NUTS & VOLTS MAGAZINE

OUR 17th YEAR

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VOL. 18 NO. 1
JANUARY 1997

Exploring Electronics And Technology For The Hobbyist And Professional

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Family Radio Service
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Nuts & Volts Magazine, 430 Princeland Court, Corona, CA 91719

NUTS & VOLTS MAGAZINE

Published Monthly By
T & L Publications, Inc.
430 Princeland Court
Corona, CA 91719
(909) 371-8497
FAX (909) 371-3052

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

Subscription Order ONLY Line
1-800-783-4624

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Deadlines should be discussed in advance with the editor, but generally all material should be submitted by the 1st of the month for the next month's issue.

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Nuts & Volts Magazine is published monthly for $19.00 per year by T&L Publications, Inc., 430 Princeland Court, Corona, CA. Application to mail at 2nd class postage rates is pending at Corona and San Diego. POSTMASTER: Send address changes to Nuts & Volts Magazine, 430 Princeland Court, Corona, CA 91719.

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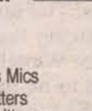

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reader FeedBack

Dear Nuts & Volts:

First, I would like to say thanks for a super magazine, I look forward to reading it every month!

I would like to respond to the NC sidebar. I think Harry is way off his mark on how the NC can compare to the PC, in reality, there is NO comparison; the NC is NOT a personal computer, nor will it ever be. In the short, it is a web browser in a box, and in the long run it is a dumb terminal. It is not geared for the home user. It will work there, but it is not meant for there. It was thought out as a replacement to the desktop computer located in the offices of the world.

Consider this, 95% of all support problems are software related (i.e., Microsoft, for the simple fact that it has 90% of the market). If you remove this problem (software from MS) 90% of the problems will magically go away!

Take this one step farther, you remove the remaining 5% of the problems (hardware and compatibility) and you are left with a VERY solid computing environment. With drop-in replacement of hardware, you are looking at a 95% reliable system, with a VERY low down time, maybe 10 minutes to replace the tube with another tube.

Now multiply these factors by 1,000. The average number of computers in a large corporate structure, and the savings are staggering. Combine this with personnel reduction (I know that sucks, but a dollar is a dollar), software unification, and the most important aspect, single point of failure. And from the large computer companies (i.e., IBM, Unisys, and Fujitsu) this is a wonderful time to swing in, tell the companies "We'll remove all your PCs, replace them with NCs, run new cables to handle voice, data, and video, ability to connect each desk with the Internet, and give you a new mainframe computers or minis (as/400) and a very small team of our techs (three-five) and all you have to do is pay X number of dollars a year, and you will have a guaranteed 24x7x365 system." Any company would be a fool not to take this offer.

By the numbers, the mainframe/mini solution is the best and most cost effective; after all, do you own your car or do you lease?

Thanks for a great mag, and see you next month!

Tony Farrell
tony_farrell@ibm.net

Dear Nuts & Volts:

Regarding Harry Helms' Nov. '96 "Software Wizardry" column: Sure, it's easy to trash the Network Computer, if you don't understand what it is.

The primary application for the Network Computer (NC) is a replacement for desktop systems wired on corporate LANs, not home machines. The business motivation: reducing the huge support costs for Wintel PCs, variously estimated to be between $5,000.00 and $13,000.00 PER MACHINE, PER YEAR. The problem: PCs have local hard disks and system software that users can customize at will, causing big maintenance headaches for network managers.

Thus, the network computer resembles NOT a dumb terminal (with no local processing capability), but rather the diskless workstation that is commonplace in the Unix world. By loading up system software over the net (the high-speed, internal corporate LAN, NOT a slow 28.8K baud modem link), every time a machine boots, it gets the latest revision of system software as configured by system administrators.

The true promise of Java and Network Computers is simplifying and standardizing the PC software architecture, so people can actually get useful work done on their machines, rather than spending all of their time tracking down software conflicts.

Fred Martin
fredm@media.mit.edu

Dear Nuts & Volts:

John Iovine's article on NiCad Batteries (Dec. '96) incorrectly stated that battery power was measured in amp-hours. In actuality, this is a measure of battery capacity not power. The capacity of a battery is the amount of stored charge (measured in coulombs Q) that the battery can effectively deliver to a load before its voltage drops below some useful threshold. Since charge is equal to current times time ($Q=IT$) for a constant or slowly varying current, we obtain the familiar amp-hour or milliamp-hour rating. Note that this should not be confused with the common kilowatt-hour (KWh) rating that is used to measure energy consumption (power X time = energy). The power company thus charges us for the total energy that we use (KWh), not the rate at which we use it (watts). Power, as usual, is found by multiplying the current times the voltage ($P=IV$) for constant or slowly varying currents and voltages. For an AC circuit, the average power (for in-phase, sinusoidal waveforms) is found by multiplying the rms current by the rms voltage ($P_{av} = I_{rms} \times V_{rms}$). For out-of-phase sinusoidal waveforms, a $\cos(\theta)$ term must be included (the power factor). All of these are derived from the fundamental equation that instantaneous power is equal to the instantaneous current times the instantaneous voltage $Pi(t) = i(t) \cdot v(t)$.

Jay Rabkin
Pasadena, CA

Response:

I stand corrected; amp-hour is capacity, not power. Good catch!

John Iovine

Dear Nuts & Volts:

Don Lancaster's Resource Bin

reader FeedBack

#58 (on page 83 of the Nov. '96 issue) talks about batteries.

In his opening remarks about batteries, he says "An electrochemical cell consists of ... an anode at the positive terminal and a cathode at the negative terminal," and a paragraph later says "a chemical reaction forces electrons from the (-) cathode over to the (+) anode."

Whoaahh! I've been taught chemistry for years, and now teach chemistry to undergraduates. I believe this is backwards.

I grabbed my Webster's Collegiate Dictionary, 5th edition, and found it defined an anode as "the positive electrode of an electrolytic cell."

This seemed to match Don's description. When I got to work I pulled out a few references, and found in the Random House Unabridged dictionary, 2nd edition, the following definition of an anode: "The negative terminal of a battery."

One says positive, one says negative. What's going on?

At this point, Don succeeded in sending me back to some fundamental studies!

Well, the answer revolves around confusion of perspective. Someone charging a battery sends electrons one way, while someone using a battery allows electrons the other way around the loop. We can talk about electron flow vs. current flow, and charging vs. using. But as soon as the terms "anode" and "cathode" come up, there is no freedom to switch around the other terms.

In ALL cases, chemical "oxidation" of some species occurs at the anode, and reduction of some chemical species occurs at the cathode. It's easy to remember because "vowels go together." In other words, "O"xidation at the "A"node, and "R"eduction at the "C"athode.

In order to reduce the charge on a chemical atom, it needs to gain electrons (negatively charged). Reduction occurs at the cathode, so electons must "go in" the cell at the cathode. This is the positive side of a garden variety household battery.

Here's how I think Don got confused. When charging the battery, electrons (-) are taken out of the anode. This makes sense, because when you charge the battery, you provide a higher voltage and put current (+) into the positive terminal. Putting current in means taking electrons out.

Now, when using the battery, the (+) terminal accepts electrons. The electrons cause chemical reduction in atom charges inside the battery at this electrode, so the electrode is now the cathode.

Using the "anode"/"cathode" terminology, the electrodes switch depending on whether you're charging or using the cell!

The dictionary quote above properly claims the anode is the positive side of an electrolytic cell. An "electrolytic cell" stores energy, or gets charged. But Don makes the subtle slip to "electrochemical cell," which now implies it's being used as a source of energy. The anode and cathode reverse!

By equating the terms electrolytic cell, electrochemical cell, and battery, Don arrived at the wrong conclusion.

For almost all readers of the *Nuts & Volts* article (who think of using D-cells, C-cells, etc), the anode is the negative side of the battery — the side with the "-" printed on the battery case.

Brian J. Mork
Juniper, CO

Dear Nuts & Volts:

Keep up the good work. Lots of great articles and advertising. Please keep the electronic advertising coming. I find stuff here I cannot find anywhere else.

Charles Martin
Stockbridge, GA

Dear Nuts & Volts:

Best electronics variety store ever. Add that to a wonderful smorgasbord of articles, it's a family policy not to bug me when *Nuts & Volts* is in my lap!

One small voice in the back row, though — either run some informational series on program language, AND how to hook-up to a computer, or stop frustrating me with yummy PIC and CPU-link projects! Please!

J. Burgmann
Sarasota, FL

Dear Nuts & Volts:

Please, more information on antennas, decoders, video capture, and cameras. Satellite TV would also be nice.

Dan Salgado
Rowland Heights, CA

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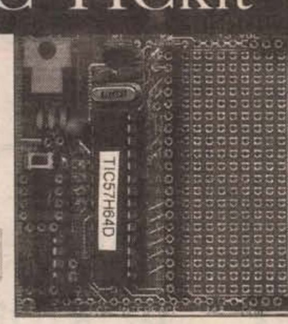

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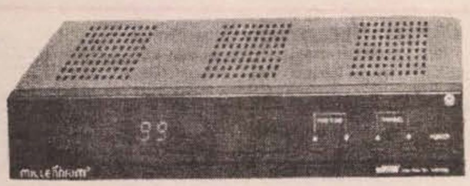

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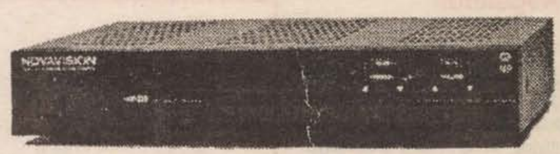

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Vout = Maximum DC regulated output voltage
Iout = Maximum DC output current

As a point of interest, the maximum continuous current for the regulator set at 5V (TTL) would be 4.329A. Keeping the regulator cool would improve the current output at the lower voltages. Heatsinking of the device will be discussed later.

A disc capacitor of 0.1 uF (C5) should be used to bypass the input, and be installed at the regulator. This will improve transient response and stability. A 10 uF solid tantalum output capacitor (C7) should be used to improve transient response, prevent feedback ringing, and improve the output impedance. The capacitor should be located at the regulator with short leads to reduce the effect of lead inductance. The adjustment terminal should also be bypassed with a 10 uF solid tantalum capacitor (C6). This improves ripple rejection from about 50 dB to 75 dB.

The current set resistor (R2) should be installed directly to the regulator socket, as this will improve the load regulation. If the current set resistor was placed at the load, with say only 0.05 ohms between the regulator and the load, the effective series loss would be increased 11.5 times to over 1/2 ohm. The parasitic loss resistance of 16GA wire translates to 20 mV/ft at 5A load current, so it is important to locate the regulator near the load. The adjust resistor (R1) should be located at the load ground to improve remote ground sensing and load regulation.

The Transformer

The proper transformer must be able to supply sufficient voltage to prevent the regulator from dropping out of regulation, yet if the voltage is too high, the excess causes unwanted heat and wastes power. When using a fullwave center tap transformer, the equation shown in Formula 1 is used to determine the transformer voltage requirement.

Remember:
Vreg = Minimum input-output voltage of the regulator
Vrect = Rectifier forward drop at 3x DC output current
Vripple = 10% of Vin = 1.655 Vpp
Vnom = Nominal line voltage in ACrms (usually 115 VAC)1
Vlow = Low-line voltage in ACrms, 10% below nominal

* The 1.1 value is a correction factor that accounts for the load regulation of the transformer. A 1.2V diode drop is a good starting point before a diode is identified. Schottky diodes improve the drop to approximately 0.5V. See Formula 2.

When a center-tapped transformer is used, correct Iout by a factor of 1.2, shown as:

Irms = Iout x 1.2 = 8A x 1.2 = 9.6A

Selecting a Rectifier

With our 8A supply, the diodes operate at 4A (center-tapped arrangement). The diodes must survive a shorted output, where the LM338K will provide 12A until it shuts down (6A per diode). Since the diodes conduct current in about 3.5mS pulses, the long term heating effect of the pulsing is roughly equivalent to 8A DC current. This gives rise to the need for a diode that will handle about 14A average current.

When the power supply is first turned on, the filter capacitor appears as a short circuit. The diodes must dissipate all of the initial current

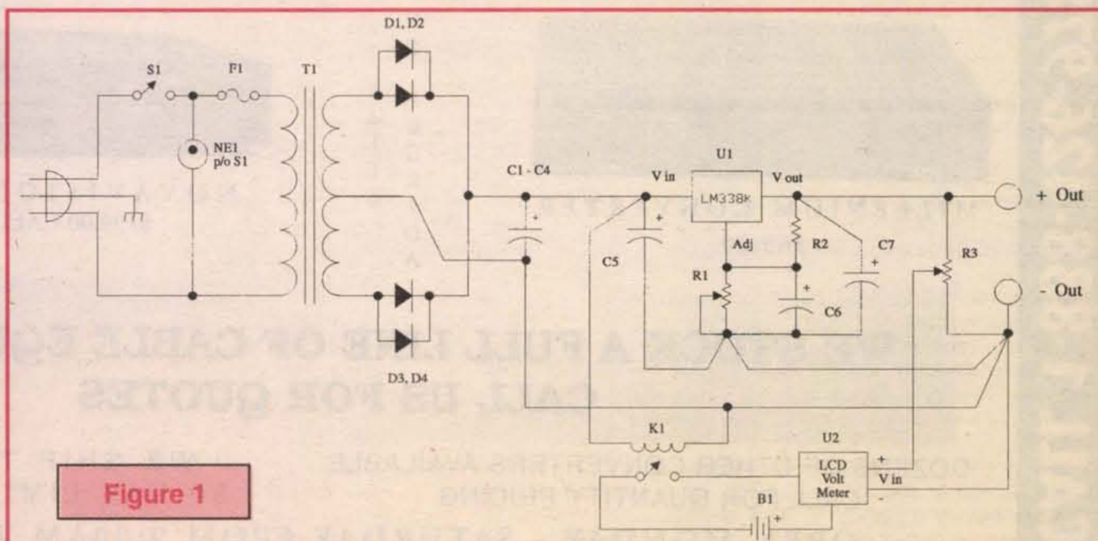

Figure 1

FORMULA 1

$$V_{rms} = \frac{V_{out} + V_{reg} + V_{rect} + V_{ripple}}{\sqrt{2}} \times \frac{V_{nom}}{V_{low}} \times 1.1^*$$

FORMULA 2

$$V_{rms} = \frac{13.8 + 2.75 + 1.2 + 1.65}{\sqrt{2}} \times \frac{115}{103.5} \times 1.1^* = 16.7706$$

FORMULA 3

$$I_{surge} = \frac{(V_{sec} \times \sqrt{2}) - V_{rect}}{\text{Transformer Resistance}} = \frac{(16.55 \times \sqrt{2}) - 1.2}{(0.1 \text{ to } 1^*)}$$

FORMULA 4

$$C = \frac{\text{Period} * I_{out}}{\text{Ripple}} = \frac{8.3\text{mS} * 8\text{A}}{1.655\text{v}} = 0.0401\text{F or } 40{,}100\text{uF}$$

(surge current) with the exception of the loss due to the resistance of the transformer secondary winding. The surge current found is shown in Formula 3.

*A good transformer has a secondary resistance on the order of 0.1 ohm, and a poor one about 1 ohm. The lower secondary resistance of a good transformer requires extra care in selecting a rectifier, as it can develop 222A of surge current. The lower resistance is desirable when you consider I2R loss. Our transformer measured at 0.14 ohms, therefore the Isurge value is 158.6088A.

The minimum peak reverse voltage should include cases where the line voltage exceeds nominal, say +10% = 18.2050Vrms. The peak of this for a fullwave center-tap configuration is then:

2 x 18.2050Vrms x 2 = 51.4916 Vpeak

The Vpeak rating should again be increased to allow for line transients. So far, we would like to ensure that our diodes have the following minimum characteristics:

- 1.2V or less forward bias drop
- 14A rms minimum average current
- 159A or better surge current capacity
- 103V minimum peak reverse voltage rating

Searching the typical catalogs show that the economical way to achieve high prv and a large average current rating is to parallel two diodes. A suitable device is found in the Diodes Incorporated series, FR805, which has the following features when operated in parallel:

- Average forward current = 8A x 2 = 16A
- Peak reverse voltage = 600V
- Forward voltage drop = 1.3V
- Maximum surge current = 300A x 2 = 600A

Notice that we violated our 1.2V maximum forward bias voltage drop rule. The effect is to increase our transformer voltage requirement by 0.2V, and to dissipate slightly more heat at the diode. The FR805 is found in a TO-220 case, which will help to eliminate waste heat of about 5W each at full power by enabling us to heatsink the rectifiers to the chassis. It is always good practice to verify the diode polarity with an ohmmeter before installing it. The diodes we received had the anode marked (-).

The Filter Capacitor

It is preferable to calculate for a capacitor conduction time equal to the entire rectifier supply period (8.3 mS). This simplifies the calculations and builds in a conservative value for the filter to compensate for the wide filter tolerances, ranging from -10 to +50%. Formula 4 shows how the capacitor value can be found.

The 8A value is used since the regulator is capable of providing 8A continuously, and the ripple current rating should be two-three times the output current from the filter (16-24A). Another important characteristic is the Equivalent Series Resistance (ESR), which will cause I2R heating and shorten the capacitor's life. Lower ESR is better, and significant reliability improvement is achieved with derating.

A way to provide substantial ripple current economically is to use inexpensive capacitors in parallel. For our supply, four Panasonic TSUP series (pn# P6913) 10,000 uFd units are used. The combined effect is:

Capacity: 10,000 uF x 4 = 40,000 uF ±20%
Ripple current: 4.42 x 4 = 17.68A rms
Working Voltage: 35V, 44V surge
Temperature rating: -40 - +85°C

Selecting a Heatsink

The LM338K will dissipate up to 50W continuously, as long as the maximum junction temperature of 125°C (257°F) is not exceeded. The short circuit heating need not be considered as the regulator will go into shutdown in this condition. Heatsink ratings and heat transfer are stated in terms of °C/W, and the principle factors are related as:

$$Pd = \frac{Tj - Ta}{Rjc + Rcs + Rsa}$$

Pd = Power dissipated in the regulator (W)
Tj = maximum junction temperature (°C)
Ta = ambient temperature (°C)
Rjc = thermal resistance: junction to case of regulator (°C/W)
Rcs = thermal resistance: case of regulator to heatsink (°C/W)
Rsa = thermal resistance: heatsink to ambient air (°C/W)

For our regulator, Pd = 50W, and we solve for Rsa as follows:

Tj = 125°C maximum
Ta = 40°C (104°F) (this is a typical design value)
Rjc = 1°C/W
Rcs = 1.2°C/W using dry 2-mil mica insulator
0.35°C/W using greased 2-mil mica insulator

$$Rsa = \frac{125 - 40}{50} - (1 + 0.35) = 0.35°C/W$$

The heatsink thermal resistance must be less than 0.35°C/W to operate the regulator at the extreme limit. The existing unit is very similar to an ECG440B, which has a thermal resistance of 1.8°C/W. A better device is an EG&G Wakefield Engineering pn# 433K, which has a thermal resistance of 0.37°C/W. That means that our 50W regulator case dissipation will elevate the 433K heatsink 0.37°C/W x 50W = 18.5°C over ambient (58.5°C).

Operating the power supply at room temperature (76°F = 24.4°C) with 13.8V at 8A continuous output develops a heatsink temperature of about 32.58°C (90.65°F).

One might think that a fan should have been installed to the existing 1.8°C/W heatsink. A 200 fpm fan would bring it into the 1.0°C/W range, which is still not quite good enough.

TABLE 1

Power Converter	High-Quality Unit
13.8 VDC ±0.3V	5-13.8 VDC variable
10A constant, 12A surge	8A constant (typ), 12A surge
150 mV rms ripple	0.3 mV rms ripple
2.5% load regulation	0.3% load regulation

Voltmeter

A good analog panel meter has an accuracy of ±2% and costs in the $40.00 range. A digital LCD panel meter (voltmeter) has accuracy on the order of ±0.5% and can be found for $20.00.

We would have used a NJM78L09A +9V regulator, but our voltmeter would not permit a common ground between the supply and the negative input terminal. We thought about using a switched capacitor to isolate the supply ground, but felt it was unnecessarily complicated compared to a 9V D cell battery. Since the unit requires 1 mA to operate, we decided to operate the meter via a relay.

A voltage divider is required for input voltages above 200 mV. The vendor recommends installing 100K and a 9.9M 0.5% metal film resistor. An alternative to 0.5% resistors is to operate the voltmeter in the 200 mV mode, and use more commonly available 1% resistors to provide the appropriate sample voltage. A divider of 2K and 198K can be made up from the standard values of 2K, 178K, and 20K. The worse case and monte carlo voltages across the 2K resistor using a perfect 13.8 VDC source would be:

Worse Case	Monte Carlo (500 Trials)
0.13800V nominal	0.13801V mean
0.14076V maximum	0.14055V maximum
0.13529V minimum	0.13562V minimum

This means that even with 1% resistors, the voltmeter could read from 14.07V to 13.52V due to the resistor tolerance alone, which is an error we can't permit. The way to solve this is to use a trimmer pot with the wiper feeding the voltmeter. The trimmer could be calibrated to produce the exact sample voltage (the more turns, the better). This voltage divider method also avoids a calibration step requiring an accurate +10VDC source.

Install a jumper at P2 for the proper decimal point on the 20V scale. The meter could also be used to measure current if a sample resistor were

TABLE 2

Items to conserve	Items to remove	New Items
Enclosure	Regulator PCB	LM338K + support
Power Switch	Heatsink	Filter capacitor
Fuse Holder	Binding posts	Binding posts
Transformer	Power cord	3 wire power cord
		Voltmeter + support
		Potentiometer
		Heatsink

installed. The problem is that 0.01 ohms would be required to produce 50 mV at 5A and this would contribute to an unacceptable error.

The Power Converter

The supplied schematic revealed that we had, in fact, purchased a regulated supply. In simplified terms, a KA723 regulator was used to drive two parallel 2N3055 transistors. The following specifications were provided, and are compared to the expected project results as shown in Table 1.

The ripple is reduced by a factor of 500 and the load regulation is improved by a factor of 8.3. See Table 2.

Modifications

Install R1 to the enclosure. Install C6 to R1, and connect the R1/C6 ground directly to the (-) output terminal. Install the TO-3 socket to the heat-sink and mount U1 via the mica using heatsink grease on both sides of the mica. Install R2 between the adjustment pin of U1 and the case connection. Install C5 between the Vin pin and the heatsink ground lug located near U1. Install C7 between the case and the ground lug. The ground lug may be attached directly to the heatsink via a nut and bolt.

Mount the heatsink so that a natural airflow will develop due to convection. Conveniently mount R3 between the (+) and (-) output terminals. Take advantage of the case as a heat sink when mounting D1-D4. Located T1 as far from the output terminals as possible, but watch the balance of the unit (center of gravity).

Use 16GA or larger wire between C1-C4(+) and U1 (Vin), between C1-C4(+) and the rectifiers, and between U1 (Out) and the (+) output terminal. Use a separate 16GA or larger conductor from C1-4(-) to the transformer center tap, and to the (-) output terminal. Keep all of these leads as short as possible. **NV**

Parts List

U1	LM338K
U2	3.5 Digit LCD Voltmeter
T1	115 VAC primary, 16.5Vrms, 10A secondary *
S1	115 VAC switch *
F1	2A slow blow fuse *
F1H	Fuse Holder *
D1-D4	FR805 rectifier
C1-4	10,000 uF, 35V, 4.42A rms ripple current minimum
C5	0.1 uF 25V
C6, C7	10 uF Tantalum 25V
R1	5K ohm linear taper
R2	220 ohm, 1/4 watt
R3	200K, trim pot
J1, J2	Binding terminals
P1	Three wire AC plug and strain relief
HS1	Heatsink, EG&G model 433K
SKT	TO-3 mounting kit and socket for U1
KIT	TO-220 mounting kit for D1-D4
GRS	Heatsink grease
K1	24 VDC relay
B1	9V D cell battery
H1	D cell battery holder
misc	hook-up wire, case, hardware

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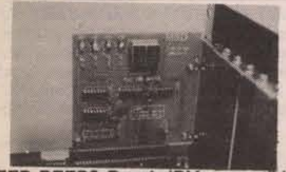

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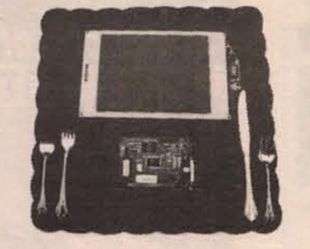

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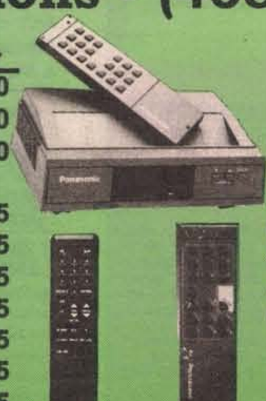

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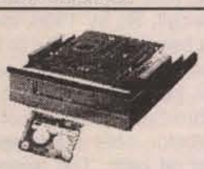

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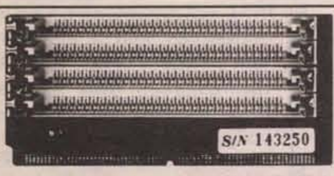

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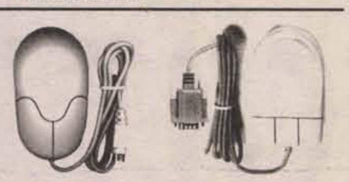

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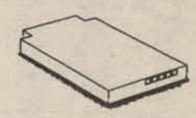

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THE DC VOLT

by Ron Tipton

How many times each day do you pick up a probe to measure a DC voltage? You probably don't keep count and neither do I, but DC voltage is one of the most common measurements we make.

The meter reads, say 4.65 volts, and we usually accept it without question. But just what is a volt and how is it maintained? That's the subject of this article and it's a fascinating look at the search for increasingly more accurate methods of building a "standard volt." This progression is summarized in the Comparison Table. There is a lot of math connected with this subject and I'm going to mostly leave it out as it's not necessary to your practical understanding.

In 1881, it was agreed internationally at a Paris (France) meeting to define electrical units in terms of the basic mechanical units of length, mass, and time. The intention was to provide a consistent base for measurements in all branches of science and engineering but, unfortunately, it has proven to be a most difficult task — more on this as we go along.

In the United States, this effort is the responsibility of the National Institute of Science and Technology (NIST) and they do an outstanding job. (Prior to August 1988, NIST was the National Bureau of Standards (NBS) so many reports, monographs, and books bear the NBS name and publication number.)

THE CURRENT BALANCE

The current balance, shown in Figure 1, is a basic apparatus for defining the ampere. The current is adjusted so the position of the movable coil is balanced between the attraction of the fixed coil and the pull of gravity. The mutual inductance between the coils, the coil dimensions, the movable coil's mass, and the acceleration of gravity relate the current to length, mass, and time. The current is also made to flow through a standard resistor, and so, by Ohm's law, we have a "standard volt." (We will ignore how we got the standard resistor, but it too is defined by the basic mechanical units.)

Although simple in concept, the mechanical and electrical properties of the coils are very difficult to measure to the required precision. Winding strain and impurities in the wire introduce still more uncertainty. So, as the "maintained" volt has improved (see Table), NIST scientists have been hard pressed to keep up with the mass, length, and time verification. But let's not get ahead of our story.

A current balance can define the standard volt, but it's not a very convenient way to calibrate voltmeters. Some sort of battery with a fixed electromotive force (EMF) and excellent long term stability would be a lot easier to use.

STANDARD CELLS

Between 1879 and 1906, the volt was maintained in the US by a group of seven Clark cells, a battery using a zinc sulfate electrolyte. During these 27 years, the cell was improved by several workers, but it had limitations — such as electrode gassing — that couldn't be overcome. Although not perfect by any means, Weston cells didn't have the gassing problem and also had an EMF temperature coefficient that was 30 times better than the Clark cell. So by 1908, the Clark cells had been phased out in favor of the more stable Weston cells. In 1965, the National Reference Group of Standard Cells consisted of 44 saturated Weston cells in a temperature controlled oil bath. The temperature was maintained at 28° C within 0.01° C.

A cell is removed from the reference group if its EMF drifts by more than 10 microvolts from its previously steady value. When a cell is removed, the average (or mean) EMF for the group is recalculated starting from the date the removed cell was added to the group. Obviously, this calls for very good recordkeeping. But since the cell group is kept fairly large, the average EMF change caused by a cell removal is usually less than one microvolt.

By 1974, cell groups were kept in enclosures with a temperature instability of less than 20 microdegrees over several days. As often happens, the cell's temperature coefficient became less important as temperature control technology improved. Ambient temperature changes now have a negligible effect on the cell EMF.

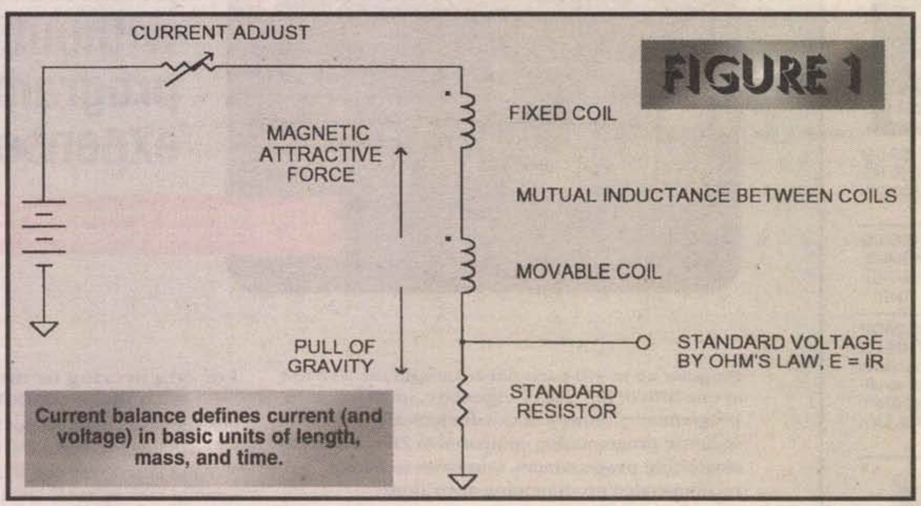
The sketch in Figure 2 shows a Weston standard cell, the only kind currently in use. "Saturated" refers to the cadmium sulfate solution; no additional cadmium sulfate will dissolve. Unsaturated cells are also used as secondary standards — more on this later.

NIST goes to incredible lengths to insure the purity of each cell "ingredient" and the result is excellent stability with a long useful life. But saturated cells are finicky. They don't like to be moved and if they are, they need a "rest period" at the new location for the EMF to settle down.

Also, they are not current sources. A discharge current of even one microampere for a few seconds changes the EMF for several minutes after the load is disconnected. A current as large as a milliampere can completely destroy the cell's usefulness.

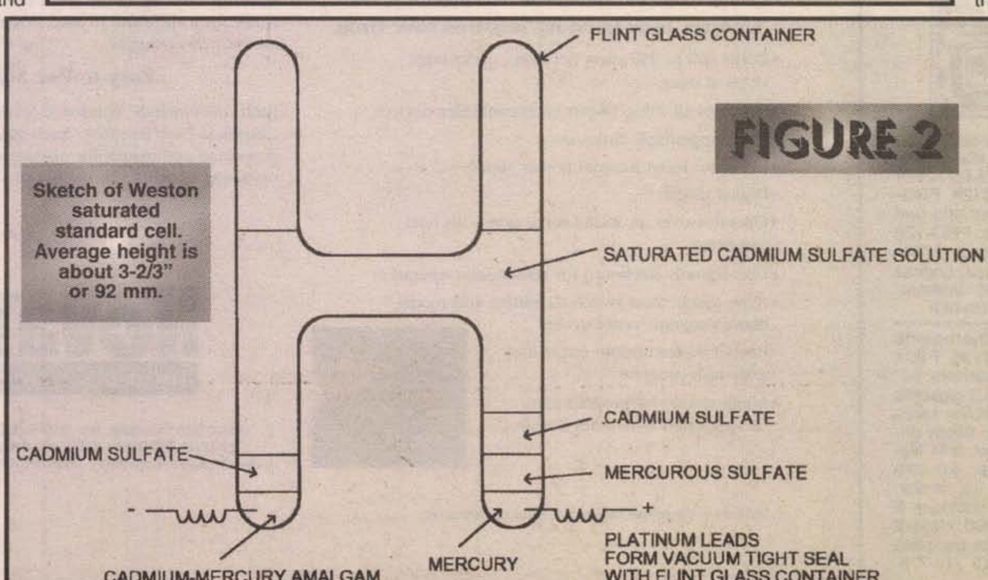
So how can we use

FIGURE 1



Current balance defines current (and voltage) in basic units of length, mass, and time.

FIGURE 2

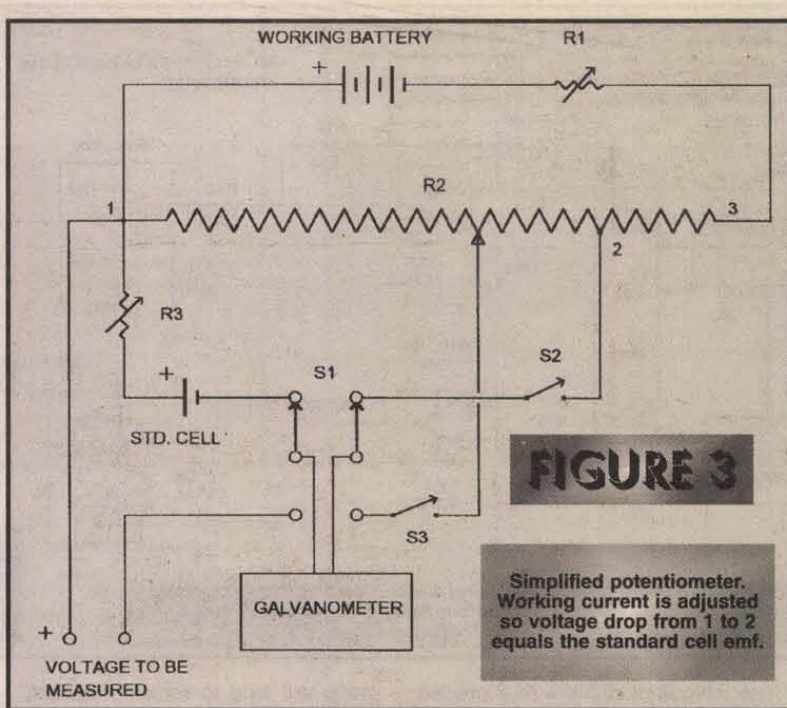


Sketch of Weston saturated standard cell. Average height is about 3-2/3" or 92 mm.

them to make practical voltage measurements?

THE POTENTIOMETER

The answer is an instrument which draws only a very brief, minute current from the cell: a laboratory potentiometer. I have diagrammed a simplified potentiometer in Figure 3 to show you how they work. The working battery is typically a two- to four-volt storage battery. The voltage isn't critical as its only job is to supply a stable working current. R3, a compensation adjustment, is first set to the EMF printed on the standard cell's label. With S1 in the "std. cell" position (as drawn in Figure 3), switch S2 is tapped and R1 is adjusted for no deflection on the galvanometer. In most potentiometers, this sets full scale to 1.6 volts (voltage drop between points one and three) because the voltage drop from point one to point two exactly balances the standard cell's EMF.



Simplified potentiometer. Working current is adjusted so voltage drop from 1 to 2 equals the standard cell emf.

To measure an unknown voltage, S1 is placed in the "down" position and switch S3 is tapped as the main dial (R2) is adjusted. R2 is a range switch in series with a long slidewire mechanically arranged in a spiral. Because of this length, any voltage between zero and 1.6 volts can be measured with a resolution of 10 microvolts. Higher voltages are handled with an accurate voltage divider called a "volt box."

Leeds and Northrup Model 7552 is a typical potentiometer. Input and output binding posts are on rear panel (not visible). Large "drum" with crank handle is the spiral slidewire.

Manufactured by companies such as Leeds and Northrup (L&N), Julie Research Laboratories, and Weston Instruments, and traditionally housed in a well crafted wooden box with a highly polished bakelite control panel, a potentiometer is a precision instrument and must be treated accordingly. In this day of many-digit digital voltmeters (DVMs), manual-balance potentiometers can appear on used-equipment dealer's shelves at bargain prices. A photo (Figure 4) of the author's L&N model 7552 is typical of the breed.

TRANSFER STANDARDS

Saturated reference cell groups in their constant temperature enclosures are difficult and expensive to move between laboratories for intercomparison. It was done for many years simply because there was no alternative. But starting about 1970, solid-state voltage references were introduced for this use, that is, as transfer standards. They are much more rugged than cells and are easier and less expensive to ship.

The solid-state units use several zener diode voltage reference modules in a constant temperature enclosure. Batteries supply power to the reference modules and temperature control during transportation.

The zener diode modules often supply 10 volts (which is preferred for calibrating digital voltmeters), as well as 1.018 volts which is compatible with existing potentiometers.

As an added advantage, some zener units can supply some output current with no loss of accuracy or need for a recovery period.

Unsaturated Weston cells are not quite as accurate, stable, or long-lived as saturated cells. But they are less expensive and can be economically shipped by common carrier. They find use as secondary standards at schools and calibration laboratories.

Standard cells have been in use for over a hundred years, but the search goes on for an even more accurate standard. In 1987, work began at NIST to maintain the US (legal) volt with a Josephson array.

THE JOSEPHSON ARRAY

In the 1960s, British physicist Brian Josephson predicted that a radio-frequency (RF) signal directed through a "sandwich" consisting of a superconductor, an insulator, and a superconductor, would produce a specific, repeatable voltage. This sandwich is now known as a Josephson junction. This is a quantum device with a junction voltage given by:

$$V_n = \frac{nfh}{2e}$$

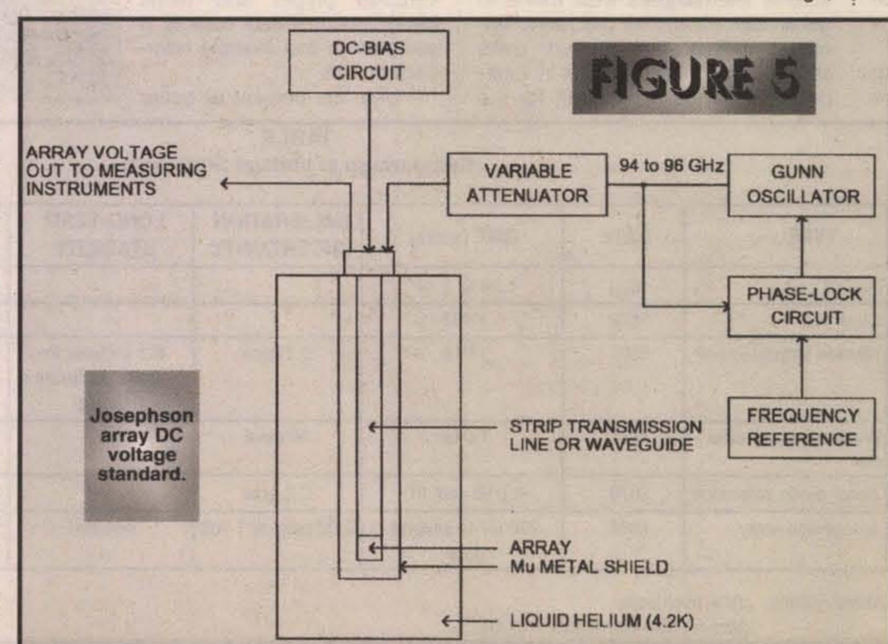
f is the frequency of the RF excitation signal, e is the charge of an electron, and h is Planck's constant. Both e and h are fundamental constants, but this isn't sufficient to tie this volt definition to length, mass, and time.

Primarily because of the physical size of practical Josephson junctions, the RF frequency is 94 to 96 GHz. Substituting into the above equation (for n = 1) gives a junction voltage of about 200 microvolts. The integer "n" varies with the DC bias current and RF excitation power. Still, many junctions in series, that is a Josephson array, are needed for a practical standard. NIST has built various size arrays to over 2,000 junctions with larger ones planned.

Individual junctions are quite small and are getting smaller as research continues on superconducting materials. NIST researchers hope to eventually produce a chip with one million junctions in one square centimeter.

There are several reasons for wanting smaller arrays. The cooling system can be smaller, there will be a lower temperature gradient across the array, and equally important, a small size makes it easier to equalize the microwave power into each junction. Equal power into each junction is needed to keep n (in the above equation) the same for the whole array.

A Josephson array standard is diagrammed in Figure 5 and you can see that it's not an instrument you could easily build at home!



Josephson array DC voltage standard.

In April 1996, NIST announced a transportable 10-volt Josephson calibration system. Its weight and size are considerably smaller than previous models, yet it holds enough liquid helium to operate for six to eight weeks. The final version of this system is designed to be cooled with a refrigeration unit.

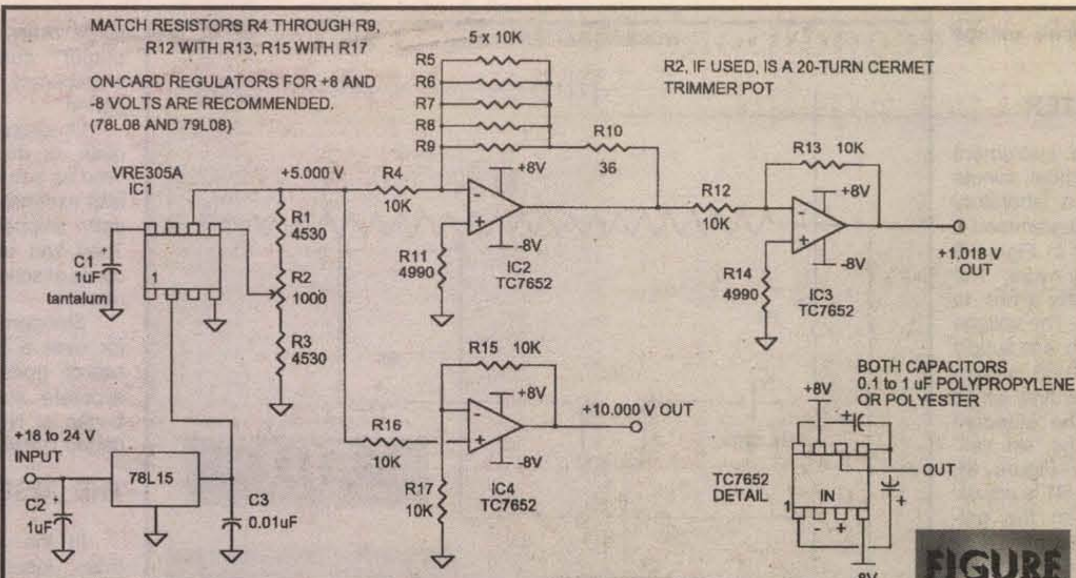
Although it is constructed as a physical instrument, the Josephson effect is fundamentally different from a standard cell or a zener reference. Some Josephson arrays can "go bad" for, as yet, unexplainable reasons, but new arrays can be built. For these reasons, the long term EMF stability is "perfect" (at our current level of understanding the process). Why then are we concerned with verifying this volt definition in terms of the basic mechanical units?

The problem lies in our imperfect knowledge of e and h, the electron charge, and Planck's constant. The volt defined by the Josephson effect has excellent long-term stability, but is this volt the right "size?" An independent measurement will either confirm the size of the volt or let us adjust e or h to bring the measurements into agreement.

A very sophisticated superconducting current balance has been built to determine the "absolute ampere." Also, work is continuing on a liquid electrometer for a direct absolute volt determination. In this apparatus, the vertical displacement caused by electrostatic attraction between a fixed plate and the surface of a mercury pool is measured by a laser interferometer.

But the difficulties in making these verification measurements are illustrated by several experiments with the above instruments, in which the residual uncertainties are about the same size as the Josephson volt uncertainty. That is, the results are inconclusive.

And so this interesting and challenging work goes on!



Suggested circuit for a voltage reference using a VRE305A and three chopper-stabilized opamps. All resistors are 1% metal film and some of the 10K resistors are matched to 1 ohm, as indicated above.

FIGURE 6

A VOLTAGE REFEENCE YOU CAN BUILD

If you want your own secondary voltage reference, here's a suggestion for one that's pretty good and easy to build.

Several companies are now producing zener diode references with a laser-trimmed buffer amplifier in an easy-to-use integrated circuit with a precise output voltage. I have evaluated many of these devices, and the best ones I've found are manufactured by Thaler Corporation (see Resources). Their VRE305A has a five-volt output with an initial error of not more than 500 microvolts (±0.01%) and a maximum temperature coefficient of 0.6 ppm per degree C — in an eight-pin DIP.

The circuit in Figure 6 will give you outputs of 1.018 and 10 volts. The specified 10,000 ohm resistors can be matched to 0.01% (1 ohm) with a 4-1/2 digit (or better) digital multimeter. (The actual resistance isn't important, just the match.) The chopper-stabilized opamps will each contribute no more than five microvolts uncertainty to the output voltage.

If you build several of these circuits and put them in a temperature-controlled box, you'll get improved long-term stability. You will also be able to intercompare their EMFs to get an idea about their drift rates. The output drift of the different units should be uncorrelated (that is, independent) so the mean EMF for the group will tend to remain constant. Adding a sealed lead-acid battery pack and a charging power supply would give you power line independence and portability. It just depends on what you need or want.

Here are a few construction suggestions.

Use a PC board and then support the board by its wire leads to minimize strain-produced stray EMFs. If this is a mechanical problem, design the enclosure so the board slides into sidewall slots or use some support that puts no tension or compression on the board.

Carefully solder the ICs to the board; don't use sockets. Don't leave out the +15 volt regulator (78L15). This preregulation virtually eliminates supply voltage variation in the VRE305 output and helps insure uncorrelated outputs if you plan to use multiple reference boards.

Use one percent or better metal film resistors with the lowest temperature coefficient you can find, even if you are going to use a temperature-controlled box. Stand the resistors up off the board's surface so you can use a copper alligator clip as a heatsink during soldering.

This is a DC circuit, so a bit more stray capacitance isn't going to matter. The trim components (R1, R2, and R3) are optional. Using these resistors will give you about one millivolt of adjustment, but the five volts will be within 500 microvolts without them. Unless you have a good DVM, you may be better off without the trim. This is a basic "building-block" circuit and I've had very good results with it. **NV**

RESOURCES

A good source of information on standard cells is NBS Monograph 84, *Standard Cells: Their Construction, Maintenance, and Characteristics.* A photocopy can be ordered from **National Technical Information Service**, 5285 Port Royal Road, Springfield, VA 22161 as publication number COM7210513/LL.

Many NIST papers on DC voltage standards and calibration have been published in the *IEEE Transactions on Instrumentation and Measurements.* You should be able to find a complete set of back issues at any large library, especially college and university libraries.

To keep up with what is going on at NIST, in general, you can get a free E-Mail subscription to the biweekly *NIST Update* newsletter by sending a "subscribe" message to **baum@micf.nist.gov**

The VRE305A voltage reference is available from the **Thaler Corporation**, 2015 N. Forbes Blvd., Tucson, AZ 85745. **(520) 882-4000**.

The TelCom TC7652 chopper-stabilized opamp can be found at **Digi-Key Corporation**, 701 Brooks Ave. South, Thief River Falls, MN 56701, **(800) 344-4539**, as their part number 10111.

TABLE
Comparison of Voltage Standards

TYPE	DATE	EMF (volts)	CALIBRATION UNCERTAINTY	LONG-TERM STABILITY	COMMENTS
Daniell cell	1836	1.04 to 1.14			Poor long-term stability
Clark cell	1872	1.433			Better stability than Daniell cell
Weston saturated cell	1892	1.018	0.1 ppm	0.1 uV/year for National Reference Group	Former US legal volt
Weston unsaturated cell	1892	1.019	50 ppm		Secondary working reference
Zener diode reference	1970	1.018 and 10	0.2 ppm		More rugged than standard cells
Josephson array	1987	200 uV to several volts	0.02 ppm at 1 volt	see text	New US legal volt

Abbreviations: uV = microvolts
ppm = parts per million = 0.0001%

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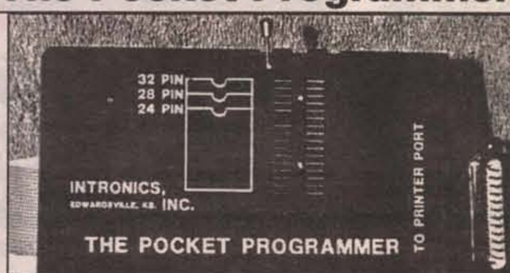

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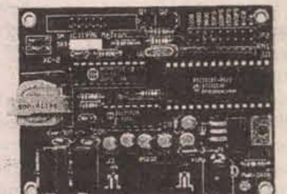

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by Karl Lunt

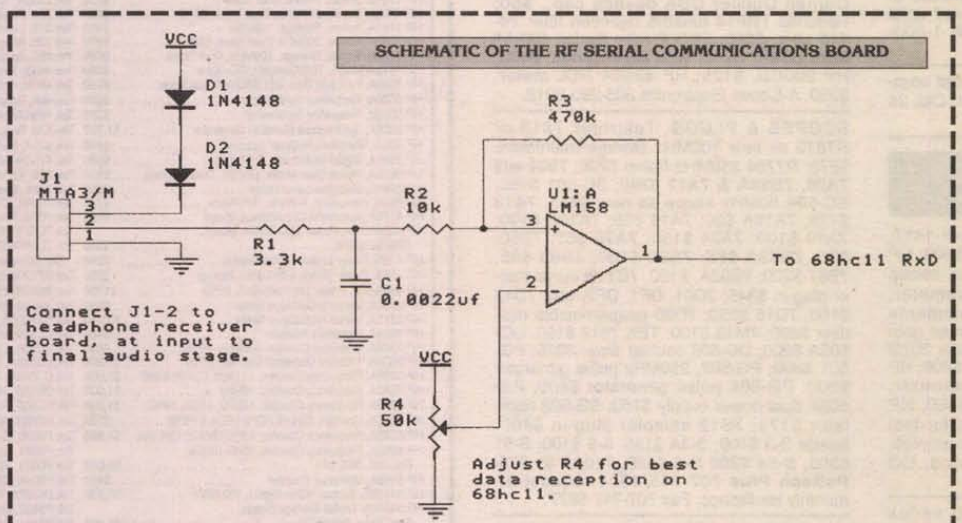
The Best in Robot Soccer

The goalie moved sharply to the left, staying between the ball and goal, while the right forward raced ahead, lining up a pass. A quick nudge sent the ball rolling across the field to the left forward, which redirected the ball into the now-open goal, well before the opposing goalie could react. This quick give-and-go play added yet another point, as the robots from the Newton Research Labs team powered their way to a 20-0 win in the finals of the first Micro-Robot World Cup Soccer Tournament.

The tournament — held November 9-12, 1996 — took place in Taejon, Korea, and included 23 teams from all over the world. It was organized by Korea Advanced Institute of Science and Technology (KAIST), sponsored by the IEEE Robotics and Automation Society, and supported by LG Semicon Co., Ltd. Known by its acronym, MIROSOT, this event featured teams of three tiny robots in a single-elimination contest based on soccer.

The MIROSOT format plays very much like the regular game of soccer, but reduced in size and with added refinements designed to help its robot competitors. The pitch, or playing surface, is a smooth, dark-green wooden surface 90 cm wide and 130 cm long, covered with a grid of white lines 10 cm apart. The boundaries are marked with wooden vertical walls five cm high. The goals, set at opposite ends of the field's length, are 30 cm wide and 12 cm high, with a five cm wall behind each goal. An orange golf ball serves as a soccer ball.

Each team consists of two forwards and a goalie. Each robot must fit within a cube 7.5 cm (about three inches) on a side, excluding any antenna. If a robot uses a gripper or other appendage, it must still fit within the assigned size, even when fully extended. All robots must be fully self-powered, using self-contained motor systems. Only wireless communications between robot and host system are permitted.



SCHEMATIC OF THE RF SERIAL COMMUNICATIONS BOARD

All control signals must be generated solely by a host computer system. No human member of a robotics team may use joystick or keyboard input to control the motion of a robot. Should a team desire to use a vision system for scanning the playing area, the camera must be mounted directly over the pitch, no closer than two meters from the surface.

Additional rules cover topics such as fouls and penalties, goal-scoring, substitutions, time-outs, free kicks, and functions of the (human) referees. As of this writing (Thanksgiving, 1996), you could find all of the above information, and much more, from the MIROSOT web site at www.mirosot.org — Oddly enough, two weeks after the event was held, I was not able to find any scoring information or even the name of the winning team.

Designing the Robots

Speaking of the winning team, the four humans involved had never even heard of MIROSOT until six weeks before the event was scheduled. Randy Sargent, Anne Wright, Carl Witty, and Bill Bailey, all members of the Seattle Robotics Society (SRS), were deep in the design of their winning AAAI entry (see my column, Oct. '96) when Randy got word of the looming soccer contest. When presented with the idea of entering this contest as well, the other three team members responded with a loud, "No way!" The AAAI design effort was already back-breaking; no one wanted to pile on yet another project.

But Randy wouldn't let the idea die, and mentally tinkered with what it would take to build so much capability into such a small package. Finally, he decided that he would spend one day, no more, trying to build a robot prototype to do the job. If, at the end of that day, he had a machine that was promising enough, he would once more ask the team about entering the MIROSOT event.

That evening, Randy had fashioned a small robot out of a cut-down 68hc11 Miniboard, some surplus gearhead motors, and two nine-volt batteries. The whole package fit within the required space, with 1/2" of headroom at the top, allocated for the not-yet-designed communications electronics. It was crude and didn't run straight, but it worked enough to convince the others that the design was indeed possible.

Following their triumph at the AAAI event, and after moving tons of computer and robot gear into a new house in Bellevue, the four teammates settled down to tackle the difficult design elements of the soccer robots. Tops on the list was some method of sending information between a host PC and the three small robots. Since the host PC would use the Newton Labs vision system to monitor the playing field, the team only needed a one-way link. But that link had to run at least 9600 baud, or it couldn't keep up with the vision system or the action.

The group quickly ran through existing possibilities, discarding each in turn. IR was out, as it was too susceptible to ambient light; the sodium vapor lights at AAAI proved that. The team couldn't find a small enough RF modem in time, and was running out of options when Randy stumbled onto the answer. He returned home one day with a couple of wireless stereo headphones from the local Radio Shack. These are basically short-range one-way FM stereo radio systems, designed to pipe audio from some source, such as your stereo TV, to one or more headsets for private listening.

Randy and Bill were intrigued about using the headset as the RF link on a robot. The transmitting side seemed simple enough; just add a resistor divider to the serial output from a PC's COM port and run the reduced signal into the audio input of the wireless headset transmitter. Whatever serial data you sent to the COM port would be transmitted as audio tones over the 900 MHz RF link and picked up on the headset's receiver.

Bill then designed a one-IC level detector and squaring circuit to convert the received signal into digital levels, for wiring directly into the Serial Communication Interface (SCI) of the Miniboard. Initial tests looked very good; the 9600 baud data stream appeared at the SCI port and was mostly accurate.

But not all of the characters came through cleanly. Tests showed that the headset's amplifier — which naturally treated the signal as audio — was trying to keep the output centered at 0 volts. Bill's circuit would then drop out some of the bits, since the signal had settled outside the detector's threshold.

Rather than give up on the whole design, the two determined by experimentation that if a data byte contained three, four, or five one-bits, the byte came through intact. Apparently, these patterns kept the receiver's output signal in a suitable range for Bill's detector circuit. Armed with this data, they developed a table of the 182 different bit patterns that could be transferred successfully. They then built a conversion scheme that let them send the commands and data they needed, using only the permitted characters.

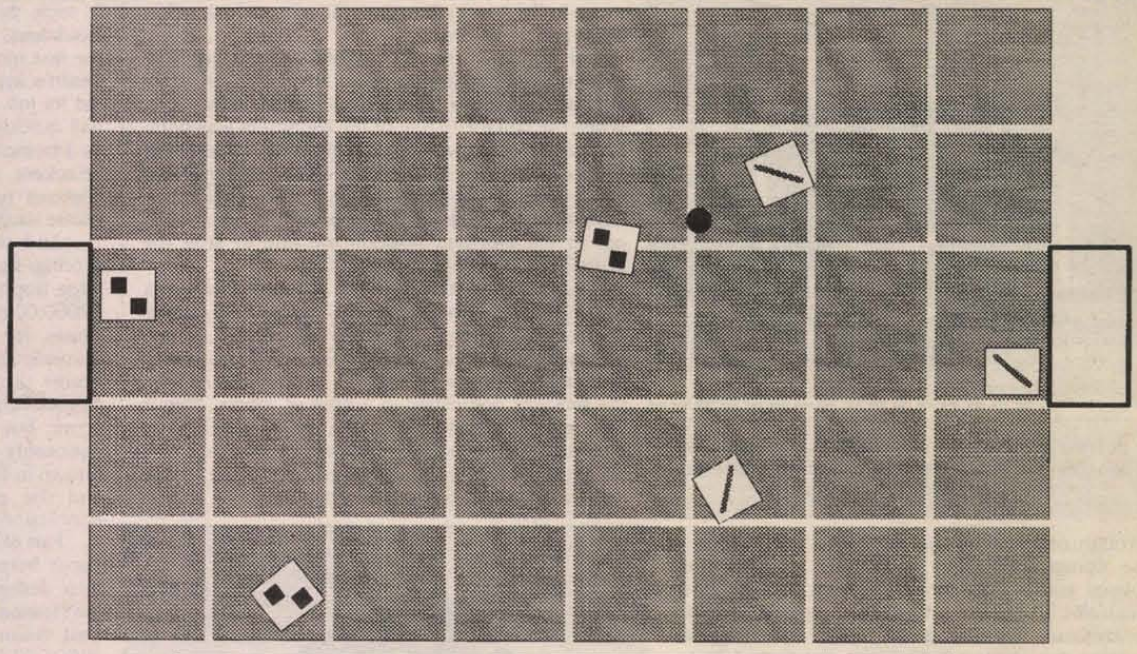
Further tests showed that the RF link worked perfectly at 9600 baud. Randy bought a few more headsets, Bill worked up a mechanical mounting scheme for the liberated receiver boards, and the RF link was in place.

