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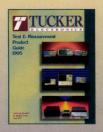
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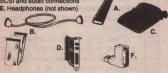
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  - nearly all audio applications ever made for PC's! vesome sound from Bose speakers!
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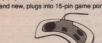
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This model rocket project aims high with BS1-IC instrumentation, plus

Adding a buffer circuit for semi-portability to the laser video project plus a

#### copper vapor laser. **DEPARTMENTS**

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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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# reader

Dear Nuts & Volts:

While scanning through the Reader Feedback column in the Jan. '96 issue, I happened upon the letter by Alan Woodman. In his letter, he describes a laser communications link for the transmission of video information. Initially, an analog communication scheme using amplitude modulation was mentioned. Then, due to a limited modulation index, this approach was discarded in favor of a digital system. So far so good.

However, the operational description of the digital approach did not make sense. In particular, the receiver was described as a pre-amp followed by a D/A converter. This will not recover the transmitted data for the following reasons:

1) The transmitted data is a serial bit stream and the D/A converter expects a parallel data word. 2) Before the serial bit stream can be converted into a parallel word, the individual received data bit plus noise waveform must be detected and sampled at the proper time. Due to bandlimiting in the channel, the transmitted pulses are not rectangular, but rounded with noise added. You want to sample the pulse at its peak and make an estimate of whether a 1 or 0 was sent. This typically requires the use of an A/D converter, decision logic, and a closed loop system to maintain bit synchronization. 3) After this is done, we still need to properly group the received bits into a word before converting them back into an analog waveform. For the six-bit word mentioned, there are six possibilities and an additional six more if the bit synchronization scheme allows for bit inversion (some phase locked loop circuits can lock-up 180 degrees out of phase, thereby inverting all the received data). This is collectively known as symbol synchronization. 4) In order to achieve the symbol synchronization previously described, some form of sync word must be appended to the transmitted data that the receiver can unambiguously recognize. For video, this can consist of horizontal and vertical line sync words. All received data between line syncs will then reconstruct the entire line (total number of bits/line equals the

number of pixels/line times the number of bits/pixel). **5)** An addi-tional phase locked loop must be used for recovery and regeneration of the horizontal and vertical sync information. If you try to simply sample these sync pulses from the composite video waveform and then somehow recover them from the receiver's D/A converter, your picture will be jumping all over the place due to clock timing differences. 6) There are additional issues concerning anti-aliasing filtering, bandwidth constraints in your channel, interlacing, DC clamping, AGC, blanking levels, etc., which must be addressed. Color video is much more complicated and requires maintenance of exact phasing information which must not be destroyed in the sampling process. Modern digital video processing also includes issues such as error correction coding, data compression, video multiplexing, closed captioning, scan rate conversion, and on and on. Note that there are now VLSI chips available which will do a

My point is not to dissuade you from pursuing your project, but to inform you of some obstacles that you might not have been aware of. Going digital has the obvious drawbacks of increased circuit complexity and channel bandwidth requirements. However, its advantages are high immunity to noise, stable, reliable and reproducible operation, amenable to error correction/data compression techniques and computer control, and micro miniaturization of circuitry into VLSI chips.

lot of this tedious processing.

Jay Rabkin Pasadena, CA

Dear Mr. lovine:

was very disappointed to read the headnote in your Jan. '96 column in Nuts & Volts Magazine. Although I enjoy the magazine's general electronics orientation, I also believe that cross-fertilization across disciplines is essential to innovation. I found your Recombinant DNA article to be one of the most interesting that I have read in Nuts & Volts. It introduced me to a new field of exploration, as well as a new company with a fasci-

Continued on page 118

Dear Nuts & Volts:

I understand there have been quite a few inquiries about PC boards for my article, "The Ultimate in Touchtone Control" in the Dec. '95 issue. As stated in the article, if there is sufficient demand, I will have the boards manufactured. If 50 people request the boards, I can have them made. Quantities less than this become too expensive for the board house to make at a reasonable price. If anyone needs further information about the article, they can contact me at the Post Office Box mentioned for ATC Electronics in the parts list sidebar. I may also be reached at my CompuServe address which is 103463,301. If E-Mail is addressed through the Internet, the address is 103463.301@compuserve.com | will be glad to help anyone who has questions or problems with the pro-

Raymond C. Buck

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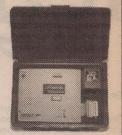
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# **MOBILE HF AMPS** REQUIRE SERIOUS CONSIDERATIONS

by Gordon West

f you operate a high-frequency, two-way radio system between 1.8 MHz to 30 MHz, there were probably some times that you wanted a little bit more "kick" in your power output. While a 6 dB, four-times power output increase only raises your signal strength at the other end by just one Sunit, there is no mistaking the increased audio punch when a power amplifier gets kicked into circuit.

Most marine SSB transceivers put out between 100 watts to 125 watts peak envelope power at their antenna terminals. Most high-frequency ham sets put out between 100 watts to 150 watts peak envelope power at their antenna output jack. Most commercial and aeronautical SSB transceivers put out between 75 watts to 125 watts at the antenna terminal. Although the specification and advertising sheets all bally-hooo "250 peak envelope power," these claims are for input power, not output power at the antenna terminals.

Commercial radio and amateur radio tube-type power amps are available from over 10 manufacturers. Henry Radio, in Los Angeles, CA, offers one of the largest selections of

Each of these 12-volt, solid-state, high-frequency power amplifiers weighs about 25 pounds and are sized about 18 inches long by 5 inches high by 10 inches wide. The SGC solid-state power amp is about pounds in weight and is sized more like a cube at 6 inches high by 13 inches deep by 11 inches wide.

All of the 12volt power amplifiers employ pairs The solid-state HF 3MHz-30MHz

power amplifier with external fans.

High Voltage Coax Seal™ keeps the feedpoint dry at half/kilowatt power levels.

whistles, or CW. Massive 100-amp power supplies are indeed available, but why not

fier. They need to be #OO, and you must install RV-type or automotive sound-system-type, 100-amp fuses right at the battery terminals. This way an accidental short-out won't cause a

A view inside the 500 watt SGC

power amplifier.

and driving down the road.

Under normal conversations on either marine band or ham band high frequency, these solid-state amps run

relatively cool. Their heatsinks are so massive that constant communications for over 45 minutes barely gets

the chassis up to 85 degrees. In the digital mode, you probably would need an external fan to keep things cool but for normal voice communications,

the fan is generally not necessary. A major consideration is the size of the battery leads feeding the ampli-

> fire in between the supply voltage and the amp. I suggest you run your radio off of one battery, and the amp off of another with a battery isolator separating the two on discharge. The amp can cause the resting battery voltage to fluctuate as much as two volts, and this might be enough to warble your transmit audio on ham or marine radio. with reports that your is "FMing." signal

Separate your two supply voltages, and you'll be all set.

Use RG8X coax between your transceiver and the amplifiers, which is perfectly okay to run in the "COR" RF sensing mode; high-frequency amplifiers type accepted for ham use MUST be hard keyed.

But these are not problems for the licensed amateur operator who may install their own amp, and LEGALLY modify their OWN amplifier to work on

500 SmartPowerCube<sup>TM</sup> 500 WATTS PEP & CW The 12-volt terminals must handle 75 amps on voice peaks. A row of status LEDs indicate proper operation. The hard key jack is on the right.

both commercial, as well as amateur, radio amplifiers that they build themselves at a separate facility in Santa Monica, CA. If you need 5,000 or 10,000 watts output, Henry Radio has just the amplifier for you.

Big kilowatt impedance matching coil is necessary for a  $50\Omega$  match for the

powerful amplifier.

But for mobile and mobile marine/aeronautical mobile applications, a 9 dB increase in power output (eight times amplification factor) can really make your signals stand out from the crowd. But the amplifier must run off of 12 volts (24 for airplanes), and there are only a few manufacturers who produce 12 volts DC, all solidstate, high-frequency power amplifiers. of MRF high-power transistors. If you see three pairs of transistors, you're probably

going to see the unit put out around 500 watts. If you see four pairs of MRF 458s, the unit will loaf at 600 watts, and could even get up to a peak of 800 watts on a whistle if it doesn't pop your massive 12-volt fuse.

The mobile 12-volt, solid-state amplifier could draw from 75 amps to 100 amps on a whistle, necessitating the need for a separate automobile storage battery to handle these big current swings on voice syllables, go with a separate gelled marine or automobile battery with a relatively inexpensive charger to stuff those amps back in after you have momentarily pulled them out on transmit? I have a little 15-amp charger that stays ahead of battery depletion quite nicely during home-station use of the mobile amplifier at my ham shack. Out in the car, I have a second battery that is easily replenished by my regular alternator as I'm yakking on worldwide ham the 10-meter band when summertime conditions bring skywave excitement. But the ham must modify his own equipment, and use it at his own sta-

Controlling the amplifier's bandpass filter network is relatively easy with a six-position rotary switch. One wire is common, and the other five wires cut in the desired filter network. If you try to transmit at 21 MHz, but have your filter network on 3.8 MHz, the unit will simply not put out power, and will probably blow a protective breaker or fuse. Resetting the circuit breaker gets you back on the air, so make sure you have the right band before you start talking. And, since most ham and marine radios have a push-to-talk line on the rear panel, getting the amp into active transmit is as simple as pushing the mike button which you have wired up to the back of the radio.

An exception to the necessary manual filter selection and manual hard keying is the export version of the SG-500 smart power cube from SGC, Inc. They offer an export model with automatic COR transmit sensing circuitry along with automatic frequency analyzer filter selection, accepting power input from 1.6 MHz all the way up to 30 MHz for full 500+++ watts power output. Radio operators wishing to enjoy the automatic band selection and keying of this SGC amplifier must certify that the amp is headed out of the country for international operation.

Typical automatic SGC T/R switching time is 10 milliseconds, with band switching automatically within 15 milliseconds, allowing the equipment to work in split-band operation quite nicely. Anywhere from 50 watts input to 100 watts will drive the amplifier at 500 watts output on a whistle easily, and well over that if you run your alternator or charger system for a 15-volt DC supply input where I have whistled up to 700++ watts output.

Your next big consideration is your antenna and ground system. The ground should be low-reactance copper foil from the chassis of the amplifier to an underwater ground shoe on a boat, or a metal chassis of a vehicle. Copper ground foil is a must at this high-power output level. For fixed station use, the powerful amplifier needs a good copper foil earth ground. Copper foil is available from all amateur radio and marine radio retail stores that sell SSB equipment.

The antenna system must be able to handle one kilowatt. You can buy high-power versions of the popular Outbacker multi-band antenna, as well as the popular mobile Hustler antennas. The big motorized high-frequency antennas, such as the "DK Special" might also handle high power as long as the weather is nice and dry. Most home amateur high-frequency antennas can easily handle 1,000 watts, but it's the mobile antennas you need to watch out for - inexpensive mobile antennas may only handle 200 watts, and will go up in smoke at any higher power level.

For marine applications, you will

need to feed the output of the amplifier into a whip pre-tuned antenna system, such as the marine Outbacker, the marine Morad antenna system, or other 50-ohm antennas. The output of the amplifier is coax cable 50-ohm, not single wire.

For marine installations employing a single-wire antenna, such as an insulated backstay, or a non-resonant 23-foot whip, you will need to abandon your present low-power automatic antenna tuner, and switch up to a kilowatt automatic antenna tuner that's going to cost some very big bucks. Both Hull (San Diego, CA) and SGC now have KW automatic antenna tuners, but their cost is thousands of dollars. You may want to come up with manual antenna tuning, or better yet, switch to the resonant 50-ohm kilowatt whip and get it away from where anyone might be standing.

You see, at 500 watts to 700 watts power output, the RF radiation is so strong it's going to do some interesting things in mobile installations. I once stalled a big luxury car waiting for a stop light next to me every time I started talking on my high-power system. I'd yak, and their car would just quit. Luckily, it didn't affect my own car. Something to check out.

Aboard boats, high-power output can cause automatic pilots to change course, weather facsimile machines to begin spitting-up FAX paper during transmissions, and all fluorescent cabin lights to glow on your every syllable. Welcome to high power.

In homes, garage doors may flap open, burglar alarms next door go off, and electric furnaces and airconditioners abruptly turn off or on. Again, welcome to high-power output.

But, if you plan to run this unit mobile in the clear of other mariners or travelers near your vehicle, you are going to experience some major improvement in talk power. Everyone will claim your audio has "more punch." Just be sure to keep everyone at least 10 feet away from your mobile whip antenna when you're pouring on the coals from one of these solid-state power amplifiers.

And, if you are using an export amp in the USA, you might enjoy the convenience of automatic band selection and automatic keying, but don't get caught using it within our borders. I run mine a lot down in Mexico, both mobile and mobile marine, and these solid-state amplifiers really make a difference on your transmit audio. NV

#### For more information, phone:

SGC, Inc., Bellevue, WA 206-746-6310 Henry Radio, Los Angeles, CA 800-877-7979 MFJ, Mississippi State, MS 800-647-1800 Transworld Communications Carlsbad, CA 619-747-1079 Hull Electronics, El Cajon, CA 619-447-0036

