA - Hamfest. Walla Walla ARC, Mary Hayter KC7PNE, 509-522-5227. E-Mail: kk7sr@arrl.net

SEPTEMBER 23-24

IL - GRAYSLAKE - Hamfest. Lake County Fairgrounds, Rts. 45 & 120. Sat: 8am-4pm, Sun: 8am-3pm. VEC Testing. Talk-in: 146.16/76 MHz (107.2 Hz PL). Chicago FM Club, Mike Brost WA9FTS, 708-457-0966. E-Mail: mbrost@cin.net Web: http://www.chicagofmclub.org

VA - VIRGINIA BEACH - Roanoke Division Convention. Virginia Beach Pavilion. Sat: 9am-5pm, Sun: 9am-4pm. Talk-in: 146.970. Tidewater Radio Conventions, Art Thiemens AA4AT, 757-484-2857. E-Mail: aa4at@arrl.net Web: http://www.vahamfest.com

SEPTEMBER 24

FL - NEW PORT RICHEY - Hamfest. New Port Richey Recreational Center, 6630 Van Buren Rd. 9am-3pm. Suncoast ARC, Ron Wright N9EE, 727-376-6575. E-Mail: n9ee@akos.net

MD - BOWIE - Hamfest. Prince George's Stadium. VEC testing. Talk-in: 147.105, 146.529. FAR, Dan Blasberg KA8YPY, 301-345-7381, E-Mail: Blasberg@Bellatlantic.net Web: http://www.amateurradio-far.org

NY - YONKERS - Flea Market. Lincoln High School, Kneeland Ave. 9am-3pm. VE Exams. Talk-in: 440.425 PL 156.7, 223.760 PL 67.0, 146.910, 443.350 PL 156.7. Metro 70cm Network, Otto Supliski WB2SLQ, 914-969-1053. E-Mail: wb2slq@juno.com Web: http://www.metro70cmnetwork.com

OH - CLEVELAND - Hamfest. 8am-2pm. VE exams. Talk-in: 146.73/R PL 110.9. Hamfest Association of Cleveland, Ron Nichols N8LZA, 1-800-CLE-FEST or 216-999-7388. E-Mail: info@hac.org Web: http://www.hac.org

SEPTEMBER 29-30

PA - TREVOSE- Convention. Mt. Airy VHF Radio Club, John Sortor KB3XG, 610-584-2489. E-Mail: johnkb3xg@aol.com Web: http://www.ij.net/packrats

SEPTEMBER 30

NY - HORSEHEADS - Hamfest. Chemung County Fairgrounds. 6am-3pm. FCC exams. Talk-in: 146.70- 444.20. ARAST, Dave Lewis, 607-589-7636. E-Mail: info@arast.org, hamfest@arast.org, or winterfest@arast.org

SD - SIOUX FALLS - Hamfest. Sioux Empire ARC, Will Gravning KE0Z, 605-647-2606. E-Mail: gravning@iw.net Web: http://www.qsl.net/w0zwy

OCTOBER 2000

OCTOBER 1

IA - WEST LIBERTY - Hamfest. Muscatine ARC & IA City ARC, Steve Fowler KA9AQR, 309-537-3678. E-Mail: sfowler@winco.net Web: http://www.qsl.net/kc0aqs/hamfest.html

Events CALENDAR

IN - BEDFORD - Hamfest. Hoosier Hills Ham Club, John Scheiwe KB9LTI, 812-279-0050. E-Mail: chairman@hoosierhillshamfest.org Web: http://www.hoosierhillshamfest.org

PA - WRIGHTSTOWN - Hamfest. Middletown Grange Fairgrounds, Penns Park Rd. Pack Rats, Joe Keer KU3T, E-Mail: ku3t@amsat.org Web: http://www.ij.net/packrats

OCTOBER 6-7

NH - ROCHESTER - Hamfest. Fairgrounds. Hoss Traders, Joe, 207-469-3492

OCTOBER 6-7-8

AZ - SCOTTSDALE - Southwestern Div. Convention. Scottsdale ARC, Walt Schuknecht N7IZM, 480-947-0338. E-Mail: n7izm@arrl.net

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. E-Mail: ky4e@excite.com

MO - WARRENSBURG - Hamfest. Warrensburg Area ARC, Denise Haye N0PVS, 816-697-3426. E-Mail: 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. E-Mail: jjjoyce@cybernex.net Web: http://www.bara.org

OCTOBER 8

CT - WALLINGFORD - State Convention. Nutmeg Hamfest Alliance, Gordon Barker K1BIY, 860-342-3258. E-Mail: k1biy@juno.com Web: http://www.qsl.net/nutmeghamfest

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. E-Mail: 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. E-Mail: n8tzy@webcombo.net Web: http://www.qsl.net/m2m

OCTOBER 13-14

FL - WALDO - Hamfest. Dixieland Music Park. Talk-in: 145.150-. Bradford Area ARC, John Bradley KU4AY, 904-782-1185. E-Mail: 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. E-Mail: k9bsl@juno.com

NJ - LEONARDO - Hamfest. Croydon Hall. VE testing. Talk-in: 145.485 -6, 151.4. Garden State ARA, Mario Sellitti N2PVP, 732-787-7184. E-Mail: gsara@arrl.net Web: http://www.monmouth.com/~gsara

VA - STAFFORD - Hamfest. Stafford ARA, Richard Diddams KF6UTH, 540-657-8322. E-Mail: rldiddams@earthlink.net Web: http://www.n4nw.org

WA - BREMERTON - Hamfest. North Kitsap ARC, Susan Johnson AB7MD, 360-697-9379. E-Mail: 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

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. E-Mail: WB2KDG@Bigfoot.com or Andy Borrok N2TZX, 718-291-2561. E-Mail: N2TZX@webspan.net

OH - LIMA - Hamfest. Northwest Ohio ARC, Greg Schwark N8WBD, 419-647-6321 or 419-647-5127. E-Mail: gas1950@aol.com

OCTOBER 21

NH - NASHUA - Hamfest. Res Ctr Church. NE Antique RC 617-923-2665

OCTOBER 22

MD - WESTMINSTER - Hamfest. Carroll County Agricultural Center. Talk-in: 145.410(-). The Carroll County ARC, Inc., E-Mail: 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. E-Mail: kc8iaq@att.net Web: http://members.home.net/dougk/useca.htm

PA - SELLERSVILLE - Hamfest. RF Hill ARC, Linda Erdman KA3TJZ, 215-679-5764

OCTOBER 28

CANADA - QUEBEC - MONTREAL - Hamfest. Montreal South ARC, Micheline Simard VE2XW, 450-446-0477. E-Mail: 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.ccse.net/~lrich/JAX HAMFEST.html

MN - ST. PAUL - Hamfest. RiverCentre. 8am-4pm. VE exams. Twin Cities FM Club, Amanda Roberts KG0AY, 612-535-0637. E-Mail: 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. E-Mail: slw@partyline.net

TN - CHATTANOOGA - Hamfest. Chattanooga ARC, David Hoffman KE4FGW, 423-877-7398. E-Mail: ke4fgw@vol.com Web: http://www.qsl.net/w4am/carc_index.html

OCTOBER 28-29

TX - EL PASO - Int'l Hamfiesta. Clay Emert K5TRW, 915-859-5502

OCTOBER 29

NY - LINDENHURST - Hamfest. Knights of Columbus Hall, 400 S. Broadway. 9am-2pm. GSBARC & SCRC, Lenore Dunlop N2KYP, 516-785-0826. E-Mail: info@gsbarc.org Web: http://www.gsbarc.org

OH - MARION - Hamfest. Marion ARC, Karen Eckard N8KE, 740-499-3565. E-Mail: meeker@gte.net

PA - CARLISLE - Hamfest. Carlisle Fairgrounds. 8am-3pm. Talk-in: 145.430. South Mountain Repeater Assn., Bill Smyser, 717-532-9870. E-Mail: smraham@aol.com Web: www.qsl.net/kb3cvo

NOVEMBER 2000

NOVEMBER 4

FL - SORRENTO - Hamfest. Lake ARA, John Gable W8KCE, 352-394-2723. E-Mail: w8kce@aol.com

NM - SOCORRO - Hamfest. Socorro ARA, Tech ARA, & City of Socorro, Al Braun AC5BX, 505-835-3370. E-Mail: ac5bx@juno.com Web: http://www.ees.nmt.edu/sara/