Next up, the team needed some type of pulse-width modulation (PWM) control for the DC gearhead motors they had selected. These were prime units, but they were never meant to run on 18 VDC. And since the event called for both speed and control, the motor controller really needed some type of feedback for sensing actual speed. But there was no physical room left for adding wheel encoders and sensors. The designers needed another way.

Bill had been working for some time on just such a speed controller, based on an idea he had picked up from Lance Keizer, one of the SRS regulars. Bill's design uses a 68hc11 A/D port to monitor the voltage on a motor's power leads, sensing the back EMF as a measure of the motor's running load. The circuit is quite simple, consisting of a few passives, including some diodes to protect the A/D port from out-of-bounds voltages. Coupled with the appropriate software, the little gearhead motors provided excellent performance. Bill's back-EMF motor sensor really deserves more attention than what little I'm providing here. Look for more info in an upcoming article.

Now Bill turned his attention to the mechanics needed to build the little robots. Three inches on a side doesn't leave a lot of room for hardware and, with Randy's help, Bill put together a robust platform with a minimalist design. Two small pieces of flat 1/8th-inch aluminum stock form the base. The motors, nestled side-by-side with the output shafts facing opposite directions, are held to the base with a thin, sheet steel clamp and metal screws. Four posts, made of threaded aluminum spacers, hold the stack of PCBs tight against the top of the insulated motor clamp.

The PCB stack consists of three boards. The cut-down Miniboard sits at the bottom, and holds the 68hc811e2 MCU, the motor power driver chips, and sundry LEDs for status. The middle board contains all of Bill's custom circuitry, including wiring for checking the remaining battery voltage. At the top sits the cannabalized RF board from the FM headset, held into place by short pieces of copper wire, acting as guys to nearby 4-40 hardware at the top of the spacer stacks.



OVERHEAD VIEW OF A TYPICAL MIROSOT ROBOT SOCCER LAYOUT

Randy's original prototype had the drive wheels attached directly to the motors, resulting in off-center wheels. The unsymmetrical layout caused the robot to lurch sideways when it started up, aggravating the control and steering problems. While Bill worked on the mechanics, Randy looked into getting the wheels back on the frame's centerline where they belonged.

The winning soccer-bot designers — clockwise from lower left: Randy Sargent, Carl Witty (holding the trophy), Bill Bailey, and Anne Wright.

He ended up building a two-gear Lego drive system, using two Lego wheel-and-gear assemblies at the center axle. Fastening the Lego drive gear to the motor shaft proved difficult, however. Since the motor already had a substantial gear reduction built in, the resulting torque would pop the wheel off the shaft after just a few starts. Various glues couldn't hold the steel shaft to the wheel, so more drastic measures were needed.

Bill machined a narrow slot down the center of a motor shaft, into which he wedged short wire. They fitted the wheel onto the shaft and tried again, but the motor's torque snapped the wire. A square metal wirewrap pin fared better; it bent, but did not break. Finally, Bill used a small piece of hacksaw blade, cut to the proper shape. Randy fitted a Lego wheel onto this shaft and key arrangement, potting the wheel in place with hot glue.

This mounting system has proved remarkably robust, and the team gets a charge out of seeing this item in the official bill of materials; "one hacksaw blade, heavily modified."

The robot power system proved another obstacle. The team had considered using small NiCd batteries for power, but abandoned that idea based on concerns over charger availability and charging time once the contest began. Instead, they opted to use a pair of nine-volt alkalines on each machine. Unfortunately, the power drain was so great that each robot could get only eight minutes of running time out of a pair of batteries. This didn't leave much spare time, since each game consisted of two five-minute halves and the team wouldn't be able to change batteries during either half. They solved the problem by sheer numbers, and boarded the flight to Korea with 100 alkaline batteries.

As the deadline raced inward, the group poured more and more energy into the project. The programming team, headed by Carl Witty, needed to build three suites of software. The 68hc11 code didn't need to do much by most robot standards; just basic command parsing and motor control. But they only had 2K of code space to work with, and translating the incoming characters into the proper numbers and letters used up a lot of space. Finally, with only bytes to spare, the 68hc11 code was ready to lock down.

The host system, however, was a different story. It consisted of two machines, the 68332 board that ran the vision system and a Pentium PC running Linux, used to calculate robot motions and direct traffic on the playing surface. The 68332 ran a suite of code for translating the color video signal into a data stream for use by the Linux box. Most of the 68332 code carried over from previous projects, but fitting it all together into a cohesive unit still took valuable time.

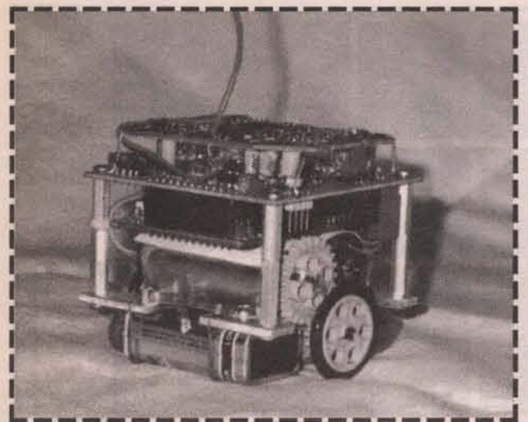
The Linux code to run the whole soccer team required a massive amount of design effort and computational capacity. The vision system, providing updates at 60 frames per second, pushed the original Pentium system to the limits as it tried to keep up with a rolling ball, the coordinate system, and all the robots running around on the field. Shortly before leaving for Korea, the group decided that they simply needed more horsepower, so they picked up a P6-180 machine.

And I do mean "shortly." In fact, the box arrived the morning before the group got on the plane for Korea. The Linux installation obviously worked, given the contest's outcome, but that was cutting it way too close.

After all this effort under vicious deadline pressure, the group was beginning to worry that maybe they weren't going to be able to pull this one off. Whereas a few weeks prior they had naively determined to grab first prize, the size of the competition and the problems they had struggled to overcome made them rethink their objectives. They freely admit that by the time they boarded the plane, their goal was simply "not to embarass ourselves."

The Big Event

After arriving in Taejon, Korea, the group went



A frontal view of a soccer-bot, showing the two-gear Lego drive. Two nine-volt batteries, front and back, act as skids.

through registration and started to meet some of the competition. The MIROSOT contest drew several teams from Korea, as well as Singapore, Australia, France, Canada, Japan, Spain, Switzerland, Taiwan, Brazil, Italy, and Romania. Besides the Newton Labs team, the United States was represented by teams from The University of California (Riverside), The University of Southern California, and Carnegie Mellon University.

Repeated tests in the set-up area showed the strength of the group's design, and they were quickly marked as the team to beat. Since they officially represented Newton Research Labs, they became known throughout the venue as "Newton Team."

The initial draw for pairings had them set to compete on the second day, but officials wanted to change that to the first day, to provide a showcase round for various government officials. Several of the competitors involved protested, and rightly so, about the last-minute proposal. The Newton Team resolved the matter by offering to hold a demonstration match on the first day. This was accepted, and the venue prepared for the first look at this American entry.

It was (you've heard this before) not a contest. Newton Team took the demo event 12-3, and at least one of the goals scored against them was an own-goal, when the NT goalie booted the ball into its own goal. Still, the crowd applauded wildly at each score, and Newton Team got a chance to work out a couple of minor bugs before the real event began.

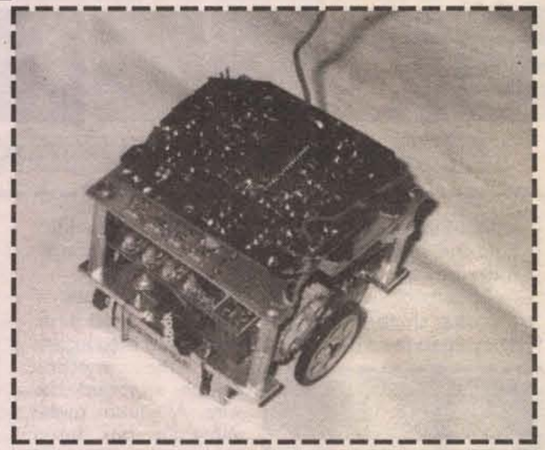
Looking back, one of the bugs was actually pretty funny. Both teams were set up for the kickoff and the referee blew her whistle to start the match. The NT goalie immediately raced the length of the pitch, elbowing its way through the crowd of robots, to take position at the opposite goal. Somewhere in the set-up, someone had not initialized a variable properly, and the goalie was determined to guard the other goal. At the first stoppage of play, the problem was corrected and the goalie took up a more orthodox style.

The demo match was as close as it ever got. Newton Team played a total of four matches in the single-elimination event, and in those four matches gave up just one goal, while scoring anywhere from 15 to 21 points per game.

The video tape of that event highlights a number of differences between the Newton Team robots and those of the other competitors. Tops on the list was the vision system frame rate. Every team used vision to guide their machines, but only the Newton Team was using a 60 Hz update rate; most settled for 10 to 15 Hz. This higher rate gave the NT machines a decided advantage in speed and reaction. Time after time, the opposing robots would either freeze in place at a crucial moment, or move in the wrong direction, reacting to a situation of an instant before.

In contrast, the NT robots were never still. Jittering around like wind-up toys on Jolt, they appeared to hover in place waiting for some cue. When the ball rolled free or the alignment was right, one of the robots would suddenly shoot off after the ball, smacking it with the front end of its frame and sending the ball towards the goal. Often, this move happened too fast for the opposing goalie, which got to the blocking position too late to stop the score.

Many times, the two NT forwards set up a passing attack or a simple give-and-go, using either a direct pass from player to player or, in one instance, a bounce shot of the wall. These would often materialize seemingly out of nowhere. At first, the ball was enmeshed in a knot of robots, then it was rolling down the field with an NT machine in pursuit. When a defender moved to intercept, the NT robot passed across to its partner, which either scored or passed back to end the play.



Looking down on a three-inch soccer robot. The top board came from a Radio Shack wireless headset, the second board holds Bill Bailey's custom electronics, and the third board is a cut-down Miniboard.

And these robots moved faster than I would have believed possible. After Newton Team's machines scored a goal, the opposing robots were set up to deliver a free kick from midfield. This meant that the ball would be placed in the center of the field, with an opposing robot immediately behind the ball and touching it. The NT machines, however, had to be set a minimum of six inches away. With monotonous regularity, an NT machine would streak to the ball and push it away from the opponent before that robot had even moved.

This doesn't mean the Newton Team design worked perfectly; only that the problems remaining were far less serious than those facing their competitors. For example, the power drain on the NT robots was so great that they slowed noticeably at the end of each half. In one case, the robots had actually dropped to about half speed, and it seemed doubtful that they would make it to the half before stopping altogether. They did, but it was a near thing.

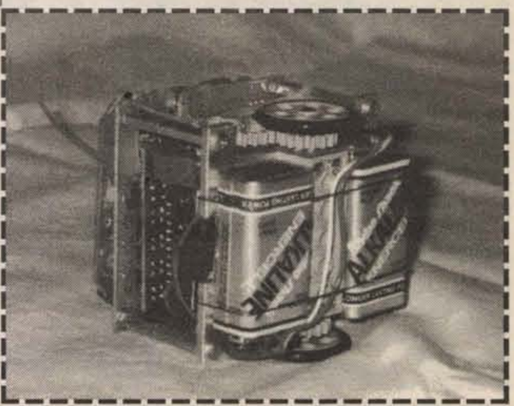
In another contest, one of the robots developed a serious guidance problem that could not be fixed before halftime, so Bill Bailey, the head robot wrangler, simply turned off the power and left the robot sitting on the pitch. Even though it did figure in a later defensive play, the Newton Team played two on one for the final 45 seconds of that half; the opposing team, however, was unable to score.

This brings up the goalie. Carl's strategy for the goalie couldn't have been simpler. Just stay between the ball, wherever it goes, and the goal. That's all the goalie had to do, and that's all it took to keep the opponents from scoring. Doubtless, other teams had the same design, but the fast motors and high frame rate of the Newton Team's system meant that the NT goalie actually did its job. Other goaltenders would not track the ball quickly enough, or would freeze momentarily as if trying to understand their instructions. The NT attackers were so fast and accurate that the slightest hesitation on the part of the defending goalie usually resulted in an NT score.

And the Newton Team robots did a lot of scoring. By the final round, played for first place, a large trophy, and the generous prize money of US $2000.00 the audience was becoming pretty jaded. Hopes for the competitors were dashed almost immediately as NT grabbed a couple of quick scores on the way to a 20-0 rout. The audience, overwhelmingly Korean, still applauded every score, but by the second half the applause was noticeably restrained. A human team would have thrown in the towel early on, but these were robots, and the contest ground along to its foregone conclusion.

Part of the MIROSOT event included a published paper from each team, describing some aspect of their design they felt most important. Accordingly, the Newton Team presented a paper entitled, "Use of Fast Vision Tracking for Cooperating Robots in the MIROSOT." As I mentioned in my previous column on the AAAI event, the Newton Research Labs' vision system, dubbed Cognachrome, is available commercially. Stop by the Newton Labs web site at www.newtonlabs.com to leaf through the technical info.

When last I talked to the Newton Team, they were planning to kick back and relax, to wind down from the grueling (and self-inflicted, I might add) pace of the past several months. Anne and Randy have taken up the Magic game, Bill wants to get back to writing software, and Carl has wads of Linux systems scattered all through the new house on which to work his own magic. But it won't take much to get them cranked up again. Randy, in particular, is usually just one E-Mail away from charging down yet another avenue, and he always brings his friends along. So stay tuned; you haven't heard the last from these SRS members. **NV**



The underside of this little robot shows the two nine-volt batteries, with the Lego axle and drive train running between them. Thin wire clamps hold the batteries to the custom metal frame.

As always, you can reach me at:
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TEST EQUIPMENT *cont.*

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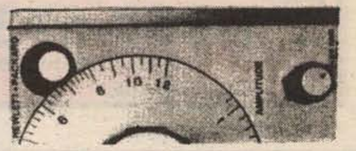

HP 204C OSCILLATOR 5Hz to 1.2MHz, .1% distortion, leveled (flat) 5V out. Sale: two for $225, one $125. Gary N6ZD, 408-385-0301 VISA/MC.

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FLUKE 5200A AC voltage standard $1,400, Fluke 5215A power amplifier $1,100; Fluke 332D DC voltage standard $500; Fluke 3330B DC voltage, current standard $200; HP 432A power meter $150; HP 3478A 5-1/2 digit multimeter $500; HP 5005A signature multimeter $250; HP 1741A 100MHz storage oscilloscope $400; Tektronix R7903 500MHz oscilloscope $300; HP 5335A universal/statistical counter $900; HP 3400A RMS voltmeter $110; Tenney BTRC temperature/humidity chamber $5,500. Credit cards accepted. Call or fax to request list of other equipment. Phone: 908-722-6157, Fax: 908-722-6391.

FACTORY NEW Wavetek RF portable power meter, complete system, 1990 price $2,860. Our price $575. 4 units available. Psitech Plus 707-745-4804, Fax 707-747-5277.

SCOPEBOOSTER KITS close out. Nov. '96 issue, $39.95, S&H $4.50. Technology Systems, PO Box 1401, Torrington, CT 06790-1401.

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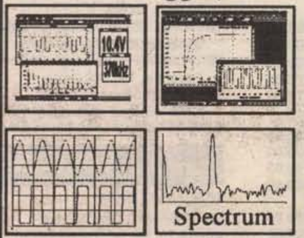

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SALE: HEWLETT Packard 3400A True RMS voltmeter $85, quantity discounts. BOONTON RF millivoltmeter 92A $125; 92B $225; 92C $300; 93AD True RMS voltmeter $375. Probes available. GERTSCH phase angle voltmeter $65; Hewlett Packard 8614A, .5-2.4 GHz $200; HP 8616A, 1.8-4.5 GHz $175. **TTI** LED display SEND/REC test sets models 1120 $250, 1122 $200 mint. **Polarad** signal generators model 1106EN w/1020T 1.8-4.4 GHz complete with acc and manual $165. Model 107E-FT 3.7-8.4 GHz $150. Mod. 107E-FWTJ $275. **Hewlett Packard** 86242A, 5.5-9.0 GHz RF plug-in $325; 86260A 12.4-18 GHz $375, 5257A .5-18 GHz transfer oscillator $250; 6406A comb. generator $275. **Interface Technology** RS-648 timing simulator & word generator complete with all manuals $150. Without manuals $100. Quantech transistor noise meter Model 310 $85. **Psitech Plus** 707-745-4804 request bi-monthly fax listings, Fax 707-747-5277.

10TH ANNIVERSARY SALE! RF EQUIPMENT: HP 8761B coaxial switch (18GHz, SMA) $90. **HP 33300D (70dB), 33304D (11dB), 33305D (110dB)** latching step attenuators (18GHz, 2W, SMA) $190, 225, 265. **HP 5342A/001** counter (18GHz, oven option) $2,000. **HP 11869A** adapter for 8350B $350. **HP 436A, 8481A** power meter, sensor $1,650. **HP 86290B, 8620C** sweep oscillator (2-18 GHz) $2,200. Excellent condition, with warranty. Pepper Systems, 214-353-0257.

LOGIC ANALYZERS Hewlett Packard 8407A & 8412A phase magnitude display w/11655A impedance probe $750; network analyzer systems. HP 8410B/8412A/8413A/8414A $950. **Tektronix 308** complete analyzer system $450. Hewlett Packard 1600A $200. Hewlett Packard channel pulse 1GHz single channel. Psitech Plus 707-745-4804, Fax 707-747-5277.

WANTED: MEASURING & Test equipment, microwave components, RF connectors, etc. **Top price paid!** Write or FAX you list to: **Steigerwald GmbH,** Ungererstrasse 180, D-80805 Munich, Germany. FAX 011-49-8441-804881.

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EQUIPMENT MANUALS we have 1000's of service and operators manuals for all types of test and measurement equipment from 1950 to present. All test equipment manufacturers are represented. Call, write, or fax your want list. Please include mfg.'s manual P/N unit serial numbers if known. **Manuals Plus,** Box 549, TAD #601, Tooele, UT 84074. 801-882-7188, FAX 801-882-7195.

FOR SALE: HP 5326A 50MHz timer/counter/voltmeter $285. Hugh M. Adams, 1011D Hondo Ave., Ft. Walton Beach, FL 32547. 904-864-2414.

HP 204B $100; HP 204C, $150; HP 209A, $200; HP 651A, $200; HP 651B, $200; HP 652A, $200; HP 653A, $250; HP 654A, $250. Plotters: HP 7475A six-pen RS 232, $150; HP 7475A HPIB, $250; HP 7470A, RS232, $150; HP 7035B, XY $200; HP 7044A, $400; HP 7045A, $400; HP 7046B, XYY, $600; HP 7550A graphics plotter, $500; HP 7562A log converter, $200; HP 7560A, $150; HP 1725A, 275MHz scope and DVM, $500; HP 1741A 100MHz storage scope, $400; HP 302A wave ana., $250. A-Comm Electronics, 303-290-8012.

SPECTRUM ANALYZERS: HP 8555A, 8552B, 141T (.01-18 GHz) $1,600. **Tek 7L5/L3,** 20Hz-5MHz $1,400; with tracking generator $1,900. **HP 3580A** 5Hz-50KHz, 1Hz RBW, adaptive sweep, tracking generator: $790 (mech), $1,250 (LED). Excellent condition, warranty. Pepper Systems, 214-353-0257.

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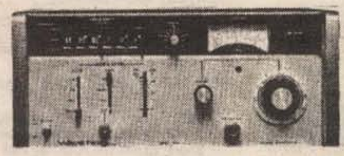
LOGIC ANALYZERS: Fluke 9010 $490 (includes docs and fancy case), pods $90; Tek 1230 $590, pods $145; Global Specialties LTC-2 $79. Synergetics Surplus, 3860 West First Street, Box 809, Thatcher, AZ 85552. 520-428-4073. synergetics@tinaja.com VISA/MC.



WAVETEK 3001-691 RF synthesized generator, AM, FM, CW, & DC (for ±500KHz sweep), 1 to 512MHz, +13 to –137 DBM, six digits, .001% stability. $745 (this month only). Gary N6ZD, 408-385-0301 VISA/MC.

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- TEK AWG5105-opt.02 Arbitrary Waveform ... $2,200.00 Generator, dual channel option
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- TEK PFG5505 Programmable ... $900.00 12 MHz Pulse/Function Generator
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T.D.R.

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- KEPCO BOP 100-4M Bipolar ... $1,000.00 Supply / Amplifier, 0-100 V, 0-4 A
- TRANSISTOR DEVICES DAL-50-15-100 ... $200.00 Programmable Load, 0-50 V, 0-15 A, 100 Watts max.

TIME & FREQUENCY

UNIVERSAL COUNTERS

- HP 5315A-001 100 MHz/100 nS ... $650.00 Universal Counter, TCXO reference
- HP 5315A-001,003 100 MHz/100 nS Universal ... $800.00 Counter, TCXO, 1 GHz C-channel
- HP 5316A 100 MHz/100 nS Universal Counter, HPIB ... $750.00
- HP 5316A-003,006 100 MHz/100 nS Counter, ... $1,100.00 1 GHz C-ch., offset/normalize
- HP 5334A 100 MHz Universal Counter, HPIB ... $875.00
- HP 5335A 200 MHz Universal / Statistical Counter ... $1,500.00
- HP E1420A-010,030 VXI card 200 MHz/ 2 nS ... $900.00 Univ. Counter,TCXO& 2.5 GHz C-ch
- PHILIPS PM6654/056 120 MHz/ 2 nS ... $850.00 Programmable High Res. Counter, OCXO,GPIB
- RACAL-DANA 1992-04,55 100 MHz/1 nS ... $850.00 Univ. Counter, 1.3 GHz C-channel,OCXO,GPIB
- TEK DC5004 Programmable 100 MHz/100nS ... $350.00 Counter/Timer, TM5000 series
- TEK DC5009 Programmable 135 MHz Univ. ... $600.00 Counter/Timer, TM5000 series
- TEK DC5010 350 MHz/3.125 nS Univ. Counter, TM5000 series ... $1,000.00
- TEK DC503A 125 MHz Universal Counter/Timer, TM500 series ... $450.00

FREQUENCY COUNTERS

- EIP 575 18 GHz Source Locking Counter, GPIB ... $3,250.00
- FLUKE 7220A-opt.111 1.3 GHz ... $650.00 Communications Counter, TCXO option
- HP 5340A-001,011 18 GHz Frequency Counter, ... $1,900.00
- HP 5340A-005,011 23 GHz Frequency Counter, HPIB ... $2,000.00 OCXO reference, HPIB
- HP 5342A 18 GHz Frequency Counter ... $2,400.00
- HP 5342A-003,011 18 GHz Freq.Counter, ... $2,750.00 +22 dBm,-20 dBm dynamic range,HPIB

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HP 5342A-01,04,05,11 24 GHz Frequency Counter, OCXO, DAC, and HPIB — $3,900.00
HP 5345A/5355A/5356B 26.5 GHz CW/Pulse Frequency Counter — $4,000.00
HP 5382A 225 MHz Frequency Counter — $200.00

STANDARDS

AUSTRON 1250A Crystal Frequency Standard, 0.1/ 1.0/ 5.0 MHz — $600.00
HP 105A Quartz Oscillator, 0.1/ 1.0/ 5.0 MHz — $750.00
HP 5087A-031 Distribution Amp., 0.1/1.0/5.0 MHz x 4 channels each — $1,250.00

AUDIO & BASEBAND

SPECTRUM ANALYZERS

HP 8556A LF Section, 20 Hz-300 kHz — $450.00
TEK 7L5-opt.025/L3-1 Spectrum Analyzer, 20 Hz-5 MHz, 75 / 600 / 1M ohms — $2,250.00

DISTORTION ANALYZERS

HP 334A Distortion Analyzer, 5 Hz-600 kHz, -60 dB, auto nulling — $550.00
HP 339A Distortion Analyzer, built-in low distortion osc. — $2,400.00
TEK DA4084 Programmable Distortion Analyzer, 0.0025% THD, w/frame — $1,500.00

RMS VOLTMETERS

FLUKE 8920A True RMS Voltmeter, 180 uV-700 V, 10 Hz-20 MHz — $700.00
FLUKE 8921A True RMS Voltmeter, 180 uV-700 V, 2 Hz-2 MHz — $700.00

OSCILLATORS

FLUKE 6011A Synthesized Generator, 10 Hz-11 MHz, 10 Hz res. — $1,200.00
HP 204D Oscillator, 5 Hz-1.2 MHz, 5 VRMS, 80 dB step attenuator — $200.00
HP 209A Sine/Square Wave Generator, 4 Hz-2 MHz, 5 VRMS max. — $225.00
HP 239A Low Distortion Oscillator, 10 Hz-100 kHz — $450.00
HP 652A Test Oscillator, 10 Hz-10 MHz — $300.00
ROCKLAND 5100 Synthesizer, 1 mHz-1.999999999 MHz — $350.00
TEK SG502 Sine/Square Osc., 5 Hz-500 kHz, 70 dB step atten.,TM500 — $350.00
TEK SG505-opt.01 Low Distortion Oscillator, 10 Hz-100 kHz, intermod.opt. — $1,000.00

MISCELLANEOUS

HP 3575A-001 Phase-Gain Meter, 1 Hz-13 MHz, dual display — $900.00
HP 4437A Step Attenuator, 0-119.9 dB, DC-1 MHz, 600 ohms unbal. — $200.00
KROHN-HITE 3103 High/Low Pass Filter, 10 Hz-3 MHz, 24 dB/octave — $500.00
KROHN-HITE 3202 Dual High-Pass/Low-Pass Filter, 20 Hz-2 MHz, 24 dB/oct — $600.00
KROHN-HITE 3342 Dual HP/LP Filter, 0.001 Hz-99.9 kHz, 48 dB/octave — $1,100.00
KROHN-HITE 3750 LP/HP/BP/BR Filter, 0.02 Hz-20 kHz, 6/12/18/24 dB/oct. — $700.00
ROCKLAND 852 Dual Highpass/Lowpass Filter, 0.1 Hz-111 kHz — $1,000.00
TEK AM502 Differential Amplifier, 0.1 Hz-1 MHz, TM500 series — $575.00

RF & MICROWAVE

SPECTRUM ANALYZERS

HP 11517A/18A/19A/20A Mixer, 12.4-40 GHz, w/adapters, for 8555A, 8565A, etc. — $675.00
HP 11970A WR28 Harmonic Mixer, 26.5-40 GHz — $1,100.00
HP 11970Q WR22 Harmonic Mixer, 33-50 GHz — $1,400.00
HP 11970U WR19 Harmonic Mixer, 40-60 GHz — $1,400.00
HP 11971A WR28 Harmonic Mixer, 26.5-40.0 GHz, for 8569B — $1,100.00
HP 11971K WR42 Harmonic Mixer, 18.0-26.5 GHz, for 8569B — $1,100.00
HP 8406A Comb Generator, 1/10/100 MHz increments, to 5 GHz — $450.00
HP 8444A-059 Tracking Generator, 0.5-1500 MHz, for 8554,8568,etc. — $1,500.00
HP 8445B Preselector, 1.8-18.0 GHz, for HP 8555A — $800.00
HP 8559A/853A Spectrum Analyzer, 10 MHz-21 GHz, 1 kHz res., w/display — $5,500.00
HP 8565A-100 Spectrum Analyzer, 0.01-22 GHz, 100 Hz min. res. BW — $5,500.00
TEK 7L13/7613 Spectrum Analyzer,1 kHz-1.8 GHz, 30 Hz min.res.,w/frame — $2,250.00
TEK TR502 Tracking Generator, 0.1-1800 MHz, for 7L12/13/14 — $1,250.00
TEK TR503 Tracking Generator, 0.1-1800 MHz, for 492/4/5/6 — $1,375.00

NETWORK ANALYZERS

HP 11589A Bias Network, 0.1-3.0 GHz, N(f/f) — $350.00
HP 11590A Bias Network, 1.0-12.4 GHz, N(f/f) — $375.00
HP 11590A-001 Bias Network, 1.0-18.0 GHz, APC7 — $450.00
HP 11665B Modulator, 0.15-18.0 GHz, for use with 8755/6/7 — $375.00
HP 11666A Reflectometer Bridge, 0.04-18 GHz, for 8755/8756 — $1,200.00
HP 8407A/8412A/8601A Network Analyzer, 100 kHz-110 MHz, with sweep generator — $1,250.00
HP 85050D APC7 Calibration Kit, for 8510 series — $1,100.00
HP 8505A-005/8503A Network An., 0.5-1300 MHz, w/S-Parameter & phase lock — $5,000.00
HP 8755C/(3)11664A/182T Scalar Network An. w/3 detectors, 10 MHz-18 GHz & frame — $1,750.00
HP 8756A/(3)11664A Scalar Network Analyzer, w/(3) detectors, 0.01-18 GHz — $3,750.00
NARDA 7000A/7202/7206 Microwave Multimeter System: scalar analysis 0.1-18 GHz — $1,950.00
WAVETEK 1038D14A/H12/V13x2 Scalar Network An,w/(3)15882 WR28 detectors,26.5-40 GHz — $2,200.00
WILTRON 640/G50/E(2)/7B50(2) Network An., w/1-1500 MHz source, (2) log amp, (2) det. — $1,675.00

SIGNAL GENERATORS

FLUKE 6060A/AN Synthesized Signal Gen., 10 kHz-520 MHz, 10 Hz res,GPIB — $2,000.00
GIGATRONICS 600/10-18 Synthesized Source, 10-18 GHz, 1 MHz res., GPIB — $2,600.00
GIGATRONICS 605/10-18 Synthesized Source, 10-18 GHz, 1 kHz res., GPIB — $3,000.00
GIGATRONICS 875/50 Levelled Multiplier, x4, 50.0-75.0 GHz output, -3 dBm — $3,500.00
GIGATRONICS 875/86 Levelled Multiplier, 26.5-40.0 & 50.0-75.0 GHz outputs — $7,000.00
GIGATRONICS 910/12-18,opt6,14,16 Synthesized Source/Sweeper, 12-18 GHz, 1 Hz res., OCXO — $3,500.00
HP 85100V Frequency Mult., 10-15 GHz in / 50-75 GHz out >0 dBm — $4,250.00
HP 8616A Signal Generator, 1.8-4.5 GHz — $450.00
HP 8640B-001,002,003 Signal Gen., 0.5-1024 MHz, AM, FM, var. audio osc. — $2,500.00
HP 8654A Signal Generator, 10-520 MHz, calibrated AM & uncal. FM — $550.00
HP 8656A Signal Generator, 0.1-990 MHz, 100 Hz res, AM, FM, HPIB — $2,900.00
HP 8660C/86602B/86632A Synthesized Signal Gen., 1-1300 MHz, 1 Hz res., AM, FM — $2,750.00
HP 8660D/86603A/86632B Synthesized Signal Generator, 1-2600 MHz — $7,000.00
WAVETEK 907 Signal Generator, 7.0-11.0 GHz, 0 dBm levelled — $1,000.00

SWEEP GENERATORS

HP 11869A Plug-in Adapter — $450.00
HP 8350A/86290B-H08 Programmable Sweep System, 2.0-22.0 GHz, +4 dBm lvl'd — $5,500.00
HP 8600A Digital Marker, for HP 8601A — $400.00
HP 8601A Generator/Sweeper, 0.1-110 MHz, +20 dBm levelled — $400.00
HP 8620C Sweep Oscillator Frame — $550.00
HP 8620C-011 Sweep Oscillator Frame, HPIB programmable — $675.00
HP 86222B-002 RF Plug-in, 10-2400 MHz, +10 dBm levelled, step atten. — $1,750.00
HP 86230B RF Plug-in, 1.8-4.2 GHz, +10 dBm unlevelled — $675.00
HP 86240A RF Plug-in, 2.0-8.4 GHz, +16 dBm levelled — $1,000.00
HP 86240A-002 RF Plug-in, 2.0-8.4 GHz, +14 dBm lvld., 70 dB step att. — $1,200.00
HP 86241A-001 RF Plug-in, 3.2-6.5 GHz, +8 dBm levelled — $500.00
HP 86242D-004,008 RF Plug-In, 5.9-9.0 GHz, +10 dBm levelled — $500.00
HP 86245A RF Plug-in, 5.9-12.4 GHz, +16 dBm levelled — $1,100.00
HP 86250D RF Plug-in, 8.0-12.4 GHz, +10 dBm levelled — $675.00
HP 86260A RF Plug-in, 12.0-18.0 GHz, +10 dBm unlevelled — $800.00
HP 86260A-H04 RF Plug-in, 10.0-15.0 GHz, +10 dBm unlevelled — $800.00
HP 86290A RF Plug-in, 2.0-18.0 GHz, +7 dBm levelled — $1,750.00
HP 86290C RF Plug-in, 2.0-18.6 GHz, +13 dBm levelled — $2,500.00
WAVETEK 962 Sweep Generator, 1.0-4.0 GHz, markers, +12 dBm unlvld. — $2,000.00

POWER METERS

ANRITSU MP-81B/ML-83A Power Meter, 75-110 GHz (WR10), -20 to +20 dBm — $2,500.00
ANRITSU MP-82B/ML-83A Power Meter, 90-140 GHz (WR8), -20 to +20 dBm — $3,250.00
BOONTON 42B/41-4E Analog Power Meter, with 1 MHz-18 GHz sensor — $500.00
BOONTON 42B/42A-S3 Analog Power Meter, with 1 MHz-8.4 GHz N(f) sensor — $375.00
GENERAL MICROWAVE 476/4240A Power Meter & Sensor, 0.01-18 GHz, -35 to +10 dBm — $375.00
HP 432A/478A Power Meter, 10 MHz-10 GHz, -20 to +10 dBm f.s. — $375.00
HP 432A/8478B Power Meter, 10 MHz-18 GHz, -20 to +10 dBm f.s. — $500.00
HP 432C Autoranging Digital Power Meter, 10 uW-10 mW f.s. — $425.00
HP 435A/8481A Power Meter, 10 MHz-18 GHz, -30 to +20 dBm — $1,000.00
HP 435A/8482A Power Meter, 100 kHz-4.2 GHz, -30 to +20 dBm — $1,000.00
HP 435A/8482H Power Meter, 0.1-4200 MHz, -15 to +34 dBm — $1,150.00
HP K486A WR42 Thermistor Mount, 18.0-26.5 GHz, for 432 series — $350.00
HP Q8486A Power Sensor, 33.0-50.0 GHz, WR22, for 435/6/7/8 — $1,500.00
HP R486A WR28 Thermistor Mount, 26.5-40.0 GHz, for 432 series — $350.00

RF MILLIVOLTMETERS

RACAL 9303 TRMS Level Meter, 10 kHz-2 GHz, -77 to +23 dBm, GPIB — $875.00

AMPLIFIERS, MISCELLANEOUS

BOONTON 82AD FM/AM Modulation Meter, 10-1200 MHz — $800.00
HP 8447A-001 Dual Amplifier, 0.1-400 MHz — $450.00
HP 8901A-002,010 Modulation Analyzer, 150 kHz-1300 MHz, OCXO, int. cal. — $5,500.00
M.P.D. LAB2-1020-2A Amplifier, 34 dB, 1.0-2.0 GHz, 2 Watts — $800.00
M.P.D. LAB2-714-3A Amplifier, 34 dB, 0.7-1.4 GHz, 3 Watts — $800.00
MARCONI TF2304 AM/FM Modulation Meter, 18-1000 MHz, FM dev.1.5-150 kHz — $500.00
MICROWAVE SEMI.CORP. MC5112 Noise Source, 25.5 dB ENR, 1.0-12.4 GHz, N(m), +28 VDC — $325.00

COAXIAL & WAVEGUIDE

AMERICAN NUCLEONICS AM-432 Cavity Backed Spiral Antenna,LHC, 2-18 GHz,TNC(f) *NEW* — $95.00
CONTINENTAL MW.&TOOL PLPT42 WR42 Low Power Termination, 18-26.5 GHz, 1 Watt — $125.00
FXR/MICROLAB S3-02N Triple Stub Tuner, 200-1000 MHz, 100 Watts max., N(m/f) — $90.00
GR 874-LTL Constant Impedance Trombone Line, 0-44 cm, DC-2 GHz — $450.00
GR 900-Q GR900 14mm Interseries Adapters — $125.00
HP 11691D Directional Coupler, 22 dB, 2-18 GHz — $450.00
HP 11692D Dual Directional Coupler, 22 dB, 2-18 GHz — $800.00
HP 776D Dual Directional Coupler, 20 dB, 940-1900 MHz — $275.00
HP 777D Dual Directional Coupler, 20 dB, 1.9-4.1 GHz — $275.00
HP 778D Dual Dir.Coupler, 20 dB, 100-2000 MHz, N(m/f/f/f) — $550.00
HP 778D-011 Dual Dir.Coupler, 20 dB, 100-2000 MHz, APC7/N(f/f/f) — $400.00
HP 8470B-012 Crystal Detector, 10 MHz-18 GHz, neg. pol., N(m) — $250.00
HP K422A WR42 Flat Broadband Detector, 18.0-26.5 GHz — $350.00
HP K532A WR42 Frequency Meter, 18.0-26.5 GHz — $500.00
HP K752 A/C/D WR42 Directional Couplers, 3/10/20 dB, 18.0-26.5 GHz — $450.00
HP K870A WR42 Slide Screw Tuner, 18.0-26.5 GHz — $275.00
HP K914B WR42 Moving Load, 18.0-26.5 GHz — $425.00
HP Q752D WR22 Directional Coupler, 20 dB, 33-50 GHz — $650.00
HP R375A WR28 Variable Attenuator, 0-20 dB, 26.5-40 GHz — $375.00
HP R422A WR28 Flat Broadband Detector, 26.5-40 GHz — $400.00
HP R532A WR28 Frequency Meter, 26.5-40.0 GHz — $500.00
HP R914B WR28 Moving Load, 26.5-40 GHz — $300.00
HP X913A WR90 High Power Load, 500 Watts, 8.2-12.4 GHz — $150.00
HUGHES 45111H-2000 WR28 Isolator, 25 dB, 26.5-40 GHz — $450.00
HUGHES 45113H-1000 WR19 Isolator, 25 dB, 40-60 GHz — $650.00
HUGHES 45514H-1001 WR15 Stepper Motor Driven 4-Port Switch, with driver — $1,675.00
HUGHES 45521H-2000 WR28 Manual 4-Position Switch — $750.00
HUGHES 45683H-1000 WR19 E-H Plane Tuner, 40-60 GHz — $400.00
HUGHES 45713H-1000 WR19 Frequency Meter, 40-60 GHz — $900.00
HUGHES 47316H-1111 WR10 Tuneable Detector, 75-110 GHz, positive polarity — $750.00
HUGHES 47974H-1000 WR15 SPST PIN Switch, 250 MHz speed, 60-62 GHz response — $375.00
M/A-COM 3-19-300/10 WR19 Directional Coupler, 10 dB, 40-60 GHz — $450.00
NARDA 25171 Level Set Attenuator, 0-17 dB, 2-8 GHz, SMA(f) — $100.00
NARDA 26298 20 dB Attenuator, 150 Watts, DC-1 GHz, N(f/f) — $200.00
NARDA 3000-SERIES Directional Couplers — $150.00
NARDA 3024 Bi-Directional Coupler, 20 dB, 4-8 GHz — $300.00
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NARDA 3753B Coaxial Phase Shifter, 0-60 deg./GHz, 3.5-12.4 GHz — $1,250.00
NARDA 4000-SERIES SMA Miniature Directional Couplers — $75.00
NARDA 4203-6 Directional Coupler, 6 dB, 2-18 GHz, SMA(f/f/f) — $225.00
NARDA 4246B-20 Directional Coupler, 20 dB, 6-18 GHz, SMA(f) — $100.00
NARDA 4317-2 Power Divider, 18.0-26.5 GHz, 3.5mm — $175.00
NARDA 4799 Level Set Attenuator, 0-15 dB, 4-18 GHz, SMA(f) — $135.00
NARDA 5070-SERIES Precision Reflectometer Couplers — $300.00
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NARDA 766-10 10 dB Attenuator, 20 Watts, DC-4 GHz, N(m/f) — $100.00
NARDA 768-20 20 dB Attenuator, 20 Watts, DC-11 GHz, N(m/f) — $125.00
NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz — $375.00
PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz — $250.00
SONOMA SCIENTIFIC 21A3 WR42 Circulator, 20 dB, 20.6-24.8 GHz — $125.00
SPACEK LABS DQ-1 WR22 Flat Broadband Detector, 33-50 GHz — $550.00
TELONIC TTF-2250-5-5EE Tuneable Bandpass Filter, 1.5-3.0 GHz, 5% 3 dB BW, N(f) — $350.00
TRG V510 WR15 Precision Rotary Vane Atten., 0-50 dB, 50-75 GHz — $1,000.00
TRG V551 WR15 Frequency Meter, 50-75 GHz — $600.00
TRG V559-10 WR15 Directional Coupler, 10 dB, 50-75 GHz — $400.00
TRG W510 WR10 Precision Rotary Vane Atten., 0-50 dB, 75-110 GHz — $1,000.00
TRG W559-10 WR10 Directional Coupler, 10 dB, 75-110 GHz — $475.00
WAVELINE 822 WR42 Precision Rotary Vane Atten., 0-50 dB, 18-26.5 GHz — $1,250.00
WAVELINE 898-DR WR42 Frequency Meter, 18.0-26.5 GHz — $350.00
WEINSCHEL 49-6-34 6 dB Attenuator, 150 Watts, DC-8 GHz, N(f/m) — $250.00
WILTRON 26N50 Precision Termination, N(m), DC-18 GHz — $250.00
WILTRON 87A50 VSWR Bridge, 2-18 GHz, 35 dB dir., APC7 test port — $600.00

LOGIC

FLUKE 9000A-series Microprocessor Pods: 6800; 6809; 8080; 8085; Z80 — $375.00
HP 5005A Signature Multimeter — $350.00
HP 8170A-002 Logic Pattern Generator, 2 MB/s, address driver option — $1,200.00
TEK 1240 Logic Analyzer, w/(36) 50 MHz channels — $1,500.00

COMMUNICATIONS

HP 4972A/18182A LAN Protocol Analyzer, with software — $2,500.00
HP 59401A HPIB Bus Analyzer — $700.00
TEK 1411R-opt.04 PAL Test Gen. w/SPG12,TSG11,TSP11,TSG13,TSG15,TSG16 — $2,750.00
TEK 147A NTSC Test Signal Generator, with noise test signal — $800.00
TEK 520A NTSC Vectorscope — $1,200.00
HP 3787B-001 Digital Data Test Set, T1/DDS/56kB/Packet, DS1 jitter — $2,750.00

MISCELLANEOUS

P.A.R. 5205-94,95,96,98 Lock-In Amp, 20 Hz-20 kHz, int. osc., lin/log, GPIB — $2,750.00
P.A.R. 5206 Two-Phase Lock-In Amplifier, 2 Hz-200 kHz — $2,500.00
P.A.R. 5208-92,94,97,98 Two Phase Lock-In Amp., GPIB 5 Hz-20 kHz or 200 kHz, — $3,250.00
TEK TM5006 5000-series 6-slot Programmable Power Module — $600.00
TEK TM503 500-series 3-slot Power Module — $175.00
TEK TM504 500-series 4-slot Power Module — $175.00
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TEK TM515 500-series 5-slot Traveller Power Module — $275.00

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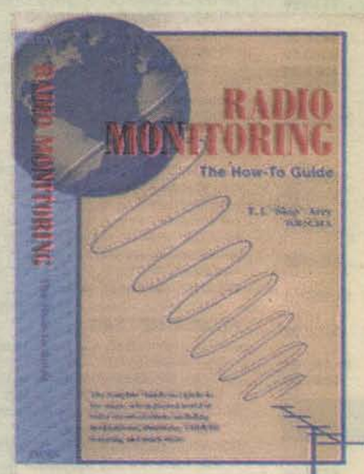
RADIO MONITORING: THE HOW-TO GUIDE



Radio Monitoring: The How-To Guide takes you to a fascinating world of action, adventure, intrigue, and awareness — and you never have to leave your armchair. This is the curious person's guide to discovery of the world in new and exciting ways. Here you'll learn how to capture radio signals from down the street, across town, around the world, and even from space, and become informed far beyond the content of TV and radio.

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GLOBAL PHONE

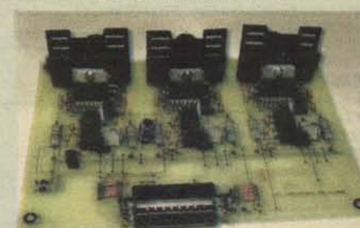
Repair technicians, field engineers, and traveling business people no longer have to be in the office to link up with colleagues for video conference discussion. Instead, they can dial them up while on the road or in the field using portable, notebook computers equipped for video conferencing.

Using Global Phone 1.5 version software, a video camera and a slide-in PCMCIA video capture card, people can use laptops to show a construction site, a crime or accident scene, or close-ups of metal fatigue symptoms. VIC Hi-Tech Corporation sells the credit-card sized PCMCIA card and portable camera as add-on options for its Global Phone video conferencing software. The only additional equipment that users require are a portable battery pack, a modem-equipped laptop, and a cellular phone card, cellular phone, or pay phone connection.

For more information contact:

VIC HI-TECH CORP.
2221 ROSECRANS AVE. STE. 237
DEPT. NV
EL SEGUNDO, CA 90245
310-643-5193
http://www.vic-corp.com

THREE-AXIS STEPPER CONTROLLER KIT



This three-axis controller kit together with included software will drive stepper motors in the full or half step modes at currents two amps per phase. The chopper frequency is 18.4 KHz and has jumper selectable phase or control chopping. An all winding off feature allows disabling the motor windings while the electronic position is maintained. Great for development, CNC, and robotic applications. The kit retails for $145.00.

For further information, contact:

CAMTRONICS, INC.
18230 130TH PL N.E., DEPT. NV
BOTHELL, WA 98011-3118
206-487-0013

KEYAT KEYBOARD PORT ADAPTER

L3 Systems announces the release of the Keyat keyboard port adapter. This new device allows

Continued on page 102

Events CALENDAR

JANUARY 1997

The Events Calendar is a free service limited to electronic events such as computer shows, hamfests, flea markets, etc. If your organization is sponsoring an event and would like a free listing, contact us at least 60 days prior to the event. Include your flyer, estimated attendance, name of the person to contact, and phone number.

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

While we strive for accuracy in our calendar, we can not be responsible for errors or cancellations. The information contained in this column is for the use of the readers of *Nuts & Volts* and may not be republished in any form without the written permission of T & L Publications, Inc.

All listing information should be sent to:
Nuts & Volts Magazine
Events Calendar
430 Princeland Court
Corona, CA 91719
Phone 909-371-8497
Fax 909-371-3052
E-mail events@nutsvolts.com

JANUARY 3-4-5

IL - PEORIA - Computer Sale/Show. Peoria Civic Center. Blue Star Productions 612-788-1901

JANUARY 4

CA - OXNARD - Computer Show & Sale. Community Center. MarketPro 1-800-708-7555
CA - SACRAMENTO - Computer Show & Sale. Scottish Rite Center. MarketPro 1-800-708-7555
CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in 619-561-0052
KY - LEXINGTON - Computer Show. Continental Inn. MarketPro 301-984-0880 xt15
MD - BALTIMORE - Computer Show. Martins West. MarketPro 301-984-0880 xt15
MI - LIVONIA - Super Computer Sales. Livonia Elks Lodge Hall, 31117 Plymouth Rd. 10am-3pm. Computers and You 313-283-1754
NH - PORTSMOUTH - Computer Show. Frank Jones Center. 10am-3:30pm. Northern Computer Shows 508-744-8440
PA - PHILADELPHIA - Computer Show. Adams Mark. MarketPro 301-984-0880 xt15
TN - MORRISTOWN - Hamfest. Lakeway ARC. Perry Hensley 423-828-4848

JANUARY 4-5

FL - CAPE CORAL - Hamfest. Ft. Myers ARC. Jackie Kampfert 941-542-6675
FL - TAMPA - Computer Show. FL State Fgnds. MarketPro 301-984-0880 xt15
PA - MONROEVILLE - Computer Show. Pittsburgh Expo Mart. MarketPro 301-984-0880 xt15
VA - CHANTILLY - Computer Show. Capital Expo Center. MarketPro 301-984-0880 xt15
VA - HAMPTON - Computer Show. Hampton Coliseum. MarketPro 301-984-0880 xt15

JANUARY 5

CA - LIVERMORE - Swapmeet. Las Positas College. Noel Anklam 510-447-3857
CA - SAN DIEGO - Computer Show & Sale. Scottish Rite Center. MarketPro 1-800-708-7555
CA - STOCKTON - Computer Show & Sale. Civic Auditorium. MarketPro 1-800-708-7555
GA - NORCROSS - Computer Show. Northeast Atlanta Hilton, 5993 Peachtree Industrial Blvd. Narissam Computer Shows 770-663-0983
IN - SOUTH BEND - Hamfest. Michiana Valley Hamfest Assn. Bob Denniston 219-291-0252
KY - FRANKFORT - Computer Show. Farnham Dudgeon Civic Center. MarketPro 301-984-0880 xt15
MD - TOWSON - Computer Show. Towson State University. MarketPro 301-984-0880 xt15
MI - GRAND RAPIDS - Super Computer Sales. Stadium Arena, 2500 Turner Ave. NW. 10am-4pm. Computers and You 313-283-1754
NJ - CHERRY HILL - Computer Show. Hilton at Cherry Hill. MarketPro 301-984-0880 xt15
PA - DICKSON CITY - Computer Show. Genetti Manor. MarketPro 301-984-0880 xt15
PA - MONROEVILLE - Computer Show. Pittsburgh Expo Mart. MarketPro 301-984-0880 xt15

JANUARY 10-11-12

WI - LA CROSSE - Computer Sale/Show. La Crosse Center. Blue Star Productions 612-788-1901

JANUARY 11

AZ - GLENDALE - Hamfest. Glendale Community College N. Lot. 6000 W. Olive. 6am-1pm. Mark KC7BXS 602-931-1204
CA - FONTANA - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves
CA - FRESNO - Computer Show & Sale. Fresno Fairgrounds. MarketPro 1-800-708-7555
CO - LOVELAND - Superfest. Larimer County Fgnds. 700 Railroad Ave. 9am-3pm. 970-352-5304
FL - FORT LAUDERDALE - Computer Show. The Westin Hotel, 400 Corporate Dr. Narissam Computer Shows 770-663-0983
MI - KALAMAZOO - Super Computer Sales. Kalamazoo County Fairground, 2900 Lake St. 10am-3pm. Computers and You 313-283-1754
NY - MARATHON - Hamfest. Skyline ARC. Barbara Mudge 607-849-6751
TX - SAN ANTONIO - Hamfest. San Antonio RC. Eric Smith 210-684-2513
VA - ANNANDALE - Computer Show. N. Virginia Community College. MarketPro 301-984-0880 xt15

JANUARY 11-12

FL - JACKSONVILLE - Computer Show Jacksonville Fairgrounds. MarketPro 301-984-0880 xt15
FL - SARASOTA - Hamfest. Sarasota ARA. Fred Auerbach 941-365-7679
GA - NORCROSS - Computer Show. North Atlantic Trade Center. MarketPro 301-984-0880 xt15
KY - LOUISVILLE - Computer Show. Commonwealth Convention Ctr. MarketPro 301-984-0880 xt15
OH - BEREA - Computer Show. Cuyahoga County Fairgrounds. MarketPro 301-984-0880 xt15
PA - ALLENTOWN - Computer Show. Allentown Fairgrounds. MarketPro 301-984-0880 xt15

JANUARY 12

AZ - PHOENIX - Computer Show & Sale. Shrine Auditorium. 10am-5pm. MarketPro 1-800-708-7555
CA - LANCASTER - Computer Show & Sale. Antelope Valley Fairgrounds. 10am-5pm. MarketPro 1-800-708-7555
CA - SANTA ROSA - Computer Show & Sale. Sonoma Co. Fairgrounds. 10am-5pm. MarketPro 1-800-708-7555
FL - WEST PALM BEACH - Computer Show. Palm Beach Airport Hilton, 150 Australian Ave. Narissam Computer Shows 770-663-0983
MD - NEW CAROLLTON - Computer Show. Ramada Conf. & Exhibition Ctr. MarketPro 301-984-0880 xt15
MI - SOUTHGATE - Super Computer Sales. Crystal Gardens, 16703 Fort St. 10am-4pm. Computers and You 313-283-1754
WI - WAUKESHA - Hamfest. West Allis RAC. Phil Gural 414-425-3649

JANUARY 18

CA - BAKERSFIELD - Computer Show & Sale. Kern Co. Fairgrounds. MarketPro 1-800-708-7555
CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052
FL - CRYSTAL RIVER - Hamfest. Sky High ARC. Chad Johnson 352-746-1299
LA - HAMMOND - ARRL Hamfest. Southeast Louisiana ARC. Jack Stang 504-542-7605
MD - FREDERICK - Computer Show. Frederick Fairgrounds. MarketPro 301-984-0880 xt15
MI - DEARBORN - Super Computer Sales. Dearborn Civic Center, 15801 Michigan Ave. 10am-3pm. Computers and You 313-283-1754
MI - FLINT - Hamfest. Southwestern Academy. 8am-2pm. Keith Allen N8QNA 810-232-5170
MO - ST. JOSEPH - Hamfest. Ramada Inn. Missouri Valley ARC. I-29 & Frederick Ave. 9am-4pm. 816-424-6484
NH - NASHUA - Electronic Fleamart. 617-923-2665
NH - SALEM - Computer Show. Rockingham Park Race Track. 10am-3:30pm. Northern Computer Shows 508-744-8440
OH - MIDDLETOWN - Hamfest. SW Ohio Digital Symposium. Hank Greeb 513-385-8363
PA - LEBANON - Computer Show. Lebanon Valley Expo Center. MarketPro 301-984-0880 xt15
VA - RICHMOND - Computer Show. The Showplace. MarketPro 301-984-0880 xt15

JANUARY 18-19

CA - VALLEJO - Computer Show & Sale. Solano Co. Fairgrounds. MarketPro 1-800-708-7555
OH - DAYTON - Computer Fair. Dayton Convention Center. Trade Show Productions 513-263-3378
OH - DAYTON - Computer Show. Montgomery County Fairgrounds. MarketPro 301-984-0880 xt15
VA - NORFOLK - Computer Show. Norfolk Scope. MarketPro 301-984-0880 xt15

JANUARY 19

CA - SAN DIEGO - Computer Show & Sale. Scottish Rite Center. 10am-5pm. MarketPro 1-800-708-7555
IL - GLEN ELLYN - Computer Show & Sale. College of DuPage. Main Arena of Phys. Ed. Bldg. 9:30am-3pm. Computer Central Shows 847-940-7547
MA - SWANSEA - Computer Show. Venus DeMilo. 9:30am-2:30pm. Northern Computer Shows 508-744-8440
MI - LANSING - Super Computer Sales. Holiday Inn South Convention Center, 6820 S. Cedar St. 10am-4pm. Computers and You 313-283-1754
MI - SOUTHFIELD - Swap & Shop. Southfield High School, 24675 Lahser Rd. 8am-3pm. Gerald Kocsis 810-746-8853
MD - BOWIE - Computer Show. Bowie State University. MarketPro 301-984-0880 xt15
NY - YONKERS - Electronic Flea Market. Lincoln High School. Kneeland Ave. 9am-3pm. Otto 914-969-1053
OH - BROADWAY - Winter Ham Radio Fair. State Hwy 347 W. of State Rt. 31. 8am-3pm. 937-246-5943
OH - NELSONVILLE - Hamfest. Sunday Creek AR Federation. Allan Withem 614-767-2766
PA - DICKSON CITY - Computer Show. Ganetti Manor. MarketPro 301-984-0880 xt15
VA - RICHMOND - Hamfest. Amateur Telecommunications Society. The Showplace, 3000 Mechanicsville Tnpk. 8:30am-3:30pm. Craig Spain 804-526-9838

JANUARY 20

MD - TIMONIUM - Computer Show. Maryland State Fairgrounds. MarketPro 301-984-0880 xt15
OH - NILES - Computer Show. Eastwood Expo Center. MarketPro 301-984-0880 xt15
VA - RICHMOND - Computer Show. The Showplace. MarketPro 301-984-0880 xt15

JANUARY 25

IN - FT. WAYNE - Computer Show. Allen County Fairgrounds. MarketPro 301-984-0880 xt15
IN - INDIANAPOLIS - AGI Computer Fair. Indianapolis Events Center. 3655 E. Raymond St. 317-299-8827
MA - STURBRIDGE - Computer Show. Sturbridge Host Hotel. 10am-3:30pm. Northern Computer Shows 508-744-8440
MO - ST. CHARLES - Hamfest. St. Louis Repeater. James E. Welby 314-353-2000
NE - KEARNEY - ARRL Hamfest. Midway ARC. Ed Bloomfield 308-237-2401
NM - ALBUQUERQUE - Winter Tailgate Hamfest.