# SURPLUS EST EQUIPMENT

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\$9500

\$3200

\$12,000

\$1850

\$1350

\$550

\$800

\$1700

\$250

\$975

\$275

\$600

\$275

\$650 \$650

\$1500

\$100

\$4250

\$1300

\$1200

\$650

\$250

\$1200

\$1250

\$7500

\$1200

\$500 \$1200

. \$150

\$275/\$225

\$500/\$350

\$1000

\$100

\$150

\$1200

\$400

\$1750

\$1000

\$850

\$1850

\$4000 \$15,000

\$2500

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HEWLETT PACKARD	8654A, Signal Generator, 10-520MHz	
11664A, Detector\$325	8654B, Signal Generator, 10MHz-520MHz	
11664C, Detector\$150	8660C/100, Synth. Signal Generator	
1630A, Logic Analyzer\$700 1630D, Logic Analyzer\$800	86602B, RF Plug-in, 1-1300MHz	\$
1630G, Logic Analyzer, 65 Channel \$1200	86603A, RF Plug-in, 1-2600MHz	. \$15
1631D, Logic Analyzer	8660C Opt. 100, Signal Generator, 1-1300MHz	
1725A, 275MHz Oscilloscope	w/86602B RF Plug-in & 86632A Mod. Plug-in	
1741A, 100MHz Storage Oscilloscope \$450	8672A, Synth. Signal Generator, 2-18GHz	
182T/8755C, Swept Amplitude Analyzer\$850	8684B, Signal Generator, 5.4-12.5GHz	
1980B, Measurescope w/1950A Plug-in \$800		
214B, Pulse Generator, 200 Watt	8756A, Network Analyzer	\$12.0
3310A, Function Generator\$250 3310B, Function Generator, .0001Hz-5MHz\$250	8903A, Audio Analyzer, 20Hz-100KHz	. \$3
3311A, Function Generator, .01Hz-1MHz \$225	HUNDREDS OF POWER SUPPLYS	IN
3312A, Function Generator, .1Hz-13MHz\$850	STOCK. CALL FOR SPECS.	
3325A, Synthesizer/Function Generator,	SESSE SERVICE DE LA PROPERTIE	30
1UHz-20.999MHz \$2300 3325A, Synthesizer/Func. Generator w/opt. 002 \$2550	TEKTRONIX	
3335A, Synthesizer/Generator, 200Hz-80MHz \$4000	11A32, Two Channel Amplifier, DC to 400MHz	. \$11
334A, Distortion Analyzer	1240/D1/D2, Logic Analyzer, 27 Channel	
3455A, Digital Voltmeter	465, Oscilloscope, 100MHz	
3468B, 3.5 Digit Multimeter	465B, Oscilloscope, 100MHz	
3490A, Digital Multimeter	475, 200MHz Oscilloscope	
3562A, Signal Analyzer	485, Oscilloscope, 350MHz	
3575A, Phase Gain Meter 1Hz-13MHz\$1000	577 D2, Curve Tracer w/177 Fixture	. 51
3580A/ANALOG, Spectrum Analyzer, 5Hz-50KHz \$1200 3581A, Wave Analyzer \$500	7104, 1GHz Mainframe W/(2) 7A29, 7B10, 7B15	. \$4
3581C, Selective Voltmeter\$800	7B92A, Delaying Dual Time Base to 500MHz	\$
3717A, 70MHz Modulator-Demodulator \$3000	7D20, Programmable Digitizer	\$
4145A, Semiconductor Parameter Analyzer\$10,000 4145B, Parameter Analyzer\$18,000	7L18, Spectrum Analyzer Plug-in, 1.5-18GHz Capable of 60GHz with Mixers	22
4192A, LF Impedance Analyzer	AA5001, Programmable Distortion Analyzer	
4261A, LCR Meter, 120Hz-1KHz	FG502, 11MHz Function Generator	
4262A, LCR Meter\$2000	FG504, Function Generator Plug-in,	
4271B, LCR Meter, 1MHz	.001Hz-40MHz	\$
435A, Power Meter	FG507, 2MHz Function Generator	
4800A, Vector Impedance Meter	OF150, Fiber Optic Cable Tester	
4815A, Vector Impedance Meter\$1000	PG501, Pulse Generator PG508, Pulse Generator Plug-in, 50MHz	5
5314A, Frequency Counter, 10Hz-100MHz	S-4, Sampling Head	5
5316A, Universal Counter, DC-100MHz \$600	S-6, Sampling Head	\$
5328A, Universal Counter, DC-100MHz \$225	SC503, 10MHz Storage Oscilloscope Plug-in	
5328B, Universal Counter	SC504, 80MHz Oscilloscope Plug-in	
5334A, Frequency Counter, 100MHz	SC504, 80MHz Oscilloscope Plug-in	
5335A, Frequency Counter, opt. 10/20	SG5010, Programmable Oscillator	
5340A, Frequency Counter, 10Hz-18GHz \$800	TR503, Tracking Generator for 492/4/5/6	. 311
5342A, Frequency Counter, 0.5-18GHz\$2250	MISCELLANEOUS	
5345A, Universal Counter \$750 5359A, Time Synthesizer \$2850	Clarostat 240C, Decade Resistor	S
54110D, Color Digitizing Oscilloscope \$4500	Datron 4200, AC Standard	
6002A, Opt. 01, Power Supply, HP-IB, 0-50V/0-10A . \$800	Eaton 2052B, Amplifier, 100-512MHz	. \$1
6114A, Precision Power Supply, 0-20V/0-2A \$550 6227B, Dual Power Supply, 0-25V/0-2A \$600	Eaton 380K11, Synthesized Signal Generator	
652A, Test Oscillator, 10Hz-10MHz\$200	Eaton PM360, AM Modulation Section	
7090A, Measurement Plotting System \$2750	Eaton PM3602, AM/FM Modulation Section EH Research 122, Pulse Generator	
7475A, 6 Pen Graphic Plotter	EH Research 122A, Pulse Generator	
7550A, Plotter	EH Research 129, Pulse Generator	5
8012B, Pulse Generator, 50MHz\$750	EH Research 137, Pulse Generator	\$
8013B, Pulse Generator, 1Hz-50MHz\$750	ENI 406L, Amplifier, 150KHz-250MHz	\$
8111A, Pulse/Function Generator, 20MHz \$1850	ENI 411LA, Amplifier, 150KHz-300MHz, 10 Watt .	. \$1:
	FI	
8165A/01/02, Signal Source	Fluke 335D, DC Voltage Standard	. 31
8349B Amplifier, 2-20GHz	Fluke 335D, DC Voltage Standard	. \$6
8349B Amplifier, 2-20GHz       \$5000         8350A, Sweep Oscillator Mainframe       \$2400         83540A, 2.0-8.4GHz RF Plug-in       \$2250	Fluke 335D, DC Voltage Standard	. \$6
8349B Amplifier, 2-20GHz \$5000 8350A, Sweep Oscillator Mainframe \$2400 83540A, 2.0-8.4GHz RF Plug-in \$2250 83540B, RF Plug-in, 2.0-8.4GHz. \$4750	Fluke 335D, DC Voltage Standard	. \$6
83498 Amplifier, 2-20GHz     \$5000       8350A, Sweep Oscillator Mainframe     \$2400       83540A, 2-0-8.4GHz. RF Plug-in     \$2250       83540B, RF Plug-in, 2-0-8.4GHz.     \$4750       83545A, Oscillator Plug-in, 5-9-12.4GHz     \$4200	Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 540B, Transfer Standard Fluke 752A, Reference Divider	. \$6 . \$7 . \$2 . \$1 . \$2
8349B Amplifier, 2-20GHz \$5000 8350A, Sweep Oscillator Mainframe \$2400 83540A, 2.0-8.4GHz RF Plug-in \$2250 83540B, RF Plug-in, 2.0-8.4GHz. \$4750	Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 540B, Transfer Standard Fluke 752A, Reference Divider Fluke 850A, 5.5 Digit Digital Multimeter	.\$6 .\$7 .\$2 .\$1 .\$2 .\$2
83498 Amplifier, 2-20GHz     \$5000       8350A, Sweep Oscillator Mainframe     \$2400       83540A, 2-0-8 4GHz     RF Plug-in     \$2250       83540A, B. F. Plug-in     \$400     \$400       83545A, Oscillator Plug-in     \$400     \$400       83572B/001-006, Oscillator Plug-in     26.5-40GHz     \$12,000       8410B, Vector Voltmeter 1MHz-1GHz     \$250       8410B, Network Analyzer System	Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 520A, Transfer Standard Fluke 752A, Reference Divider Fluke 8505A, 0.5 Digit Digital Multimeter Fluke 8505A, Digital Multimeter	. \$60 . \$71 . \$20 . \$11 . \$21 . \$11
83498 Amplifier, 2-20GHz \$5000 8350A, Sweep Oscillator Mainframe \$2400 83540A, 2-0-8.4GHz RF Plug-in \$2250 83540B, RF Plug-in, 2-0-8.4GHz. \$4750 83545A, Oscillator Plug-in, 5-9-12.4GHz \$4250 83572B/001-006, Oscillator Plug-in, 26.5-40GHz \$12,000 8405A, Vector Voltmeter 1MHz-1GHz \$250 8410B, Network Analyzer System w/8412A, 8743A & 8411A \$600	Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 520A, AC Voltage Calibrator Fluke 540B, Transfer Standard Fluke 752A, Reference Divider Fluke 8505A, 6.5 Digit Digital Multimeter Fluke 8506A, Digital Multimeter, Krohn-Hite 3100R, Tunable Filter	. \$60 . \$71 . \$20 . \$11 . \$21 . \$11
83498 Amplifier, 2-20GHz     \$5000       8350A, Sweep Oscillator Mainframe     \$2400       83540A, 2-0-8 4GHz. RF Plug-in     \$2250       83540B, RF Plug-in, 2-0-8 4GHz.     \$4250       83545A, Oscillator Plug-in, 5-9-12-4GHz     \$4200       835728/001-006, Oscillator Plug-in, 26.5-40GHz     \$12,000       8405A, Vector Voltmeter MHz-1GHz     \$250       8410B, Network Analyzer System     w/8412A, 8734A     8411A       8411A, 0714B, Frequency Converter. 11 to 18GHz     \$500	Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 540B, Transfer Standard Fluke 540B, Reference Divider Fluke 8505A, 6.5 Digit Digital Multimeter Fluke 8506A, Digital Multimeter Krohn-Hite 3100R, Tunable Filter Krohn-Hite 3103/R3103, Tunable Filter/	. \$6 . \$7; . \$2; . \$1; . \$2; . \$1; . \$1; . \$1;
83498 Amplifier, 2-20GHz \$5000 8350A, Sweep Oscillator Mainframe \$2400 83540A, 2-0-8.4GHz RF Plug-in \$2250 83540B, RF Plug-in, 2-0-8.4GHz. \$4750 83545A, Oscillator Plug-in, 5-9-12.4GHz \$4250 83572B/001-006, Oscillator Plug-in, 26.5-40GHz \$12,000 8405A, Vector Voltmeter 1MHz-1GHz \$250 8410B, Network Analyzer System w/8412A, 8743A & 8411A \$600	Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 520A, Transfer Standard Fluke 752A, Reference Divider Fluke 8505A, 0.5 Digit Digital Multimeter Fluke 8505A, Digital Multimeter Krohn-Hite 3100R, Tunable Filter Krohn-Hite 3103/R3103, Tunable Filter/ Rack Version \$2	. \$6 . \$7; . \$2; . \$1; . \$2; . \$1; . \$1; . \$1;
8349B Amplifier, 2-20GHz         \$5000           8350A, Sweep Oscillator Mainframe         \$2400           83540A, 2-0-8 4GHz         RF Plug-in         \$2250           83540A, 2-0-8 4GHz         \$4750           83545A, Oscillator Plug-in         \$4200           83572B/001-006, Oscillator Plug-in         26.5-40GHz         \$12,000           8405A, Vector Voltmeter 1MHz-1GHz         \$250           8410B, Network Analyzer System         w/8412A, 8743A & 8411A         \$600           8411A/01B, Frequency Converter .11 to 18GHz         \$500           8443A, Tracking Generator/Counter         \$350           8447B, Automatic Preselector         \$450           8447A, Amplifier, 0.1-400MHz         \$300	Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 520A, AC Voltage Calibrator Fluke 540B, Transfer Standard Fluke 752A, Reference Divider Fluke 8505A, 6.5 Digit Digital Multimeter Fluke 8506A, Digital Multimeter Krohn-Hite 3100R, Tunable Filter Krohn-Hite 3103/R3103, Tunable Filter/ Rack Version \$2 Krohn-Hite 3202/R3202, Tunable Filter/	. \$6 . \$7! . \$2! . \$1: . \$2: . \$1: . \$1: . \$1: . \$1:
8349B Amplifier, 2-20GHz       \$5000         8350A, Sweep Oscillator Mainframe       \$2400         83540A, 2-0-8 4GHz, RF Plug-in       \$2250         83540B, RF Plug-in, 2-0-8 4GHz       \$4750         83545A, Oscillator Plug-in, 5-9-12-4GHz       \$4200         83572B/001-006, Oscillator Plug-in, 26.5-40GHz       \$12,000         8405A, Vector Voltmeter 1MHz-1GHz       \$250         8410B, Natwork Analyzer System       \$600         8411A, Ang 743A, 8, 8411A       \$600         8443A, Tracking Generator/Counter       \$350         8445B, Automatic Preselector       \$450         8447A, Ampliffer, 0.4-400MHz       \$300         8447B, Ampliffer, 0.4-1,3GHz       \$350	Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 520A, Reference Divider Fluke 8505A, 6.5 Digit Digital Multimeter Fluke 8505A, Digital Multimeter Fluke 8505A, Digital Multimeter Krohn-Hite 3103R, Tunable Filter/ Krohn-Hite 3103R3103, Tunable Filter/ Rack Version \$2 Krohn-Hite 3202/R3202, Tunable Filter/ Rack Version \$5 Krohn-Hite 3342, Tunable Filter/ Standard Standar	. \$6 . \$7! . \$2! . \$1: . \$1:
8349B Amplifier, 2-20GHz         \$5000           8350A, Sweep Oscillator Mainframe         \$2400           83540A, 2-0-8 4GHz. RF Plug-in         \$2250           83540A, 2-0-8 4GHz. RF Plug-in         \$2250           83545A, Oscillator Plug-in, 5-9-12-4GHz         \$4200           83572B/001-006, Oscillator Plug-in, 26.5-40GHz         \$12,000           8405A, Vector Voltmeter 1MHz-1GHz         \$250           8410B, Network Analyzer System         w/8412A, Br343A         8411A         \$600           8411A/01B, Frequency Converter 11 to 18GHz         \$500         \$443A, Tracking Generator/Counter         \$350           8445B, Automatic Preselector         \$450         \$450         \$300           8447A, Amplifier, 0.1-400MHz         \$300         \$304           8447C, Amplifier, 0.4-1.3GHz         \$300           8447C, Amplifier, 0.5-00MHz         \$300	Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 520A, AC Voltage Calibrator Fluke 520A, Factor Standard Fluke 752A, Reference Divider Fluke 8505A, 6.5 Digit Digital Multimeter Fluke 8506A, Digital Multimeter Krohn-Hite 3103R Junable Filter Krohn-Hite 3103R3103, Tunable Filter/ Rack Version Krohn-Hite 3202/R3202, Tunable Filter/ Rack Version Storensen QRD 30-1, Power Supply, 30V-1A	\$66 \$77 \$22 \$11 \$21 \$11 \$11 \$75/\$:
8349B Amplifier, 2-20GHz         \$5000           8350A, Sweep Oscillator Mainframe         \$2400           83540A, 2-0-8 4GHz, RF Plug-in         \$2250           83540A, 2-0-8 4GHz, RF Plug-in         \$2250           83545A, Oscillator Plug-in, 5-9-12-4GHz         \$4200           83572B/001-006, Oscillator Plug-in, 26.5-40GHz         \$12,000           8405A, Vector Voltmeter 1MHz-1GHz         \$250           8410B, Network Analyzer System         w/8412A, 8743A         8411A           \$600         8411A/018, Frequency Converter: 11 to 18GHz         \$500           8443A, Tracking Generator/Counter         \$350           8445B, Automatic Preselector         \$450           8447B, Amplifiler, 0.1-400MHz         \$300           8447B, Amplifiler, 0.4-1.3GHz         \$350           8447C, Amplifiler, 30-300MHz         \$300           8503A, S-Parameter Test Set         \$1150	Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 520A, Transfer Standard Fluke 752A, Reference Divider Fluke 8505A, 0.5 Digit Digital Multimeter Fluke 8505A, Digital Multimeter Fluke 8505A, Digital Multimeter Krohn-Hite 3100R, Tunable Filter Krohn-Hite 3103R/3103, Tunable Filter/ Rack Version Krohn-Hite 3202/R3202, Tunable Filter/ Rack Version Krohn-Hite 3342, Tunable Filter Sorensen QRD 30-1, Power Supply, 30V-1A Sorensen QRD 30-1, Power Supply, 30V-2A	. \$66 . \$77 . \$22 . \$11 . \$22 . \$1 . \$1 . \$3 . \$1 . \$1 . \$3 . \$1 . \$1 . \$1 . \$1 . \$1 . \$1 . \$1 . \$1
8349B Amplifier, 2-20GHz         \$5000           8350A, Sweep Oscillator Mainframe         \$2400           83540A, 2-0-8-4GHz         RF Plug-in         \$2250           83540A, 2-0-8-4GHz         \$4750           83545A, Oscillator Plug-in         \$4200           835752B/OS-1006, Oscillator Plug-in         26.5-40GHz         \$12,000           8405A, Vector Voltmeter 1MHz-1GHz         \$250           8410B, Network Analyzer System         w/8412A, 8743A         8411A         \$600           8411A/01B, Frequency Converter. 11 to 18GHz         \$500         \$441A/01B, Frequency Converter. 1350           8445B, Automatic Preselector         \$450         \$450         \$476         Amplifier. 0.4-00MHz         \$300           8447B, Amplifier, 0.4-13GHz         \$350         \$300         \$447C, Amplifier. 30-300MHz         \$300           8501A, Storage Normalizer         \$700         \$505A, Network Analyzer         \$2500	Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 520A, AC Voltage Calibrator Fluke 520A, Reference Divider Fluke 8505A, 6.5 Digit Digital Multimeter Fluke 8505A, Digital Multimeter Fluke 8505A, Digital Multimeter Krohn-Hite 3100R, Tunable Filter Krohn-Hite 3103/R3103, Tunable Filter/ Rack Version \$2 Krohn-Hite 3202/R3202, Tunable Filter/ Rack Version Krohn-Hite 3342, Tunable Filter Sorensen QRD 30-1, Power Supply, 30V-1A Sorensen QRD 40-2, Power Supply, 30V-1A Sorensen QRD 40-2, Power Supply, 40V-2A Valhalia 2701B, DC Calibrator.	\$66 \$77 \$22 \$11 \$21 \$11 \$21 \$12 \$12 \$13 \$13 \$14 \$15 \$15 \$15 \$15 \$15 \$15 \$15 \$15 \$15 \$15
8349B Amplifier, 2-20GHz         \$5000           8350A, Sweep Oscillator Mainframe         \$2400           83540A, 2-0-8.4GHz, RF Plug-in         \$2250           83540A, 2-0-8.4GHz, RF Plug-in         \$2550           83545A, Oscillator Plug-in, 5-9-12.4GHz         \$4200           83572B/001-006, Oscillator Plug-in, 26.5-40GHz         \$12,000           8405A, Vector Voltmeter MHz-1GHz         \$250           8410B, Network Analyzer System         w/8412A, 8743A 8 8411A         \$600           8411A/01B, Frequency Converter 11 to 18GHz         3500           8443A, Tracking Generator/Counter         3350           8445B, Automatic Preselector         \$450           9447B, Amplifier, 0.1-400MHz         \$300           847B, Amplifier, 0.4-13GHz         \$350           8501A, Storage Nommalizer         \$700           8501A, Storage Nommalizer         \$700           8503A, S-Parameter Test Set         \$1150           8505A, Network Analyzer         \$2500           8508A, Vector Voltmeter         \$4750	Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 520A, AC Voltage Calibrator Fluke 520A, Factor Standard Fluke 752A, Reference Divider Fluke 8505A, 6.5 Digit Digital Multimeter Fluke 8506A, Digital Multimeter Krohn-Hite 3103R Junable Filter Krohn-Hite 3103R Junable Filter/ Rack Version Krohn-Hite 3202/R3202, Tunable Filter/ Rack Version Krohn-Hite 3202/R3202, Tunable Filter/ Sorensen QRD 30-1, Power Supply, 30V-1A Sorensen QRD 40-2, Power Supply, 40V-2A Valhalla 2701B, DC Calibrator Wavetek 166, Pulse Function Generator	. \$66 . \$77 . \$20 . \$11 . \$2 . \$1 . \$3 . \$17 . \$5 . \$1 . \$1 . \$2 . \$1 . \$1 . \$2 . \$1 . \$1 . \$1 . \$1 . \$1 . \$1 . \$1 . \$1
8349B Amplifier, 2-20GHz         \$5000           8350A, Sweep Oscillator Mainframe         \$2400           83540A, 2-0-8 4GHz         RF Plug-in         \$2250           83540A, 2-0-8 4GHz         \$4750           83545A, Oscillator Plug-in         \$4200           83572B/001-006, Oscillator Plug-in         26.5-40GHz         \$12,000           8405A, Vector Voltmeter 1MHz-1GHz         \$250           8410B, Network Analyzer System         w/8412A, 8743A 8 8411A         \$600           8413A/10B, Frequency Converter .11 to 18GHz         \$500           8443B, Atroaking Generator/Counter         \$350           8447B, Amplifier         0.1-400MHz         \$300           8447B, Amplifier         0.1-3GHz         \$350           8503A, Storage Normalizer         \$700           8503A, Network Analyzer         \$250           8503A, Network Analyzer         \$4750           853A, Display for Spectrum Analyzer Plug-in         \$2250	Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 520A, AC Voltage Calibrator Fluke 520A, Reference Divider Fluke 8505A, 6.5 Digit Digital Multimeter Fluke 8505A, Digital Multimeter Fluke 8505A, Digital Multimeter Krohn-Hite 3100R, Tunable Filter Krohn-Hite 3103/R3103, Tunable Filter/ Rack Version \$2 Krohn-Hite 3202/R3202, Tunable Filter/ Rack Version Krohn-Hite 3342, Tunable Filter Sorensen QRD 30-1, Power Supply, 30V-1A Sorensen QRD 40-2, Power Supply, 30V-1A Sorensen QRD 40-2, Power Supply, 40V-2A Valhalia 2701B, DC Calibrator.	. \$66 . \$77 . \$20 . \$11 . \$2 . \$1 . \$3 . \$17 . \$5 . \$1 . \$5 . \$1 . \$1 . \$1 . \$1 . \$1 . \$1 . \$1 . \$1
8349B Amplifier, 2-20GHz         \$5000           8350A, Sweep Oscillator Mainframe         \$2400           83540A, 2-0-8 4GHz. RF Plug-in         \$2250           83540A, 2-0-8 4GHz. RF Plug-in         \$2250           83545A, Oscillator Plug-in, 5-9-12-4GHz         \$4200           83572B/001-006, Oscillator Plug-in, 26.5-40GHz         \$12,000           8405A, Vector Voltmeter MHz-1GHz         \$250           8410B, Network Analyzer System         w/8412A, B743A         8411A           8411A, Brayaka, 8411A         \$600           8413A, Tracking Generator/Counter         \$350           8445B, Automatic Preselector         \$450           8447B, Amplifiler, 0.1-400MHz         \$300           8447B, Amplifiler, 0.4-1.3GHz         \$350           8501A, Storage Nomalizer         \$700           8503A, S-Parameter Test Set         \$115           8505A, Network Analyzer         \$250           853B, IF Section Plug-in         \$225           8552B & 8552B, Spectrum Analyzer         \$600	Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 520A, AC Voltage Calibrator Fluke 520A, Factor Standard Fluke 752A, Reference Divider Fluke 8505A, 6.5 Digit Digital Multimeter Fluke 8506A, Digital Multimeter Fluke 8506A, Digital Multimeter Krohn-Hite 3103R3103, Tunable Filter/ Rack Version Krohn-Hite 3202/R3202, Tunable Filter/ Rack Version Krohn-Hite 3202/R3202, Tunable Filter/ Sorensen QRD 30-1, Power Supply, 30V-1A Sorensen QRD 40-2, Power Supply, 40V-2A Valhalla 2701B, DC Calibrator Wavetek 166, Pulse Function Generator Wavetek 178, Automatic Synthesizer Wavetek 178, Automatic Synthesizer Wavetek 178, Automatic Synthesizer Wavetek 186, Phase Lock Generator, 5MHz Wavetek 2002, Signal Generator, 1-2500MHz	. \$66 . \$77 . \$22 . \$11 . \$21 . \$3 . \$11 . \$3 . \$11 . \$5 . \$11 . \$11 . \$2 . \$11 . \$2 . \$11 . \$2 . \$11 . \$2 . \$11 . \$2 . \$11 . \$11
8349B Amplifier, 2-20GHz         \$5000           8350A, Sweep Oscillator Mainframe         \$2400           83540A, 2-0-8-4GHz         RF Plug-in         \$2250           83540A, 2-0-8-4GHz         \$4200           83545A, Oscillator Plug-in         \$4200           83572B/001-006, Oscillator Plug-in         26.5-40GHz         \$12,000           8405A, Vector Voltmeter 1MHz-1GHz         \$250           8410B, Network Analyzer System         w/8412A, 6743A         8411A         \$600           8413A, Tracking Generator/Counter         \$350         8445B, Automatic Preselector         \$350           8447B, Amplifier, 0.1-400MHz         \$300         8447B, Amplifier, 0.1-400MHz         \$300           8447C, Amplifier, 30-300Mbz         \$300         8501A, Storage Normalizer         \$700           8505A, Network Analyzer         \$2500           8505A, Network Analyzer         \$250           852B, IF Section Plug-in         \$250           852B, BFSSB, Spectrum Analyzer Plug-in         \$250           852B, BSSB, Spectrum Analyzer         \$100           8014 Maintriame         \$150	Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 520A, Transfer Standard Fluke 752A, Reference Divider Fluke 8505A, Digital Multimeter Fluke 8505A, Digital Multimeter Fluke 8505A, Digital Multimeter Krohn-Hite 3100R, Tunable Filter Krohn-Hite 3103/R3103, Tunable Filter/ Rack Version \$2 Krohn-Hite 3202/R3202, Tunable Filter/ Rack Version \$5 Krohn-Hite 3342, Tunable Filter Sorensen QRD 30-1, Power Supply, 30V-1A Sorensen QRD 40-2, Power Supply, 30V-1A Sorensen QRD 40-2, Power Supply, 40V-2A Valhalia 2701B, DC Calibrator. Wavetek 166, Pluse Function Generator Wavetek 178, Automatic Synthesizer Wavetek 178, Automatic Synthesizer Wavetek 186, Phase Lock Generator, 5MHz Wavetek 2002A, Signal Generator, 1-2500MHz Wavetek 2002A, Signal Generator, 1-2500MHz	. \$66 . \$77 . \$22 . \$11 . \$21 . \$3 . \$11 . \$3 . \$11 . \$11 . \$11 . \$2 . \$11 . \$11 . \$11 . \$11 . \$11
8349B Amplifier, 2-20GHz         \$5000           8350A, Sweep Oscillator Mainframe         \$2400           83540A, 2-0-8.4GHz. RF Plug-in         \$2250           83540A, 2-0-8.4GHz. RF Plug-in         \$2250           83545A, Oscillator Plug-in, 5-9-12.4GHz         \$4200           83572B/001-006, Oscillator Plug-in, 26.5-40GHz         \$12,000           8405A, Vector Voltmeter MHz-1GHz         \$250           8410B, Network Analyzer System         w/8412A, 8743A 8 8411A           8411A/01B, Frequency Converter 11 to 18GHz         \$500           8441A/D1B, Frequency Converter 11 to 18GHz         \$350           8443B, Automatic Preselector         \$450           8447B, Automatic Preselector         \$450           8447B, Amplifiler, 0.4-1.3GHz         \$350           8447B, Amplifiler, 0.4-1.3GHz         \$350           8501A, Storage Nomalizer         \$700           8503A, S-Parameter Test Set         \$115           8508A, Vector Voltmeter         \$475           852B, IF Section Plug-in         \$250           852B, B 6553B, Spectrum Analyzer         w/141T Mainframe           8552B, 85555A, Spectrum Analyzer         \$100	Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 520A, AC Voltage Calibrator Fluke 520A, Factor Standard Fluke 752A, Reference Divider Fluke 8505A, 6.5 Digit Digital Multimeter Fluke 8505A, Digital Multimeter Krohn-Hite 3100R, Tunable Filter Rack Version Krohn-Hite 3202/R3202, Tunable Filter/ Rack Version Krohn-Hite 3342, Tunable Filter Sorensen QRD 30-1, Power Supply, 30V-1A Sorensen QRD 40-2, Power Supply, 40V-2A Valhalla 2701B, DC Calibrator Wavetek 166, Pulse Function Generator Wavetek 178, Automatic Synthesizer Wavetek 186, Phase Lock Generator, 5MHz Wavetek 2002, Signal Generator, 1-2500MHz Wavetek 2002A, Signal Generator, 1-2500MHz Wavetek 2000A, Signal Generator, 1-2500MHz	\$60 \$70 \$20 \$11 \$20 \$11 \$21 \$11 \$21 \$11 \$21 \$11 \$21 \$11 \$21 \$11 \$21 \$11 \$21 \$11 \$21 \$11 \$21 \$11 \$21 \$11 \$21 \$11 \$21 \$11 \$21 \$11 \$21 \$11 \$21 \$2
8349B Amplifier, 2-20GHz         \$5000           8350A, Sweep Oscillator Mainframe         \$2400           83540A, 2-0-8-4GHz         RF Plug-in         \$2250           83540A, 2-0-8-4GHz         \$4200           83545A, Oscillator Plug-in         \$4200           83572B/001-006, Oscillator Plug-in         26.5-40GHz         \$12,000           8405A, Vector Voltmeter 1MHz-1GHz         \$250           8410B, Network Analyzer System         w/8412A, 6743A         8411A         \$600           8413A, Tracking Generator/Counter         \$350         8445B, Automatic Preselector         \$350           8447B, Amplifier, 0.1-400MHz         \$300         8447B, Amplifier, 0.1-400MHz         \$300           8447C, Amplifier, 30-300Mbz         \$300         8501A, Storage Normalizer         \$700           8505A, Network Analyzer         \$2500           8505A, Network Analyzer         \$250           852B, IF Section Plug-in         \$250           852B, BFSSB, Spectrum Analyzer Plug-in         \$250           852B, BSSB, Spectrum Analyzer         \$100           8014 Maintriame         \$150	Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 520A, Transfer Standard Fluke 752A, Reference Divider Fluke 8505A, 0.5 Digit Digital Multimeter Fluke 8505A, Digital Multimeter Fluke 8505A, Digital Multimeter Fluke 8505A, Digital Multimeter Krohn-Hite 3100R, Tunable Filter Krohn-Hite 3100R, Tunable Filter Rack Version Krohn-Hite 3202/R3202, Tunable Filter/ Rack Version Sorensen QRD 30-1, Power Supply, 30V-1A Sorensen QRD 40-2, Power Supply, 40V-2A Valhalla 2701B, DC Calibrator. Wavetek 166, Pulse Function Generator Wavetek 178, Automatic Synthesizer Wavetek 178, Automatic Synthesizer Wavetek 186, Phase Lock Generator, SMHz Wavetek 2002A, Signal Generator, 1-5200MHz Wavetek 2002A, Signal Generator, 1-5200MHz Wavetek 3000-200, Signal Generator, 1-520MHz Wavetek 3000-200, Signal Generator, 1-500MHz Wavetek 3000-200, Signal Generator, 1-520MHz	. \$66 . \$77 . \$22 . \$11 . \$2 . \$12 . \$17 . \$16 . \$17 . \$17 . \$17 . \$2 . \$17 . \$17
8349B Amplifier, 2-20GHz         \$5000           8350A, Sweep Oscillator Mainframe         \$2400           83540A, 2-0-8 4GHz. RF Plug-in         \$2250           83540A, 2-0-8 4GHz. RF Plug-in         \$2250           83545A, Oscillator Plug-in, 5-9-12-4GHz         \$4200           83572B/001-006, Oscillator Plug-in, 26.5-40GHz         \$12,000           8405A, Vactor Voltmeter MHz-1GHz         \$250           8410B, Network Analyzer System         w/8412A, Br343A         8411A         \$600           8411A/01B, Frequency Converter         11 to 18GHz         \$500           8441A, Tracking Generator/Counter         \$350         \$445B, Automatic Preselector         \$450           8447B, Amplifier, 0.1-400MHz         \$300         \$300         \$447B, Amplifier, 0.4-30MHz         \$300           8501A, Storage Normalizer         \$700         \$500A, S-Parameter Test Set         \$1150           8508A, Display for Spectrum Analyzer Plug-in         \$2250         \$552B, B, IF Section Plug-in         \$2250           8552B, 8 B555A, Spectrum Analyzer         w/141T Mainframe         \$150           8559A W/182T, Spectrum Analyzer, 0.01-21GHz         \$350           8559A W/182T, Spectrum Analyzer, 0.01-21GHz         \$350	Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 520A, Reference Divider Fluke 8505A, 6.5 Digit Digital Multimeter Fluke 8505A, Digital Multimeter Fluke 8505A, Digital Multimeter Krohn-Hite 3100R, Tunable Filter Krohn-Hite 3103/R3103, Tunable Filter/ Rack Version \$5 Krohn-Hite 3202/R3202, Tunable Filter/ Rack Version \$5 Krohn-Hite 3342, Tunable Filter Sorensen QRD 30-1, Power Supply, 30V-1A Sorensen QRD 30-1, Power Supply, 40V-2A Valhalia 2701B, DC Calibrator. Wavetek 166, Pulse Function Generator Wavetek 178, Automatic Synthesizer Wavetek 188, Phase Lock Generator, 5MHz Wavetek 2002, Signal Generator, 1-2500MHz Wavetek 3000, Signal Generator, 1-520MHz	. \$66 . \$77 . \$22 . \$11 . \$27 . \$11 . \$3 . \$17 . \$11 . \$2 . \$11 . \$1
8349B Amplifier, 2-20GHz         \$5000           8350A, Sweep Oscillator Mainframe         \$2400           83540A, 2.0-8.4GHz, RF Plug-in         \$2250           83540B, RF Plug-in, 2.0-8.4GHz         \$4250           83545A, Oscillator Plug-in, 5-9-12.4GHz         \$4200           83572B/001-006, Oscillator Plug-in, 26.5-40GHz         \$12,000           8405A, Vector Voltmeter MHz-1GHz         \$250           8410B, Network Analyzer System         w/8412A, 8743A & 8411A         \$600           8411A/018, Frequency Converter .11 to 18GHz         \$500           8443A, Tracking Generator/Counter         \$350           8445B, Automatic Preselector         \$450           8447B, Amplifier, 0.1-400MHz         \$300           8447B, Amplifier, 0.4-13GHz         \$350           8447C, Amplifier, 30-300MHz         \$350           8501A, Storage Normalizer         \$700           8503A, S-Parameter Test Set         \$1150           8508A, Vector Voltmeter         \$4750           852B, IF, Section Plug-in         \$600           8552B & 8553B, Spectrum Analyzer         \$1500           8552B & 8555A, Spectrum Analyzer         \$1800           8557A/18ZT, Spectrum Analyzer         \$1600           8559A W/18ZT, Spectrum Analyzer         \$1500           <	Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 520A, Transfer Standard Fluke 752A, Reference Divider Fluke 8505A, 0.5 Digit Digital Multimeter Fluke 8505A, Digital Multimeter Fluke 8505A, Digital Multimeter Fluke 8505A, Digital Multimeter Krohn-Hite 3100R, Tunable Filter Krohn-Hite 3100R, Tunable Filter Rack Version Krohn-Hite 3202/R3202, Tunable Filter/ Rack Version Sorensen QRD 30-1, Power Supply, 30V-1A Sorensen QRD 40-2, Power Supply, 40V-2A Valhalla 2701B, DC Calibrator. Wavetek 166, Pulse Function Generator Wavetek 178, Automatic Synthesizer Wavetek 178, Automatic Synthesizer Wavetek 186, Phase Lock Generator, SMHz Wavetek 2002A, Signal Generator, 1-5200MHz Wavetek 2002A, Signal Generator, 1-5200MHz Wavetek 3000-200, Signal Generator, 1-520MHz Wavetek 3000-200, Signal Generator, 1-500MHz Wavetek 3000-200, Signal Generator, 1-520MHz	. \$66 . \$77 . \$22 . \$11 . \$27 . \$11 . \$3 . \$17 . \$11 . \$2 . \$11 . \$1
8349B Amplifier, 2-20GHz         \$5000           8350A, Sweep Oscillator Mainframe         \$2400           83540A, 2-0-8-4GHz. RF Plug-in         \$2250           83540A, 2-0-8-4GHz. RF Plug-in         \$2250           83545A, Oscillator Plug-in, 5-9-12-4GHz         \$4200           83572B/001-006, Oscillator Plug-in, 26.5-40GHz         \$12,000           8405A, Vactor Voltmeter MHz-1GHz         \$250           8410B, Network Analyzer System         w/8412A, 8743A 8 8411A           8411A/01B, Frequency Converter 11 to 18GHz         \$500           8441A/01B, Frequency Converter 11 to 18GHz         \$350           8443B, Automatic Preselector         \$450           8447B, Automatic Preselector         \$450           9447B, Amplifiler, 0.4-1.3GHz         \$350           8447B, Amplifiler, 0.4-1.3GHz         \$350           8501A, Storage Nommalizer         \$700           8503A, S-Parameter Test Set         \$1150           8503A, Network Analyzer         \$250           852B, R Sector Voltmeter         \$475           852B, B Se553B, Spectrum Analyzer         \$100           8552B, Spectrum Analyzer         \$1600           8553A, Villaminame         \$1600           8554A/VILLATION Analyzer         \$1600           8558A, Willaminame <td< td=""><td>Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 520A, AC Voltage Calibrator Fluke 520A, Factor Standard Fluke 752A, Reference Divider Fluke 8505A, 6:5 Digit Digital Multimeter Fluke 8506A, Digital Multimeter Krohn-Hite 3100R, Tunable Filter Rack Version Krohn-Hite 3202/R3202, Tunable Filter/ Rack Version Krohn-Hite 3342, Tunable Filter Sorensen QRD 30-1, Power Supply, 30V-1A Sorensen QRD 40-2, Power Supply, 40V-2A Valhalla 2701B, DC Calibrator. Wavetek 166, Pulse Function Generator Wavetek 178, Automatic Synthesizer Wavetek 186, Phase Lock Generator, 5MHz Wavetek 2002, Signal Generator, 1-2500MHz Wavetek 3000, Signal Generator, 1-250MHz Wavetek 3000, Signal Generator, 1-520MHz Wavetek 3000, Signal Generator, 1-520MHz Wavetek 3001, Signal Generator, 5Hz-50MHz Wavetek 3001, Signal Generator, 5Hz-50MHz Wavetek 801, Pulse Generator, 5Hz-50MHz</td><td>\$60 \$71 \$21 \$21 \$31 \$31 \$75/\$3 \$00/\$3 \$11 \$31 \$31 \$31 \$31 \$31 \$31 \$31 \$31 \$</td></td<>	Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 520A, AC Voltage Calibrator Fluke 520A, Factor Standard Fluke 752A, Reference Divider Fluke 8505A, 6:5 Digit Digital Multimeter Fluke 8506A, Digital Multimeter Krohn-Hite 3100R, Tunable Filter Rack Version Krohn-Hite 3202/R3202, Tunable Filter/ Rack Version Krohn-Hite 3342, Tunable Filter Sorensen QRD 30-1, Power Supply, 30V-1A Sorensen QRD 40-2, Power Supply, 40V-2A Valhalla 2701B, DC Calibrator. Wavetek 166, Pulse Function Generator Wavetek 178, Automatic Synthesizer Wavetek 186, Phase Lock Generator, 5MHz Wavetek 2002, Signal Generator, 1-2500MHz Wavetek 3000, Signal Generator, 1-250MHz Wavetek 3000, Signal Generator, 1-520MHz Wavetek 3000, Signal Generator, 1-520MHz Wavetek 3001, Signal Generator, 5Hz-50MHz Wavetek 3001, Signal Generator, 5Hz-50MHz Wavetek 801, Pulse Generator, 5Hz-50MHz	\$60 \$71 \$21 \$21 \$31 \$31 \$75/\$3 \$00/\$3 \$11 \$31 \$31 \$31 \$31 \$31 \$31 \$31 \$31 \$
8349B Amplifier, 2-20GHz         \$5000           8350A, Sweep Oscillator Mainframe         \$2400           83540A, 2-0-8 4GHz         RF Plug-in         \$2250           83540A, 2-0-8 4GHz         \$4200           83545A, Oscillator Plug-in         \$5250           83545A, Oscillator Plug-in         \$4200           83572B/001-006, Oscillator Plug-in         26.540GHz           \$12,000         \$405A, Vector Voltmeter 1MHz-1GHz         \$250           \$410B, Network Analyzer System         w/8412A, 8743A 8 8411A         \$600           \$441A/D, Frequency Converter         11 to 18GHz         \$500           \$443A, Tracking Generator/Counter         \$350           \$445B, Automatic Preselector         \$450           \$447A, Amplifier         0.1-400MHz         \$300           \$447A, Amplifier         0.4-1.3GHz         \$350           \$447A, Amplifier         0.4-1.3GHz         \$350           \$503A, Storage Nomalizer         \$700           \$504A, Storage Nomalizer         \$700           \$505A, Network Analyzer         \$250           \$553A, Display for Spectrum Analyzer Plug-in         \$2250           \$552B & 8555B, Spectrum Analyzer         \$150           \$552B & 8555B, Spectrum Analyzer         \$1600           \$574/18	Filke 335D, DC Voltage Standard Filke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 520A, Fransfer Standard Fluke 8505A, Digital Multimeter Fluke 8505A, Digital Multimeter Fluke 8505A, Digital Multimeter Fluke 8505A, Digital Multimeter Krohn-Hite 3100R, Tunable Filter Krohn-Hite 3103/R3103, Tunable Filter Rack Version Krohn-Hite 3202/R3202, Tunable Filter/ Rack Version Strohn-Hite 3342, Tunable Filter Sorensen QRD 30-1, Power Supply, 30V-1A Sorensen QRD 40-2, Power Supply, 40V-2A Valhalla 2701B, DC Calibrator. Wavetek 166, Pluse Function Generator Wavetek 178, Automatic Synthesizer Wavetek 2002A, Signal Generator, 1-2500MHz Wavetek 3000, Signal Generator, 1-520MHz Wavetek 801, Pilse Generator, 5Hz-50MHz Wavetek 801, Pilse Generator, 5Hz-50MHz Wavetek 801, Pulse Generator, 5Hz-50MHz Wavetek 802, Pulse Generator, 5Hz-50MHz	\$60 \$71 \$22 \$11 \$21 \$31 \$75/\$: \$11 \$3 \$11 \$21 \$3 \$11 \$3 \$11 \$3 \$11 \$3 \$11 \$3 \$11 \$3 \$11 \$4 \$11 \$11 \$11 \$11 \$11 \$11 \$11 \$11
8349B Amplifier, 2-20GHz         \$5000           8350A, Sweep Oscillator Mainframe         \$2400           83540A, 2-0-8 4GHz         RF Plug-in         \$2250           83540A, 2-0-8 4GHz         \$4200           83545A, Oscillator Plug-in         \$5250           83545A, Oscillator Plug-in         \$4200           83572B/001-006, Oscillator Plug-in         26.5-40GHz         \$12,000           8405B, Vector Voltmeter MHz-1GHz         \$250           8410B, Network Analyzer System         w/8412A, Br343A         8411A         \$600           8411A/D18, Frequency Converter         11 to 18GHz         \$500           8441A, Tracking Generator/Counter         \$350         \$445B, Automatic Preselector         \$450           8447A, Amplifier         0.1-400MHz         \$300         \$300           8447B, Automatic Preselector         \$450         \$450           8447A, Amplifier         0.1-400MHz         \$300           8501A, Storage Nomalizer         \$700         \$501A, Storage Nomalizer         \$700           8501A, Storage Nomalizer         \$250         \$505A, Network Analyzer         \$250           8528, Display for Spectrum Analyzer Plug-in         \$2250           85528, B SS55S, Spectrum Analyzer         \$150           85528, B SS55S, Spectrum An	Filke 335D, DC Voltage Standard Filke 5100B/05, Multifunction Calibrator Filke 5101B/03, Calibrator Filke 5200A, AC Voltage Calibrator Filke 5200A, AC Voltage Calibrator Filke 520A, Fransfer Standard Filke 752A, Reference Divider Filke 8505A, Digital Multimeter Filke 8505A, Digital Multimeter Filke 8505A, Digital Multimeter Krohn-Hite 3100R, Tunable Filter Krohn-Hite 3103/R3103, Tunable Filter Krohn-Hite 3202/R3202, Tunable Filter/ Rack Version \$5 Krohn-Hite 3342, Tunable Filter Sorensen QRD 30-1, Power Supply, 30V-1A Sorensen QRD 30-1, Power Supply, 30V-1A Sorensen QRD 40-2, Power Supply, 40V-2A Valhalia 2701B, DC Calibrator Wavetek 166, Plase Lock Generator Wavetek 168, Plase Lock Generator, 5MHz Wavetek 2002A, Signal Generator, 1-520MHz Wavetek 3000, Signal Generator, 1-520MHz Wavetek 3000, Signal Generator, 1-520MHz Wavetek 3000, Signal Generator, 1-520MHz Wavetek 801, Pluse Generator, 5Hz-50MHz Wavetek 802, Pulse Generator, 5Hz-50MHz Wavetek 802, Pulse Generator, 5-12-50MHz Wavetek 907A, Signal Generator, 5-12-50MHz	. \$66 \$77 \$22 \$11. \$21. \$3. \$11. \$3. \$1. \$1. \$1. \$2. \$1. \$1. \$1. \$1. \$1. \$1. \$1. \$1. \$1. \$1
8349B Amplifier, 2-20GHz         \$5000           8350A, Sweep Oscillator Mainframe         \$2400           83540A, 2.0-8.4GHz, RF Plug-in         \$2250           83540B, RF Plug-in, 2.0-8.4GHz         \$4250           83545A, Oscillator Plug-in, 5-9-12.4GHz         \$4200           83572B/001-006, Oscillator Plug-in, 26.5-40GHz         \$12,000           8405A, Vector Voltmeter MHz-1GHz         \$250           8410B, Network Analyzer System         w/8412A, 8743A & 8411A         \$600           8411A/018, Frequency Converter .11 to 18GHz         \$500           8443A, Tracking Generator/Counter         \$350           8445B, Automatic Preselector         \$450           8447B, Amplifier, 0.1-400MHz         \$300           8447B, Amplifier, 0.4-13GHz         \$350           8447C, Amplifier, 0.3-0300MHz         \$300           8501A, Storage Normalizer         \$700           8503A, S-Parameter Test Set         \$1150           8508A, Vector Voltmeter         \$4750           852B, IF, Section Plug-in         \$600           8552B, IS, Section Plug-in         \$600           8552B & 8553B, Spectrum Analyzer         w/141T Mainframe         \$1800           8554A WH8ET, Spectrum Analyzer         3150           8552B & 8555A, Spectrum Analyzer         3160	Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 520A, Reference Divider Fluke 8505A, 6.5 Digit Digital Multimeter Fluke 8505A, Digital Multimeter Fluke 8505A, Digital Multimeter Krohn-Hite 3100R, Tunable Filter Krohn-Hite 3103/R3103, Tunable Filter/ Rack Version Krohn-Hite 3202/R3202, Tunable Filter/ Rack Version S5 Krohn-Hite 3342, Tunable Filter Sorensen QRD 30-1, Power Supply, 30V-1A Sorensen QRD 30-1, Power Supply, 40V-2A Valhalia 2701B, DC Calibrator. Wavetek 166, Pulse Function Generator Wavetek 178, Automatic Synthesizer Wavetek 188, Phase Lock Generator, 5MHz Wavetek 2002, Signal Generator, 1-2500MHz Wavetek 3000, Signal Generator, 1-520MHz Wavetek 8001, Signal Generator, 5Hz-50MHz Wavetek 8001, Signal Generator, 5Hz-50MHz Wavetek 907A, Signal Generator, 5Hz-50MHz Wavetek 907A, Signal Generator, 5Hz-50MHz Wavetek 907A, Signal Generator, 7-12-4GHz Wiltron 560A, Scalar Network Analyzer Wiltron 560A, Scalar Network Analyzer Wiltron 560A, Scalar Network Analyzer	. \$66 \$77 \$22 \$11. \$21. \$3. \$11. \$3. \$11. \$11. \$2. \$11. \$2. \$11. \$11. \$11.
8349B Amplifier, 2-20GHz         \$5000           8350A, Sweep Oscillator Mainframe         \$2400           83540A, 2-0-8 4GHz         RF Plug-in         \$2250           83540A, 2-0-8 4GHz         \$4200           83545A, Oscillator Plug-in         \$5250           83545A, Oscillator Plug-in         \$4200           83572B/001-006, Oscillator Plug-in         26.5-40GHz         \$12,000           8405B, Vector Voltmeter MHz-1GHz         \$250           8410B, Network Analyzer System         w/8412A, Br343A         8411A         \$600           8411A/D18, Frequency Converter         11 to 18GHz         \$500           8441A, Tracking Generator/Counter         \$350         \$445B, Automatic Preselector         \$450           8447A, Amplifier         0.1-400MHz         \$300         \$300           8447B, Automatic Preselector         \$450         \$450           8447A, Amplifier         0.1-400MHz         \$300           8501A, Storage Nomalizer         \$700         \$501A, Storage Nomalizer         \$700           8501A, Storage Nomalizer         \$250         \$505A, Network Analyzer         \$250           8528, Display for Spectrum Analyzer Plug-in         \$2250           85528, B SS55S, Spectrum Analyzer         \$150           85528, B SS55S, Spectrum An	Filke 335D, DC Voltage Standard Filke 5100B/05, Multifunction Calibrator Filke 5101B/03, Calibrator Filke 5200A, AC Voltage Calibrator Filke 5200A, AC Voltage Calibrator Filke 520A, Fransfer Standard Filke 752A, Reference Divider Filke 8505A, Digital Multimeter Filke 8505A, Digital Multimeter Filke 8505A, Digital Multimeter Krohn-Hite 3100R, Tunable Filter Krohn-Hite 3103/R3103, Tunable Filter Krohn-Hite 3202/R3202, Tunable Filter/ Rack Version \$5 Krohn-Hite 3342, Tunable Filter Sorensen QRD 30-1, Power Supply, 30V-1A Sorensen QRD 30-1, Power Supply, 30V-1A Sorensen QRD 40-2, Power Supply, 40V-2A Valhalia 2701B, DC Calibrator Wavetek 166, Plase Lock Generator Wavetek 168, Plase Lock Generator, 5MHz Wavetek 2002A, Signal Generator, 1-520MHz Wavetek 3000, Signal Generator, 1-520MHz Wavetek 3000, Signal Generator, 1-520MHz Wavetek 3000, Signal Generator, 1-520MHz Wavetek 801, Pluse Generator, 5Hz-50MHz Wavetek 802, Pulse Generator, 5Hz-50MHz Wavetek 802, Pulse Generator, 5-12-50MHz Wavetek 907A, Signal Generator, 5-12-50MHz	. \$66 \$77 \$22 \$11. \$21. \$3. \$11. \$3. \$11. \$11. \$2. \$11. \$2. \$11. \$11. \$11.
8349B Amplifier, 2-20GHz         \$5000           8350A, Sweep Oscillator Mainframe         \$2400           83540A, 2.0-8.4GHz, RF Plug-in         \$2250           83540B, RF Plug-in, 2.0-8.4GHz         \$4250           83545A, Oscillator Plug-in, 5-9-12.4GHz         \$4200           83572B/001-006, Oscillator Plug-in, 26.5-40GHz         \$12,000           8405A, Vector Voltmeter MHz-1GHz         \$250           8410B, Network Analyzer System         w/8412A, 8743A & 8411A         \$600           8411A/018, Frequency Converter .11 to 18GHz         \$500           8443A, Tracking Generator/Counter         \$350           8445B, Automatic Preselector         \$450           8447B, Amplifier, 0.1-400MHz         \$300           8447B, Amplifier, 0.4-13GHz         \$350           8447C, Amplifier, 0.3-0300MHz         \$300           8501A, Storage Normalizer         \$700           8503A, S-Parameter Test Set         \$1150           8508A, Vector Voltmeter         \$4750           852B, IF, Section Plug-in         \$600           8552B, IS, Section Plug-in         \$600           8552B & 8553B, Spectrum Analyzer         w/141T Mainframe         \$1800           8554A WH8ET, Spectrum Analyzer         3150           8552B & 8555A, Spectrum Analyzer         3160	Fluke 335D, DC Voltage Standard Fluke 5100B/05, Multifunction Calibrator Fluke 5101B/03, Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 5200A, AC Voltage Calibrator Fluke 520A, Fransfer Standard Fluke 752A, Reference Divider Fluke 8505A, Digital Multimeter Fluke 8505A, Digital Multimeter Fluke 8505A, Digital Multimeter Krohn-Hite 3100R, Tunable Filter Krohn-Hite 3103/R3103, Tunable Filter Rack Version Fluke 8505A, Digital Multimeter Krohn-Hite 3202/R3202, Tunable Filter Rack Version Fluke 8505A, Standard Fluke 8505A, Sweep Generator, 0.1-26.5GHz Fluke 8505A, Sweep Generator, 0.1-26.5GHz	. \$66 \$77 \$22 \$11. \$21. \$3. \$11. \$3. \$11. \$11. \$2. \$11. \$2. \$11. \$11. \$11.