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. E-Mail: KR4NQ@bigfoot.com Web: www.totr.radio.org

TX - ODESSA - Hamfest. West TX ARC, Craig Martindale W5BU, 915-366-4521. E-Mail: w5bu@hotmail.com

NOVEMBER 5

IA - DAVENPORT - Hamfest. Davenport RAC, Dave Mayfield W9WRL, 309-762-6010. E-Mail: hamfest@gwltd.com Web: http://www.gwltd.com/hamfest

NOVEMBER 11

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

NOVEMBER 17-18

LA - MONROE - Hamfest. Twin City Ham Club, Jim Ragsdale W5LA, 318-396-9529. E-Mail: W5LA@hamtutor.com Web: http://www.tchams.org/users/hamfest

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

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. E-Mail: jboyer@ail.com Web: http://www.acarts.com

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. E-Mail: 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. E-Mail: 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. E-Mail: ellie@premierweb.net

DECEMBER 2-3

FL - PALMETTO - Hamfest. Manatee County Convention and Civic Center. FL Gulf Coast ARS, Jean Endicott KC4KZU, 727-525-5178. E-Mail: kr4yl@arrl.net Web: http://www.fgcarc.org

DECEMBER 3

IN - GREENFIELD - Hamfest. Greenfield High School Pavilion, Broadway St. 8am-2pm. HARC, Tom Donaldson N9LFU, E-Mail: tomd@freewwweb.com General info: 317-326-3168. Web: www.w9atg.org

MI - MT. CLEMENS - Hamfest. L'Anse Creuse High School. 8am-2pm. FCC exams. Talk-in: 147.080+, simplex 146.520. L'Anse Creuse ARC, Donna Luh KA8QBD, 248-651-7387. E-Mail: jrluh@aol.com Web: http://www.ameritech.net/users/lc-arc/index.html

DECEMBER 9

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

JANUARY 2001

JANUARY 6

WI - WAUKESHA - Hamfest. Waukesha Co. West Allis RAC, Phil Gural W9NAW, 414-425-3649

JANUARY 12-13

FL - FT. MYERS - Hamfest. Ft. Myers ARC, Earl Spencer K4FQU, 941-332-1503. E-Mail: k4fqu@juno.com

JANUARY 20

MO - ST. JOSEPH - Hamfest. MO Valley & Ray-Clay ARCs, Carlene Makawski KA0IKS, 816-279-3406. E-Mail: nem3238@ccp.com Web: http://www.kc.net/~oconnor

JANUARY 21

NY - YONKERS - Flea Market. Lincoln High School, Kneeland Ave. 9am-3pm. VE Exams. Talk-in: 440.425 PL 156.7, 223.760 PL 67.0, 146.910, 443.350 PL 156.7. Metro 70cm Network, Otto Supliski WB2SLQ, 914-969-1053. E-Mail: wb2slq@juno.com Web: http://www.metro70cmnetwork.com

JANUARY 27

FL - ARCADIA - Hamfest. DeSoto ARC, Doug Christ KN4YT, E-Mail: kn4yt@cyberstreet.com

JANUARY 28

OH - DOVER - Hamfest. Tusco ARC, Gary Green KB8WFN, 740-922-4454. E-Mail: kb8wfn@tusco.net

Classified Ads

Continued from page 62

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The deadline for the NV/Express PCB design contest is July 19th.
Hurry while there's still time!
See page 10 for details.

reader FeedBack

Continued from page 17

and it is achieved in the RadioShack 43-443. Note that you can't measure this resistance with a DMM or most other ohmmeters. There are diodes and transistors in the circuit and the ohmmeter voltage is too low to turn them on. You need to apply a higher voltage, preferably near the phone line on-hook voltage af about 48 volts, and measure the current.

Bill Stiles
Hillsboro, MO

Circuit Board Source

Dear Nuts & Volts:

SMTH Circuits, located in British Columbia, Canada, is a source of low-cost, high-quality prototype PC boards. For $99.00 plus shipping, they will supply two 5 x 8 panels of one ounce copper with plated-through holes. If you transmit your files to them by 7 AM Pacific Standard Time, they will ship your boards the next business day. To see their offer for yourself, visit http://www.smthcircuits.bc.ca/ and look in the Protos Specials section under CAP Protos Service.

I thought *Nuts & Volts* readers should know about this source of PC boards. Other than being a very satisfied customer, I am in no way connected with SMTH Circuits.

John Smith

Infrared Detector Article

Dear Nuts & Volts:

So, before I could finish the article I ran to the nearest RadioShack to buy the proper components to build the infrared detector. While I was there, I saw that they sell this cute little device by the same name, Cat No. 276-1099, Infrared Sensor. So, I bought it too and wonder to this day how that little gizmo works.

It contains no batteries, and is "charged" by local lighting. When you flash your HP 48 or your Palm PDA infrared emitter, you see it show up on the test strip area. Would you guys please find out what that test strip is and how it works?

Thanks a bunch!

Korbet Finley
Via Internet

How about it? Anybody know?

Cutting PC Boards

Regarding the article on cutting PC boards, I mentioned on a message board that it would be appearing in *Nuts & Volts*, in answer to someone who complained about how hard it is to do this particular job.

A reply appeared from a well-known hobbyist/professional, R. G. Keen. The text follows:

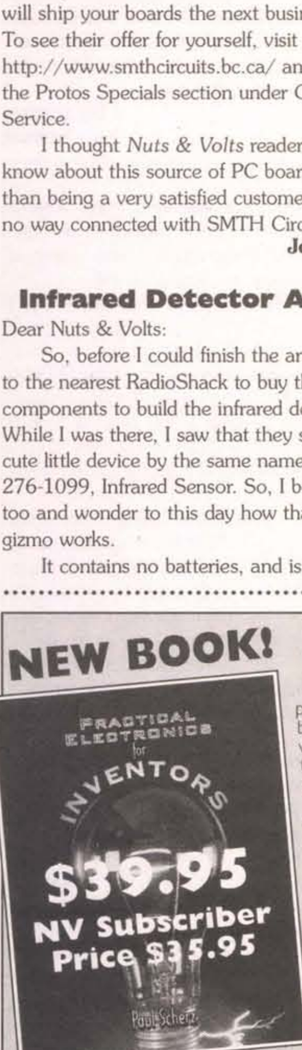
"I'm glad you did a write-up on that. I use this trick to cut things, but I use an air powered die grinder with a cutoff wheel. It will happily eat 1/8" steel sheet. I hope you rigged up some vacuum attachment to keep the glass fiber dust out of the air around the tool. Lungs are sensitive! I have to wear a filter mask when I use the die grinder cutoff."

While I would not have done the article if I thought that a whole vacuum arrangement would be needed, Keen's comment about wearing a filter mask is appropriate. Also, Dremel's Owner's Manual recommends that any rotary cutting tool be used in a well-ventilated area.

Readers should be aware of these common-sense safety precautions.

Steve Daniels
Author
A PC Board Cutting Jig For The Dremel Tool
June '00 Issue

NEW BOOK!



Practical Electronics for Inventors gives you information you need, in a format you can work with. Packed with hand-drawn illustrations, this learn-as-you-go guide shows you what a particular device does, what it looks like, how it compares with similar devices, and how it is used in applications. Written by Paul Scherz, an inventor and electrical hobbyist, this reference provides beginning hobbyists and inventors with an intuitive grasp of the theoretical and practical aspects of electronics — just the kind of insight you need to get your projects up and running.

Starting with a light review of electronics history, physics, and math, the book provides an easy-to-understand overview of all major electronic elements:

Basic passive components • Resistors, capacitors, inductors, transformers • Discrete passive circuits • Current limiting networks, voltage dividers, filter circuits, attenuators • Discrete active devices • Diodes, transistors, thrysistors • Microcontrollers • Rectifiers, amplifiers, modulators, mixers, voltage regulators

Along with coverage of integrated circuits (ICs), digital electronics, and various input/output devices, *Practical Electronics for Inventors* takes you through reading schematics, building and testing prototypes, purchasing electronic components, and safe work practices. You'll find all this — and more — in the guide that's destined to spur you on to new levels of creativity.

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Newsbytes continued from page 17

phone? According to the results of the "Wireless Phone Owner Profile" study by eBrain Market Research, it is a possibility. Three in 10 wireless phone owners stated that they would be more likely to give up their home telephone than their wireless phone. That likelihood increased among certain segments of the population — for wireless phone users in the 18- to 34-year-old age group, the likelihood increased to 45 percent, and among wireless phone owners with personal communication services (PCS), the number increased to nearly 50 percent.