Events CALENDAR

Tom Ellis 505-291-8122
PA - YORK - Computer Show. Holiday Inn Holidome & Conference Center. MarketPro 301-984-0880 xt15
TN - GALLATIN - Hamfest & Computer Show. Gallatin Civic Center off Hwy 31E. 8am-2pm. Bill Ferrell 615-230-7923
VA - HARRISONBURG - Computer Show. Rockingham Co. Fgnds. MarketPro 301-984-0880 xt15

JANUARY 25-26

CA - SACRAMENTO - Computer Show & Sale. Cal Expo. MarketPro 1-800-708-7555
CA - VENTURA - Computer Show & Sale. Ventura Fairgrounds. MarketPro 1-800-708-7555
FL - ORLANDO - Computer Show. Central FL Fairgrounds, Bldg. B. MarketPro 301-984-0880 xt15
MD - GAITHERSBURG - Computer Show. Montgomery Co. Fairgrounds. MarketPro 301-984-0880 xt15
OH - CINCINNATI - Computer Show. Cincinnati Gardens. MarketPro 301-984-0880 xt15

JANUARY 26

CA - SANTA ANA - Swapmeet. ACP Parking Lot. Mary Russo 714-558-8813
IL - VILLA PARK - Hamfest. WCRA. 630-545-9950
IN - FT. WAYNE - Computer Fair. Ramada Hotel, off I-69 exit 105A. 10am-3pm. AGI Services 317-299-8827
IN - SOUTH BEND - Computer Show. Century Center. MarketPro 301-984-0880 xt15
MD - ODENTON - Hamfest. Maryland Mobileers ARC. Jim Botluk 410-280-9815
MI - MADISON HEIGHTS - Super Computer Sales. UF & CW Hall, 876 Horace Brown Dr. 10am-4pm. Computers and You 313-283-1754
MI - MIDLAND - Computer Show. Holiday Inn. US-10 @ Eastman Rd. Exit. Five Star Productions. 810-230-0988
NH - NASHUA - Computer Show. Sheraton Tara Hotel. 10am-3:30pm. Northern Computer Shows 508-744-8440
OH - DOVER - Hamfest. Ohio National Guard Armory. 2800 N. Wooster Ave. Howard Blind 330-364-5258
PA - WILKES BARRE - Computer Show. Genetti's Best Western. MarketPro 301-984-0880 xt15
VA - RICHMOND - Computer Show. VA Sports Arena. MarketPro 301-984-0880 xt15

JANUARY 28

MD - ODENTON - Swapfest. Odenton Vol. Fire Dept. Hall, 1425 Annapolis Rd. 8am-2pm. Bill Ziegler 410-987-2384

JANUARY 31-FEBRUARY 1-2

MN - ROCHESTER - Computer Sale/Show. Mayo Civic Center. Blue Star Productions 612-788-1901

FEBRUARY 1997

FEBRUARY 1

CA - FRESNO - Computer Show & Sale. Fresno Fairgrounds. MarketPro 1-800-708-7555
CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in 619-561-0052
MA - HYANNIS - Computer Show. Tara Cape Codder Hotel. 10am-3:30pm. Northern Computer Shows 508-744-8440
TX - AMARILLO - Hamfest. Potter Cty. ARES. Ben Pollard 806-381-8810

FEBRUARY 1-2

FL - MIAMI - Tropical Hamboree. Dade Radio Club. Youth Fair & Exposition Center. 10901 SW 24th St. Sat. 9am-5pm. Sun. 9am-4pm. 305-642-4139
MD - NEW CAROLLTON - Computer Show. Ramada Conference & Exhibition Center. MarketPro 301-984-0880 xt15
MD - PIKESVILLE - Computer Show. Pikesville Armory. MarketPro 301-984-0880 xt15
MO - ST. CHARLES - Computer Show. St. Charles Exposition Hall. St. Charles Ctr. I-70 & 5th St. Sat. 10am-4pm. Sun. 11am-3pm. Computer Central Shows 888-296-6066
MS - JACKSON - State Convention. Travis Cliett 601-939-9236
OH - COLUMBUS - Computer Show. Ohio Exposition Center. MarketPro 301-984-0880 xt15
PA - GREENSBURG - Computer Show. Greengate Expo Center. MarketPro 301-984-0880 xt15
VA - CHANTILLY - Computer Show. Capital Expo Center. MarketPro 301-984-0880 xt15

FEBRUARY 2

CA - LIVERMORE - Swapmeet. Las Positas College. Noel Anklam 510-447-3857
CA - OXNARD - Computer Show & Sale. Community Center. 10am-5pm. MarketPro 1-800-708-7555
CA - STOCKTON - Computer Show & Sale. Civic Auditorium. 10am-5pm. MarketPro 1-800-708-7555
MA - BRAINTREE - Computer Show. Sheraton Tara Hotel. 10am-3:30pm. Northern Computer Shows 508-744-8440

FEBRUARY 7-8-9

WI - MADISON - Computer Sale/Show. Dane Co. Expo Center. Blue Star Productions 612-788-1901

FEBRUARY 8

CA - FONTANA - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves
FL - ARCADIA - Hamfest. Doug Christ 941-494-5070
FL - FORT LAUDERDALE - Computer Show. The Westin Hotel, 400 Corporate Dr. Narissam Computer Shows 770-663-0983
FL - MILTON - Hamfest. Mark McAnally 904-626-7686
KS - LACYGNE - ARRL Hamfest. Mine Creek ARC. Bill VanKirk 913-795-2080
MN - BLAINE - Midwinter Madness. National Sports Center, Exit #32 off 35 W, N. of Minneapolis/St. Paul. 8am-3pm. RARC 612-537-1722
SC - CHARLESTON - Hamfest & Computer Show. Stall H.S. in N. Charleston. I-26 & Ashley Phosphate Rd. Northwoods Mall, Waccamaw. Jenny Myers 803-747-2324

FEBRUARY 8-9

FL - JACKSONVILLE - Computer Show. Jacksonville Fairgrounds. MarketPro 301-984-0880 xt15
MD - NEW CAROLLTON - Computer Show. Ramada Conference & Exhibition Center. MarketPro 301-984-0880 xt15
PA - KING OF PRUSSIA - Computer Show. Valley Forge Convention Ctr. MarketPro 301-984-0880 xt15
TN - NASHVILLE - Computer Show. Nashville Armory. MarketPro 301-984-0880 xt15
VA - CHANTILLY - Computer Show. Capital Expo Center. MarketPro 301-984-0880 xt15
WV - CHARLESTON - Computer Show. Convention Center. MarketPro 301-984-0880 xt15

FEBRUARY 9

CA - LANCASTER - Computer Show & Sale. Antelope Valley Fairgrounds. 10am-5pm. MarketPro 1-800-708-7555
CA - SANTA ROSA - Computer Show & Sale. Sonoma Co. Fairgrounds. 10am-5pm. MarketPro 1-800-708-7555
FL - WEST PALM BEACH - Computer Show. Palm Beach Airport Hilton, 150 Australian Ave. Narissam Computer Shows 770-663-0983
OH - MANSFIELD - Hamfest & Computer Show. Richland Co. Fgnds. 7am. Pat Ackerman N8YOB. 419-589-7133
PA - LATROBE - Hamfest. Chestnut Ridge ARC. 1811 Ligonier St. 8am-3pm. Bill Demosky 412-539-1552

FEBRUARY 14-15-16

FL - ORLANDO - HamCation & Computer Show. Central FL Fgnds., 4603 W. Colonial Dr. St. Rd. 50. Fri. 5pm-9pm, Sat. 9am-5pm, Sun. 9am-3pm. 407-823-7133

FEBRUARY 15

CA - BAKERSFIELD - Computer Show. Kern Co. Fairgrounds. MarketPro 1-800-708-7555
CA - VALLEJO - Computer Show & Sale. Solano Co. Fairgrounds. MarketPro 1-800-708-7555
CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in 619-561-0052
IN - INDIANAPOLIS - AGI Computer Fair. Indianapolis Events Center. 3655 E. Raymond St. 317-299-8827
MD - BALTIMORE - Computer Show. Martin's West. MarketPro 301-984-0880 xt15
MI - TRAVERSE CITY - Hamfest. Cherryland ARC. Joe Novk 616-947-8555
NH - SEABROOK - Computer Show. Greyhound Park. 10am-3:30pm. Northern Computer Shows 508-744-8440
NY - HORSEHEADS - Hamfest. State Armory, 128 Colonial Dr. Jack Slocum 607-739-4866
OR - RICKREAL - Salem Hamfair. Polk Co. Fairgrounds. 9am-3pm. James Pardey 503-651-3216
PA - OBERLIN - Winter Hamfest. Oberlin Fire Co. HRAC AnswerLine 717-232-6087
TX - SMITHVILLE - ARRL Hamfest. Bastrop Co. ARC. Charlie Claiborne 512-360-3670
VA - ANNANDALE - Computer Show. Northern VA Comm. College. MarketPro 301-984-0880 xt15

FEBRUARY 15-16

GA - NORCROSS - Computer Show. North Atlanta Trade Center. MarketPro 301-984-0880 xt15
PA - MONROEVILLE - Computer Show. Pittsburgh

Events CALENDAR

Expo Mart. MarketPro 301-984-0880 xt15
VA - ROANOKE - Computer Show. Civic Center. MarketPro 301-984-0880 xt15

FEBRUARY 16

CANADA - BC - WESTMINISTER - Hamfest. Burnaby ARC. Harry Curtis 604-530-3962
CA - SAN DIEGO - Computer Show & Sale. Scottish Rite Center. 10am-5pm. MarketPro 1-800-708-7555
IL - ROCK ISLAND - Hamfest. QCCA Expo Center, 2621 4th Ave. Davenport RAC. Kent Williams K9UQI 309-796-0718 4-9pm only
IN - NOBLESVILLE - Computer Fair. Hamilton Co. Fairgrounds, off I-37 exit Pleasant Rd. near Walmart. 10am-3pm. AGI Services 317-299-8827
MA - TAUNTON - Computer Show. Taunton Holiday Inn. 10am-3:30pm. Northern Computer Shows 508-744-8440
MD - BOWIE - Computer Show. Bowie State University. MarketPro 301-984-0880 xt15
NC - ELKIN - Hamfest. Briarpatch ARC & Foothills ARC. Jimmy Holbrook 910-957-3820
NY - FREEPORT - Hamfest. Long Island Mobile ARC. Mark Nadel 516-796-2366
PA - LANCASTER - Computer Show. Holiday Inn Lancaster Host. MarketPro 301-984-0880 xt15

FEBRUARY 17

CA - MODESTO - Computer Show & Sale. Centre Plaza at Red Lion. MarketPro 1-800-708-7555
MA - BOXBOROUGH - Computer Show. Holiday Inn. 10am-3:30pm. Northern Computer Shows 508-744-8440
OH - NILES - Computer Show. Eastwood Expo Center. MarketPro 301-984-0880 xt15
PA - ALLENTOWN - Computer Show. Allentown Fairgrounds. MarketPro 301-984-0880 xt15
VA - RICHMOND - Computer Show. The Showplace. MarketPro 301-984-0884 xt15

FEBRUARY 22

AR - RUSSELLVILLE - Hamfest. AR River Valley. Dallas Scott 501-967-3317
FL - SPRING HILL - Hamfest. Hernando County ARA. Lee Kent 352-799-1638
GA - DALTON - Hamfest. Dalton ARC. Harold Jones 706-673-2291
IN - LAPORTE - Hamfest. LaPorte Civic Center. 8am-2pm. John N9ROH, POB 30, LaPorte, IN 46352
ND - BISMARCK - CDARC Hamfest. Radisson Inn. 8am-4pm. Tim Rasset 701-663-6620
NH - MANCHESTER - Computer Show. Center of NH Complex. 10am-3:30pm. Northern Computer Shows 508-744-8440
NJ - TRENTON - Computer Show. Trenton State. MarketPro 301-984-0880 xt15
TX - ORANGE - Hamfest. Orange ARC. Irene Thomas 409-745-3061
VT - MILTON - Hamfest. Milton High School. Radio Amateurs of Northern Vermont. Mitch Stern 802-879-6589

FEBRUARY 22-23

CA - SACRAMENTO - Computer Show & Sale. Cal Expo. MarketPro 1-800-708-7555
CA - VENTURA - Computer Show & Sale. Ventura Fairgrounds. MarketPro 1-800-708-7555
FL - TAMPA - Computer Show. FL State Fairgrounds. MarketPro 301-984-0880 xt15
MD - GAITHERSBURG - Computer Show. Montgomery County Fairgrounds. MarketPro 301-984-0880 xt15
OH - CINCINNATI - Conv. Great Lakes Division Convention. Cincinnati Gardens Exhibition Center, 2250 Seymour Ave. 8:30am-5pm. Stan Cohen 513-531-1011
OH - DAYTON - Computer Show. Montgomery Co. Fairgrounds. MarketPro 301-984-0880 xt15
TN - KNOXVILLE - Computer Show. Knoxville Fairgrounds. MarketPro 301-984-0880 xt15

FEBRUARY 23

DE - NEWARK - Computer Show. University of DE. MarketPro 301-984-0880
IL - GLEN ELLYN - Computer Show & Sale. College of DuPage. Main Arena of Phys Ed Bldg. Corner of Park Blvd. & College Rd. Computer Central Shows 847-940-7547
MA - WESTFORD - Hamfest. Greater Boston Antique Radio Collectors. Lisa Friedrichs 508-371-0512
ME - PORTLAND - Computer Show. Verillo's Conv. Center. 10am-3:30pm. Northern Computer Shows. 508-744-8440
MI - DEARBORN - Swap'n Shop. Dearborn Civic Center. 8am-3pm. Neil Coffin 313-261-5486
OH - CUYAHOGA FALLS - Hamfest. Emidio's Party Center, 48 Bath Rd. 8am-2pm. Bob Recny N8SQT 330-864-5810
PA - PITTSBURGH - ARRL Hamfest. South Hills ARC. Eric Hegerle 412-341-02270

MARCH 1997

MARCH 1

AL - TUSCALOOSA - Black Warrior Swapfest. Kelly Bruce 205-339-7882
CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052
GA - ATHENS - Hamfest. NE Georgia Bubba Net. James Daniel 706-742-2777
MD - NEW CARROLLTON - Computer Show. Ramada Conference & Exhibition Center. MarketPro 301-984-0880 xt15
NJ - ABSECON - Springfest '97 Hamfest. Holy Spirit High School. Shore Points ARC 609-653-1987
NJ - PARSIPPANY - Hamfest. PAL Building. Split Rock/West Morris Radio Clubs. Bernie 201-584-5399
OK - ELK CITY - ARRL Hamfest. West Central OK ARC. Earl Bottom 405-473-2572
TN - CLEVELAND - Hamfest. Ocoee ARS. Alan Pinney 423-478-1141

MARCH 1-2

FL - FT. LAUDERDALE - Computer Show. War Memorial Auditorium. MarketPro 301-984-0880 xt15
IN - FT. WAYNE - Computer Show. Allen County Fairgrounds. MarketPro 301-984-0880 xt15
PA - HARRISBURG - Computer Show. Farm Show Complex. MarketPro 301-984-0880 xt15
VA - NORFOLK - Computer Show. Norfolk Scope. MarketPro 301-984-0880 xt15

MARCH 2

CA - LIVERMORE - Swapmeet. Las Positas College. Noel Anklam 510-447-3857
MA - SWANSEA - Computer Show. Venus DeMilo. 9:30am-2:30pm. Northern Computer Shows 508-744-8440
MD - FREDERICK - Computer Show. Frederick Fairgrounds. MarketPro 301-984-0880 xt15
PA - TREVOSE - Photographic Swap/Shop Show. Radisson Hotel. 10am-3pm. OMM Productions 610-527-5903

MARCH 7-8

ME - LEWISTON - State Convention. Dave Blethen 207-353-6433

MARCH 7-8-9

LA - LAFAYETTE - ARRL Hamfest. Acadiana ARA. L. Al Oubre 318-367-3901
NE - NORFOLK - State Convention. Rick Kropf 402-371-7684

MARCH 8

CA - FONTANA - Inland Empire ARC Amateur & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves.
FL - ENGLEWOOD - HamCom '97. Tringali Community Center, SR 776 Englewood East. 8am-3pm. George Shreve 941-697-3445
IN - INDIANAPOLIS - AGI Computer Fair. Indianapolis Events Center. 3655 E. Raymond St. 317-299-8827
KY - HAZARD - ARRL Hamfest. Kentucky Mountains ARC. 8am-2pm. John Farler 606-436-5354
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Continued on page 112

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by TJ Byers

THE NUTS & VOLTS SOLAR WORKSHOP

Welcome to The N&V Solar Workshop ...

Building A Small Solar Power Plant

One of the many letters that prompted me to write the *Nuts & Volts* Solar Workshop came from Eric of Palm Springs, who asked "Can you provide guidance on building a small solar station ... to provide solar power (photovoltaics) for an electrical sprinkler system?" Since then, I've received requests for solar-powered satellite dishes, Malibu lights, and other small applications.

Now that we have some theory and hands-on experience under our belts, I feel confident to push forward to bigger and better things. In this segment of the Solar Workshop, I'll show you exactly how to design and assemble a photovoltaic system that will run Eric's sprinklers or Craig Hueser's satellite dish. I'll be drawing from material presented in the last two Solar Workshops (Nov. and Dec. '96), so you might want to have those issues handy.

The Workshop

A 12-Watt Solar Installation

I hope you brought your work clothes, because we're going to spend a lot of time in the Workshop today, getting our hands dirty at times. If you don't completely understand some of the concepts set forth or have questions not answered here, take a moment to sit in on the Classroom, where there's a question and answer session in progress.

About the System

The first thing you do when designing a solar installation is to determine the system parameters. Always begin with the device to be powered and work backwards from there.

Let's take the sprinkler scenario, for example. We'll call this System A. The selenoids draws about 2 amps of current for two hours a day. The same is true of the satellite dish, which also draws 2 amps of current in short spurts, probably for a total of an hour a day. We'll call the dish System B. Both devices are 12-volt operated, and need to have power available on demand, not just when the sun is willing to shine.

So for this design, we'll need a storage battery, which means we'll also need a charge controller, like the one described in the Dec. '96 Solar Workshop. Figure 1 shows a block diagram of our system. If you're ready, let's get started.

Amp-Hours vs. Watts

The following is going to be the hardest part of the design because it's not easy to understand the first time around. Typically, household appliances are rated in watts. For example, a 100-watt light bulb uses 100 watts of power. A toaster may consume 1,100 watts, and your TV is most likely a 250-watt consumer. The only thing these appliances have in common is their wattage rating, because heaven knows a TV set isn't the same thing as a toaster (well, mostly not, except for the crummy shows on it).

Photovoltaics work from two different camps. On one side, you have solar panels, which are rated in watts. Battery-operated devices, on the other hand, are rated in amp-hours, or Ah. What's an amp-hour? It's one amp of current flowing through a device (load, if you will) for one hour. One amp-hour doesn't equal one watt, though. Watts are the product of voltage times current (W = E x I), whereas amp-hours are the product of current times time (Ah = I x t).

If we turn on the sprinklers (system A) for two hours a day, and they draw 2 amps of current, then they consume 4 Ah of power. The satellite dish (system B) also draws 2 amps of current, but for only one hour a day, for a total of 2 Ah. To satisfy the needs of system A alone, we need 4 Ah; system B needs 2 Ah daily. Together they need 6 Ah. For the rest of this discussion, let's focus on system A, the sprinkler system, which is 4 Ah.

How much is that in watts, you ask? That's a good question because you can't buy an amp-hour solar panel. To get a wattage rating, we need to know the voltage of the system. In this case, it's 12 volts. If we multiply 12 volts by 2 amps, we get 24 watts; 12 volts at 1 amp is 12 watts. At this point, time isn't a factor, but it will be soon, so listen up.

Insolation

The next step is to introduce the element of time. We already know the time of the load, because it's expressed in amp-hours. What we need to determine is the amount of time the photovoltaics will be generating energy, which we'll then convert into amp-hours.

The amount of potentially useful radiation is called the insolation value. Solar insolation varies widely from one point on the planet to another, and involves many factors. Thankfully, the US Weather Bureau has rendered all these factors into simple insolation maps, like the one shown in Figure 2.

However, this map doesn't work for microclimates, such as a town nestled against a hillside. Fortunately, I've located a site on the Internet (http://solstice.crest.org/renewables/solrad/data/index.html) sponsored by CREST (Center for Renewable Energy and Sustainable Technology) which has an interactive solar radiation and climate database for hundreds of cities in the US and its territories. You click on your city from a map (Figure 3), and up pops a detailed chart of your solar and weather conditions for the whole year.

However, if you look at the insolation map in Figure 2 carefully, you'll notice that the majority of cities in the continental US have an insolation value between 5 and 6. This means that over the course of a year, you can expect to receive five to six hours of productive solar power on average. These are the numbers we'll use for the next part of our design.

Crunching the Numbers

Let's say that we want to translate 4 Ah into wattage for San Francisco, which has an insolation rating of 5.5. First, we need to calculate the current using the formula

I = Ah/insolation value

or

I = 4/5.5

which is 0.73 amps. This tells us that a sustained current of 0.73 amps for 5.5 hours is the equivalent of 4 Ah.

Now that we have a current value, it's easy enough to calculate wattage. Let's assume, for the moment, the voltage is 12 volts. Plugging these values into our W = EI formula gives us an answer of 8.76 watts. Now we're getting somewhere.

We now know that we need at least a nine-watt solar panel to keep our system afloat. Rather than have you wade through all the calculations, ripping out your hair or clawing at your face, I've done the homework for you in Table 1. Notice that the farther south you go, the higher the insolation value, and the smaller the solar panel wattage requirement.

Sizing the System

The next step is to match the numbers in Table 1 to your load and solar conditions. This time, let's pick Los Angeles, which has an insolation value of 6.0,

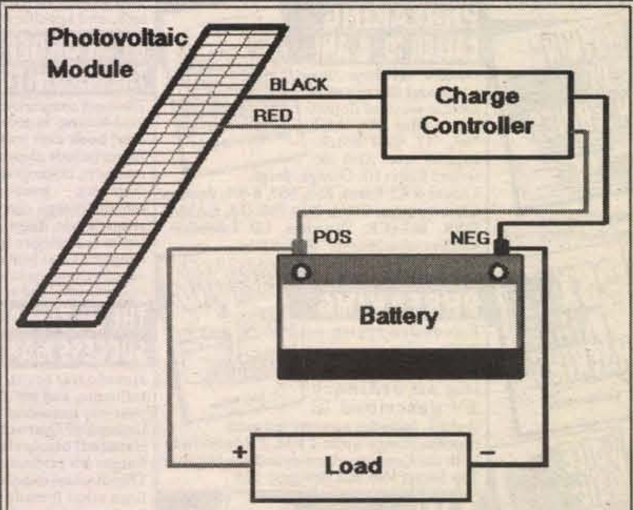


Figure 1

A typical solar installation consists of three parts: photovoltaic module, charge controller, and a battery. The load can be anything you want, from sprinklers to motor to lamps.

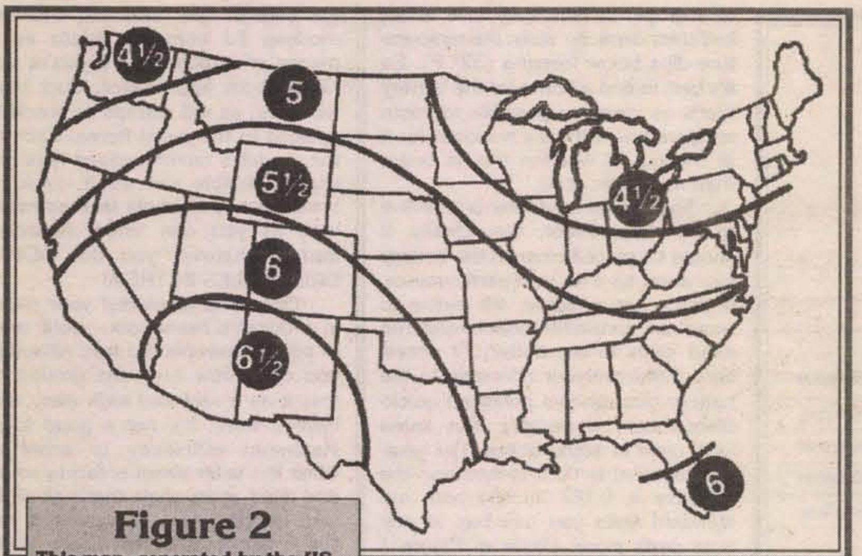


Figure 2

This map, generated by the US Weather Bureau, shows the number of hours of productive sunlight you can expect per day over the course of a year.

operating with a 4 Ah load. Our chart tells us the current is 0.66 amps and that the photovoltaic requirements are somewhere between 7.9 and 8.7 watts.

Why the two wattage ratings? Because not all solar panels are rated at the same voltage. Some vendors rate them at 12 volts (nominal) and others at 13.2 volts, the minimum voltage needed to charge a 12-volt battery. For now, let's go with the higher voltage, which specifies 8.7 watts.

Keep in mind that this is the power used on a daily basis, and not the power we need to generate. As I discussed last month in the Classroom (you did attend, didn't you?), you have to put more power back into a battery than you took out. Which means our battery will go dead in short order if we use an 8.7-watt solar panel.

Typically, you need to return at least 10 percent more power than you take out. The size of the solar panel has now jumped from 8.7 to 9.6 watts; let's call it 10 watts.

That done, we now need to match the photovoltaics to a battery. We know that the battery must be able to supply 4 Ah on a daily basis. However, fully depleting a battery on a regular basis (deep cycling) shortens its life. Moreover, what happens if the sun doesn't shine for a day or two? Do you go without the sprinklers or forego watching TV? Hardly — you just buy a bigger battery.

But here's where you have to be careful, because oversizing the battery is as bad as undersizing it. Unless the battery is exercised, the plates will sulfate and suffocate the battery. Let's see what size is the best for this application.

If we select an 8 Ah battery, it will last two days without sunshine, and discharge to only 50 percent on average. That's cool, but not good enough. A 12 Ah battery would be better because it gives us three days of cushion and only discharges 33 percent daily. (When used in a system with a 3 Ah rating, this changes to four days storage and 25 percent daily discharge.)

This is the battery we'll select for our Los Angeles solar site. If we follow this same scenario for Seattle, it would be wise to up the size of the battery to 20 Ah because of the more severe weather conditions. A 20 Ah battery will typically last up to five days and discharge to only 20 percent on average.

Shopping for Solar

With grocery list in hand, it's time to go shopping for the parts needed to put this system together. Let's tackle the solar panel first.

Depending on your geographical location, the solar panel will vary in size between 10 watts and 12 watts. Well, I did some shopping around and came up with solar panels from three vendors that fill the bill (see "Where To Buy" for details). All sell for under $100.00.

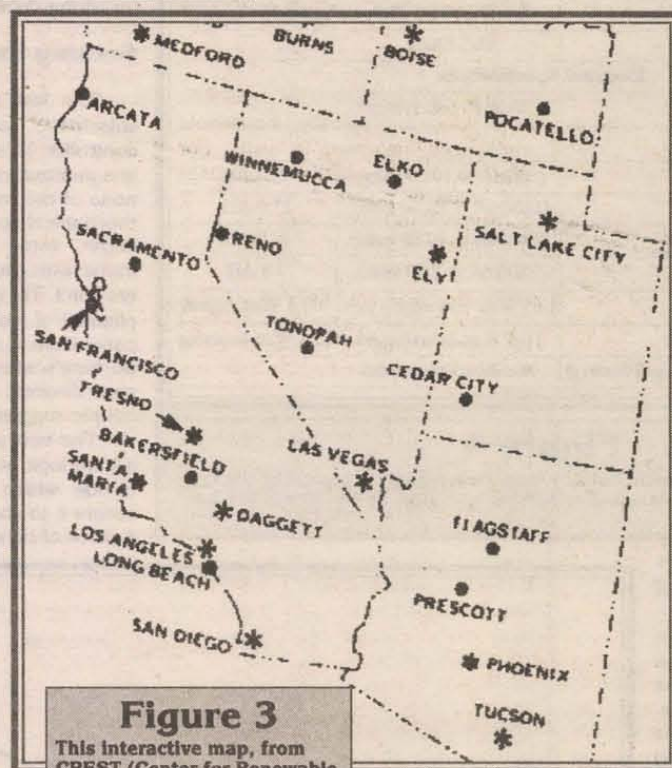


Figure 3

This interactive map, from CREST (Center for Renewable Energy and Sustainable Technology), lets you focus in on microclimates for precise weather and solar conditions.

The first is the 10 Watt Lite "Clone" (part number 11-560) from Alternative Energy Engineering. This module was made in Korea as a power supply for a pump in a solar water heating system, but the dimensions were wrong. AEE bought a large quantity at a good price, and they're passing the savings on to you. The price is $95.00. This stainless-steel-backed panel measures 10.6" x 17.6" and comes unframed.

Next is a 12-watt module from Jade Mountain (catalog number PV908). The solar panel was made by Chronar, which went out of business about 10 years ago. Jade Mountain acquired several thousand of these panels and is selling them for $95.00. The module measures 12" by 36" and comes fitted in a metal frame.

Last, but not least, is the 11-watt solar panel from Solar Electric. Made by Unisolar, this flexible panel is unbreakable and is often used in RV and marine applications. It measures 12" by 24" and sells for $99.00 unframed, or $129.00 framed.

Finding a suitable battery isn't as easy as it first appears, especially if you're looking for a low-cost unit with good quality. My pick is the Model PS-12120 from Power-Sonic (Figure 4). It provides 12 Ah of power, and retails for under $50.00 (call Power-Sonic for the dealer nearest you). It's a sealed, maintenance-free battery of spill-proof construction with valve — regulated recombination (see the Dec. '96 Classroom for details).

The battery can withstand between 200 and 1,000 charge/discharge cycles, depending on the average depth of discharge, and recovers quickly from a very deep discharge. Under normal usage, the battery will last about five years. Power-Sonic also carries a full line of photovoltaic batteries ranging in

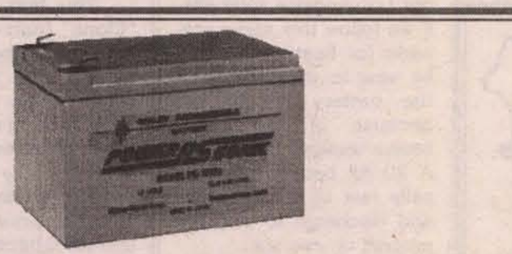
HOT! Photovoltaic Web Sites

CREST, the Center for Renewable Energy and Sustainable Technology (http://solstice.crest.org/) is specifically geared to providing info via the Internet, and includes a good database of US climate data, including detailed solar data on hundreds of cities (Figure 3).

The Solar and Renewable Energy Resources list (http://www.ises.org/pages/solarinfo.html), maintained by the International Solar Energy Society, is the most comprehensive solar Website I've ever seen. ***This is a must — check it out.***

The National Renewable Energy Laboratory's Web site (http://www.nrel.gov/research/pv/tapsun.html) includes a comprehensive discussion of the economics of photovoltaics and descriptions of a range of applications.

The US Department of Energy's "Energy Efficiency & Renewable Energy Network" (http://www.eren.doe.gov/) is a good general source on efficiency and renewable energy, and includes a range of databases.



PS-12120 / 12V-12.0 Amp. Hr. Battery		
Finished Specifications		
Dimensions:		
Length	5.94 inches	151 millimeters
Width	3.86 inches	98 millimeters
Height	3.70 inches	94 millimeters
Height over Terminals	3.94 inches	100 millimeters
Approximate Weight	9.0 pounds	4.1 kilograms
Terminals: Polarized		
Quick Disconnect Tabs	(pos)0.250"x0.032"	(neg)0.187"x0.032"
Case:	ABS Plastic	
Electrical Specifications		
Nominal Voltage:	12 Volts (6 cells in series)	
Nominal Capacity:		
20 hour rate	(600mA to 10.50 volts)	12.0 AH
10 hour rate	(1100mA to 10.50 volts)	11.0 AH
5 hour rate	(2000mA to 10.20 volts)	10.0 AH
1 hour rate	(7800mA to 9.00 volts)	7.8 AH
Energy Density (20 hour rate)	1.69 Watt-hours/cubic inch	103.6 Watt-hours/l
Specific Energy (20 hour rate)	16.4 Watt-hours/pound	35.1 Watt-hours/kg
Internal Resistance (Fully Charged Battery)	16 milliohms (approx.)	

Figure 4
The PS-12120 sealed lead-acid battery from Power-Sonic is typical of the type of battery needed for our design. For harsher climates, up the size of the battery to 20 Ah.

capacity from a few amp-hours up to hundreds of amp-hours.

Of course, Power-Sonic isn't the only maker of batteries. More are listed in the "Where To Buy" box. Moreover, batteries of this capacity can often be found on the surplus market for pennies on the dollar. While a car battery could be used in this application, it won't last more than a year because it's oversized and intolerant of the photovoltaic's erratic charging cycles. But if you want to see for yourself, who am I to stop you?

Assembly

Now comes the fun part — getting our hands dirty. Let's begin by positioning the battery in a warm, cozy place where it's not exposed to the elements. Lead-acid batteries lose a lot of their power when the temperature drops. In fact, they lose about half their capacity when the temperature dips below freezing (32° F). So it's best to find a home for the battery that's as close as possible to room temperature. If there's no room for it at the inn, a wooden box is better than no shelter at all.

The charge controller is sensitive to its environment, too. Ideally, it should be placed close to the battery in a warm spot for best performance. If that's not possible, it's better to move the controller indoors and run extra wires to the battery, if necessary. The controller connects to the battery through two polarized quick-disconnect connectors, the same kind used in automobiles. The positive terminal is 0.25 inches and the negative is 0.187 inches; both are standard sizes you can buy at any auto parts store. (Refer to Figure 1 for wiring details.)

Seeking the Solar Angle

The last step is mounting the solar panel and connecting it to the controller. This is going to take some imagination on your part because none of the modules have the same mechanical specifications. Some are larger, some smaller. One has a frame with mounting holes, the others don't. Things get even more complicated if you bought your solar panel from a different manufacturer. So here's where I leave you to your own devices. However, here are a couple suggestions.

The best place to start is to take a hard look at what you've got, then decide which is the best way to secure it to something solid, such as a piece of plywood or plastic pipe. In the case of the unframed Unisolar module, I'd consider Velcro as a means of attachment. If you're not fussy about appearance, duct tape will work, as will clamps or brackets epoxied to the metal frame. Each of the modules recommended here are slightly flexible and won't crack or break, but you should take as much care as you can when mounting them. Whatever you do, DON'T DRILL HOLES IN THEM!

Once you've placed your panel in a suitable framework, you'll need to point it towards the sun. Although you can throw it on the ground or toss it on a roof and walk away and have it work, it's not a good idea. Maximum efficiency is achieved when the solar panel is facing south and tilted at an angle that's equal to your latitude plus 15 degrees. If you live in Los Angeles, the angle of the tilt will be 50 degrees (35 degrees + 15). San Francisco is 53 degrees, and Seattle is 62 degrees.

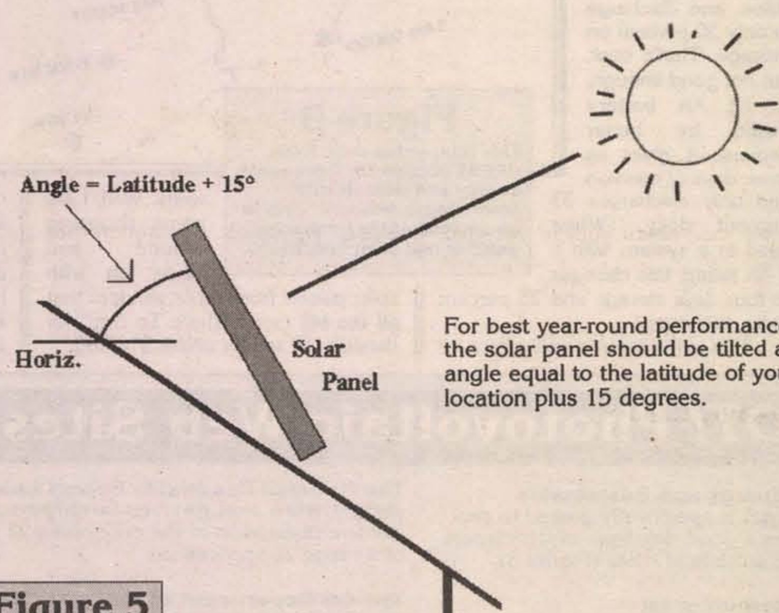
If you don't know your latitude, you can find it on almost any map. Another way to determine your solar angle is to pound a stake in the ground on a sunny day and wait for high noon (make sure the stake is straight up and down). Notice that the stake casts a shadow on the ground. At noon, drive a small tent peg into the ground at the tip of the shadow. Now run a piece of string from the peg to the top of the stake (Figure 5). This is the angle you want for your solar panel.

Of course, the length of the shadow is going to vary over the course of a year, so you may want to take the measurement around the vernal or autumnal equinox (March 21 or September 22) for best results. (The equinoxes are the days when the planet is evenly aligned toward the sun, with neither the north nor the south pole tilted toward Sol.)

After the solar panel is securely in place, run the wires to the charge controller. Be sure to observe polarity because you'll have to splice onto the short leads coming from the module.

If you're using the charge controller described in last month's Solar Workshop, set the value of Rs to 10 ohms. By the way, I made a mistake describing the calibration and operation of the controller last time. I stated that 12.6 volts was the trip point, when in fact it's 14.2 volts. Whatever made me think 12.6 volts could charge a battery to 13.2 volts is beyond me (12.6 is the nominal voltage of a 12-volt battery). Obviously, it was a typo that I perpetuated once I made it.

With a voltmeter, monitor the voltage across the battery as it recharges. When the battery voltage reaches 14.2 volts (not



For best year-round performance, the solar panel should be tilted at an angle equal to the latitude of your location plus 15 degrees.

Figure 5

Table 1. Solar Panel Wattage Requirements

Insolation Value	Current (amps)	Wattage @ 12.0V	Wattage @ 13.2V
4 Ah			
5.0	0.80	9.6	10.5
5.5	0.73	8.8	9.6
6.0	0.66	7.9	8.7
3 Ah			
5.0	0.60	7.2	7.9
5.5	0.54	6.5	7.1
6.0	0.50	6.0	6.6

Table 2. Most Popular Module Comparisons (source: Jade Mountain)

Brand	Watts	Cost	Price/watt
Used Solarex PL110	60	$220.00	$3.67
Solec Specials	misc.	misc.	$4.50
Solec 90s	90	$445.00	$4.95
Solec 100s	100	$525.00	$5.25
Solec 80s	80	$432.00	$5.40
Solec 55s	55	$300.00	$5.45
Siemens PC4	75	$416.00	$5.55
Kyocera	51	$295.00	$5.78
Solec 40s	40	$240.00	$6.00
Solarex MSX	60	$382.00	$6.37
Siemens M-55	53	$345.00	$6.51
Siemens M-75	48	$319.00	$6.65

12.6 volts as previously stated), advance VR1 until the relay just pulls in. If you decide to buy your controller instead of building it, it will come already calibrated. Charge controllers are available from the same people who sold you the photovoltaic panel.

Lastly, connect your load to the completed solar generator. Again, be sure to observe polarity if your device is polarity-sensitive (e.g., radio or TV). Now sit back and enjoy the fruits of your labor.

The Classroom

Frequently Asked Questions

I planned to give a lecture on photovoltaic theory today. You know, something about boring quantum physics and how it makes a solar cell produce electricity. But I've received so many requests from readers who are unclear on the practical aspects of solar power, that I decided the time would be better spent if I turned this Classroom session into a question and answer period. You ask the question, and I'll do my best to answer it. First question please.

1-What are photovoltaics?

Photovoltaics are solid-state semiconductor devices that convert light directly into electricity. They're usually made of silicon, the same material used to fabricate transistors, LEDs, and microprocessors.

2-How does it work?

When sunlight hits the face of a solar cell, photons are absorbed in the semiconductor material, which pump up the energy level of the electrons in the silicon and sets them free. Metal contacts on both sides of the solar cell collect these free electrons and make them available to external devices, like motors and lamps.

As the electrons flow through these devices, they give up their energy, which causes the motor to spin or the lamp to light, and return to the solar cell where they're recycled. There are no moving parts and no materials are consumed or emitted.

3-Does solar electricity come from light, heat, or from some other force radiated by the sun?

It comes from light. While silicon solar cells respond to most wavelengths of visible light, they're most sensitive to light in the red part of the spectrum, including that which extends into the infrared region.

4-Where can I use photovoltaics?

Well, you can use the electricity generated by photovoltaics to power any electrical device, including lamps for lighting, motors to pump water, radio transmitters, and much more. Presently, photovoltaics are finding widespread use in remote locations where conventional electricity isn't available, such as remote radio sites and vacation cabins.

5-Is there a limit to solar power?

The only limitation is the cost of the equipment and the amount of space you have for the installation. Because photovoltaics are modular, you can keep on adding as many solar panels as you wish to the array to increase the power output — well, at least until you run out of real estate.

6-What does solar power cost?

That depends on the application. Systems of 100 watts or more generally cost between $10.00 and $30.00 per watt at the time of installation. Smaller systems are typically more expensive — but not always.

For example, the 12-watt installation described in the Workshop costs just $17.00 per watt. The photovoltaics themselves account for one-third to one-half the cost of any system (Table 2). The rest of the costs are incurred by the support equipment, batteries and controllers, and labor. While it's hard to compare photovoltaic costs to utility-provided electricity, the life cycle cost of solar generated energy generally ranges from $0.30 to $1.00/Kwh.

7-In reference to your Oct. '96 issue, can you tell me where I can buy 40-watt solar panels for about $100.00?

You can't anymore. These were surplus ARCO Solar modules salvaged from the Lugo substation project in Hesperia, CA. These panels are now sold out. However, Carrizo Solar, the Lugo dismantler, has acquired a large number of utility grade photovoltaic modules (Solarex PL-110) from the Omniplex Museum in Oklahoma City. You can buy these 60-watt (actually, 70-watt) modules from Jade Mountain for $220.00 each, which makes them just slightly more costly ($3.67 per watt) than the ARCO Solar modules.

Unfortunately, they're four-volt panels, so you'll need four of them for 12-volt operation. But four modules nets you 240 watts or better, making them ideal for large power installations.

8-Do photovoltaics work on cloudy or rainy days?

Because photovoltaics respond best to low-frequency light in the red part of the spectrum, their output is only slightly affected by the weather. Typically, they can generate between 50 percent to 70 percent of their rated output under a bright overcast.

A dark, stormy day can reduce that number to 10 percent of full sun intensity, but they will still chug away as best they can. Only the cloak of night can stop them from generating electricity.

Where To Buy

AAA Solar Service & Supply, Inc.
800-245-0311
http://www.rt66.com/aaasolar

Alternative Energy Engineering
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Redway, CA 95560
800-777-6609
http://www.asis.com/aee/index.htm

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http://www.rt66.com/carrizo/

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http://www.power-sonic.com

PV Resources International
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Mesa, AZ 85202
602-897-6427

Siemens (Previously ARCO Solar)
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Camarillo, CA 93011
805-482-6800

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Nevada City, CA 95959
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San Diego, CA 92109-1602
800-842-5678
http://www.solarelectricinc.com

Solarex Corporation
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Frederick, MD 21703
301-698-4200
http://www.solarex.com/

Speciality Concepts, Inc.
8954 Mason Ave.
Chatsworth, CA 91311.
818-998-5238
http://www.wp.com/SCINC

9-What if it's snowing. Won't they freeze up?

Contrary to "practical" logic, where cars and buses grind to a halt on a snowy day, photovoltaics actually generate more power at lower temperatures. This is because photovoltaics are semiconductor devices (diodes, to be exact) which produce electricity from light, not heat. And, like most semiconductors, they operate more efficiently at cooler temperatures.

10-How about fog?

Unfortunately, fog is the fly in the ointment. Very little solar energy penetrates a heavy fog, such as you find in San Francisco and other port cities during certain times of the year. The solution is to oversize your system so that you can survive until the fog passes.

11-How about indoors?

Indoor light levels, even in a bright office, are dramatically lower than outdoor light levels, typically by a factor of several hundred or more. Photovoltaics designed for outdoor use will generally not produce any useful power under these conditions. However, there is a class of photovoltaics designed specifically for indoor use, like the cells found on calculators, which work great indoors, but perform poorly in full sunlight.

12-I want to set up a small solar generator in my back yard, but the apartment building next door blocks the sun for most of the day. Does the collector have to face south?

Yes, south is where the power is (in the Southern Hemisphere, north is where the power is). However, you may be able to collect some rays by angling the solar panel to pick up bounced or scattered light (perhaps off a neighboring window) and gain some power there. What I'd do is ask permission to put the solar array on the roof of the offending building. Explain to the owner it's like a satellite dish, and that it does no harm. After all, you have nothing to lose and everything to gain. Good luck!

13-What maintenance is required of photovoltaics?

Virtually none, except for wiping or hosing down the panels from time to time. But that's not even needed unless you live in an area where it never rains. If you have a battery in your system, you'll need to monitor it according to the manufacturer's instructions.

14-How long do photovoltaics last, and will my modules lose power over time?

That depends on the construction of the cell and the process used to make it. Single crystal cells (CZ) are the most stable and lose hardly any power over their 30-year lifespan.

Polycrystalline cells last almost as long, but they generally lose some of their oomph over the years (expect to see 80 percent of their original power after 20 years).

Thin film and amorphous cells have a predictable falloff in output in the first few months of operation, which slows down and stops after some time. The modules' output from then on is relatively stable.

Depending on the manufacturer, this drop-off can be anywhere from 20 percent to 50 percent. The life expectancy of a thin-film cell is in the range of 5 to 10 years.

15-Besides photovoltaic modules, what else do I need in my system?

Although a solar-powered system can be quite simple, you'll probably want no less than the minimal set-up described in this month's Workshop, which includes a battery and charge controller. In larger systems or systems that have to run AC appliances, an inverter is required. Beyond that, it's just a matter of the hardware, fuses, and wire needed to keep things together. Really, it's nothing fancy or complicated.

16-Can photovoltaics be used for space heating or heating pools?

At these prices, I wouldn't think so. If you're out in the sticks, it's cheaper to use propane for heating.

17-What do you know about photovoltaic electric cars? When will I be able to buy one?

Uh ... well, it sounds like this session is winding down. I'm sure more than a few of you still have things to do in the Workshop, so let's call it a day. See you next time. **NV**

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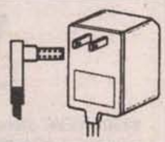

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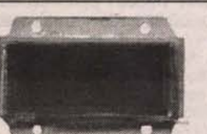

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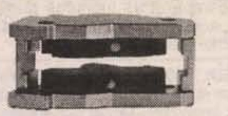

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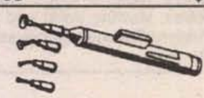

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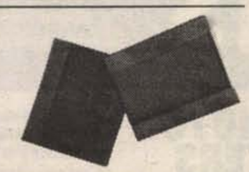

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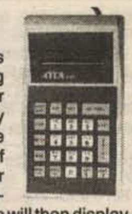

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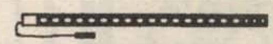

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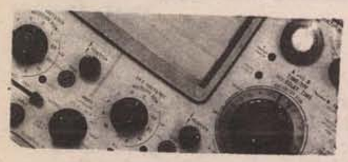
FILMOHM 7147 step attenuators 1-110 dB, 0-250 MHz, 75 ohms, $80; Honeywell 1858 Visorder with plug-ins, $600; Grayson Stadler 1701 audiometer, $300; GR1925 multifilter, $400; HP140T, 8554B, 8553B spec. analyzer, $1,500; HP 8016A, word generator, $500; HP 8018A serial data gen., $500; HP 8006A word gen., $150; HP 8406A comb. gen., $500; HP 2225A, printer HPIB, $100; Phillips 6672A 1GHz counter $450; EIP 371 source locking counter 18GHz, $1,200; Pulse Instruments PI 5800A data generator, $800. A-Comm Electronics 303-290-8012.



50MHz SCOPE BARGAIN Tektronix 453, solid-state. Dual trace. Sensitivity=5 millivolts. Excellent condition. manual copy. New probe. $295 (this month only). Gary N6ZD, 408-385-0301 VISA/MC.

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WANTED: RADIO service monitors, IFR, Motorola, Marconi, HP signal generators, spectrum analyzers, and late model HP equipment. 716-763-9104 or 716-661-9964. Fax: 716-763-0371. http://www.netsync.net/users/amtronix

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FREQUENCY COUNTER HP 5245L DC-500MHz, excellent condition. Meets NIST calibration. $400. 909-469-9100.

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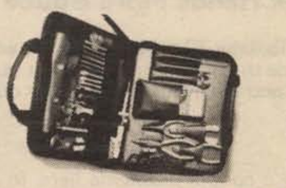

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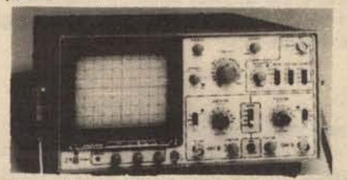

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WANTED: LATE MODEL TEST EQUIPMENT (Tektronix, HP, Fluke). Also we buy test equipment manuals, catalogs. Pepper Systems, 214-353-0257; 214-902-9511 FAX.

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DATA PRECISION 6000 FFT waveform analyzer, 610 plug-in, GPIB, RS-232, plotter options, manual, $900. Fluke 45 dual display DMM, 5 digits, true RMS, RS-232 I/O, manual, $400. 505-988-5233.

ELECTRONICS Q & A

With TJ Byers

In this column, I answer questions about all aspects of electronics, including computer hardware and software. This column doesn't replace the Tech Forum that you've grown to love and support. Instead, it will supplement it, so feel free to participate as always with your questions and answers. You can reach me on America Online at TJBYERS, on the Internet at TJBYERS@aol.com or by snail mail at *Nuts & Volts Magazine*, 430 Princeland Ct., Corona, CA 91719.

Notebook Needs More Space

Q. I have a Toshiba T2200SX notebook with an itty-bitty 80 MB hard disk. Can I upgrade the hard disk to a bigger one? Ideally, I want to remove the internal one and replace it with the new one.

Hai N. Nguyen
via Internet

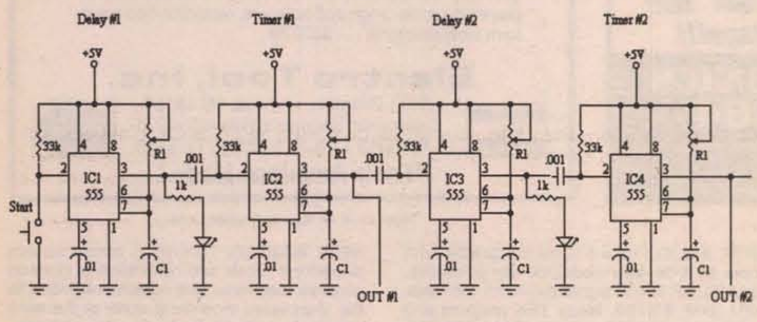
A. *You have a couple problems here, in that this is a pretty old notebook and I'm not sure the upgrade is money well spent. Yes, you can replace the old hard disk with a new one — but I wouldn't tackle that task unless you've done it before. Cracking the shell on this system isn't easy (lots of hidden screws and wires), and once you get it open, you need to gingerly take out the old hard disk and insert the new. What I suggest is taking it to an expert, like Precision Digital Services (800-216-5525; http://www.pdsusa.com/t2000.html). For $325.00 they'll upgrade you to 350 MB and for $895.00 they'll install a 2.1 GB hard disk, postage included. If you think you can handle the mechanics, you can probably do the upgrade to 1.2 GB yourself for about $350.00. However, you might want to consider putting this money towards a new Pentium notebook, instead.*

Sequence Timer

Q. I'm looking for a circuit that would provide a cascaded string of 10 timers with different delay off and on times. Each stage would consist of two timers: one for delay and one for power on. I'd like each timer to be pot adjustable from two seconds to about five minutes. As a final request, I'd like to have a switch which would enable me to route the output of the final timer so that it could start the cycle all over again. If this is too complex a design, or beyond the scope of your 555 "Timer Wizards," I'd be glad to pay someone to provide me with this design.

Don Fleshren
Sterling, VA

A. *Great, send me a check because here it is! Just kidding. How about a check to the subscription department and a kind letter to my editor. This design is based on the 555 timer, and is relatively simple to construct and use. I only included two stages, but it's easy enough to expand this to as many stages as you wish.*

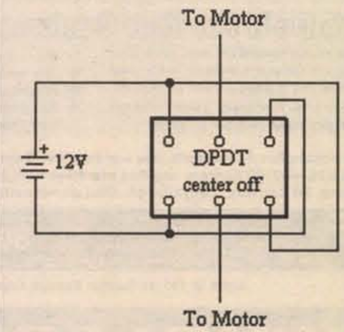


IC1 is the first delay timer. When it expires, it triggers IC2, which can now power whatever you want using logic output #1 to drive a transistor, relay, or other device. (Just for fun, I've connected output IC1 to an LED so that you can see where you are in the sequence, in case you get lost.) At the end of IC2's cycle, IC3 is triggered, which now pauses for whatever time you set the potentiometer for, after which IC4 kicks in ... well, you get the picture. If you want this to be recursive, simply provide a path from the last stage to S1. To reduce part count, use a 556 chip which contains two 555 circuits. If you need more precise timing, you'll have to go to a digital design, in which case you can get your checkbook ready.

Solar Satellite Dish

Q. I just bought an old C-band satellite dish hooked up to a Toki receiver that I'd like to convert to solar power. I've already taken the first step by buying a 2.25W panel from Electronic Gold Mine, but I'm not clear on how to hook it up to my 12-volt battery that provides the power to turn the dish. The dish has a Dayton DC model 4Z14S motor driving a worm gear to turn this dinosaur, and I would like to be able to switch directions inside the house, which I do now by just reversing the wires from a 12-volt, 2A power supply.

Craig Hueser
Clovis, CA



A. *The first part of your question is answered in this month's Solar Workshop beginning on page 40. To reverse the motor remotely, I'd use a pair of DPDT relays installed at the antenna site and two momentary push-button switches inside the house. Unfortunately, the parts will cost about $25.00, which is half of what you paid for your dish, so here's a simpler circuit using a $3.00 Radio Shack switch (275-709 or 275-710).*

DOS Invasion Stopped

Q. How do you prevent someone from shelling out to DOS while in another program (for example, pressing CTRL-F1 in WordPerfect)? This could mean the destruction of my machine if I can't stop it (security reasons).

Garrison Tuerack
Glendale, NY

A. *You can't. However, I have two possible solutions that may curtail persons from messing with your PC via DOS. First, you can limit their access by using passwords that you find in Windows 95 (look under Start/Help/Index/Password). Encoding files or making them read-only is another method. Secondly, if this is such a threat to you, what I'd do is give this person his or her own computer terminal and link it to yours via LAN (local area network) or modem. That'll certainly stop him dead in his tracks.*

Solar Panels For Sale

Q. In reference to your October Q & A response "Solar Powered Sprinklers," please tell me where I can buy 40-watt solar panels for about $100.00.

C.H. Nelson
KA6ZWM

A. *Check out this month's Solar Workshop on page 40.*

Ohmmeters And Lies

Q. The power source for my "Olympus cold light supply" model ILK-5 has a bad power supply. The power supply looks very similar to that found in a PC as far as the layout goes, and I've even tried to use the repair tips put forth in your September 1996 article on repairing PC power supplies, but to no avail. I am not sure of the correct resistance values for the transformer windings, which I suspect is the culprit. Any suggestions will be helpful.

David Johnson
via Internet

A. *Well, your ohmmeter won't tell you whether the transformer is good or not because the resistance is so low that it can't indicate a shorted winding. Given the fact that transformers seldom go bad, I'd look elsewhere first — mostly at the semiconductors. If memory serves me right, cold-light power supplies use a high-kick boot to ignite the tube. It could be that your tube isn't getting the kick it's looking for, which is why there's no light. Again, zero in on the semiconductors; if in doubt, replace them, it's cheap enough. BTW, are you sure the lamp itself is good?*

DTMF Decoder

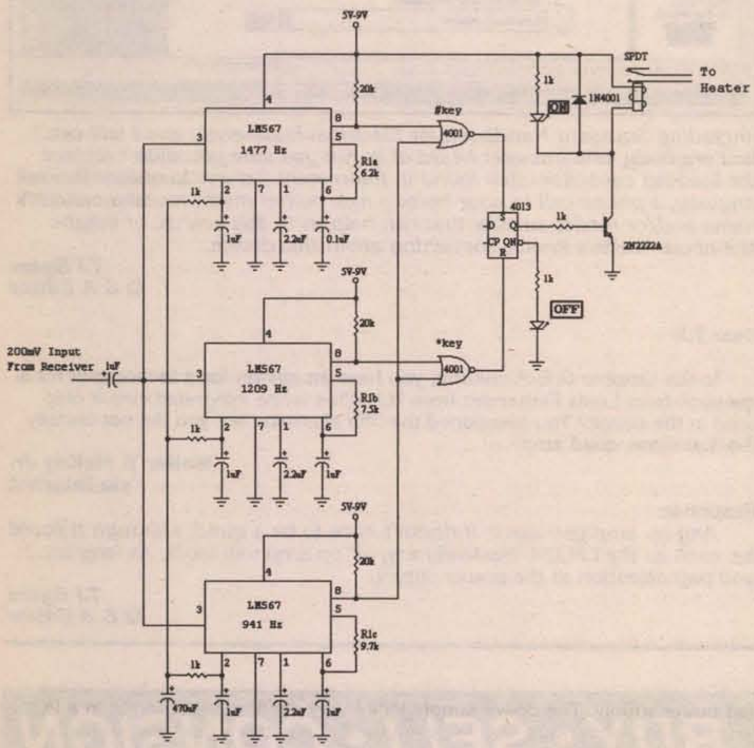
Q. I have a small airplane that has a engine heater pad attached to the oil pan which uses approximately 300 watts of power. I'd like to be able to remotely turn it on and off via my two-meter transceiver using a tone signal. I live only a few miles away and my base station has a strong signal at the hangar where the airplane is. What I'd like too, if possible, is to be able to tell the status of the heater (either on or off) from my home.