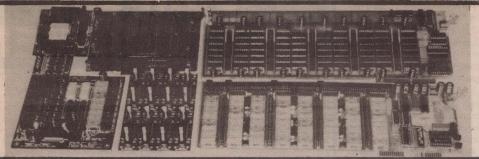


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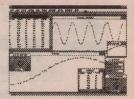
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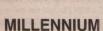
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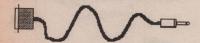
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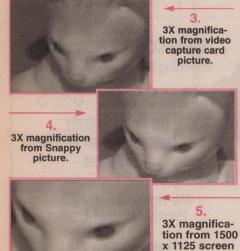
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# 1. 640 x 480 Snappy video capture.





resolution.

he Snappy video digitizer from Play, Inc., provides high-quality video capture from an inexpensive device that connects to the IBM printer port. The Snappy suggested retail price is \$199.95, but its street price is closer to \$189.95.

Snappy boasts 16.8 million color capture. Compare this to the average video capture card that captures 256 or 32K colors.

Figures 1 and 2 show the same scene, same screen resolution of 640 x 480 pixels, using the same video camera and lighting; one was

# Snappy

captured from a standard video capture card, the other from Snappy.

While the pictures at first appear the same, notice what happens when we enlarge the same section of each picture (see Figures 3 and 4). Figure 3 shows the video capture card picture. It is starting to show pixelation and become blocky. These effects become more noticeable when the picture file is printed. Figure 4 shows the Snappy picture.

Snappy also has the ability to break through the 640 x 480 pixel resolution barrier and capture a picture at 1500 x 1125 (see Figure 5). This picture is at the same magnification as Figures 3 and 4. Notice the absence of grain and pixelation in Figure 5. This file would print very well.

#### ----- Making Toast

Many of the research and development people at Play, Inc., who developed the Snappy cut their teeth on Amiga video technology. They bought the

technology. They bought the
Amiga's highly acclaimed
"Video Toaster." For those
non-Amiga enthusiasts, the
Video Toaster provides
broadcast quality titling and
video special effects for a
fraction of the standard cost.

If you'd like to see the Toaster in action, watch an episode of the science fiction show *Babylon 5*. All special effects for the show are created using Amiga's Lightwave software and Toasters.

Although the Amiga (and Commodore, for that matter) computer is no longer in production, they still remain hard at work in Hollywood. Many small cable companies use the Amiga and Toaster for special effects and titling.

Sometime next year, a video effects board named "Trinity" — that is an advanced version of the Amiga's toaster — will become available from Play, Inc. for the IBM PC. Well that's enough of this, back to the Snappy.

#### ----- Snappy Technology

Snappy uses a new technology it calls "Software Time Base Correction" that enhances the video signal as it is being digitized. I'm glad the former New Tek people

have discovered the way to digitize color video without resorting to making three passes using different color filters in front of the camera (soft applause).

#### ----- System Requirements

The Snappy requires a 386 processor or better, 4 megabytes of RAM, Windows 3.1 or higher, mouse, 3.5" floppy drive, hard drive with at least 4 megabytes of free

space, and a printer port. Most PCs only come with a single parallel port and, if you're like most people, you have a printer connected to it. Well not to worry, you can purchase a simple Data Transfer A-B Switch that will allow you to connect two devices to your single printer port.

#### ----- Software Installation

Software installation is a snap. Place the installation disk in the 3.5" floppy. From the Program Manager Windows, choose the RUN command from the FILE menu. Type A:\Setup and press Return. If your 3.5" floppy is

the B drive on your computer, then type B:\Setup. Follow the installation directions on the screen.

The software creates a "Snappy" work group that contains the Snappy icon. Double click on the icon, as you would do for all other Windows software, to start the program.

#### ----- Working with Snappy

An overview of the Snappy connection to the computer is illustrated in Figure 6. The Snappy device plugs into the computer's printer port, either directly or through an A-B switch. The Video Out of the video camera or VCR is connected to the Video In of the Snappy. If you want, the Snappy device has a Video Thru that allows one to connect a monitor to view the incoming video picture.

Once you have the Snappy set up, double click on the Snappy icon to start the program. If you didn't plug the Snappy into the parallel port, or forgot to switch the A-B switch to the Snappy, you are now looking at an error message (see Figure 7). Simply hit the cancel button, connect the Snappy, and restart the program. The opening screen on the Snappy is illustrated

by John lovine

Clicking on the Preview button



in Figure 8.

Overview of Snappy connection into computer system using a data switch box on the printer port.

allows you to view the video picture sent by the camera. The preview feature allows one to work without having a monitor connected to Snappy's Video Thru jack. However, the preview picture is a small (160 x 120 pixels) black and white picture that is only updated two times a second. The preview mode is illustrated in Figure 9. If there is no video signal being sent to the Snappy in preview mode, the screen is filled with static.

When you have the picture established in the preview screen, click on the Snap button. The program immediately starts digitizing the video picture, while making the sound of a camera shutter. When the program finishes capturing the video, it displays the picture on the screen. Hit the ESC key to return to the main menu screen. Once at the



7. Error message from Snappy program if Snappy device isn't connected to computer's printer port.



8. Snappy's opening screen.



9. Snappy's preview mode.



10. Snappy's "Setup" screen.



11. Snappy's "Adjust" screen.

main menu, you can save the current picture or start over.

#### ----- Setup & Adjust

An in-depth discussion of the Setup and Adjust options are beyond the confines of this article. I will give a quick cursory look at these control features. Clicking on the Setup button brings up the Setup screen (see Figure 10). Most of the controls are self-explanatory. Under Video Source, you may choose either "Live Camera" or "Tape/VCR." Selecting "Live Camera" informs Snappy that you have a stable video source. If you are not sure of your video source, choose the "Tape/VCR" option.

To take a really good picture with a "Live Camera," turn off the auto-iris and/or auto focus on the video camera. Avoid illumination by fluorescent lights; their flicker may interfere with Snappy.

"Snap Type" options are "Moving Video," "Still Video," "High-Quality Still," and "Highest-Quality Still." Each option determines how many fields the Snappy uses to capture the video. For those of us who are not familiar with TV or NTSC technology, the picture on the TV screen is updated 60 times a second. Each update is called a field. Each complete TV picture is comprised of two fields. So we can deduce that the TV screen picture changes 30 times a second.

The "Moving Video" option captures one picture field in 1/60 of a second. "Still Video" uses two picture fields and provides image enhancement processing to improve picture quality. "High-Quality Still" uses a four field picture capture. Naturally, the video picture can not be moving. This option takes twice as long as "Still Video." "Highest-Quality Still" uses eight picture fields.

The "Image Type" option allows you to chose "Color" which is the standard option, Black & White, Color Negative, and Black & White negative. These options allow one to digitize negatives into positive images and vice versa. When using the "Color Negative" option, it will be necessary to adjust the color sliders (see the following section on "Adjust" controls), to compensate for the orange mask used on color negatives.

By clicking on the "Adjust" button on the main screen, you are taken to another screen (see Figure 11). On this screen, you have nine controls for adjusting different aspects of the picture. The preview window allows you to view the changes you make to the picture.

Each one of the slider controls
— "Color," "Brightness," "Contrast,"
"Picture," and "Sharpness" — may
be adjusted from a value of -50 to
+50.

The top button controls adjust "Hue," "Red," "Green," and "Blue."

Using the Adjust controls properly can improve the quality of the digitized image.

#### --- Digital Paint & Morphing

Snappy is intelligently packaged with two additional software products: Fauve Matisse SE (Snappy Edition) is a 24-bit paint program, and Gryphon Morph is a morphing program.

Once you have a digital picture on your computer, the two most commonly employed softwares used to manipulate those images are a paint and morph program. Each of these full-featured programs deserves a review of their own, which we can not do right here.

The Fauve Matisse program employs most of the tools common for paint programs. It has interesting perspective and filter tools that I have not seen in other software packages costing more than the whole Snappy outfit.

The Gryphon Morphing software is capable of generating high-quality morphing movies from still picture files. This morphing package was used in Bram Stoker's Dracula and for the generation of a few *Time Magazine* covers. It has a few interesting features I haven't seen in other morphing packages.

One is the ability to create "Flip Books." The "Print Flipbook" option from the file menu prints the individual frames of an .AVI movie for collation into a flipbook. The second featured I noticed is the "Caricature" option. This feature allows you to generate caricatures from still photographs. While similar to the standardized "Warp" feature of most morphing software, it contains masking controls ideally suited to generate caricatures.

#### ----- Overview

The Snappy is an excellent product. It surpasses video capture cards in image quality and brings one into the arena of true digital photography. But don't put your video capture card out to pasture just yet. Snappy cannot create or record digital movies (.AVI) from a video source.

The additional software packages make the Snappy an exceptional buy. If you don't yet own a morphing and paint program, this is the way to go. NV

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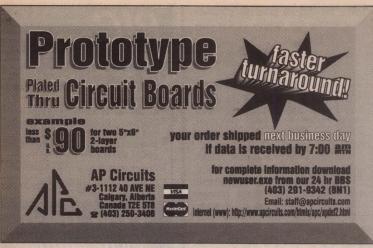
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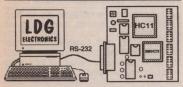
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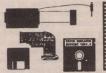
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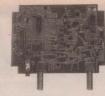


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Conducted by Anthony Charlton

We've discovered is needed for our laser video project. This is a buffer circuit that connects between the receiver and the VCR which enables us to record the video information extracted from the laser beam, and at a comfortable cable length. This adds semi-portability to the project. In case you missed any part of this project, it has appeared each month since the Oct. '95 issue, when we began it. A block diagram of the receiver portion appears in Figure 1.

The circuit is built around a Maxim current-mode feedback amplifier. As is, it acts as a buffer, increasing the signal current available from the receiver. (The receiver circuit is temporarily located on a breadboard while I try different optoelectronics as sensors and optimize the passive components of the circuit.)

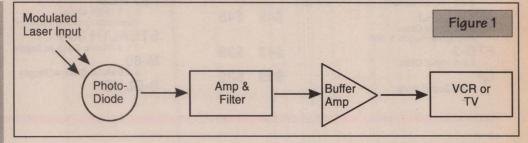
An SMT version of the MAX4112 was chosen as

An SMT version of the MAX4112 was chosen as the amplifier/buffer in accordance with the criteria we laid down in the LEoct95. It has a remarkable bandwidth of 500 MHz (!) and that is well beyond the maximum bandwidth of 4.2 MHz of B & W video coming from the camera. The output drive current can range up to 80 mA, giving us plenty of drive power. And the distortion is extremely low as evidenced by Figure 2, which shows the IC's response to a large signal (2 volts p-p) whose frequency is 333 MHz. Better responses than this occur at lower frequencies, the distortion being virtually nothing at 4.2 MHz. The only criteria that the MAX4112 doesn't currently meet is easy availability for the experimenter. Since this is a relatively new IC, it hasn't been stocked by Digi-Key yet, but it is available through other Maxim distributors. I'll provide a list of these or arrange to supply this component once we do the whole integrated schematic and Parts List for the entire project.

Figure 3 shows the schematic. The IC is configured as a unity-gain, non-inverting amplifier. The input and output are standard RG-58U 75-ohm coaxial cable. Maxim warns of the necessity of proper power supply bypassing and board layout. In keeping with this, I built the circuit on a small Surfboard™ model 9081 and installed SMT bypass capacitors where shown. The Surfboard was mated with an unetched copper-clad board, copper side down, glued to its underside. This is to establish a ground plane.

The bypass capacitors were mounted as follows. One end is soldered to the Surfboard's copper trace as close as possible to the IC. Then a hole was drilled through both boards. Next, a resistor lead was inserted through the hole. First, one end was soldered to the copper board and allowed to cool. Then the other end was quickly soldered to the chip capacitor. It is important not to overheat the chip caps. Then both wire ends were trimmed. Finally, 10 uF-15 uF low ESR (that stands for Effective Series Resistance) solid tantalum capacitors are added between the plus and minus supply leads and the ground plane. I used SMT capacitors that were on hand.

I chose to use 1/4 watt 1% metal film resistors. This was much cheaper than using chip resistors whose order minimum is 200 pieces per value. It is important to keep those resistor leads short to minimize inductance which will degrade video quality. Here's a tip: Fingernail clippers do a great job of cut



ting small wire and resistor leads. They are only about \$2.00 at any drug store.

This buffer allows several feet of cable between the buffer and the VCR. We found this to be important, as the nature of the camera and the transmitting laser requires semi-portability. And this circuit satisfies that requirement nicely.

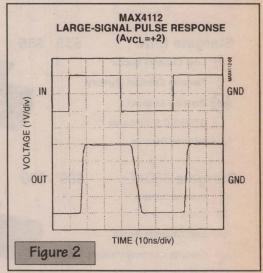
#### A Copper Vapor Laser

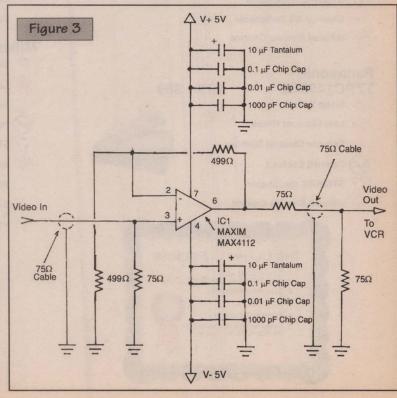
Commercial copper vapor lasers are common. Enterprising amateurs have also built them in their basement laboratories. One such project is sketched in Figure 4. Unfortunately, both the powerful wattage of the output light and the fact the power supply involves lethal voltages and currents precludes us from actually building this laser project. However, the theory and mechanical details of this novel laser are very interesting, and that's why it is presented here.

Copper vapor can be made to lase in the visible spectrum at 510.6 nM (green) and 578.2 nM (yellow). The energy level of the copper atom permits lasing if the atoms are bombarded by electrons. A simplified energy level diagram appears in Figure 5. Five energy

states are shown. The GROUND state is the lowest energy state the atom normally occupies. Remember that as energy is added to an atom, its electrons become progressively more excited, occupying orbits further and further away from the NUCLEUS of the atom. When they drop back towards the nucleus, they emit PHO-TONS, or "packets" of light. If the right optical and energy input conditions are met in the laser system, a concentrated laser beam is emitted. In this case, the beam is emitted in powerful bursts and not continuously.

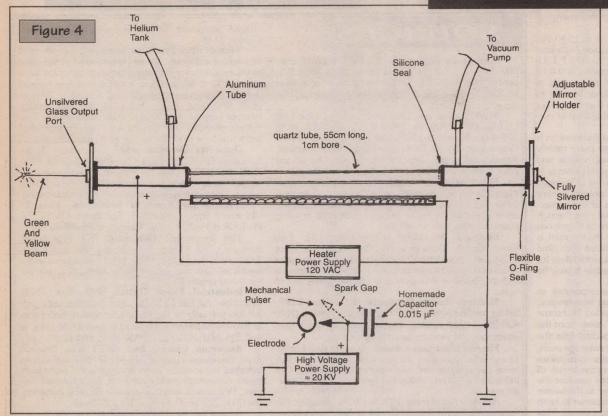
Note the energy levels A1/A2 and B1/B2. Initially, the atoms are excited to an energy state B by the electrical discharge. Should an atom jump from B2 to A1, green light will be emitted. Being of shorter wavelength, the green light





# THE LASER

## **EXPERIMENTER**



**Highly Excited** Figure 5 **Atoms** B<sub>2</sub> **B1** 578.2 nM NCREASING 510.6 nM Yellow Laser Light HZHRGY Green Laser Light Atoms \_ Excited By Electricity **Ground State** 

is more energetic, and hence emitted, in this case, from a jump from a larger energy level to a smaller one. Yellow light is emitted by jumping from B1 to That is a lesser energy level difference, and hence the light emitted is of a longer, less energetic wavelength.

It is interesting to note that each element and compound has its own unique set of enerlevels possible. Quantum theory reminds us that the energy levels are DISCRETE . that is, one cannot arbitrarily have, say a 512 nM or 575 nM wavelength output from a copper atom. The wavelengths are well-defined by the laws of nature that govern energy absorption and light emission. Light may be emitted by one of two processes in this case. Either spontaneously by the excited atom as its electron(s) seek to return themselves to the ground state, or by (and get this) PROXIMITY of a wave-length of light at either exact color to an excited atom. This latter fact is fascinating because it implies action at a distance. Like gravity, a force is felt between excited atoms and a lasing (or light emitting) wavelength. Of course, this is at an ultramicroscopic scale. Let's use a little imagination, even though our analogy isn't perfect. Imagine the sun to be dark instead of bright. Now imagine the planets orbiting the sun to be dark also. Consider that each planet nor-

mally revolves about the sun at X number of miles. Now, if you add energy to any planet, what's going to happen? It will have increased velocity and tend to orbit at a further distance. Let's pretend that the only way an energized planet can return to its "normal" orbit is to emit energy in the form of a burst of light. Thus, from an observer at a distance, the sun-planet system will emit light each time it's stimulated and the planet falls back to its original position.

But here's where it gets eerie. Imagine a light-beam entering into the "solar system." Even though the beam may not come directly in contact with an energized "planet" (electron) it has the capability of stimulating the emission of light equal to its own wavelength, provided the "solar system" (atom) is allowed by nature to emit light equal to the incoming wavelength. Action at a distance. But this is all a well-known fact. Lasers are functional BECAUSE of this phenomena!

A further stipulation would be that the planets can orbit only at fixed distances from the sun. When energy is absorbed or released from any planet, its movement in this model would be akin to "jumping" from one orbit at a pre-ordained distance to another, transferring energy in the process. And here's where this model breaks down: In the astronomical

world, planets can (and do) orbit at any distance the physics of the system dictates. For instance, it is believed that billions of years ago, our moon was very much closer to the earth than it is now. If the moon behaved like subatomic particles, it would still be stuck in the same orbit after all this time unless energy had been exchanged in the meantime.

#### Stimulating Copper Vapor To Lase

Copper boils at 2595 C. (4703 F.). While the copper vapor laser operates at considerably less than atmospheric pressure, and thus copper will boil at a lower degree figure, it does not do so by a significant amount. The high temperature is certainly impractical for a laser to operate at. With a stroke of genius, the problem was circumvented by researchers using copper chloride instead of pure copper in the device. That enabled operation at a much more modest 400 C. (750 F.). The laser tube and its associated heater are housed in an "oven" which is built from inexpensive silica firebrick.

Another unusual property of this laser is that it requires a double-discharge pulse to operate. The first pulse disassociates the copper-compound molecules and ionizes (excites) some of the released atoms. The second pulse must be delayed long enough to allow the copper atoms to settle back to the ground state, but it must occur fast enough so the copper won't have time to recombine with the chloride. If the pulse criteria is met, the laser can operate successfully. With this laser, the timing between the two pulses is approximately 150 microseconds.

To achieve the double-pulses requires expensive and complicated electronics. Or does it? The amateur builder of this laser ingeniously solved the problem by inventing a MECHANICAL device to properly time the pulses. A rotating disk made from thick plastic bolted to a thick aluminum flange revolves at about 6,000 RPM. It is driven by a motor-pulley combination and set into precision ball bearings to achieve this speed safely and without wobble. Set into the disk is an electrode. Two stationary, adjustable spark-gap electrodes are positioned very close to the corresponding electrode in the rotating disk. Once the two

# THE LASER

# **EXPERIMENTER**

stationary and the rotating electrodes are in close proximity, the electricity jumps the gap and energizes

The power supply produces 120 mA at 15 KVAC which is rectified and stored in a homemade capacitor. The peak DC voltage of the supply is 15,000 \* 1.41 the AC value or 21,150 VDC. The capacitor is 0.015 microfarads. At 21,150 volts, the stored energy is equal to about 3.4 Joules. Since the laser fires up to 50 times per second, you get the idea that the power supply is quite dangerous to produce this level of cur-

An important caveat of this type of laser design is minimizing inductance so the discharge pulse rapidly disassociates the copper chloride at high speeds and energy. While 3.4 Joules is not that much energy (a camera flash is about four times this level of energy), the SPEED at which the discharge occurs is very rapid, being on the order of a fraction of a microsecond. It is not unlikely the top current that runs through the heated copper vapor may reach tens of thousands of amperes. The corresponding laser light output is very strong, even though for a brief instant each time the laser pulses. Although I have no measured data for the actual light energy output, it is feasible it may be well over 100 watts per pulse.

A simple heating system was incorporated to keep the laser at the required operating temperature. An ordinary quartz tube plus an inserted Nichrome heater element was mounted about 1" away from the laser tube. Glass fiber insulation is packed into the spaces where the heater and laser tube enter the oven, which greatly reduces heat loss and helps to maintain as even a temperature as possible along the length of the laser tube. A thermocouple is used to measure the temperature of the oven. The AC power to the heater is adjusted using a variable-voltage transformer to keep the heater on track at the required temperature. This system also enables adjustment of the temperature to produce maximum laser output.

One mirror is all that's required with this particular laser. A fully silvered microscope slide, coated with reflective aluminum, is mounted at the rear of the laser. The output beam exits through a clear glass microscope slide. Vapor from the copper lasing medium can be a problem if deposited on either slide. To reduce this problem, the laser is flushed with pure Helium gas before operating. After flushing, the Helium is stabilized at 10 torr, which is 1/76th of atmospheric pressure.

A second addition to the laser's construction prevents the condensation of the lasing medium on the slides, which would quickly quench lasing action. That is two 6" long aluminum tubes that extend off the quartz lasing cavity. They serve to cool and condense any vapor before it gets to the optical elements.

#### Conclusion

It is an endless source of fascination to see what laser experimenters are doing on their own. Should you have any ideas for future columns, or like to share work you've done that is not proprietary (secret), we'd love to hear from you at the Laser Experimenter's P.O. Box, listed elsewhere in this article. Next month, we'll look at another amateur-built laser and present more laser theory. NV

#### **Closing Quote:**

"Who shall assign a limit to the discoveries of future ages? Who can prescribe to Science her boundaries, or restrain the active and insatiable curiousity of man within the circle of his present acquire-

- Thomas Chalmers (1780-1847)

#### SOURCES

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nthony Charlton is an active electronics and sci-Lence "do-it-yourself" project designer, does custom R & D, and writes technical articles. Previous work experiences include design of hardware and software for microprocessor-based process control systems, and electronic design. His hobbies include lasers, gardening, target shooting, and model rocketry.

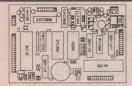
#### LASER NEWS AND DEVELOPMENTS

#### **FDA Halts Nighttime** Las Vegas Laser Light Shows

ne can think of few events more frightening than being blinded. Especially in the midst of operating equipment. And this terror is greatly magnified if you were at that moment, piloting an airplane. In several cases, this is exactly what happened to commercial airline pilots flying the airspace over Las Vegas. Fifty one incidents in the last two years have occurred with flights in and out of three Las Vegas area

The most serious incident involved a Southwest Airlines Boeing 737 on Oct. 30, 1995 when pilot Shelby LaCroix had just taken off from McCarran International Airport and was hit by a laser. As he struggled to regain his sight, the co-pilot took control of the aircraft. LaCroix recounts "Had it hit me and the other pilot simultaneously, I shudder to think what would have happened." Following the incident, the FDA sent a letter to a half dozen Las Vegas casinos telling them to shut off their lasers until further notice. The ban affects only the Las Vegas area according to Associated Press. However, it may be extended to other areas where high power lasers pose a threat to pilots.