The results of the study also show the role that convergence is playing in the future of the wireless industry. Currently, only one in 10 wireless phone owners have the capability to view E-Mail on their phone, and as such, wireless phones serve primarily as a voice communication device.

However, when asked about their preferences for converged products versus stand-alone products, more than half of the wireless phone owners expressed a desire for a combination wireless phone and Palm PC. In addition, 38 percent of owners expressed an interest in a wireless phone with the capability to view E-Mail; a percentage that jumped to 50 percent among 18- to 34-year olds.

Although the demand for next generation wireless phones with added features and capabilities is evident, the research shows that an overwhelming number of today's consumers express a preference for mobile voice communication over mobile E-Mail communication devices when faced to choose between the two. Only 17 percent of wireless phone owners would choose mobile E-Mail over mobile voice communications. That preference remained fairly consistent across gender, age, and income differences.

• • • • • •

INCONSISTENT GPS RECEPTION CREATES PROBLEMS FOR CAR NAVIGATION MAKERS

While the GPS (Global Positioning System) satellite network covers the entire planet, its signals don't always get through to receivers on the ground. GPS receivers need an unobstructed view of the sky so they can "see" a minimum of three satellites at one time. Buildings, highway overpasses, terrain, lush foliage, and even heavy rain can block reception and cause serious problems for automotive and hand-held navigation systems that rely solely on GPS.

To resolve this problem, engineers at Blaupunkt — the World's largest unit-supplier of car navigation systems — turned to one of the oldest of all navigation techniques — dead reckoning. Dead reckoning is simply a matter of recording distance and direction traveled from a known starting point. Blaupunkt's TravelPilot® car navigation systems use dead reckoning plus map-matching technology to determine exactly where the car is on a digital map. Since these techniques are almost always more precise than GPS — ±2.5 meters for TravelPilot, compared to ±10 meters for GPS* — Blaupunkt uses GPS as a back-up and for navigation off digitally mapped roads. On mapped roads, TravelPilot systems can usually navigate normally for several hours even when a metal cover is placed over the GPS antenna to block the signals.

Blaupunkt's TravelPilot RNS-149 is a combined car navigation system and CD car stereo that easily replaces a factory car radio. It provides spoken, turn-by-turn route guidance using digital navigation data stored on CD-ROMs, and outstanding sound quality from radio and CD. Blaupunkt is also coming out with the new TravelPilot DX-N, a stand-alone navigation system that does not require replacing the car radio.

This unit also has a video moving map display.

For Blaupunkt dealer locations and product information, call 1(800) 950-BLAU [2528].

* Until recently, when the U.S. Department of Defense stopped intentionally degrading the signals, consumer GPS accuracy was only ±100 meters, making it unsuitable for turn-by-turn route guidance even with good GPS reception.

Aside from this, you need to get creative. The first method I would consider is to choose a 2/3 version of the same battery commonly called for example a "Sub-C," Sub-D," or "2/3 AA" battery.

Using these batteries will allow you to have 1/3 more room inside the battery holder which will allow you to add the necessary amount of extra batteries to raise the voltage to its proper rating. The only drawback here is the shorter running time of the smaller batteries because they have a smaller amp/hour ratings than their counterpart.

However, because of the cost of recharging vs. new batteries, this pays off in the long run and you can always build a secondary battery pack for quick swapping.

The second method would be to open up your receiver in hopes of finding some free-space inside to install one [or more] necessary batteries in that space that might exist, to make up for the lower voltage of your pack.

Using this method, you can always place two of the smaller 1/3 or 2/3 size batteries in parallel in different placements inside the box if there isn't enough room for a single larger or normal battery. Doubling up two, 2/3 size batteries, assures that you don't compromise the battery amp hour rating of the rest of the battery pack because the double configuration actually has a slightly higher amp/hour value.

You can even mix several "parallel configuration" AAA batteries spread around the case to make up a larger type "D-Cell" for example, but keep in mind what your amperage requirements for this unit are before you even start to design an alternate system.

A third method can be an external battery pack complete with power jack and or cigarette lighter plug. Using this method allows you to place a large capacity 6 or 12-volt battery system complete with voltage regulator, because once outside your case, there are no space limitations.

A fourth method is to install lithium-ion batteries and a small voltage regulator to adjust these batteries to the correct voltage. With 3.6 volts per cell you have plenty of left over space to design and install a voltage regulator within that space and not only does the lithium batteries have a cell voltage of 3.6, but it also has a higher amperage rating exceeding all standard batteries for size or volume.

Chris
Bieber, CA

ANSWER TO #6007 - JUNE 2000

Does someone know of a company that can reprogram doorbell sounds in wireless doorbells or who has wireless doorbell kits?

Sound generator chips such as those used in doorbells are mask programmed. This means the programming information is a part of the silicon and cannot be changed.

In integrated circuit fabrication, masks are used in the various stages of depositing and etching the silicon to create the circuit.

If you have the skills to write software for microcontrollers, you might be able to replace the pre-programmed melody generator chip in your doorbell with one of your own design. That way you could use the transmitter and receiver portions of the existing wireless doorbell system.

There are numerous companies that advertise kits and development boards based on popular microcontroller chips, such as the Microchip PIC, in *Nuts & Volts.*

Tim Godfrey
via Internet

ANSWERS TO #60011 - JUNE 2000

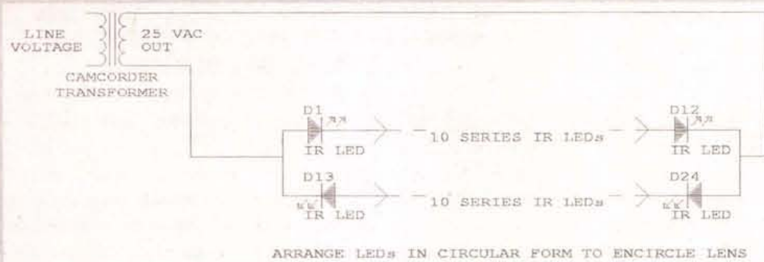
I would like to attach infrared LEDs to my CCD camera to have the ability to view in low-light situations. I have seen CCD with the infrared LEDs in a circular pattern around the lens. I would like to build a similar type of unit.

For the power source, I want to tap into the 24V AC that is supplied with the camera. Is there a web site or someone that can supply me with the schematics?

#1 A workable solution is to use 24 IR LEDs strung together in a pair of 12-LED strings, then connecting the strings "back-to-back." The transformer will illuminate *all* 24 LEDs at a 60 Hz rate, one "string" per half cycle.

Since the forward voltage of LEDs is around 2.5 volts, each string will "absorb" the full amount of the transformer voltage on each half-cycle and the "reverse" voltage across any one LED will never exceed the forward voltage of its "opposing partner."

Furthermore, the current draw probably won't exceed 20 mA, so your camcorder's power transformer shouldn't be overloaded.



The attached schematic details how to connect everything. It's up to you to fashion a suitable circular holder to hold all the LEDs for mounting on the front of your lens.

Ken Simmons
Auburn, WA

#2 You would power these infrared LEDs exactly as if you would power regular LEDs. Using your 24V source, you should be able to power in series at least 10 LEDs.

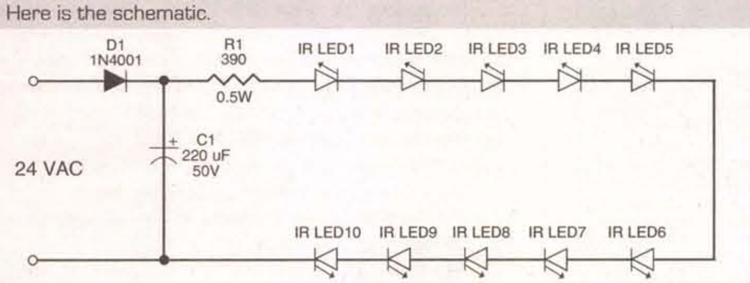
Each LED will drop approximately 2.0V and you must limit the LED's current with a fixed resistor R1.

The current through the LEDs will determine the IR brightness. Obviously, you will have to adjust the value of the limiting resistor R1, depending on the number of LEDs you will use and the brightness you need.

Remember that these IR LEDs emit light which is invisible to the human eye, so you will have to use your camera when you adjust the LED current (brightness).

If you want to use your 24VAC source, first you have to rectify it with D1 and filter it with C1 to obtain a DC source.