Tom Hale
Cotuit, MA

A. *Using a single tone to remotely trigger your heater isn't a good idea because your receiver is likely to run across that tone many times during the course of a day. A better solution is to use touch-tone telephone sounds, or DTMF. Basically, DTMF codes are two tones which, when combined, represent the numbers 0 through 9 plus a star and pound key, as shown in the table below.*

Frequency	Designation	R1	Character	DTMF Code
697 Hz	A	13K	1	A + E
770 Hz	B	11.8K	2	A + F
852 Hz	C	10.7K	3	A + G
941 Hz	D	9.7K	4	B + E
1209 Hz	E	7.5K	5	B + F
1336 Hz	F	6.8K	6	B + G
1477 Hz	G	6.2K	7	C + E
			8	C + F
			9	C + G
			0	D + F
			*	D + E
			#	D + G

What you do is send these codes from your house to the hangar by simply holding the transceiver's microphone to the earpiece of a telephone while you press the desired button. At the receiving end, you'll need a DTMF decoder, like the one shown below, connected to the audio output of your rig.



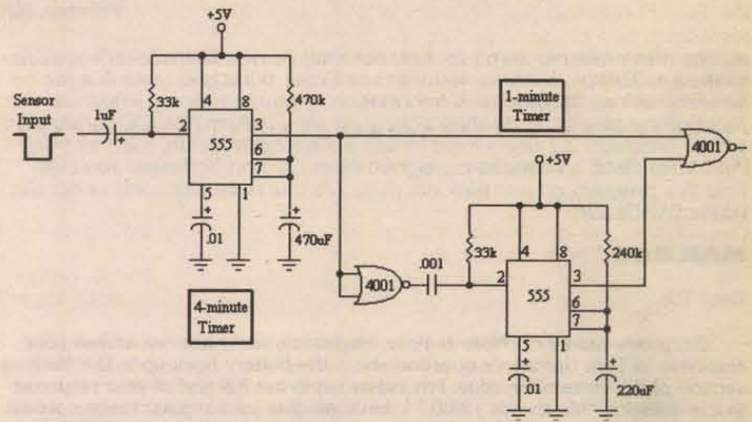
I've designed this circuit to respond to the pound and star keys of your phone pad. To turn the heater off, press star; to turn it on, press pound. If you'd rather use a different key combination, simply replace R1 with the values shown in the chart above. Because of variations in the 0.1 uF timing capacitor, though, you may need to trim the resistance a bit to get your receiver to respond properly (I suggest a potentiometer in series with a slightly lower value resistor). I couldn't come up with a simple solution for checking the status of the heater (one that doesn't involve keying the receiver's mike or dialing a phone), so I added a couple LEDs to the circuit so that you can see the status of the heater when you walk into the hangar (sigh). By the way, this design will work in other applications to activate or deactivate appliances and other items. In fact, you can have up to 12 separate commands by simply adding more LM567 decoders of the right frequency and the proper logic gates. This circuit alone can have three responses by adding another NOR gate to detect the number "0;" a fourth LM567 and three more NOR gates will net you six commands. Have fun flying!

Security Alarm Unarmed

Q. I would like to ask a question regarding a security circuit, specifically one that can turn on an alarm from a sensor input then turn off the alarm after a given time. The catch is that I want the alarm to turn off after about a minute, but I don't want it to trigger again for about four minutes – regardless of what the sensor does during this four-minute "cooling-off" period.

Paul Hazelman
Cherry Valley, CA

A. *One of these days, I really have to compile an article of the 555 designs I've put together over the years. Meanwhile, here's one that'll work for you.*



It uses two 555 chips: one with a four-minute time-out and the other with a one-minute time-out. When the sensor triggers the four-minute timer, its output starts the one-minute time. The 4001 NOR gate now goes low and sets off your alarm. After one minute, the one-minute timer times out, and its output goes low, which causes the alarm driver to go high. This is how the circuit will stay until the four-minute timer times out, after which the alarm can again respond to sensor stimulus.

Electronic Barometer

Q. Can you tell me if an electronic barometer kit or assembled unit exists which uses a pressure sensor chip and RS-232 output? I want to plug this into my Sun Sparc5 and program it to give a reading every 30 minutes.

Donald F. Parsons
via Internet

A. *Jeeze, I don't know where to begin to answer this question, because many, many vendors have products that fall into this category. If I read your question right, though, I think what you're looking for is a unit that detects and reports changes in weather conditions. If this is the case, I've located two promising candidates.*

AgriWeather, Inc.
800-584-9331
http://www.agriweather.com/NIMDIG.htm

Druck, Ltd.
England
http://www.druck.com/index.html

Too Hot To Handle 486DX4

Q. I have an intermittent problem with a dedicated MPEG audio playback system I'm trying to put together. The project involves a couple dozen systems built around a popular Taiwanese 486DX4-100 motherboard mounted inside a conventional enclosure, and nearly all systems exhibit the same problem – which is two fold. First, during play, the computer will sometimes quit playing and refuse to boot. If I reseat any of the cards or even lift the PC a couple inches and drop it, the unit boots and will continue to run for hours, days, or weeks before the problem occurs again. Second, on occasion, the audio drops out for a few seconds and then returns. This, too, happens on the same infrequent basis. The systems consist of just a dedicated MPEG decoder, 2 MB of RAM, CD-ROM, and a serial port; there's no keyboard, disk drive, or video display. I don't get it.

Boyd Collings
via Internet

A. *To begin with, the 486DX4 is a hot chip – literally. This sucker gets hot enough to fry an egg when it's going full blast, which I assume it must do from time to time as it wades through your MPEG files. Therefore, I think heat build-up is your problem. During times of stress, the chip will expand slightly, which could cause a misalignment of the pins in your ZIF socket. By turning the system off to tinker with the adapter cards or* *to drop the system on the table gives the geometry time to realign itself through cooling or shock (the drop). If the chip doesn't already have its own cooling fan, get one. Next, make sure there's an unrestricted flow of air across the chip at all time; e.g., no cables or cards blocking an air path. Finally, you might want to consider adding an extra cooling fan to your cabinet. They're cheap and easily installed.*

Viewing Application-Specific Files

Q. My son disappeared along with all his personal papers. I believe his records are still on computer disks. Is there any way to unlock the code to retrieve the information?

Phil Clock
Proctor, MN

A. *The files probably aren't locked, but may be in a format that's specific to the application, such as WinWord or Excel. What you need is a file viewer that can decipher this information. If you're running Windows 95, this is done simply by double-clicking on the file from Start/Programs/Explorer. Windows 3.1 users need to use a viewing program, such as Drag And View Gold, a shareware program from Canyon Software. You can find this program on our Web site (http://www.nutsvolts.com) under the name DVAOL.ZIP.*

MAILBAG

Dear TJ:

I'm a new reader of *Nuts & Volts Magazine*, and I just ran across your response to Tom Harrison's question about the battery back-up in the Mailbag section of the November issue. I'm interested in the full text of your response to the question "It's always 12:00." I don't imagine your regular readers would want to see reprints of old questions, so I'm wondering if you can E-Mail me the original response? If not, I'll understand.

Eric Bonnie
via Internet

Response:

At some point, (hopefully after the Holidays), we plan to have the Electronics Q & A column on our Web site (http://www.nutsvolts.com), but until then I suggest you buy a back issue for that month. Not only will you find the answer to your question, but a lot of other great features, too. The cost is $5.00 each prepaid and includes postage for delivery inside the US. (P.S.: Please don't tell any one that I sent you that file via E-Mail.)

TJ Byers
Q & A Editor

Dear Mr. Byers:

I wrote you last month asking if you knew the formula for fluorescent capacitor ballast values. Your reply was they won't work as a ballast. The reason I asked was because I bought a twin-lamp F40 shop light in 1985 that went very noisy after just a few months and, upon pulling it apart, I discovered that it had a paper/foil capacitor of the cheapest quality money can buy instead of a ballast transformer. After measuring its value with my digital capacitance meter, I replaced it with an exact value and everything worked fine. Unfortunately, I sold my house with the lamp still attached and I can't remember the value of the capacitor. I would appreciate it if you could research your data base on this subject.

Chris
Bieber, CA

Response:

Well, I did another search of my data bases and engineering manuals (including Standard Handbook for Electrical Engineers), and I still can't find anybody who has ever heard of it. Are you sure you didn't replace the lead-lag capacitor often found in fluorescent fixtures to reduce flicker? Anyway, a phone call to your home's new owner might reveal a vendor's name and/or model number that can help us in this search, or maybe one of our readers knows something about this device.

TJ Byers
Q & A Editor

Reader's Tip

Do you know what ATAPI means, or how it applies to your computer? If computer jargon confuses you, check out PC Webopaedia Lite from Sandy Bay Software at the address below. Here you'll find computer-related definitions from the excellent Random House Personal Computer Dictionary in Windows help file format, for free! The help file contains clear, concise, and up-to-date definitions of nearly 2,000 computer terms with 70 illustrations and 30 tables. What's more, the PC Webopaedia Web site is linked to thousands of other Web pages containing related information and up-to-the-minute additions.

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J. Golomb
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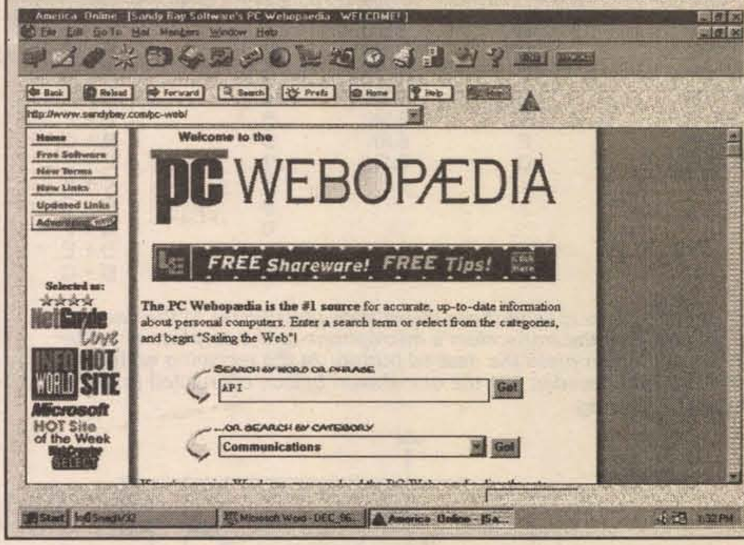

Dear TJ:

In the October Q & A column, you have an answer for a tachometer for a question from Louis Fernandez from NJ. What is the integrated circuit chip used in the circuit? You mentioned the 555 alternate, but you did not identify the, I assume, quad amp.

Walter T. McKay Jr.
via Internet

Response:

Any op amp you want. It doesn't have to be a quad, although it could be, such as the LM324. Basically any ol' op amp will work, as long as you pay attention to the power supply.

TJ Byers
Q & A Editor

TEST EQUIPMENT *cont.*

HP 400EL AC voltmeter $95. Also misc. PD & HP power supplies. Ed Matsuda 619-479-0225 E-Mail: ematsuda@themall.net

BATTERY ANALYZER with PC interface. DOS or Windows software $279. **LaMantia Products**, 1136 Aldersbrook Road, London, ON, N6G 2X8. 519-472-5566 Fax 519-472-1702.

MANUALS, HP, Tektronix, Fluke; over 1,500 in stock. Call or write with specific needs. Also used test equipment. Allen Fulmer, 2538 Sweetgum Way, West Clearwater, FL 34621. 813-796-3424.

WAVETEK 3001 generator, new cal. $550. Cushman CE 15 spectrum analyzer, new CRT $1,000. 414-769-3227.

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Last month, we discussed many of the specifications used to describe oscilloscope performance. Analog bandwidth and probe considerations were explored in conjunction with determining how much scope is enough. This month, we continue with a discussion on digital storage scopes and information on a few specialty scopes.

How Much Scope is Enough? Part 2

by Jeffrey Mazur

SELECTING A DIGITAL STORAGE SCOPE

Specifications

A DSO processes signals in two stages: acquisition and display. The acquisition stage samples and digitizes the signal for storage into memory. The display stage then creates a viewable image on the CRT based on these samples. Additional processing may also be done, e.g., to interpolate or peak detect amongst the data samples.

When analyzing the bandwidth specifications of DSOs, there are actually two distinct parameters to consider. First, is the absolute bandwidth of the input circuits. Just as with an analog scope, this specification determines the highest frequency that can be measured with reasonably low distortion.

Secondly, the sample rate (how many times the signal is sampled per second) also sets an upper frequency limit to signals which can be accurately displayed by the DSO. This sometimes leads to confusion, especially when you consider that DSOs operate in one of two fundamental modes of waveform acquisition: real-time and equivalent-time sampling.

Real-Time Sampling

To create a waveform accurately, DSOs must gather a sufficient number of samples. In theory, a digital scope needs at least two samples per period to faithfully reproduce a sinewave; otherwise the acquired waveform will be a distorted representation of the input signal. The Nyquist theory further states that sampling at less than this rate will create false signals, or aliases (see Figure 1). In practice, most DSOs need at least 2.5 samples per period and, ideally for more accurate display, signals should be over-sampled at a rate of at least five times the highest input frequency (the five times rule again).

Thus, the sampling rate usually limits the highest frequency which a digital scope can acquire in real-time. Because of this limitation in real-time acquisition, most DSOs specify two bandwidths: analog and real-time. The analog bandwidth — defined by the circuits composing the input path of the scope — determines the highest frequency signal a DSO can accept without adding distortion. The second bandwidth, called the real-time bandwidth, defines the maximum frequency the DSO can acquire by sampling the entire input waveform in one pass — using a single trigger — and still gather enough samples to reconstruct the waveform accurately. The following equation describes the maximum real-time bandwidth:

Real-Time Bandwidth = Sample rate / 2.5

For some DSOs, the real-time bandwidth can theoretically exceed the analog bandwidth. But since the input path distorts any signal above its frequency limit, the real-time bandwidth can only be equal to or less than the analog bandwidth.

Both sample rate and bandwidth can affect a scope's ability to catch short transitions or "glitches" in an otherwise stable waveform. For example, Figure 2 shows how a glitch might be missed when it occurs between samples; unless it just happens to fall during a sample time, it will go completely unnoticed. Increasing the sample rate would be the only reasonable approach to avoid this.

Figure 3 shows some real-life examples of how an oscilloscope with inadequate bandwidth and sample rate can hide information. In this figure, a 50 MHz signal is viewed with three different bandwidth and sampling rates. Example 1 of Figure 3 clearly shows a glitch. It has a risetime of approximately 500 pS and was acquired with 1 GHz bandwidth at a 5 GS/s (Samples per second) sampling rate. In Example 2, the bandwidth is still 1 GHz, but the sampling rate has been reduced to 1 GS/s. Example 3 shows the waveform captured with 250 MHz bandwidth and a sampling rate of 1 GS/s. Note that in both Examples 2 and 3, the glitch is concealed from the user.

Equivalent-Time Sampling

When a DSO uses equivalent-time sampling, it can acquire any signal up to the analog bandwidth of the scope regardless of the sample rate. In this mode, the scope gathers the necessary number of samples across several triggers. The input signal therefore must be repetitive to generate the multiple triggers needed for equivalent-time sampling. In equivalent-time, a slower, lower-cost digitizer provides the same accuracy on repetitive waveforms as a higher cost DSO would do with a faster sampler.

In order to achieve a more accurate waveform, most DSOs use a technique called random equivalent-time sampling. Although the samples are acquired sequentially after each trigger, each acquisition starts at a slightly different time with respect to the trigger. Figure 4 depicts how random equivalent-time sampling compares to real-time sampling.

Interpolation Modes

After gathering samples of the input signal, the display section then uses these points to create a waveform on the oscilloscope screen. In the Dot Mode, a scope will display the sample points directly, with no interpolation (i.e., without attempting to fill in missing points between them). This is sometimes useful — it presents the sampled data in its raw form — but most often, some form of interpolation will be used to create a more readable display. When a scope interpolates, it draws lines between the samples on the display, creating a continuous waveform instead of a string of individual dots.

Creating the missing points requires some compromise. As shown in Figure 5 (bottom), one approach would be to simply draw a line between each sample point. This is known as linear interpolation; waveforms reconstructed in this fashion have a jagged, angular look to them. This method works well with pulses and digital signals, but may produce distortions on sinewaves.

Sine interpolation, as shown in Figure 5 (top), connects the samples using a curve fit. Ideal for sinusoidal signals, this approach can produce apparent overshoot or undershoot when displaying pulses. Most DSOs offer a modified sine interpolation that reduces the inaccuracies when displaying pulses. This sin(x)/x method uses an adaptive prefilter to locate and compensate for fast signal transitions. Although this method requires more calculations than linear or sine interpolation, the result is a much smoother, yet more accurate display.

However, there is no substitute for having enough samples to recreate a waveform accurately. Figure 6 shows how linear and sin(x)/x interpolation affects the display of sine, triangular, and

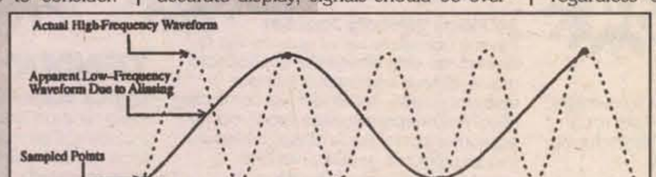


Figure 1. Aliasing caused by sampling at too low of a rate.

Figure 2. A momentary glitch between sample points can be missed on a DSO.

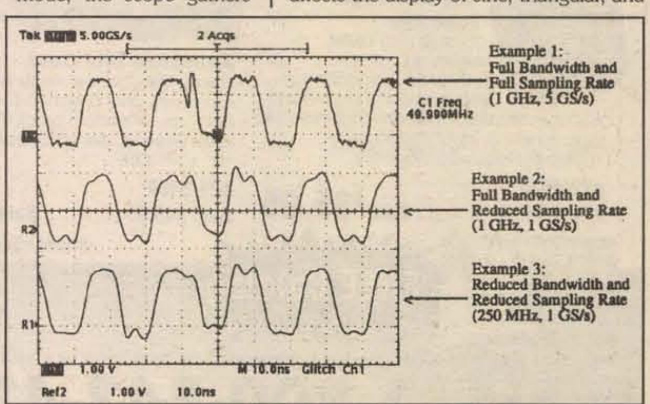


Figure 3. Three examples of how an oscilloscope with inadequate bandwidth and sample rate can hide information.

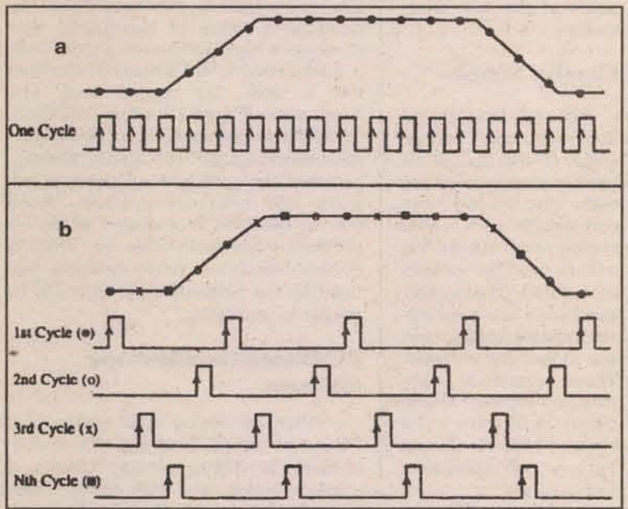


Figure 4. Real-time sampling, a) captures all samples in one pass; equivalent-time sampling, b) requires several cycles.

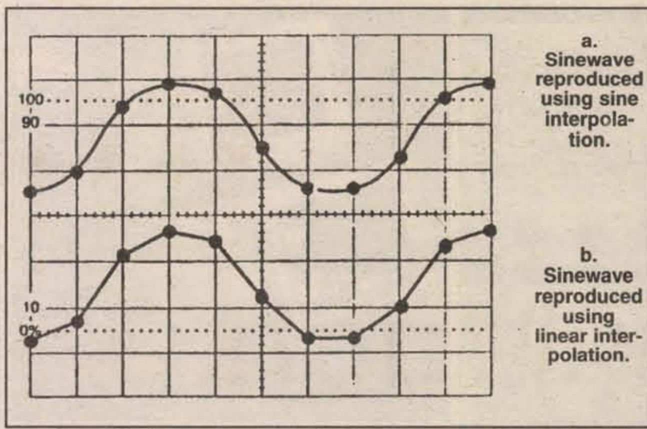


Figure 5. Effects of a) sine and, b) linear interpolation on a sinewave.

squarewaves which have been sampled at just the minimum rate (1.25 times the Nyquist rate, or 2.5 samples per cycle). Figure 7 shows the same results when sampled at twice that rate.

Two conclusions can be drawn from these waveforms. First, if there are not enough points to accurately recreate the waveform, the interpolation method will fill in all of the points between samples and probably give a distorted and inaccurate view of the true signal.

Secondly, even when the triangle and squarewaves are sampled at five times their fundamental frequency, they still do not look very much like triangle or squarewaves. This is because these signals contain higher order harmonics which are necessary to reconstruct the waveform accurately.

Although these harmonics theoretically go on forever, their amplitude rapidly decreases. It is usually sufficient to include up to the fifth harmonic for a reasonable display of a squarewave. Therefore, a good rule of thumb is to use a sample rate which is at least — you guessed it — five times higher than the equivalent frequency sinewave. If we use our previous rule of sampling at five times the input frequency, this means that the sample rate must be at least 25 times the fundamental frequency of the squarewave.

Other Acquisition Modes

Many scopes offer other acquisition modes which allow more accurate representations of the sampled signal. For example, by adding a peak detector, the scope can retain the minimum and maximum levels of the input signal for a given sample period. This greatly enhances the scope's ability to catch glitches.

An averaging mode is useful for displaying noisy signals. The scope will display a waveform that is the result of several acquisitions averaged over time. Of course, the signal must be repeating and stable for this mode to be effective. Beware, however. Although this method can reduce noise in the vertical channel, it can add "noise" in the horizontal channel in the form of jitter. This is caused by the fact that the sample clock runs asynchronously to the trigger event and, therefore, the waveform horizontal position has an ambiguity of plus or minus 1/2 clock period.

Memory Depth

One of the greatest features of a DSO is the ability to show the waveform before the trigger point. Since the scope is continuously sampling the signal waiting for a trigger event, it has a history of the signal already in memory when that event occurs. Thus, it can immediately display the waveform leading up to the trigger instead of recording in and displaying those samples taken after the trigger.

Most DSOs allow the trigger point to be displayed either toward the start, in the center, or toward the end of the captured display. Larger memory will allow more of the waveform to be captured giving you a longer look at the signal. Alternatively, you could use the larger memory to sample at a faster rate, giving a more detailed (i.e., higher resolution) picture of the waveform.

When comparing memory depth, however, always check whether the listed amount is per channel or combined total. For example, a scope claiming a 32K record length may assume that only one channel is operating. For a dual channel display, the memory would only store 16K samples per channel.

SPECIALIZED SCOPES

We have seen that analog scopes are sometimes best for catching elusive glitches and metastability which often do not appear on a DSO. On the other hand, signals which do not occur at a reasonable rate will also not leave much of a trace on an analog scope. For catching these types of signals, you need a specialized scope such as the Tektronix 2467B BrightEye™, or the TDS 700A TruCapture™ DSO.

The Microchannel Plate

The Tektronix 2467B scope uses a special Microchannel plate (MCP) CRT to enhance the display of high-speed, low-repetition rate signals. Basically, the MCP amplifies the intensity of the electron beam to yield a brighter display on the face of the CRT. The results are quite impressive as shown by the comparison to a conventional scope in Figure 8.

InstaVu

The Tektronix TDS 700 series (Figure 9) are DSOs that solve this problem with a different approach. Figure 10 shows why a conventional DSO will miss many low-repetition rate signals.

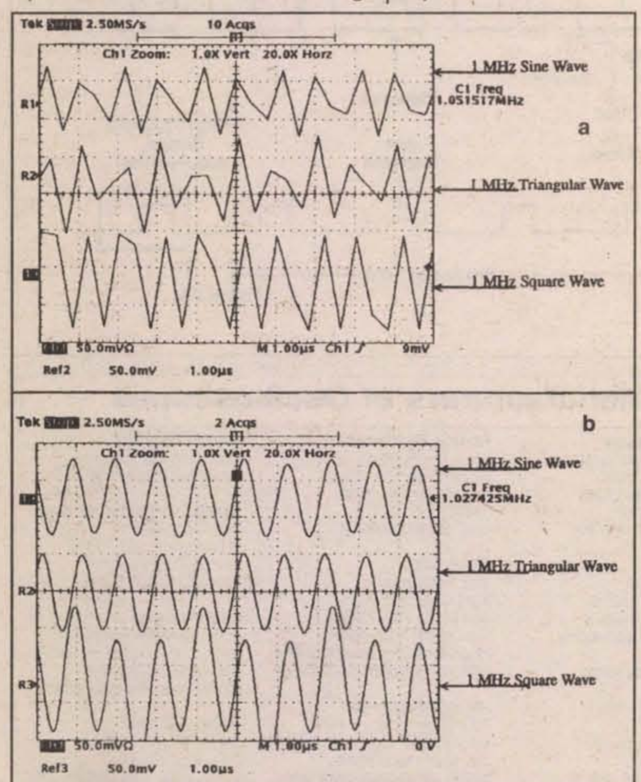


Figure 6. In a) a 1 MHz signal is captured at 1.25 times the Nyquist rate (2.5 MS/s) using linear interpolation; in b), the same signals using sin(x)/x interpolation.

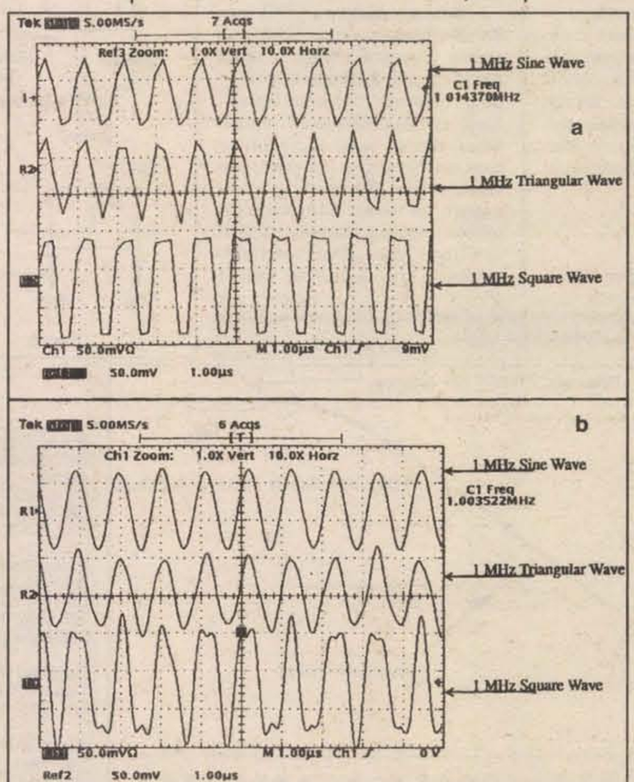


Figure 7. In a) a 1 MHz signal is captured at 2.5 times the Nyquist rate (5 MS/s) using linear interpolation; in b), the same signals using sin(x)/x interpolation.

How Much Scope is Enough?

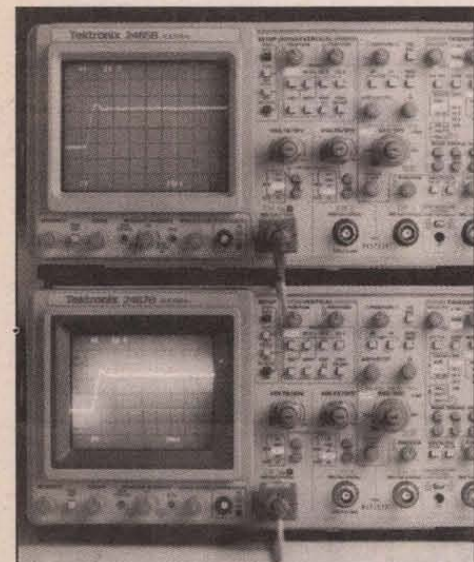


Figure 8. In this comparison of a conventional 2465 analog scope to the 2467B with MCP, the infrequent, erroneous pulse is totally invisible to the 2465. The 2467B, however, intensifies this weak trace to make it visible. Note the INTENSITY settings of the two scopes (in the lower left corner) — all the way up on the 2465, but only half-way on the 2467B.

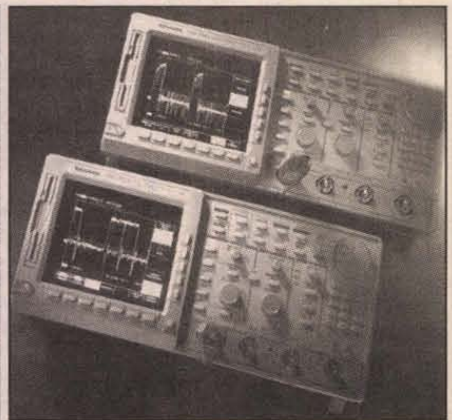


Figure 9. Tektronix TDS 700 series of DSOs with InstaVu.

Because the DSO spends much of its time processing the acquired samples, it is not available to begin sampling again for a relatively long period of time. If the event of interest occurs during these processing times, it will be missed by the DSO.

The TDS 700 addresses this problem with a new mode called InstaVu™. By creating a tighter integration between the acquisition and display sections — and multiplexing four independent channels — up to 400,000 waveforms per second can be captured. This almost equals the capture rate for an analog scope (see Figure 11). Unfortunately, this much power does have its price — literally; the InstaVu family of scopes start at $10,000.00.

TruTrace

A new feature found on the Classic 6000 DSO from Gould Instrument Systems, is the ability to emulate the Z-axis, or intensity modulation, inherent in analog scopes. Called TruTrace, this feature helps distinguish infrequently occurring events from normal waveforms and also can reveal details in long waveform records that a DSO's min/max or peak detection mode throws away. For example, consider a false pulse that occurs only one percent of the time. On an analog scope, this pulse would show up as a faint trace against the brighter waveform of the normal signal. This intensity difference provides information about the signal which is often lost on a DSO.

When a standard DSO uses its min/max mode to display all values recorded within a given sample point, it creates a band of dots between these extremes. Each dot is illuminated equally which throws away any information on how often a particular value occurs. By creating a histogram of when the signal is within certain discrete ranges, TruTrace can then intensity-modulate the display to restore much of this lost information.

Combo Scopes

Although InstaVu and TruTrace can restore some of the feel of an analog scope, there are those who still feel more comfortable with a true analog scope but once in a while need the features of a DSO. Fortunately, there are a few combination analog/digital storage scopes still available. These essentially combine two separate instruments into one. The Fluke PM3394 (Figure 12) is a good example of such a scope.

On the digital side, the PM3394 offers 200 MS/s — which allows up to 25 GS/s in equivalent-time sampling — and 8K (standard) or 32K (optional) of acquisition memory. The touch of a button however transforms the PM3394 into a full-featured 200 MHz analog scope.

Handheld Oscilloscopes

When performing field service, especially in hostile environments, a DSO would usually be considered a luxury. Fortunately, however, Fluke has designed a series of instruments that combine a high-performance DSO with a full-featured DMM (Digital Multimeter) into a sleek, but rugged case. The Scopemeter (Figure 13) offers dual-trace, 100 MHz performance at 5 GS/s (equivalent-time) and 30K of memory. Battery-powered and packaged in a shock-proof, water, and dust-proof enclosure, allows you to take the Scopemeter where no ordinary scope would dare go. There is even an interface to send waveforms captured by the Scopemeter to your PC or printer for archiving.

PC-Based Oscilloscope Systems

After the analog input stages of a DSO (i.e., sample/hold and D-to-A conversion), lie digital memory circuits, a microprocessor, and the display hardware. Realizing that these latter functions are all found in every common personal computer, several manufacturers have designed PC-based DSO systems. These consist of some software and a plug-in card, or similar device, which contains all of the analog circuitry. By using the PC's memory, CPU, and monitor display, it is possible to build a decent DSO for very little cost.

For example, the O-Scope I from Allison Technology Corp. turns your PC into a DSO for as little as $129.00 (in kit form). The O-Scope Ie (Figure 14) adds

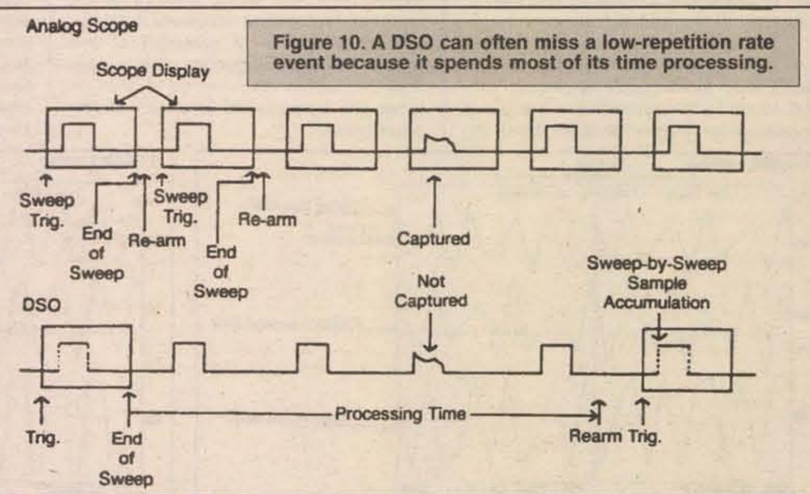
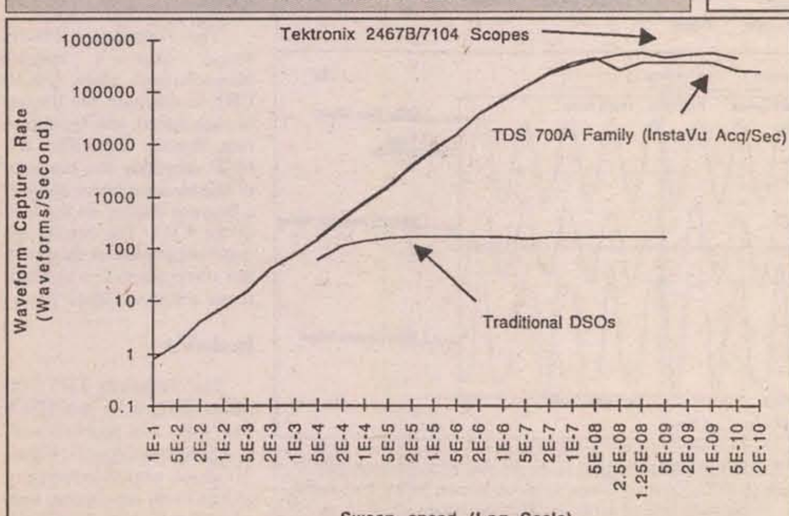


Figure 10. A DSO can often miss a low-repetition rate event because it spends most of its time processing.

Figure 11. Comparison of the capture rate of the TDS 700A vs. analog and conventional DSOs.



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How Much Scope is Enough?

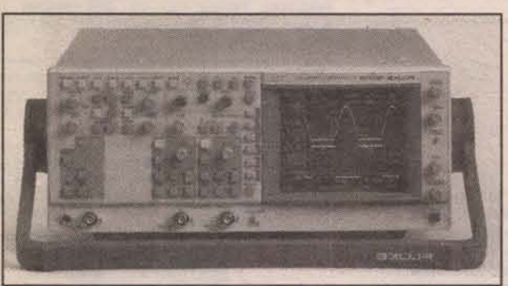


Figure 12. Push a button on the Fluke PM3394 combination DSO and it becomes a true analog scope.

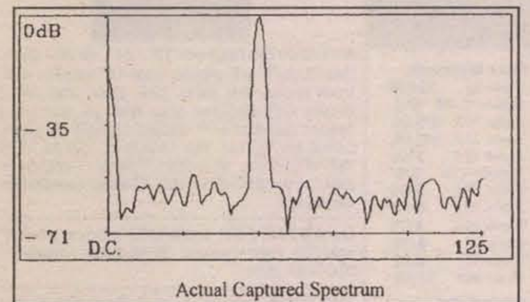


Figure 15. Spectrum display from the O-Scope.

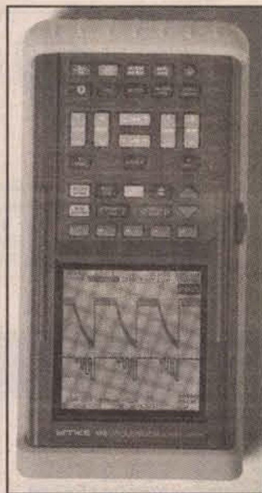


Figure 13. Fluke 99B Scopemeter handheld DSO.

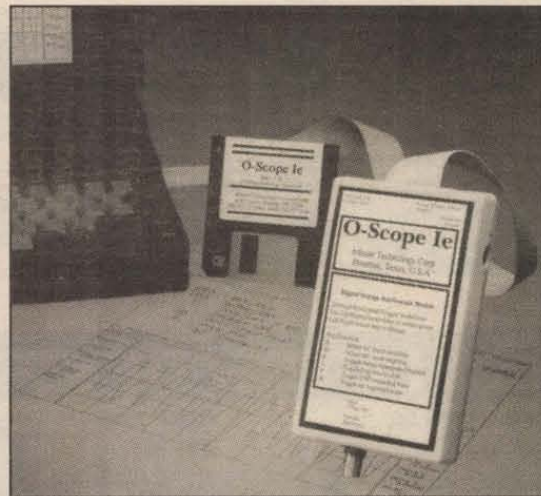


Figure 14. The O-Scope turns your PC into a low-end DSO.

The author wishes to thank Tektronix, Inc. (especially Heather Wyse) for their help in preparing this article. Many of the photos and drawings used are Copyright Tektronix, Inc. "All rights reserved" and were reproduced with permission.

external trigger capability, and the top-of-the-line O-Scope II offers dual input with X-Y capability for only $349.00. By using the computational power of the PC, all of these models can also generate a spectrum display of the sampled signal (see Figure 15).

So what's the catch? At these prices it almost sounds too good to be true. And it is. When you look closer at the specs on these units you find that the bandwidth is only 22 KHz (250 KHz for the O-Scope II). This all but relegates these devices for analyzing audio or other low-frequency signals. It also makes them ideal for long-time data logging where the time between samples may be measured in seconds or even minutes.

Of course, there are more expensive PC-based solutions, some of which have bandwidths up to 400 MHz. As the cost approaches that of a dedicated DSO, however, you then need to consider whether any advanced features are worth giving up portability and/or tying up your PC.

CONCLUSION

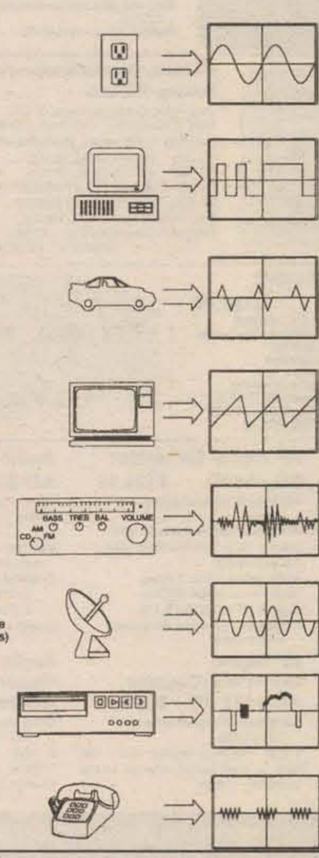
Choosing the right scope is not difficult if you know what to look for. Read the specifications carefully, especially when comparing one brand of scope to another.

Start with your application and the types of signals you are likely to encounter. Figure 16 shows some common scope applications and the typical frequencies involved. Use this only as a general guideline — the actual signals may be much higher. Whenever you need to see the fine details of a signal, such as high-frequency noise or signal spikes, be sure to allow adequate bandwidth. Analyzing noise spikes on even a lowly 60 Hz power line may require a 100 MHz scope!

In general, engineering and design applications will require a higher quality scope. For circuit design and performance evaluation, high speed, fast risetime, and accurate amplitude measurements are necessary. Consider using an oscilloscope with at least 200-300 MHz bandwidth for these jobs.

Typical service or repair applications are less demanding. The absolute accuracy of a waveform may not be as critical; just knowing that the signal is present and that it has the approximate waveshape as expected may be enough. Relative observations, such as comparing a device under test against a known working unit, do not require the extreme accuracy of a high-end scope. A general-purpose scope with 100 MHz bandwidth should prove adequate.

Of course, when working on very high-frequency RF circuits (VHF up to microwave), you will need the highest bandwidth available. Many scopes are designed for just this purpose. These scopes are capable of analyzing signals well into the 10-50 GHz range. **NV**



	Typical Highest Frequency	Bandwidth Required	Need Storage?
AC Line	50-60 Hz	1 KHz	No
Computer	50-150 MHz	100-500 MHz	Yes
Auto	0-5 MHz	25 MHz	No
TV	5 MHz	25 MHz	Desirable
Stereo	20 KHz	1 MHz	No
Satellite (Microwave Applications)	1-10 GHz	1-10 GHz	No
VCR	5 MHz	25 MHz	Desirable
Phone	5 KHz	1 MHz	Desirable

Figure 16. Sources of common waveforms and the oscilloscope requirements to view them.

PC-BASED DSOs

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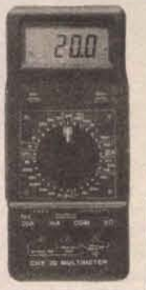

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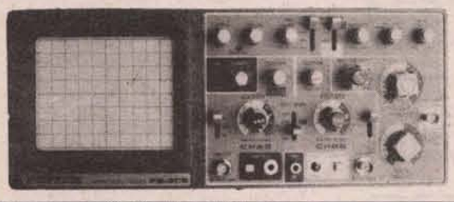

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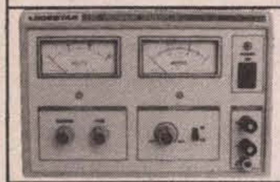

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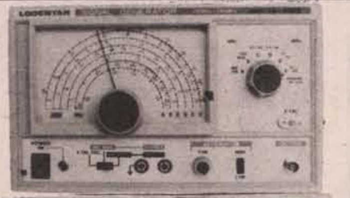

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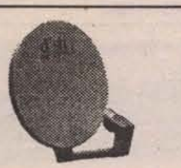

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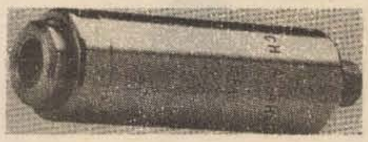

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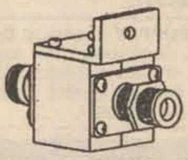

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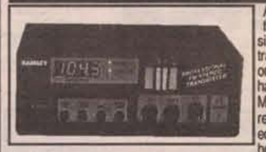

A truly professional frequency synthesized FM Stereo transmitter station in one easy to use, handsome cabinet. Most radio stations require a whole equipment rack to hold all the features we've packed into the FM-100. Set frequency easily with the Up/Down freq buttons and the big LED digital display. Plus there's input low pass filtering that gives great sound no matter what the source (no more squeals or swishing sounds from cheap CD player inputs!) Peak limiters for maximum 'punch' in your audio - without over modulation, LED bargraph meters for easy setting of audio levels and a built-in mixer with mike and line level inputs. Churches, drive-ins, schools and colleges find the FM-100 to be the answer to their transmitting needs, you will too. No one offers all these features at this price! Kit includes sharp looking metal cabinet, whip antenna and 120 volt AC adapter. Also runs on 12 volts DC.

We also offer a high power export version of the FM-100 that's fully assembled with one watt of RF power, for miles of program coverage. The export version can only be shipped outside the USA, or within the US if accompanied by a signed statement that the unit will be exported.

FM-100, Professional FM Stereo Transmitter Kit.......$299.95
FM-100WT, Fully Wired High Power FM-100..........$429.95

Speech Descrambler Scrambler

Decode all that gibberish! This is the popular descrambler / scrambler that you've read about in all the Scanner and Electronic magazines. The technology used is known as speech inversion which is compatible with most cordless phones and many police department systems, hook it up to scanner speaker terminals and you're in business. Easily configured for any use: mike, line level and speaker output/inputs are provided. Also communicate in total privacy over telephone or radio, full duplex operation - scramble and unscramble at the same time. Easy to build, all complex circuitry contained in new custom ASIC chip for clear, clean audio. Runs on 9 to 15VDC, RCA phono type jacks. Our matching case set adds a super nice professional look to your kit.

SS-70A, Speech Descrambler/Scrambler Kit...........$39.95
CSS, Custom Matching Case and Knob Set...........$14.95
SS-70AWT, Fully Wired SS-70A with Case.............$79.95
AC12-5, 12 Volt DC Wall Plug Adapter.................$9.95

Tone-Grabber Touch Tone Decoder / Reader

Dialed phone numbers, repeater codes, control codes, anywhere touch-tones are used, your TG-1 will decode and store any number it hears. A simple hook-up to any radio speaker or phone line is all that is required, and since the TG-1 uses a central office quality decoder and microprocessor, it will decode digits at virtually any speed! A 256 digit non-volatile memory stores numbers for 100 years - even with the power turned off, and an 8 digit LED display allows you to scroll through anywhere in memory. To make it easy to pick out numbers and codes, a dash is inserted between any group or set of numbers that were decoded more than 2 seconds apart. The TG-1 runs from any 7 to 15 volt DC power source and is both voltage regulated and crystal controlled for the ultimate in stability. For stand-alone use add our matching case set for a clean, professionally finished project. We have a TG-1 connected up here at the Ramsey factory on the FM radio. It's fun to see the phone numbers that are dialed on the morning radio show! Although the TG-1 requires less than an evening to assemble (and is fun to build, too!), we offer the TG-1 fully wired and tested in matching case for a special price.

TG-1, Tone Grabber Kit.............................$99.95
CTG, Matching Case Set for TG-1 Kit................$14.95
TG-1WT, Fully Wired Tone Grabber with Case.........$149.95
AC12-5, 12 Volt DC Wall Plug Adapter................$9.95

Mini-Peeper Micro Video Camera

Super small, high quality fully assembled B & W CCD TV camera the size of an ice cube! Provides excellent pictures in low light (2 lux), or use our IR-1 Infra-Red light source to invisibly illuminate an entire room on a pitch black night! Imagine the possibilities... build it into a smoke detector, wall clock, lamp, book, radio. Exact same camera that's in big buck detective catalogues and stores. Kit includes: fully assembled CCD camera module, connectors, interface PC board kit with proper voltage regulation and filtering, hook-up details, even a mini microphone for sensitive sound! Two models available: Wide Angle Lens 3.6mm/f2, adjustable focus lens, 92 degree view; Pinhole Lens 5.5mm/f4.5, 60 degree view. The Pinhole Lens is physically much flatter and provides even greater depth of focus. The camera itself is 1.2" square. The Wide Angle Lens is about 1" long, Pinhole Lens about 1/2", interface PC board is 1" x 2" and uses RCA jacks for easy hook-up to VCRs, TVs or cable runs. Power required is 9 to 14 VDC @ 150 mA. Resolution: 380 x 350 lines. Instruction manual contains ideas on mounting and disguising the Mini-Peeper along with info on adding one of our TV Transmitter kits (such as the MTV-7 unit below) for wireless transmission!

MP-1, Wide Angle Lens CCD TV Camera Outfit........$169.95
MP-1PH, Pin-Hole Lens CCD TV Camera Outfit........$189.95

MicroStation Synthesized UHF TV Transmitter

Now you can be in the same league as James Bond. This transmitter is so small that it can fit into a pack of cigarettes - even including a CCD TV camera and battery! Model airplane enthusiasts put the MTV-7A into airplanes for a dynamite view from the cockpit, and the MTV-7A is the transmitter of choice for balloon launches. Transmitter features synthesized, crystal controlled operation for drift-free transmission of both audio and video on your choice of frequencies: Standard UHF TV Channel 52 (which should only be used outside of the USA to avoid violating FCC rules), and 439.25 MHz or 911.25 MHz which are in the amateur ham bands. The 439.25 MHz unit has the nifty advantage of being able to be received on a regular 'cable-ready' TV set tuned to Cable channel 68, or use our ATV-74 converter and receive it on regular TV channel 3. The 911.25 MHz unit is suited for applications where reception on a regular TV is not desired, an ATV-79 must be used for operation. The MTV-7A's output power is almost 100 mW, so transmitting range is pretty much 'line-of-sight' which can mean many miles! The MTV-7A accepts standard black and white or color video and has its own, on-board, sensitive electret microphone. The MTV-7A is available in kit form or fully wired and tested. Since the latest in SMT (Surface Mount Technology) is used to provide for the smallest possible size, the kit version is recommended for experienced builders only. Runs on 12 VDC @ 150 mA and includes a regulated power source for a CCD camera.

MTV-7A, UHF TV Channel 52 Transmitter Kit..........$159.95
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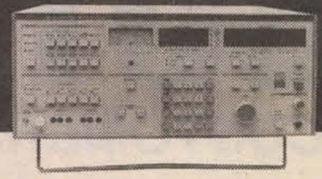

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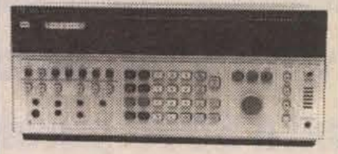

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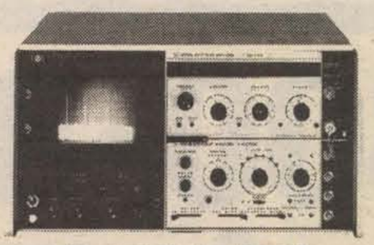

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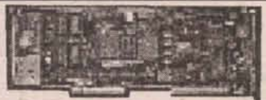

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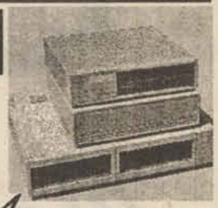

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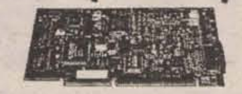

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Write In 48 on Reader Service Card.

RS-232 DIGITAL INPUT/OUTPUT

BY TERRY J. WEEDER

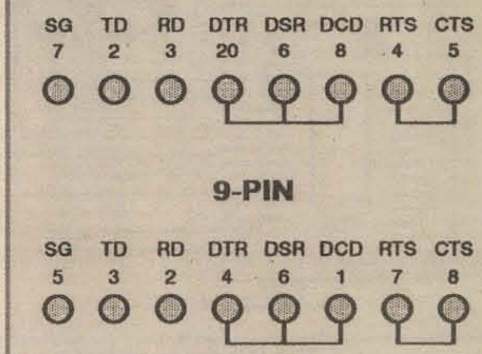
The potential to write/create computer programs to incorporate into your own custom applications is an asset which every computer owner has, though most seem to overlook it or just plain take this for granted. Sure, all the bells and whistles, and fancy graphics accompanying the herd of software packages which come with your computer keep you entertained at first, however, you still have not truly discovered the capability of this desktop tool until you've jumped in and started building your own programs.

If you've never tried it before and don't know where to start, check out that easy-to-learn programming language called QBASIC which can be found in your DOS directory. Of course, in order to fully appreciate the power at hand, being able to link these programs with external switches and relays is a must, and can now be accomplished using your serial port and an I/O module costing as little as $32.00.

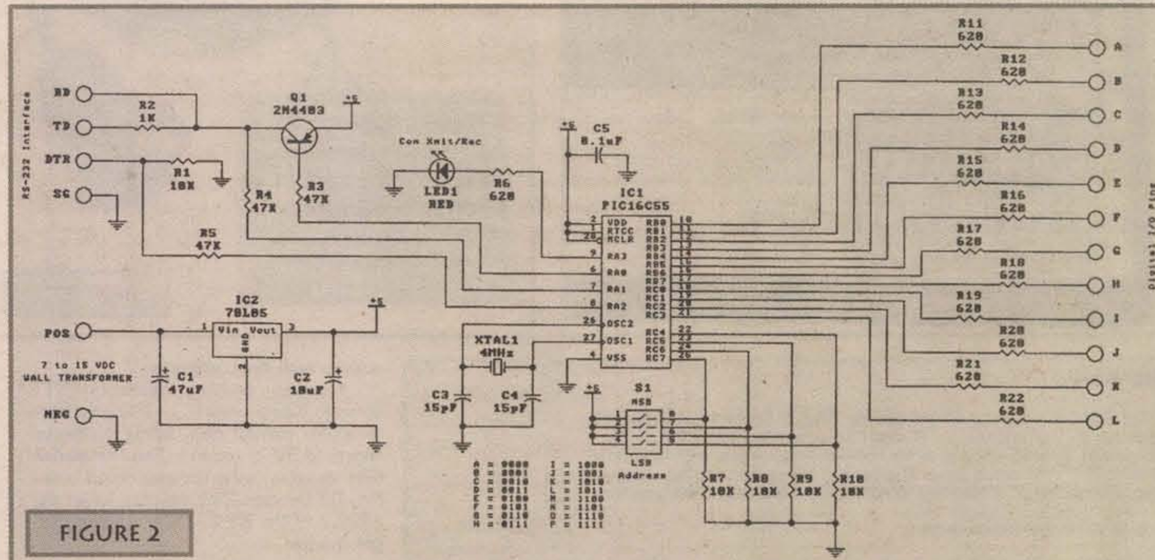
The RS-232 digital input/output module as described in this text connects directly to the serial port of a PC and enables your home-brewed computer program to interact with its outside environment. Twelve I/O pins are available and can be individually configured for input or output. The module is addressable using a DIP switch setting on the board, and is specifically designed to share the same RS-232 port with other units. Up to 16 units may be stacked in parallel on the same com port allowing a total of 192 I/O points.

Using an I/O pin for an input allows your program to sense button presses, change of state of switches, alarm trips, etc. Setting a pin for an output will let your program turn on/off electrical devices with the aid of a relay, triac, or switching transistor. In addition, there are a few special commands which use 8 of the 12 I/O pins as a group. A 4x4 matrix keypad can be decoded allowing 16 buttons to be monitored using only eight I/O pins. These keypads come in handy to use, for instance, on a security access panel activating an electro-mechanical lock, or a control panel for your computer-based alarm system. You can also read or write an eight-bit word directly to these eight I/O pins.

The set of commands which can be issued from your program via the com port to configure and control the I/O module is shown in Listing 1. These include:



Pin diagram for both a 9 and 25 pin RS-232 connector. Wire the "RD," "TD," "DTR," and "SG" pads on the I/O board to the corresponding pins of your connector. Include the jumpers as shown.



Schematic diagram of the I/O module. The microcontroller (IC1) is manipulated by the PC via the serial port — acting on specified I/O pins, and reporting any action sensed by an I/O pin.

HIGH/LOW — Sets a specified I/O pin to a desired state.

TOGGLE — Changes a specified I/O pin to the opposite state.

BUTTON — Configures a specified I/O pin to sense a button press using automatic debounce and repeat if the button is held down.

SWITCH — Configures a specified I/O pin to sense a switch transition using automatic debounce.

MATRIX — Configures the first eight I/O pins to be used to decode a 4x4 matrix keypad using automatic debounce and repeat.

READ — Reads the state of a specified I/O pin, or reads the first eight I/O pins as an eight-bit port.

WRITE — Writes data to the first eight I/O pins as an eight-bit port. Data can be in the format of hex, binary, or an ASCII character.

LISTING 1

COMMAND SET

TITLE	COMMAND	DESCRIPTION
HIGH	H pin	Make pin an output and set it high (pin = A-L).
LOW	L pin	Make pin an output and set it low (pin = A-L).
TOGGLE	T pin	Make pin an output and toggle state (pin = A-L).
BUTTON	B pin	Make pin an input and respond to button press. Returns "pinL" when pressed (pin = A-L).
SWITCH	S pin	Make pin an input and respond to switch transition. Returns "pinL" or "pinH" when toggled (pin = A-L).
MATRIX	M	Make pins A-D an output, pins E-H an input, and decodes 4x4 matrix keypad presses. Returns "Mrow,col" (row = A-D, col = E-H).
READ	R pin	If pin = A-L, make pin an input and read state. Returns "pinH" or "pinL." If pin = P, make pins A-H an input and read pins as eight-bit port.
WRITE	Wfd	Make pins A-H an output and writes data(d) to pins as eight-bit port; format(f) can be "h" for hex, "b" for binary, or "$" for ASCII character.

Note, all commands must be preceeded by the WTDIO header character D, and address character A-P. All responses from the WTDIO will also contain this preface.

Have your QBASIC program send these commands out the comport to control the I/O module.

Circuit Theory

Refer to the schematic diagram shown in Figure 2. The heart of the circuit is IC1 (part no. PIC16C55-XT/P), an EPROM-based eight-bit CMOS microcontroller manufactured by Microchip. This microcontroller has two eight-bit I/O ports, one four-bit I/O port, and an internal EPROM memory which holds the program used for encoding/decoding the data sent to and from the computer, reading and writing to the I/O pins, and reading the DIP switch setting (S1) which sets the board address. Crystal (XTAL1) sets the clock frequency. A detailed description of IC1's firmware is explained later.