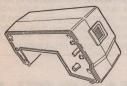
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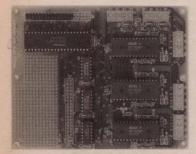
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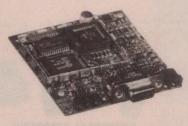
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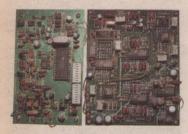
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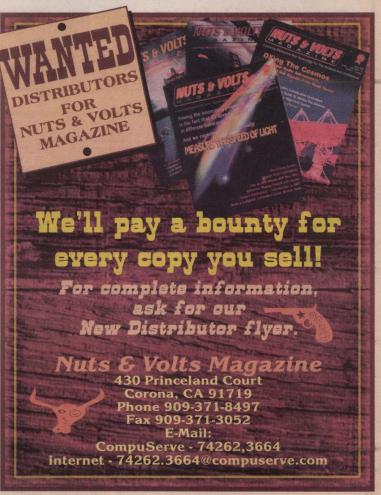
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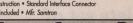
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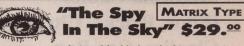
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# Stamp Putting the Spotlight on BASIC Stamp Projects, Hints, and Tips

instruction in your programs - is:

IF condition THEN label

odel rockets and Stamp microcon-Atrollers appeal to educators for many of

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cell in the top of hupothe dermic syringe. The bulb moves up and down the syringe based on the acceleration of the

= equal rocket. The syringe is greater than

two is equal to ten) is an example of a false condition. The comparison operators, also called relational operators, available in PBASIC are:

acceleration

>= greater or equal <= less or equal

not equal less than

In this syntax, condition is a comparison that

can be true or false; for example 2 = 10 (read as

#### Model Rocket Project Aims High with BS1-IC Instrumentation

Measuring Rocket Acceleration and Velocity, and Truth and Consequences with IF/THEN

You don't have to take my word for it. This month, I'm turning the first part of the column over to Dave Bodnar, Technology Coordinator for the Mount Lebanon School District of Pittsburgh, PA. Last summer, Dave combined Stamp electronics with model-rocket pyrotechnics to create a couple of high-flying Stamp applications. Here's a description in Dave's own words:

"Enclosed you will find the prototypes of the rocket sensors that I put together this summer. One senses the rocket's speed by measuring the speed of a propeller on the nose cone. The other measures acceleration.

The speed device uses an infrared photo transistor/emitter pair to detect the spinning of the propeller. A split wheel chops the light that normally goes between the emitter and detector. The two LEDs and buzzer are used to let the launch crew know when it is time to launch the rocket. The Stamp's internal memory is used to store the data that is collected. I have enclosed a disk with the results of the first few flights. Note that the power source for the speed sensor is a set of watch batteries in the base of the nose

The system is operable and can be brought to life by connecting the sets of red/black wires. While making up the drawing of the circuit, I noticed that I had mislabeled the RESET and +5 pins and attached things incorrectly. Fortunately, the RESET pin seems to supply enough current to run the circuit and pressing the reset button in the nose cone shorts the +5 and ground to do a type of reset!

The acceleration sensor works on the same principle as the first device except that it senses the brightness of the light that falls on a CdS

tape to keep out light. The small switch on the top of the gold cells is the power switch. The cells are 2/3 of a nine-volt battery. They serve as a power source and a weight for the

The data is collected by connecting a small PC (I used an HP 95LX) via the serial port. The data is continuously output after the

Figure 1 shows the basic construction of Mr. Bodnar's instrumented model rockets, while Listings 1 and 2 are the programs that run them.

#### **BASIC for Beginners**

Last month, I equated a BASIC program to a to-do list. The computer starts at the top of the program and performs the instructions in order of appearance.

However, the real power of programming is the ability to make decisions. The program is still a list of actions to do, but the order in which they're performed (and whether some of them are performed at all) can be based on conditions that exist at the time the program

In BASIC, you describe decisions and their consequences with the IF/THEN instruction.

The syntax of this instruction - the correct way to use and express this

velocity Free-spinning propeller IR LED connected to power supply IR phototransistor (NPN) 470 BS1-IC Ready-to-launch LEDs 470 pin 3 buzzer serial data out

- · All pin numbers refer to their PBASIC names.
- · Power supplied by button cells in base of nose cone.
- · The acceleration probe shares the same basic circuitry, but uses a different sensor and power source, as shown at right.

Figure 1 Diagrams of the velocity and acceleration probes

#### **BS1-IC** and ready-to-launch **LED** indicators in nosecone photocell 'accel" data to BS1-IC via Pot instruction 1.5V cells removed from 9V compression sprind tiny light bulb (wires routed up through syringe plastic plunger to syringe body (covered with opaque tape CdS photocell

## Stamp Applications:

Listing 1, Model Rocket Velocity Probe, by Dave Bodnar REM Rocket telemetry program MINIMUM memory implementation REM for use with PROPELLER/SPEED sensor only REM uses internal STAMP memory for data storage 'RKT\_SPD1.BAS (was RKT\_MIN5.BAS) D. Bodnar 7-6-95 6:53

Symbol Prop = 0 Symbol LED1 = 2 Symbol LED2 = 3 Symbol Buzz = 5 Symbol Ser\_out = 7 Symbol Delay = 8000 Symbol STOPmem=2 'pin 0 for propeller 'pin to show ready for launch 'pin (another) to show ready for launch pin for Piezo buzzer 'pin for serial output of data (orange wire)
'better at about 8000-1000 for testing only

realstart: read 255,b11

'memory end location for writing 'debug b11,cr

b11=b11-1 b10=b11

HIGH buzz

'make copy for later

high LED2:high LED1 pause Delay HIGH buzz low LED2 pause Delay LOW buzz high LED2:low LED1 pause Delay Low LED2

'Both on FIRST 'RED only on (LED1)

'GREEN only on (LED2)
'LAUNCH ready

waitforlaunch: high LED1 pulsin prop,1,w2 low LED1 if w2=0 then waitforlaunch: High LED2 LOW buzz

'stay here till LAUNCH detected 'flash RED while waiting

gosub GETnWRITEit: if b11 >STOPmem then start: Low LED2 HIGH buzz

'loop till RAM full

doneloop: b9=b10 'debug "start of end",cr LOW buzz

serout ser\_out,n2400,("START",#b9,13,10) 'send "Start" & amount of RAM pause 2000

loop: HIGH buzz

read b9, b7:b9=b9-1:read b9,b8 debug #b9,"+1 hi=",#b7," lo=",#b8 w2=b7\*256 + b8 debug " ",#w2,cr LOW buzz

serout ser\_out, n2400,(#w2,13,10) high LED1:Pause 20:low LED1:pause 20

b9=b9-1 if b9 > STOPmem then loop pause 5000 goto doneloop:

GETnWRITEit: HIGH buzz:PAUSE 40 pulsin prop, 1,w2 b7=w2/256

'take reading

b8=w2-w1 debug #b11,"hi=",#b7," lo=",#b8, " 16bit=",#w2,cr Write b11,b7:b11=b11-1:write b11,b8:b11=b11-1 LOW buzz:PAUSE 40

If you have trouble remembering which way the < should point, just use this mnemonic: The symbol is the mouth of a greedy alligator who always snaps up the larger of the two meals offered. So x > y reads x is greater than y.

When PBASIC processes an IF/THEN instruction, it determines whether the condition is true or false. If it's true, the next instruction the program executes will be the one specified by the label following THEN. If the condition is false, PBASIC will just go on to the next instruction in the program 'Listing 2, Model Rocket Acceleration Probe, by Dave Bodnar REM Rocket telemetry program MINIMUM memory implementation REM uses internal STAMP memory for data storage 'RKT\_ACC1.BAS (was RKT\_MIN5.BAS) D. Bodnar 7-6-95 6:27

Symbol Accel = 1 Symbol LED1 = 2 Symbol LED1 = 2 Symbol LED2 = 3 Symbol Ser\_out = Symbol Delay = 8000

'pin 1 for acceleration pin to show ready for launch pin (another) to show ready for launch pin for serial output of data (orange wire) better at about 8000 - 1000 for testing only

realstart: read 255,b11 b10=b11-1

high LED2:high LED1 pause Delay low LED2 pause Delay high LED2:low LED1 pause Delay Low LED2

'memory end location for writing 'make copy for later

'Both on FIRST 'RED only on (LED1)
'GREEN only on (LED2)
'LAUNCH ready

gosub GETnWRITEit: b6=b2-3

waitforlaunch: high LED1 pot accel, 170, b2 low LED1 if b2>b6 then waitforlaunch: High LED2

'stay here till LAUNCH detected 'flash RED while waiting

start: gosub GETnWRITEit:

low LED2:pause 20:high LED2:pause 5

if b11 >1 then start: Low LED2 'loop till RAM full

doneloop: serout ser\_out,n2400,("S",#b9,13,10)

'send "Start" & amount of RAM

pause 2000

read b9, b2: serout ser\_out, n2400,(#b2,13,10) high LED1:Pause 20:low LED1:pause 20 b9=b9-1 if b9 > 1 then loop pause 5000 goto doneloop:

**GETNWRITEit:** pot accel,170,b2 Write b11,b2:b11=b11-1

'take reading

in normal to-do list fashion.

Let's put this information to work in a simple application. Suppose we're monitoring a burglar alarm system that's wired so that a 0 appears on pin 1 when all doors and windows are shut, and a 1 when any are opened. When the system is turned on, opening a door or window should trigger the

alarm. Here's a straightforward way to express that in PBASIC:

Monitor:

IF pin1 = 1 THEN Alarm **GOTO** Monitor

SOUND 7.(90.100.120.100) **GOTO Alarm** 

In the section labeled Monitor, if pin 1 is 0 meaning all is secure - the program just goes back to Monitor and checks the pin again. However, if pin 1 is 1 - meaning a door or window has been opened - the program goes to the instructions that start with the label Alarm. Here PBASIC generates a two-tone sound through pin 7 to attract attention. (Don't worry about understanding the specifics of instructions like Sound they're just fill-in-the blank forms for performing a simple action.)

Before I go on, I want to explain what labels like Monitor and Alarm are and how they work. You can see from the example that decisions and repeated actions depend on telling PBASIC to go to a specific point in the list of instructions that makes up a program. In old versions of BASIC, each line began with a number, so you specified the "where" of a GOTO or IF/THEN instruction with the number of the destination line.

Line numbers don't say much about the "what" or "why" of these destinations, so modern BASICs like PBASIC use labels instead. A label is just a word that you, the programmer, have picked to mark a place in the program. To let PBASIC know that it's a label, you end the chosen word

## Stamp Applications:

with a colon (:). There are other rules about labels, but we'll leave it at that for now.

I want to leave you with a further thought about IF/THEN: Suppose we wanted another condition that could trigger the alarm - say a panic button on pin 2. It would normally read 0, but if you heard a strange noise in the bushes, you could push the button to put a 1 on pin 2 to triager the alarm. In other words, you want the alarm to go off if there's a door/window open OR the panic button is pressed. A small change to the IF/THEN instruction does the job:

IF pin1 = 1 OR pin2 = 1 THEN Alarm **GOTO** Monitor

Looky there: The idea of OR is expressed the same in PBASIC as in plain English! From this simple foundation, we'll examine the whole system of truth and consequences called Boolean logic in the next installment. NV

#### Sources

For more information on the BASIC Stamp, contact: Parallax, Inc.

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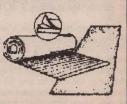




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#### by Karl Lunt

#### Son of BOTBoard

arvin Green, who developed that staple robotics tool, the BOTBoard, just released his next generation robot brain dubbed, appropriately, the BOTBoard-2. I've been using one of his prototype boards for some time now, and thought I'd pass along my impressions.

Like its predecessor, the BB2 uses a 68hc11 and supporting circuitry. The BB2, however, supports 32K of expanded memory, including battery-

backup if you decide to add static RAM.

The BB2 also contains artwork for a MAX232 RS-232 level-shifter and a pinout for a nine-pin serial connector. This really makes it easy to hook the board to your PC or Mac; you don't have to build an external level-shifter.

Of course, you can use the normal BOTBoard fourpin serial cable on the BB2, if you choose. Marvin included pads for mounting the usual four-pin MTA connector used on the BOTBoard. Those of you who already have a BOTBoard serial cable with built-in adapter can use the same cable on your BB2. Other carryovers from the BOTBoard include four

Other carryovers from the BOTBoard include four servo ports, on-board reset switch, and connectors for the 68hc11's port A and port E pins. Note, however, that the BB2 uses a pair of 10-pin IDC connectors for these ports, rather than a single, larger connector as on the BOTBoard.

Marvin then added several extras, essential to robot development. The BB2 contains a 1" x 5" prototyping area, large enough to hold some substantial circuitry. What's more, he arranged the prototyping area so pairs of pads are joined with traces, creating a versatile experimenter's layout. This really simplifies wiring extra circuitry into the prototyping area.

Since the BB2 uses the 68hc11 in expanded mode,

Since the BB2 uses the 68hc11 in expanded mode, many of the I/O pins become unavailable, as they now carry bus signals for the external memory. To help you recover the missing I/O lines, Marvin has added partial decoding for addresses from \$4000 to \$7fff.

His board divides this address range into four equal parts, and generates separate \*READ and \*WRITE signals for each of the four regions. For example, you get a pad that provides a low signal whenever your program reads an address in the range \$4xxx, and a separate signal for writes to \$4xxx.

Marvin brought six of these signals and the eight-bit data bus out on a 16-pin IDC connector. This lets you build a custom expansion board that simply hooks onto the BB2, either directly or using a ribbon cable.

Other goodies you can add directly on-board include a piezo speaker for sound effects and an LED under software control. Marvin's layout also provides a 10-pin IDC connector for the SPI bus and a separate connector for wiring in a battery-backup supply.

He also includes pads for a four-position DIP switch. Two of these switches control the MODA and MODB pins, so you can change 'hc11 configurations without having to move jumpers around. The other two switches are uncommitted; you can run wires from their pads to whatever I/O lines or signals you need.

Finally, the really advanced hacker will find spare pads provided on all vital 68hc11 signals, in case you need to do a real mondo hack. For example, all of the multiplexed bus traces contain spare vias for making connections with wirewrap wire.

The BB2 comes with a very nice technical booklet, which includes the full schematic, a parts list (with vendor names and typical prices), and good information on how to wire up the many BB2 options. It provides details on adding extra eight-bit input and output latches, sample code for moving servo motors, and a schematic for building a BOTBoard-style RS-232 serial cable.

Bottom line: This is a well-designed board for the advanced robotics hobbyist, especially if you intend to use RC servo motors to drive your 'bots. I personally think the blank board is worth much more than the \$18.00 (or \$45.00 for three boards) that Marvin is charging. Be sure to add \$3.00 to your order to cover the cost of shipping and handling. Oregon residents already know they don't have to add sales tax, 'cause there isn't any in Oregon ...

If you want to

# AMATEUR ROBOTICS

take a closer look at the BB2 materials, check out Marvin's Web page at: http://www.rdrop.com/users/marvin

#### Hacking the BB2

Naturally, I can't leave well enough alone. As soon as I got my BB2 up and running, I started hacking on it. I had wired it up to hold 32K of static RAM, complete with a backup lithium battery, but I wanted to do more.

First up was some software. I used a 68hc11e1 for my MCU; this device has 512 bytes of EEPROM and 512 bytes of on-chip RAM. The extra RAM is always nice: it makes a good place to stash the stack.

nice; it makes a good place to stash the stack.

But the EEPROM has real possibilities. It runs from \$b600 to \$b7ff, and provides enough room for some sophisticated assembly language code. In my case, I added a \$19 loader.

Those of you who read last month's article will remember the S19 loader I installed in BYRD, my Back Yard Research Drone robot. The loader I wrote for the BB2 is similar, and provides a smooth way to install and test new programs. In fact, the loader is so powerful that I no longer even use PCBUG11. I just start up a comm program, such as Crosstalk, and download my software.

The only problem I had to solve involved starting the loader, called E9BUG, from reset. The 'hc11e1 is normally used in expanded mode, and it is difficult to pass control to \$b600 to start my \$19 loader.

So I start the 'hc11e1 in special bootstrap mode, by setting the DIP switches appropriately. The 'hc11 comes out of reset by sending a break signal out the serial port's (SCI) transmit line. If it sees a break on its receive line, the 'hc11 responds by jumping to \$b600.

The only trick is getting the break character to the SCI receive line. While most comm packages let you send a break signal, which will probably do the job, I chose a simple hardware mod instead.

I just hooked a SPST pushbutton switch across the SCI Rx and Tx lines at the 68hc11. Note that I wired this switch to the pins as they come from the MCU, NOT after the signals have been converted to RS-232 levels.

Now the reset sequence is just slightly more complicated than normal. I hold down the SCI button, press and release the reset button, then release the SCI button. Bingo; my S19 loader starts up and I'm ready to send my software.

This works because the closed pushbutton switch routes the break signal that the 'hc11 sends back to the 'hc11 receive line. Thus, the 'hc11 gets a break signal immediately, and transfers control to \$b600, starting up E9BUG.

Of course, E9BUG has to figure out when you've released the pushbutton; otherwise, it won't be able to recognize legal commands from garbage. So it sends out a stream of nulls (\$00) until it fails to see a null on its input port. This means you have released the pushbutton, breaking the connection between the 68hc11's transmit and receive pins.

Naturally, your comm software is also seeing this stream of nulls, but most comm programs will ignore them. If your program has problems with this, just change the E9BUG source file to send a different test character.

Once my E9BUG monitor has control, I can download any Motorola S19 object file by simply doing an ASCII send operation. Most comm programs support this, and can even suspend transmission of one line until the receiving computer (in this case, the BB2) acknowledges receipt of the previous line. If your comm program has this support, just set it so it waits for a CR before sending the next line of a file.

E9BUG remembers the execution address of the last S9 record it receives, so starting your downloaded program requires nothing more than sending a lower-case-x after you finish downloading. E9BUG will immediately jump to the execution address from your last

downloaded file

Note that this works with S19 files created with the Motorola FREEWARE asmhc11 assembler, and with files compiled by SBasic and tiny4th, since they use the asmhc11 assembler in the final step of compilation.

It will NOT work, however, with the older as11 assembler, since that assembler does not preserve the execution address in the S9 record. If you are still using the as11 assembler, I urge you to dump it and move to the more flexible asmhc11 program. My SBasic and tiny4th distribution files contain the asmhc11 assembler; you can get these files from my FTP site at:

ftp://cherupakha.media.mit.edu/pub/incoming/karl\_lunt

E9BUG does have a command for supplying your own execution address. You simply enter a lowercase-j followed immediately by a four-digit hexadecimal address. For example, to set an execution address of \$8000, you would enter:

#### j8000

Note that E9BUG does not accept any intervening spaces, nor does it allow backspaces to correct mistakes. If you make a mistake, simply press RETURN, then enter the command again.

Note that the j-command only sets the execution address; it does not transfer control to the address you provide. After you have entered the correct j-command, you use the x-command, described above, to actually start execution at that address.

E9BUG's simple command set opens up many possibilities. It lets you download S19 files quickly, without having to resort to PCBUG11. It lets you provide an execution address of your own, or use the address contained in an S9 record. Finally, it allows you to jump to any of several routines that you might already have stored in the BB2's on-board battery-backed RAM.

But the BB2 only has one 28-pin memory socket, usually filled with a 62256 32K static RAM chip. While this is plenty of space for programs, it can prove inconvenient during development.

Development code tends to run away during tests, which usually trashes the RAM holding the code under test. This naturally forces another reload. You can remove the BB2's write-enable jumper after each download, preventing writes to memory after the runaway, but this is an extra step that I'd personally like to avoid.

Besides, what you really need during development is a solid monitor program, tucked away in EPROM where it can't be corrupted, and where it can't interfere

with the program you're developing.

Fortunately, it's easy to find a good 68hc11 monitor program. Motorola's BUFFALO monitor has been around for years, and the source code is readily available at a number of FTP sites. BUFFALO offers a variety of powerful functions, including built-in assembler and disassembler, breakpoints, and single-step execution.

But BUFFALO was written to work in a far more complicated environment than a BB2, so it contains several features you won't need. I spent a couple of weekends editing the source code for BUFFALO 3.4, and stripped out all the extraneous code. I also cleaned up the menu text quite a bit.

The resulting BUFFALO monitor takes up about 7K of code space, and can fit anywhere in the BB2's address space. It does not take over the vector area, as the original BUFFALO does, and I placed the RAM vari-

As always, you can reach me at:
Karl Lunt
2133 186th Pl., S.E.
Bothell, WA 98012
E-Mail: karl@mav.com

#### ROBOTICS . . . ROBOTICS . . . ROBOTICS . . . ROBOTICS . . . ROBOTIC

ables that my new BUFFALO needs in the upper section of the 'hc11e1's 512-byte RAM space, to free up as much lower RAM as possible for development pro-

So, now I have this cool monitor program, but nowhere to put it, since the BB2 only has the one 28-pin socket and it already contains a RAM chip. I needed to add a second 28-pin socket, with address decoding for a 27c64 EPROM chip.

This hack actually proved quite easy to do. To add a second 28-pin socket, you will need the following components:

- · One 14-pin solder-tail IC socket
- One 28-pin solder-tail IC socket
  One 74hc20 IC
- Some 30 AWG wirewrap wire
- · Some 1/16" heatshrink

NOTE: You MUST use a 28-pin socket with leaftype pins; you CANNOT use a machine-pin socket for this mod!

Begin by locating a place in the prototyping area for the 14-pin socket. I mounted my socket immediately below the silk-screened legends for C15 and C16, near the MAX232 pad layout. I positioned the chip with pin 1 toward the C15 legend and pin 14 toward the C16 leg-

Use wirewrap wire to connect the 74hc20 as shown in the accompanying schematic. The pad traces on the prototyping area will make this job easier. Leave the connection from pin 8 of the 74hc20 off for now; we'll get to it later.

Note that four of the 74hc20's connections run to I/O select pads provided by Marvin for device decoding. As shown, this mod uses 6000R, 6000W, 7000R, and 7000W. This combination means that the new 28-pin device will reside in the address space from \$6000 to \$7fff, and that the device is read/write capable.

You have some flexibility here. For example, if you know you will always put read-only devices such as

You are now ready to put the RAM chip into the 28-pin socket on the BB2. Visually inspect the RAM chip's pins, and clean off any deposits you might have picked up during soldering. Align the RAM chip properly in its socket, then carefully push the chip into its socket. Power up the BB2 and verify that the RAM chip still works properly.

Connect the wirewrap wire from the new socket's pin 28 to a convenient pad on the BB2 that holds +5 VDC. DO NOT connect this pin to the battery backup circuitry! If you don't have an expansion connector wired into EXP1, you can use pin 1 of this pad layout as a source of +5 VDC.

Connect the wirewrap wire from the new socket's pin 20 to pin 8 on the 74hc20's socket. If necessary, you can route this wire through a convenient pad in the prototype layout, in order to reach pin 8.

Insert a 74hc20 IC into the 14-pin socket, and insert a 28-pin 8K memory chip into the new 28-pin socket. Power up the BB2 and verify memory at the addresses you have selected for the new socket.

Note that you can use a 6264 RAM chip or a scrap 27c64 EPROM for this test, since all you really care about is whether the chip responds to the memory addresses. Even if you wired your socket up for read-only operation, you can still verify that some type of data exists in the address range.

You have just added a separate 8K memory socket to your BB2. You can burn a copy of my modified BUF-FALO monitor into a 27c64 and install the chip into the new socket. Once installed, you just use E9BUG's j- and x-commands to set up the execution address and start running BUFFALO.

Note that if you wired your 74hc20 for different addresses than I show here, you have to edit the BUFFA-LO source file so it assembles at your socket's address. Just change the equate for ROMBS, near the top of BUF-FALO, to the proper address and reassemble.

One nice feature of the BB2 and BUFFALO combination is the ability to single-step through your code. To do this, you must provide a connection between the

68hc11's XIRQ and OC5 pins. On the by first

BB2, you can do this installing a two-pin header in the XIRQ pad on the SPI layout and the pad immediately below

it. Then run a wire between this empty pad and the pad labeled 3 on the PORTA layout.

To enable single-step, simply put a jumper on these two pins; removing the jumper disables the single-step. Note that with the jumper in place, you will not be able to run a servo motor connected to servo header S4.

#### U1: A 74HC20 U1: B 74HC20 SOCKET, PIN 20 Pin 14 = +5 Pin 7 = GND Schematic of BOTBoard-2 memory expansion hack EPROMs into this new socket, you can omit the connec-

tions to 6000W and 7000W; just wire those pins on the 74hc20 to the corresponding xxxxR lines. This leaves 6000W and 7000W free for later use with output-only devices such as eight-bit latches.

You can also move the new 28-pin socket to \$4000 through \$5fff, by using the 4000R, 4000W, 5000R, and 5000W pads instead.

After you have wired the 74hc20 to suit your needs, it is time to install the new 28-pin socket. Begin by selecting a known good 62256 32K static RAM chip. Be sure you have tested this chip in your BB2, using a program like PCBUG11, and know it works properly. What you are about to do to it will make it very difficult to replace, should the chip prove defective later on.

Push the chip's pins into a piece of black anti-static foam, and heat up a fine-tipped soldering iron. Fit the 28-pin leaf-pin socket over the pins of the RAM chip, so the socket's pin 1 matches up with the RAM chip's pin 1. Make sure that each socket pin is centered on and touches the matching pin of the RAM chip.

When properly positioned, you should have what looks like a very tall socket, with a RAM chip nestled underneath. Make sure the underside of the socket sits flush against the top of the RAM chip.

Carefully bend pins 28 and 20 of the socket outward, away from the corresponding RAM pins. You want to bend them out just enough to break electrical connection, but not enough to damage the pins.

Carefully solder all socket pins EXCEPT 28 and 20 to the corresponding RAM pins. Work quickly on each pin, and make sure you get a good solder flow between the two pins.

Cut a 3" piece of 30 AWG wirewrap wire, strip 1/8" insulation from each end, and carefully solder one end to pin 28 of the socket. Make sure you don't accidently solder this pin to the underlying pin 28 on the RAM chip! Run a small piece of heatshrink over the entire pin and shrink it into place.

Perform the same step above for pin 20 of the socket.

#### **Tamiya Kits**

Tamiya offers a small selection of very well-made kits for building sturdy, high-torque gear boxes of various reductions. One of these kits could serve as an excellent starting point for a robotic sculpture or demonstration.

For example, I just finished assembling a Tamiya Worm Gear Box. The gear box, including a small 3 VDC motor, could serve as the core to a single motor drive system. By adding a second gear box, I could make a dual-drive system for a small robopet.

I bought my gear box kit from Edmund Scientific for \$16.95 plus shipping, and have to say I was impressed with the kit's quality. It reminded me of the model airplanes I built as a kid; snap the pieces apart from their "tree" carrier, then fit them together.

But these plastic pieces were very well designed, and fit together perfectly. What's more, elements such as the axle and gear holder were made of high-quality metal, with a smooth finish and good machining.

The gear box kit comes with enough plastic gears generate one of two gear reductions, either 336:1 or 216:1; I chose to build the 336:1 box. You also get a small bag of metal screws, nuts, and other assorted hardware, including a small Allen wrench for tightening the metal grub screw when mounting the gear holder onto the axle.

The kit contains a spare axle and mounting hardware, so you can add your own wheels and have most of a single-motor car all done. It also has various control horns for hooking up your own control rods, pulleys, or cams

It even includes a tiny tube of gear grease, with

more than enough lubricant to complete the kit. The instructions warn you to use only the supplied grease, to prevent chemical damage to the plastic gears.

The instructions consist of a single sheet of paper, printed with clear pictures of each step and very terse instructions in both Japanese and English.

My gear box kit went together in about an hour, and I only had one problem. That involved pressing a small metal shaft into the helical gear. You need to get a little rough with this step. I ended up using a hammer to GENTLY tap the shaft into the gear. Be sure to tap the shaft all the way into the gear.

When I tried to fit the helical gear into the housing, the exposed end of the shaft bound in its fitting, preventing the gears from turning smoothly. I spent a few minutes spinning the gear by hand, and carefully crimping the tip of the shaft to remove some of the edges. Eventually, I got the gear shaft to spin freely in the housing.

I then assembled the housing, using the supplied metal screws, and snapped the 3 VDC motor in place. When I applied power from a pair of C-cells, the output shaft started turning at about 30 RPM.

Tamiya designed this gear box to make it as easy as possible to build into larger frames, such as robots and toy cars. This attention to detail shows up in several ways. The output shaft is threaded at either end, with grooves for E-rings and holes for locking shafts. The included control horns mount easily to the shaft, giving you plenty of options for using the power this unit gen-

Overall dimensions are quite compact. The output shaft is 3.25" long and sits perpendicular inside the gear box housing, which measures 3" long, including motor, by 1-3/8" across at the mounting ears. The housing is less than 1.25" high, and the whole unit weighs less than two ounces.

I find the Tamiya Worm Gear Box to be a rugged, well-designed drive system that is reasonably priced. True, you could buy a plastic toy car and hack the gear system out of it, but for little more than the cost of the toy, you can use instead a professional-looking, well designed gear box.

Edmund Scientific also sells two other Tamiya gear boxes. The High Power Gear Box kit yields gear ratios of 41.7:1 or 64.8:1, while the High Speed Gear Box sports 11.6:1 or 18:1 ratios.

If you need a gear box for that next robot, Halloween project, or kinetic sculpture, check out the Tamiya gear boxes. I certainly like what I've seen.

#### Lagniappe

If you haven't seen the latest Mondo-tronics catasend some E-Mail to Roger Gilbertson (info@mondo.com) and let him know you want one right away. Mondo-tronics is fast becoming the one-stop source of complete amateur robotics items such as books, kits, videos, and software. You can buy many of Scott Edward's BASIC Stamp boards, plus Marvin Green's BOTBoard and finished machines such as the PC Rover.

Roger started out years ago by offering the Shape Memory Alloy Muscle Wires, and still sells some very good project kits using SMA wires. He also carries a wide assortment of plastic robot kits, including the Tamiya Gear Box kits. And the catalog is colorful, densely packed, and quite weird in places; very entertaining.

I recently saw an American Science & Surplus catalog for the first time in a couple of years. Offering without a doubt the oddest assortment of gadgets, gee-

gaws, and whigmaleeries imaginable; this company belongs in every robot hacker's list of resources.

The catalog sports everything from ammo boxes to parking meters. glow-in-the-dark human skulls to rubber iguanas, gearhead motors to pensharpeners shaped like a human nose. If the Mondotronics catalog is weird. the

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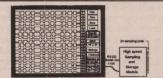
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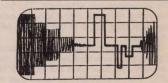
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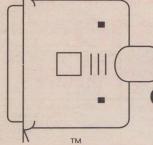
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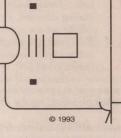


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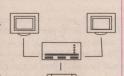
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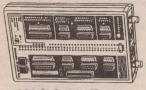
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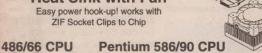
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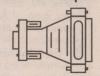
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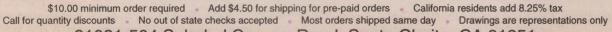
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## CELLCLAR EXTENSIONS ON TRIAL

n what is probably the first case of its kind, a Kentucky man has been indicted on federal fraud charges for cloning extension phones to existing cellular service agreements. Don Billy Yates of Lexington, KY was indicted on November 2, 1995 by a federal grand jury. The indictment charges Yates with "possessing and using equipment for altering and modifying telecommunications instruments with intent to defraud cellular phone companies."