Here is the schematic.



Haim Sandel
Scottsdale, AZ

ANSWERS #6009 - JUNE 2000

Does anyone have information on how to build a shift register circuit for generating pseudo random output sequences?

#1 In his Dec. '86 *QEX* article, "Experimenting With Direct-Sequence Spread Spectrum," Andre Kesteloot shows a detailed circuit diagram for building a seven-stage, 2 MHz pseudo-random sequence generator using a 74164 shift register, and a couple of exclusive OR gates.

His article was republished in *The ARRL Spread Spectrum Sourcebook* ISBN 0-87259-317-7 that can be ordered for $20.00 at **www.arrl.org**.

Jack Dennon
Warrenton, OR

#2 The circuit configuration that generates a pseudo-random sequence is a Linear Feedback Shift Register, or LFSR. These are used in cryptography and in direct sequence spread spectrum communication systems to generate the spreading code.

The input to the shift register is a linear sum of certain bits within the register. Since the input is a single bit, the summation process reduces to a tree of XOR gates. This tree of XORs is sometimes called a parity tree. To make the most random data possible for a given size of shift register, you want a maximal length LFSR. The maximal length for a given number of bits N is 2^N - 1. IE an eight-bit LFSR has 255 unique states.

The other state is disallowed, and you must insure the LFSR cannot get into that state, or provide extra logic to get it out. The disallowed state for the XOR tree implementation is all zeros.

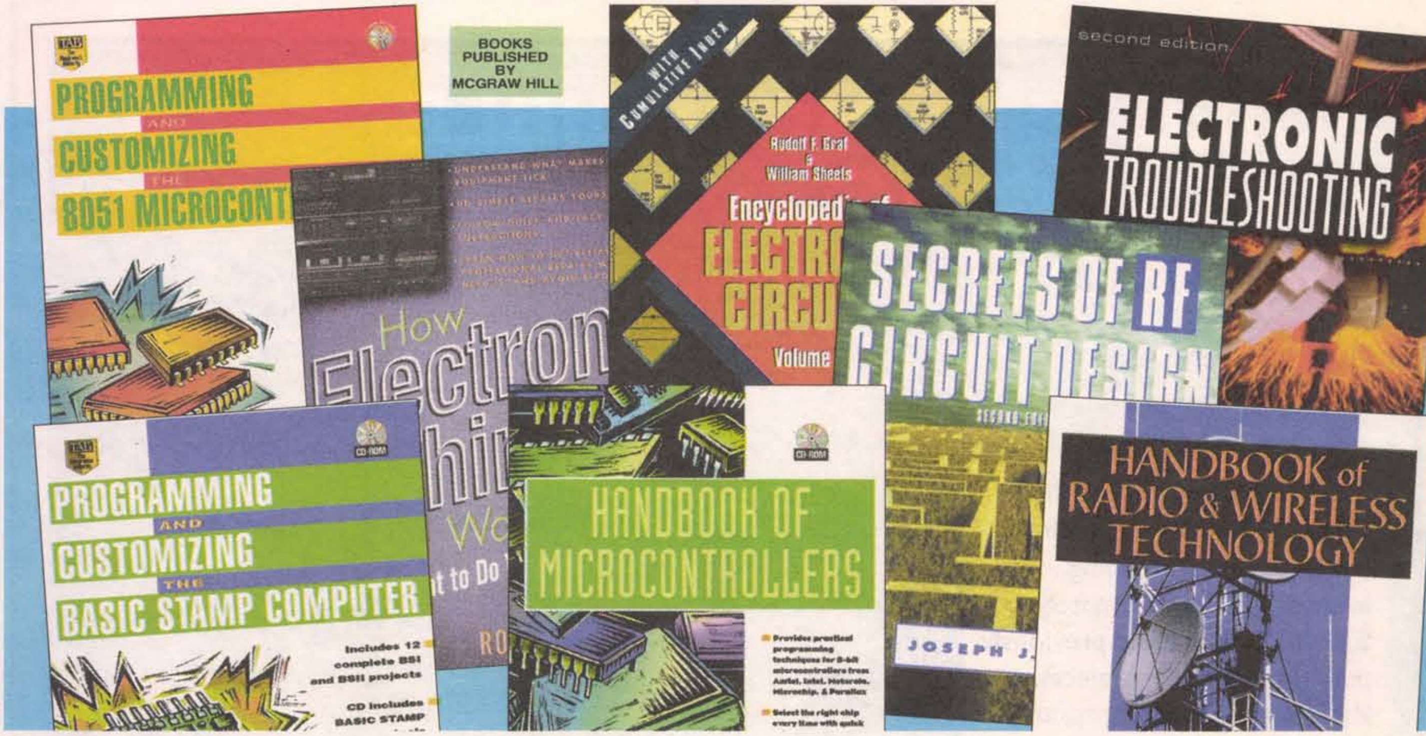
I found a listing of maximal length LFSR feedback terms at **http://pecan.srv.cs.cmu.edu/afs/cs.cmu.edu/local/mosaic/common/omega/Web/People/Koopman/lfsr/index.html**

The feedback terms are shown for shift register lengths from 4 to 27 bits.

The author has generated multiple solutions for each length. You just need one solution, so use the first one. They are represented as a hex number.

For example, for length 8, the first solution is 8E. Look at the number in binary: 10001110. The 1s indicate bits that are used in the XOR feedback. The least significant bit (on the right in the binary representation) corresponds to the Q output of the first stage, driven by the XOR tree.

Tim Godfrey
via Internet



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McComb, G — The Robot Builder's Bonanza	$18.95	$17.05
Predko, M — Handbook of Microcontrollers	$54.95	$49.45
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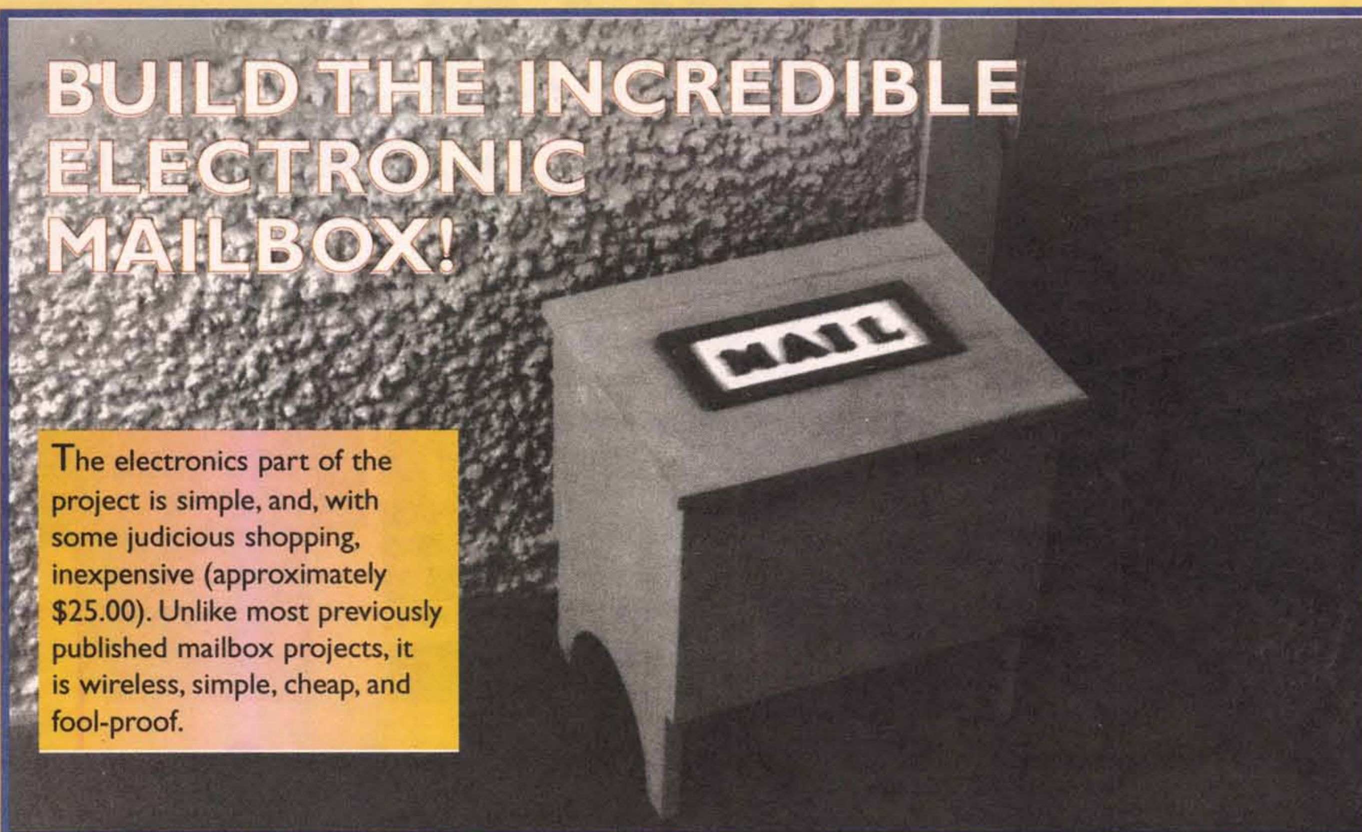

The electronics part of the project is simple, and, with some judicious shopping, inexpensive (approximately $25.00). Unlike most previously published mailbox projects, it is wireless, simple, cheap, and fool-proof.

by Russ Shumaker

Nooo, not E-Mail ... think "US Post Office." This simple, inexpensive device transmits a wireless signal from your mailbox, which sounds a chime in the house, and announces the arrival of your mail.