The voltage levels used for serial communications on an RS-232 port are +3V to +25V for a logic 0, and -3V to -25V for a logic 1. Most RS-232 devices use +12V and -12V, respectively. Bit 0 of port-A is used to send data to the serial port. A logic 1 is generated by placing bit 0 at a high level which turns off Q1, thus allowing the -12V from the TD (Transmit Data) pin to be applied to the RD (Receive Data) pin through R2.

Bit 0 is sent low to produce a logic 0 which turns on Q1, pulling the RD pin to +5V. Because the TD pin of an RS-

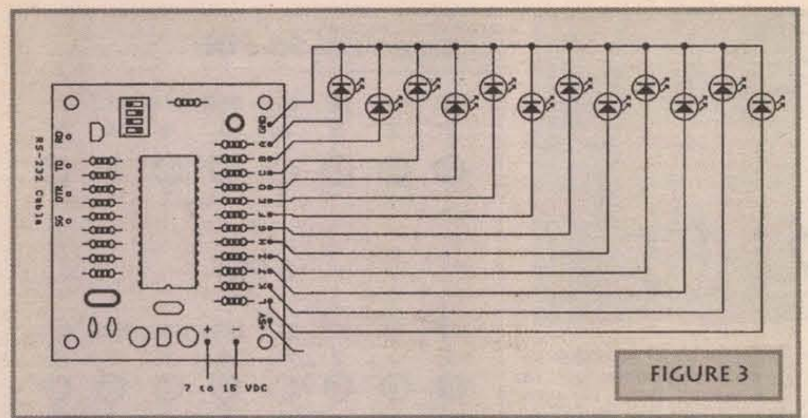


FIGURE 3

Use this set-up to test out your circuit.

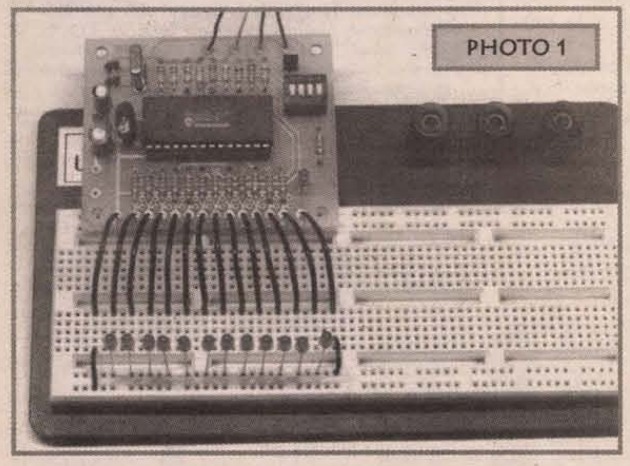


PHOTO 1

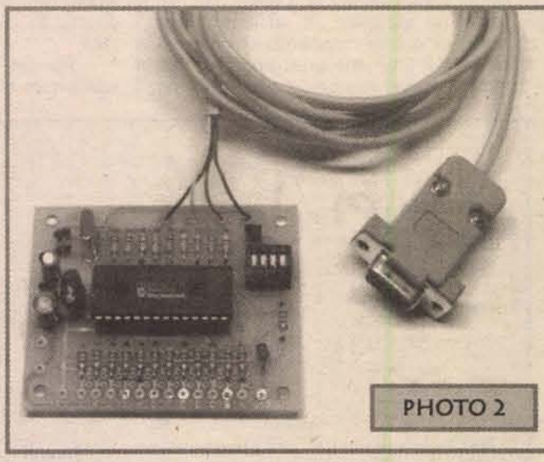


PHOTO 2

LISTING 2

```
'This QBASIC program will test out the RS-232 Digital Input/Output kit.
'Set the WTDIO address to "A". Start the program then hit "C" on the
'keyboard. Type in any one of the valid commands you wish to send to
'the WTDIO then press enter. The WTDIO will respond to the command and
'return any data (if applicable) which will be displayed on the monitor.

'Hit "ESC" to exit the program.

     CLS
     OPEN "COM1:1200,N,8,1" FOR RANDOM AS #1
     ON COM(1) GOSUB RECEIVE
     COM(1) ON

     DO
        KEY$ = INKEY$
        IF UCASE$(KEY$) = "C" THEN
           INPUT "Enter Command:", OUT$
           GOSUB TRANSMIT
        END IF
     LOOP UNTIL KEY$ = CHR$(27)
     CLOSE #1
     END

RECEIVE:
     COM(1) OFF                      'disable event trapping
     IF INPUT$(2, #1) = "DA" THEN    'test for WTDIO header character "D" and
                                     'address "A"
        LINE INPUT #1, IN$           'get response from WTDIO board
        PRINT IN$                    'print response to screen
     ELSE LINE INPUT #1, DISCARD$    'discard data using different header
     END IF
     COM(1) ON                       'enable event trapping
     RETURN

TRANSMIT:
     COM(1) OFF                      'disable event trapping
     OUT$ = "DA" + OUT$              'append header character "D" and address "A"
     PRINT #1, OUT$                  'send string to WTDIO
     LINE INPUT #1, DISCARD$         'discard echo
     COM(1) ON                       'enable event trapping
     RETURN
```

Use this simple QBASIC program to test out your circuit. Hit "C" to send a command to the I/O module. Any data returned will be displayed on your monitor.

232 port is normally at a marking level (-12V), it is possible to "steal" from it the negative voltage needed for communications at RS-232 levels and a separate supply is not required.

Bit 2 of port-A is tied to the DTR (Data Terminal Ready) pin through R5 and determines when the unit is plugged into an active RS-232 port.

Bit 1 of port-A is tied to the RD pin through R4 and is used to verify an idle RS-232 state prior to sending any serial data. This will avoid a collision with the data sent from any other projects which are sharing the same RS-232 port.

Power for the circuit is supplied from a standard wall transformer with an output in the range of 7 to 15 VDC. IC2 — a 78L05 voltage regulator — drops the input voltage to 5V which is required by the circuit. C1 and C2 stabilize the operation of the regulator and provide filtering. LED1 is used to indicate communications activity with the computer.

Current limiting resistors R11 through R22 protect IC1's I/O pins from excessive current flow during accidental shorts to 5V or ground. The DIP switch (S1) together with the pull-down resistors R7 through R10 are used to set the address of the RS-232 digital input/output module.

The PIC Firmware

A PIC16C55 programmed with the "RS-232 digital input/output" firmware is available from the supplier mentioned in the parts list. The source and object code files have been placed on the *Nuts & Volts* web site for those who have the proper equipment and wish to program their own, or simply wish to explore the program line-for-line.

At power-up, the program stored in IC1's EPROM enters a loop which monitors the com port and any of the I/O pins which have been configured for input. If a start bit is detected at the com port, the program branches to a routine which begins by reading the first character sent from the PC. This is the header character and determines if the data to follow is meant for the RS-232 digital input/output kit, or used by some other kit sharing the same com port.

Immediately following this header character is the address character (A-P). IC1 reads the DIP switch setting to determine if there is an address match and, in turn, either fetches or discards the remainder of the data stream.

IC1 reacts to any valid command received from the com port by updating the state and/or configuration of any specified I/O pin(s) and returning any required data. When data is to be returned, IC1 first listens to the com port to determine if it is available, then sends the header and address characters followed by the response, as depicted in Listing 1. The data stream is terminated by a carriage return and the program returns to the main loop.

If an action is sensed at any of the I/O pins which have been set up for a switch, button, or matrix keypad, the action is verified after a 65ms delay — used for debounce purposes — then IC1 sends the appropriate indication to the com port in the same manner mentioned above. If configured for button or matrix, this response will be repeated for as long as the button is held down. The matrix decoding process is accomplished simply by individually setting each one of the row pins (A-D) low, then scanning the column pins (E-H) to see if any has been shorted to the row pin through a pressed button on the keypad.

Construction

The complete circuit fits nicely on a PC board measuring just under 3" x 2.5". The artwork is provided here for those who wish to etch and drill their own PC boards, or a pre-fabricated one can be purchased from the supplier mentioned in the parts list.

Refer to the parts placement diagram shown in Figure 11, identify the component side of the PC board which is marked, and begin by soldering in the 28-pin IC socket. The resistors can be mounted next. Notice the extra holes/pads near resistors R11 through R22. These are for optional 10K pull-up resistors mounted vertically and should be left blank for now. Solder in the capacitors paying particular attention to the orientation of the polarized caps C1 and C2. When mounting the LED, identify the anode which is the long lead; this should correspond with the pad labeled "A" on the parts placement diagram.

Care should be taken when soldering in the transistor (Q1) and the regulator (IC2) to avoid a solder bridge between the closely spaced pads. The crystal (XTAL1) should be mounted leaving a small gap between the bottom of its case and the PC board to avoid the chance of its metal case shorting the two pads together. Finish by installing the DIP switch (S1).

Obtain a piece of four-conductor telephone cord to be used as your RS-232 cable, and a connector (both available from Radio Shack). Figure 1 shows the hook-up diagram for both a 9-pin and a 25-pin RS-232 connector. Match the "SG," "DTR," "TD," and "RD" connections on the PC board with their corresponding pins on the connector you are using as shown in the diagram. Solder a jumper wire on the RS-232 connector between pins "RTS" and "CTS," and between "DTR," "DSR," and "DCD" as shown.

Use a DC wall transformer (also available from Radio Shack) with an output voltage in the range of 7 to 15 VDC. Cut off the connector at the end of the wires, use a voltmeter to determine positive and negative, and solder those wires to the "POS" and "NEG" connections on the PC board.

After all the components and wires have been soldered, closely examine both sides of the PC board for solder bridges and/or cold solder joints and re-

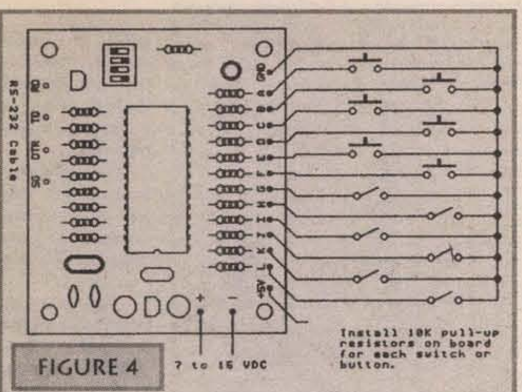


FIGURE 4

Notice the ease at which the I/O module can be wired up to switches, buttons, or alarm contacts.

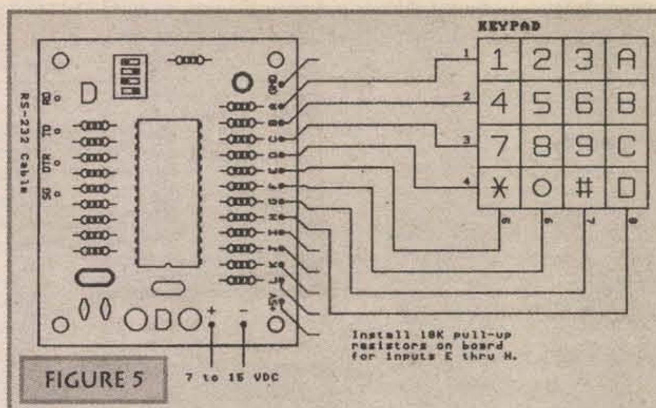


FIGURE 5

Decode a 4x4 matrix keypad using this set-up.

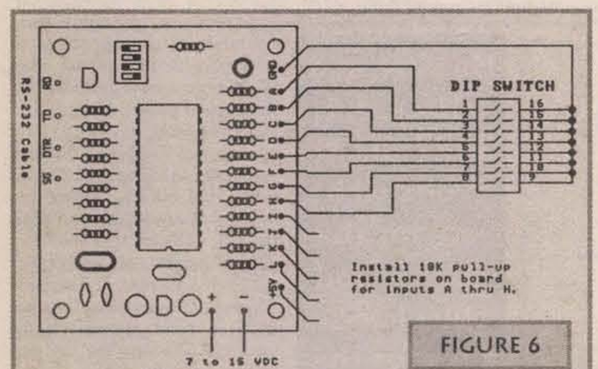


FIGURE 6

A DIP switch can be used with the READ command to set/change a variable or configuration within your program from a remote location.

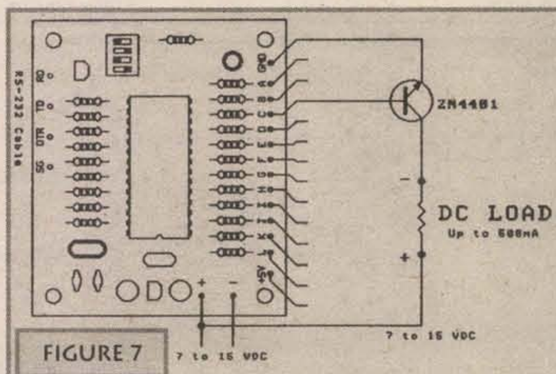
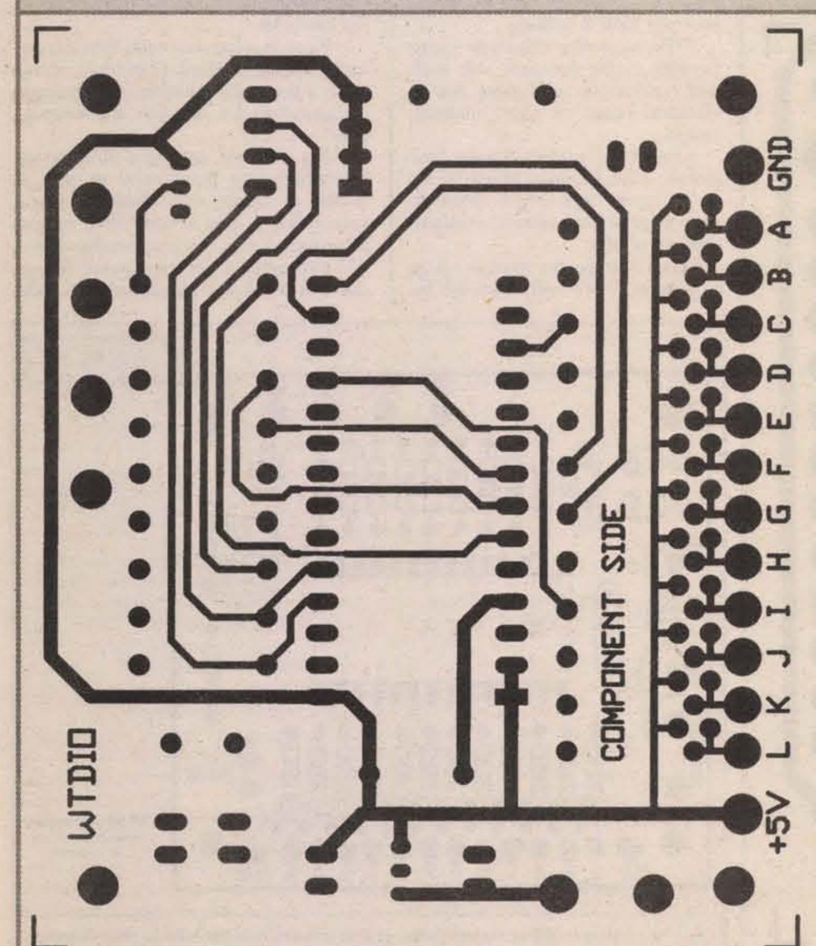


FIGURE 7

Turn on/off a DC load up to 500mA using this circuit.

TOP SIDE / SCALE 2:1



solder, if necessary. Carefully plug IC1 into its socket using the orientation as shown in the parts placement diagram.

Operation

The RS-232 digital input/output kit can share the same serial port as other kits of its kind simply by wiring each kit in parallel to the same RS-232 connector. You must, however, remove R1 and R2 on any subsequent kit, i.e., of all the kits parallelled on the same port, only one kit should have R1 and R2 installed).

Doing this will allow you to piggyback up to 16 I/O modules and use them on the same port which currently supports the home automation controller and/or telephone/computer interface kits as described in the July/August '96 issues of *Nuts & Volts*.

Solder a solid-conductor wire onto each I/O pad (A through L) and run the opposite ends to a solderless breadboard, as shown in Photo 1. Use the set-up shown in Figure 3 along with the simple QBASIC program shown in Listing 2 to test out your circuit.

Plug the wall transformer into an electrical outlet and plug the RS-232 connector into your PC. *Note*: Always apply power to your kit before plugging into an active RS-232 port or the oscillator may fail to start.

Start the program, then hit "C" on your keyboard. A prompt will appear asking you to type in a command. Type "HA" — using caps — then hit enter. LED1 will flash as the unit receives the data from the serial port, then the I/O pin labeled "A" will change to an output and be set high, which will turn on its LED on the breadboard.

Hit "C" again and type in "LA." This will set I/O pin "A" back to low, thus turning off the LED. Try this command using each I/O pin label and watch as the corresponding LEDs turn on and off.

If LED1 on the I/O board does not flash when sending data out the com port, there is either a wiring error in your serial cable or your program is not accessing the correct port. Closely examine your cable including the jumpers on the RS-232 connector, and verify that the serial port you are plugging into is the same one you are opening in your QBASIC program.

With correct hook-up to the serial port, and the QBASIC program not running, the DTR, TD, and RD pads on the board will all be a negative voltage. After starting the program, the DTR pad will change to a positive voltage.

The WRITE command can be used to send an eight-bit word to pins A through H, and can be of three different formats selected by the character which precedes the data. For example, decimal value 74 can be sent as a hex character pair using the syntax "Wh4A," as a binary string using "Wb01001010," or as an ASCII character using "W$J."

Creating Your Own Program

The RS-232 digital input/output module communicates at 1200 baud, no parity, eight data bits and one stop bit. Your program should contain the line OPEN "COM1:1200,N,8,1" FOR RANDOM AS #1, or similar. Also, the ON COM GOSUB statement should be used as shown in the sample program to handle branching to a subroutine when data is received from the module.

All data sent by the I/O module to the serial port is preceded by the header character (D) and the board address character (A-P), then ending with a carriage return. All commands sent by the PC to the I/O module must also be preceded by these header and address characters.

Two important notes here: because of the structure of the RS-232 interface used by the I/O module, all characters that are sent to the module are also echoed back to the PC. Therefore, your program must use the COM(1) OFF statement prior to using the PRINT #1, and then a LINE INPUT #1 statement to dump all echoed characters in the buffer before issuing a COM(1) ON statement.

Also, always use the COM(1) OFF statement at the beginning of your subroutine branched to by the ON COM GOSUB statement, then a COM(1) ON statement at the end, after all characters have been received. Failure to turn off event trapping as mentioned above will cause communications errors between the PC and the I/O module.

Figure 4 demonstrates the ease at which this module can be wired to buttons and switches. Pull-up resistors should be installed on the I/O board for each; these can be mounted vertically in the extra holes provided near the I/O pads.

Normally-closed alarm zones can be

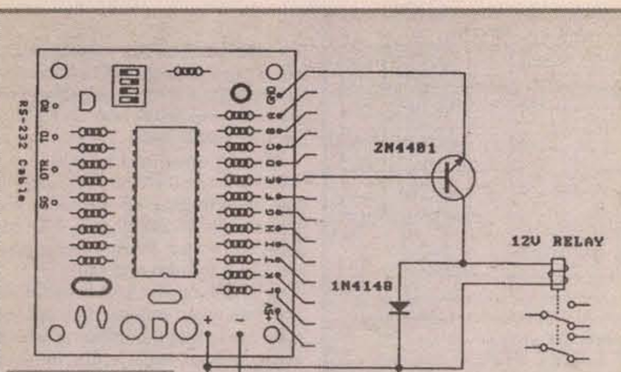


FIGURE 9

For larger currents, a relay can be used as shown. Supply voltage should be that which is required by the relay (up to 25 VDC).

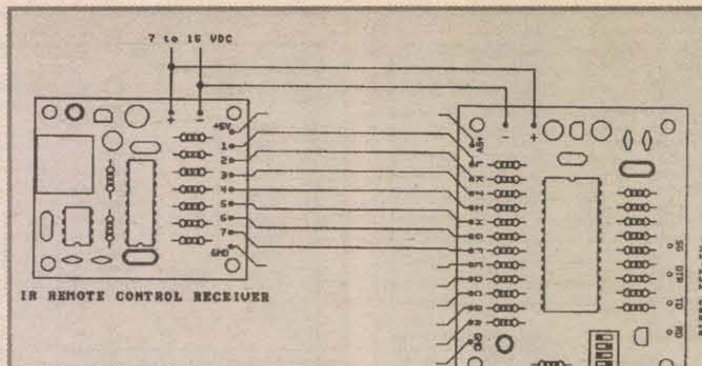


FIGURE 10

A standard TV remote transmitter can send commands to your PC using the IR remote control receiver kit as shown here (see source mentioned in parts list).

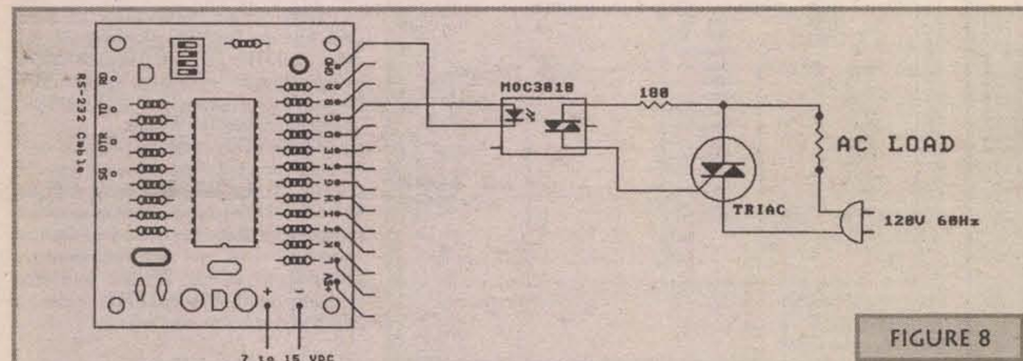
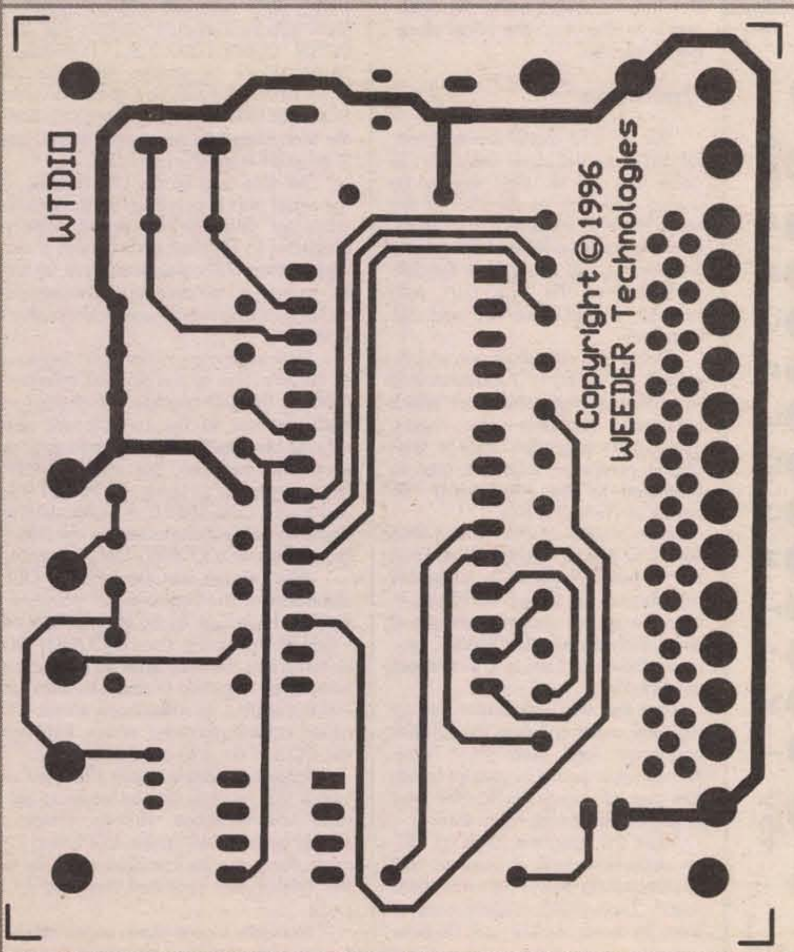


FIGURE 8

Lamps, stereos, coffee makers, etc. can be switched using a triac as shown in this circuit.

Be sure and check out the Nuts & Volts web site for the source and object code files for the PIC!

BOTTOM SIDE / SCALE 2:1



wired to each of the 12 inputs. Configuring these for switches will return a response to your PC whenever any loop is broken.

The automatic debounce incorporated in the firmware will work well, preventing false trips due to electrical noise or short intermittences.

To further protect against false alarms, your program could be set up to ignore trips which return to their original state within a minimal amount of time.

Figure 5 shows the module set-up to decode a 4x4 matrix keypad. Be sure to install pull-up resistors on I/O pins E through H before issuing the matrix command.

When a button is pressed, the row and column characters are returned to the PC.

For example, pressing button 6 will return "MBG," pressing button 8 will return "MCF," etc. A DIP switch is used in Figure 6 to remotely set or change a configuration or variable within a program which issues the READ command periodically. Again, use pull-up resistors on the input pins.

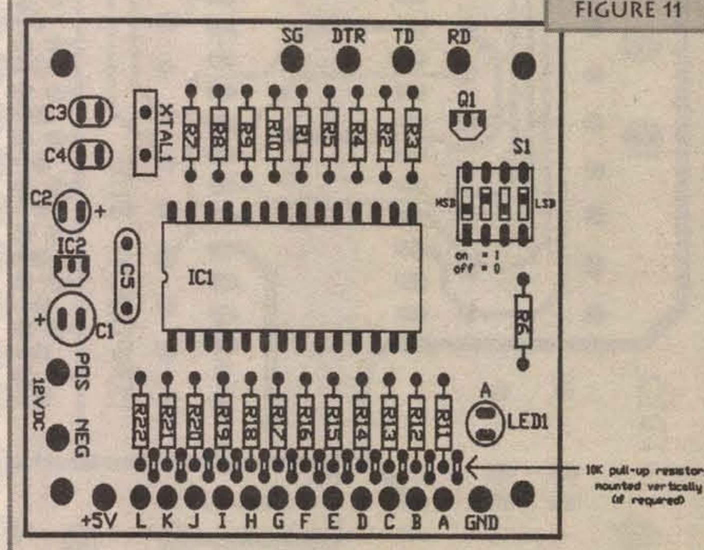
Figures 7 through 9 give examples of using an I/O pin with the HIGH, LOW, or TOGGLE commands to turn on/off electrical devices. These circuits can be copied on each I/O pin. A standard TV remote transmitter can be used to send commands to your PC using the set-up shown in Figure 10.

Configure these I/O pins for switches and have your program respond to the transitions. Detailed information about the IR remote control receiver kit can be obtained from the source mentioned in the parts list.

Keep in mind that each time a command is sent to the I/O module acting upon a particular I/O pin, any previous configuration for that pin will be canceled.

For instance, setting a pin high or low which was being used to read a switch or button will disable it from responding to that action. Also, issuing a command which acts upon any of the I/O pins used for decoding a matrix keypad will disable the matrix function. **NV**

FIGURE 11



Use this parts placement diagram when assembling the board.

Parts List • Parts List • Parts List • Parts List

Resistors *(All are 1/4-watt, 10% units)*
R1, R7, R8, R9, R10 - 10,000 ohm
R2 - 1,000 ohm
R3, R4, R5 - 47,000 ohm
R6, R11, R12, R13, R14, R15, R16, R17, R18, R19, R20, R21, R22 - 620 ohm

Capacitors
C1 - 47 uF, 35-WVDC, electrolytic
C2 - 10 uF, 35-WVDC, electrolytic
C3, C4 - 15 pF, ceramic disc
C5 - 0.1 uF, Mylar

Semiconductors
IC1 - PIC16C55-XT/P (pre-programmed) 8-bit microcontroller
(Microchip)
IC2 - 78L05 low power 5-volt regulator
LED1 - light emitting diode, red
Q1 - 2N4403, general-purpose PNP silicon transistor

Other Components
S1 - DIP switch, 4-pole
XTAL1 - 4 MHz crystal

Miscellaneous
PC board, 28-pin IC socket, DC wall transformer, RS-232 connector & cable, 10K pull-up resistors, solder, etc.

The following items are available from

Weeder Technologies, P.O. Box 421, Batavia, OH 45103. **513-752-0279.**

Complete kit of parts including double-sided etched and drilled PC board and all board mounting components (WTDIO-K), **$32.00**

A pre-programmed PIC16C55 only (PIC-DIO), **$18.00**

IR Remote Control Receiver kit (WTRCR-K), **$32.00**

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Stamp Applications:

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

by Scott Edwards

Motors fascinate Stamp users. They seem to be looking for a mythical universal motor-controller that interfaces to Stamps, controls any motor from 0.1 to 100 amps at 1 to 50 volts, is 100% efficient, and costs less than $5.00.

We keep those on a shelf in the back, between the perpetual-motion machines and the replacement teleporter pattern buffers.

This month, we'll look at several types of practical motor-control circuits suitable for use with the Stamps.

Electronic Control for DC Motors Using Discrete Bridge Circuits

Gallery of motor-control circuits and motor-control basics

DC Motor ABCs

Before we look at our gallery of circuits, let's agree on a couple of terms:

· In this article, motor means a permanent-magnet, direct-current (DC) motor of the sort used in toys, models, cordless tools, and robots. These motors are particularly versatile because both their speed and direction can be readily controlled; speed by the voltage or duty cycle of their power supply, and direction by its polarity. DC motors also work as generators. Since generators slow down when they are heavily loaded, DC motors can be electronically braked.

· Control means at least on/off and direction control. Variable speed and braking are also desirable.

Most people already know a bit about DC motors from science-fair demonstrations like Figure 1. When the motor is disconnected from the battery, it is off; when it is connected with the red wire to the + terminal and black to -, it turns forward; and when the wires are reversed, the motor turns backwards.

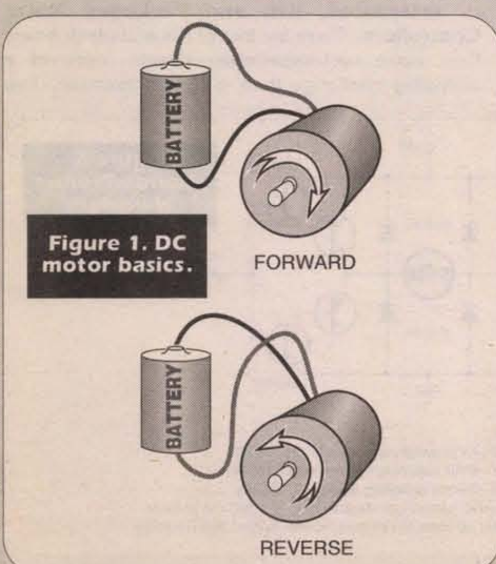


Figure 1. DC motor basics.

You can also demonstrate the motor/generator braking effect. Disconnect the battery and spin the motor shaft with your fingers, noticing how freely it spins. Now connect (short) the motor power wires together and try it again. The motor is harder to spin. The short-circuit load on its generator output makes it harder to turn.

Manual Motor Controllers

Figure 2 shows how our understanding of DC motor control translates into five manual motor-control circuits using switches.

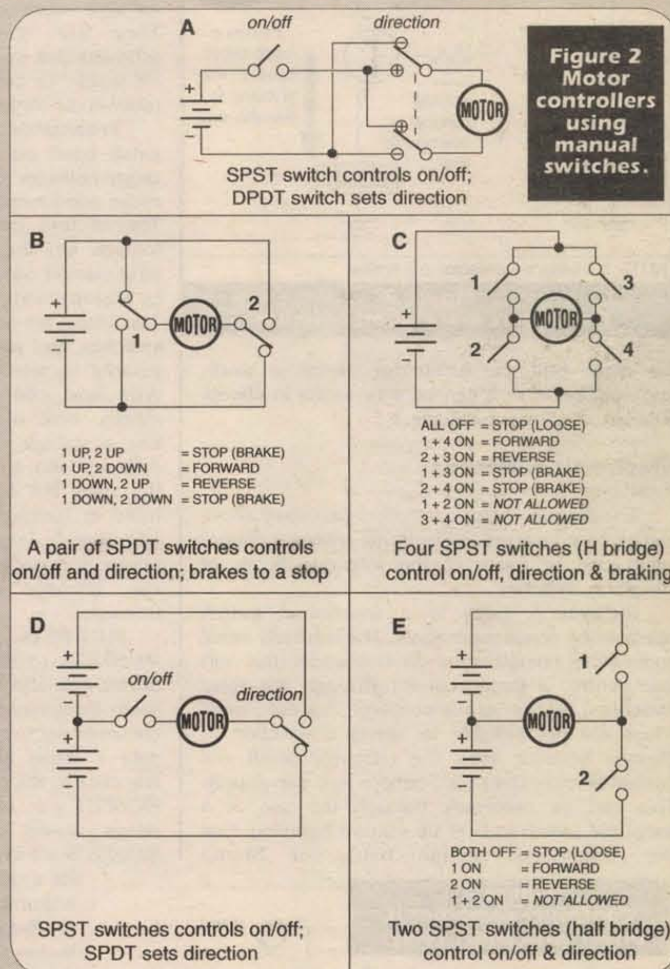


Figure 2 Motor controllers using manual switches.

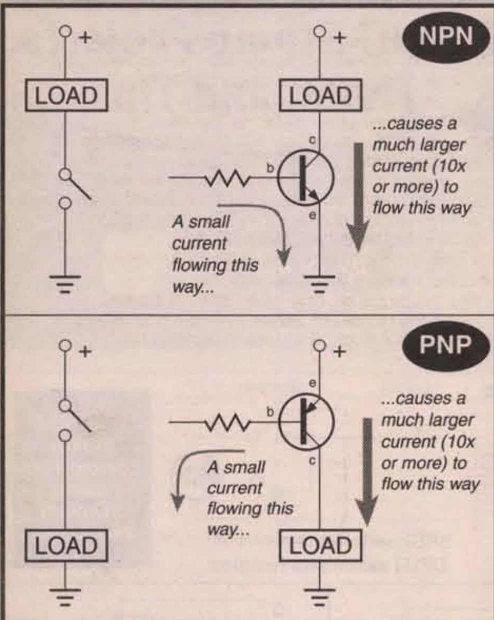
Figure 2a is the most closely related to the science-fair demo. A single-pole, single-throw (SPST) switch turns power to the motor on or off, while a double-pole, double-throw (DPDT) switch controls the polarity of the motor connections.

Don't be scared off by this talk about poles and throws. The component we call a switch can actually contain several switches, all activated by the same handle. These joined switches are indicated on a schematic by a dotted line joining their symbols. Each joined switch is referred to as a pole. So a switch component containing two switches is a double-pole unit.

Throws refer to the number of circuits a switch can make. An ordinary on/off switch makes or breaks just one connection, so it's a single-throw switch. The direction switches at the top of Figure 2 select one of two connections, so they are double-throw switches.

Figure 2b uses a pair of SPDT switches to control direction and on/off. If the two switches are set so that they both connect to the same power-supply rail, the circuit brakes the motor using the motor/generator principle. Figure 2c is very similar, but uses four SPST switches. These switches must be turned on and off in specific combinations to run and stop the motor. Note that a couple of switch settings are not allowed, because they would short out the power supply.

You might consider Figures 2d and e to be cheater's solutions to the motor-controller problem. They use a second battery to reverse the motor, thereby simplifying the arrangement of switches. However, extra batteries mean extra weight and expense. And the batteries may wear out at different rates, since, in most applications, motors spend more time going in one direction or



NOTE: b = base; c = collector; e = emitter

Figure 3
Transistors make good switches.

the other. Still, the half-bridge design is worth knowing, because it can be very useful in cheap, efficient, dual-motor designs.

Electronic Switches

The manual motor controllers described above can all be converted to electronic (Stamp) control using one or more of the following types of electronic switches:

Relays. A relay is a mechnical switch operated by an electromagnet. The relatively small current that energizes the electromagnet (the coil) can control a larger current through the relay switch(es), known as the contacts. However, most relays are not suitable for direct connection to Stamps because even the relatively small coil current is more than the Stamp's pins can supply. This can be overcome through the use of a transistor switch to beef up current handling. See the Transistors section below or Stamp Applications No. 6 (available from the *Nuts & Volts* Web site) for more info.

Relays have two useful properties for small motor controllers: **(1)** Their contacts have very low on-resistance, meaning that very little power is wasted. **(2)** They are available in just about any combination of poles and throws you can imagine. As we'll see, solid-state multipole/multithrow switches are usually built up from many SPST units.

On the downside again, relays are slow, make noise, and wear out. They are almost useless in schemes that switch power on and off rapidly to control motor speed (duty-cycle control).

Transistors. By allowing a small base current to control a larger collector current, transistors make good switches; see Figure 3. They're fast, quiet, and can last forever. On the other hand, the base current can be somewhat high by Stamp standards (20 to 25 mA). Transistors are usable only as SPST switches, and you have to consider polarity in selecting the transistor type and connecting the load. Finally, even a fully-on transistor has a voltage drop between the collector and emitter. It's typically 0.5 volts, but can be one volt or more in Darlington configurations (discussed later). This wastes power and generates heat, which can damage or destroy the transistor.

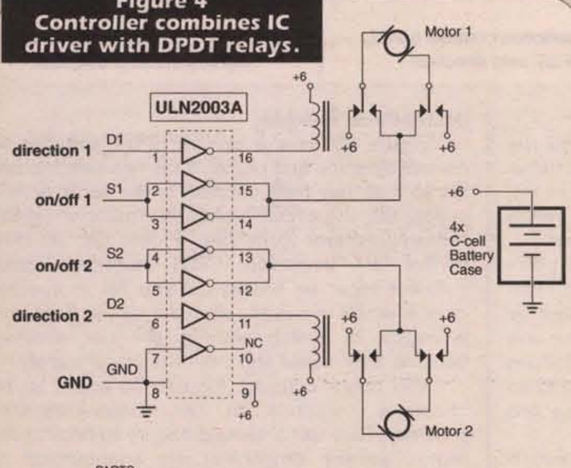
MOSFETs. At first glance, MOSFETs (metal-oxide semiconductor field-effect transistors) would seem to eliminate all the problems of relays and conventional transistors. Their control input — the gate — draws almost no current. It switches in response to the presence of a voltage. A turned-on MOSFET can offer an on-resistance that many relays would envy. And reasonably priced MOSFETs are available in current ratings that look like a misprint — 50 amps or more out of a thumbnail-sized package.

Really, the only trouble with MOSFETs is that they are at their best with supply voltages above 10 volts, and with control voltages higher than the supply. And if they are to be switched on and off rapidly, you can forget about that "almost no gate current" stuff because the gate acts like a pretty high capacitance. MOSFETs don't hold up well in tinkerers' workshops where anti-static precautions (grounded work surfaces, wrist straps, etc.) are unheard of.

I'll catch some flak for saying this, but MOSFETs' special handling and design requirements make them unsuited to beginners' skills. If you need this kind of high efficiency, but aren't up to building it yourself, see the next section.

Integrated, Kit, and Packaged Motor Controllers. There are lots of ICs and black boxes that make motor-controller design more of a shopping challenge than a design exercise. Two

Figure 4
Controller combines IC driver with DPDT relays.



PARTS:
Relays—DPDT, 1A (or more) contacts, 5Vdc coil (JC: 99346)
ULN2003—7-channel Darlington transistor array (JC: 34278)
Motors—DC permanent magnet motors, ≤ 500 mA at 4Vdc
[See Sources for Jameco (JC) contact info]

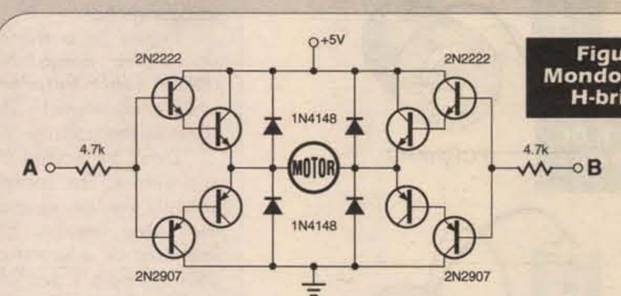


Figure 5
Mondo-Tronics H-bridge.

A	B	
0	0	stop
0	1	forward
1	0	reverse
1	1	stop

PARTS:
2N2222—NPN switching transistor (JC: 28628)
2N2907—PNP switching transistor (JC: 28644)
1N4148—Silicon switching diode (JC: 36038)
Motors—DC permanent magnet motors, ≤ 300 mA at 6Vdc
[Available as complete kit from Mondo-Tronics, see Sources]

Sources

For more information on the BASIC Stamp, contact:

Parallax, Inc.
3805 Atherton Road, #102, Rocklin, CA 95765
phone **(916) 624-8333**
Internet **http://www.parallaxinc.com**

Mondo-Tronics offers goodies for robotics, including the motor controller and motor-gearbox mentioned in the article *(controller is part no. 3-301).*

Mondo-Tronics Inc
524 San Anselmo Ave. 107-11, San Anselmo, CA 94960
phone **415-455-9330**; **http://www.robotstore.com**

Wirz Electronics
sells H-bridge driver ICs. See them at
http://cec.wustl.edu/~blw2/index.html

Jameco supplies many of the electronic components listed in the circuits.

Jameco Electronic Components
1355 Shoreway Road, Belmont, CA 94002-4100
phone **415-592-8097** or **800-831-4242**
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ICs that are popular with robotics enthusiasts are the L293D and LMD18200. Wirz Electronics sells these parts and provides design information via the Internet; see Sources. Basic specs are:

L293D: motor supply voltages up to 36V, current to 1A (2A peak). Voltage drop across each leg of H-bridge, 1 to 2V.

LMD18200: motor supply voltages of 12 to 55V, current to 3A. On-resistance of each leg of H-bridge 0.33½ typical, 0.6½ max.

The robotics-supply store Mondo-Tronics offers motor-control kits that are inexpensive, educational, and easy to build. The program listing is an example of motor speed- and direction-control using their Mini Dual H-bridge Motor Driver kit, shown in the accompanying photos. Mondo also carries suitable DC motor assemblies (like the Tamiya motor/gearbox in the picture) and robotic components.

A nice feature of Mondo's controller kits is that all have the same connector layout and interface requirements. If you build a small robot (or motorized widget) and later want to build a larger one, just swap motor controllers.

Packaged motor controllers — called electronic speed controls (ESCs) — are available from hobby shops for use in remote-control cars, boats, etc. Some ESCs are brutes capable of switching 10s or 100s of amperes. Best of all, they accept just a servo-control pulse train input to operate. That's a 1- to 2-ms pulse repeated 60 times a second. As the Stamp and Counterfeit application notes show, it's relatively easy to generate these pulses from PBASIC. If you need to control more than one motor, or your PBASIC program is too tied up to meet the 60-pulse-per-second requirement, you can use my company's Mini SSC (serial servo controller) to generate eight continuous pulse streams. See Sources for catalog information.

Example Circuits. Figures 4, 5, and 6 are representative motor-control designs derived from the ideas presented in Figure 2a, c, and e. These are tested, proven circuits suitable for use with small DC motors. Even if your application requires a much larger motor, it makes sense to get your feet wet with smaller motors so that you can begin to understand some of the issues involved. And a small geared motor assembly, like the Tamiya unit shown in the photo, has enough oomph to propel robots up to a couple of pounds at reasonable speeds. This particular motor was used to test the control circuits presented here, and draws approximately 250 mA at 3.0 VDC. Note that current is dependent on voltage, so the figures in the descriptions below are based on actual measurements.

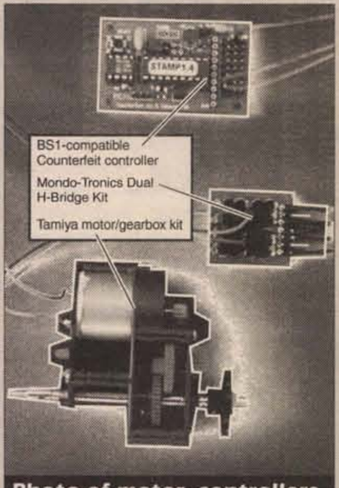


Photo of motor, controllers.

Figure 4, Dual Relay Controller. This design uses DPDT relays to control motor direction, and an IC-packaged transistor array to turn the relays and motors on and off. Experienced eyes will spot an apparent error — this design gangs two of the ULN2003 Darlington transistor outputs together for motor on/off control. This is normally a bad idea, because slight differences in transistor characteristics will cause one of the transistors to bear all of the load. However, because these transistors are on the same silicon die, their characteristics and temperature are close enough to identical to make this trick safe.

Because the transistors inside the ULN2003 are Darlingtons, they require only a small (<1mA) control current to turn on. The downside is that they have a higher-than-normal voltage drop of about 1.5V. If the circuit is driving our sample motors, that means that the motors get 4.5V x 0.40A = 1.8 watts (W) of power, while 1.5V x 0.40A = 0.6W is wasted. (This assumes no loss through the relay contacts.) So 75% of the total 2.4W gets to the motor. To be fair, we need to also factor in the relay coil current, 4.5V x 0.1A = 0.45W to the waste (non-motor) side of the balance sheet. Now our total is 2.85W, of which the motor gets 63%.

Figure 5, Darlington H-bridge. This is the circuit used in the Mondo Mini H-bridge kits. It also uses Darlington pairs of transistors to keep control current to approximately 1mA. As with other Darlington arrangements, the penalty is increased voltage drop — I measured it at about 1.2V per conducting leg of the bridge for a total of 2.4V (since two legs of the H have to be conducting for the motor to move).

With the sample motors, the motors get 3.6V x 0.30A = 1.08W of power, while 2.4 x 0.30A = 0.72W is wasted. So 60% of the total 1.79W gets to the motor.

Figure 6, Half bridge. This circuit offers the pleasant combination of high efficiency and low parts count, at the expense of splitting the battery supply into separate sections

The circuit takes advantage of the Stamps' relatively high-current outputs to eliminate the need for an input transistor or Darlington. Where the previous circuits needed just 1 mA of control current, this one requires almost 10 mA. It's a worthwhile trade for the reduced parts count.

Performance of a half bridge varies depending on which transistor is turned on; the PNP transistor dropped 0.5V and the NPN just 0.3V. Taking the worst case, the motor received 2.5V and drew 0.27A for 0.675W of power. The transistor wasted 0.27A x 0.5V = 0.135W. So 83% of the power goes to the motor.

I substituted high-performance switching transistors in the circuit (Zetex ZTX689B for NPN and ZTX788B for PNP; see Sources). I also changed the upper 4.7K resistor to 1K to prevent the high-gain transistors PNP from switching partly on due to the difference between the motor supply (6V) and the logic-level input (5V).

The improved tran-sistors reduced the worst-case voltage drop to 0.2V. This improved performance as follows: motor, 0.81W; waste, 0.058W; efficiency, 93%.

So splitting the battery supply may be

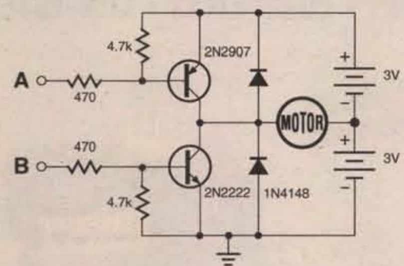
Listing. BS1 Program to Demonstrate Mondo-Tronics H-bridge

```
' Program: MONDOMOT.BAS (Demonstrate Mondo-Tronics H-bridge)
' This program demonstrates the Mondo motor controller to
' control the direction and speed of a DC motor. Connect
' input A of the controller to Stamp pin 0; B to pin 1; and
' GND to GND. Run the program. The motor will slowly accelerate
' to top speed, then stop and repeat the acceleration in
' reverse. This program uses a carry-the-1 method of generating
' duty cycle control of motor speed. When you add a number to an
' "accumulator" (a memory location of fixed size), the accumulator
' will overflow if the result is bigger than it can hold. The
' larger the number added, the more likely an overflow or "carry"
' is. This program adds the desired motor duty cycle to an
' accumulator, and turns the motor on only when there's a carry.
' Higher duty cycles make the motor run faster. This method works
' well with the Stamp because it is more or less independent of
' speed.

SYMBOL motAcc = b11        ' Motor-speed "accumulator."
SYMBOL motDir = bit0       ' Motor direction: 0=fwd; 1=reverse.
SYMBOL spd = b10           ' Motor speed, 0 (off) to 15 (full on).
SYMBOL cycles = b9         ' Number of loops at a given speed.
SYMBOL A_ = pin0           ' Controller A input.
SYMBOL B_ = pin1           ' Controller B input.

dirs = %11                 ' Set pins 0 and 1 to output.
again:
 for cycles = 0 to 255                 ' Turn 255 cycles at each
speed.
   gosub motor                         ' Output to motor.
  next
  spd = spd +1                         ' Increase speed.
  if spd <= 15 then again              ' If speed is > 15, then..
  spd = 0                              ' ..turn motor off..
  motDir = motDir ^ 1                  ' ..and reverse direction.
goto again                             ' Loop forever.
motor:
  motAcc = motAcc & %1111              ' Limit motAcc to 4 bits.
  motAcc = motAcc + spd                ' Add speed.
  if motAcc >= 16 then motOn ' If carry, then turn on motor.
  A_ = B_                              ' Otherwise, motor off.
return

' If you look at the table accompanying the H-bridge, you'll
' see that the motor is on only when inputs A and B are opposite.
' Programming shorthand for this is to set A to the motor
' direction, and make B = NOT A. PBASIC1 does not have a NOT
' function per se (see LET in the manual), so we make do by
' XORing A with 1, which has the same effect: B = A ^ 1.
motOn:
  A_ = motDir: B_ = A_ ^ 1
return
```



A	B	
0	0	forward
0	1	PROHIBITED
1	0	stop
1	1	reverse

PARTS:
2N2222—NPN switching transistor (JC: 28628)
2N2907—PNP switching transistor (JC: 28644)
1N4148—Silicon switching diode (JC: 36038)
Motor—DC PM motor, ≤ 300 mA at 3Vdc
[See Sources for Jameco (JC) contact info]

Figure 6
Half bridge is cheap, efficient.

Stamp Applications:

worthwhile when you have to get the most out of a set of batteries. If you tear apart motorized toys, you may find a circuit like this.

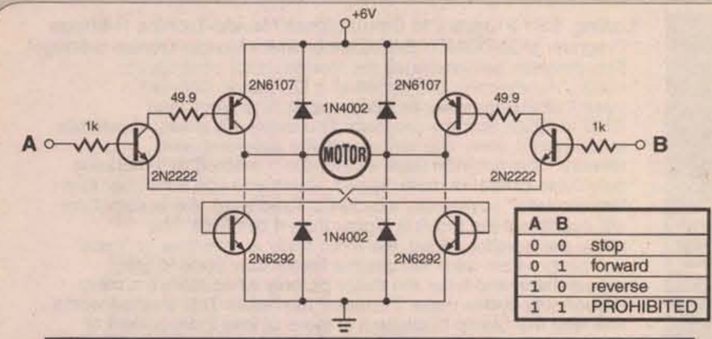


Figure 7. Ingenious H-bridge design by Rick Moll.

The half bridge can make sense for small robots with dual drive motors for propulsion and steering. Wire the motors so that they use opposite battery supplies when the robot is rolling forward, and you'll even out the wear on the batteries.

Figure 7, Ingenious H-bridge. I did not design and have not had a chance to build this last circuit, but I was struck by its cleverness. It was designed by Rick Moll, editor of the late lamented *Robotics Practitioner* magazine.

The circuit is an H-bridge with a twist — each input transistor transfers current out of the base of a PNP and into the base of the opposite NPN. The current switches on both transistors to make the motor run. Control current is approximately 3.6 mA; not as low as the Darlington's, but better than the half bridge. And there's no voltage-drop penalty; figure a 0.5V drop across each leg of the circuit, for a total 1V drop. Almost the best of both worlds. This H-bridge cannot brake the motor, since that requires turning both NPNs or both PNPs on simultaneously.

Wrap-up

I'm out of space, but I've just scratched the surface of this fascinating subject. I'll revisit motor control in a future column. The continuation of last month's BASIC for Beginners will appear next month. **NV**

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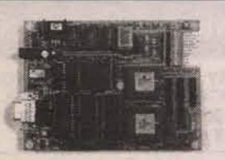

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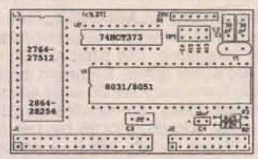

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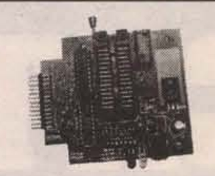

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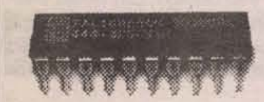

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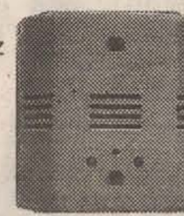

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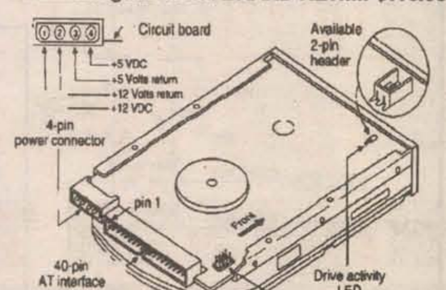

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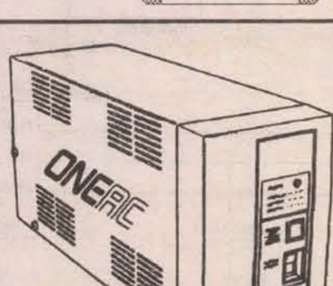

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By Jeffery Kerr

Building an industrial strength motor controller on a hobbyist budget

Back in November, I wrote about the advantages a DC servo motor control has over the basic stepper motor. I also described some of the considerations that ought to go into crafting a reliable servo motor controller. This time around, we'll get down to the brass tacks of building an industrial strength servo motor control system on a hobbyist budget.

Actually, I'll be describing two separate controllers: a simple single-axis controller with an RS232 interface, and an RS485-based motor control module which can be daisy-chained to easily create multi-axis systems. These controllers can either execute position or speed control for small DC motors with TTL-compatible incremental encoders. They are both based on the *PIC-SERVO* motor control chipset which provides virtually all the servo control and communications functionality.

The PIC-SERVO Chipset

The *PIC-SERVO* chipset consists of two pre-programmed microcontrollers (one PIC16C73 and one PIC16C54) which together perform four critical motor control functions:

1. The *PIC-ENC* chip (a PIC16C54) performs the time-intensive task of counting optical encoder transitions to form a 16-bit motor position. This 16-bit position count is read by the *PIC-SERVO* (a PIC16C73) and augmented with two more bytes to form a 32-bit position count. The *PIC-ENC* can count transitions at up to 500 KHz. This means that a motor with a 100-line encoder (a total of 400 encoder transitions/revolution) can rotate at up to 75,000 RPM.
2. The *PIC-SERVO,* at rates up to 2 KHz, reads the current motor position, compares it to the desired position, and then applies a PID (*proportional-integral-derivative*) control filter to produce the proper control signal for the power amplifier. This control signal is a 20 KHz PWM amplitude output, plus a direction output bit.
3. To create smooth motions from one goal point (or velocity) to the next, the *PIC-SERVO* also performs *trajectory profiling* calculations which will smoothly accelerate the motor up to the operating velocity, slew at a constant speed, and then decelerate smoothly to a stop at the desired goal position. (In velocity mode, the trajectory profiling simply accelerates smoothly from the current velocity to the new goal velocity.)
4. The *PIC-SERVO* has an asynchronous serial interface and command protocol which allows it to communicate over a standard serial port. The communications protocol supports multiple devices so that several motors can be controlled directly from a single serial port.

The *PIC-SERVO* also performs a handful of other useful little functions (detecting error conditions, reading limit switches, homing, etc.), but the functions listed above really define the core of the servo controller. Complete documentation for the *PIC-SERVO* chipset can be found on the Web at:
http://users.aol.com/dcservo/picservo.html

The Single-Axis Controller

Figure 1 is a schematic for a very basic *PIC-SERVO*-based motor controller. As you can see, all that is needed besides the *PIC-SERVO* chipset is an RS232 transceiver chip like the MAX232 — and a PWM — power amplifier. Your host computer's COM port will send motion commands directly to the *PIC-SERVO* through the MAX232, and the *PIC-SERVO* produces a PWM and direction output for the LMD18200 power amplifier.