"The entire cellular phone industry will be watching the case because it is thought to be the first such criminal prosecution in the United States," notes Thomas Tolliver of the Lexington Herald-Leader.

And watch they will. Fraudulent use of a cellular phone has traditionally involved programming the mobile identification number (MIN) and electronic serial number (ESN) of an unsuspecting subscriber's cellular phone into an additional phone which then became an electronic "clone" of the original. The cellular bandit would place calls with this duplicate phone, causing the charges to appear on the victim's monthly bill. Cellular carriers end up absorbing the costs of these calls, claiming their collective losses exceed \$300 million annually.

An increasingly popular practice is so-called "legal cloning" which involves creating a second phone programmed as the duplicate of a phone used with an active cellular service agreement. This process allows a cellular customer to effectively have an "extension" phone and the choice of using either unit to place or receive calls. Although the technical process involved in creating an extension cellular phone is the same technology abused by cellular bandits, it is quite obvious that consumers do not use cellular extensions in a fraudulent manner. No matter which phone is in use, the customer pays for each call.

As a whole, the cellular industry has disliked this practice since it deprives them of the revenue generated through one-time activation fees and the base charge assessed against every cellular phone number assigned. This per-number charge is often itemized on the customer's bill as an "access fee" and ostensibly covers the cost of accounting, preparing bills, and accommodating the user's cellular phone within the network

Whether or not a customer places and receives calls, his or her cellular phone is periodically transmitting information to the cellular network which, in turn, keeps track of the transceiver's approximate location. Since each transceiver consumes resources within the network to some extent, the "access fee" assessed by carriers is generally not an unreasonable charge.

What it appears that the cellular industry is currently trying to do is set a precedent in which they claim they are actually entitled to these access fees and activation charges whether or not a customer consumes resources within the network. Although there is much more to explore in this regard, let's first examine the case at hand in detail.

What follows is the text of the affidavit attached

## SECRET SERVICE TARGETS "EXTENSION" CLONER

to the criminal complaint against Mr. Yates. It has been extracted from case number 95-5108M,

United States v. Don Yates, filed in the United States District Court, Eastern District of Kentucky. This is what James W. Cobb, Special Agent, US Secret Service, has to say in his affidavit of September 21, 1995.

#### THE AFFIDAVIT FOR COMPLAINT

James W. Cobb, being first duly sworn upon his oath, deposes and says:

- 1. That he is a Special Agent of the United States Secret Service and has been so employed since December 12th, 1983, and that he has been assigned to and participated in the investigation of cases involving violations of federal law prohibiting the unauthorized use of access devices in violation of Title 18, United States Code, Section 1029.
- 2. That on or about August 15th, 1995, your complainant interviewed Special Agent Tom Tamburello, US Secret Service, Philadelphia Field Office, who stated that on 4/13/95 he, along with other agents of the Secret Service, executed a search warrant on J.E.M. Marketing located at 13 Lynford Road, Cherry Hill, NJ. This business was operated by Irv, Gary, and Jody Epstein and was in the business of manufacturing copycat "black boxes" used to illegally reproduce the telephone numbers and electronic serial numbers of cellular phones.
- 3. That on that same day, Special Agent Tamburello advised that pursuant to the execution of the aforementioned federal search warrant, a list of purchasers of copycat black boxes was located in the aforementioned suspect location. This list identified a Don Yates, Lexington, KY as one of several purchasers of the illegal "black boxes" manufactured by J.E.M. Marketing.
- 4. That on August 16th, 1995, your complainant interviewed Dan Ambrosini, Cellular One, 124 Keeneland Drive, Richmond, KY. Ambrosini had previously telephoned the US Secret Service in Lexington, KY to complain about a Don Yates who was using an illegally obtained "black box" to reproduce the telephone numbers and electronic serial numbers of previously issued telephones. Ambrosini stated that Yates has started a business wherein he charges customers \$150.00 to duplicate ("clone") the

telephone numbers, and electronic serial numbers, belonging to their original cellular telephones into additional tele-

phones, thereby avoiding the activation fees and monthly service fees for each additionally cloned phone.

These monthly service fees include a one time activation fee of \$35.00 per each additional cellular telephone, along with monthly service fees ranging between \$25.00 and \$150.00. Ambrosini advised that the actual loss in dollars to the cellular telephone industry is unknown to date due to their inability to differentiate between calls made on the originally purchased telephone and any phone "cloned" by Don Yates. Ambrosini added that the telephone numbers and electronic serial numbers that are issued to their customers are the property of the cellular carrier, not the customer themselves, and that these numbers are used to facilitate calling and tracking for billing purposes. Ambrosini advised that customers using a cellular telephone with a telephone number and electronic serial number can obtain telephone service throughout the United States.

5. That on September 13th, 1995, SA James Burch, United States Secret Service, telephoned Don Yates at 606-272-1440. SA Burch, acting in an undercover capacity, questioned suspect Yates about the procedures involved with obtaining a "cloned" phone and also inquired about the costs involved. SA Burch told me that Yates stated he could duplicate the telephone number of his (Burch's) cellular telephone onto additional cellular telephones wherein the cellular system would only "see" the original phone as being used. Yates stated that the only fee would be a one time programming fee to him. Yates stated that although he (Burch) would have to pay the carrier for the additional air time generated by the second phone, he would not have to pay for any extra additional charges on a monthly basis for having additional cellular telephones. Yates told Burch he operates his business out of a van and would meet him when Burch was ready to "clone" cellular telephones.

6. That on September 18th, 1995, Cellular One Communications, Richmond, KY, provided two cellular telephones to the US Secret Service for use in an undercover transaction with Mr. Yates. In a signed sworn affidavit, Cellular One technician John Herbst stated that the first phone, a Motorola "M" series telephone, mechanical serial number F09LFD8438AG, was programmed with electronic serial number

8262DD8D and telephone number 606-544-5592. Herbst further stated that the second telephone, a Motorola "DCP 550" series cellular telephone, mechanical serial number F09HLD8415BG, was programmed with electronic serial number C34815C8 and contains no telephone number (Mobile Identification Number).

7. That later on September

Author's Note: This article represents information available to the author as of 12/16/95. Because the criminal proceeding documented herein was expected to be decided shortly, it is likely that an outcome has been reached and will be reported in the next issue ("Full Duplex," Nuts & Volts Magazine). As with coverage of any issue that does not remain static, this article is simply a snapshot of the situation as of the date mentioned.

Like any other person charged with a crime, Mr. Yates should be considered innocent of the charges brought against him unless proven otherwise. Statements of 'fact' as set forth in the criminal complaint quoted herein are not necessarily factual as they represent only the observations and allegations of a single law enforcement official.

Special thanks to the Independent Cellular Services Association (ICSA) and Gary L. Smith, a reader from Kentucky, for providing copies of court documents and newspaper clippings related to this case. This article would not have been possible without their assistance.

## CELLULAR EXTENSIONS ON TRIAL

18th, 1995, an undercover meeting was arranged between SA James Burch and suspect Don Yates. SA Burch told me that during this meeting, Don Yates took both of the aforementioned cellular telephones from him, recorded the telephone number (from the previously programmed "M" series telephone), by turning on the telephone, and the electronic serial number, which is listed on the rear of that same telephone, and then transferred those numbers to the previously blank telephone by connecting this second telephone, via a patch cord, to a black box located in his briefcase. Yates then keyed in the unauthorized telephone number and electronic serial number by using a key pad on the front of the copycat "black Yates then tested the "cloned" telephone to ensure its operation. Upon completion of this process, Burch asked Yates how much he owed him for this service and Yates replied \$150.00. Burch then provided this amount in cash.

**8.** That on 9/21/95 the aforementioned cellular telephones, previously programmed and provided by Cellular One technician John Herbst, and subsequently cloned by Don Yates, were again analyzed by Mr. Herbst at Cellular One Communications, Richmond, KY. Following his examination of the subject second cellular telephone, the Motorola "DCP 550," Herbst stated that this telephone, which previously contained no telephone number and had an ESN of C34815C8, now contained telephone number 606-544-5592 and an ESN of 8262DD8D. These two numbers were previously programmed into the Motorola "M" series telephone which was provided to Don Yates by SA James Burch as his legitimately purchased cellular telephone.

#### THE INACCURACIES

Anyone with even a bit of knowledge pertaining to the operation of cellular phones and networks has probably laughed at some of the blatantly incorrect information within Agent Cobb's affidavit. The most glaring error is the assertion made that electronic serial numbers and mobile phone numbers are the property of the cellular carrier.

Serial numbers are assigned and programmed by the manufacturers of cellular hardware, and begin with a prefix that was assigned to each manufacturer by the Federal Communications Commission. Since this assignment is a matter of public record, not only are serial numbers not the property of a carrier, but at least two of the eight hexadecimal digits are a matter of public record. If there is any claim to an ESN being proprietary, the information should be considered the property of the phone's owner since he has purchased the hardware bearing (or containing) such ESN.

Since a cellular carrier is not a telephone company in the technical sense, cellular telephone numbers don't really belong to them either. Since cellular carriers rely on the landline telephone company (local exchange carrier) to route all calls into and out of the cellular network, such cellular numbers were no doubt assigned by the local telephone company. With all phone numbers moving toward "portability" (like tollfree 800 numbers) in which a customer can keep a phone number no matter which carrier he or she chooses, these numbers will soon become the customer's property as well. At this point, like a specific frequency in the radio spectrum, a carrier may be authorized to assign numbers from a pool set aside for their use, but they certainly don't own the numbers in the sense that one owns intellectual or real property.

Although it may seem to be a minor point, this becomes very important when it is part of the foundation of a criminal case. Left unchallenged, the concept

of a carrier owning ESNs and MINs lends great credibility to a carrier alleging that their numbers have been "stolen" or "used without permission." The technical reality, however, is that carriers are not entitled to claim ownership or control over these digits. A phone number is simply an address pointing to a customer.

The affidavit also contains a misleading statement that "customers using a cellular telephone with a telephone number and electronic serial number can obtain telephone service throughout the United States." This is self-evident, much like saying that a person with money can buy something. What the statement fails to mention is that such service can only be obtained if the telephone number and ESN reside in a cellular network database and are deliberately validated to allow calls to be made. As written, the statement gives the false impression that mere possession of these two numbers will somehow magically allow uncontrolled use of the cellular telephone network

Also interesting is the assertion that the Cellular One technician provided the agents with a Motorola phone containing no telephone number. Those of us who have programmed cellular phones know that there is no such thing as a phone without a telephone number. All Motorola phones come pre-programmed from the factory with the same number stored inside the NAM, and it is impossible to place the phone in a state where it contains no MIN at all. No matter what you do, it will always contain a 10-digit (decimal) number. Even more lack of attention to detail is displayed in the incorrect identification of the flip-fone as a "DCP 550" rather than the proper "DPC 550" which is an acronym for Motorola's trademark of Digital Personal Communicator.

#### THE CRUX OF THE ISSUE

The biggest falsehood set forth in the affidavit (in your author's opinion) is also the foundation for the entire case. With the programming or cloning of an extension phone, the only monies not being collected by the cellular carrier are the activation fee and the monthly access charge. Why do you suppose the affiant (or Cellular One representative) chose to claim that "the actual loss in dollars to the cellular telephone industry is unknown to date due to their inability to differentiate between calls made on the originally purchased telephone and any phone 'cloned' by Don Yates." This comment has nothing to do with extension cellular phones because the customer pays for any use of the phone, original or extension.

In this case, the carrier seems to be claiming that they are lawfully entitled to collect an activation fee and a monthly access fee for every transceiver owned by a customer. From there the issue becomes clouded by falsehoods regarding undetermined losses and claims to ownership of the ESN that really belongs to the customer. Throw in comments about an ESN and MIN allowing access to the network from anywhere in the country, and to a non-technical person it would appear that there might actually be some fraud going on. It's pretty apparent that, in this case, smoke and mirrors are being used to distort the truth.

In a recent issue, we mentioned the petition for reconsideration that has been ongoing before the FCC. A portion of the issue before the FCC is an assumption on the part of the Commission that carriers are entitled to activation and access fees. Assumption is the key in that debate, as there does not appear to be any regulatory mandate which entitles carriers to assess these charges. In a written statement to the FCC, Mr. Jers T. Glover, Chief Counsel

for Advocacy, Small Business Administration, made the following statement:

"What [the] proposed rule would not prevent is the offering of cellular extension service by some party other than the licensed cellular providers for the area. As the Office of Advocacy noted in its ex parte communication in support of the petition for reconsideration, nothing in the Communications Act mandates that cellular telephone companies are entitled to any specific amounts of revenue for its development of public resources. [The] proposal would protect cellular companies to the extent possible from fraud without denying the public needed competition in the provision of cellular extension telephone service."

Here we have one federal agency telling another that it supports the rights of both customers and small businesses to compete with the cellular industry in providing "extension" cellular phones. Meanwhile, another branch of the government has slapped together a case to prosecute an individual for engaging in the very same business being advocated by the Small Business Administration.

#### CONCLUSION

Extension cellular phones are a lot like a landline extension. One still has only one number and can only make or receive one call at a time. Since subscribers only use one phone at a time, there are no additional cellular network resources being consumed. Unlike a second, independent phone, the carrier is still tracking just one phone. Because no additional tracking or billing is required, carriers would be hard pressed to explain why they should be entitled to any monthly access fees for an extension phone. Additionally, the carrier did not incur any costs in setting up a new account, checking a credit report, paying a sales commission, and programming the extension phone. As such, there is certainly no justification for an activation charge.

Your author sees little more than a monopolistic, anti-competitive attitude on the part of the cellular industry. With little regard to the desire or benefit of consumers, the industry has made it clear that they wish to control every aspect of service, and it's no different than the Bell System of old (and we know what finally happened in that case). Basically, carriers have become complacent in collecting activation and access fees simply because they can.

New technology and enterprising small businesses have come along and provided consumers with other options, and now the carriers are threatened and up in arms. What seems to be overlooked is that it is no fraud to avoid paying these activation and access fees. As long as we pay for the airtime we use, consumers are not stealing anything. If there is any violation of regulation taking place with cellular extension phones, it is a violation of a short-sighted FCC rule that may very well be overturned this year.

Don Yates has become the unfortunate victim of the Secret Service and/or the cellular industry in their zeal to ensure the revenue streams to which they've become accustomed. With literally hundreds, if not thousands, of individuals and businesses throughout the country offering cellular extension programming services, Mr. Yates just happened to be in the wrong place at the wrong time, and has become the principal in a case that will set a major precedent either for or against consumers of cellular telephony services. Yates' trial is scheduled to begin in early January.

"We plan to defend the case vigorously," says his attorney, Burl McCoy. "I have no doubt a jury will find him not guilty." **NV** 

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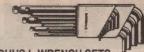
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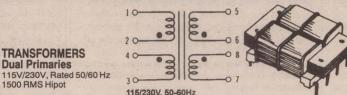
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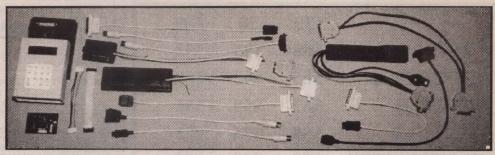


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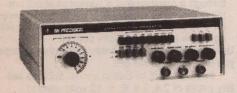
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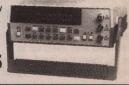
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## Build a by Fred Blechman Nickel-Cadmium Battery Zapper

hey're everywhere! They're in cars, in homes, in offices, on the street, in cabinets, on desks, in clothes, in airplanes - all over the world! Am I referring to bacteria or viruses? No! I'm referring

to nickel-cadmium rechargeable batteries!

These ubiquitous marvels of chemical power are in wireless and cellular phones, computers, calculators, flashlights, portable radios and televisions, camcorders, rechargeable power tools, and toys of all sorts. And while they normally can be recharged and used again many times, sometimes they refuse to charge and are thrown away!

Never fear, "Zapper-Man" is here! Build the "Ni-Cd Battery Zapper" described in this article, from scratch or from a kit, and you may never

have to throw away a Ni-Cd battery again.

Unless you've been hiding in a cave for the last 40 years, you know that "regular" (zinc-carbon) batteries give pretty good service, but when they're pooped, out they go. You know that alkaline batteries last a lot longer, but (with the exception of a new, expensive type) they are not rechargeable, and also must be tossed out when their voltage gets too low. You are probably also aware that nickel-cadmium batteries (frequently referred to as "nicad," "NiCad," "Ni-Cad," or "Ni-Cd" batteries — and I'll use the latter) have less operating capacity for their size, but can be recharged and used up to 1,000 times — thus making them the least expensive in the long run. They also can provide higher current, which is

required in some applications.

The downside of Ni-Cds, in addition to their greater original cost, is the bother of recharging them, and the frustration when they "die" virtually without warning.

#### What Are The Problems?

The chemistry of nickel-cadmium batteries is complex, and the details are well beyond the intent of this article. Suffice it to say they are pretty particular about their operating environment and how they are discharged and recharged

Their normal charged voltage is 1.2 volts, and they will operate with a relatively flat discharge

curve to about 1.1 volts when they begin to drop voltage rapidly. The usable period of operation above 1.1 volts depends, of course, on the discharge rate and the original battery charge.

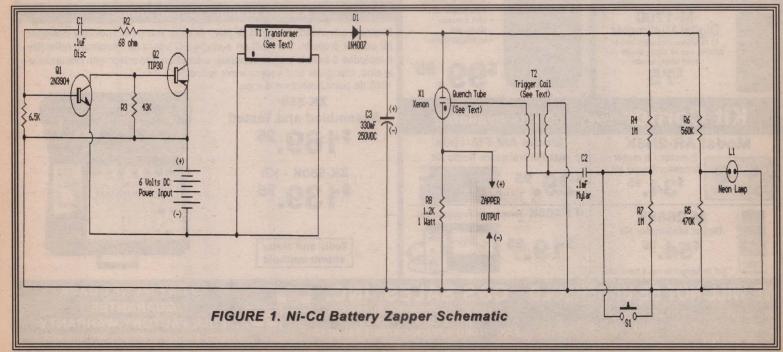
So-called "memory" problems, wherein the Ni-Cd battery seems to "remember" its last operating voltage before recharging, and virtually quits at that voltage in successive uses, can be defeated by what is called a "deep discharge." Properly, a Ni-Cd cell should be discharged through a resistance at a current of about onethird of its rated hourly life (say, 50 milliamperes for a 150 milliamp-hr (mAH) rating) until the voltage is no less than .5 volts per cell.

Unfortunately, if you discharge below that voltage

you may damage the cell.

In the case of Ni-Cds in series, such as battery packs of 2.4, 3.6, 6, or 12 volts used in phones and computers, the weakest cell can reverse polarity and make the whole pack unusable! Although only one cell in the pack may be bad, you are faced with an expensive replacement

In the recharging process, if you overcharge Ni-Cd cells with too much current for too long, or at too high an ambient temperature, even though they are "sealed" they will vent the gas caused by a pressure build-up. This leads to premature loss of capacity. Solution: Use a current-regulated



charger designed for that cell or pack.

One of the most common problems is that defects in manufacture, abusive use, complete discharging, non-use, and old age, allow "whiskers" (sometimes called "dendrites") to form between the positive and negative terminals of the battery. These tiny, threadlike paths are essentially short circuits that allow the battery to self-discharge. If the whiskers are not excessive, the battery can be charged, but will self discharge in a short time. If the whiskers are prolific, the battery will refuse to charge to its normal voltage, or may not accept ANY charge! That's when it appears "dead" and is usually thrown away.

#### **Save That Battery**

This is where the "Ni-Cd Battery Zapper" comes in. This device is designed to blast the inside of the battery between the positive and negative terminals with a burst of current that will vaporize the whiskers and clear the battery back to essentially its original state.

In the case of battery packs, where the cells are generally connected in series, you can access each cell to determine which (usually one) is the culprit and zap that, restoring the whole pack to normal operation. This can save \$100.00 or more for typical laptop computer battery packs!

How do you access a single cell in a pack? If the pack is sealed in plastic shrinkwrap, use straight pins to pierce the shrinkwrap where the bulges indicate battery connections. If the pack is sealed in hard plastic, more drastic measures apply. You can usually wedge, cut, or saw the pack open. If it is destroyed in the process, it was no good anyhow! Also, you might be able to salvage the GOOD cells for other use.

#### Kit Or Build From Scratch?

The Ni-Cd Battery Zapper can be built from a kit and used directly, or packaged as I'll describe. Most of the parts are common, but a few are unusual; for those I've given a source

A printed circuit board comes with the kit, but the circuit can be built on a perforated board. If you choose to make your own printed circuit board, the pattern is shown.

#### **Theory Of Operation**

The schematic for the Ni-Cd Battery Zapper is shown in Figure 1. This circuit produces a high voltage (up to 180 volts!) that results in several amps of current to blast away the whiskers that frequently form in Ni-Cd batteries.

Transistors Q1 and Q2, and associated com-

ponents R1, R2, R3, and C1, form an oscillator which converts the input DC (typically 6 volts, and shown as a battery pack in the schematic) to an AC voltage that is fed to the primary of transformer T1. This voltage is stepped up by T1's secondary and rectified by diode D1. The current through D1 charges large electrolytic capacitor C3, building up the voltage to approximately 180 volts over a period of a few minutes.

When enough charge is accumulated across C3 (160 VDC or more), the voltage at the divider formed at the junction of R5 and R6 reaches the firing point for neon lamp L1, lighting it to indicate that the circuit is almost ready for zapping.

During the charging time, the voltage at the junction of resistors R4 and R7 slowly charges capacitor C2. When pushbutton switch S1 is pressed, C2 suddenly discharges through S1 to ground, creating a pulse through the primary (right side in the schematic) of trigger transformer T2

The secondary of T2 provides a high-voltage trigger pulse to xenon flash ("quench") tube X1. X1 flashes and provides a very low-resis-

tance path that discharges C3 instantly through the output leads that connect to the Ni-Cd battery being zapped. Resistor R8 allows a discharge path if no battery is connected to the out-

#### Construction

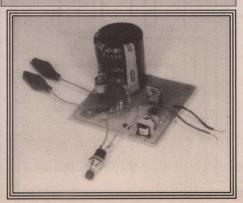
The printed circuit board pattern is shown in Figure 2, and the parts layout in Figure 3. The Parts List shows the required parts and sources.

If you have a good stock of parts, you might want to build this unit from scratch. However, several parts (T1, T2, X1, C3) are rather uncommon, but are stocked by The Electronic Goldmine (see "Sources"). The combination of other capacitors, transformers, or xenon tubes might not work properly in this circuit.

The printed circuit board is only available with the complete

#C6278 kit from Gateway Electronics. If you prefer, you can make your own PC board, or use any insulated board. If you use your own non-PC board, group the parts approximately as shown in Figure 3.

Ribbon cable connects from the circuit board and battery case to the switches, lights, battery holders, and terminals mount-ed on the lid (left). Below, the assembled, but unpackaged Zapper is shown.



FOIL PATTERN OF PC BOARD

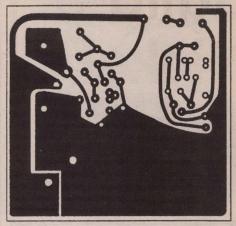
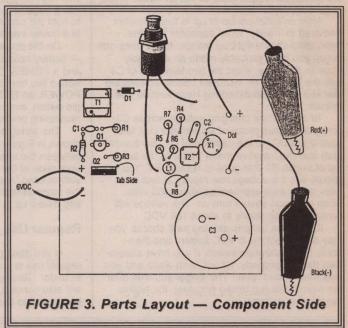


FIGURE 2. Printed Circuit Board Foil Pattern — Foil Side



Assemble the circuit following the parts list and parts layout using 60/40 rosin core solder only. Install all the components as shown, strictly observing polarities and the facing direction shown for the transistors. Install C3 last, to allow for easy installation of the other components

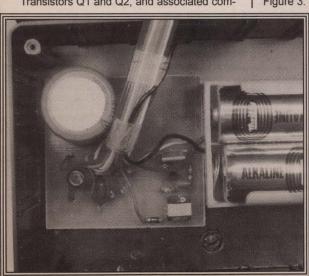
The xenon quench tube (X1) comes in a plastic bag, and its leads have been coated with a special flux for good soldering. Hold X1 by the glass part to keep from running the flux off its leads. It mounts with its dot facing mylar capacitor C2. Make sure that the leads of X1 are firmly soldered. Also note that the wire extending from the top of T2 is bent over and soldered to the

copper foil band around X1 The red clip lead connects to the (+)

point on the output, and the black clip goes to the (-) point. Connect pushbutton switch S1 to the appropriate points on the project board using small lengths of insulated wire.

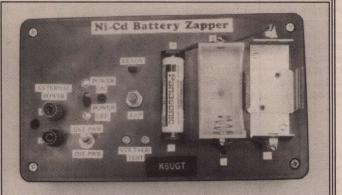
#### **Testing The Zapper**

After rechecking the assembly for correct parts placement, connect 6 VDC (your choice: lantern battery or four C or D cells





The lid of the cabinet contains the "user interface," while the circuit board and internal batteries are inside the cabinet (left). Below is the Zapper packaged in a plastic project box.



in series) to the appropriate points on the board Be aware that the unit can generate over 180 VDC, so be careful not to come in contact with the board, the output clips, or the terminals of the large electrolytic capacitor.

After an initial period of up to fives minutes (required to initially "form" capacitor C3), the neon lamp should light up orange. If this does not occur, you have probably made an assembly error. In this case, short the two terminals of C3 with the blade of an insulated handle screwdriver and see the Troubleshooting Hints section that follows.

To monitor the charging voltage across C3, connect the plus probe of a voltmeter (set to at least 200 VDC) to the cathode of D1 (the banded end) and the negative meter probe to the terminal of switch S1 that goes to resistor R7. You should see the voltage rise rapidly at first and then slowly as it approaches about 160 volts, when the neon should turn on. The voltage will continue to rise slowly to about 180 VDC

If the neon lamp is glowing as it should, you may disconnect the 6 VDC battery and then press the pushbutton switch. If you have assembled the unit properly, X1 will flash white and you may hear a loud "pop." The longer you wait after the neon lights (up to two minutes), the higher the zapping voltage.

#### **Packaging**

I don't like to connect clip leads to a project with high voltage on the loose! I built my Zapper into a large enough cabinet (see "Optional Parts") to hold the circuit board and four C-size batteries in a holder inside the case. See the photos.

On the cover, I mounted the "external" parts battery holders, READY neon, ZAP pushbutton,

and a POWER ON/OFF switch. I also added two terminals for EXTERNAL POWER, an EXT.PWR/INT.PWR toggle switch, and two VOLTAGE TEST monitoring points.

The wiring and additions are shown in Figure 4. The connections between the internal parts and the underside of the cover were made with colored "ribbon cable" to keep the interconnecting wires from getting mixed up.

#### Regular Use — Board Only

If you don't package the unit, regular use is just as described earlier under "Testing," except that you will also connect the Ni-Cd battery to be zapped to the OUTPUT clip leads

- red to (+), black to (-). This is best done putting the Ni-Cd battery in a battery holder that has either wires or terminals. If you have a multi-cell Ni-Cd battery pack, you must zap only a single cell, as described earlier under Save That Battery.

After the neon light comes on, wait about another 10 seconds for the voltage to build closer to its maximum. Keep your face away from the circuit board and the Ni-Cd battery and press push-button switch S1. You may have to press more than once. If the Ni-Cd did, in fact, have a bunch of whiskers, you will hear a loud "pop" and may see sparks at the junction of the clip lead and the battery. This is normal.

It is a good idea to repeat the process again on your bad Ni-Cd cell to insure that all whiskers have been blown. You will notice that the pop lessens each time. The Ni-Cd will NOT be charged up after zapping, but it will now be able to accept a charge - and it should be connected to a charger soon after it has been zapped. Most zapped Ni-Cds will store the same capacity as they did when they were new.

If you did not hear a loud pop you may not

#### #C6278 Kit Parts List

. 1 uF disc ceramic capacitor . 1 uF mylar capacitor — 330 uF 250 volt electrolytic capacitor (special) 1N4007 1-amp 1000 volt silicon diode

Neon lamp
 2N3904 NPN general-purpose silicon transistor
 TIP30 PNP 30-watt silicon power transistor
 6.5K 1/4-watt carbon resistor

R2 — 68 ohm 1/4-watt carbon resistor
R3 — 43K 1/4-watt carbon resistor
R4, R7 — 1M 1/4-watt carbon resistor
R5 — 470K 1/4-watt carbon resistor
R6 — 560K 1/4-watt carbon resistor

S1 — Normally-open pushbutton switch

T1 — White-dot inverter transformer (special) Red trigger transformer (special)

- Xenon quench tube (special)

Misc. — Circuit board, clips, wire, solder

#### Optional Parts for the Packaged Unit

Project Case — 7-7/16" x 4-1/4" x 2-3/8" (Radio Shack Cat. No. 270-224) Battery Holders — 1 each size AA, C, D Binding Posts — 1 red, 1 black

Binding Posts — 1 red, 1 black
Int.Pwr/Ext.Pwr Switch — Single-pole double-throw (SPDT)
Power On/Power Off Switch — Single-pole single-throw (SPST)
ON Indicator — Red light-emitting diode (LED)
LED Resistor — 150 ohm 1/4-watt carbon resistor
Test Points — 2 screws and nuts

Ribbon cable, hook-up wire

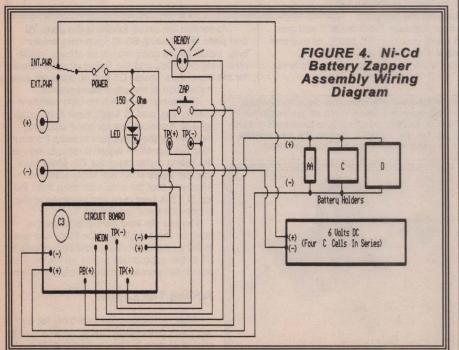
#### Sources

The complete NICAD BATTERY ZAPPER KIT #C6278, with all parts shown under the Kit Parts List, including an etched and drilled printed circuit board, is available from Gateway Electronics Corp., 8123-25 Page Boulevard, St. Louis, MO 63130 (Info: 314-427-6116; Order: 800-669-5810.) The price is \$18.75 plus \$4.25 shipping and handling. MO residents must add sales tax. Gateway carries many kits, as well as standard and unusual parts.