There were a few minor postal problems in the Resident Techie's household. In spite of a post office box, an awesome quantity of mail would arrive at the house each day. The postal carriers would curse, swear, and invoke deities upon the household each time they attempted to stuff 10 pounds of mail into the five-pound mailbox.

The second part of the postal problem was due to two businesses being run from home offices, with the mails being of key importance to livelihoods. Each of the resident business partners (spouses), usually too engrossed in a project (or too lazy) to look, would ask the other, several times a day, "Has the mail come yet?" hoping the other will go out and look.

The Resident Techie immediately recognized a problem and trundled off to the workshop. The solution would be electronic, of course (at least part of it).

The solution to the first part of the problem was easy. A sewing chest was purchased from a store which sells unfinished furniture, painted with leftover paint that matches the house trim, and ensconced with wooden letters from a craft store, to read "MAIL." It is a rather handsome mailbox that holds considerable cargo. A mail carrier mumbled something about falling to his knees and kissing the hem of the occupant's garment, but it has yet to be seen. A new mailbox was necessary in this situation, but the electronics part of the project can certainly be installed onto most existing mailboxes. If you are a woodworker and an electronic hobbyist, you've got it knocked.

Figure 1 — ELECTRONIC MAILBOX COMPONENTS — consisting of, left to right: the reed switch and permanent magnet actuator, the control box, and the receiver, which is to be plugged into an outlet inside the house.

The electronics part of the project is simple, and, with some judicious shopping, inexpensive (approximately $25.00). Unlike most previously published mailbox projects, it is wireless, simple, cheap, and fool-proof.

The system consists of: a reed switch and magnetic actuator, a pulse module, and a wireless doorbell transmitter and receiver. See Figure 1.

Description

The circuit is activated by a normally-closed reed switch mounted inside the mailbox, which is held open by a permanent magnet mounted to the inside of the lid. See Figure 2. When the mailbox is opened, the magnetic switch contact closes. This applies power to a monostable circuit on the Pulse Module which, in turn, generates a momentary pulse output to a reed relay. This reed relay contact is wired in parallel with the push-button contacts of a wireless doorbell transmitter. This sends a signal to the doorbell receiver plugged in anywhere inside the house and VIOLA! ... announces the arrival of the latest issue of *Nuts & Volts*.

The switch certainly could be wired directly to the doorbell transmitter and it would function fine ... most of the time. Several doorbells were tested, and they are all designed to operate from a momentary switch closure. Occasionally, the mailbox will be left open which, in turn, keeps the switch contacts closed. When this happens, some doorbells ring continuously until the contacts are opened again. Others won't ring at all, until the lid is closed, reopening the contacts. This is the purpose of the monostable circuit. If the mailbox is left open, the doorbell

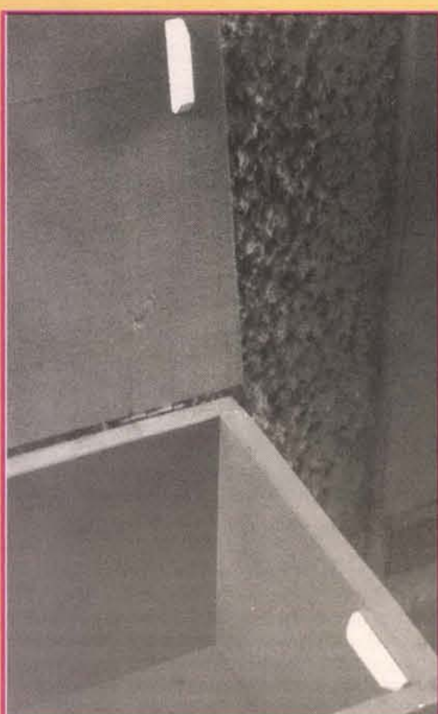

Figure 2 — MAILBOX SWITCH AND ACTUATOR MOUNTING — the reed switch is mounted inside the edge of the mailbox, and the magnetic actuator is mounted on the lid, so when the lid is closed, the magnet is next to the switch, and holds the switch contacts open. When the lid is opened, the switch contacts close.

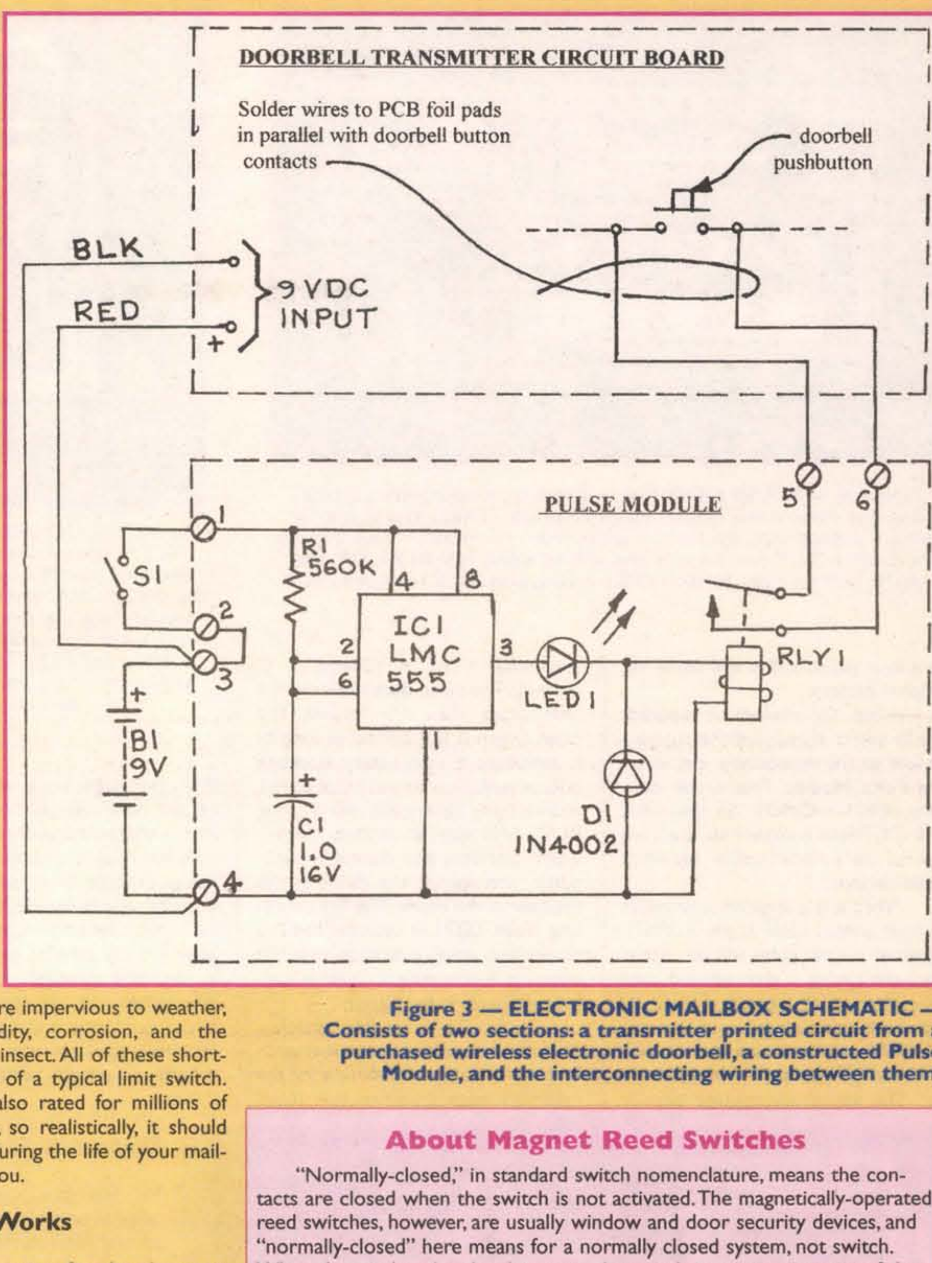

Figure 3 — ELECTRONIC MAILBOX SCHEMATIC — Consists of two sections: a transmitter printed circuit from a purchased wireless electronic doorbell, a constructed Pulse Module, and the interconnecting wiring between them.

will still get a momentary contact closure, and operate correctly.