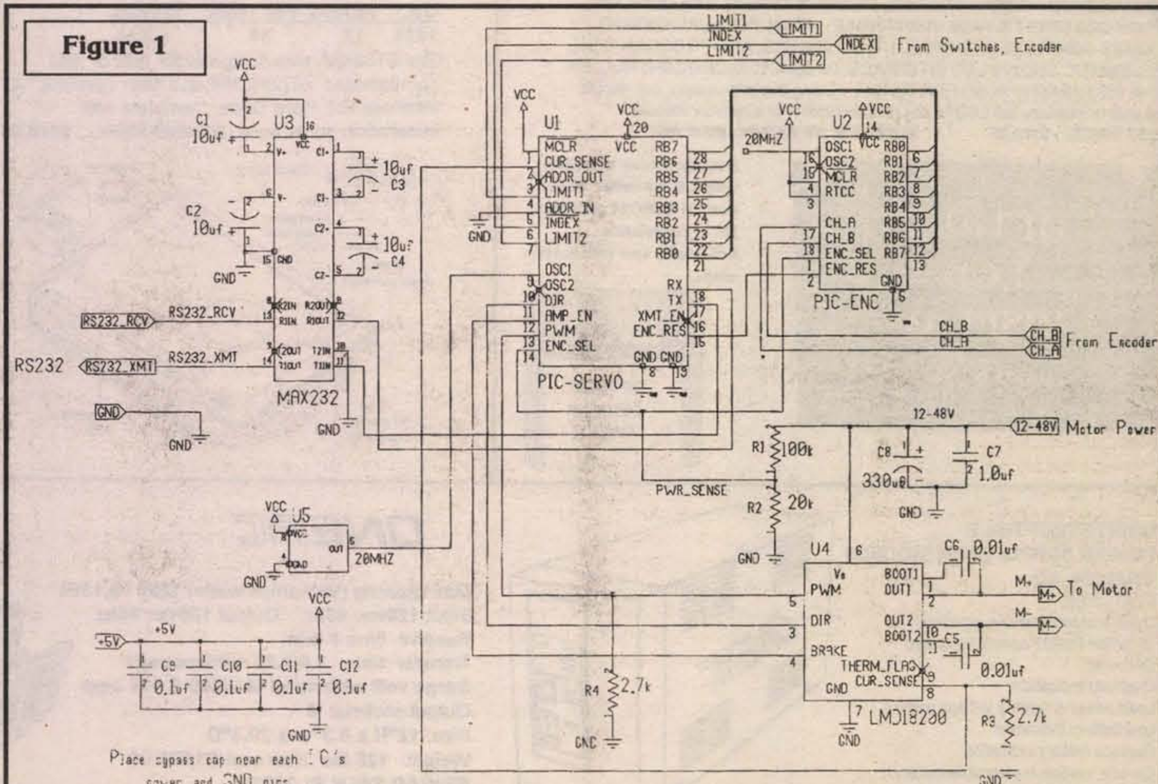
Garden variety TTL optical encoder signals can be connected directly to the CH-A and CH-B inputs of the *PIC-ENC.* If your encoder has an index pulse output, it can be connected to the index input on the *PIC-SERVO.* Otherwise, the index input can be used as a general-purpose input. The *PIC-SERVO* reads the encoder position from the *PIC-ENC* over an eight-bit bus with an addition of a byte select line (ENC_SEL) and a reset line (ENC_RES).

The LMD18200 is an H-bridge power amplifier which can drive up to three amps continuously, and six amps peak, and can operate with a supply from 12V to 55V. It has an automatic thermal shutdown, with a thermal shutdown warning output which is activated if thermal shutdown is imminent. (This output is ignored in this design, but could easily be connected to one of the limit switch inputs.) The device is also overcurrent and undervoltage protected.

The design is pretty straightforward, but there are a few things to note:

1. Some optical encoders (like the HP HEDS5510 series) do better with a 2K pull-up resistor to +5V on the encoder signal lines. To

Figure 1



further improve the noise immunity, you may want to run the encoder signals through a Schmitt-Trigger buffer.

2. The LMD18200 amplifier has the brake input, which disables the amplifier when high, connected directly to the amplifier enable output of the *PIC-SERVO*, which is normally used to disable the amplifier when low. This doesn't really matter because the actual use of this bit is controlled in your software. The only thing to note is that on power-up, the brake will be low (amp enabled), but the PWM signal will also be low (so that no drive current will be applied). This will create a self-braking effect in the motor, rather allowing the motor to freewheel. You'll see in the next circuit that an inverter is used, which allows the motor to free-wheel on power-up.
3. The current sense output of the LMD18200 is connected to ground through a 2.7K resistor. This will cause the pin to produce a voltage of about one volt per amp of motor current. This pin is then connected to the *PIC-SERVO*'s analog input for current monitoring. The slightly cheaper version of this amplifier — the LMD18201 — is pin compatible, but does not have the current sense output (its pin 8 should be connected directly to ground).
4. The MAX232 chip actually has two receivers and two drivers. The spare receiver can be connected to your RS232 port's DTR or RTS to give you an extra output bit, and the spare driver can be connected to DCD, DSR, or CTS to give you a spare input.
5. The ENC_SEL pin on the *PIC-SERVO* is a dual-purpose pin which gets used for both hi/lo byte selection and for detecting the presence of the motor power supply voltage. As shown in the schematic, it is connected to the motor supply voltage through a high-impedance voltage divider. If the *PIC-SERVO* ever detects a loss of motor power, it will automatically disable the servo. If you want to override this protection, simply tie the ENC_SEL pin to +5V through a 5K resistor.
6. If you are running your motor control signals more than a foot or so, you should be very careful with your cabling. At a minimum, the M(+) and M(-) leads should be twisted together and CH-A and CH-B of the encoder should each be twisted with ground or +5V. It would be even better to separately shield the motor wires and the encoder wires.

The Expandable Control Module

Figure 2 is a schematic of the daisy-chainable motor control module. This circuit is the actual circuit used on the *PIC-SERVO* Experimenter's board (see the *PIC-SERVO* web site for more information). The motor control, encoder interface, and power amplifier all work the same as in the single axis design, but some of the finer points of the RS485 interface and the daisy-chaining need a little discussion.

A Bit About RS485

For the most part, RS485 serial communications is conceptually identical to RS232 communications. The two main differences are that **1**) the signals are differential rather than single ended, and **2**) RS485 driver outputs may be disabled with an output enable signal, allowing multiple transmitters to be connected to the same differential pair of wires.

The differential signals, in addition to being generated easily from a 5V source, provide much better noise immunity than RS232 signals. If RS485 cabling is done properly (shielded twisted pairs, etc.), the signals can be driven up to 4,000 ft. at rates up to one megabit per second. (For compatibility's sake, we'll just be running at up to 115.2 Kilobits/second.)

The output enable input available on most RS485 driver chips is what allows *networks* of devices (up to 32) to hang off of a single RS485 port. In general, there are two different types of RS485 networks: two-wire half-duplex networks, and four-wire full-duplex networks.

With the half-duplex network, all nodes both send *and* receive over the same pair of wires. As you would imagine, this type of network requires a sophisticated enough communications protocol to prevent two different nodes from speaking at the same time. In a real-time control network, communication errors over a half-duplex network can create real problems.

The four wire, full-duplex network typically has a master node which transmits to all of the slave nodes over one dedicated pair of wires, and then all of the slaves transmit back to the master over a shared pair of wires.

In this scheme, slaves do not communicate directly with one another. The advantage is that the communications protocol can be much simpler, and the host can always send commands to the slave modules, even if one is confused and speaking out of turn. This is the protocol used by the *PIC-SERVO*, and as we will see later on, is very robust and nearly fool-proof.

The master node on a full-duplex RS485 network does not ever need to disable its transmit signal because its transmit lines are not shared. Therefore, the master node can use a standard RS232 port with a simple RS232 - RS485 signal adapter. These adapters are commonly available from places like Jameco, or you can easily build your own using the MAX232 from the first circuit, and the LTC491 from the second circuit, hooked back-to-back.

Daisy-Chaining

With any sort of network with multiple devices, each device must have a unique address for making sure that information goes to the right place. Typically, you would have a set of dip switches or jumpers for setting unique addresses. Not only is this a pain, but it also uses up several I/O pins. The *PIC-SERVO* takes advantage of the RS485 network topology — nodes hanging off of a single straight cable — to allow the master to dynamically set the address of each of the controllers on power-up.

The scheme works like this ... The *PIC-SERVO* has two pins used for addressing: ADDR_IN and ADDR_OUT. On power-up, all *PIC-SERVOs*, have a default address set to 0, the ADDR_OUT is set high, and all communications are disabled until the ADDR_IN pin goes low.

Once the ADDR_IN pin goes low, communications are enabled, and the *PIC-SERVO* will respond to any command sent its default address of 0.

One of the commands in the *PIC-*

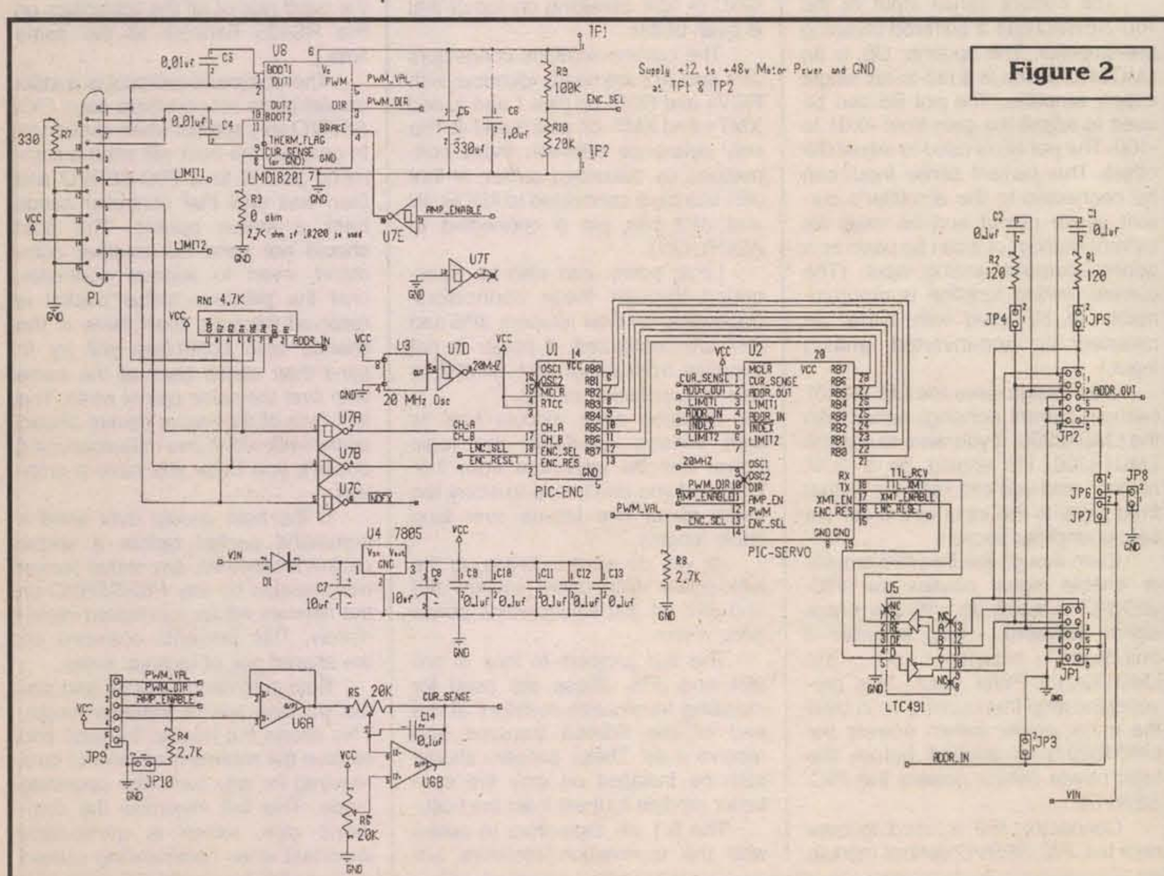


Figure 2

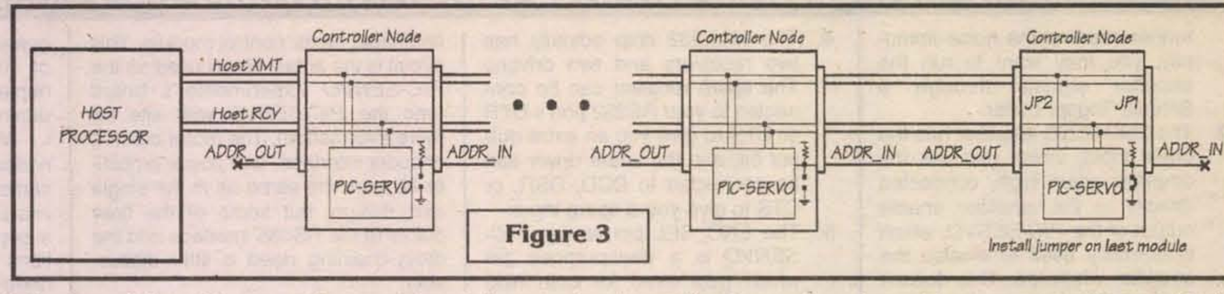


Figure 3

SERVO command set is used to change the address to a different value from the default. When this command is issued, the chip will then lower its ADDR_OUT signal.

Figure 3 shows how ADDR_IN and ADDR_OUT are used to initialize several daisy-chained *PIC-SERVO* controllers with unique addresses. On power-up, only the last *PIC-SERVO* in the chain — with its ADDR_IN line tied low — will be enabled for communications. The first command issued by the host will be to change the address of device 0 from 0 to 1. The end *PIC-SERVO* will become device 1 and then enable the communications of the adjacent *PIC-SERVO* by lowering its ADDR_OUT. This adjacent *PIC-SERVO* will then wake up with device address of 0. The next command from the host will be to change the address of a device 0 from 0 to 2. This process proceeds until all of the *PIC-SERVOs* in the chain have been assigned unique addresses.

Furthermore, because each *PIC-SERVO* will always send back a status packet after it receives a command, the number of controllers can be determined dynamically by continuing to issue change-address commands until no status packet is received in return.

To support this dynamic daisy-chaining address scheme, jumper JP3 in Figure 2 should only be installed on the last *PIC-SERVO* control module in the chain. You will also notice that the two communications connectors, JP1 and JP2, are nearly identical, except for that one has pin 5 connected to ADDR_IN and one has pin 5 connected to ADDR_OUT.

Additional Resources

Complete information about the *PIC-SERVO*, including data sheets, application notes, ordering information, and test software for DOS and Windows (with C and Visual Basic source code) can be found at the *PIC-SERVO* web site:

http://users.aol.com/dcservo/picservo.html

This site also has details for making your own RS232-RS485 converter. In fact, for the really ambitious and entrepreneurial-spirited motor control hacker, this site even has complete copies of the Gerber files used for fabricating the *PIC-SERVO* Experimenter's board and the Z232-485 converter board. Knock yourself out.

All the parts for these two controller circuits, except for the *PIC-SERVO* chipset, can be ordered from Digi-Key. The *PIC-SERVO* chipset can be ordered from **HdB Electronics** (Phone: **1-800-287-9432**, Fax: **1-415-368-1347**). Bare circuit boards for the circuit in Figure 2 (the *PIC-SERVO* Experimenter's board) can also be ordered from HdB Electronics. *(Pre-assembled versions of this board are also available.)*

When interconnecting modules, the end module should have JP1 left open, with JP2 connected to JP1 of the previous module. The module closest to the master, or host, will have JP2 connected to the host's RS485 compatible serial port.

Other Points of Interest

Referring back to Figure 2, you will notice that all of the encoder signals are run through Schmitt-Trigger inverters and have pull-up resistors. Note that as long as the both CH-A and CH-B of the encoder are inverted, position counting will happen exactly as if neither of the signals were inverted.

Inverters were used rather than non-inverting buffers because I opted to invert the amplifier enable signal before feeding it into the LMD18201's brake input; the spare inverters were handy so I used them. (I also used one of the inverters to buffer the clock signal, although this probably wasn't necessary.)

The current sense input of the *PIC-SERVO* has a buffered inverting pre-amplifier. The op-amp, U6, is an LMC6492 which is a rail-to-rail single supply amplifier. The pot R5 can be used to adjust the gain from -0.01 to -100. The pot R6 is used to adjust the offset. This current sense input can be connected to the amplifier's current sense output and be used for current limiting, or it can be used as a general-purpose analog input. (The current limiting function is programmable to be used with either an inverted or non-inverted analog input.)

This design uses the LMD18201 (without current sensing) rather than the LMD18200. If you want to use the LMD18200, R3 should be a 2.7K resistor, and you can feed the output from pin 8 to the input of the current sense amplifier section.

Even though the inverted amplifier enable signal causes the *PIC-SERVO* to wake up with the brake signal activated, I also included a pull-down resistor on the LMD18201's PWM input. This prevents the amp from turning on in case the motor power (which powers the LMD18201) is applied before the logic power (which powers the *PIC-SERVO*).

Connector JP9 is used to connect the *PIC-SERVO* control module to an external amplifier for applications where the three amp continuous output of the LMD18201 is not beefy enough. The amplifier enable output appearing on this connector has an optional pull-down resistor (via jumper JP10) for external amplifiers which are enabled if the amp enable signal is left floating. This connector also has an input pin for the op amp section.

The motor connector, P1, has pins for the motor power, encoder inputs, limit switch inputs, and a pin pulled up to 5V with a 330-ohm resistor for driving the LED portion of an optical limit switch. If the motor is located more than a foot or so from the controller, care should be taken in the cabling to isolate the motor power wires from the encoder wires.

It is quite easy to pick up unwanted feedback loops if the encoder signals pick up too much noise from the motor power wires. At a minimum, the motor power wires should be twisted together and the encoder CH-A and CH-B wires each twisted with either GND or +5V Shielding on top of that is even better.

The communications connectors JP1 and JP2 are nearly identical, with RCV+ and RCV- on pins 1 and 2, and XMT+ and XMT- on pins 3 and 4. The only difference between these connectors, as described earlier, is that JP1 has pin 5 connected to ADDR_IN and JP2 has pin 5 connected to ADDR_OUT.

Logic power can also be transmitted through these connectors, depending on how jumpers JP6 and JP7 are configured. If power is not supplied from either JP1 or JP2, it can be supplied from JP8.

Because each module has its own voltage regulator, the logic power can be anywhere from 7.5-24V, and you don't have to worry too much about line losses over long cable lengths.

If you do want to break up the logic power distribution, jumpers JP6 and JP7 let you select which power goes where.

The last jumpers to look at are JP4 and JP5. These are used for installing termination resistors at the end of the RS485 transmit and receive lines. These jumpers should both be installed on *only* the controller module furthest from the host.

The 0.1 uF capacitors in series with the termination resistors are used to save power when no data is being transmitted. When the PIC-SERVO disables its transmit driver, however, a lingering charge on C1 may cause havoc with RS485 receivers with insufficient biasing, particularly at higher communications rates. If this is the case, C1 can simply be shorted out.

Communications Software

The full command set of the *PIC-SERVO* is a bit too involved to discuss here, but I can give you the basics of the communications protocol. Note that you will use the same protocol described here whether you are talking to a single-axis system, or if you are talking to a whole network of controllers.

The *PIC-SERVO* wakes up with a default baud rate of 19,200 bps. After initialization, the baud rate can be boosted as high as 115,200 bps. (The *PIC-SERVO* has a special group command format, described in the datasheet, which lets you change the baud rate of all the controllers on the RS485 network at the same time.)

The command protocol is a strict master/slave set-up where each *PIC-SERVO* only speaks when spoken to. In general, the host will send a command packet to a *PIC-SERVO* and then wait until that controller sends back a status packet. The host should not send out another command, even to another controller, until the previous status packet is received because then there is the chance both controllers will try to send their status back at the same time over the same pair of wires. The first byte of the status packet should come back within one millisecond; if it doesn't, you know you have a problem.

If the host should ever send a command packet before a status packet is received, any status packet transmission by any *PIC-SERVO* on the network will be terminated immediately. This prevents collisions on the shared pair of receiver wires.

Both command packets and status packets are of variable length. This allows the host to transmit and receive the minimum amount of data required for any particular operating mode. This will maximize the command rate, which is particularly important when commanding splined

Parts List for Single-Axis Controller

U1, U2	*PIC-SERVO* chipset
U3	MAX232 transceiver
U4	LMD18200 PWM amplifier
U5	20 MHz TTL/CMOS oscillator
C1-C4	10 uF electrolytic capacitor
C5, C6	0.01 uF monolithic capacitor
C7	1.0 uF monolithic capacitor
C8	330 uF electrolytic capacitor
C9-C12	0.1 uF monolithic capacitor
R1-R4	1/8W resistor (assorted values)

Parts List for Multi-Axis Control Module

U1, U2	*PIC-SERVO* chipset
U3	20 MHz TTL/CMOS oscillator
U4	7805 +5V voltage regulator
U5	LTC491 RS485 transceiver
U6	LMC6492 rail-rail op-amp
U7	74HCT14 Schmitt-Trigger inverter
U8	LMD18201 PWM amplifier
C1, C2	0.1 uF monolithic capacitor
C3, C4	0.01 uF monolithic capacitor
C5	330 uF electrolytic capacitor
C6	1.0 monolithic capacitor
C7, C8	10 uF electrolytic capacitor
C9-C14	0.1 monolithic capacitor
R1, R2	120 ohm, 1/4W resistor
R3, R4, R8	2.7K, 1/8W resistor
R7	330 ohm, 1/8W resistor
R5, R6	20K pot
R9	100K resistor
R10	20K resistor
RN1	4.7K, 8 pin resistor network

motions.

All command packets consist of the following bytes:

Header byte (0xAA)
Address byte
Command byte
Data bytes (0 -15 depending on the command)
Checksum byte

The header byte is always sent at the beginning of a command packet to help synchronize communications between the host and the *PIC-SERVO*. When the *PIC-SERVO* is expecting to receive a new packet, it will throw out all incoming bytes until it sees a header byte. It will then interpret the data following the header byte as a command packet.

Each *PIC-SERVO* can have an address of 0-255 which is set as described earlier. Each controller will only respond to command packets where the address byte matches its own address. All other command packets will be received, but ignored.

The command byte is broken up into an upper and lower nibble. The lower nibble is the command number between 0 and 15. The upper nibble contains the number of additional command bytes required by that particular command number.

For example: The command to set the PID servo gains requires 13 additional data bytes, the command to change the baud rate requires only one additional byte, and the command to reset the position counter requires no additional data bytes.

The *PIC-SERVO* will always try to read the specified number of data bytes, independent of however many are actually required by the given command. The reason for this is that we may wish to communicate with devices other than the *PIC-SERVO* on the same RS485 network.

For example: A data acquisition system designed to work on the same network may know nothing about *PIC-SERVO* commands, but it still must read in the proper number of bytes in order to maintain synchronization. Likewise, the *PIC-SERVO* will know nothing about the commands for other devices, but is still required to read in a complete packet's worth of bytes.

The last byte in a data packet is an eight-bit checksum of all of the previous bytes in the packet *except* the header byte. If this checksum does not match the checksum computed by the *PIC-SERVO*, the command will not be executed, but a communications error bit will be set in the returned status packet. Note again that only the *PIC-SERVO* with the matching address will send back a status packet in the event of a checksum error.

The status packet returned by the *PIC-SERVO* consists of the following bytes:

Status byte
Status data bytes (0-14)
Checksum byte

The status byte contains basic information about *PIC-SERVO*, including a communication error flag, a move done flag, assorted error flags, and limit switch input values. The additional status data bytes may include a variety of additional data including the current motor position, the current Motor velocity, the A/D value, etc. Exactly which data is included in these additional status bytes is programmable by the host.

For example: A tracking application may require the current position to be returned with every command, but velocity, A/D value, and home position may not be required. Once the required status data bytes are specified (using a define-status command), they will be returned after every subsequent command, even if that command had a checksum error.

The details of commands for the *PIC-SERVO* can be found in the *PIC-SERVO* datasheet, along with the particulars for initializing devices, sending commands synchronously to groups of controllers, status data options, etc. In general though, there are commands for initializing the address and baud rate, reading and defining status packet data, loading motion parameters and starting motions, loading PID servo parameters, stopping the motor in various modes, resetting the position counter and status bits, and homing and I/O commands.

Other Network Devices

As mentioned earlier, the communications protocol was designed so that devices other than the *PIC-SERVO* can be operated on the same network. In fact, I have built data acquisition boards, multi-function I/O boards, and even a simple sound board, which all operate quite nicely on the same cable as the *PIC-SERVO* controllers. Unlike other RS485-based networks (like the CAN bus), the *PIC-SERVO*'s full-duplex network protocol is much simpler and can be easily implemented for any eight-bit microcontroller, even with only a software UART.

The only commands which must be supported by all controllers are the set-address command, the set-baud command, the hard-reset command, and the command to read the controller device type. **NV**

*The PIC-SERVO chipset was designed by **J. R. Kerr Prototype Development** to support industrial development projects in robotics and machine design. The PIC-SERVO chipset, as well as a low-cost experimenter's board, are now available as products. Please visit http://users.aol.com/dcservo/picservo.html for complete documentation, application notes, sample schematics, and ordering information. You can E-Mail any questions about the PIC-SERVO to **DCSERVO@aol.com***

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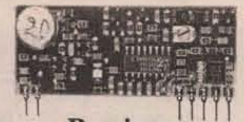


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Questions & Answers

TECH FORUM

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

QUESTIONS

Can someone give me information on building directional AM broadcast band antennas, or a simple antenna preselector/booster? I've seen a device called a Select-A-Tenna advertised and would like to home-brew something along these lines.

1971 **Gary De Pietro, Deltona, FL**
gary.depietro@dlbbs.com
gary.depietro@juno.com

I have a Uniden satellite receiver. Is it possible to capture weather signals from any satellite and send it to the TV? I would need a loop Yagi to get 1691 MHz and downcount to 137.5 MHz. Will this receiver do the job?

1972 **Richard Trowbridge, Tucson, AZ**

I have a nice little laptop sharp PC 5500 (Model #5541). It's old, but dear. I wonder if it can be upgraded either CPU, memory, or anything. I have tried to obtain a manual from Sharp, but they sent the wrong one. Does anyone have a similar model? It works off 10 nicads (at 1.2 volts), but the supply feeds it 17 volts. Why the higher voltage?

1973 **Jim Wiggins, Atlanta, GA**

What's the simplest, reliable method of sensing a load to make a gasoline 120-volt generator throttle up, then to come back to idle when the load is removed. There is 12 volts present when the power plant is in idle mode. What circuitry would this require?

1974 **John W. Jones II, El Dorado Springs, MO**

I would like information on how to use the WWV time signal that is broadcast on 25 MC to set a digital clock each time it receives the signal.

1975 **W. Schopp, Livermore, CA**

When tuning in stations, my AM/FM radio integrated receiver started fading, then returning to normal. There is also lots of static. The antenna checked out okay. What is the problem?

1976 **S. Palaski, Crestline, CA**

I recently bought a used Identity Systems Technology, Inc. hand scanner, part #GS8-Rev. #114 ID SCAN GS8.01. I need the card and software to make this thing work. I can't find IST on the Net. Any ideas on how to interface it? Any information would be helpful.

1977 **Jim Poelstra, Stockton, CA**
E-Mail: jimpolstrami@juno.com

In the Sept. '96 issue you ran an article on the repair of PC power supplies. In the PC power supply, there is also a POWER OK signal which is sent to the motherboard, or received from the motherboard(?). I assume it originates in the power supply.

Just what is the characteristics of that signal, and how does one simulate it if they want to use a power supply which either doesn't have that POWER OK capability, or the POWER OK circuit is faulty.

1978 **Joseph A. Dickerson, Baltimore, MD**

ANSWERS

ANSWER TO #12964 - DEC. 1996

Every gel-cell I've encountered uses good old fashion lead/acid technology, with a modern gelled electrolyte. A 12V gel-cell has the same charging characteristics as a common automobile battery. The internal resistance of the battery will limit the charging current of the cell.

As long as Mr. Delany's alternator is functioning correctly, no additional regulation should be required for charging the gel-cells. The simplest connection would be directly to the car batteries terminals. A 12V gel-cell has a voltage of 13.8V when fully charged, the same as a car battery.

I've float charged my gel-cells on the output of my 13.8V/35A power supply constantly, and when I want to take them mobile, I float charge them from my car's cigarette lighter. I've done this for over two years without any damage to my gel-cells.

Darryl Gibson
via Internet

ANSWER TO #12967 - DEC. 1996

You can't run this motor on the specifications you mentioned because the windings in the motor are wound for a different impedance.

The purpose of the 400 cycles is to reduce the amount or size of the windings necessary. The faster rate of cycle lowers the resistance for a given, while maintaining the same amount of power output.

Applying a slower frequency such as 60 Hz will overheat the windings while producing less power, and the motor may not run at all.

Rewinding the motor is impractical because purchasing a replacement motor is far cheaper.

Making a solid-state 400 Hz inverter is only practical if this application warrants it, and the only inexpensive alternative is a WW2 surplus inverter which is commonly referred to as a Dynamo or Dynamotor.

This inexpensive unit can be purchased through surplus companies such as Fair Radio Sales in Lima, OH, and are usually less than $30.00.

These units usually consist of 12 or 24 VDC motor attached to an alternator which spins at an exact rate, and the alternator, in turn, produces 400 cycles at the desired AC voltage. Each unit has a maximum amperage and voltage rating while maintaining 400 Hz. Choose a unit that has more amps and volts than necessary. You can lower the input voltage to the Dynamo slightly for a voltage adjustment as long as you don't go overboard and smoke the windings.

Unfortunately, a variable output voltage to control the RPM on your motor is impractical due to the three phase requirements of your motor. You can purchase a three-phase chopper circuit similar to a light dimmer and install it on the Dynamo output, but because these units consist of two perfectly matched single units, they are usually very expensive. A three-phase chopper will lower the voltage while maintaining the 400 cycles.

I use a miniature Dynamo to operate my gyroscopes and power this unit from my wall socket using a 120 volts light dimmer, diode bridge, and capacitor to achieve the 24 DC volt input to the Dynamo. Varying the unit's input by ±20% hasn't caused any adverse effects to either the Dynamo or the gyro which spins at over 50,000 RPM.

Chris
Bieber, CA

ANSWER TO #12963 - DEC. 1996

First, in direct answer to your question, there is no book that I am aware of that will give you hook-up techniques for your situation. Most people have manuals that come with each piece of gear when purchased that show them the proper usage and installation requirements to enjoy their devices.

To assist you with your situation, the following explanation is given. It seems like you wanted to record tape and play tape on your VCR at the same time. This is not possible. Then it was not stated in what fashion you wanted to operate. That is, did you want to watch a broadcast television station and record a satellite program or record a broadcast television program and watch a satellite program?

You did not describe the connec-

ANSWER INFO

- Include the question number that appears directly below the question you are responding to.
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All questions should relate to one or more of the following:
1) Circuit Design 3) Problem Solving
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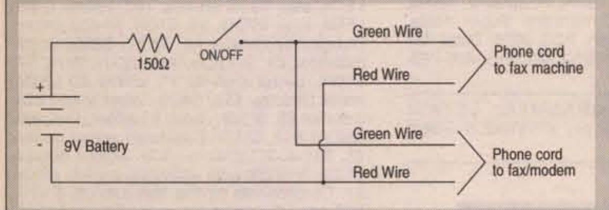
- No questions will be accepted that offer equipment for sale or equipment wanted to buy.
- Selected questions will be printed one time on a space available basis.
- Questions may be subject to editing.

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

TECH FORUM

ANSWER TO #12962 - DEC. 1996

Your hunch that a little money could be saved by building your own fax machine to PC fax/modem interface is correct. The following circuit will do the job at a very minimal cost:



The ON/OFF switch is not required if the interface is disconnected when you're finished scanning. The black and yellow phone cord wires are not used.

I have successfully used this interface with a Brother InstaFax 300, Sharp FO-510, and Tandy 1500 fax machine to scan graphics and text into my PC. The software I use is Windows Procomm Plus Ver. 2.0. The scanning procedure is very simple. Set the fax resolution and prepare to transmit the document as you normally would, select "Receive Fax Now" from the fax pull-down menu, and lift the handset and push the start button on the fax machine. With some fax machines you may need to key in a phone number before they will transmit.

John McMichael
Laramie, WY

tion capabilities of your equipment, so I will make some assumptions. It would be best if you had two separate input connections to chose from on your television. Let's assume you don't. The easiest way to approach this is split the output of both your broadcast feed and your satellite feed. Hook one of each to two A/B type switches. One switch will feed the VCR and the other will feed the TV. The problem then arises on how to view the recorded material. You would need a third A/B switch for the input to the TV to select from either the VCR feed or the "antenna" feed. WIth this combination of switches you can do all you wish. The only drawback is all the additional wiring and switch signal losses.

A simpler method would be using a newer television that has two or more antenna/source connections that can be viewed independently. This would eliminate at least one of the three switches above. Even simpler would be to own a second VCR and the multiple input television. Then wiring would remain simple and you could record anything to your hearts content.

Mark Hanz
Houston, TX
mhanz@wt.net

ANSWER TO #12965 - DEC. 1996

You can find lightening arrestors by calling most amateur radio dealers. One would be Amateur Electronic Supply, 1-800-558-0411. They stock lightening arrestors and are affordable.

Mark Hanz
Houston, TX
mhanz@wt.net

ANSWERS TO #12966 - DEC. 1996

I'm assuming the spindle and not the reel is missing and so aside from getting new or used parts from somewhere, with the help of a good mechanic or tinkerer, you can replace the take-up spool with a motor out of an old VCR and adapt it as a take-up spindle either directly or via a belt drive.

The problem with the take-up spindle is that it has to feed at a higher rate than the tape speed because the reel speed varies according to the amount of tape on it. Consequently, you need a very weak motor which attempts to spin too fast while not adding any significant pull to the tape because any excess pull will speed up the feed rate of the tape, and thus change the recording or playback speed. In essence, it slips like a clutch and continually tries to accept more tape than is available, while not pulling at the tape too hard.

VCR motors are perfect for this job because they do the same function in the VCR and draw very little power.

Chris
Beiber, CA

Many radio stations use reel-to-reel tape recorders for program production. You might try contacting the engineer at your local station to see where he obtains parts. He might even have some parts that he could sell or give to you. He may also know a good source for reel-to-reel tapes. If not, Radio Shack stocks 5" take-up reels (cat. no. 44-278), 7" reels (44-279), and 5" tapes (44-1883), plus 7" tapes (44-1884).

Packet modems for the Commodore 64 are available through the special order catalog at Radio Shack (11264678) as a kit. The case is part #11264686. Other sources have this modem also.

Steven Vail
Martinsville, IN

ANSWER TO #12968 - DEC. 1996

Nuts & Volts may have the solution to your remote control application. In the Dec. '96 issue, check out the Street Smart Security ads on pages 34 and 102. On page 80, Inventive Solutions is selling schematics and documentation for remote control RF and IR transmitter and receiver boards for $5.00.

John McMichael
Laramie, WY

MANUALS/SCHEMATICS WANTED

WANTED: COLLINS Radio Company literature. Jim Stitzinger, 805-259-2011, FAX 805-259-3830.

WANTED: MANUAL for Dana 5005/5006 digital multimeter. Phone/fax 505-988-5233.

WANTED: DIAGRAMS for radio frequency heating equipment. Induction, dielectric, plastic, microwave. YOUNGSON's, INC., 6701 Melrose Ave., Louisville, KY 40216. 502-448-6228.

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WANT: OPERATING and programming manuals for TI-59 printing calculator and PC-400 printer and blank and programmed cards. Manual for Heath 10-4550 scope with electrical diagram. Weitermann, 3737 Oakwood, Hubertus, WI 53033. 414-628-4321 evenings.

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WANTED: DELCO RADIO. Disabling sequence/factory back-up code for disabling theftlock on my Delco radio/CD model no. 16163141. Also schematics for repair of above radio and other Delcos. '58 Mike, PO Box 921, Midlothian, IL 60445. 708-389-2493.

WANTED: TEST EQUIPMENT SERVICE MANUALS! And catalogs, for HP, Tektronix, Fluke, etc. Pepper Systems, 214-353-0257; 214-902-9511 FAX.

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Honolulu 96814

IDAHO
Hi-Tech Surplus
605 E. 44th St.
Boise 83714
The Current Source
5159 Glenwood
Boise 83714

ILLINOIS
City Newsstand
4018 N. Cicero
Chicago 60641
Pick's Electronics
Lewis Park Mall
Carbondale 62901
Tower Records/Video/Books
383 W. Army Trail Road
Bloomingdale 60108
2301 N. Clark St. #200
Chicago 60614
1209 E. Golf Road
Schaumburg 60173

INDIANA
Harbourtown Sales
108 Park 32 West Dr., #D
Noblesville 46060

KANSAS
Lloyd's Radio & Electronic, Inc.
220 W. Harry St.
Wichita 67213

LOUISIANA
Gameforce Central HQ
13623 Hooper Rd. #CA
Baton Rouge 70818
Lakeside News
3323 Severn Ave.
Metairie 70002
Tower Records
408 N. Peter St.
New Orleans 70130

MARYLAND
Keep In Touch Communications
700 Mace Ave., Store B
Baltimore 21221
Silicon Valley Electronics
2014-A Industrial Drive
Annapolis 21401
Tower Records/Video
2566 Solomons Island Road
Annapolis 21401
1601 Rockville Pike #210
Rockville 20852

MASSACHUSETTS
Tower Records #172
360 Newbury St.
Boston 02115

MICHIGAN
Family Electronics
111 E. Superior St.
Alma 48801
Little Professors Book Center
22174 Michigan Ave.
Dearborn 48124
MW Electronics
229 E. Michigan Ave.
Paw Paw 49079
Purchase Radio Supply, Inc.
327 E. Hoover Ave.
Ann Arbor 48104
Tower Records
1214 S. University Ave.
Ann Arbor 48104

MINNESOTA
Radio City, Inc.
2633 County Road 1
Mounds View 55112

MISSOURI
Accurate Instruments
11201 E. 24 Highway
Independence 64054
Electronics Exchange
8644 St. Charles Rock Road
St. Louis 63114
Stewart & Associates
204 Sonderen St.
O'Fallon 63366

NEVADA
Amateur Electronic Supply
1072 N. Rancho Drive
Las Vegas 89106
Less Buster's Electronics
2930 N. Las Vegas Blvd. VSTG-22
North Las Vegas 89030
Radio World
1656 Nevada Hwy
Boulder City 89005
Tower Records/Video
4580 W. Sahara Ave.
Las Vegas 89102
6450 South Virginia
Reno 89511

NEW JERSEY
JR Tech Systems
1309 Highway 71
Belmar 07719
Tower Records
809 Route 17 South
Paramus 07652

NEW YORK
All Phase Video Security, Inc.
70 Cain Drive
Brentwood 11717
Ham Central
3 Neptune Road
Poughkeepsie 12601
Hirsch Sales Corporation
219 California Drive
Williamsville 14221
Tower Records/Video
105 Old Country Road
Carle Place 11514
350-370 Route 110
Huntington 11746
1961 Broadway
New York 10023
383 Lafayette St.
New York 10003

OHIO
Compustuff
2751 Medina Road
Medina 44258
Dayton Software
3903 Wilmington Pike
Kettering 45429
Digital One
7603 Mentor Ave.
Mentor 44060
Footsteps
4925 Jackman Rd. Store #58
Toledo 43613
Hosfelt Electronics, Inc.
2700 Sunset Blvd.
Steubenville 43952
Keyways, Inc.
611 S. Main St.
Miamisburg 45342
Leo's Book Shop
330 N. Superior St.
Toledo 43604
Magazines & More
26880 Brookpark Rd Ext.
North Olmsted 44070
Powermaxx, Inc.
1587 U.S. Route 68 North
Xenia 45385

OREGON
News & Smokes
2295 W. Main St.
Medford 97501
News & Smokes #8
259-C Barnett Road
Medford 97501
Norvac Electronics
7940 SW Nimbus Ave. Bldg. 8
Beaverton 97005
960 Conger
Eugene 97402
1545 N. Commercial NE
Salem 97303
Powell's Technical Bookstore
33 NW Park
Portland 97209
Tower Books
1307 NE 102nd Ave.
Portland 97220

PENNSYLVANIA
Lehman Scientific
2997-F Cape Horn Road
Red Lion 17356
Penn Electronics
2310 A Walnut St.
Harrisburg 17103
Surplus Al
RR 1 Box 337
Hunlock Creek 18621
Tower Books
425 South St.
Philadelphia 19147
Tower Records
340 W. Dekalb Pike
King of Prussia 19406

SOUTH CAROLINA
555 Electronics
5646 Farrow Road
Columbia 29203

TENNESSEE
Tower Books
204 West End Ave.
Nashville 37203

TEXAS
Electronic Parts Outlet
3753-B Fondren Rd.
Houston 77063
Tanner Electronics
1301 W. Beltline #105
Carrollton 75006
The Communication Source
2713 Galleria Drive
Arlington 76011
Tower Records
2403 Guadalupe
Austin 78705

UTAH
Omega Electronics
1500 North 150 West
Provo 84604

VIRGINIA
Electronic Equipment Bank
323 Mill Street NE
Vienna 22180
Riley's Distributing
1045 Edom Road
Harrisonburg 22801
Satellite Headquarters
7920 Timberlake Road
Lynchburg 24502
Tower Records/Video/Books
4110 W. Ox Road #12124
Fairfax 22033
1601 Willow Lawn Drive
Richmond 23230
8389 E. Leesburg Pike
Vienna 22182
VA Ham Radio Supply, Inc.
2208 Childress Rd.
Christiansburg 24073

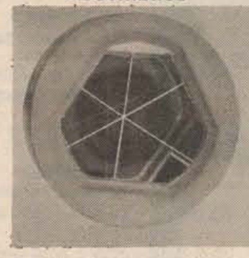
WASHINGTON
A-B-C Communications, Inc.
17541 15th Avenue NE
Seattle 98155
Amateur Radio Supply Co.
5963 Corson Ave. S. #140
Seattle 98108
Supertronix
18650 68th Avenue South
Kent 98032
Tower Books
10635 NE 8th St.
Bellevue 98004
20 Mercer St.
Seattle 98109
2501 S. 38th St.
Tacoma 98409

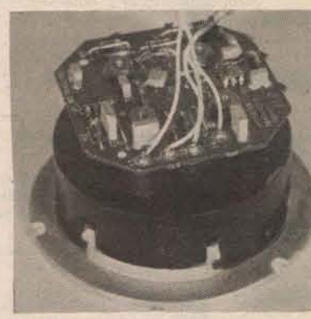
WISCONSIN
Amateur Electronic Supply, Inc.
5710 W. Good Hope Road
Milwaukee 53223
Little Professor Book Center
307 N. Bridge St.
Chippewa Falls 54729
News & Hobby Center
4758 Packard Ave.
Cudahy 53110

IMPOSSIBLE? SONY TRINITRON MONITOR 17" $175.00 RESOLUTION TO 1280 X 1024

REFRESH TO 75 HZ (NOT MULTISYNC) USED-LIKE NEW .25 DOT PITCH

Fascinating Corner Cube Prism Assemblies



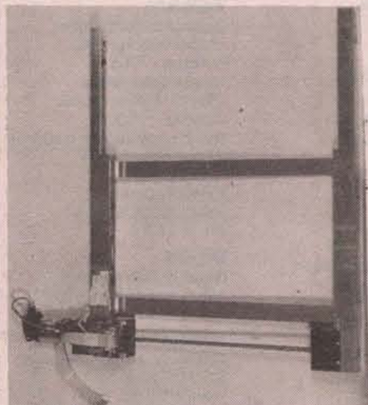


This is our most popular item. Originally used on Hewlett Packard workstations, it carries HP number 98789A. Brought back from their Singapore design center, they saw little use. We have sold over 500 of them. Available in several different configurations. **For Macintosh, with cables, fine tuned for Mac...$225.00.** Because this is not a Multisync monitor, we recommend that for **IBM compatibles** the monitor be used with the **Photon Torpedo graphics card.** We sell the combination for **$375.00** including the approprate cable. Experimenters can use the basic $175.00 Monitor on the IBM at one resolution only, by ordering a cable and sync adapter for **$50.00.** Shipping weight is 52 Lbs.

I also have Trinitron 20" monitors at $500.00. Similiar specs.

Aircraft type Nickel Cadmium Batteries. Vented construction for fast charging. Used surplus from commercial and military aviation, communications. Each cell is 1.25 Volts. Tested and guaranteed.

40 Amp-Hr.................$8.00 2 Lbs
23 Amp Hr...................$5.00 1 Lb
10 Amp-Hr...........$4.00 Postpaid
5 Amp-Hr.............$2.50 Postpaid



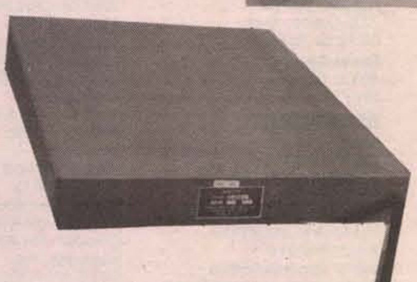
Linear Motion Mechanism. This consists of a pair of timing belts that move a cross slide. It is driven by a Maxon DC gearhead motor with a Hewlett Packard encoder. The assembly includes opto limit switches. 15" motion . 0.005 accuracy. Excellent for mat cutters, sewing machines, light machining...........**$99.00 Postpaid**

Linear Motion mechanism. Driven by Maxon motor shown below and timing belt. Steel rail with recirculating ball slide. About 4" motion. Opto limit switches.Suitable for small machine tools etc......**$59.00**

One of the most fascinating optical components. The corner cube (retroreflector) directs light precisely back to its source. Used by surveyors for distance measurements, planted on the moon by the Apollo astronauts, these beautiful gem-like prisms are usually priced in the $200-$300 price category. Two types are available:

1. 60mm diameter 5 sec accuracy, surveyor type, mounted with bolt hole in back. 20mm offset. **$49.00 Postpaid.**
2. Military assembly with corner truncated and electronic unit with IR filter mounted. If anyone knows what these were used for, please let me know. **$49.00 Postpaid**

Maxon DC Motor with gearhead and Hewlett Packard encoder. 7/8" Diam. Various gear ratios............**$39.00 PP**



Light table uses grid type flourescent tube. Requires Neon sign transformer to operate. **Closeout ...$30 PP**
Neon sign transformer 15KV.............$30.00 15 Lbs

Size 12" x 18"

DC Current Transformer Measure currents of up to 200 Amperes with no drop.

Nemec LTA 50P. Measures to 50A at 0.25% accuracy. Wire goes through toroid....**$10.00 Postpaid.**

Sealed Nickel Cadmium Rechargeable Battery Packs. These are new, but slightly outdated. Tested and guaranteed full capacity.

Military Starlight pack, 4.8 Volts 2.8 Amp-Hr (Shown)......$5.00 PP
DEC pack 10AA cells...$4.00 PP
Quantum pack 4 cells.$2.50 PP

Dear Readers,

Ordering from V&M Surplus is easy. No minimum order, no hidden charges, most items postpaid. Your satisfaction guaranteed, or your money back. I am an avid collector, right now I am looking for the following items: Norden Bombsight, M209 Converter (crypto-machine), K9 Ball Turret Sight. Cash or trade. *Franklin G. Fink*

Vision and Motion Surplus
222 Pleasant Street
Marlboro, MA 01752
1-800-471-0747, 1-508-485-3561

Sony XC37 Scientific grade Monochrome camera. 2/3 inch equivalent. With quality Computar 25mm lens. No weak or missing pixels. 12VDC. Free extension tube set. **Price reduced $229.00 Postpaid**

Calcomp 1044 "E" size plotter. Excellent condition with manual. **Sheet or roll paper..........$600.00**

Write in 127 on Reader Service Card.

Don Lancaster's

RESOURCE BIN

number sixty

Finding answers on the web.

Our usual reminder here that the *Resource Bin* is now a two-way column. You can get tech help, consultant referrals, and off-the-wall networking on nearly any electronic, *tinaja questing*, personal publishing, money machine, or computer topic by calling me at 520-428-4073 weekdays 8-5 Mountain Standard Time.

I'm now in the process of setting up my new *Guru's Lair* web site you will find at (where else?) *www.tinaja.com*

This is the place you go for instant tech answers. Among the many files in our library, you will find complete reprint sets for all of the *Resource Bin* and other columns.

You will get the best results if you have both *Netscape Gold* and *Acrobat Reader 3.0*. You download these from *www.netscape.com* or *www.adobe.com*

Getting Web Answers

This month, I was going to tell you about a few of my favorite web sites. But I've had so many calls and letters asking how to do web research, that I thought we'd first look into how you use the web to find useful info.

Nailing the goodies.

For instance, I just got a call from someone beginning a major university study on exactly how cellular phones interfere with hearing aides. Entering the key words of *cellular phone hearing aide interference* into *Alta Vista* quickly led to the definitive Swedish study on this subject.

Somebody else wanted to know all about formaldehyde litigation. This time *Deja News* gave us hundreds of useful results. A few of which end up hilarious. If you didn't happen to be the one in the barrel.

Or, in this case, the jar.

First off, note that the really superb stuff may not yet be net available. For somebody somehow has to pay for all top quality research.

Your "best" info traditionally comes from premium data bases. Each field has its name brand biggie or two. The doctors use *Medline.* Lawyers use *Lexus* or *Nexus.* Engineers often will start off by using *INSPEC.* Then may step over to *MathSci* or *Compendex.*

Librarians prefer *Bowker, Oxbridge,* or *Gale.* Accessing *Ulrich's Periodicals Dictionary, Books in Print,* that *Science Citations Index,* or else the *Encyclopedia of Associations.*

These premium data bases typically had to get accessed through fee-based online services, such as *Dialog* That do charge as much as $2.00 per minute. But often end up by far your fastest and cheapest way to get crucial information in a big hurry.

A fine pair of offline traditional info sources are *UMI* and *The Information Store*. These are your places to go for hard copy reprints of nearly anything. But you'll have to know the *exact* title, author, journal, and page.

Thanks to Adobe's new *Acrobat 3.0*, instant reprints that are faster, better, and cheaper are quickly being offered online by the thousands from many hundreds of sites. Freebie Acrobat 3.0 readers at *www.adobe.com*

NEXT TIME:
Don tells us all about his favorite world wide web sites.

More webmasters are discovering that they can get zillions of hits by up-front paying for and then distributing premium research. Material that is not available elsewhere on the net. As an example, free *Medline* access can now be found on a dozen web sites.

Even if they seem weaker, new and free services sometimes may cut into the traditional territory of all the one-time big players. For instance, *Books in Print* is not yet on the net. At least I have yet to find it. But *Amazon Books* has a free book search service which sometimes is "almost as good."

Let's look at a few key tools needed to get web answers ...

A Master Resource

There are several hundred sites that specialize in providing search engines and related web access tools. One of the best *meta* sites that I've found is *lookup.com* who have gathered up 74 of the best search engines all together in one place, at one time.

Iffen the right one don't git ya, the left one will.

I have got a link for this site on my *Guru's Lair* at *www.tinaja.com* — Links to other mentioned sites also show up here. Additional answer getting tools will often be found on the Guru's Lair *webmastering* library shelf.

The Yahoo Dice

The highest profile search engine is *Yahoo*, but I don't care for them. First, because it is way too painful to enter your own site into their registry. And second, because I'll usually get faster and better results elsewhere.

But one handy feature of Yahoo is their *dice icon* which will warp you somewhere in cyberspace, totally at random. I like to hit their dice at least 30 times a day. First, to get a full and accurate picture of what the net is all about. Second, to pin down sites I wouldn't have otherwise found.

The dice also gets you started on the *avalanche effect.* For most, any site will provide a *hot links* button, one which leads you into dozens or hundreds of new sites of potential use to you, and those sites direct you to yet thousands more. By linking the links, you should be able to waltz around cyberspace with a vengence. Theoretically, *any* site is less than a dozen mouse clicks away from a random selection.

Incidentally, these Yahoo dice also tell you a lot about the "severity" of all the porn on the net. I have found that something around one dice hit in 175, yields content someone might find offensive. Around one hit in 1374 is a real porno site. And fewer than one hit in 19,763 is a primo porno site.

At least that's the number of times so far that I have hit the dice without being able to find one. Let me know if you have any better luck.

A faster accessing mirror for these Yahoo dice is on *www.tinaja.com*

Whenever it comes to serious web searching, instead of picking Yahoo, I very much prefer ...

Alta Vista

You'll find a dozen or more

SOME TRADITIONAL RESEARCH TOOLS

Adobe Systems PO Box 7900 Mountain View CA 94039 (800) 833-6687	**Compendex** 1 Castle Point Terrace Hoboken NJ 07030 (201) 216-8500	**Information Store** 500 Sansom St #400 San Francisco CA 94111 (415) 433-5500	**Medline** 8600 Rockville Pike Bethesda MD 20894 (800) 638-8480	**Soc Am Scientists** 1549 El Prado San Diego CA 92101 (800) 873-8767
Amazon Books Box 80387 Seattle WA 98108 (800) 201-7575	**Dialog Info Svcs** 3460 Hillview Ave Palo Alto CA 94304 (415) 858-2700	**Inspec/IEEE** 445 Hoes Ln Piscataway NJ 08855 (201) 981-0060	**Nomadness Report** PO Box 2185 El Segundo CA 90245 (310) 322-1655	**Synergetics** Box 809 Thatcher AZ 85552 (520) 428-4073
Books in Print 121 Chanlon Rd New Providence NJ 07974 (908) 464-6800	**Encycl of Assns** 835 Penobscot Bldg Detroit MI 48226 (313) 961-2242	**Lexus/Nexus** 9443 Springboro Pike Dayton OH 45401 (513) 865-6800	**Oxbridge** 150 5th Ave #202 New York NY 10011 (212) 741-0231	**Ulrich's Dictionary** 121 Chanlon Rd New Providence NJ 07974 (908) 771-7714
RR Bowker 121 Chanlon Rd New Providence NJ 07974 (908) 464-6800	**Gale Research** 835 Penobscot Blvd Detroit MI 48226 (313) 961-2242	**MathSci** Box 6248 Providence RI 02940 (401) 455-4000	**Science Citation Index** 3501 Market St Philadelphia PA 19104 (215) 386-0100	**UMI** 300 N Zeeb Rd Ann Arbor MI 48106 (800) 521-3044

major Internet general search engines. With names like *Yahoo, Alta Vista, Matilda, Webcrawler, Magellan, Disinformation, Lycos, Excite*, or *Inktomi*.

Many of these go to the trouble of having an entire warehouse full of linked PCs that maintain a *complete* model of some 100 million web pages. These models create a back index of which words appear where.

When combined with *relevance* stats of how often your word appears how close to your other selected words, a quite fast and ultra powerful search ability usually results.

To use any search engine, you enter one or more keywords. These days, a keyword can be any word or number that appears in the document, not just a selection from a restricted list. The engine chomps on through everything it knows about the net and finds those pages with the highest number of hits on the most keywords.

You do have to carefully choose the keywords. Select too loose, and you'll find thousands of false hits. Too tight, and you will get nothing. Sometimes you have to find one useful hit to spot those real words that the authors will use for your target subject.

I guess I like *Alta Vista* the best. At least it is usually my starting point on typical searches. Deeply buried in my *www.tinaja.com* web site is a story on the *Mount Graham Aerial Tramway*, an utterly amazing engineering feat from the 1920s. I'll use this tram query string to find out how good an Internet search engine really is.

Alta Vista nails it in five seconds flat as numero uno on their hit list.

Whois and WhoWhere

How do you find out if a company has a web site? Or if an author has an E-Mail address? Several specialized net services ease these tasks.

Two examples are located at *Whois* and *WhoWhere*.

Whois is a service from the Internet registration service you should find at *www.internic.org.* — You can use *Whois* to find out whether a domain name is in use or to find the name and address of an existing domain name or to pin down the location of a company.

WhoWhere at *www.whowhere.com* is more people oriented. You enter their name in any order and back comes a list of exact matches, near misses, and at least one or more "pretty nigh, but not plumb" wild guesses.

Needless to say, if you are active on the net and want to be reached, it is essential that you go out of your way to make sure you get listed.

You'll also find an *Internet Address Finder* at *www.iaf.net* — Plus the *Domain Name Search* at *alfredo.wustl.eduhtbindomain_search?* — But, at least on all my tests, these two sites could not find a pig in a dishpan.

News Groups

A *newsgroup* is simply a collection of people who publically E-Mail each other via the Usenet. Newsgroups are places where you can post questions and get answers.

Typically, a newsgroup will have a single, tightly targeted interest. Such as the owners of 1987 tan Volkswagen 4WD non-Westy Synchro Vanagons having double diff locks but no Saint Bernards. You will find many tens of thousands of newsgroups.

Most newsgroups are *moderated*. A moderator is a person in charge who filters all the raw input into coherent text. Some moderators edit heavily; anything goes with others.

A moderator will often maintain a *FAQ*, or *Frequently Asked Questions* file or library. This allows somebody new to the group to pick up the basics and not have to ask a lot of very tedius and repetitive questions.

As you might guess, the quality of newsgroups varies all over the lot. A few promptly offer current and expert opinion. Sadly, others are plagued by totally irrational and juvenile flaming egomaniac newbies who flat out do not have the faintest clue. And, in the process of proving so, drive those real experts away.

Always remember that NET stands for *Not Entirely True.* Do *not* ever use newsgroup info as your sole source! Anybody posting to a newsgroup has an axe to grind. And a hidden agenda that almost always is not in your best interests. There is no peer review, nor any competence filtering.

Always be sure to independently check all newsgroup content! Newsgroups are intended to give you *possible* or even *probable* answers.

But *never* act on them without an independent check. Especially if the content is medical, financial, or legal in nature. Always verify.

Most newsgroups are free and open to anybody. Others require passwords and might involve charges. Typically, you E-Mail a usegroup using the word *subscribe* in the message. Or *subscribe digest* to get the summary transcript, rather than zillions of shorter ones. To get off a group, you'll typically put the word *unsubscribe* in your E-Mail. The main site header message often gives you specific details.