If you need just the "special" parts marked with an asterisk in the Kit Parts List (and all kinds of other goodies!), you can get them from The Electronic Goldmine, P.O. Box 5408, Scottsdale, AZ 85261. Minimum order is \$10.00 and shipping is \$4.00. AZ residents must add sales tax. Telephone (602) 451-7454 to order or ask for their 96-page heavily-illustrated glossy catalog. The special parts and their Electronic Goldmine name and part numbers are:

T1 — Tiny Inverter Transformer #N1703, \$2.00 T2 — Trigger Coil #N1700, \$1.25 X1 — Quench Tube #A1048, \$1.00 C3 — High Voltage Span In Country

- High Voltage Snap In Cap #G6747, \$2.00



have made a good firm connection between the clip leads and the Ni-Cd, or the Ni-Cd was not shorted. The unit DOES NOT produce a loud pop when a good cell has been zapped, but neither does it harm the cell. Incidentally, the Zapper cannot repair cells in which the electrolyte has been totally released, such as when a cell has been badly overcharged.

The battery or batteries that supply power to the unit should be replaced when it takes longer than five minutes for neon L1 to light.

#### Packaged Unit Use

If you package the unit as I have, as shown in Figure 4, then you can use either internal or external power. Internal power should use "C" or "D" cells. For external power, use a six-volt lantern battery or a well regulated adjustable DC power supply set for about 6 volts, observing polarity. The Zapper will draw about 100 milliamperes at first, moving up to about 300 milliamps, during each charge.

Place the Ni-Cd battery to be zapped in the appropriate battery holder, observing polarity. Set the EXT.PWR/INT.PWR switch to the proper setting, then put the POWER switch in the ON position. The red LED should light immediately.

In about two minutes (up to five minutes if the Zapper hasn't been used for awhile), the READY neon bulb should light. Wait about 10 more seconds, then press the ZAP switch (maybe more than once) and you should see the xenon tube flash and hear a pop.

If you'd like to monitor the internal charging voltage, use a voltmeter set for at least 200 volts connected to the VOLTAGE TEST points, observing polarity. Be cautious about touching these test terminals with your fingers since up to 180 volts can be present!

#### **Troubleshooting Hints**

Recheck all resistors for the proper values installed in the proper places. Look for solder bridges across parts (or printed circuit traces). Check for cold solder joints and reheat, adding solder to any suspect connections.

Referring to Figure 3, make sure that both transistors have their flat sides facing the direction shown. Check to make sure that proper polarity was observed mounting electrolytic capacitor C3 and diode D1. Check to make sure xenon quench tube X1 is connected with its white dot closest to capacitor C2, and the white dot lead of transformer T1 is closest to capacitor C1.

If the C3 voltage (measured at the test points) does not reach high enough to light the neon bulb, change resistor R6 to 470K; this will raise the voltage at the junction of R5 and R6. Happy Zapping! NV

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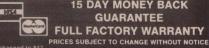
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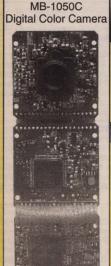
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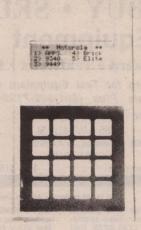
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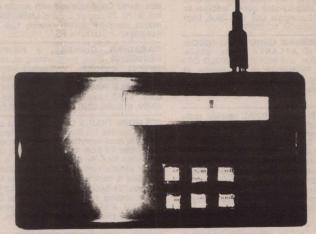
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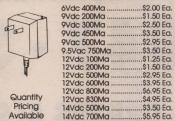
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## TECH FORUM

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 pro vide 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

I'm working on a 68701/6803 microcontroller project. I want to connect my MPU to the PC at the best possible rate. Since this MPU is limited to a max clock of 4 MHz, I need to have my PC work at 7200 baud. Do you know a way or can you point me to someone, or a book that would tell me how to use my PC at a non-standard serial rate? I have a card that uses four serial ports and FULLY emulated the 16550 UARTs. They use a 16-bit divisor latch and I know a value of 0010H will give me the correct rate. I just don't know how to and where to put this value. Maybe someone has a driver for setting your own rates. ANY language would be fine.

Patrick O'Toole

Question #1: I am rebuilding an electronic flash from the 60s that operates at 2 KV. If I place three 1 KV diodes in series, does this essentially triple their operating voltage?

Question #2: I am looking for DOS fonts. I have surfed (small waves, larger board) the NET, gone door-to-door, and used my last 800 number. The "fontware upgrade" must meet IceAge Technology; Packard Bell AT (8088), DOS 3.3, and Works 2.0. Currently, I have two printer residing fonts that I'm bored to tears with. Will pay-to-own.

**Brad Budinger** Morongo Valley, CA

1) Is there any packet or RTTY for an old Atari 800 XE computer?

2) Is there any way to make a data/fax modem to pick up automatically when it's connected to my voice line?

2963

**Charles Oblender** Milan, OH

I need help in programming a real old programmable scanner. So far, I have had no luck finding information about the scanner or the company that made it. It is made by Tennelec, Inc. of Oak Ridge, TN and is their Memoryscan Model MS-2. It is programmed in binary using a O's and 1's pushbutton on the front panel to set the frequency. The problem is knowing how to program the frequencies using binary. If someone can tell me how to do this or tell me where to write for a manual, it would be greatly appreciat-

2964

**Tim Naami** Cary, IL

I would like to buy (or find a way to modify) a Walkman-type tape cassette player so that it can play tapes at 1/4

and/or 1/8 normal speed. I already have a commercially made recorder from Viking International that records and plays back at 1/6 speed. This recorder works well, but it is too big to carry around conveniently. I'd like to use the modified Walkman at work to play back tapes recorded off AM/FM radio with the Viking International machine the previous night.

I only record talk shows (i.e., no music) so voice quality playback (3 KHz bandwidth) would be sufficient. Nice optional features for the Walkman would be autoreverse and variable speed control. The variable speed control should permit playback at up to 50% speedup from the nominal 1/4 and 1/8 speed playback.

Any suggestions as to where to buy such a Walkman or how to modify an existing unit?

**David Feustel** Ft. Wayne, IN

I need switch settings for an Arche 386 25 computer. Currently I have the machine set up with eight 256K memory SIMMs and wish to upgrade to eight 1 meg memory SIMMs. As you may have already guessed, the user lost track of the users manuals, and the OEM is out of business. I am keenly aware that this machine may not have been designed for use with 1 megs, but I need to know that one way or the other.

**Richard Dittmer** Waterloo, IA

Does anyone know of a good source of repair information for the QMS line of CX-engine laser printers (PSJet, PSJet+, 800, 800+, etc.)? I have the catalog from The Printer Works which is a good start, but I need a source of schematics, waveforms. etc., for repair and troubleshooting. QMS is notoriously close with this information.

Steve Bepko Baltimore, MD

I need a hard disk "internal" drive and probably a control card with cables for an IBM Model #5150, speed 8088. Could you try and get me the estimate for these products? I have "A & B" floppy drives at this time, 5-1/4" disk. Please send the information on this PC.

Walter E. Kenpton Muskegon, MI

1) Many of the PCs at the lab have a display problem: If the screen is adjusted in text mode (640 x 480) for size, centering, and aspect ratio and the program switches to 800 x 600 mode, then the image shifts enough that an inch of one side is squished into

1/16" and the other side has an extra blank inch. The horizontal and vertical sizes change, and the aspect ratio changes so much that circles are very oval. Since the monitors are the same brand (CTX), my first guess was differences in the video cards (which vary enough to give programming problems in achieving certain displays, particularly text mode info prompts in graphic mode screens). I now suspect the monitors and that a monitor might have internal adjustments to get equal displays of each raster type. Can someone explain well enough to at least avoid the problem when purchasing and maybe to correct it when it does occur?

2) In MS-DOS (5.0), the following command gets the current drive:\directory TRUENAME|FIND ":\"
The |FIND ":\" is to eliminate a leading blank line and may be omitted. This works even if an ECHO OFF command has shut off the prompt, or if ASSIGN, APPEND, SUBST, etc. has put you in some strange place you really don't know about. How do you get a batch program to use the result seamlessly in the middle of a single-line command? (Some commands may need it twice in the same line.) If there were some way to get it into an environmental variable, then it would be easy to use. The method must not take too much space, no more than 512 bytes (preferably much less). The method must be automatic with no intervention from the keyboard. The ultimate goal is to make a startup batch driveindependent: 1.44 MB drives are sometimes B: but sometimes A: and the program may be on one or more logical hard drives, any of 32 possibili-

2969

**Alex Beveridge** Macomb. IL

Does anyone have a diagram of an ohmmeter that has zero ohms at full scale when probes are shorted? A Dcell for low ohms and two AA cells for high ohms, similar to the old Simpson 260. There are some nice 50 microamp meters on the surplus market with an ohms scale on them.

29610

Joe Kish Clakamas, OR

I have questions regarding upgradmy multimedia PC 486-SX2-66 MHz w/4 MB RAM:

1) For upgrading its memory of 4 MB RAM, is it okay to buy RAM-Doubler or Memory Module to upgrade/make its memory to 8 MB

2) Is it better to buy six-function multifunction (printer, fax, scanner, copier, etc.) in color or black or white, or is it better to buy a color bubble-jet

#### **ANSWER INFO**

· Include the question number that appears directly below the question you are responding to.
• Payment of \$25.00 will be paid with-

in four weeks of publication if your answer is printed.

· Only one answer per question will be printed.

 If you do not want your name, address, or phone number available to the reader please so indicate or it will be assumed that you have no objec-

. In the event that more than one person submits the same solution, the choice will be made at the discretion of the publisher.

· Due to space limitations, we can not reprint the original questions with the answer. The question number and the issue it appeared in are printed above the answer.

#### QUESTION INFO TO BE CONSIDERED FOR PUBLICATION

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

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

#### INFORMATION/RESTRICTIONS

. No questions will be accepted that offer equipment for sale or equipment wanted to

· 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.

printer? (They cost about \$900.00, \$600.00, and \$300.00 for color multi, B & W multi, and color bubble jet print-

29611

Ramesh Saxena Culver City, CA

I need assistance in drawing the circuit for the timer and one touch as used on the TV game "Jeopardy" on ABC. If the system can be bought, please advise on company and address.

29612

**McDonald Knights** Orlando, FL

#### TECH FORUM

I have an old, giant television antenna on my roof. Is there anything I can use it for, such as extending the range of a 900 MHz cordless phone? 29613 Joe Phoe

Whitestone, NY

Does any company build a laser capable of cutting cloth? Does anyone have a schematic for one?

29614 W.R. Elliott Lawndale, NC

I need a 40-message (or more) alphanumeric pager combining Motorola advisors variable beep alert and flashing indicators with NEC ability to delete any message, not all in overload advisor. How can I make a magnetic card reader into a car anti-theft device? How many times can Motorola cell phones be programmed before defaulting? We're getting new area codes and both my phones have been done twice already.

615 Grant Maxwell Nanaimo, Canada

I have a 400 cycle, 440 volt power plant. Is there any practical way to convert to 60 cycle, 220 volts? It is a 35 KV unit and has its own DC generator for field excitation. Any ideas will be appreciated.

29616

Stanley Kelember Brookfield, NY

I understand XTs and ATs can have CD-ROMs. If so, what software is needed? Also what type: single, double speed? What about memory? Does any need to be allocated to the CD-ROM? If so, what needs to be put in autoexec and config files along with device statements?

MDW Sacramento, CA

This question has been puzzling me for some time. Those familiar with Microsoft Windows know you can use wallpaper or background images. Is it possible to hook my camcorder up to my computer and use its video output as my Windows background?

9618 Al Gabriel Queens, NY

I have two TVs (Zenith model M25 10W) and Panasonic (model CTK-2770S); both with no horizontal output (i.e., white horizontal line). Both sets have similar source of voltages (high and low), a flyback transformer (horizontal output). On the Panasonic, I tried replacing all burned out semiconductors related to the flyback. They too burned out. The yoke checked okay. What is the best way to attack this problem? I do not have a high-voltage probe for my DVM, nor will it read below 2 ohms. I'd greatly appreciate any help.

29619 Nicho

Nicholas O'Shana, Jr. Bristol, CT

I have an electric car which has the 20/6 volt 120 volt system for a charger. I use two big diodes with the ground as a CT on the 240 volt house line. With this setup, all the current from both hot legs goes back through the ground wire. Any ideas how to lessen the load on that ground? Must

be light and able to handle 20 to 40

29620

Steve Clunn Ft. Pierce, FL

Like many people a few years back when eight-bit computer systems reigned supreme, I purchased a Tandy/Radio Shack Model 100 portable computer. One of the most annoying things about it and its major drawback was the lack of a non-bulky storage device other than the cassette recorder. So when a company called A & J Micro Drive created a small portable "B track-like" tape-based storage device called the "System 100," I bought one. Hopefully one of your readers may be able to help me resolve a few problems I have with this unit. They are as follows:

a) A & J Micro Drive was located at 1050 East Duane Avenue, Suite L, Sunnyvale, CA 94086. Their telephone numbers used to be (408) 732-9292 voice and (408) 732-6464 BBS. Does anyone know their new telephone numbers or if they are still in business?

b) I need a schematic for their "System 100" tape drive for the Model 100. It's a device similar to the EXATRON Stringy Floppy for the TRS-80 Model I, except that it is a serial device rather than a parallel device. Basically, I need to know which connectors on the System 100's internal circuit board go to which pins in the DB25P connector which attaches to the TRS-80 Model 100's serial port.

c) The A & J Micro Drive BBS was used to download their software for this device into the Model 100 so that it could operate off of the Model 100's RS-232 port. Does anyone still have a working copy of that software or know from whom or where it may be obtained?

d) I would like to interface this device to an IBM PC, similar to the way LAPDOS by Traveling Software of Seattle, WA does for the Tandy/Radio Shack portable disk drive (P/N 26-3808) to a IBM PC or compatible.

29621 Daniel S. Mouradian Countryside, IL

I have an MVRAT M1200 fax. When I turn it on all indicator lights come on and a high pitch tone. What is the problem? It will not send or receive a fax.

29622

Robert Mosely, Sr. Worcester, MA

I'm looking for voice mail software that runs under MS-DOS and will work on an 8086 CPU.

29623

Robert Clay Jamul, CA E-Mail: bob@sdsu.edu

#### **ANSWERS**

#### ANSWER TO #1965-JAN. 1996

Here is what you need to control your satellite receiver (and other equipment too) via infrared signals from your IBM PS/2 for under \$200.00:

1. A One For All brand universal remote control (made by Universal Electronics). You will want the One For All 5, 6, or 8 as they have a hidden serial port in the battery compartment.

The One For All 12 will be upgradeable so you can send it back to Universal Electronics for an update if it doesn't work with your equipment right out of the package.

2. An extended code list for your equipment. You can call, write (contact information on the package), or E-Mail (help@ueic.com) Universal Electronics for this list. These codes allow you to send every function that can be sent to your equipment even if it hasn't been assigned to a key on the remote.

3. A special serial cable to connect the remote to your PC. There is levelshifting electronics built into the con-

nector shell.

**4.** Infrared Direct Control (IRDC) software by D. Huras Software. This allows your PC to push buttons on the remote either manually, through batch files, or via DDE. There is a version for both MS-DOS and Windows. There is a section in the manual specifically on scheduling IR signals.

5. Scheduling software that can tell IRDC what buttons to push. For example, there is one bundled with Central Point's PC Tools and the shareware task switcher Back 'N Forth. IRDC can also be operated from VisualBasic or any scheduling software that can run a program with command line parameters or send DDE commands.

All of the above can be purchased through most home automation dealers. My favorite is Worthington Distribution, phone: 800-282-8864, fax: 717-226-0470, E-Mail: worthdist@aol.com and www.http://www.hometeam.com/worthing/

Doug Smith Roscoe, IL

#### ANSWER TO #129512-DEC 1995

1. If I understand correctly, you wish to connect your television and VCR sound through your stereo system. This is a simple matter if your VCR or TV have line out jacks on either one of them (most VCRs will). Your stereo should already be configured with the equalizer, but if it isn't, the signal order should be as follows: from the receiver "Tape Out" left and right to the equalizer's "Line In" left and right; EQ "Line Out" to the receiver "Tape In" left and right.

To connect the signals inside the receiver, you want to set the tape monitor selector to ON. This takes the Tape Out signal from the receiver, processes it through the EQ and then back to the Tape In on the receiver, you use the tape monitor to hear the equalized music. If you have a tape deck, it should be connected to the equalizer in through its Tape Out and Tape In connections. The EQ will usually have a tape monitor switch on it to listen to the tape deck equalized, of course.

You then need to connect the Line or Audio Out from your VCR to the line input on your receiver, if you have a spare input on your receiver. If you don't have an extra input, you can buy a switching device which selects either the CD player or the VCR signal automatically. These switches are priced under \$70.00 and are available from MCM Electronics (1-800-543-4330, cat. #80-540).

2. As for your blown speakers, you didn't really give enough information to

completely help you. You believe that both your tweeter and your woofer were burned out because the fuse was too high in value. I suspect that, unless these speakers were very small and cheap, they were damaged by a fault from the amplifier. A 2-amp fuse should blow when the input power to the speaker system exceeds 32 watts continuous average power. (By the way, there is no such unit as "Watts RMS"—never was, never will be. Check any linear circuits textbook.) The wonderful people in the electronics marketing world thought that attaching the word "average" to a product's specification would harm its reputation.

So, unless your speakers are rated to handle less than 32 watts continuously, the fuse value isn't the cause. I suspect that what may have caused the speaker's demise was either a DC voltage present on the amplifier's output, or some sort of instability in the amplifier. Your tweeter, if it has the appropriate crossover should be protected from DC, but the woofer will not have any protection. By the time the fuse can blow, the damage may have already been done. If your tweeter doesn't have a crossover, it needs one; tweeters cannot handle the low-frequency energy that drives the woofer.

I would suggest looking in Parts Express 1-800-338-0531, or MCM Electronics 1-800-543-4330 for replacement parts for your speakers, but have your amplifier checked out. If you briefly connect a bass driver to it, and the cone jumps in or out and stays there with no music playing, then you definitely have DC present on your amplifier outputs.

Vincent L Worley Oakland, MD

#### ANSWER TO #12953-DEC 1995

If you want to make your 8088 a 286, why not replace the mother-board? If you have a standard mother-board footprint for the 8088, then you should be able to remove and toss the 8088 mother-board and replace it with a 286. These can be purchased for next-to-nothing used from many computer dealers. Of course, for approximately the same next-to-nothing price you can get a 386 mother-board. That is why the adapter board system has long ago dried up.

Now a couple of parting comments. This all assumes that the power supply is good and has a high enough rating to take your new board. (This same problem applies to the adapter boards.) The second comment is, why bother? You will end up with a computer with a very out-dated CPU and extremely outdated support hardware. If you want a 286, you probably can pick one up for well under \$100.00. I frequently am offered 8088 and sometimes 286 systems for the trouble of picking them up.

Ray Todd Stevens Bedford, IN

#### ANSWER TO #1964-JAN 1996

A digital voice recording CMOS chip has recently become available and is currently being used in everything from personalized talking greeting cards to talking cameras and keychain

Continued on page 119

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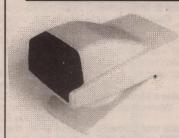
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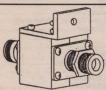
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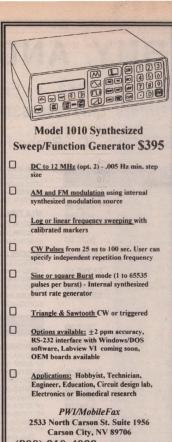
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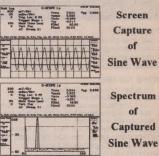
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L.C.R		TEK DC5010 350 MHz/3. TEK DC503A 125 MHz U
BOONTON 62AD 1 MHz Inductance Meter, 2-2000 uH	\$700.00	TEK DC509 135 MHz Hig
E-S.I. 296V 4-1/2 Digit LCR Bridge, 120 Hz & 1 kHz.  HP 4261A 3-1/2 digit LCR Meter, 120 Hz/1 kHz.  HP 4262A-003,004 3-1/2 digit LCR Meter,	\$1,100.00	Universal Counter/Tim TEK DC510 350 MHz/3.1
120 Hz/1 kHz/10 kHz. HPIB		FREQUENCY COL
HP 4271B-101/16022A 1 MHz LCR Meter,	\$900.00	FLUKE 7220A-opt.111 1.3 Counter, TCXO option
STANDARDS		HP 5305B/5300B-001 1.3
E.S.I. RS-925 9-Decade Resistor, 0.01 ohm-1.2 Megohm	\$1,600.00	Counter Package w/To HP 5340A-001,011 18 GH
E.S.I. SR1010 Resistance Transfer Standards, 1 ohm-100 K/step FLUKE 5450A Programmable Resistance Standard, 2 & 4 wire	\$700.00	OCXO reference, HPII HP 5340A-005,011 23 GH
E.S.I. SHI UIV Desistance transler Standards, 1 Mini Fu Onstep FLUKE 5450A Programmable Resistance Standard, 2 & 4 wire GR 1409-SERIES Standard Mica Capacitors, 0.65% accuracy GR 14135-Decade Precision Capacitor, 0-1.1110 uF, 1 pF res GR 1432-U 4-Decade Resistor, to 11,111 ohms, 0.1 ohm res GR 1432-U 4-Decade Resistor, to 111.10 ohms, 0.01 ohm resolutii GR 1433-V 6-Decade Resistor, to 111.110 ohms, 0.1 ohm res	\$150.00	HP 5342A 18 GHz Freque
GR 1432-N 5-Decade Resistor, to 11,111 ohms, 0.1 ohm res.	\$275.00	HP 5342A-001,011 18 GH HP 5342A-003,011 18 GH
GH 1432-U 4-Decade Hesistor, 0-111.10 onms, 0.01 onm resoluting GR 1433-X 6-Decade Resistor, to 111,111.0 onms, 0.1 ohm res GR 1434-G 7-Decade Resistor, 0-1,111,111.0 ohms, 0.1 ohm res.	\$550.00	+22 dBm,-20 dBm dyr HP 5342A-01,04,05,11 24
	\$500.00	OCXO, DAC, and HPI HP 5345A/5355A/5356A-
HI & LO RESISTANCE GR 1666 DC Resistance Bridge, 1 micro-ohm - 100 kilohms	\$750.00	Counter, 0.4-18.0 GHz HP 5361A-006 20 GHz Pr
HP 4328A-001 Milliohmeter, 0.001-100 ohms f.s., battery option VALHALLA 4150-ATC 4-1/2 digit	\$1,350.00	Counter, 10 Watt prote
Ohmmeter, 20 milliohms-2 kilohms, 4-wire	\$1,000.00	HP 5382A 225 MHz Freq SYSTRON-DONNER 609
CURVE TRACERS	******	SYSTRON-DONNER 624 Frequency Counter, O
TEK 576 CurveTracer, with standard test fixture	\$2,350.00 \$2,250.00	TEK 7D14 525 MHz Freq TEK DC504 80 MHz Fred
TEK 7CT1N Curve Tracer, to 0.5W, 7000 series	\$400.00	STANDARDS
T.D.R. TEK 1503-opt.04 Time Domain Reflectometer,	\$2,000.00	HP 105A Quartz Oscillato
0-50,000 feet,chart recorder		HP 5087A-031 Distributio 0.1/1.0/5.0 MHz x 4 ch
POWER SUPPLIES		HP 5359A Time Synthesi width 5 nS-160 mS, jit
FOWER SOFFEIES		DESCRIPTION OF THE PERSON NAMED IN COLUMN 1
SINGLE OUTPUT	64 000 00	AU
HP 6023A Autoranging Power Supply, to 20 V / 30 A / 240 Watts . HP 6031A Autoranging Supply,	\$2,000.00	SPECTRUMANA
to 20 V / 120 A / 1000 W max., HPIB HP 6038A Autoranging Supply, to 60 V / 10 A / 200 W max., HPIB	\$1,600.00	HP 3581A Wave Analyze HP 3582A Dual Channel
HP 6201B 20 V at 1.5A CV/CC Power Supply	\$200.00	25.6 kHz, HPIB
HP 6228B Dual 50 V at 1 A CV/CC Power Supply, tracking	\$650.00	HP 3586C Selective Level HP 8556A LF Section, 20
HP 6038A Autoranging Supply, to 60 V / 10 A / 200 W max., HPIB HP 6201B 20 V at 1.5 A CV/CC Power Supply HP 6207B 160 V at 200 mA CV/CC Power Supply HP 6228B Dual 50 V at 1 A CV/CC Power Supply, tracking HP 6260B-207 10V at 100 A CV/CC Power Supply HP 6261B-027 20 V at 50 A CV/CC Power Supply HP 6263B 20 V at 10 A CV/CC Power Supply HP 6263B 40 V at 50 A CV/CC Power Supply HP 6267B 40 V at 50 A CV/CC Power Supply HP 6267B 40 V at 30 A CV/CC Power Supply HP 6268B 40 V at 30 A CV/CC Power Supply HP 6268B 40 V at 50 A CV/CC Power Supply	\$675.00	DISTORTION ANA
HP 6263B 20 V at 10 A CV/CC Power Supply	\$400.00	HP 334A Distortion Analy
HP 6267B 40 V at 10 A CV/CC Power Supply	\$550.00	HP 339A Distortion Analy HP 8903A Audio Analyze
HP 6268B 40 V at 30 A CV/CC Power Supply HP 6299A 100 V at 750 mA CV/CC Power Supply	\$250.00	TEK DA4084 Programma Analyzer, 0.0025% Th
HP 6299A 100 V at 750 mA CV/CC Power Supply HP 6384A 4.0-5.5 V at 8 A CV/CL Power Supply HP 6439B 60 V at 15 A CV/CC Power Supply	\$175.00 \$550.00	RMS VOLTMETER
HP 6448B 600 V at 15.A CV/CC Power Supply KEITHLEY 240A HV Power Supply, 0-1200 V, 0-10 mA, CV/CL	\$850.00	FLUKE 8920A True RMS
SORENSON DCR 110-45T 110 V at 45A CV/CC Power Supply.	\$2,200.00	HP 3400A RMS Voltmeter,
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	commerci, colorado coceo	
	SORENSON DCR 300-8A 300 V at 8 A CV/CC Power Supply, 208/230 VAC line	\$950.00
	SORENSON SRL 60-8 60 V at 8 A CV/CC Power Supply, low noise TEK PS501-1 Power Supply,	\$950.00
	0-20 V, 2 mV res. , 400 mA, TM500 series	\$175.00
	MULTIPLE OUTPUT	\$650.00
	HP 6227B Dual 25 V at 2A CV/CC Power Supply, tracking HP 6253A Dual Output 20 V 3 A CV/CC Power Supply	\$500.00
	HP 6255A Dual Output 40 V 1.5 A CV/CC Power Supply	\$500.00
	HP 59501 A HPIB Isolated DAC/Power Supply Programmer	. \$175.00
	HP 6824A Bipolar Power Supply/Amplifier, to 50 V, 1A HP 6827A Bipolar Power Supply/Amplifier, to 100 V, 500 mA KEPCO BOP-100-4M 100 V, 4A Four	\$400.00 \$800.00
	Quadrant Bipolar Supply / Amplifier	
	KEPCO BOP-36-5M Bipolar Op Amp/Power Supply, to 36 V, 5A	\$550.00
	TIME & FREQUENCY	
	UNIVERSAL COUNTERS	
	HP 5314A 100 MHz/100 nS I Iniversal Counter	\$225.00
	HP 5315A 100 MHz/100 nS Reciprocal Counter, high res. audio HP 5315A-001 100 MHz/100 nS Universal	\$650.00
	Counter, TCXO reference HP 5316A-003 100 MHz/100 nS	\$1,000.00
	Universal Counter, HPIB, 1.0 GHz C-chan. HP 5335A 200 MHz Universal / Statistical Counter	\$1,500.00
	HP 5370B-001 100 MHz Univ.  Time Int. Counter, 20 pS single shot, OCXO	\$2,250.00
	Time Int. Counter, 20 pS single shot, OCXO HP E1420A-010,030 VXI card 200 MHz/2 nS Univ. Counter, TCXO& 2.5 GHz C-ch	
	Univ. Counter, TCXO& 2.5 GHz C-ch PHILIPS PM6654/056 120 MHz/ 2 nS Programmable High Res. Counter, OCXO, GPIB	\$950.00
	TEK 7D15 225 MHz Universal Counter/Timer, 7000 series	\$275.00
	Counter/Timer, TM5000 series TEK DC5009 Programmable 135 MHz Univ.	
	Counter/Timer, TM5000 series	
	TEK DC5010 350 MHz/3.125 nS Univ. Counter, TM5000 series TEK DC503A 125 MHz Universal Counter/Timer, TM500 series	\$1,000.00
	TEK DC509 135 MHz High Resolution	
	TEK DC510 350 MHz/3.125 nS Universal Counter, TM500 series	\$750.00
	FREQUENCY COUNTERS FLUKE 7220A-opt.111 1.3 GHz Communications	\$650.00
	Counter, TCXO option HP 5305B/5300B-001 1.3 GHz	\$450.00
	Counter Package w/TCXO ref., high res. audio HP 5340A-001,011 18 GHz Frequency Counter,	\$1,900.00
	OCXO reference, HPIB HP 53404-005 011 23 GHz Frequency Counter HPIB	\$2 000 00
	HP 5342A 18 GHz Frequency Counter HP 5342A-001,011 18 GHz Frequency Counter, OCXO, HPIB HP 5342A-003,011 18 GHz Freq Counter,	\$2,350.00
	HP 5342A-003,011 18 GHz Freq. Counter, +22 dBm,-20 dBm dynamic range,HPIB	\$2,750.00
	HP 5342A-01,04,05,11 24 GHz Frequency Counter,	\$3,900.00
	OCXO, DAC, and HPIB HP 5345A/5355A/5356A-06 Pulse/CW Frequency	\$3,500.00
	Counter, 0.4-18.0 GHz, HPIB HP 5361A-006 20 GHz Pulsed/CW Frequency	\$6,750.00
	Counter, 10 Watt protection HP 5382A 225 MHz Frequency Counter	\$200.00
	HP 5382A 225 MHz Frequency Counter SYSTRON-DONNER 6054B 24 GHz Frequency Counter SYSTRON-DONNER 6245A-opt.12 18 GHz	\$1,875.00
	Frequency Counter, OCXO option TEK 7D14 525 MHz Frequency Counter, 7000 series	\$175.00
	TEK DC504 80 MHz Frequency Counter	\$125.00
	HP 105A Quartz Oscillator, 0.1/1.0/5.0 MHz	\$750.00
	0.1/1.0/5.0 MHz x 4 channels each	
	HP 5359A Time Synthesizer, pulse width 5 nS-160 mS, jitter<200pS	\$2,000.00
	AUDIO A DACEDAND	Sec.
	AUDIO & BASEBAND	
	SPECTRUMANALYZERS	\$9F0.00
	HP 3581A Wave Analyzer, 15 Hz-50 kHz HP 3582A Dual Channel FFT Spectrum Analyzer,	\$2,500.00
	25.6 kHz, HPIB HP 3586C Selective Level Meter, 50 Hz-32.5 MHz, 50 & 75 ohms	\$1,200.00
	HP 8556A LF Section, 20 Hz-300 kHz	\$500.00
	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	\$1,500.00