The wireless doorbells are available at hardware stores, builder's suppliers, and mail order. Many choices are available, and several makes and models were tried ... all successfully. Sources for the prototype doorbell are listed elsewhere in the article.

Any momentary limit switch with normally-closed contacts could be used; a magnetically-operated reed switch was used on the prototype for reliability. The contacts are hermetically sealed within a glass tube, and are impervious to weather, dirt, humidity, corrosion, and the occasional insect. All of these shorten the life of a typical limit switch. They are also rated for millions of operations, so realistically, it should never fail during the life of your mailbox ... or you.

How It Works

The circuitry for the electronic mailbox is shown in Figure 3. When the mailbox is shut, no standby power is used; this prolongs battery life. The prototype has been in ser-

About Magnet Reed Switches

"Normally-closed," in standard switch nomenclature, means the contacts are closed when the switch is not activated. The magnetically-operated reed switches, however, are usually window and door security devices, and "normally-closed" here means for a normally closed system, not switch. When the window (or door) is open, the switch is not in proximity of the magnet, and the contacts close. The magnet holds the contacts open. If you are still thoroughly confused, just use the switch specified in the parts list, and you will be okay.

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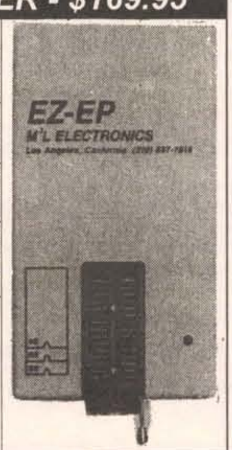

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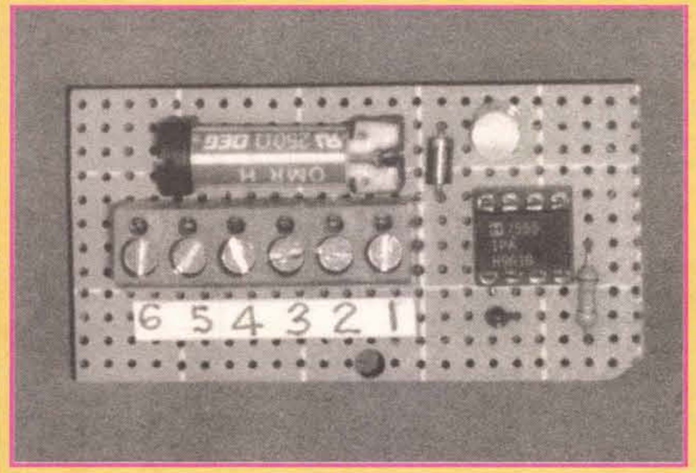

Figure 4 — PULSE MODULE — Prototype component placement is shown, and is not critical. The hole below the terminal block is a pass-through for the wires from terminals 1 and 2 going to Switch S1. Components are, left to right, top: RLY1, D1, and LED1. Left to right bottom: TB1-6, IC1, and R1. C1 is below IC1

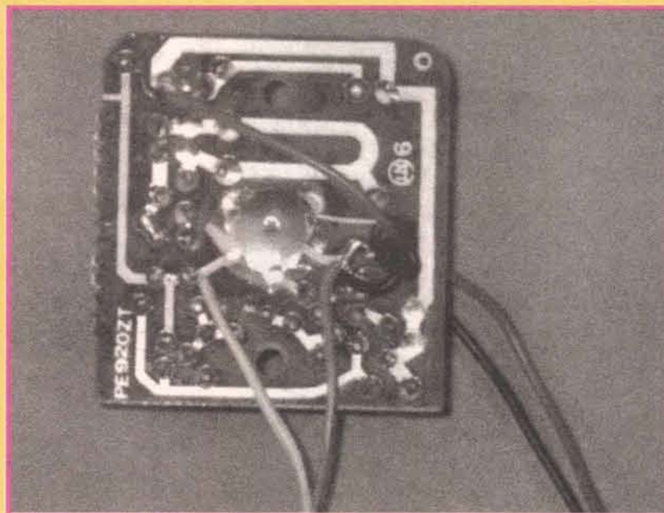

Figure 5 — DOORBELL TRANSMITTER MODULE ASSEMBLY — The round disc in the center is a metal "clicker." It is the doorbell switch contact. When the doorbell button is pressed, the disc is flattened against the board, shorting the foil pads, and completing the circuit. It is held on with transparent tape, and may be temporarily removed, or discarded. The wires from the bottom are to be added, in parallel across the switch contacts, soldered to any convenient foil pads. The wires from the right are existing power-in from the battery.

vice four years, and is still using the original battery.

When the mailbox is opened, the S1 switch contacts close, applying power to the monostable circuit on the Pulse Module. This circuit consists of IC1, a CMOS 555 timer, R1, and C1. These components are configured as a monostable one-shot multivibrator.

When it is energized, it provides a single output pulse at pin 3 of IC1. Another output pulse will not occur until the circuit is shut off, and then re-energized. A standard 555 IC timer can certainly be used, but the CMOS version uses less power, thus conserving battery life a bit more.

The approximate pulse time is (seconds) = 1.1 R (Ohms) x C (Farads). The pulse duration here is a little more than 1/2 second. The pulse length is not critical, as long as it simulates a momentary doorbell button push. The output pulse of IC1 momentarily energizes reed relay RLY1, providing a contact closure which activates the doorbell transmitter, and sounds the chime in the receiver in the house. The light-emitting diode, LED1, is optional, but is a convenient visual indication that the circuit is functioning. It lights whenever the relay is energized.

Diode D1 is a free-wheeling diode, and its sole purpose is to protect the IC1 output by dissipating any reverse-voltage inductive kick (back EMF) that might occur when shutting off the reed relay, RLY1. It probably isn't necessary here, but might be if a different relay is chosen. It is a good design practice when using semiconductors to activate electro-mechanical relays, albeit sometimes conservative. A relay contact output is used in lieu of a transistor so it will be compatible with any doorbell circuit. Luck would have it that the doorbell selected couldn't use a common ground, or would require a weird voltage.

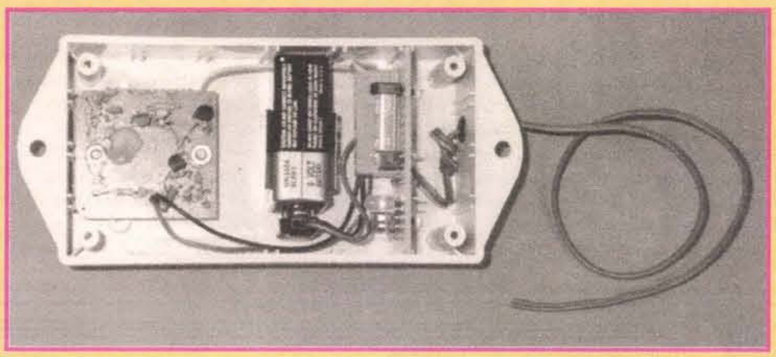

Figure 6 — BOX ASSEMBLY — Box is shown with the cover removed. Mount components inside the box, using #4 screws, nuts, and standoffs. The components are, left to right, doorbell transmitter PC board, nine-volt battery, holder, and clip, and the Pulse Module assembly.

Enclosure Selection

The box used for the original unit was selected for several reasons. First, it is non-metallic; this is important. A metal circuit enclosure might weaken or block the transmitted radio signal. It may also work fine, but try it first.