Let's look at three examples. Shawn Carlson's *Society of Amateur Scientists* has both a web site at *www.sas.org* and a newsgroup. To subscribe, E-Mail the word *subscribe* to *postmaster@sas.org.* — To unsubscribe, E-Mail the single word *unsubscribe.* This is one example of an *automated list robot.* To ask a question or provide an answer, you E-Mail your contribution to *talk@sas.org*

Steve Roberts is big on nomadics. His web site is *www.microship.com* — You subscribe to his newsletter by sending E-Mail to *wordy@qualcomm.com* — This is one instance of an unautomated, or a *personally handled request.*

Links to both of these sites can be found on *www.tinaja.com*

And to access the Vanagan Synchro stuff, you'll E-Mail a *subscribe vanogon firstname lastname* message directly to LISTSERV@lenti.med.umn.edu

Deja News and Friends

Exactly how do you find out which newsgroups are for you? Two useful resources are *Deja News* and *PAML.* The latter is an acronym that is short for *Public Accessible Mailing Lists.*

Which is a directory of some 12,000 newsgroups. Arranged alphabetically and by subject.

Once selected, specific details show up on who hosts the newsletters and how to subscribe. There's only a few hundred subjects, instead of a good in-depth search engine. For instance, you can quickly find *automotive,* but not search on *Synchro.*

Instead, your general power search tool is *Deja News.* You simply enter a search string, and Deja News returns *every* newsgroup message where all of your words appear. Either as a quick search on current contents or for an in-depth scan of older content.

Let's look at another example. I got this call the other day from a person who was looking for a schematic on an older PowerMate power supply. A call to PowerMate revealed that they flushed all their old docs.

Uh, this one is a rather specialized request. PowerMate products weren't all that popular. You could probably trace out the supply in a few minutes or fix it with a scope.

If you get on *Deja News* and look for *PowerMate,* you should get several hundred *false hits* on NEC computers, on strange vacuum cleaners, and even on Coleman generators. Oops.

All of my usual ploys of tightening the search or patiently mining their dregs for a gem or two did not seem to work this time.

So, you can use the *indirect method* instead. Get on *Deja News* and search for *Power Supply Schematic Wanted.*

Not surprisingly, nobody seems to have already asked about PowerMate products. You will get around 15 current hits and maybe a hundred or so on the backlist.

Of these, your most promising candidate sites are *sci.electronics.basics, sci.electronics.repair, sci.electronics.misc, sci.electronics.design,* and possibly over at *misc.industry.electronics.*

Your next step is to check out these groups for activity and relevance. You then post your question to the best of them. Chances are you should score an answer in a day or two. Provided, of course, that you post a concise and answerable question.

You do have to be careful what you enter as keywords. Too tight and you get no hits. Enter too loose and you'll get overwhelmed. You are also sure to find a lot of false hits. I was recently searching on *vacuum forming* and kept getting all sorts of returns on *fruitcake*. Which, I guess, is something that I've always suspected.

Putting my own name through Deja News also led to bunches of false hits. Apparently because the word "don't" is treated the same as "don."

Deja News also has a handy feature which can tell you exactly *where else* any particular individual happens to be posting messages. This can be real useful to evaluate the credibility of your new source and to lead you on to other interesting sites.

The Deja News web site is up at *xp9.dejanewsdnquery.xpPAML* is found at *www.NeoSoft.cominternet-pamlindex-index.html*

This Month's Contests

Let's have us a pair of contests this month. Tell me about a web searching or web access or web answer finding resource that I don't yet know about.

Or else finish this sentence for me: "You are spending too much time on the net if ..." For instance: "You are spending too much time on the net if the *Yahoo* dice keep repeating."

There will be a largish pile of my new *Incredible Secret Money Machine II* books going to the dozen or so better entries, plus an all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for two that will go to the very best of all.

Send all your written entries to me here at *Synergetics*, rather than to *Nuts & Volts* editorial. **NV**

*Microcomputer pioneer and guru Don Lancaster is the author of 33 books and countless tech articles. Don maintains his no-charge US tech helpline found at **(520) 428-4073**, besides offering all of his own books, reprints, and consulting services. Don also has two free catalogs full of his resource secrets waiting for you. Your best calling times are 8-5 on weekdays, Mountain Standard Time.*

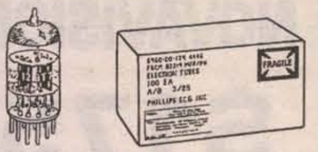
*Don is in the process of setting up his Guru's Lair at **http://www.tinaja.com***

*Full reprints and preprints of all Don's columns and ongoing tech support appear here. You can reach Don at Synergetics, Box 809, Thatcher, AZ 85552. Or send any messages to his US Internet address of **don@tinaja.com***

MISC. ELECTRONICS FOR SALE *cont.*

ELECTRONIC PARTS SALE: Carbide PC drills $0.30 ea. Mallory #FP433.3, 450V, Quad Lytics $3.75 ea. Mot. #MTP50N05E, 50A MOS-FETs (1-9) $1.55 ea., (10+) $1.25 ea. Mot. #MJ15024 & MJ15025 transistors (1-9) $1.75 ea., (10+) $1.25 ea. Gold plated dual 5 way binding posts (1-4) $2.25 ea., (5+) $1.85 ea. 25A/400V bridge rectifiers (1-4) $1.75 ea., (5+) $1.25 ea. Many other elec. parts. Call/send for free flyer. Hoffman Industries, 853 Dundee Ave., Elgin, IL 60120. Ph: 847-622-8201, Fax: 847-622-8202 (Visa, MC, Discover, Amex).

TUBES: RADIO and television 70 year collection, from 4 pins to compactors, new and used. Will test all first. Name your wants and what you want to pay. 718-531-5676.



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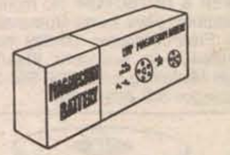

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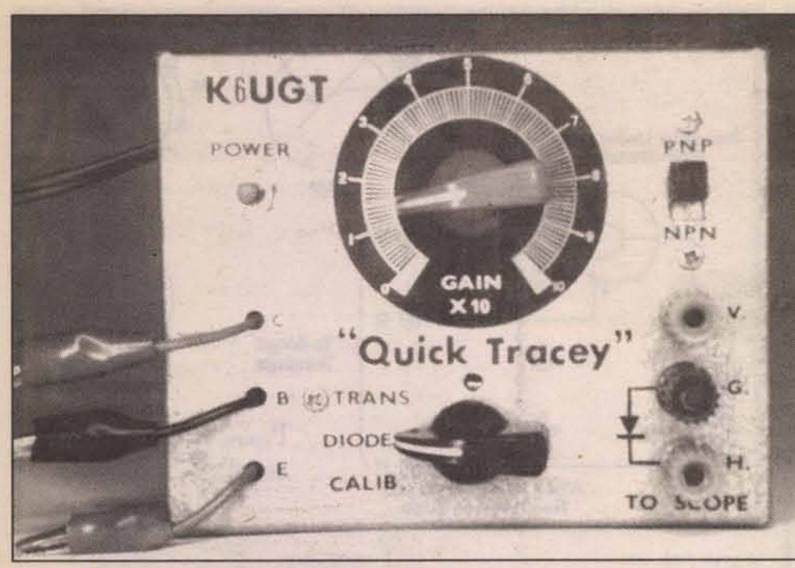


Quick Tracey Semiconductor Sleuth

by Fred Blechman

In the "lineup" were Danny Diode, Zachary Zener, Sammy Selenium, "Silly" Con Rectifier, Tommy Transistor, Usiah Unijunctlon, and Phineas Photoconductor. The problem: which one was the "bad guy?" Clearly a case for that surreptitious semiconductor sleuth, Quick Tracey ...

Using your oscilloscope and "Quick Tracey," it's a simple, quick job to wade through various types of "bargain" semiconductors and sort out the bad ones by interpreting a trace on your scope screen. Quick Tracey's regular "report" can include checking transistors for polarity (PNP or NPN), approximate gain, and linearity. Also, all tests are "dynamic" rather than "static," and will thus uncover some defects that static tests won't show.

When testing diodes, shorts or opens show up like the proverbial sore thumb; so does reverse polarity. On low-voltage zeners, not only will you be able to tell if they are good or bad, but you'll also be able to estimate their breakdown voltage. Even the less common semiconductors, such as unijunction transistors, tunnel diodes, and silicon-controlled-rectifiers, are cases easily handled by Quick Tracey. Costing under $20.00 to build from all new parts (and less if you have some common parts in your junk box), Quick Tracey even has its own built-in calibration circuit.

Modus Operandi

Figure 1 is the schematic of the complete Quick Tracey. Since this actually contains three circuits (calibrate, diode test, and transistor test) we have shown each circuit separately in Figures 2, 3, and 4 to simplify the explanation of circuit operation. Although Quick Tracey can be used without any understanding of the circuit theory, you'll find other uses for the unit if you are familiar with its "modus operandi" (that's Latin for "how da' t'ing woiks").

Figure 2 shows the power and calibration circuit. When pushbutton switch S1 is depressed, equal voltages appear across Rl and R2 (since they have the same resistance value), thus giving equal deflection voltages across the scope vertical and horizontal inputs. (The scope sweep selector must be set to "horizontal input" or "external sweep.") By proper adjustments of the scope vertical and horizontal gain controls, you will get a sloping 45 degree line on the screen. This, in effect, sets the scope controls for equal gain on the vertical and horizontal inputs.

IMPORTANT NOTE: The 45-degree slant shown in the Figure 2 illustration, leaning to the right, may lean to the LEFT on your scope. If this is so, then ALL your scope traces will be the opposite (mirror-image) of the illustrations in this article. This has to do with your scope's horizontal deflection (left-to-right or right-to-left), which varies with different manufacturers.

Figure 3 shows the diode test circuit. Think of the diode under test as a switch; when it's conducting (forward-biased), it's like a closed switch, and when it's reverse-biased, it's like an open switch.

Now when we apply 6.3 volts AC, we are alternately opening and closing this "switch" (the positive half-cycle forward biases the diode, the negative half-cycle reverse biases the diode).

When the diode is conducting, it's the same as if we had shorted the horizontal scope terminal to the ground terminal, and the full voltage appears across Rl. The scope shows only a vertical line under this condition. However, on the other hand, when the diode is not conducting, there is NO current flowing through Rl, therefore NO vertical deflection, but FULL horizontal deflection. (The scope, remember, draws only infinitesimal current at 60 cycles, 6.3 volts.)

When the recurrent half-cycles are combined in the scope trace, the pattern is half vertical and half horizontal for a perfect diode. The poorer the diode, the less perfect the pattern. Representative traces for typical cases are shown in Figure 3.

When testing a low-voltage zener diode, the horizontal leg will "break down" at some distance out from the junction if the zener is rated at less than 10 volts. Higher voltage zeners can only be checked on Quick Tracey for diode action, but not zener effect.

Poor diode back resistance shows up on the trace as a down-ward slanting of the horizontal leg; with poor forward conduction, the vertical leg slants to the right. Selenium rectifiers, for example, usually show a relatively high forward resistance, high-voltage drop (short vertical leg) and poor recovery characteristics (rounded junction of horizontal and vertical trace).

All testing done with the Quick Tracey is done at a very low power level; there is no danger in harming the unit under test. Even the touchy 1N23 microwave crystal diodes are undisturbed by Quick Tracey's investigation, although they do yield a peculiar trace (see Figure 3 microwave diode pattern). The 1N23 is a low-voltage, low-current diode, and the lower curved leg shows breakdown (though controlled, therefore not damaging) at the test voltage. Later on, we'll show you how to use the diode test circuit for other tests.

Figure 4 shows the PNP transistor test circuit. With a PNP transistor under test, the emitter has positive battery voltage applied through Rl, and the collector is at negative battery potential. However, unless there is current flow in the base-emitter circuit, only a very small leakage

Figure 1. Schematic diagram of Quick Tacey.

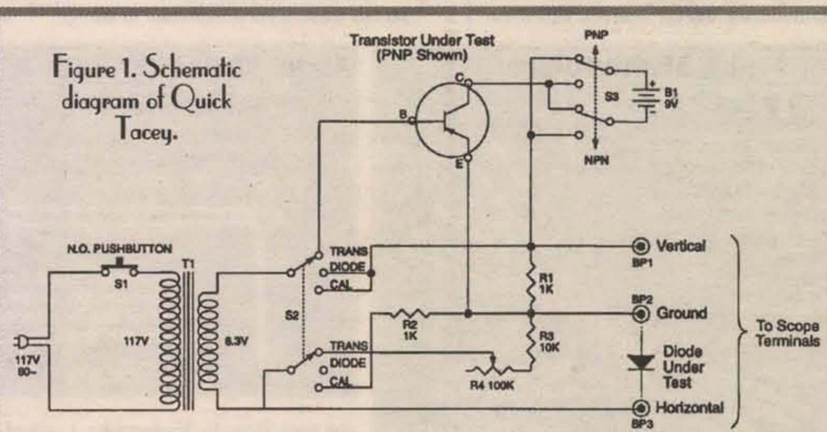
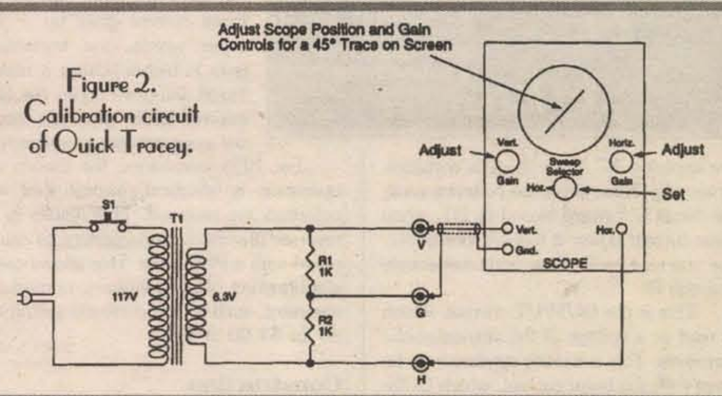


Figure 2. Calibration circuit of Quick Tracey.



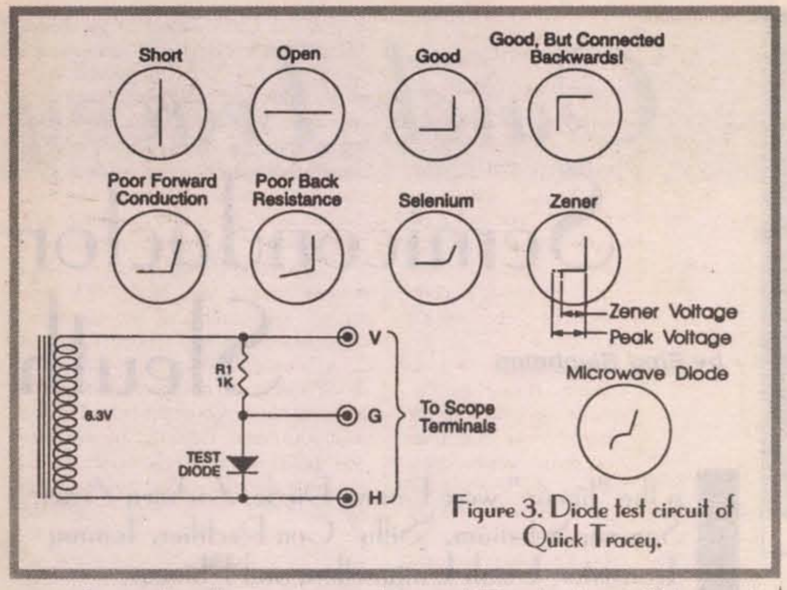


Figure 3. Diode test circuit of Quick Tracey.

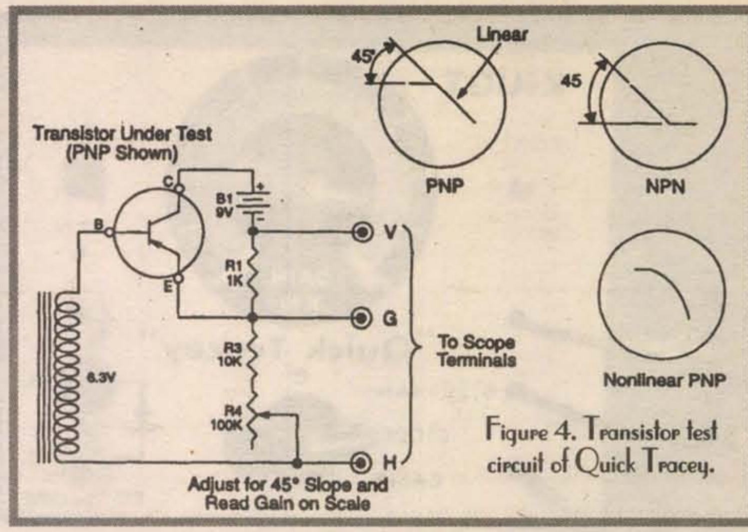


Figure 4. Transistor test circuit of Quick Tracey.

current flows in the collector-emitter circuit; that's what transistors are all about.

Notice that the base is directly connected to one side of the 6.3 volt AC supply, and the emitter is connected to the other side through R3 and R4. Therefore, whenever the alternate half-cycles make the emitter positive with respect to the base, emitter-base current flows through R3 and R4 (R3 is used for current-limiting when R4 is set at zero).

This current flow is measured as a voltage across R3 and R4 at the horizontal scope terminals, and is a measure of the transistor INPUT current. Since we are applying AC, this voltage is constantly varying. Now, since the collector-emitter circuit is forward biased by B1, when base current flows, it follows that collector current will flow simultaneously through Rl.

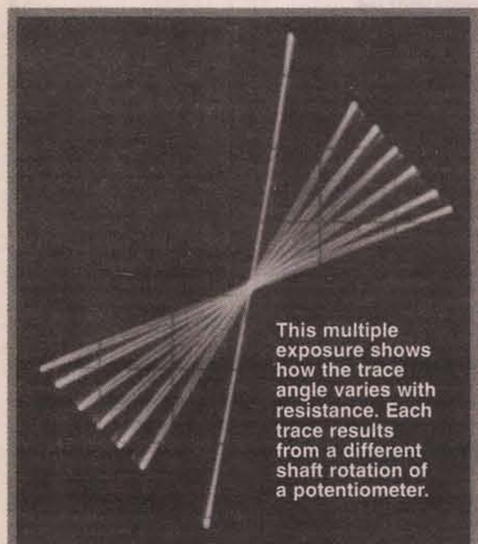
This is the OUTPUT current, which is read as a voltage at the vertical scope terminals. This is exactly synchronous (in step) with the input current, which CONTROLS the output current.

What does all this mean? Well, remember we calibrated the scope for equal vertical and horizontal deflection back in Figure 2, and now we use this fact to set our transistor-test scope trace slope to 45 degrees, using the R4 gain control. When the slope is 45 degrees, it means that the "input" and "output" VOLTAGES are equal. However, the voltages are dependent on the current flow through resistors Rl, R3, and R4.

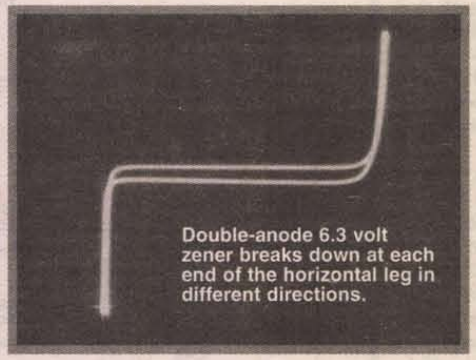
Remember Ohm's Law? If R4 is set at zero to get a 45 degree slope, then there is 10 times the current flowing through 1K output resistor Rl than flowing through 10K input resistor R3 to make their voltage drops equal. Plainly and simply, the output current is 10 times the input current, so the transistor has a "beta" (current gain) of 10.

As the value of R4 is increased to set the trace slope to 45 degrees, the ratio of output current to input current goes up — in other words, the transistor gain is higher. Using a numbered dial plate under the R4 control knob, you can read the approximate gain directly.

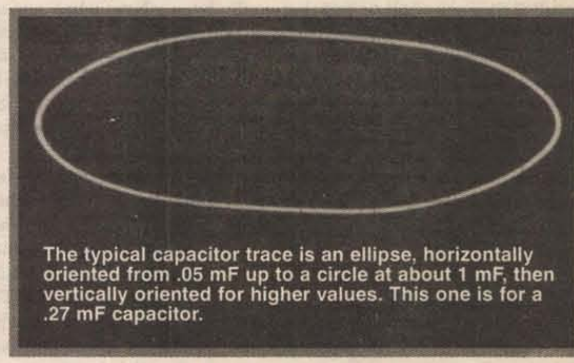
For NPN transistors, the theory of operation is identical, except that all polarities are reversed. This results in a reversed (inverted) scope pattern as compared with a PNP trace. This allows easy identification of an unknown, unmarked transistor, such as are currently selling at 20 for $1.00 or less.



This multiple exposure shows how the trace angle varies with resistance. Each trace results from a different shaft rotation of a potentiometer.



Double-anode 6.3 volt zener breaks down at each end of the horizontal leg in different directions.



The typical capacitor trace is an ellipse, horizontally oriented from .05 mF up to a circle at about 1 mF, then vertically oriented for higher values. This one is for a .27 mF capacitor.

Construction

The photos show our original unit — which, by the way, was built over 30 years ago and still functions perfectly! None of the wiring is critical, so you can decide which features you want to incorporate. You may have many of the parts in your junk box.

First of all, decide on the cabinet you will use. If you use an aluminum cabinet (the Radio Shack #270-239 should do nicely if you use a small transformer for T1), be certain that your 117 VAC input voltage is isolated from the cabinet.

Certainly, placing the gain control, polarity switch, binding posts, and function switch on the front panel are logical. The power switch (S1) could be a toggle or slide switch instead of the pushbutton specified in the parts list; we preferred a pushbutton to insure that the unit was OFF except when actually viewing a trace.

Various transistor sockets could be wired in parallel instead of the three alligator clip leads. A screw-type terminal strip could replace the five-way binding posts. Any 6.3-volt transformer will do; we used the least expensive one we could find. If you can't find a 6.3-volt transformer, use half of a 12-volt center-tapped transformer, such as a Radio Shack #273-1365.

Function switch S2 is any two-pole three-position type — rotary or slide; you can use three positions of Radio Shack's #275-1386 two-pole six-position rotary switch. The battery, a standard transistor radio nine-volt type, is held to the case with a home-made bracket made from a thin 1.5" by 2" piece of scrap aluminum.

The battery connector was salvaged from a dead battery of the same type. A terminal strip was used to anchor the alligator clip leads, and another terminal strip to anchor the power cord and transformer input leads. With the push-to-test power switch, a pilot light is not necessary.

Dry transfer labels or decals complete the job. NOTE: You may have a problem finding the nice dial plate shown in the photo (30 years ago they were readily available), but you can instead easily mark the front panel with decal numbers or make a paper dial plate.

Sleuthing With Quick Tracey

CALIBRATION: Regardless of whether you're "investigating" diodes, transistors or whatever, you must first calibrate the unit. Plug the line cord into a 117V, 60 cycle source and connect the scope as shown in Figure 2. Be sure to set the scope sweep selector to the horizontal input. Put S2 in the "Calibrate" position and depress power switch S1.

A slanted line will appear on the scope screen; adjust the vertical and horizontal gain and position controls until this line is in the center of the screen, at a 45 degree angle, and filling about two-thirds of the screen diameter. You are now calibrated for equal vertical and horizontal voltages at the Quick Tracey output terminals. As mentioned earlier, the line may slant in the opposite direction, in which case, all other test traces will be flipped horizontally.

DIODES: To test a diode or rectifier, connect it between terminals G (ground) and H (horizontal), with the cathode connected to H, as shown in Figure 3. Put S2 in the "Diode" position. The trace tells the story when Sl is depressed. Compare your pattern with the typical traces shown in Figure 3.

Connecting the diode backwards will give you an inverted trace, which

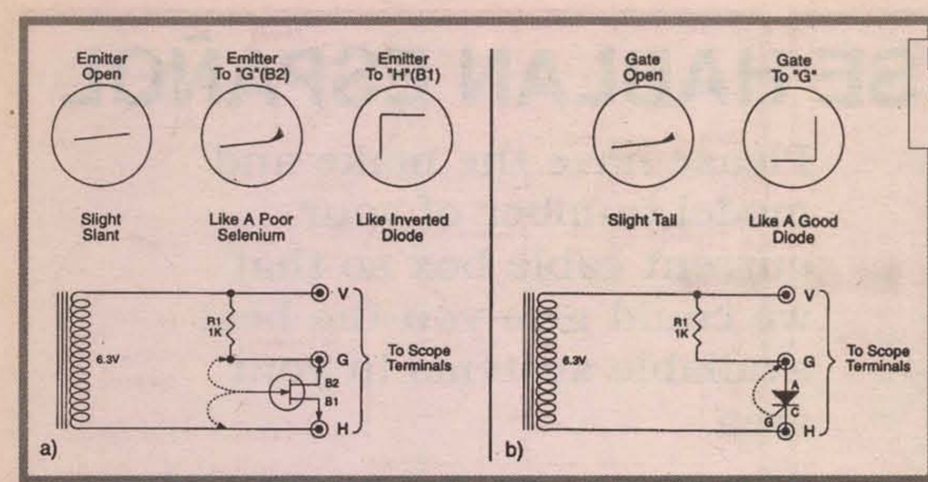
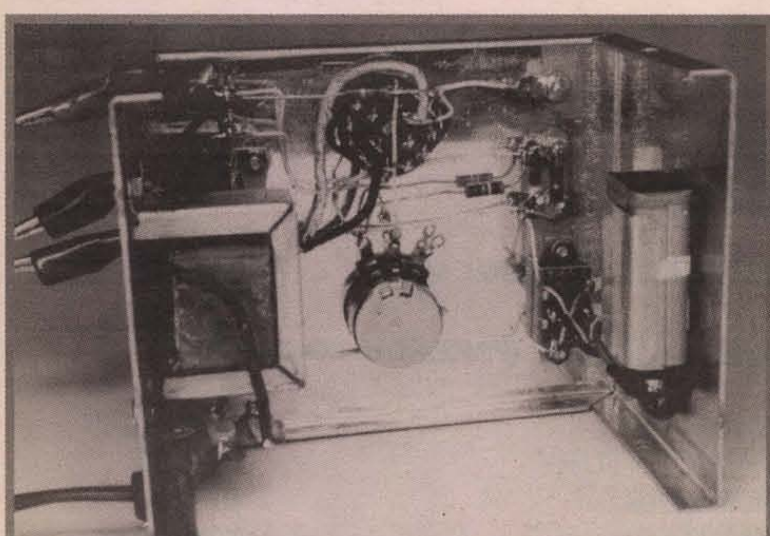


Figure 5: a) Unijunction transistor test; b) silicon-controlled rectifier test.

allows you to determine the cathode of unmarked diodes. Zener breakdown voltage can be estimated as a proportion of 10 volts by measuring the distance of the breakdown point from the junction, as compared to a regular diode (Figure 3 zener pattern).

Shorted or open diodes are instantly spotted by the straight vertical or horizontal line. Selenium rectifiers usually have a rounded junction and a slanted, shorter vertical leg. Tunnel diodes (where as the voltage increases, the resistance increases, then decreases, then increases again) show a distinctive double-curve trace.



Although there is not much inside Quick Tracey, the reflections from the mirror finish make it look like there is. The nine-volt battery is held to the side of the box with a simple homemade aluminum bracket.

TRANSISTORS: Connect the collector, base, and emitter transistor leads to the C, B, and E of Quick Tracey. Put the polarity switch S3 in the more common NPN position, unless you know for sure that you are testing a PNP transistor. Put function switch S2 in the "Transistor" position. When S1 is depressed, you should get a sloping pattern with a flat bottom section. Adjusting Quick Tracey's gain control, R4, should change the slope. Don't touch the scope controls which you previously calibrated for equal gain! If you get no significant pattern, or the gain control has no effect, you may have a PNP transistor under test, so flick S3 to the PNP position. Still nothing? Throw the transistor away — it's no good.

On a good transistor, you will get a trace like the patterns shown in Figure 4. Using the gain control on Quick Tracey, set the slope to about 45 degrees, and read off the approximate gain on the R4 scale. Even with the gain control set to minimum, you still have a gain of 10, because of the series current-limiting resistor R3.

Of course, all this assumes that the transistor is properly connected. Transistor basing is pretty well standardized these days, and there are many sources of basing diagrams. If you're not sure, try various combinations; Quick-Tracy is very forgiving of "goofs" and we have yet to hurt a transistor or diode by hooking it up wrong on Quick Tracey. You will get some mighty weird patterns with some mis-connections, and that should tip you off.

Minor variations in the trace can be significant. For instance, if the sloped line is perfectly straight, the transistor has linear response (at least in the low current range). A curved, sloping line is characteristic of RF transistors, which need not be linear in most applications. A short "tail" at the top of the NPN slope (or bottom of the PNP slope) is "leakage," which is probably not going to bother you unless you have a critical application. This tail is common, but no tail is preferable.

Incidentally, on all Quick Tracey testing, don't be upset if the traces show dual lines on some oscilloscopes. This is due to a non-linear condition in the scope common at the Quick Tracey working frequency of 60 cycles, and is not the fault of the part you are testing.

Defective transistors will either exhibit no trace at all, or one which is obviously not right. Finding defective transistors in "bargain" packs is a cinch with Quick Tracey. You can sort them out by approximate gain, linearity, and type (PNP or NPN), and use colored dots of paint for coding. Quick Tracey will uncover the high percentage of undesirables in many bargain packs.

Odd Jobs For Quick Tracey

Using the principles outlined in the circuit descriptions, the astute reader will realize that Quick Tracey can be used for many other tasks, some of which follow:

(1) Relative Resistance Measurement: Set for diode test. Connect unknown resistor as for diode, except there is no polarity consideration. A horizontal trace means a high resistance; as resistance decreases, the trace slants more and more vertical. Vertical, as you recall, means a short circuit. A resistance of 100K shows an almost horizontal trace, tilting upward to about 20 degrees at 10K, 70 degrees at 1K, and essentially vertical at 100 ohms or less. This is a good way to test potentiometers for open spots or noise (noise will make the trace fuzzy as you rotate the shaft).

(2) Capacitance Testing: You can not only tell if the capacitor is good (at low voltage), but you can estimate the value of capacitance for all units from .05 microfarads to several hundred microfarads, including those difficult-to-test low-voltage transistor electrolytics! Even more surprising, you don't have to worry about polarity when testing an electrolytic. Just use Quick Tracey as for diodes. The pattern will be a horizontal long and thin ellipse for .05 mF, growing to a circle at about 1 mF, and becoming a vertical ellipse beyond that value, slowly closing to a vertical line at several hundred microfarads (which is essentially a short circuit to 60 cycles). You can make a calibration chart from known values, plotting value against ellipse proportions.

(3) Testing Photoconductors: These devices have a very high "dark resistance," and a relatively low resistance when exposed to light. Connect the leads of a photoconductor as described for diode testing, except there is no polarity to worry about. Cover the face of the cell with your hand. When S1 is depressed, you should get an almost horizontal line (depending on the normal dark resistance of the type of cell you are using). When you remove your hand and expose the cell to light, the line will tilt towards vertical if the cell is good. The more light, the more vertical. A graph of the trace angle plotted against light intensity could be used as a rough light measurement device. Some types of cells show relatively little change; others will go from straight horizontal to straight vertical!

(4) N-Type Unijunction Transistor Testing: As shown in Figure 5A, connect Base 2 to the G terminal of Quick Tracey, Base 1 to the H terminal. Leave the emitter unconnected. Set S2 to "Diode" and depress S1. You should get a slightly slanted horizontal line, since the unijunction has a high resistance with an open emitter. Now touch the emitter to G and then to H and you should get the traces shown in Figure 5A.

(5) Silicon-Controlled-Rectifier (SCR) Testing: Connect the anode and cathode as shown in Figure 5B. Leave the gate unconnected. Set Quick Tracey for diode test. When S1 is depressed, you'll get a horizontal line, perhaps with a curved tail. When the gate is connected to G (use a clip lead), you'll get a trace that looks like a normal diode. The vertical leg shows that the SCR is properly conducting during the half-cycle when the anode and gate are positive with respect to the cathode.

Our original Quick Tracey prototype has been in use for over 30 years, and has easily paid for itself in savings on bargain transistors, diodes, and SCRs. Super-sleuth Quick Tracey will uncover defects that other testers miss, and show some things that only the most expensive testers check.

Quick Tracey's fee is low for the service performed. Quick Tracey's motto: "Stamp out bad semiconductors!" **NV**

PARTS LIST

TI - Small 6.3-volt filament transformer *(see text)*
SI - Normally open SPST pushbutton switch *(see text)*
S2 - two-pole three-position miniature rotary switch *(see text)*
S3 - DPDT slide switch
BPI, BP2, BP3 - five-way binding posts (Radio Shack 274-62)
BI - 9V battery, Burgess 2U6 or equivalent
RI, R2 - 1K 1/4-watt carbon resistor
R3 - 10K 1/4-watt carbon resistor
R4 - 100K linear-taper potentiometer
Cabinet - *See text*
Dialplate - Mallory #380, Ohmite #5000 *(see text)*

Miscellaneous: AC line cord, pointer knob, three alligator clips, dry transfer lettering, wire, solder, screws, nuts, aluminum scrap for battery mounting bracket, and terminal strips.

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by Harry Helms

Software Wizardry

Last year in this column, we discussed using custom con-trols in developing Windows software. Custom control technology has advanced so rapidly that a good chunk of that earlier column is now obsolete information. Forget about the .VBX and .OCX controls mentioned in the previous column – Microsoft has now decreed that the future of custom controls now revolves around something they call ActiveX controls.

ActiveX isn't nearly as new as its name, however. ActiveX control technology is really an improvement of existing .OCX controls. Like .OCX controls, ActiveX components are "packages" of code that accomplish specific functions and communicate with Windows programs and other ActiveX components. However, there are some major differences between ActiveX components and .OCX controls.

For one, ActiveX controls can be used in Web pages, stand-alone applications written in Visual Basic or C++, and in Visual Basic for Applications (VBA) macros written for Windows applications like Excel or Adobe's PhotoShop.

Another major difference is that ActiveX controls can be developed using the comparatively simple Visual Basic language, unlike the heavy duty C++ programming required for .OCX development.

Finally, ActiveX controls can also work with the Macintosh version of Internet Explorer (version 2.1), as well as the Mac version of Netscape Navigator with the ActiveX controls plug-in.

Microsoft is backing ActiveX to the hilt as the basis for Windows programming, macro development for Windows applications, and to add functionality to Web pages. ActiveX is Microsoft's main counter-strike against Java for Web development. All this means is that it doesn't matter if you love or hate ActiveX technology; you'll need to know something about it.

ActiveX technology is developing rapidly and is in a major state of flux. For the very latest developments, you must visit Microsoft's Web home page at http://www.microsoft.com – Several ActiveX controls can be downloaded free from this site along with documentation for ActiveX technologies.

The Idea Behind Controls

In the previous column on controls, I compared Windows to a solderless breadboard. A solderless breadboard has a pattern of conducting strips underneath that allows easy interconnection of integrated circuits and other electronics parts along with common connection points for the supply voltage and ground. In the same way, the Windows operating system provides pathways for different programs to communicate with each other, standard memory locations, etc. The "integrated circuits" of Windows are controls. In fact, Windows itself is nothing more than a large collection of controls.

Controls are an example of object-oriented programming. Controls are not subroutines; instead, the programming code and data of each control is "encapsulated" and entirely separate from other controls (that is, objects) and the rest of the program. Because of this, controls can be re-used from one application to another without modification. You don't program controls; instead, you set their "properties."

Properties include such things as the name by which the control is referred to in a program, the text of any caption displayed by the caption, and the foreground and background colors of the control and any displayed text. Each control will have its own individual set of properties, and their settings can be changed during execution of the program in which they are used. For example, you could change the text of a control's caption property as a result of program execution.

Some familiar Windows controls include buttons, message boxes, horizontal and vertical scroll bars, radio buttons, check boxes, and even windows themselves. Not all controls are visible to users. One very useful control that has been available since the introduction of Visual Basic is the timer. Its properties allow it to trigger another event, such as displaying a message box, after a pre-set amount of time. However, this control is not displayed in the user application (although it is visible to programmers).

All About ActiveX Components

Controls respond to events, such as a mouse click, the cursor entering and/or leaving a certain area, calculation of a certain numeric or logical value, occurrence of an error, etc. Events are communicated to/from controls via messages passed between controls and the user interface (i.e., Windows). The exact event(s) a certain control will respond to can usually be set like other properties, although some controls are written to respond only to one event.

Controls must be used within "containers." A container is Windows itself, an applications program, a programming environment (like Visual Basic, Visual C++, or Delphi), or a Web browser.

The first controls available for use with Windows applications were .VBX (Visual Basic extension) controls, which were 16-bit controls. Visual Basic came supplied with a set of controls, and soon a cottage industry grew up to supply additional .VBX controls. .VBX controls could also be used in Microsoft's Visual C++ and Borland's Delphi, and they could be created using C++ and the Microsoft Foundation Classes (MFC) library of routines for C++ programmers.

.VBX controls were replaced by .OLE (object linking and embedding) controls, which were soon renamed .OCX controls. These were similar to .VBX controls, but were 32-bit controls designed to take advantage of Microsoft's OLE standard to allow communication between Windows applications. .OCX was also part of a concerted effort by Microsoft to force Windows users to migrate to a 32-bit environment as quickly as possible.

While Microsoft was focusing on desktop PCs and their hard drives, Netscape and Sun were focusing on the Internet and emerging Web technologies. When Netscape released their Navigator browser and Sun released the Java programming language for Web applications, Microsoft was caught flat-footed. They were desperate to come up with some sort of meaningful response.

The response turned out to be ActiveX.

Inside an ActiveX Control

All Windows controls, including ActiveX, are based on Microsoft's component object model (COM). The COM standard describes how any object used as a control is able to communicate with other controls. Such communications are called messages, and involve the properties and status of a control (such as its background color or whether it is enabled or not), and data and instructions for other controls. Messages are passed between controls through interfaces. Control interfaces are a set of software protocols that allow controls to make requests of each other and transfer data. COM also specifies that controls are not stand-alone programs, but instead must be used within a container.

While the COM standard was originally developed for Windows, it is not restricted to Windows. COM now includes cross-platform support with full binary capability, as demonstrated by the recent introduction of ActiveX controls for Mac browsers.

The next element of an ActiveX control is OLE. OLE is best known for its linking and embedding between Windows applications. OLE means you can embed an Excel spreadsheet in a Word document, and if changes are made in the Excel spreadsheet, the embedded copy in the Word document is automatically changed. OLE also enhances data transfer between objects and controls, as well as data storage by both.

When Microsoft decided to get serious about the Web, they had no trouble getting a competing browser ready, since a browser is a relatively simple development task (compared to an operating system, for example). Responding to Java was a little more difficult, since developing a new programming language would not be a simple task. Moreover, Microsoft wanted a high level of integration between its desktop software and Web software. The obvious solution was to enable .OCX controls to use Web browsers as a container. However, the .OCX specification needed to be modified for use over the Web. The result was ActiveX.

One big problem with many .OCX controls was that they were simply too big for efficient transfer over the Web at 28.8 or slower rates. ActiveX solves this problem by significantly reducing the mandatory "overhead" called for in the .OCX specification, such as the object linking and embedding software protocols. Since ActiveX controls will not have parts of a word processing document embedded in them, or be linked to a spreadsheet, such protocols are unnecessary. (Such OLE protocols can be added to ActiveX if desired, however.)

In programming environments like Visual Basic, Visual C++, or Visual Basic for Applications, ActiveX controls can be added to their "toolboxes," much like the standard button, slider, text box, etc. controls supplied with those programming environments. ActiveX controls are used like the standard controls by clicking on the desired control in the toolbox and locating the icon for the control on a form. (See the sidebar about Visual Basic for Applications.)

Microsoft's Internet Explorer browser comes supplied with several ActiveX controls specifically developed for use with Web pages. A list of these is given in Table 1. If a Web page using those controls is browsed, those controls are automatically loaded from the PC's hard drive. If the control is not one of those supplied with Internet Explorer, the control is automatically downloaded and installed on the user's hard drive (we'll discuss this in more detail later). While the latest version of Netscape's Navigator browser does not support ActiveX, a "plug-in" for Navigator that supports ActiveX is available. This can be included on the Web page and downloaded by users. For more information about this plug-in, visit http://www.ncompasslabs.com

Adding ActiveX controls to Web pages you're developing is a different matter, however. You'll have to go into the HTML file for the Web page to add them.

Adding ActiveX Controls to HTML Files

ActiveX controls are used as part of a scripting language for a HTML browser, such as the VBScript used with Internet Explorer 3.0. ActiveX controls are "declared" by placing a description of the control and its properties between a pair of OBJECT tags. The declaration includes a name for the control, and the control is referred to by that name in VBScript.

Let's suppose that you want to use a timer control in a HTML file. Here's the code you would use:

```
<OBJECT
    classid="clsid:59CCB4A0-727D-11CF-AC36-
    00AA00A47DD2"
    id="tmrEventTrigger"
>
<param name="Interval" value="500">
<param name="Enabled" value="True">
</OBJECT>
```

The "classid" line is a unique identifier for the specific ActiveX control that is being made available for use (in this case, the timer). When your browser encounters the classid line, it checks your PC to see if a copy of that control is located somewhere on your hard drive. If not, the Internet Explorer browser will display a message box notifying the user that the control is not available and must be downloaded. The user has the option of canceling the download or proceeding.

The "id" is the name by which the control will be referred to in VBScript; you can use any name you want as long as it follows Visual Basic naming conventions. (Notice we use the "tmr" prefix to identify the name as belonging to a timer control.) For controls that are visible to the user (unlike the timer), an "align" can follow "id" to specify where on the Web page the control should be placed. The "param name" lines identify and initially set the properties of a particular control. For a timer, the properties are "enabled" (whether the control is functional or not) and "interval" (the time interval in milliseconds before the timer event will be triggered). Different ActiveX controls will have different properties to be set.

Using ActiveX controls in HTML documents is simplified through the use of the ActiveX Control Pad, which contains a full set of the controls included with Internet Explorer 3.0. A beta version of this is currently available from Microsoft's Web site. To be honest, using ActiveX controls in HTML documents is currently a big pain in the nether regions, and Control Pad is far from a satisfactory solution. However, future Web authoring tools from Microsoft and other vendors are expected to have extensive support (like point-and-click from a toolbar) for ActiveX controls.

Creating ActiveX Controls

"Creation" of an ActiveX control does not always involve writing a lot of original code. Some ActiveX authoring tools, like the forthcoming new version of Visual Basic, will allow you to enhance existing ActiveX controls by adding new properties and events to them. (See the accompanying sidebar about new developments in Visual Basic.) These same tools also let you create new ActiveX controls by assembling existing controls into new controls. However, you cannot distribute (whether for free or for profit) any controls you create using existing controls without obtaining the permission of the original control developer(s).

Totally new ActiveX controls can be created using any 32-bit Windows programming environment that can produce a stand-alone executable (.EXE) file. This includes C, C++, Visual J++ (Microsoft's visual Java programming tool), and the forthcoming new versions of Visual Basic and Delphi. If you use C++, developing an ActiveX control is greatly simplified by using version 4.1 or later of Visual C++ and the Microsoft foundation classes (MFC) library. Microsoft has recently introduced a new tool called the ActiveX template library (ATL), which includes several C++ templates that do a lot of the tedious work of OLE programming for you.

Developing ActiveX controls is not something for the casual programmer, however. You'll need a good understanding of the Windows applications program interface (API) and the registry, which is the Windows95/NT system-level database that will largely replace .INI files in all current and future versions of Windows. The Windows95 registry is REGEDIT and the Windows NT version is REGEDT32. You should also be familiar with basic registry system calls. This emphasis upon the registry is because all ActiveX controls are "inventoried" there using their "classid" identifiers. When a Web page using an ActiveX control is accessed by a PC using Internet Explorer 3.0, Windows looks at the registry to see if the control is already on the PC's hard drive.

You will also need to have a good understanding of how OLE functions and OLE calls to develop ActiveX components. In particular, knowledge of the various COM interfaces and calls will be necessary so your ActiveX controls can successfully communicate with other controls, applications, and Windows itself. None of this – the registry, OLE, COM interfaces – is especially difficult, but it is unfamiliar to many Windows developers. To help developers, Microsoft has an ActiveX software development kit (SDK) that contains a library of COM interfaces and calls, utilities, sample controls, and a documentation library. Information on obtaining the SDK can be obtained from the Microsoft Web site.

Earlier in this month's column, we mentioned that ActiveX controls can be used with Macintosh Web browsers. ActiveX controls for Web pages can also be developed on the Macintosh. The only Macintosh programming environment suitable for ActiveX control development is Metrowerks Code Warrior used in conjunction with Microsoft's ActiveX SDK for the Macintosh.

There is promise that ActiveX control development will soon get much easier for Windows developers. For several weeks prior to writing this column, I have been using a beta version of the control creation edition (CCE) of Microsoft's Visual Basic. The CCE will be incorporated in the upcoming version 5.0 of Visual Basic, and it greatly simplifies the development of ActiveX controls. The CCE handles most of the OLE and COM calls/interfaces for developers, allowing programmers to focus on developing the control itself rather than spending time and effort on the control's communications with other controls and Windows. The big disadvantage of the CCE is that it uses Visual Basic to develop ActiveX controls, which limits the power and versatility of the controls. However, the trade-off for simpler, faster development is worth it in many situations. Expect to see a version of the CCE to start appearing in the future versions of other programming tools like Visual C++, Delphi, etc.

Security Issues

Two concerns whenever any software – like ActiveX controls – is transferred over the Web involve getting payment from developers who use the control and protecting against viruses and other corruption. On the first point, ActiveX has a lot going for it; on the second, it significantly lags Java-based code.

ActiveX allows controls to be distributed with either a developer or a runtime license. A developer license lets users use the control when developing other software or Web pages. In contrast, a runtime license lets users access the control as part of an application or Web page, but prevents the control from being copied into another application or development tool. Licensing agreements can be implemented on-line, if desired. For example, if a user accesses a Web page using runtime licensed controls, the controls could not be downloaded to the user's PC and displayed until the user completed an on-line licensing agreement. Many ActiveX developers, like Microsoft, distribute controls that require no runtime licensing, but which do implement developer licensing. However, there is no requirement to implement any licensing arrangements.

When it comes to preventing a virus or other problem from entering a user's PC via a downloaded ActiveX control, however, ActiveX is currently a less secure technology than Java. Tests conducted by several industry publications have clearly shown that a virus can be introduced into a PC far more easily by downloading an ActiveX control than by downloading a Java applet. Not surprisingly, Microsoft disputes the severity of the problem and promises that any security concerns will be addressed in future updates to ActiveX technology. However, this security "hole" will be a real limiting factor in the use of downloaded ActiveX controls on the Web until it is successfully resolved. Perhaps the best short-term strategy is to restrict use of ActiveX controls on Web pages to those controls already part of Internet Explorer 3.0.

Table 1
ActiveX Controls Supplied with Internet Explorer 3.0

Web Browser: Displays HTML pages and ActiveX controls
HTML Layout: Displays two-dimensional HTML areas
Gradient: Shades a specified area of a HTML page or transitions between colors
Hotspot: Adds transparent hotspot to a HTML document
Image: Displays .WMF, .JPG, .GIF, or .BMP format image files
Label: Creates text labels
TextBox: Creates multiple line text-entry and text-display boxes
ComboBox: Creates a drop-down option list and select box
ListBox: Creates a scrollable list of options
CheckBox: Lets users select options by checkable boxes
OptionButton: Lets users select between multiple options
ToggleButton: Creates a button with a toggle (on/off) selection
CommandButton: Creates a pushbutton control
ScrollBar: Creates horizontal and vertical scroll bars
TabStrip: Creates multiple pages that can be selected via tabs
SpinButton: Creates a button that can be pushed up or down
Menu: Creates a pull-down menu or menu button
Popup: Displays specified HTML documents in a pop-up window
ActiveMovie: Displays streaming and non-streaming media, including sound, video, and video synchronized with sound
Chart: Creates various types of charts in different styles
Marquee: Scrolls an HTML file in a horizontal or vertical direction at a specified rate
StockTicker: Continuously displays changing data that can be downloaded from a specified URL
Timer: Causes certain actions to be performed or scripts executed at specified time intervals
Preloader: Downloads a specified URL and puts it into the cache

Software Wizardry

The Future of ActiveX

In previous columns, I've stressed how programming is moving toward an object-based model in a visual environment. Programming in the future will largely involve the skillful assembly and manipulation of objects to create applications instead of the writing of thousands of lines of code. ActiveX is a major step toward realizing that future.

There are three big advantages of ActiveX controls over Java applets. Perhaps the most important is that ActiveX controls can be used in Web pages, in stand-alone applications, and in Visual Basic for Applications macros while Java applets are generally restricted to Web pages. For developers, this means a far larger market for ActiveX controls than for Java applets, and I expect more ActiveX controls to be created than Java applets.

A second advantage is that ActiveX controls can be created using a variety of programming languages that many people already know, like C++ and Visual Basic. Java applets must be written in Java, which is a relatively difficult language most developers will have to learn. (If they already know Java, Visual J++ can be used to create ActiveX controls.)

The final big advantage is that a substantial number of ActiveX controls are already available – over 1,000 as of September, 1996 – with more introduced each month.

Because of these factors, I believe a good working knowledge of ActiveX will soon be an absolute necessity for Windows programmers and Web page developers. I also feel that people who can create ActiveX controls are going to be in very big demand over the next few years. The ActiveX wave will be enormous, and those who are prepared to surf it will be in for the ride of their lives! **NV**

A Marriage Between the BeBox and the Macintosh???

My column a few months ago about Be, Inc., and their BeBox provoked a lot of interest. Now, it seems as though *Nuts & Volts* readers weren't the only ones excited over the BeBox.

It's no secret that Apple's efforts at developing a new version of its Macintosh operating system have not been very successful. System 8 — code-named "Copland" — had been promised since 1993, but Apple announced in mid-1996 that it was abandoning the effort. In the meantime, Windows95, and especially Windows NT, closed the gap on the Mac's System 7. In several key areas — such as multitasking, protected memory, and file systems — Windows NT is clearly superior to System 7 and even the promises of System 8.

In my column about the BeBox, I noted the many links between Be and Apple. Be was founded by former Apple executive Jean-Louis Gassée, the BeBox uses PowerPC microprocessors, and it is possible to develop software for the BeBox on the Macintosh. One big difference, however, is the Be operating system. The "BeOS" is a couple of quantum levels above anything available on a desktop short of a workstation. It's the sort of operating system that could give Apple a decisive advantage over a Windows PC.

Gil Amelio, Apple's new CEO, must've thought so too. At the time this was written, Apple and Be admitted they are in negotiations over licensing the BeOS to Apple!

In the fall of 1996, Be released a version of the BeOS for Power Mac platforms. Power Computing, the Mac clone manufacturer, started bundling it with their Power Mac clones. Tests by Macintosh magazines showed the Power Computing clones ran faster and had fewer problems (crashes, "hang ups," etc.) when running BeOS instead of System 7 and its enhancements.

Whether Apple will license BeOS, and whether Apple will make changes to it, was still not finally decided at the time this was being written. However, the raw performance of the BeOS, coupled with its state-of-the-art multitasking and multimedia features, would make it a natural for the Macintosh. With no viable options of its own, the decision to license BeOS would seem like a no-brainer. I hope Apple has done so by the time you read this!

Big Changes in Visual Basic

Late in 1996, Microsoft made two moves to increase Visual Basic's popularity. One – the control creation edition (CCE) – is discussed in this month's column. The other move was more subtle, but may have even greater long-term impact.

Figure 1 shows the opening screen that greets you when you open Visual Basic CCE. Notice that you have a choice of three options for a new project: a standard .EXE file, a control group (CTLGROUP), and an ActiveX control. The standard .EXE file is similar to programs created with previous versions of Visual Basic, and these files are intended for distribution on floppies or CD-ROMs. A CTLGROUP file is a collection of ActiveX controls that make up a new ActiveX control. The ActiveX option is the one you select when you want to create a new ActiveX control from scratch.

When creating a new ActiveX control, Visual Basic CCE discards all elements of Visual Basic not required for a functioning control. This includes items like the Jet database engine, report writing functions, file management functions, etc. Through such "streamlining," Visual Basic CCE produces compact, executable files well-suited for distribution over the Web or included as part of larger applications.

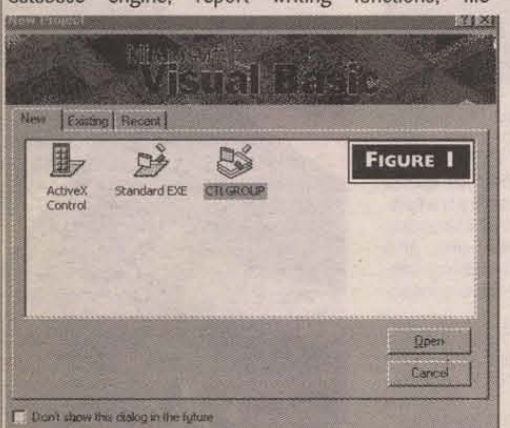

FIGURE 1

Figure 2 shows the design interface of Visual Basic CCE, and this interface will be used in all future versions of Visual Basic. The interface shown in Figure 2 is set for ActiveX control design, and displays three windows: a properties window, a form layout window, and a project window. The properties window lets you view a list of control properties in alphabetical or categorical order. The form layout window lets you arrange the visual appearance of the control. The project window shows all the files that go into making the control. In Figure 2, only one file (Axbutton.vbp) is in use.

Figure 3 shows the code window for the Axbutton control. If you've used Visual Basic before, this code will look very familiar: it is Visual Basic! There are a few new additions to facilitate Web use (such as for handling URLs), but it is essentially the same Visual Basic that's been around for years.

Microsoft also recently announced that it has licensed Visual Basic for Applications (VBA) to other software companies. This is part of Microsoft's strategy to make VBA the standard macro scripting language for applications programs. Among the first adopters of VBA include Great Plains Software, Adobe, Micrografx, Visio, Autodesk, Intergraph, Texas Instruments, Rockwell, Seagate Software, Symantec, and Siemens. Many of these companies – Texas Instruments, Rockwell, Siemens, etc. – produce Windows software for manufacturing and industrial applications where the required macros can be quite complex. But VBA will also be the macro language for future editions of such popular applications as Adobe's PhotoShop. Of course, VBA will remain the macro language for all of Microsoft's applications.

C and C++ will still be required tools for many advanced programming tasks (such as writing device drivers), but Visual Basic will let you create stand-alone applications, ActiveX controls, and develop macros for a growing number of applications software. Add its ease of use and short learning curve to such versatility, and you get the feeling that Visual Basic will soon be *the* programming language to know for most technical professionals.

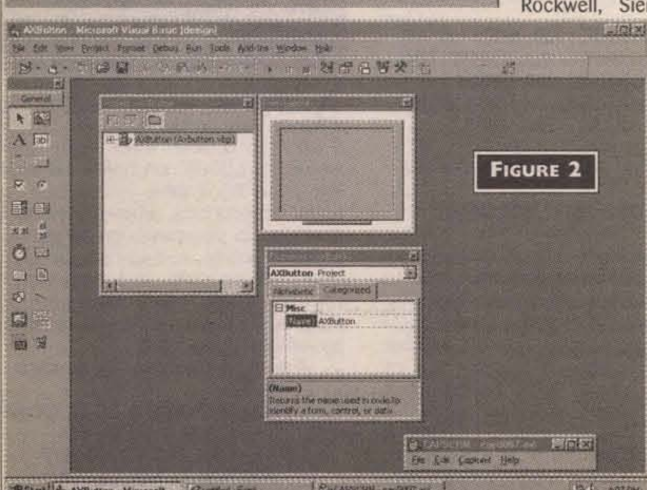

FIGURE 2

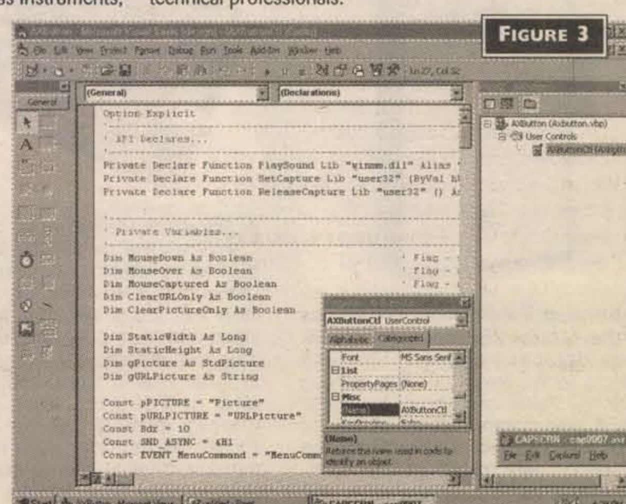

FIGURE 3

Continued from page 34

you to connect to a PC's keyboard port using either RS-232 or RS-485 interfaces, and still be able to use the existing keyboard. The Keyat is designed to aid software testing, allowing a test controller to simulate keyboard use without having to add any special software or communication hardware to the target computer system you are testing. The Keyat is addressable, and the RS-485 interface allows you to have one host computer control the testing of up to 58 target systems simultaneously.

You can send the Keyat ASCII, scan codes or keyboard codes. The Keyat can also monitor keyboard sessions for developing regression test data, or for detecting key combinations which are causing software problems. The compact unit (3.5"x2.2"x1.5") comes complete with manual and keyboard adapter cable.