Analyzer, 0.0025% THD, w/frame RMS VOLTMETERS

\$700.00 \$250.00 \$200.00



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OSCILLATORS	
FLUKE 6011A Synthesized Generator,	\$1,200.00
10 Hz-11 MHz, 10 Hz res.	
HP 204D Oscillator, 5 Hz-1.2 MHz, 5 VRMS,	\$200.00
80 dB step attenuator	\$225.00
HP 209A Sine/Square Wave Generator, 4 Hz-2 MHz, 5 VRMS max. HP 652A Test Oscillator, 10 Hz-10 MHz	\$300.00
ROCKLAND 5100 Synthesizer, 1 mHz-1.999999999 MHz	\$400.00
TEK SG502 Sine/Square Osc. 5 Hz-500 kHz.	\$350.00
70 dB step atten. TM500	4000.00
FILTERS, MISCELLANEOUS	
HP 3575A-002 Phase-Gain Meter, 1 Hz-13 MHz, dual display	\$900.00
KROHN-HITE 3202 / 3202R Dual	\$600.00
High-Pass/Low-Pass Filter, 20 Hz-2 MHz, 24 dB/oct KROHN-HITE 3342 Dual HP/LP Filter,	\$1,100.00
0.001 Hz-99.9 kHz, 48 dB/octave	41,100.00
TEK AM502 Differential Amplifier, 0.1 Hz-1 MHz, TM500 series	\$575.00
DE & MICDOWAVE	
RF & MICROWAVE	
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RF & MICROWAVE	
SPECTRUMANALYZERS	
SPECT HUMANALYZEHS HP 11970K WR28 Harmonic Mixer, 26.5-40 GHz HP 11970K WR42 Harmonic Mixer, 18.0-26.5 GHz HP 11970Q WR22 Harmonic Mixer, 33-50 GHz HP 11970Q WR19 Harmonic Mixer, 40-60 GHz HP 11971K WR48 Harmonic Mixer, 26.5-40.0 GHz, for 85698 HP 11971K WR42 Harmonic Mixer, 26.5-40.0 GHz, for 85698 HP 11971K WR42 Harmonic Mixer, 18.0-26.5 GHz, for 85698 HP 14971K WR42 Harmonic Mixer, 18.0-26.5 GHz, for 85698 HP 84306A Comb Generator, 17/10/100 MHz increments, to 5 GHz HP 8443A Tracking Generator, for 85538, LED display HP 8444A Tracking Generator, 0.1-1300 MHz, for 85548 HP 8444A-059 Tracking Generator, 0.5-1500 MHz, for 8554, 8568, etc.	\$1,100.00
HP 11970K WR42 Harmonic Mixer, 18.0-26.5 GHz	\$1,100.00
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 8443A Tracking Generator, for 8553B, LED display	\$700.00
HP 8444A Tracking Generator, 0.1-1300 MHz, for 8554B	\$1 500.00
0.5-1500 MHz, for 8554,8568,etc.	\$1,000.00
HP 8445B Preselector, 1.8-18.0 GHz, for HP 8555A HP 8552B IF Section	\$800.00
HP 8552B IF Section	\$750.00
HP 8553B HF Section, 1 kHz-110 MHz	\$800.00
HP 8553B RF Section, 1 kHz-110 MHz HP 8554B RF Section, 0.1-1250 MHz HP 8554B/8552B/141T SpectrumAnalyzer,	\$2,000.00
100 kHz-1250 MHz, 100 Hz resolution HP 8555A RF Section, 0.01-18 GHz HP 8555A/8552B/141T Spectrum Analyzer System,	6050.00
HP 8555A/R552B/141T Spectrum Analyzer System	\$2.250.00
10 MHz-18 GHz, 100 Hz res.	
HP 8555A/8552B/8445/141As above,w/1.8-18 GHz	\$3,000.00
Preselector, opt.003 freq.display  HP 8558B/181TR Spectrum Analyzer,	\$2 250 00
0.1-1500 MHz, 1 kHz res., w/display	\$2,200.00
TEK 496P SpectrumAnalyzer, 10 kHz-1.8 GHz, 30 Hz res., GPIB .	\$5,500.00
TEK 496P SpectrumAnalyzer, 10 kHz-1.8 GHz, 30 Hz res., GPIB . TEK 7L12/7613 SpectrumAn.,	\$1,875.00
100 kHz-1.8 GHz, 300 Hz min.res.,w/display TEK 7L18/7603 SpectrumAnalyzer,	\$3 400 00
1.5-18.0 GHz, 30 Hz res., w/display	
TEKTR503 Tracking Generator, 0.1-1800 MHz, for 492/4/5/6	. \$1,750.00
NETWORKANALYZERS	
нР 11590A Bias Network, 1.0-12.4 GHz, N(f/f)	\$375.00
HP 11590A-001 Bias Network, 1.0-18.0 GHz, APC7 HP 11665B Modulator, 0.15-18.0 GHz, for use with 8755/6/7 HP 8407A/8412A/8601A NetworkAnalyzer,	\$450.00
HP 11665B Modulator, 0.15-18.0 GHz, for use with 8755/6/7	\$375.00
100 kHz-110 MHz, with sweep generator	\$1,250.00
100 kHz-110 MHz, with sweep generator HP 85021A Directional Bridge,	\$1,200.00
0.01-18.0 GHz.APC7, for 8755/6/7	
HP 85027E Directional Bridge, 10 MHz-26.5 GHz, for 8757 series . HP 85050D APC7 Calibration Kit, for 8510 series	\$2,000.00
HP 8505A-005/8503A NetworkAn.,	\$5,000.00
0 5-1300 MHz w/S-Darameter & phace lock	
HP 8755C/(3)11664A/181T Scalar NetworkAn	\$1,750.00
HP 8756A/(3)11664A Scalar NetworkAnalyzer,	\$3,750.00
w/(3) detectors, 0.01-18 GHz	64 050 00
NARDA 7000A/7202/7206 Microwave Multimeter	
System: scalar analysis 0.1-18 GHz WILTRON 560/3x-7S50 Scalar Network	\$2,000.00
Analyzer w/3 detectors 0.01-18.5 GHz	
WILTRON 640/G50/E(2)/7B50(2) Network An.,	\$1,675.00
FLUKE 6060A/AN Synthesized Signal Gen.,	\$2,000,00
10 kHz-520 MHz, 10 Hz res,GPIB	\$2,000.00
FLUKE 6060B-488 Synth. Signal Gen.,	\$3,750.00
10 kHz-1050 MHz 10 Hz res GPIR	
GIGATRONICS 600/10-18, opt.06 Synthesized Source,	\$3,000.00
GIGATRONICS 605/0.01-8.0, opt.3	\$3,000.00
Synthesized Source, 10 MHz-8 GHz, 1 kHz res., GPIB GIGATRONICS 875/50 Levelled Multiplier,	\$3 500 00
v4 50 0-75 0 GHz output -2 dRm	
GIGATRONICS 875/86 Levelled Multiplier,	\$7,000.00
26.5-40.0 & 50.0-75.0 GHz outputs GIGATRONICS 910/12-18,opt6,14,16 Synthesized	
Source/Sweener 12-18 GHz 1 Hz res OCXO	
HP 85100V Frequency Mult.,	\$4,250.00
10-15 GHz in / 50-75 GHz out >0 dBm	
HP 8640B Signal Generator, 0.5-512 MHz, AM, FM	\$2,750,00
0.5-1024 MHz, AM, FM, var, audio osc.	
HP 8654A Signal Generator, 10-520 MHz,	\$625.00
calibrated AM & uncal. FM HP 8660C/86602B/86633B Synthesized	
Signal Generator, 1-1300 MHz, AM, FM	φ <u>ε</u> ,1 30.00
HP 8660C/86603A/86633B Synth. Sig. Gen.,	\$4,500.00
1-2600 MHz, AM, FM, digital sweep HP 8683B Signal Generator,	
HP 8683B Signal Generator,	. \$5,000.00
E.O. O.O GITE, AIR, TTOI III, T disc	

HP 8684B Signal Generator, 5.4-12.5 GHz,	\$5,000.00
AM, WBFM, Pulse WILTRON 6742A Synthesizer/Sweep Generator,	\$9,000.00
18.0-26.5 & 26.5-40.0 GHz SWEEP GENERATORS	
GIGATRONICS 900/0.05-12, opt.3 Synthesized	\$4,500.00
Sweep/Sig. Gen., 50 MHz-12 GHz, 1 kHz res. HP 8350A/86290B-H08 Programmable	\$5,500.00
Sweep System, 2.0-22.0 GHz, +4 dBm lvl'd	\$500.00
HP 8620C Sweep Oscillator Frame. HP8 8620C-011 Sweep Oscillator Frame, HPIB programmable. HP8 8620C-011 Sweep Oscillator Frame, HPIB programmable. HP8 8620A RF Plug-in, 10-1300 MHz, +10 dBm levelled. HP8 86222A-002 RF Plug-in, 10-2400 MHz,	\$550.00
HP 86220A RF Plug-in, 10-1300 MHz, +10 dBm levelled	\$800.00
70 dB step attenuator HP 86222B-002 RF Plug-In, 10-2400 MHz,	
crystal markers, 0-70 dB atten	6075.00
crystal markers, 0-70 dB atten HP 86230B RF Plug-in, 1.8-4.2 GHz, +10 dBm unlevelled	\$1,000.00
HP 86240B RF Plug-in, 2.0-8.4 GHz, +13 dBm levelled	\$1,000.00 \$500.00
HP 86242D-004,008 RF Plug-In, 5.9-9.0 GHz, +10 dBm levelled HP 86245A RF Plug-in, 5.9-12.4 GHz, +16 dBm levelled	\$500.00 \$1,100.00
HP 86250D RF Plug-in, 8.0-12.4 GHz, +10 dBm external levelling	\$550.00 \$700.00
HP 86260A RF Plug-in, 12.0-18.0 GHz, +10 dBm unlevelled	\$1,000.00
HP 86290A RF Plug-in, 2.0-18.0 GHz, +7 dBm levelled	\$1,750.00
WAVETEK 1001A Sweep Generator, 0.5-300 MHz	\$350.00
WAVETEK 2002A Signal/Sweep Generator, 1-2500 MHz, +10 dBm levelled	. \$1,650.00
WAVETEK 907 Sweep/Signal Generator,	
WAVETEK 954 Signal/Sweep Generator,	
WAVETEK 962 Sweep Generator, 1.0-4.0 GHz,	
WILTRON 6619A-003 Prog. Sweep Gen.,	
WILTRON 6637A-40.02 Sweep Gen. 2.0-18.6 GHz.	. \$4,500.00
+14 dBm levelled, 70 dB atten. WILTRON 6647A-40,02 Sweep Gen., 0.01-18.6 GHz,+14 dBm levelled, 70 dB atten.	. \$6,500.00
POWER METERS	
BOONTON 4200-01B/-4G Power Meter w/sensor,	. \$1,500.00
BOONTON 42B/41-4E Analog Power Meter,	\$650.00
with 1 MHz-18 GHz sensor BOONTON 42B/42A-S3 Analog Power Meter,	\$375.00
with 1 MHz-8.4 GHz N(f) sensor GENERAL MICROWAVE 476/4240A	\$375.00
Power Meter & Sensor, 0.01-18 GHz, -35 to +10 dBm	\$750.00
HP 432A/478A Power Meter, 0.01-10 GHz, -20 to +10 dBm f.s	\$375.00
HP 432C Autoranging Digital Power Meter, 10 uW-10 mW f.s	\$425.00
HP 432A/478A Power Meter, 0.01-10 GHz, -20 to +10 dBm f.s HP 432A/8478B Power Meter, 0.01-18 GHz, -20 to +10 dBm f.s HP 432C Autoranging Digital Power Meter, 10 uW-10 mW f.s HP 435A/8481A Power Meter, 10 MHz-18 GHz, -30 to +20 dBm HP 435A/8482H Power Meter, 0.1-4200 MHz, -15 to +34 dBm HP 435A/8483A Power Meter, 0.1-2000 MHz,	\$1,150.00
-30 to +20 dBm. /5 onms	
HP 435A/8484A Power Meter, 10 MHz-18 GHz, -70 to -20 dBm HP 436A Digital Power Meter	\$1,000.00 \$1,200.00
HP 436A-022 Digital Power Meter, HPIB option	\$1,400.00 \$ \$400.00
HP 436A Digital Power Meter, I of MHZ-16 GHZ, 70 to -20 dBir HP 436A-022 Digital Power Meter, HPIB option. HP K486A WR42 Thermistor Mount, 18.0-26.5 GHz, for 432 serie HP Q8486A Power Sensor, 33.0-50.0 GHz, WR22, for 435/67/8. HP R486A WR28 Thermistor Mount, 26.5-40.0 GHz, for 432 serie	\$1,500.00
RF MILLIVOLTMETERS	
RACAL 9303 TRMS Level Meter,	\$875.00
AMPLIFIERS, MISCELLANEOUS	
AILTECH 7616 Noise Source, 1.0-12.4 GHz, N(m), 15 dB ENR AILTECH 7618E Noise Source,	\$375.00
10 MHz-18 GHz, SMA(m), 15 dB ENR AMPLIFIER RESEARCH 1W1000 Amplifier,	
20 dD asia 4 4000 MHz 4 Methandard	
30 ab gain, 1-100 Mirz. 1 wat output BONTON 82AD FWAM Modulation Meter, 10-1200 MHz ENI 403LA Amplifier, 37 dB gain, 150 kHz-300 MHz, 3 Watts ENI A300 Amplifier, 55 dB, 0.3-35.0 MHz, 300 Watts HP 11720A Pulse Modulator, 2-18 GHz, -80 dB or/off ratio HP 8447A-001 Dual Amplifier, 0.1-400 MHz	\$800.00
ENI A300 Amplifier, 55 dB, 0.3-35.0 MHz, 300 Watts HP 11720A Pulse Modulator, 2-18 GHz, >80 dB on/off ratio	\$3,500.00 \$950.00
HP 8447A-001 Dual Amplifier, 0.1-400 MHz HP 8901B-001.003 Modulation Analyzer, 150 kHz-1300 MHz	\$500.00 \$9,000.00
HP 8901B-001,003 Modulation Analyzer, 150 kHz-1300 MHz HUGHES 1177H01F000TWT Amplifier, 30 dB, 2-4 GHz, 10 Watts	\$1,750.00
HUGHES 1177H02R000 TWT Amplifier,	
M.P.D. LAB2-1020-2A Amplifier, 34 dB, 1.0-2.0 GHz, 2 Watts	\$1,000.00 \$1,000.00
MARCONITF2304AWFM Modulation Meter,	\$500.00
18-1000 MHz, FM dev.1.5-150 kHz MICROWAVE SEMI. CORP. MC5112 Noise Source,	\$325.00
25.5 dB ENR, 1.0-12.4 GHz, N(m), +28 VDC	
COAXIAL & WAVEGUIDE	
ADAMS-RUSSELL 1538-5013 High	\$50.00
AMERICAN NUCLEONICS AM-432 Cavity	\$95.00
Backed Spiral Antenna, LHC, 2-18 GHz, TNC(f) *NEW* BIRD 8325-30 30 dB Attenuator, 500 Watts, DC-500 MHz FXR/MICROLAB S3-02N Triple Stub Tuner,	\$325.00
200-1000 MHz, 100 Watts max., N(m/f)	403.00
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GR 874-LTL Constant Impedance	\$450.00
Trombone Line, 0-44 cm, DC-2 GHz GR 900-LB Precision Slotted Line, 0.3-8.5 GHz,	
E0.Ohma 0.19/ tol	
GR 900-Q GR900 14mm Interseries Adapters HP 11691D Directional Coupler, 22 dB, 2-18 GHz HP 11692D Dual Directional Coupler, 22 dB, 2-18 GHz HP 1172A DC Blocking Capacitor,	. \$125.00
HP 11691D Directional Coupler, 22 dB, 2-18 GHz	\$500.00
HP 11692D Dual Directional Coupler, 22 dB, 2-18 GHz	\$135.00
HP 778D Dual Directional Coupler, 20 dB, 450-940 MHz.  HP 776D Dual Directional Coupler, 20 dB, 450-940 MHz.  HP 776D Dual Directional Coupler, 20 dB, 940-1900 MHz.  HP 777D Dual Directional Coupler, 20 dB, 19-4.1 GHz.  HP 778D Dual Dir.Coupler, 20 dB, 100-2000 MHz, N(m/t/t/t)  HP 778D-011 Dual Dir.Coupler, 20 dB, 10	. \$275.00
HP 775D Dual Directional Coupler, 20 dB, 450-940 MHz	\$275.00
HP 776D Dual Directional Coupler, 20 dB, 940-1900 MHz	\$275.00
HP 777D Dual Directional Coupler, 20 dB, 1.9-4.1 GHz	\$550.00
HP 778D-011 Dual Dir. Coupler, 20 dB, )	. \$400.00
HP 8472A Crystal Detector,	\$150.00
10 MHz-18 GHz, neg. pol., SMA(m) HP K422A WR42 Flat Broadband Detector, 18.0-26.5 GHz	\$350.00
UD VESSA WID 40 Francisco and Martin 10 0 00 F CU-	SEUV UV
HP Q752D WR22 Directional Coupler, 20 dB, 33-50 GHz	. \$650.00
HP R422A WR28 Flat Broadband Detector, 26.5-40 GHz	\$400.00
HP 07520 WR22 Directional Coupler, 20 dB, 33-50 GHz HP R422A WR28 Flat Broadband Detector, 26.5-40 GHz HP R432A WR28 Frequency Meter, 26.5-40.0 GHz HUGHES 45342H-1110 WR22 Dual Directional Coupler, 10 dB, 33-50 GHz	\$875.00
Directional Coupler, 10 dB, 33-50 GHz	. 4075.00
2-20 GHz, SMA(f/m)/SMC(f), 10 uV/uW WA-COM 3-19-300/10 WR19 Directional	0450.00
	\$450.00
Coupler, 10 dB, 40-60 GHz MAURY MW. J320-series WR22 Calibrated	\$375.00
Mismatch VSWR values 1 1-2 0	
MILLIWAVE S91-1777B Amplifier, 2.7 dB,	\$150.00
18.0-26.5 GHz, +19 dBm Po, SMA(f) MINI-CIRCUITS ZHL-2000Amplifier, 20 dB,	\$85.00
NARDA 26298 20 dB Attenuator, 150 Watts, DC-1 GHz, N(f/f)	. \$200.00
NARDA 3000-SERIES Directional Couplers	\$150.00
NAHDA 3022 Bi-Directional Coupler, 20 dB, 1-4 GHz	2320.00
NARDA 26298 20 dB Attenuator, 150 Watts, DC-1 GHz, N(I/I) NARDA 3000-SERIES Directional Couplers NARDA 3020 Bi-Directional Coupler, 20 dB, 1-4 GHz. NARDA 3024 Bi-Directional Coupler, 20 dB, 4-8 GHz. NARDA 3090-SERIES Precision High Directivity Couplers NARDA 3698NF High Power Termination,	\$225.00
NARDA 369BNF High Power Termination,	\$325.00
NARDA 4000-SERIES SMA Miniature Directional Couplers	\$75.00
100-2000 MHz, APC7/N(f/f/f	\$225.00
NARDA 4246R-10 Directional Coupler 10 dR 6-18 GHz SMA(f)	
	\$100.00
NARDA 5070-SERIES Precision Reflectometer Couplers	\$100.00
NARDA 5070-SERIES Precision Reflectometer Couplers	\$100.00 \$300.00 \$275.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(t/m) NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz	\$300.00 \$275.00 \$375.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(I/m) NARDA 792FF Variable Attenuator, 0-20 dB, 2-0-12.4 GHz OMNI-SPECTRA 2082-5810-02Adj. Phase Trimmer,	\$300.00 \$275.00 \$375.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(//m) NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz OMNI-SPECTRA 2082-5810-02Adj. Phase Trimmer, 8-18 GHz. 10 deu./GHz range. SMM/m/f)	\$300.00 \$275.00 \$375.00 \$50.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Hatenuator, 150 Watts, DC-6 GHz, N(//m) NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz OMNI-SPECTRA 2082-5810-02Adj. Phase Trimmer, 8-18 GHz, 10 deg./GHz range, SMA(m/f) PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz PRD N2334232 Slotted 1.ms. 3-12 GHz.	\$300.00 \$275.00 \$375.00 \$50.00 \$250.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Hatenuator, 150 Watts, DC-6 GHz, N(//m) NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz OMNI-SPECTRA 2082-5810-02Adj. Phase Trimmer, 8-18 GHz, 10 deg./GHz range, SMA(m/f) PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz PRD N2334232 Slotted 1.ms. 3-12 GHz.	\$300.00 \$275.00 \$375.00 \$50.00 \$250.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Hatenuator, 150 Watts, DC-6 GHz, N(//m) NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz OMNI-SPECTRA 2082-5810-02Adj. Phase Trimmer, 8-18 GHz, 10 deg./GHz range, SMA(m/f) PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz PRD N2334232 Slotted 1.ms. 3-12 GHz.	\$300.00 \$275.00 \$375.00 \$50.00 \$250.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(t/m) NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz OMNI-SPECTRA 2082-5810-02Adj. Phase Trimmer, 8-18 GHz, 10 deg./GHz range, SMA(m/f) PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz PRD N233A/232 Slotted Line, 3-12 GHz, N(m/f), wicarriage & detector SPACEK LABS DC-1 WR22 Flat Broadband Detector, 33-50 GHz TRG V510 WR15 Precision Rotary Vane Atten, 0-50 dB, 50-75 GHz	\$300.00 \$275.00 \$375.00 \$50.00 \$250.00 \$175.00 \$550.00 \$1,000.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(//m) NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz OMNI-SPECTRA 2082-5810-02Adj, Phase Trimmer, 8-18 GHz, 10 deg./GHz range, SMM (m/f) PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz PRD N2334223 Slotted Line, 3-12 GHz, N(m/f), wicarriage & detector SPACEK LABS DG-1 WR22 Flat Broadband Detector, 33-50 GHz TRG V510 WR15 Precision Rotary Vane Atten, 0-50 dB, 50-75 GHz TRG V510 WR15 Frecisions Rotary Vane Atten,	\$300.00 \$275.00 \$375.00 \$50.00 \$175.00 \$550.00 \$1,000.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(t/m) NARDA 792FF Variable Attenuator, 0-20 dB, 2,0-12-4 GHz OMNI-SPECTRA 2082-5810-02Adj, Phase Trimmer, 8-18 GHz, 10 deg./GHz range, SMA(m/t) PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz PRD N233A/232 Slotted Line, 3-12 GHz, N(m/t), Wacarriage & detector SPACEK LABS DC-1 WR22 Flat Broadband Detector, 33-50 GHz TRG V510 WR15 Precision Rotary Vane Atten., 0-50 dB, 50-75 GHz TRG V551 WR15 Frequency Meter, 50.0-75.0 GHz.	\$300.00 \$275.00 \$375.00 \$50.00 \$175.00 \$550.00 \$1,000.00 \$600.00 \$400.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(t/m) NARDA 792FF Variable Attenuator, 0.20 dB, 2.0-12.4 GHz OMNI-SPECTRA 2082-5810-02Adj. Phase Trimmer, 8-18 GHz, 10 deg./GHz range, SMA(m/f) PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz PRD N233A/232 Slotted Line, 3-12 GHz, N(m/f), with carriage & detector SPACEK LABS DC-1 WR22 Flat Broadband Detector, 33-50 GHz TRG V510 WR15 Precision Rotary Vane Atten, 0-50 dB, 50-75 GHz TRG V551 WR15 Frequency Meler, 50.0-75.0 GHz TRG V559-10 WR15 Directional Coupler, 10 dB, 50-75 GHz WAVELINE 808 WR42 Var. Phase	\$300.00 \$275.00 \$375.00 \$50.00 \$175.00 \$550.00 \$1,000.00 \$600.00 \$400.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(//m) NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz OMNI-SPECTRA 2082-5810-02Adj, Phase Trimmer, 8-18 GHz, 10 deg/GHz range, SM4/m/f) PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz PRD N233A/232 Slotted Line, 3-12 GHz, N(m/f), wicarriage & detector SPACEK LABS DC-1 WR22 Flat Broadband Detector, 33-50 GHz TRG V510 WN15 Precisions Rotary Vane Atten. 0-50 dB, 50-75 GHz TRG V559+10 WR15 Prierctional Coupler, 10 dB, 50-75 GHz WAVELINE 808 WR42 Var. Phase Shifter.0-180 dec. age read, 18-26-56Hz	\$300.00 \$275.00 \$375.00 \$50.00 \$250.00 \$175.00 \$50.00 \$1,000.00 \$400.00 \$375.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(//m) NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(//m) NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz OMNI-SPECTRA 2082-58 10-02Adj. Phase Trimmer, 8-18 GHz, 10 deg./GHz Tange, SMd/m/f) PAMTECH KYG 1014 WR42 Junction Circulator, 18.0-26.5 GHz PRD N2334-232 Slotted Line, 3-12 GHz, N(m/f), wicarriage & detector SPACEK LABS DO-1 WR22 Flat Broadband Detector, 33-50 GHz TRG V510 WR15 Precision Rotary Vane Atten, 0-50 dB, 50-75 GHz TRG V559-10 WR15 Directional Coupler, 10 dB, 50-75 GHz WEINSCHEL 1515 Power Divider, DC-18 GHz, SMd/(I/I/f) WEINSCHEL 1515 Power Divider, DC-18 GHz, SMd/(I/I/f)	\$300.00 \$275.00 \$375.00 \$50.00 \$250.00 \$175.00 \$50.00 \$1,000.00 \$400.00 \$375.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(t/m) NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz OMNI-SPECTRA 2082-5810-02Adj, Phase Trimmer, 8-18 GHz, 10 deg./GHz range, SMA(m/t) PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz PRD N233A/232 Slotted Line, 3-12 GHz, N(m/f), wicarriage & detector SPACEK LABS DC-1 WR22 Flat Broadband Detector, 33-50 GHz TRG V510 WR15 Precision Rotary Vane Atten., 0-50 dB, 50-75 GHz TRG V551 WR15 Frequency Meter, 50.0-75.0 GHz TRG V559-10 WR15 Directional Coupler, 10 dB, 50-75 GHz WAVELINE 808 WR42 Var Phase Shifter,0-180 deg., gage read, 18-26.5GHz WEINSCHEL 3200-1 Programmable StepAtten., 0-127 dB, DC-2 GHz, SMA "NEW"	\$300.00 \$275.00 \$375.00 \$50.00 \$175.00 \$550.00 \$1,000.00 \$400.00 \$400.00 \$375.00 \$125.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(l/m) NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(l/m) NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz OMNI-SPECTRA 2082-58 10-02Adj. Phase Trimmer, 8-18 GHz, 10 deg./GHz Tange, SMA(m/l) PAMTECH KYG 1014 WR42 Junction Circulator, 18.0-26.5 GHz PRD N2334-232 Slotted Line, 3-12 GHz, N(m/l), wicarriage & detector SPACEK LABS DO-1 WR22 Flat Broadband Detector, 33-50 GHz TRG V510 WR15 Precision Rotary Vane Atten, 0-50 dB, 50-75 GHz TRG V510 WR15 Frequency Meter, 50.0-75.0 GHz. TRG V559-10 WR15 Directional Coupler, 10 dB, 50-75 GHz WEINSCHEL 1515 Power Divider, DC-18 GHz, SMA(l/l/l) WEINSCHEL 1515 Power Divider, DC-18 GHz, SMA(l/l/l) WEINSCHEL 1515 Power Divider, DC-18 GHz, SMA(l/l/l) WEINSCHEL 1300-1 Programmable StepAtten, 0-127 dB, DC-2 GHz, SMA "NEW"	\$300.00 \$275.00 \$375.00 \$50.00 \$175.00 \$175.00 \$550.00 \$1,000.00 \$400.00 \$375.00 \$125.00 \$125.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(l/m) NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(l/m) NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz OMNI-SPECTRA 2082-58 10-02Adj. Phase Trimmer, 8-18 GHz, 10 deg./GHz Tange, SMA(m/l) PAMTECH KYG 1014 WR42 Junction Circulator, 18.0-26.5 GHz PRD N2334-232 Slotted Line, 3-12 GHz, N(m/l), wicarriage & detector SPACEK LABS DO-1 WR22 Flat Broadband Detector, 33-50 GHz TRG V510 WR15 Precision Rotary Vane Atten, 0-50 dB, 50-75 GHz TRG V510 WR15 Frequency Meter, 50.0-75.0 GHz. TRG V559-10 WR15 Directional Coupler, 10 dB, 50-75 GHz WEINSCHEL 1515 Power Divider, DC-18 GHz, SMA(l/l/l) WEINSCHEL 1515 Power Divider, DC-18 GHz, SMA(l/l/l) WEINSCHEL 1515 Power Divider, DC-18 GHz, SMA(l/l/l) WEINSCHEL 1300-1 Programmable StepAtten, 0-127 dB, DC-2 GHz, SMA "NEW"	\$300.00 \$275.00 \$375.00 \$50.00 \$175.00 \$175.00 \$550.00 \$1,000.00 \$400.00 \$375.00 \$125.00 \$125.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(t/m) NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(t/m) NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz OMNI-SPECTRA 2082-5810-02AdJ, Phase Trimmer, 8-18 GHz, 10 deg, GHz Targae, SMA(m/t) PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz PRD N233A/232 Slotted Line, 3-12 GHz, N(m/t), wicarriage & detector SPACEK LABS DC-1 WR22 Flat Broadband Detector, 33-50 GHz TRG V510 WH15 Precisions Rotary Vane Atten. 0-50 dB, 50-75 GHz TRG V559-10 WR15 Prierctional Coupler, 10 dB, 50-75 GHz. WAVELINE 808 WR42 Var Phase Shifter, 1980 deg, agge read, 18-26.5 GHz WEINSCHEL 3200-1 Programmable StepAtten. 0-127 dB, DC-2 GHz, SMA *NEW* WILTRON 60A50-opt, 1 SWR Bridge, 5-2000 MHz, APC7 test port, 46 dB dir. WILTRON 60N50 SWR Bridge.	\$300.00 \$275.00 \$375.00 \$50.00 \$250.00 \$1,000.00 \$400.00 \$400.00 \$1,000.00 \$400.00 \$200.00 \$400.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(l/m) NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz OMNI-SPECTRA 2082-5810-02Adj, Phase Trimmer, 8-18 GHz, 10 deg/GHz range, SM4(m/l) PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz PRD N233A/232 Slotted Line, 3-12 GHz, N(m/l), wicarriage & detector SPACEK LABS DC-1 WR22 Flat Broadband Detector, 33-50 GHz TRG V510 WR15 Precisions Rotary Vane Atten, 0-50 dB, 50-75 GHz TRG V551 WR15 Frequency Meter, 50.0-75.0 GHz. TRG V559-10 WR15 Directional Coupler, 10 dB, 50-75 GHz WAVELINE 808 WR42 Var, Phase Shifter, 1980 deg, 3gge read, 18-26.5 GHz WEINSCHEL 1515 Power Divider, DC-18 GHz, SMA(l/l/l/l) WEINSCHEL 1515 Power Divider, DC-18 GHz, SMA(l/l/l/l) WEINSCHEL 3200-1 Programmable StepAtten, 0-127 dB, DC-2 GHz, SMA "NEW" WILTRON 60A50-opt. 1 SWR Bridge, 5-2000 MHz, APC7 test port, 46 dB dir. WILTRON 60N50 SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 60N50 SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 60NFS0 SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir.	\$300.00 \$275.00 \$375.00 \$50.00 \$250.00 \$1,000.00 \$400.00 \$400.00 \$1,000.00 \$400.00 \$200.00 \$400.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(l/m) NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(l/m) NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz OMNI-SPECTRA 2082-5810-02Adj, Phase Trimmer, 8-18 GHz, 10 deg./GHz Tange, SM4/m/l) PAMTECH KYG 1014 WR42 Junction Circulator, 18.0-26.5 GHz PRD N2334-223 Slotted Line, 3-12 GHz, N(m/l), wicarriage & detector SPACEK LABS DC-1 WR22 Flat Broadband Detector, 33-50 GHz TRG V510 WR15 Frequency Meter, 50.0-75.0 GHz. TRG V550 WR15 Frequency Meter, 50.0-75.0 GHz. TRG V559-10 WR15 Frequency Meter, 50.0-75.0 GHz. TRG V559-10 WR15 Directional Coupler, 10 dB, 50-75 GHz WAVELINE 808 WR42 Var. Phase Shifter, 0-180 deg., gage read, 18-26.5GHz WEINSCHEL 1515 Power Divider, DC-18 GHz, SM4(l/l/l), WEINSCHEL 1300-1 Programmable Step Atten. 0-127 dB, DC-2 GHz, SMA 'NEW' WILTRON 60A50-opt. 1 SWR Bridge, 5-2000 MHz, APC7 test port, 46 dB dir. WILTRON 60NS SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 60NS SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 60NS SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 60NS SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 60NFSO SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 60NFSO SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 60NFSO SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir.	\$300.00 \$275.00 \$375.00 \$50.00 \$175.00 \$175.00 \$1,000.00 \$400.00 \$400.00 \$125.00 \$125.00 \$125.00 \$125.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(l/m) NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz OMNI-SPECTRA 2082-5810-02Adj, Phase Trimmer, 8-18 GHz, 10 deg/GHz range, SM4 (m/l) PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz PRD N233A/232 Slotted Line, 3-12 GHz, N(m/l), wicarriage & detector SPACEK LABS DC-1 WR22 Flat Broadband Detector, 33-50 GHz TRG V510 WR15 Precisions Rotary Vane Atten, 0-50 dB, 50-75 GHz TRG V510 WR15 Precisions Rotary Vane Atten, 10-50 dB, 50-75 GHz WAVELINE 806 WR42 Var. Phase Shifter. 1980 deg. 3gge read, 18-26.5 GHz WEINSCHEL 1515 Power Divider, DC-18 GHz, SMA(f/l/l) WEINSCHEL 300-1 Programmable Step Atten, 0-127 dB, DC-2 GHz, SMA 'NEV' WILTRON 60A50-0pt 1 SWR Bridge, 5-2000 MHz, APC7 test port, 46 dB dir. WILTRON 60N50 SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 60N50 SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 60N50 SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 6750 SWR Bridge, 5-2000 MHz, N(f) test port, 40 dB dir. WILTRON 7550 SWR Bridge, 2-18 GHz,	\$300.00 \$275.00 \$375.00 \$50.00 \$175.00 \$175.00 \$1,000.00 \$400.00 \$400.00 \$125.00 \$125.00 \$125.00 \$125.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(l/m) NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(l/m) NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz OMNI-SPECTRA 2082-5810-02Adj, Phase Trimmer, 8-18 GHz, 10 deg./GHz Tange, SM4/m/l) PAMTECH KYG 1014 WR42 Junction Circulator, 18.0-26.5 GHz PRD N2334-223 Slotted Line, 3-12 GHz, N(m/l), wicarriage & detector SPACEK LABS DC-1 WR22 Flat Broadband Detector, 33-50 GHz TRG V510 WR15 Frequency Meter, 50.0-75.0 GHz. TRG V550 WR15 Frequency Meter, 50.0-75.0 GHz. TRG V559-10 WR15 Frequency Meter, 50.0-75.0 GHz. TRG V559-10 WR15 Directional Coupler, 10 dB, 50-75 GHz WAVELINE 808 WR42 Var. Phase Shifter, 0-180 deg., gage read, 18-26.5GHz WEINSCHEL 1515 Power Divider, DC-18 GHz, SM4(l/l/l), WEINSCHEL 1300-1 Programmable Step Atten. 0-127 dB, DC-2 GHz, SMA 'NEW' WILTRON 60A50-opt. 1 SWR Bridge, 5-2000 MHz, APC7 test port, 46 dB dir. WILTRON 60NS SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 60NS SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 60NS SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 60NS SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 60NFSO SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 60NFSO SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 60NFSO SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir.	\$300.00 \$275.00 \$375.00 \$50.00 \$175.00 \$175.00 \$1,000.00 \$400.00 \$400.00 \$125.00 \$125.00 \$125.00 \$125.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Hatenuator, 150 Watts, DC-6 GHz, N(t/m) NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz OMNI-SPECTRA 2082-5810-02Adj, Phase Trimmer, 8-18 GHz, 10 deg, GHz range, SM4 (m/t) PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz PRD N233A/232 Slotted Line, 3-12 GHz, N(m/t), wicarriage & detector SPACEK LABS DQ-1 WR22 Flat Broadband Detector, 33-50 GHz TRG V510 WR15 Precisions Rotary Vane Atten. 0-50 dB, 50-75 GHz TRG V559-10 WR15 Priceitonal Coupler, 10 dB, 50-75 GHz WAVELINE 808 WR42 Var, Phase Shifter, 0-180 deg. gage read, 18-26.5GHz WEINSCHEL 3200-1 Programmable StepAtten. 0-127 dB, DC-2 GHz, SMA "NEW" WILTRON 60ASO-pol. 1 SWR Bridge, 5-2000 MHz, N(m) test port, 4 dB dir. WILTRON 60N50 SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 80NFS OSWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 80NFS OSWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 80NFS OSWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 87ASO VSWR Bridge, 2-18 GHz, 35 dB dir., APC7 test port	\$300.00 \$275.00 \$375.00 \$50.00 \$175.00 \$175.00 \$1,000.00 \$400.00 \$400.00 \$125.00 \$125.00 \$125.00 \$125.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N(l/m) NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz OMNI-SPECTRA 2082-5810-02Adj, Phase Trimmer, 8-18 GHz, 10 deg/GHz range, SM4 (m/l) PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz PRD N233A/232 Slotted Line, 3-12 GHz, N(m/l), wicarriage & detector SPACEK LABS DC-1 WR22 Flat Broadband Detector, 33-50 GHz TRG V510 WR15 Precisions Rotary Vane Atten, 0-50 dB, 50-75 GHz TRG V510 WR15 Precisions Rotary Vane Atten, 10-50 dB, 50-75 GHz WAVELINE 806 WR42 Var. Phase Shifter. 1980 deg. 3gge read, 18-26.5 GHz WEINSCHEL 1515 Power Divider, DC-18 GHz, SMA(f/l/l) WEINSCHEL 300-1 Programmable Step Atten, 0-127 dB, DC-2 GHz, SMA 'NEV' WILTRON 60A50-0pt 1 SWR Bridge, 5-2000 MHz, APC7 test port, 46 dB dir. WILTRON 60N50 SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 60N50 SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 60N50 SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 6750 SWR Bridge, 5-2000 MHz, N(f) test port, 40 dB dir. WILTRON 7550 SWR Bridge, 2-18 GHz,	\$300.00 \$275.00 \$375.00 \$50.00 \$175.00 \$175.00 \$1,000.00 \$400.00 \$400.00 \$125.00 \$125.00 \$125.00 \$125.00
NARDA 5070-SERIES Precision Reflectometer Couplers NARDA 769-30 30 dB Hatenuator, 150 Watts, DC-6 GHz, N(t/m) NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz OMNI-SPECTRA 2082-5810-02Adj, Phase Trimmer, 8-18 GHz, 10 deg, GHz range, SM4 (m/t) PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz PRD N233A/232 Slotted Line, 3-12 GHz, N(m/t), wicarriage & detector SPACEK LABS DQ-1 WR22 Flat Broadband Detector, 33-50 GHz TRG V510 WR15 Precisions Rotary Vane Atten. 0-50 dB, 50-75 GHz TRG V559-10 WR15 Priceitonal Coupler, 10 dB, 50-75 GHz WAVELINE 808 WR42 Var, Phase Shifter, 0-180 deg. gage read, 18-26.5GHz WEINSCHEL 3200-1 Programmable StepAtten. 0-127 dB, DC-2 GHz, SMA "NEW" WILTRON 60ASO-pol. 1 SWR Bridge, 5-2000 MHz, N(m) test port, 4 dB dir. WILTRON 60N50 SWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 80NFS OSWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 80NFS OSWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 80NFS OSWR Bridge, 5-2000 MHz, N(m) test port, 40 dB dir. WILTRON 87ASO VSWR Bridge, 2-18 GHz, 35 dB dir., APC7 test port	\$300.00 \$275.00 \$375.00 \$50.00 \$175.00 \$175.00 \$1,000.00 \$400.00 \$400.00 \$125.00 \$125.00 \$125.00 \$125.00