Secondly, it has molded-in circuit board guides. These allow a module to be installed edgewise, requiring no fasteners, which contributes to the compactness of the package, and ease of assembly.

The third reason was that it had molded-on mounting lugs (ears). This is nice to have, but not absolutely essential. Angle brackets, Velcro, double-sided foam tape, or screws through the back of the box can also be used for mounting.

This box is mounted in the recessed bottom of the mailbox, which is on a roofed porch; its direct weather exposure is minimal. If weather may be a problem, there are many weatherproof ABS plastic electrical and telephone outdoor junction boxes available at builder and electrical suppliers, and hardware stores.

Construction

Nothing is critical, except the non-metallic enclosure. The circuit is ridiculously simple, and hardly warrants the time and humbug of a PC board. Point-to-point wiring works fine. Perf board could be used, but project board is more convenient because it has a solder pad around each hole, so the components can be soldered in place before making the wire connections. Cut the board to size to fit the molded-in card slots in the box. If the specified box is used, the board size is 1-1/4" x 2-3/8". Light gauge wire can be used. Wire wrap wire (30 ga., solid) is ideal.

Figure 4 shows the component placement on the Pulse Module. The terminal numbers were identified on the board with typewriter correction tape and a fine-line pen.

Remove the doorbell transmitter PC board assembly from its original case. See Figure 5. Locate the two foil pads on the board that are shorted when the door bell button is pressed. The plastic button can be

PARTS LIST FOR THE INCREDIBLE ELECTRONIC MAILBOX

Wireless Doorbell Transmitter and Receiver — see text.
S1 - Magnetic Switch and Actuator (RadioShack No. 49-533, or equivalent).
B1 - Alkaline Battery, nine volt.
R1 - Resistor, 560K-ohm, ¼ Watt, 5%.
C1 - Capacitor, 1.0-µF, 16-WVDC (minimum) Electrolytic.
IC1 - LMC555 CMOS Timer Integrated Circuit.
LED1 - Light-emitting Diode, T-1 or T-1¾ size, any color.
D1 - General-Purpose Diode, 1N4001, or equivalent.
RLY1 - Reed Relay, 5VDC coil, SPST, Normally open, 200 ohm minimum coil resistance, (RadioShack 275-232, or equivalent).

ADDITIONAL PARTS
Non-metallic Project Box (PacTec FLXT4624, RadioShack No. RSU 11658564, or equivalent).
Project Board (RadioShack No. 276-149, or equivalent), cut to size to fit Project Box, above; see text.
Battery Holder (RadioShack No. 270-326, or equivalent).
Battery Snap Connector (RadioShack No. 270-325, or equivalent).
Terminal Block (RadioShack No. 276-1388, or equivalent) — Optional.
Misc. — Solder, Wire, Grommet, Hardware, eight-pin IC Socket, etc.

About Wireless Electronic Doorbells

These are very popular now with the do-it-yourselfers because wires don't have to be fished through the walls. They are very readily available at a decent cost. The cost seems to increase with the effective distance and fancy features, like Westminster chimes. Most often, a bare-bones model will work fine. Before modifying the doorbell and drilling holes in your mailbox, test it first — transmitter and receiver — where they will be used.

The doorbell of choice that was used in the prototype was selected because of:

- Best effective distance
- Most reasonable cost
- Transmitter operates from standard nine-volt battery; some models use a more expensive, special 12-volt battery, which is not always easy to find.
- Receiver requires no battery; it plugs into the wall. Some receivers are battery-operated.
- Additional chime units for other rooms are available, at a very reasonable cost.

tossed. Solder a 5" length of light gauge insulated wire onto each of these pads. Strip the free ends of these wires about 1/4". Connect a nine-volt battery to the board, and plug in the door bell receiver. Touch the ends of the two wires together; the doorbell should sound if the wires are connected correctly. Connect the two wires to terminals 5 and 6 of the Pulse Module. Polarity doesn't matter.

Mount the door bell transmitter in the new box with two #4 flat head screws and nuts, on 1/4" standoffs. Use the two existing mounting holes in the PC board.

Mount the other components in the box, as shown in Figure 6. Cut off the battery connector close to the snaps, and strip the ends of the wires about 1/4". These will connect to the Pulse Module terminals 3 and 4, as shown on the schematic, Figure 3. The new nine-volt battery connector will also connect to terminals 3 and 4. Cut the wires to length, as required. Install both red wires to terminal 3, and both black wires to terminal 4.

Install a 1/8" grommet into a hole in the end of the box. This will be the exit hole for the wire pair connected to the magnetic switch. This wire can be any light gauge twin lead, like intercom wire, and needs to be long enough to reach the magnetic reed switch.

If additional weather protection is required around the wire exit, use a smaller hole, and a daub of silicon sealer instead of a grommet. Tie a strain-relief knot in the wire, inside the hole. The battery holder can be installed with a #4 screw and nut, or double-sided foam tape. Again, see Figure 7 for component positions inside the box.

The pulse module is installed by sliding it into the slots in the box, after connecting the wires to it. The box lid holds it in place.

Installation

Before doing anything, test the doorbell transmitter and receiver where they will be used. If you would like to install the transmitter electronics inside a metal mailbox, definitely try it first.

If it doesn't work, there are a few possible options: consider a new, non-metallic mailbox or possibly mounting the electronics externally, in a non-metallic box. Roadside mailboxes can have the electronics mounted in a weatherproof box externally on the backside or underneath.

If the rural mailbox is across the road from the house, remember that there will be a mail carrier's vehicle between the transmitter and receiver when it is activated. This may affect signal transmission.

The electronics part of it is a simple, fun, inexpensive, one-evening project, the results of which have spoiled the Resident Techie and family. If you're due for a new mailbox as well, that could be a fun project for the whole family. Put them to work painting. **NV**

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16518A...$1,600	66102A...$537	85719A...$689	FSEA20...$10,940	6062A...$1,550
16522A...$3,182	66103A...$429	8590L...$3,540	FSEA30...$21,776	6080A...$1,433
16533A...$1,916	6612B...$408	8591C...$6,198	FSEB20...$19,452	**ENI**
16557D...$5,535	6621A...$1,069	8591E...$5,667	FSEB30...$29,732	240L...$894
1660CS...$4,074	6622A...$1,366	8593E...$10,047	FSEK30...$39,453	5100L...$6,334
1662AS...$2,542	6623A...$1,336	8594E...$7,228	FSEM20...$17,601	525LA...$2,340
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41425A...$587	81110A...$3,541	8722D...$45,912	370A...$14,313	TDS820...$5,362
4142B...$3,784	8114A...$3,954	8722ES...$43,823	371A...$16,135	TLA714...$5,584
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54615B...$2,443	8481A...$330	E4418A...$1,214	TDS3054...$5,149	41800...$784
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60501B...$604	85052D...$1,667	E4432A...$4,075	TDS540C...$5,592	TBER2090SP$2,711
60502B...$747	8508A...$2,385	E4432B...$8,661	TDS540D...$7,466	TBERD2209.$2,201
60504B...$906	85107B...$54,767	E4433B...$9,528	TDS640A...$2,610	TBERD224..$2,498
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XK-150 DIGITAL/ANALOG TRAINER

Elenco Electronics announces the newest addition to its long line of electronics trainers: the XK-150 digital/analog trainer.

The XK-150 is a complete mini-lab for building, testing, and prototyping analog and digital circuits. It contains a breadboard, a function generator, a range of digital and clock functions, and four power supplies which make it an excellent choice for schools, hobbyists, and electronic labs.

This digital/analog trainer is especially designed for prototyping and school projects. It has a breadboard with 830 tie points including two bus strips.

The built-in analog function generator can generate sine and squarewaves, up to 4 Vpp in amplitude for sinewaves and up to 12 Vpp for squarewaves.

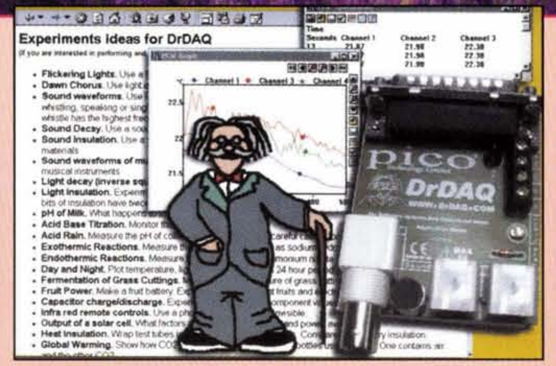
The digital section contains eight data switches, two no-bounce logic switches, eight buffered LED readouts, and a 5 Vpp squarewave clock with switchable frequencies. These features give the XK-150 flexibility for prototyping and learning applications.