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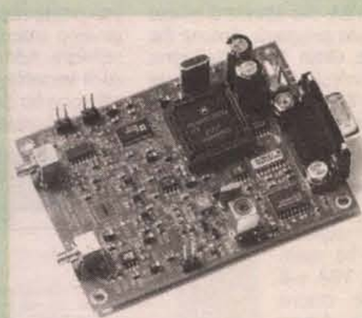

Novatech Instruments, Inc. introduces the model DDS6m direct digital synthesizer module. The DDS6m is a 40 MHz signal source on a 2.5" x 3.5" circuit board. It provides both sine and clock output signals simultaneously and is RS232 programmable from 100 Hz to 40 MHz in 0.025 Hz steps. The frequency setting can be saved in EEPROM memory so it returns to the saved value after a power interruption. The DDS6m has excellent spectral purity with a typical phase noise value being <125 dBc @ 1 KHz offset. The timebase is jumper selectable between an internal 5 ppm crystal oscillator or an external clock input. The phase of the output signal is programmable in 11.25 degree increments.

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ELECTRONIC IMAGERS

Electrim Corporation announces the addition of two cameras to their solid-state electronic imagers. The new color model, the EDC-1000E permits the user to digitize an RGB color image at up to 652x494 pixels (with 24-bit color depth). The monochrome model, the EDC-1000N, provides 256 gray scales at 652x494 pixel resolution. Like their earlier versions of electronic imagers, the EDC-1000E and EDC-1000N are compact, digitally controlled/digital output, television-like cameras.

The EDC-1000E and EDC-1000N use low noise (15 electrons per pixel) frame transfer CCD image sensors operating in non-interlaced (progressive scan) mode. Other features include: low dark current, anti-blooming, high photo response uniformity, 7.4μ square pixels, geometric fidelity, no dead space between pixels, computer controlled exposure time, computer control of gain and dark level, computer controlled sub-array scanning, asynchronous scanning (external triggering of frame reset and scan), and data collection rates of up to two megabytes per second.

Price of the EDC-1000E is $900.00 and price of the EDC-1000N is $800.00. All Electrim cameras include camera head, ISA interface card, cable, and software.

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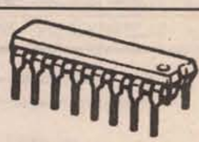

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Thiefbug, Model TX-BUG1

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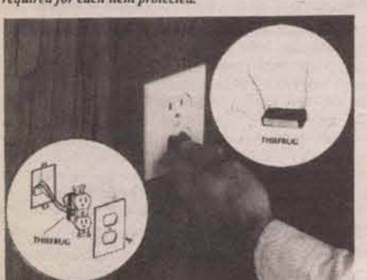

The Thiefbug is concealed in the electrical outlet box, where it cannot be seen or detected. Installation is easy, all you need is a screwdriver. Instructions are included.

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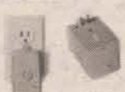

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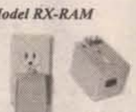

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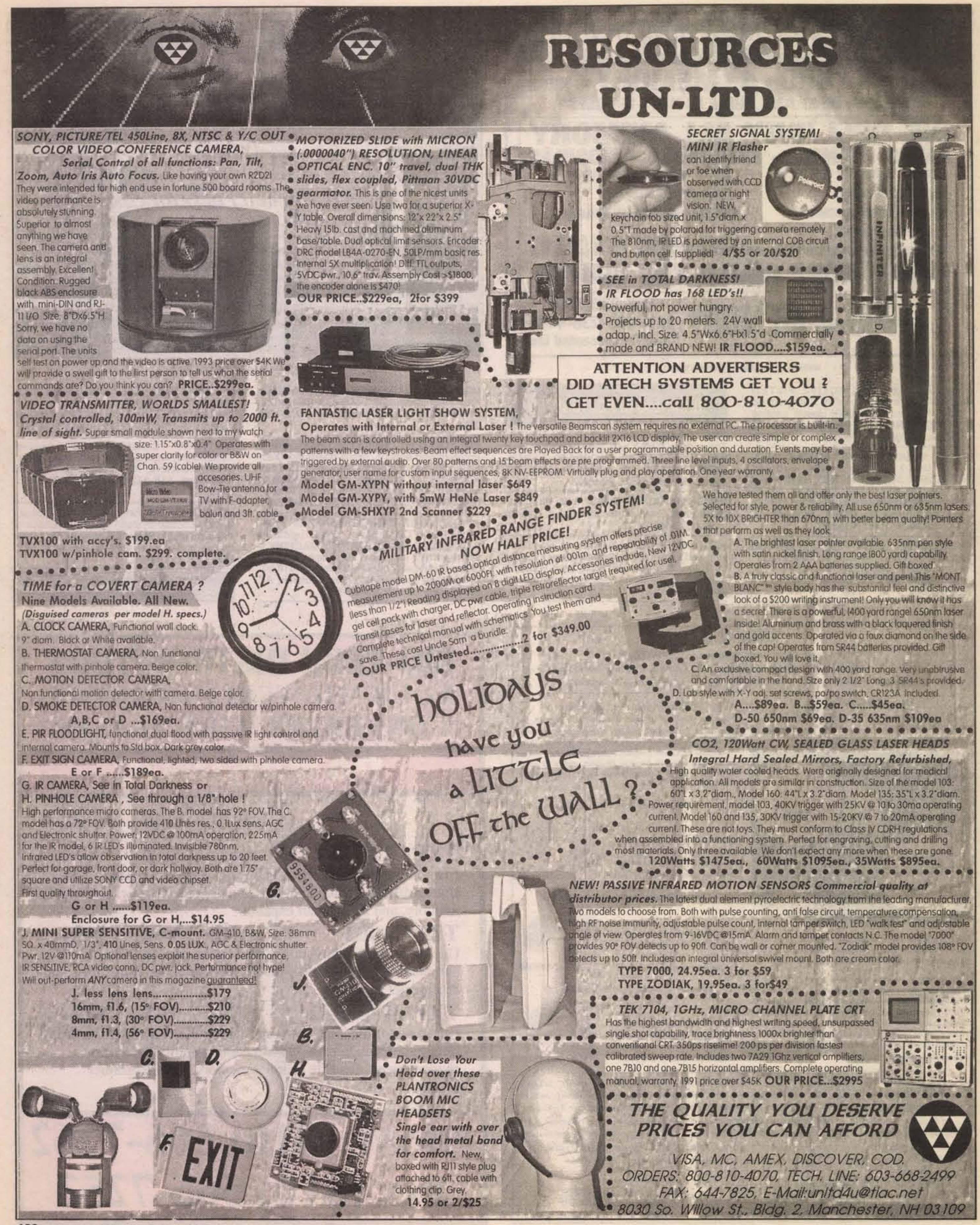

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Doing the Numbers — Or Distributing Saltwater Taffy?

Open Channel

by Joseph J. Carr
K4IPV

"He uses statistics as a drunken man uses a lamp post — for support rather than illumination."

—Andrew Lang

One of the things I enjoy doing every year is judging science fairs. I volunteer for one high school, two middle school (which we called "Junior High School" when I was a kid), and one area-wide (multi-school) fair. Over the 10 years that I have done this chore, there has been a noticeable decline in the ability of students — not all, but all too many — in analyzing and presenting data. And that touches one of my pet peeves.

When I see a person (whether a kid or not), who uses a voltmeter to find a potential of V = 4.56 volts, and a current of I = 126 mA (0.126 A), the calculated resistance R = V/I is not 36.19047619 ohms! I don't care what your calculator or improperly written BASIC computer program says, the correct answer is "36" or — if you have particularly good meters — maybe "36.2"... but certainly not 36.19047619. Good analysis of data is critical.

Analyzing Test & Measurement Data

Data that is not analyzed is a bit like bread that hasn't risen: all the ingredients are there, but somehow it isn't quite the same loaf. One of Reid's Rules is that no data should be collected without analysis. Unfortunately, the analysis step is all too often overlooked.

One reason for bypassing the analysis function is that people frequently don't know how to analyze numerical data. That problem is easily rectified by knowledge. But there is another problem that is less easy to deal with. Many people are, by their nature, action oriented, while many others are more reflective. A story borrowed from the medical world (where it highlights the difference between surgeons and internists):

A Surgeon and an Internist were out hunting quail. A bird flew up from cover, and the Surgeon shouts: "Quick! Shoot it ... it's a quail!" The Internist retorts: "No, first rule out dove and pheasant!"

Why Analysis?

Numbers have meaning, and when properly collected data contains information that you need to do your job, they have a critical meaning. That information isn't always on the surface, and may not jump out at you until the data are analyzed, patterns noted, and exceptions explained. Analysis is the art of breaking something apart, looking at the constituent pieces, and then reassembling them into a whole that is better understood.

Analyze ALL of the Data

Data analysis need not be complex, but it must be complete. On January 28, 1986, that came into violent focus as the space shuttle Challenger exploded a little more than a minute into its lift-off flight, killing all seven people aboard. Subsequent investigation revealed the cause of the accident was failure of the "O" ring seals on one of the two solid fuel booster rockets.

It is now known that the seals have a high probability of failure at cold temperatures; the temperature prior to launch was only 36° F. The question that had to be asked was whether or not the facts were known — or should have been known — prior to the accident. According to the findings of the Commission empaneled to investigate the accident:

"The managers compared as a function of temperature of the flights for which thermal distress of O-rings had been observed [author's note — see Figure1] — not the frequency of occurrence based on all flights [Figure 2]. In such a comparison, there is nothing irregular in the distribution of O-ring "distress" over the spectrum of joint temperatures at launch between 53° F and 75° F. When the entire history of flight experience is considered, including 'normal' flights with no erosion or blow-by, the comparison is substantially different [Figure 2].

"This comparison of flight history indicates that only three incidents of O-ring thermal distress occurred out of 20 flights with O-ring temperatures at 66° F or above, whereas all four flights with O-ring temperatures at 63° F or below experienced thermal distress.

"Consideration of the entire launch temperature history indicates that the probability of O-ring distress is increased to almost a certainty if the temperature is less than 65° F."

Disaster could have been prevented by correct data analysis.

Without proper data analysis, and possibly succumbing to program and political pressures, the managers responsible for flight readiness certification used a probability of failure of 1-in-100,000. There was no provable basis for this figure. It was probably only a hunch or guess based on the experience of the managers (unless it was made up). That incident shows the folly of using experience rather than data as a guide.

The engineers, by the way, using real data accumulated on both the shuttle launches and more than 1,500 US Army launches of a similar design calculated a 1-in-55 to 1-in-70 probability of mishap ... a much riskier assessment. The 1-in-100,000 number was used, without analysis or basis in reality, and the result was tragedy. Where did that 100,000 figure come from? Whether it was simply made up, or guessed at, it was none the less little more than a PFA (plucked from air) estimate.

An incident in the investigation showed the folly of dismissing the concerns of the technical people. An engineer who reported the dismal prospects of 1-in-55 was sarcastically told to "... put on your management hat ...", implying that he should accept the 1-in-100,000 and go with the launch decision. One of the Commissioners investigating the accident remarked something to the effect: "Asking an engineer to 'put on his management hat' is usually tantamount to an invitation to commit malpractice."

The lesson to take away from the Challenger accident is that numbers have meaning. Properly collected and analyzed data would have revealed the weakness, and made it possible to make a correct flight decision. But, by examining only part of the data, and using PFA probabilities, seven lives were lost and the US space program was set back many, many months.

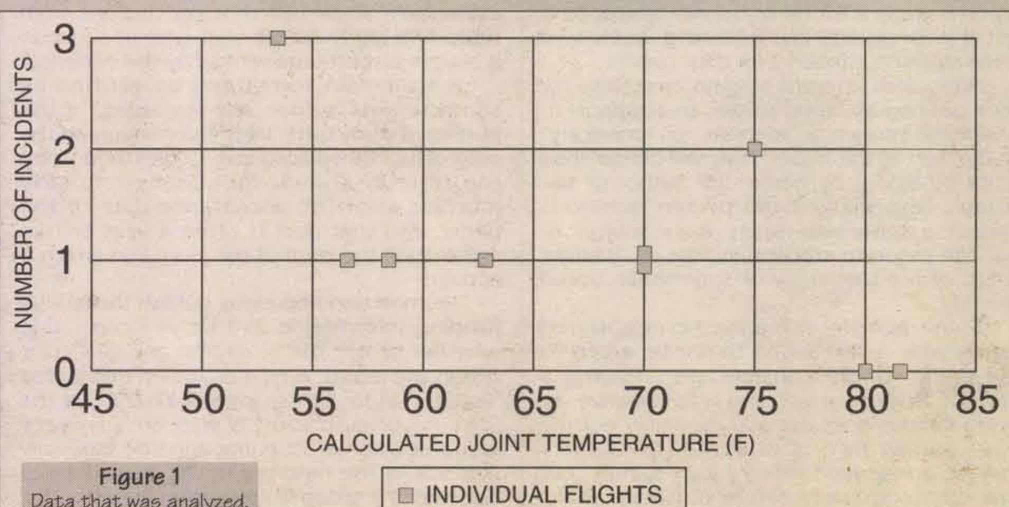

Figure 1
Data that was analyzed.

Is Saltwater Taffy Being Distributed?

Advocates for causes want you to accept their point of view. Otherwise, you cannot be persuaded to their way of thinking. The tendency — and temptation — is for strong advocates to overinterpret favorable data, and either underinterpret or suppress unfavorable data. How do you separate trash from treasure? How do you detect whether the offered food is nutritious, or merely saltwater taffy? Several tactics help shed light on the truth.

First, *ask who is supplying the information.* There are advocacy groups that put out information to support or refute a position on controversial issues. When dealing with the northwest timber issue, for example, one finds opinions from both sides. Both sets of opinions are based on facts and supported by extensive studies, but they reach contradictory conclusions.

Both the lumber industry and the environmentalists have truth and beauty on their side, according to their own estimation. The sad fact is that both are equally suspect. Leaving out the possibility of fraud and deceit, most people are biased in one way or another. And those biases tend to color the interpretation of facts, affect which facts are put into play, and decide which studies are declared valid and which are not. And when you crank in the possibility of outright deceit — rooted in an "ends justify the means" ethic — the situation becomes even murkier.

Newspapers and magazines often misinterpret studies. While some of them are guilty of blatant advocacy, they are also afflicted by three pressures that force distortion: deadlines, the need to "scoop" the competition, and the fact that startling results "sell" better than the truth. Add to that the fact that journalists are rarely competent to interpret scholarly work, and the result is bad information being presented to the public. No one should accept popular media articles on any subject without independent verification.

Verification doesn't mean seeing the same material in two or more different media sources. Journalists often pick-up stories from other publications. Seeing the same material in three publications could mean that one reporter wrote it for his or her newspaper (and got it wrong), and the following week, two more reporters cribbed it for their papers.

Advocates attempt to gain credibility for their position by citing studies that support it. And if the study is a "scientific" or "university" study, then all the better. They will bolster their point by citing, by name, the author of the study ... especially if the person quoted is famous, a well-known expert on the subject, or has the requisite credentials. "Dr. M. Weldon Smith of the University of Smyrnaville stated recently ..."

Some people cite a well-credentialed expert who is later found to not be expert in the matter under consideration. Having a doctoral degree, or winning a Nobel Prize, or being famous does not add credibility outside one's narrow field of expertise. Tom Clancy may be a real good military yarn spinner, but that does not qualify him as a military affairs expert.

When a study is cited by an advocate, it is a good idea to look further. I often follow-up on footnotes in order to judge the quality of research. In one case, an advocate's paper had plenty of footnotes, so on the surface looked pretty good. Footnotes are a paper's bona fides, they tell readers that the author did her homework. In that case, I found that a critically important footnote didn't even exist! The journal cited was real, but when the actual copy of the cited issue was located in a library, the article claimed in the footnote did not exist. Checking the annual index for that year, and the two years either side of it, revealed no articles or letters by the author cited in the paper. Mistake? Possibly. Deceit? I'd bet on it!

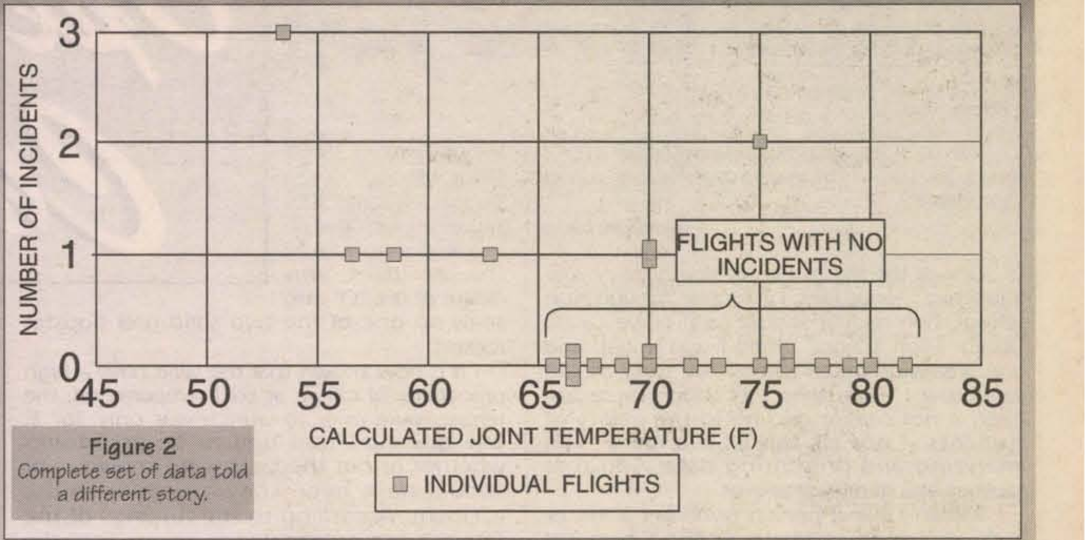

Figure 2
Complete set of data told a different story.

Critical footnotes need to be examined carefully to see:

a) Does the cited source actually exist?
b) Is the source accurately quoted?
c) Is the source fairly used?

The last criterion — fairly used — is especially important. Very often, one finds that cited sources are either taken out of context, or the conclusions of the study are twisted beyond recognition. If the author of the study would be surprised at the conclusions drawn, then it's a good bet that the study is not fairly used. While it is possible that an advocate could fairly draw different conclusions from those of a study author, that type of situation is always suspect until verified by the evidence.

A study can sometimes be verified by contacting its author. Ask the author if the published study is the latest information on the subject (published academic studies tend to lag the state of knowledge). Some scholarly journals print the acceptance date of the paper, and that date is often a year or two earlier than the issue of the journal in which it appears.

Journals also frequently publish the study's funding information so that you can judge whether or not there may be any particular bias in the results. A typical citation might read "Funded under NIH grant XXX-YZ-1230." If the funding organization is also an advocacy group or commercial entity, then be especially skeptical of the reported results (regardless of how well the group fits your own biases).

When you call the author of the study, ask about the methodology used. A lot of studies, especially those in the social sciences, are terribly sensitive to the methodology. Responsible researchers recognize that fact, and take it into account when reading the study, but journalists often don't. By understanding the methodology, it is often possible to detect any biases, flaws, or limitations to the study.

Also, find out whether the journal in which a published study appears is peer reviewed or merely editor reviewed. A peer review publication sends every manuscript out to one or more disinterested reviewers. They ask hard questions, provide critique, and serve as general quality control. They point out weaknesses, and suggest areas for improvement.

Another factor often left out of popular expositions of scholarly research is critical qualifying factors. Studies are often tightly controlled as to the conditions being examined, and may not be valid in situations that depart from the controlled situation. It is often the case that studies will look at very narrow populations, and the results are not applicable to the population at large.

It may also be true that the interpretation of a study is different because critical information is left out of the report. A report says that the US population grew by 22 million people in the decade of the 1980s. On the surface, that figure looks horrific: 22 million new mouths to feed, with the required new jobs to support them! But a critical bit of information was missing: that growth rate for the decade was 9.8 percent, and was the second lowest on record.

Even the multi-hundred billion dollar US budget deficits of recent years doesn't look too awful when viewed as a percentage of gross national product (GNP). At least one paper in *Harvard Business Review* argued that the deficit is not so horrible as people believe, and may actually stimulate the economy if the debt is incurred for the right things.

Another thing that distorts the interpretation of otherwise valid studies out is the improper combining of the results of two or more studies. This mistake is the "apples and oranges fallacy." Advocates cite two or more studies on the same subject to bolster their position in a manner that suggests the studies are somehow mutually reinforcing or complementary. A conclusion drawn as a synthesis from the results of two or more non-related studies is always suspect, and may be quite meaningless.

Studies almost always have some constraints, a basic methodology, and some (hopefully not hidden) basic assumptions. If the two studies cited do not share those factors in common, then drawing any conclusion that depends on combining them is invalid. The synthesized result is meaningless unless there is some means for compensating for the fundamental differences in the studies. Unless one is counting the category "fruit," one cannot fairly compare apples and oranges. It is very difficult for a layperson to make valid comparisons in such cases, so be wary when it is done without a good reason.

Scientific Studies

Scientific studies seem to be particularly subject to abuse when presented to a lay audience. Few people outside science understand that the results of studies are always considered tentative. They also understand that very few issues can be definitively proven by a single study. The public is often confused when two or more studies seem to contradict each other. "Is vitamin-C good for the common cold or not?" "Does eating bran lower cholesterol or not?"

Science makes progress by iteratively examining issues, and then holding up new data to public (and often very brutal) examination. As a result, each new study should build on earlier work, and refine its focus to overcome objections to the earlier studies. After this is done a number of times, some good approximation of the truth should emerge. But if one takes a "snapshot" of the research by looking at only one study at a single point in time, then an erroneous picture is seen. Scientists understand this problem, and account for it in their thinking, but laypersons rarely know how to look at studies. All that disagreement between studies may indicate is that scientists haven't refined their knowledge of a subject well enough to ask nature the right question ... yet.

Some General Advice

We can list several questions that should be asked of any claimant of truth:

- How do you know that such-and-such is true?
- Is the published data preliminary or final?
- Do other experts in the field concur?
  — Is their concurrence general or highly specific?
- What is the information based on?
- Have the assertions been validated in a formal study or experiment?
- Was the study designed according to generally accepted standards?
- Who funded the work?
- What stake does the researcher have in the outcome (reputation, $$$, promotion potential)
- Who disagrees with the conclusions and why?
- How sure are you of the conclusion?
- Are the conclusions backed up by statistical evidence?
- Have the studies been replicated by others?
  What were the results?
- Were the results reasonably consistent from one study to the next?
- Are other explanations possible?
- Who else in the field has seen the work?
  — Was it peer reviewed?
- What methodology was employed?
- What are the study's weak points?
- What criticism has been received? From who?
- Do you agree with the advocate's conclusions drawn from your study? Was your work fairly used?

When evaluating a researcher, look for agendas (hidden and otherwise), the backgrounds and qualifications of the researchers, their normal job function, their self-proclaimed mission (if any), and the source of funding to detect possible biases in the study. Ask a real pertinent question: "Why is this person interested, and how does it affect the results?" The word "interested" to mean "has a stake in" rather than "curious about."

It is also relevant to know what peer recognition the researcher enjoys (or is afflicted by). It may also be pertinent to note who referred you to that researcher. Was it someone you respect? Was it a self-nominated advocate? Do they have a general reputation for reliability and integrity?

So Why Bother?

So why should you care that saltwater taffy is being distributed by those trying to persuade you? Because it pulls out your dental fillings, rips off your crowns, rots your teeth, raises your blood sugar level, is hard to chew, is generally unhealthy, yet doesn't provide any form of intellectual or spiritual nourishment in return for all its evils. It's icky stuff, so shun it. Better yet, stick the taffy maker to the wall with his own stuff.

Integration Revisited

The column on methods of integration must have really struck a resonant chord. I received 14 E-Mails, all of the positive. A surprising number of them came from E-Mail addresses ending in "*.edu" indicating an educational institution. Several told me they were going to incorporate some of the material into various classes (electronics technology, introduction to laboratory Science, and math were mentioned.) Several of them suggested other methods. Those might form the basis for a future column, but probably not for a year or so (we don't like to repeat the same topic too often in deference to readers who don't care for that topic, and only tolerate it knowing their favorite topic is coming up soon). Thanks for the comments and suggestions.

Sensor-to-Computer Analog-to-Serial Interface Module

Another area where readers have responded positively is sensors and the associated interfacing circuits (I am writing a book on the topic, but I'm not sure the publisher approved my title: with all due apologies to Jane Austin, it was *Sensors & Sensorability*). As part of the research for the book, I started using Parallax BASIC Stamp and Micromint Pic-Stic modules. Micromint has a new product out that sensor users will find interesting.

The Answer MAN module comes in two varieties: one priced at $49.00 and the other (Answer MAN Senior) at $149.00 It is a 28-pin DIP module that incorporates eight-bit programmable digital inputs and outputs, analog inputs and outputs, power supply regulation, communications line drivers (RS-232A, RS-422, and RS-485). The Answer MAN will read frequency, count events, provide a pulse width modulation (PWM) output, among other abilities. It sounds a bit like a souped-up version of their PicStic products.

For information, contact: Chris White, Micromint, Inc., 4 Park Street, Vernon, CT 06066; (voice) **860-871-6170**, (FAX) **860-872-2204**. The data sheet is available on their web site at **http://www.micromint.com/** — Try it ... it may solve a lot of serial input problems. **NV**

Figure 3
Micromint Answer MAN.

Connections ...

I can be reached in either of two ways: **1)** by snail mail at P.O. Box 1099, Falls Church, VA 22041, or **2)** via Internet E-Mail at carrjj@aol.com — I appreciate your comments, suggestions, and criticisms.

ROBOTICS

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HARDWARE & SOFTWARE ENGINEERING. Zagros Robotics, PO Box 460342, St. Louis, MO 63146-7342. 314-768-1328, zagros@mo.net

Events CALENDAR

Continued from page 37

WI - WAUKESHA - Swapfest & Computer Expo. County Expo Center, N1 W24848 Northview Rd. 8am-2pm. SEWFARS 414-650-0724

MARCH 15

CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052

GA - MARIETTA - ARRL Hamfest. Kennehoochee ARC. Margaret Durham 770-977-4405

NH - SALEM - Computer Show. Rockingham Park Race Track. 10am-3:30pm. Northern Computer Shows 508-744-8440

TN - KNOXVILLE - Hamfest. Kerbela Shrine Temple. 8am-4pm. Paul Baird 423-986-9562

VA - HARRISONBURG - Computer Show. Rockingham Co. Fgnds. MarketPro 301-984-0880 xt15

MARCH 15-16

FL - TAMPA - Computer Show. Florida State Fairgrounds. MarketPro 301-984-0880 xt15

GA - NORCROSS - Computer Show. North Atlanta Trade Center. MarketPro 301-984-0880 xt15

OK - TULSA - State Convention. Merlin Griffin 918-272-3081

PA - MONROEVILLE - Computer Show. Pittsburgh Expo Mart. MarketPro 301-984-0880 xt15

TX - MIDLAND - ARRL Hamfest. Midland ARC. Beverley Harwood 915-686-1841

MARCH 16

IL - STERLING - Hamfest. Sterling High School Field House, 1608 4th Ave. 815-336-2434

MA - WORCESTER - Computer Show. Crowne Plaza Hotel. 10am-3:30pm. Northern Computer Shows 508-744-8440

OH - MAUMEE - Hamfest/Computer Fair. Lucas Co. Recreation Center, 2901 Key St. 8am-3pm. TMRA. Paul Hanslik 419-243-3836

PA - YORK - ARRL Hamfest. Keystone VHF. John H. Shaffer 717-764-8193

WV - CHARLESTON - Hamfest & Computer Show. Jimmie Hewlett 304-768-1142

MARCH 21-22-23

WI - MILWAUKEE - Computer Show. Milwaukee State Fair. Blue Star Productions 612-788-1901

MARCH 22

FL - AVON PARK - Hamfest & Computer Show. National Guard Armory, 2500 US Hwy 27 South. 8am-2pm. Clyde Scruggs 941-453-7181

FL - STUART - Hamfest. Martin Co. Fairgrounds. Martin County ARA. Romund Madson 561-337-1841

MA - ROCKLAND - Computer Show. Sons of Italy. 10am-3:30pm. Northern Computer Shows 508-744-8440

MO - KANSAS CITY - ARRL Hamfest. Ararat Shrine RC. Steve Dowdy 816-941-0620

NJ - WEST ORANGE - Hamfest. West Orange H.S. 600 Pleasant Valley Way. 9am-2pm. Jim Howe 201-402-6066

MARCH 22-23

FL - JACKSONVILLE - Computer Show. Jacksonville Fairgrounds. MarketPro 301-984-0880 xt15

IN - INDIANAPOLIS - Computer Show. Indiana State Fairgrounds. MarketPro 301-984-0880 xt15

IN - NASHVILLE - Computer Show. Nashville Armory. MarketPro 301-984-0880 xt15

MARCH 23

IL - GLEN ELLYN - Computer Show & Sale. Harper College. 9:30am-3pm. Computer Central Shows 847-940-7547

IL - GRAYSLAKE - LAMARSFEST '97. Lake County, IL Fairgrounds. 8am-2pm. Frank Avellone 847-234-4124

NC - KINSTON - ARRL Hamfest. Dwon East Hamfest Assn. Dough Burt 919-524-5724

NH - NASHUA - Computer Show. Sheraton Tara Hotel. 10am-3:30pm. Northern Computer Shows 508-744-8440

NJ - TRENTON - ARRL Hamfest. Delaware Valley Radio Assn. Darryl Foyuth 609-882-2240

NY - YONKERS - ARRL Hamfest. Westchester Emergency Communications Assn. Thomas Raffaelli 914-741-6606

OH - MADISON - ARRL Hamfest. Lake County ARA. Roxanne 216-256-0320

PA - WILKES BARRE - Computer Show. Genetti's Best Western. MarketPro 301-984-0880 xt15

VA - ROANOKE - Computer Show. Civic Center. MarketPro 301-984-0880 xt15

MARCH 28-29

GA - COLUMBUS - ARRL Hamfest. Columbus ARC. Randy Hancock 706-596-8820

MARCH 29

IN - MICHIGAN CITY - Hamfest & Computer Fleamarket. Michigan City High School, 8466 W. Pahs Rd. 8am-2pm. Ron Stahoviak 219-325-9089

MD - GAITHERSBURG - Computer Show. Montgomery Co. Fgnds. MarketPro 301-984-0880 xt15

OH - COLUMBUS - Computer Show. Veterans Memorial. MarketPro 301-984-0880 xt15

by Gordon West

FAMILY RADIO SERVICE ON THE AIR

The Federal Communications Commission (FCC) has gone full circle on its personal radio service called Citizens Band (CB). Class A Citizens Band on UHF frequencies 462 MHz/467 MHz attracted only a few licensees almost 50 years ago. The equipment was bulky, and I can remember the frequency tuning process of a Vocaline Class A CB as slightly squeezing, or slightly separating two parallel plates to put yourself on channel.

Class A Citizens Band ultimately turned into the UHF general mobile radio service (GMRS), a well-disciplined radio service continuing to fare well today under the guidance of Personal Radio Steering Group, Inc., P.O. Box 2851, Ann Arbor, MI 48106; 313-MOBILE3. If any one non-profit group deserves due credit in keeping a radio service created by the FCC orderly and useful, credit goes to the Personal Radio Steering Group for their untiring efforts in watching over GMRS.

A GMRS radio requires the operator to be licensed by the Federal Communications Commission for which the FCC would normally issue one channel pair spaced 5 MHz, with a second channel or channel pair assigned at the request of the applicant. The channel pair 462.675 MHz/467.675 MHz could also be used for the purpose of soliciting or rendering assistance to a traveler, or for communicating in an emergency pertaining to the immediate safety of life or the immediate protection of property.

Most recently, the FCC also granted small base stations and portable operations in the simplex mode on the following 462 MHz intersticial frequencies:

462.5625
462.5875
462.6125
462.6375
462.6625
462.6875
462.7125

If you possessed a valid GMRS license, you could operate voice on these intersticial frequencies with no more than five watts of effective radiated power.

Keep these five-watt intersticial frequencies in mind when we soon talk about the new Family Radio Service operating on these same frequencies, but with only one-half watt of power. Guess who has the advantage!

In the mid-1950s, the FCC also established Class D Citizens Band under Part 95 as an additional short-range radio service operating on 27 MHz. Just like Class A CB, a license was required, and an operator would receive a grant to operate on any one of the 27 MHz 23 channels. As 27 MHz Citizens Band began to grow popular in the 60s and 70s among truckers and radio enthusiasts, the channels were expanded from 23 to 40, and millions of 27 MHz CB radio operators began to go out of control.

Ultimately, the FCC could not keep up with licensing nor control on the band, and simply threw in the towel saying the rules still hold, but you no longer need a license for Class D 27 MHz CB. And that's the way it is today — an unlicensed radio service, totally out of control with a "no license, no rules" philosophy by many of the operators.

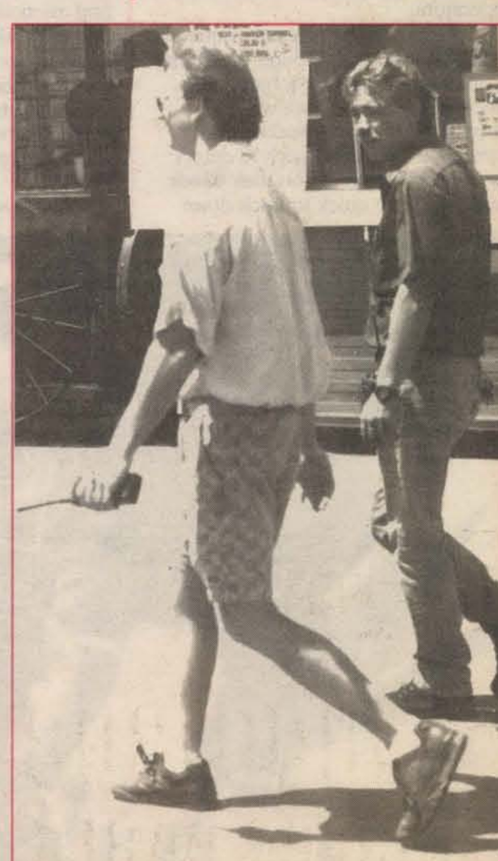
REACT still tries to do their best on Channel 9, the designated emergency channel, but since no one needs a license, how can anyone really control the rule violators?

Interesting to note, the FCC has recently unlicensed the domestic use of VHF marine radios, as well as VHF aeronautical radios. Mariners and pilots are hoping that undisciplined chaos doesn't break loose on these important bands, too. Time will tell.

But there was still a void in a radio service that would allow short-range, handheld-to-handheld communications among family and friends, backpackers and skiers, business and pleasure.

The GMRS UHF Citizens Band Radio Service was not a likely candidate for short-range casual or business communications because FCC licensing was still a requirement, the equipment relatively expensive, and the same licensing requirements even to get access at those seven relatively new intersticial frequencies.

Business band radio on both VHF and UHF required FCC licensing, and the channels were jammed pack and not authorized for personal communications. There was even a period when business band itinerant channels were used for unit-to-unit communications, but these channels

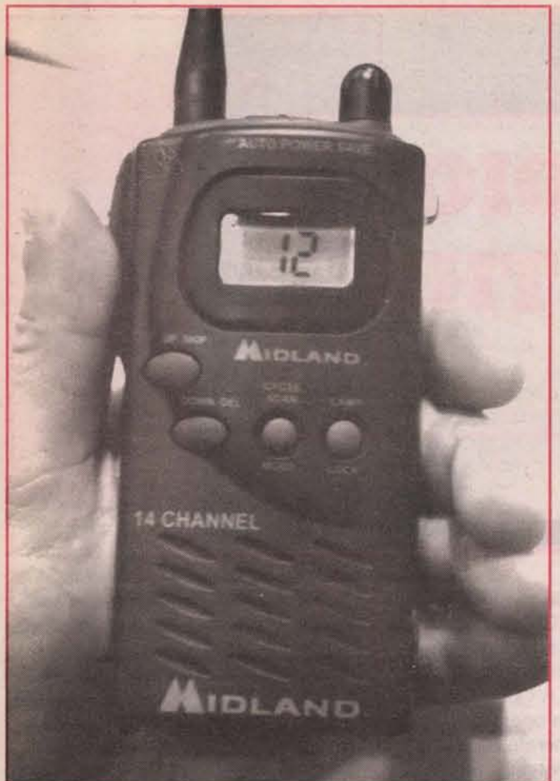


The small FRS radios operate just like bigger, commercial handheld radios.

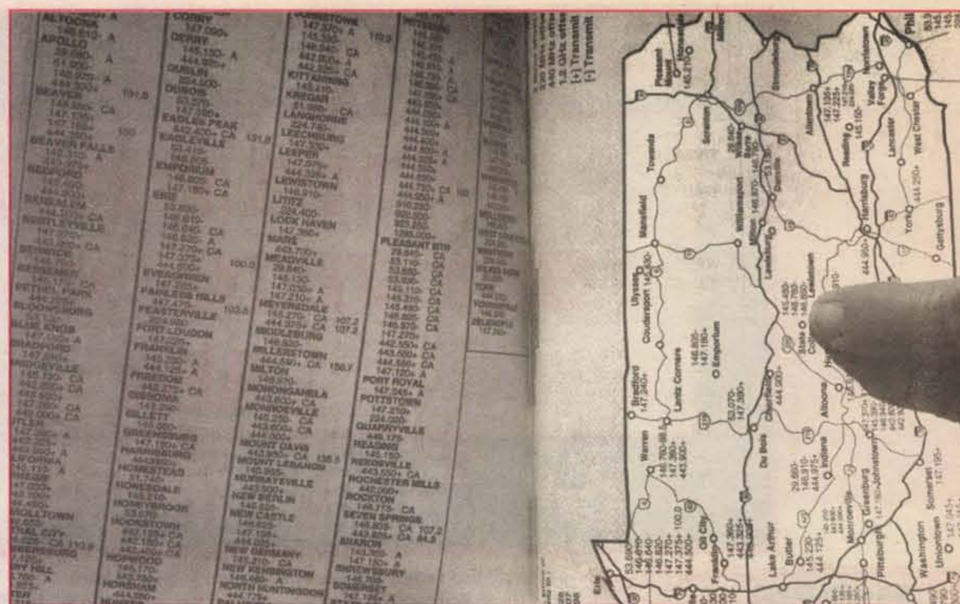
GMRS CHANNELS ...

GMRS FREQUENCY ALLOCATIONS
FCC Rules Part 95, Subpart A

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



All channel, half-watt, UHF family radio service portable transceiver.



A cloned ham radio gets new hams on the air *fast* (through local repeaters)!

were soon filled with high-powered stations and now the itinerant channels on both VHF, as well as UHF are considered just about useless by the thousands of licensed and unlicensed operators.

Ham radio for pleasure required the ham test, even though the Morse Code requirement for a ham radio Technician class license was dropped. Long-term licensed ham operators were also quick to detect unlicensed operators on their bands, and they were quick to track down unlicensed operators and get them off of their valuable VHF and UHF frequency assignments.

Using marine VHF radios that were relatively inexpensive because of the number of sets coming in from Japan was also not a wise choice for the casual hunters or skiers wanting to stay in touch. The FCC views the marine and aviation services as safety of life, and they take swift action to track down unlicensed operators. But now that the marine VHF and aeronautical service have gone FCC unlicensed, time will tell whether or not illegal operators are quickly apprehended.

About a year ago, amateur radio operator Robert Miller AA5FL, proposed a new short-range UHF radio system called Family Radio Service, utilizing intersticial (split frequencies) within the GMRS band.

Channel 1 - 462.5625 MHz
Channel 2 - 462.6875 MHz
Channel 3 - 462.6125 MHz
Channel 4 - 462.6375 MHz
Channel 5 - 462.6625 MHz
Channel 6 - 462.6875 MHz
Channel 7 - 462.7125 MHz

Channel 8 - 467.5625 MHz
Channel 9 - 467.5875 MHz
Channel 10 - 467.6125 MHz
Channel 11 - 467.6375 MHz
Channel 12 - 467.6625 MHz
Channel 13 - 467.6875 MHz
Channel 14 - 467.7125 MHz

Miller's proposal for the new 14 channels situated in between the long-standing GMRS channels took about one year from concept to FCC rulemaking. His vice-president position with Radio Shack most likely had a big impact on the FCC, realizing that a low-cost, short-range, no-license radio service would be a boon to both the public, as well as the economy with the expected millions of little radios to be sold. But for the licensed GMRS operators throughout the country, low-power "anything goes" radio sets in between regular GMRS mobile and repeater output frequencies could spell big-time problems.

The Personal Radio Steering Group (313-MOBILE3) did an exemplary job of investigating all positions in this issue, and presenting a professional un-emotional, alternate opinion on how half-watt, unlicensed, handheld FRS radio sets could cause interference to their long-standing, professionally licensed and managed, general mobile radio service.

Although the Commission ultimately adopted the Bob Miller Radio Shack Family Radio Service proposal, the Personal Radio Steering Group newsletter *PERSONAL RADIO EXCHANGE* indicates two parties have filed Petitions for Reconsideration of the rules that the FCC recently adopted for the Family Radio Service. But it may be too late — the newsletter indicates Family Radio Service models "are already on the market, and we expect to see many (sold) before the end of the Christmas 1996 shopping season."

Now that the Family Radio Service is on the air with brand new equipment, some surprises are taking place out in "radio land." Some of these "surprises" were anticipated, yet others may show the creativity of radio enthusiasts wanting to "do their thing" on the new 14 UHF intersticial frequencies.

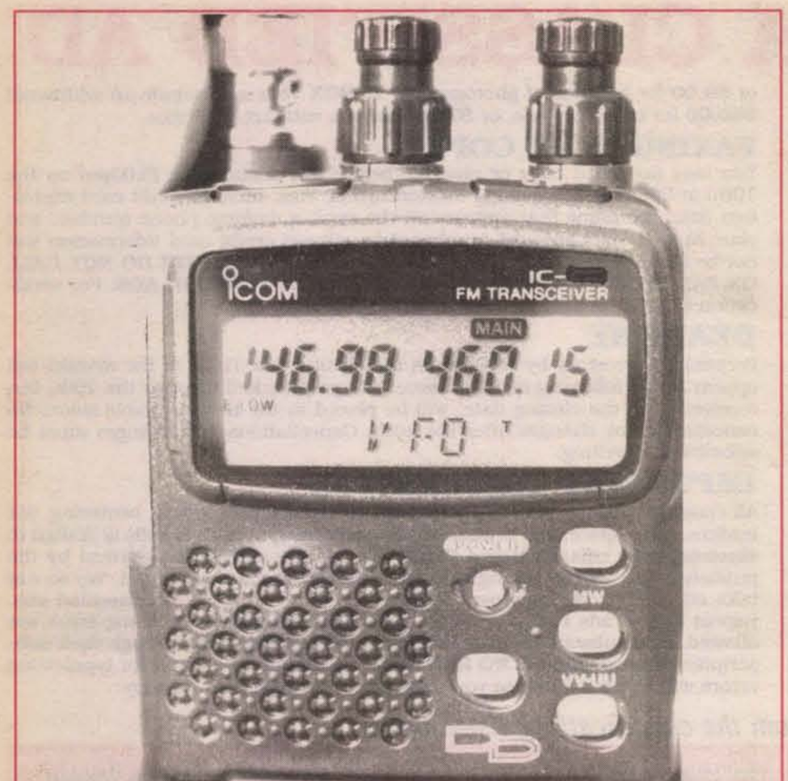
The first revelation came when new FRS operators discovered the first seven channels already occupied with licensed GMRS operators running LEGALLY 10 times more power on Channels 1 through 7. FCC Rule 95.29(f) allows five watt ERP licensed GMRS operators to use voice on the following intersticial channels:

Channel 1 - 462.5625 MHz
Channel 2 - 462.5875 MHz
Channel 3 - 462.6125 MHz
Channel 4 - 462.6375 MHz
Channel 5 - 462.6625 MHz
Channel 6 - 462.6875 MHz
Channel 7 - 462.7125 MHz

Licensed GMRS users on the first seven Family Radio Service frequencies not only could run 10 times more power, but also operate small base stations or mobile stations that sounded a lot louder than the small half-watt Family Radio Service portable stations. This "loudness" is due to the fact that FRS equipment operates at 3 KHz deviation, and GMRS equipment might operate up to 5 KHz deviation. The more deviation, the louder the signal appears out of the little FRS handheld sets.

Both FRS, as well as GMRS

FRS handhelds can keep you in touch in a shopping mall or trade show.



In a matter of seconds, ham radios may be cloned for instant repeater access and public safety receive.

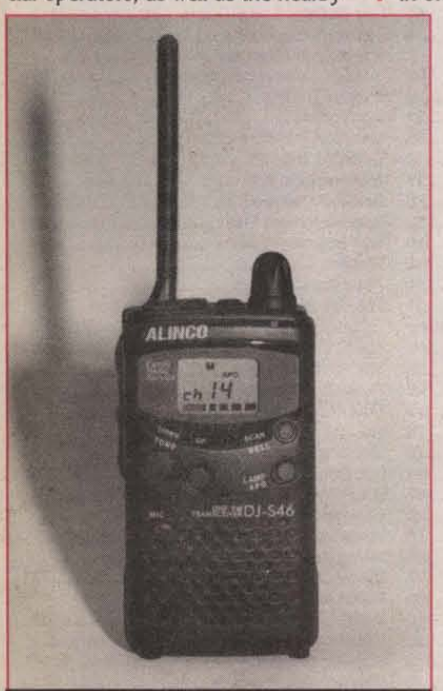
operators, on these interstitial frequencies would sometimes be clobbered with co-channel interference on regular GMRS channels because the 50-watt output GMRS systems would repeat out right next to the first seven interstitial frequencies.

Immediately Family Radio Service operators saw the benefit of choosing FRS Channels 8 through 14 to get away from GMRS interstitial operators, as well as the nearby outputs of GMRS repeaters. And good news for FRS operators — the 467 MHz FRS channels were absolutely clear and quiet. If you have FRS equipment now, Channels 8 through 14 are your best choice for good range.

So far, FRS units on Channels 8 through 14 have not caused interference or desensitization to licensed GMRS repeater systems which listen in on 467 MHz, and transmit out on 462 MHz. This was a concern of GMRS operators. I suggest you do not operate your small FRS radio near repeater sites that may have GMRS systems.

So how far do these small half-watt FRS units actually transmit on simplex?

About one mile in residential neighborhoods, a few hundred yards inside shopping malls, and up to five miles down at the beach or on lakes and rivers. And for the Family Radio Operators interested in being the first to talk half-watt handheld to half-watt handheld over 100 miles, you are too late — I have already done it with a pair of little handhelds between a mountain top in Santa Monica, CA, and a little FRS handheld aboard a boat near the Mexican border. On this line-of-sight basis, our 100-mile contact was absolutely noise-free, and we probably could have extended it an additional 50 miles or so if the boat operator had more gas. But FRS equipment is really intended for short range — parents to kids in a shopping mall — two skiers out on the slopes — one residential block captain to another three blocks away. And with one-half watt output on UHF, the little FRS equipment goes hundreds of times further than 49 MHz CB play toys, and usually a lot further than Class D Citizens Band when the channels are crowded with skywave interference. On FRS, skip is nonexistent.



New Alinco family radio service UHF radio with flip-up antenna for extra range.

Innovative Family Radio Service operators were quick to discover they could turn their little handheld with voice-activated transmit into a quasi-repeater station, repeating signals from other handhelds, or for that matter, any other radio service.

Although FRS equipment may not have the antenna system enhanced or added to, placing a VOX-operated FRS unit high atop an office building could act as a type of repeater. There is even talk of the relatively obscure amateur radio digital talker simplex repeaters being interfaced with a VOX-operated FRS transceiver.

These digital store-and-forward ham radio simplex "repeaters" listen to about 30 seconds of conversation, and then voice out this same digitally memorized conversation on the same frequency — much like a long delay echo device, but one that could allow a VOX-operated FRS set being placed in operation not necessarily envisioned by how typical FRS sets would be used.

Everyone is hoping the new 14 channels of FRS will blossom with useful communications in an orderly manner. Although Part 95 rules don't spell out exactly what may or may not be transmitted over FRS, it is everyone's hope that intentional interference, sound effects, obscene and indecent language won't take place on FRS.

After all, the intent of FRS is as a family radio service where mom and dad can chat, and still keep track of the kids out on the lake, or in that big shopping mall. This is the way Bob Miller has envisioned it, and everyone hopes this new Family Radio Service will maintain some semblance of sanity and civility for its intended short-range service.

I encourage everyone who operates on GMRS, or who plans to operate on Family Radio Service, to sign up for the Personal Radio Steering Group newsletter to stay up-to-date on this exciting existing and new UHF radio service. (Subscriptions are available for $30.00 a year, first class mail, PRSG, P.O. Box 2851, Ann Arbor, MI 48106.)

Equipment from Motorola, Radio Shack, Cobra, Alinco, and Midland is just hitting the marketplace, with prices from $50.00 on up to a couple hundred bucks. Keep in mind your best channels are 8 through 14, and let's see some good radio operators on this newly created set of frequencies, paired closely and shared with the presently licensed GMRS. **NV**

NEWS ANNOUNCEMENT

CLONING AROUND AT ALL HAM RADIO OUTLET STORES

Beginner ham radio operators can now buy ICOM America single-band and dual-band VHF/UHF transceivers pre-programmed with their local area "Top 40" VHF and UHF active frequencies.

"Local open repeaters, simplex, and local public safety channels will give the beginning operator a head start in taking advantage of their new ICOM equipment which has been cloned by their local ham radio outlet dealer," explains Jim Newcomb N7MBA, of ICOM America. "This Top 40 list will also add exposure to all of the local amateur radio clubs who sponsor a repeater and may hold evening nets," adds Newcomb.

Will a pre-programmed radio lead to a beginner not learning how to program in additional frequencies? "In a trial program between HRO, ICOM America, and Gordon West Radio School students, we found a much higher enthusiasm for newcomers learning how to clone and change memorized frequencies with this equipment, and beginners began programming and reprogramming at a much higher rate than other students who started off with a radio and an uncharged battery with only 144 MHz and 446 MHz coming up in the VFO mode," explains Newcomb. "We think ham radio outlet stores are offering the new operator a major benefit in being able to tune in and take advantage of all of the local radio systems in their area, pre-memorized in their new VFO/UHF radio set," finalizes Newcomb.

To receive a list of "Top 40" frequencies for your local area served by a local ham radio outlet store, simply stop in and ask for the list which is absolutely free.

HOW TO PLACE A CLASSIFIED AD

TYPE or PRINT your **ELECTRONICALLY RELATED** ad copy **CLEARLY (not all caps)** on a separate piece of paper. Spell out words when submitting hand-written copy. Calculate the number of words and multiply it by the appropriate rate (see RATE PER WORD section). Include any charges for **bold** and/or CAPPED words, any artwork costs that would be applicable, and/or costs for boxing your ad (explained below). Choose the appropriate classification for your ad(s) to appear in (see below). If no classification is indicated, it will be placed in Misc. Electronics or wherever we deem most suitable. **Enclose your name, address, phone number, and *Nuts & Volts* account number from your mailing label** (if available) for identification purposes. Include full payment — **CLASSIFIEDS RUN ON A PRE-PAID BASIS ONLY** — and mail your completed order to:

NUTS & VOLTS MAGAZINE, 430 Princeland Ct., Corona, CA 91719.

RATE PER WORD

The ad rate for **current PAID subscribers** is **60¢** per word. All others pay **$1.20** per word. There is a **$9.00 minimum** charge per ad per insertion.

WORDS IN BOLD AND/OR ALL CAPS

Words to be set in **bold** or CAPS are each 10¢ extra PER WORD. **BOLD CAPS** are 20¢ extra per word. The first two words of each ad are bold capped at no charge. Indicate bold words by underlining. Words normally written in caps (e.g., IBM) and accepted abbreviations such as VAC or MHz are NOT charged as all cap words. Use a two-letter abbreviation for states.

PHOTOS, DRAWINGS, AND BOXES

A photo or drawing may be run at the top of your classified ad for an additional **$10.00** (1" depth max.) for camera-ready art. No wording is allowed in this area. Add a one-time charge of **$5.00** to enlarge, reduce, or duplicate line art, or **$8.00** for halftone of photographs. To **BOX** your ad, include an additional **$50.00** for copy-only ads, or **$75.00** for ads with art or photos.

FAXING IN AD COPY

You may fax in ad copy or changes before the closing date (5:00pm on the 10th) at 909-371-3052 using MasterCard or Visa. Include credit card expiration date, the name that appears on the card, a daytime phone number, and your *Nuts & Volts* account number. Ads without credit card information will not be listed as received until payment is received in full. **WE DO NOT CALL OR FAX BACK VERIFICATION OR QUOTES OF FAXED-IN ADS.** For verification of faxed-in ads, please call 909-371-8497.

DEADLINE

Prepaid ads received by 5:00pm on the closing date (10th of the month) will appear in the following month's issue. Ads postmarked through the 10th, but received after the closing date, will be placed in the next available issue. No cancellations or changes after the 10th. Cancellations and changes must be submitted in writing.

IMPORTANT INFORMATION

All classified ads are running copy only. No special positioning, centering, dot leaders, extra space, etc. is allowed. All advertising in *Nuts & Volts* is limited to **electronically related items ONLY**. All ads are subject to approval by the publisher. We reserve the right to reject or edit any ad submitted. We do not take ad copy or changes over the phone. We do not bill for classified ads. Repeat ads or ads run in multiple classifications within the same issue are allowed. Paid subscribers may run ads at the 60¢ rate only through their subscription expiration date. **NO REFUNDS**. Credit only. No credit for typesetting errors will be issued unless you *clearly* print or type your ad copy.

Choose a category for your ad from the classifications listed below.

10. Ham Gear For Sale
20. Ham Gear Wanted
30. CB/Scanners
40. Music & Accessories
50. Computer Hardware
60. Computer Software
70. Computer Equipment Wanted
80. Test Equipment
85. Security
90. Satellite Equipment
95. Military Surplus Electronics
100. Audio/Video/Lasers
110. Cable TV
115. Telephone/Fax
120. Components
125. Microcontrollers
130. Antique Electronics
135. Aviation Electronics
140. Publications
145. Robotics
150. Plans/Kits/Schematics
155. Manuals/Schematics Wanted
160. Misc. Electronics For Sale
170. Misc. Electronics Wanted
175. BBS & Online Services
180. Education
190. Business Opportunities
200. Repairs/Service

ADVERTISER'S INDEX

ADVERTISER'S INDEX

FIND WHAT YOU NEED by product/category.

Use this index-by-product to find what you need *FAST!*

BASIC STAMP® COMPUTERS

Tiny computers run PBASIC™ programs

BASIC Stamps are component-sized computers that run PBASIC programs. They have 8 or 16 I/O lines, which can be used for a variety of digital and analog purposes. And their language is both familiar and extensive; the language includes FOR...NEXT, IF...THEN, and GOTO, as well as XOUT, SHIFTOUT, DTMFOUT, and other special commands.

If you've heard about BASIC Stamps, but never took the plunge, now you can do so for less. We now offer a "Starter Kit" for just $79. The kit contains everything you need to get your feet wet.

New BASIC Stamp Starter Kit for $79! Contains our original BASIC Stamp rev. D, plus software, cable, and manual.

FaxBack #6002

BS2-IC™ Module — $49

- *16 I/O lines*
- *500 instructions max.*
- *4000 instructions/sec.*
- *50k baud serial I/O*
- *24-pin DIP module*

Same I/O instructions as BS1, plus touch-tones, frequency generation, pulse counting, serial shift registers, X-10 powerline control, etc. I/O functions common to both modules have a higher resolution on the BS2-IC, due to its faster clock speed.

FaxBack #6004

BS1-IC™ Module — $34

- *8 I/O lines*
- *80 instructions max.*
- *2000 instructions/sec.*
- *2400 baud serial I/O*
- *14-pin SIP module*

I/O instructions for pushbuttons, potentiometers, pulse measurement, PWM, serial I/O, sound, etc.

Programming Package — $99

Contains items needed to program BASIC Stamp modules; includes cables, PC software, manuals, and free technical support.

Carrier Boards — $15-$20

Provide small prototyping area, 9-volt battery clips, and programming connector. Not absolutely necessary, but recommended to make programming and experimentation easy.

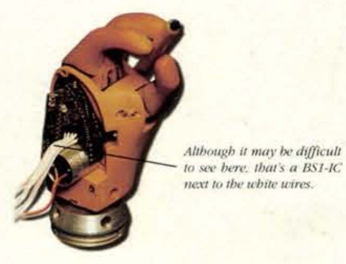
New! 4-line Serial LCD — $109

New 4-line serial LCD display is fun and useful for projects that require interaction with people. The display only takes one I/O line to operate, and can be controlled using simple SEROUT instructions in your BASIC Stamp programs.

Charles Walsh and his students in Great Falls, Montana, use BASIC Stamps in robotics projects.

Marvin Green and his students in Hillsboro, Oregon, use BASIC Stamps to make small robots.

John McLean uses BASIC Stamps to gather data in Lechuguilla Cave (America's deepest cave, located in Carlsbad Caverns National Park).



Although it may be difficult to see here, that's a BS1-IC next to the white wires.

Issac Kurtz and John Bishop use BASIC Stamps in artificial hands at the Bloorview MacMillan Centre in Toronto, Canada.

BASIC Stamp discussion list on the Net!

The list works like this: lots of people (currently 900) subscribe to the list, and then all questions and answers to the list are distributed to all members. It's a fun, fast, and free way to discuss BASIC Stamp issues.

To subscribe to the list, send email to **majordomo@parallaxinc.com** *and write* **subscribe stamps** *in the body of the message.*

PARALLAX®

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0996NVSL

Write in 194 on Reader Service Card.

NUTS & VOLTS MAGAZINE
430 PRINCELAND COURT
CORONA, CA 91719

ADDRESS CORRECTION REQUESTED

BULK RATE
U.S. POSTAGE
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ENTERPRISES