There are four built-in power supplies and all of these supplies are regulated and protected against shorts.

At a list price of only $116.50, it's a great buy for schools, hobbyists, and electronic labs.

For more information, contact:

ELENCO ELECTRONICS, INC.
150 W. CARPENTER AVE., DEPT. NV
WHEELING, IL 60090
847-541-3800 FAX: 847-520-0085
E-MAIL: elenco@elenco.com
WEB: http://www.elenco.com



DrDAQ PC SCIENCE LOGGER

DrDAQ is a low-cost data logger designed for educational use which simply plugs into a PC's parallel port for display or data-gathering.

This $99.00 unit is unique in many ways: built-in sensors for light and temperature and a microphone for sound; use any pH probe for acid-base measurements; capture fast signals like sound waveforms; use outputs for control experiments; comes complete with software, cables, and documentation; and DrDAQ doesn't need any external power.

DrDAQ is supplied with both PicoScope (oscilloscope) and PicoLog (data logging) software and is expected to be of value to a wider audience than just educators.

For more information, contact:

SAELIG COMPANY
1193 MOSELEY RD., DEPT. NV
VICTOR, NY 14564
716-425-3753 FAX: 716-425-3835
E-MAIL: saelig@aol.com
WEB: www.saelig.com

JSB-440 TEMPERATURE MODULE

The new JSB-440 USB temperature module from J-Works, Inc., facilitates digital I/O temperature measurement from any Universal Serial Bus (USB). This low-cost module offers a new level of control for general-purpose temperature measurement applications.

The JSB-440 communicates with DS-1820 temperature controllers, and returns temperature values over the plug-and-play USB.

JSB-440 features include: Supports up to 30 DS-1820 temperature controllers; automatically identifies DS-1280 IDs; accuracy of ±0.5°C; communicates over 1-Wire™ interface; Windows-based driver and USB cable are provided; RJ-11 DS-1820 connector; two Darlington outputs, and two 5V inputs.

The JSB-440's measurement range is -15° to 105°C. Its operating temperature range is -40° to 85°C.

Pricing for the Model JSB-440-10 temperature module, board-only version, is $75.00 each. Model JSB-440-15, the board-only version with JDS-120-01, is $85.00 each. The JSB-440-20, with case, is $89.00, while Model JSB-440-25, with both case and JDS-120-01, is priced at $99.00.

For more information, contact:

J-WORKS, INC.
12328 GLADSTONE ST. #1, DEPT. NV
SYLMAR, CA 91342
818-361-0787 FAX: 818-270-2413
E-MAIL: sales@j-works.com
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MC2000-074 CONTROLLER

Vesta Technology announces the new MC2000-074 controller, with its 20 MHz, eight-bit PIC processor, and Vesta's fast and feature-rich Vesta Single Tasking Basic (VSTB) language.

The MC2000-074 is just under an inch square, and uses the Dev-074 carrier board to provide its pin compatible connectors for two serial ports, an LCD port, a keypad port, a TTL port, nine pins for general I/O, and a connector for Vesta's own SPI and IIC compatible VAST port.

The new MC2000-074 attributes a great deal of its eas-of-use to its programming language, Vesta Basic. VSTB is fast (12,000 lines per second on the MC2000-074), and supports executable files up to 32K, but requires less code than conventional PIC languages for most tasks.

Vesta Basic's IDE also provides some essential features, such as single-click compile and download, and a powerful animated debug direct from the SBC.

The MC2000-074 runs on just 9 mA, and has a software-controlled sleep mode that requires only 2 mA, making it perfect for low-power applications.

The MC2000-074 is available in two different memory configurations for $59-$69 individually, in discounted quantities, or in development kits that include carrier board, language CD, debug cable, keypad, LCD, and battery for $179.00.

For more information, contact:

VESTA TECHNOLOGY, INC.
11465 W. I-70 FRONTAGE RD. N.
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WHEAT RIDGE, CO 80033
303-422-8088 FAX: 303-422-9800
E-MAIL: vesta@vestatech.com
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Temperature Test: Measures from 0° to 1832° F (probe supplied!)
Diode Test: Tests if diodes are shorted or open

Specifications
Accuracy

Vdc:	±1.0% reading +5 digits
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Adc:	±1.2% reading +5 digits
Aac:	±1.5% reading +5 digits
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See the web site for details

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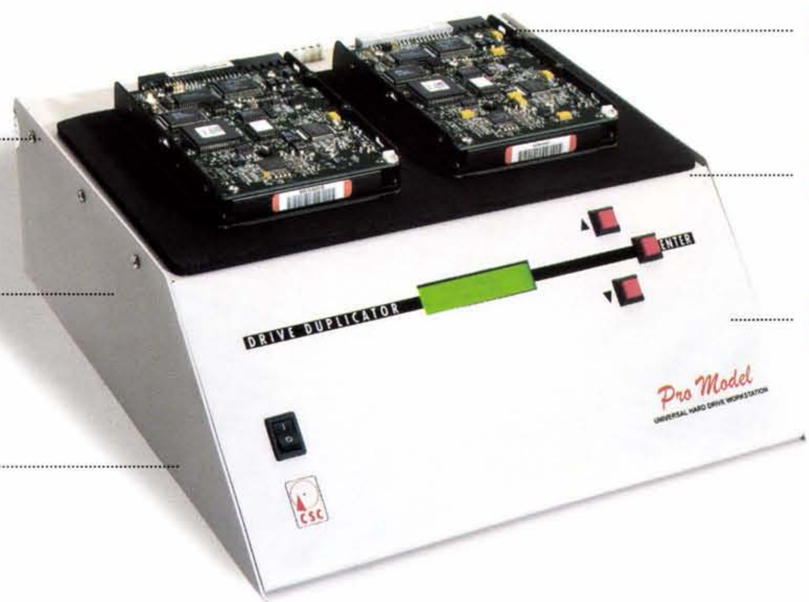

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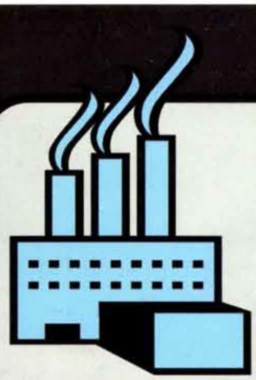

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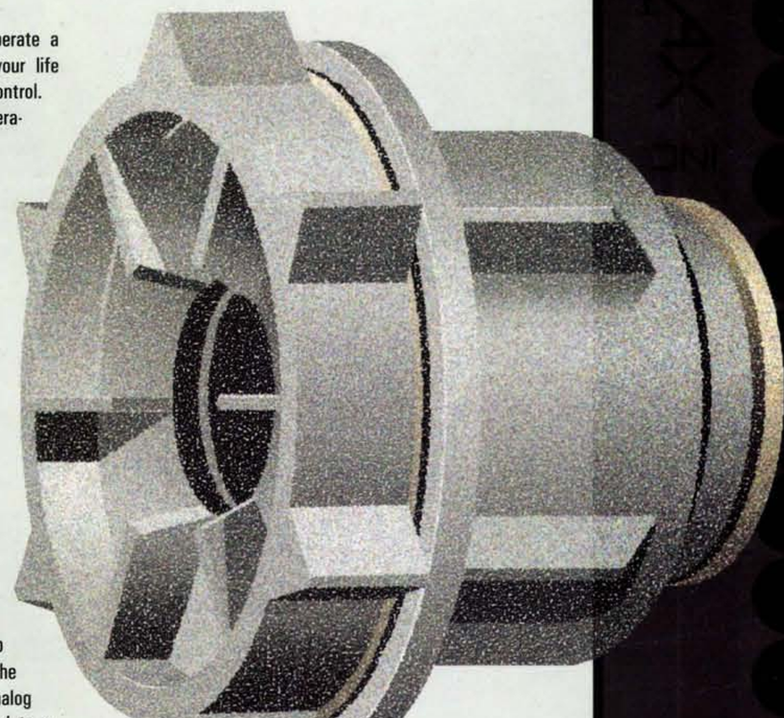

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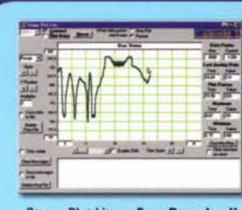

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