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## Radio Signals on the Move — Part 2

ast month, we looked at some of the basic mechanisms of radio propagation. In that article, we focused on the basic paths of propagation, but dealt most with ionospheric propagation (which is the cause of shortwave "skip" communications). In this month's column, we will take a look at some of the pathology of radio propagation.

#### Ionospheric Variation and Disturbances

The ionosphere is an extremely dynamic region of the atmosphere, especially from a radio operator's point of view, for it significantly alters radio propagation. The dynamics of the ionosphere are conveniently divided into two general classes: regular variation and disturbances. Let's look at both types of ionospheric change.

#### Ionospheric Variation

There are several different forms of variation seen on a regular basis in the ionosphere: diurnal; 27-day (monthly); seasonal; and 11-year cycle.

Diurnal (daily) variation. The sun rises and falls on a 24-hour cycle, and because it is a principal source of iononization of the upper atmosphere, one can expect diurnal variation. During daylight hours, E and D levels exist, but these disappear at night. The height of the F2 layer increases until midday, and then decreases until evening when it disappears or merges with other layers. As a result of higher absorption in the E

and D layers, lower frequencies are not useful during daylight hours. On the other hand, the F layers reflect higher frequencies during the day. In the 1 to 30

MHz region, higher frequencies (>11 MHz) are used during daylight hours and lower frequencies (<11 MHz) at

27-Day Cycle. Approximately monthly, this variation is due to the rotational period of the sun. Sunspots are localized on the surface of the sun, so they will face the earth only during a portion of the month. As

new sunspots are formed, they do not show up on the earthside face until their region of the sun rotates earthside.

Seasonal Cycle. The earth's tilt varies the exposure of the planet to the sun on a seasonal basis. In addition, the earth's yearly orbit is not circular, but elliptical. As a result, the intensity of the sun's energy that ionizes the upper atmosphere varies with the seasons of the year. In general, the E. D. and F layers are affected, although the F2 layer is only minimally affected. Ion density in the F2 layer tends to be highest in win-

by Joseph J. Carr K4IPV Open Channel



ter, and less in summer. During the summer, the distinction between F1 and F2 layers is less obvi-

11-Year Cycle. The number of sunspots, statistically averaged, varies on an approximately 11year cycle. As a result, the ionospheric effects that affect radio propagation also vary on an 11year cycle. Radio propagation in the shortwave bands is best when the average number of sunspots is highest. Peaks occurred in 1957, 1968, 1979, and 1990. Currently, we are in the pit between peaks, so the higher end of the short-

wave bands aren't all that swift. But we are also on the upswing to the next peak in 2001 (or so - the "11 years" isn't always exact).

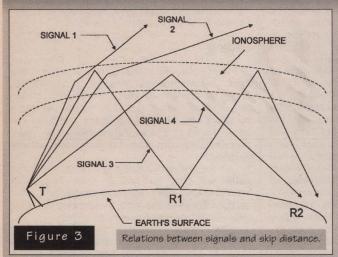
In doing some reading on another topic (the three great Flu epidemics of the 20th century), I came across a notation that the influenza virus undergoes a major change every 11 years, and that 1957 and 1968 were peak Flu years. Notice anything? Eleven-year cycle, with peaks corresponding to two of the sunspot peaks, ought to elicit some interesting research. What doesn't fit this pattern is the 1918-1919 Flu epidemic (which killed millions of people) that occurred in between peaks (1913 and 1924).

Events on the surface of the sun sometimes cause the radio mirror to seem almost perfect, and makes spectacular propagation possible. At other times, however, solar disturbances disrupt radio communications for days at a time.

There are two principal forms of solar energy that affect shortwave communications: electromagnetic radiation and charged solar particles. Most of the radiation is above the visible spectrum in the ultraviolet and x-ray/gamma-ray



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region of the spectrum. Because electromagnetic radiation travels at the speed of light, solar events that release radiation cause changes to the ionosphere about eight minutes later. Charged particles, on the other hand, have finite mass, so they travel at a considerably slower velocity. They require two or three days to reach

Various sources of both radiation and particles exist on the sun. Solar flares may release huge amounts of both radiation and particles. These events are unpredictable and sporadic. Solar radiation also varies on an approximate 27day period, which is the rotational period of the sun. The same source of radiation will face the earth once every 27 days, so events tend to be somewhat repetitive

Solar and galactic noise affects the reception of weak signals, while solar noise will also either affect radio propagation or act as a harbinger of changes in propagation patterns. Solar noise can be demonstrated by using an ordinary radio receiver and a directional antenna, preferably operating in the VHF/UHF regions of the spectrum. Aim the antenna at the sun on the horizon at either sunset or sunrise. A dramatic change in background noise will be noted as the sun slides across the horizon.

Sunspots. A principal source of solar radiation, especially the periodic forms, is sunspots (Figure 1). Sunspots can be as large as 70,000 to 80,000 miles in diameter, and generally occur in clusters. The number of sunspots varies over a period of approximately 11 years, although the actual periods since 1750 (when records were first kept) have varied from 9 to 14 years. The sunspot number is reported daily as the statistically massaged Zurich Smoothed Sunspot Number, or Wolf Number. The number of sunspots greatly affects radio propagation via the ionosphere. The low was in the range of 60 (in 1907), while the high was about 200 (1958).

Another indicator of ionospheric propagation potential is the Solar Flux Index (SFI). This measure is taken in the microwave region (wavelength of 10.2 cm, or 2.8 GHz), at 1700 UT at Ottawa, Canada. The SFI is reported by the National Bureau of Standards (NBS) radio stations WWV (Fort Collins, CO) and WWVH (Maui, HI).

The ionosphere offers different properties that affect radio propagation at different times. Variations occur not only over the 11-year sunspot cycle, but also diurnally and seasonally. Obviously, if the sun affects propagation in a sig-

nificant way, then differences between nighttime and daytime, and between summer and winter, must cause variations in the propagation phenomena observed.

#### **Disturbances**

Disturbances in the ionosphere can have a profound effect on radio communications . . . and most of them (but not all) are bad. In this section, we will briefly examine some of the more common forms

Sporadic E Layer. A reflective cloud of ionization sometimes appears in the E layer of the ionosphere; this layer is sometimes called the Es layer. It is

believed that the Es layer forms up from the effects of wind shear between masses of air moving in opposite directions. This action appears to redistribute ions into a thin layer that is radio-reflective

Sporadic E propagation is normally thought of as a VHF phenomenon, with most activity between 30 and 100 MHz, and decreasing activity up to about 100 MHz. However, about 25 to 50 percent of the time, sporadic E propagation is possible on frequencies down to 10 or 15 MHz. Reception over paths of 1400 to 2600 miles are possible in the 50 MHz region when sporadic E is present. In the northern hemisphere, the months of June and July are the most prevalent sporadic E months. On most days when sporadic E is present, it lasts only a few hours

Sudden Ionospheric Disturbances (SIDs). The SID, or "Dellinger Fade," mechanism occurs suddenly, and rarely gives any warning. Solar flares (Figure 2) are implicated in SIDs. The SID may last from a few minutes to many hours. It is believed that SIDs occur in correlation with solar flares or "bright solar eruptions" that produce immense amounts of ultraviolet radiation that impinges the upper atmosphere. The SID causes a tremendous increase in D layer ionization, which accounts for the radio propagation effects. The ionization is so intense that all receiver operators on the sunny side of the earth experience profound loss of signal strength above about 3 MHz. It is not uncommon for receiver owners to think their receivers are malfunctioning when this occurs. The sudden loss of signals on sunny side receivers is called Dellinger fade. The SID is often accompanied by variations in terrestial electrical currents and magnetism levels.

An interesting anomaly is seen when SIDs occur. The shortwaves drop in the bucket, and may stay there for awhile. But distant VLF signals, especially in the 15 to 40 KHz region, experience a sudden increase in intensity. This is due to the fact that the SID event results in deep ionization way into the D-layer. This ionization increases absorption of HF signals. But the wavelength of VLF signals is close to the distance from the earth's surface to the bottom of the D-layer, so that space acts like a gigantic "wavequide" (as used in microwave)

when the SID is present ... thus propagating the VLF signal very efficiently.

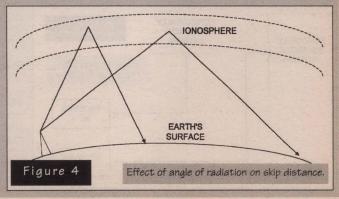
**Ionospheric Storms**. The ionospheric storm appears to be produced by an abnormally large rain of atomic particles in the upper atmosphere, and is often preceded by SIDs 18 to 24 hours earlier. These storms tend to last from several hours to a week or more, and are often preceded by two days or so by an abnormally large collection of sunspots crossing the solar disk. They occur most frequently, and with greatest severity, in the higher latitudes, decreasing toward the Equator. When the ionospheric storm commences, shortwave radio signals may begin to flutter rapidly and then drop out altogether. The upper ionosphere becomes chaotic, turbulence increases, and the normal stratification into "layers" or zones diminishes.

Radio propagation may come and go over the course of the storm, but it is mostly dead. The ionospheric storm, unlike the SID which affects the sunny side of the earth, is worldwide. It is noted that the MUF and critical frequency tend to reduce rapidly as the storm commences.

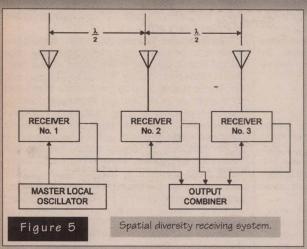
An ionospheric disturbance observed by me in November, 1960 was preceded by about 30 minutes of extremely good, but abnormal propagation. At 1500 hours EST, European stations were noted with S9+ signal strengths in the 7000 to 7300 KHz region of the spectrum, which is an extremely rare occurance. After about 30 minutes, the bottom dropped out and even AM broadcast band skip (later that evening) was nonexistent. At the time, the National Bureau of Standard radio station, WWV, was broadcasting a "W2" propagation prediction at 19 and 49 minutes after each hour. It was difficult to hear even the 5 MHz WWV frequency in the early hours of the disturbance, and it disappeared altogether for the next 48 hours. Of course, as luck would have it, that event occurred during the first weekend of the ARRL Sweepstakes contest that year ... and you should've heard the griping at the meeting of the Potomac Valley Radio Club between those two weekends.

#### **Great Circle Paths**

A great circle is a line between two points on the surface of a sphere such that it lays on a plane through the earth's center and including the two points. When translated to "radiospeak, a great circle is the shortest path on the surface of the earth between two points. Navigators and radio operators use the great circle for similar, but different reasons. The navigator — in order to get from here to there - and the radio operator get a transmission path from here to



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The heading of a directional antenna is normally aimed at the receiving station along its great circle path. Unfortunately, many people do not understand the concept well enough, for they typically aim the antenna in the wrong direction. For example, I live near Washington, DC, which is on approximately the same latitude as Lisbon, Portugal. If I catch a lift on Superman's back, and he flies due east, we'll have dinner in Lisbon, right? Wrong. If you head due east from Washington, DC, across the Atlantic, the first landfall would be West Africa, somewhere near Zaire or Angola. Why? Because the great circle bearing 90 degrees takes us far south. The geometry of spheres, not flat planes, governs the case.

Long Path vs. Short Path. The earth is a sphere (or more precisely, an "oblique spheroid"), so from any given point to any other point there are two great circle paths: long path (major arc) and short path (minor arc). In general, the best reception occurs along the short path. In addition, short path propagation is more nearly "textbook" compared with long path reception. However, there are times when long path is better, or is the only path that will deliver a signal to a specific location from the geographic location in question.

#### Using the lonosphere

mediumwave radio signals back to earth via the ionosphere gives rise to inter-continental HF radio communications. This phenomena becomes possible during daylight hours and for awhile after sunset when the ionosphere is ionized. Figure 3 reiterates the mechanism of long distance skip communications. The transmitter is located at

The refraction of high-frequency and some point T, while receiving stations are located at

not refracted sufficiently to be refracted back to earth, so they are lost in space. Signal 3, however, is refracted enough to return to earth, so it is heard at station R1. The skip distance for signal 3 is the distance from T to R1. At points between T and R1, signal 3 is inaudible, except within groundwave distance of the transmitter site (T). This is the reason why two stations 40 miles apart hear each other only weakly, or not at all, while both stations can communicate with a third station 2000 miles away. In amateur radio circles, it is common for South American stations to relay between two US stations only a few miles apart. For an example of this problem, listen to the Inter American and Halo Missionary Nets on 21.290 MHz (15-M)

sites R1 and R2. Signals 1 and 2 are

daily from about 1700Z to 2100Z (ending time dependent upon traffic).

Multi-hop skip is responsible for the reception of the signal from transmitter T at site R3. The signal reflects (not refracts) from the surface at R1, and is retransmitted into the ionosphere where it is again refracted back to earth.

Figure 4 shows a situation where skip signals are received at different distances depending upon the angle of radiation of the transmitting antenna. A high angle of radiation causes a shorter skip zone, while a lower angle of radiation results in a longer skip zone. Communication between any particular locations on any given frequency requires adjustment of the antenna radiation angle. Some international shortwave stations have multiple antennas with different radiation angles to ensure that the correct skip distances are available.

#### **Gray Line Propagation**

The gray line is the twilight zone between the night and daytime halves of the earth. This zone is also called the planetary terminator. It varies up to +23 degrees either side of the north/south longitudinal lines, depending on the season of the year (it runs directly north/south only at the vernal and autumnal equinoxes). The D layer of the ionosphere absorbs signals in the HF region. This layer disappears almost completely at night, but builds up during the day. Along the gray line, the D layer is rapidly decaying west of the line, and has not quite built up east of the line.

Brief periods of abnormal propagation occur along the gray line. Stations on either side of the line can be heard from regions, and at distances

> that would otherwise be impossible on any given frequency. For this reason, radio operators often prefer to listen at dawn and dusk for this effect.

#### **Propagation Predictions**

Propagation predictions for the VLF through low VHF bands are published each month in several magazines. Ham radio operators often use those in OST magazine, while SWLs and others tend to prefer those pubsuch lished in magazines Monitoring Times. These charts relate time of day in Universal Coordinated

Time (UTC, old GMT) and frequency for transmission to different parts of the world.

#### Fading

Skip communications is not without problems. One phenomena is fading, i.e., a variation in signal strength as perceived at the receiver site. This problem can sometimes be overcome by using one of several diversity reception systems. Three forms of diversity technique are used: frequency diversity, spacial diversity, and polarity diversity.

In the frequency diversity system, the transmitter will send out two or more frequencies simultaneously with the same modulating information. Because the two frequencies will fade differentially, one will always be strong

The spacial diversity system (Figure 5) assumes that a single transmitter frequency is used. At the receive site, two or more receive antennas are used, spaced one-half wavelength apart. The theory is that the signal will fade at one antenna while it increases at the other. A three antenna system is often used. Three separate, but identical, receivers often tuned by the same master local oscillator, are connected to the three antennas. Audio mixing, based on strongest signal, keeps the audio output constant while the RF signal fades.

Polarity diversity reception (Figure 6) uses both vertical and horizontal polarization antennas to receive the signal. Like the space diversity system, the outputs of the vertical and horizontal receivers are combined to produce a constant

level output.

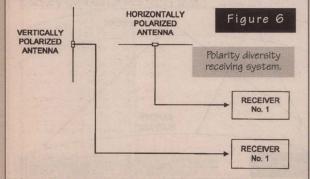
Another form of fading, selective fading, derives from the fact that fading is a function of frequency. The carrier and upper and lower sidebands of an AM signal have slightly different frequencies, so they arrive out of phase with each other. Although this type of fading is lessened by using single sideband transmission, that does not help AM users. In those systems, some people use a filtering system that eliminates the carrier and one sideband, it then reconstitutes the AM signal with a product detector

SSB receivers with stable local and product detector oscillators, and a sharp IF bandpass filter, can be used to reduce the effects of differential fading of AM signals due to phasing of the LSB, USB and carrier components. Carefully tune the receiver to only one sideband of the signal, and note when the heterodyne beatnote disappears. The correct point is characterized by the fact that you can then switch among USB, LSB, and CW modes without changing the received signal output.

#### Connections ...

This month's column (and last month's) are the result of people contacting me either by US postal mail or E-Mail. I can be reached at P.O. Box 1099, Falls Church, VA 22041, or by Internet at carrjj@aol.com NV

oe has written a lot about antennas and propagation. Two of his related books are Joe Carr's Receiving Antenna Handbook (HighText, \$19.95, 1-800-247-6553), and Practical Antenna Handbook (TAB/McGraw-Hill, \$26.95, 1-800-233-1128).





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Dimn:1-3/1	16"Sq. T:.18"	WT: .03
STOCK #	DESCRIPTION	PRICE
7075-PMN	Peltier Module	\$16.95

adaptors allow two pieces of phone

equipment to share one outlet. One RJ-11 type "Mod" plug to two RJ-11 type "Mod" jacks.

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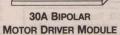
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ton DTMF touch-tone encoder. 9V DC input (red+ black-), adjustable output level, output tone corresponds to keypad buttons, white numbers on black keypad. 6" leads

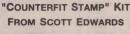
	Common: 6 Output: Yel	Black lead		
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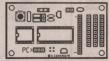
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Fuji 2DI-30A-120A Hi-Current NPN 1/2 bridge module. Rated: Ic= 30A, Vc=1200V. VBE = 10. Base Current 2A. 2.5KV Isolation. For motor control, in-

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### 12V STEP MOTOR

MFG: NMB
P/N:PM55L-048-HPA7
TYPE: 2 Phase 6 lead
COIL RATING: 12VDC/10ohm
HOLDING TORQUE: 1500 gm/cm STEP ANGLE: 3.6 deg.

Bronze bearings, Dual, 5/32" (4mm) dia. X 11/32" (9mm) steel shafts. 2-9/ 16" mounting ctrs. 14" leads. 16 tooth X 5/16" dia brass gear pressed on front shaft

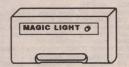
L: 1-11/16"max Dia: 2-3/16" less ears

STOCK #	DESCRIPTION	PRICE	
7345-MSN	12V Step Motor	\$3.95	1



MPG: MG
P/N: PS53
Input: 115 VAC
Output: 13-14V50A
Specifications/Features:
Adjustable 13-14VDC. Short Circuit,
Overload & Thermal protected. Metal Case, Heavy duty power cord, Line Fuse Switch & Output to Binding Post.

L: 11.9" V	V: 10" H: 11.9"	WT: 30
STOCK #	DESCRIPTION	PRICE
7269-PSN	13.8V 50A Supply	\$184.95



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Pocket sized "Black Light" used to detect fluorescent inks, paints etc. Unit runs off 2 "AA" cells. With belt clip & Push button switch for convience in use.

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6929-MEN	LCD Meter	\$9.95
STOCK #	DESCRIPTION	PRICE
W: 2-5/8" F	1:1-3/4" D:3/8"	W1:.1

### 4A 13.8VDC REGULATED

"Y" ADAPTOR

SPECIAL

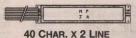
STOCK #



WT: .005

PRICE per

5383-PSN	4A Bench P/S	\$19.95
	DESCRIPTION	
L. 9-1/2 V	1.5-1/4 H.5-1/2	WI. 5.5



Short Circuit & Overload Protected. 110/
120VAC Input. With Metal Case, Power
Cord, Line Fuse and Switch For Cellular
Phones, Auto Accessories, Test Equipment. Binding post & Cigarette plug socket for output.
L:9-1/2" W: 5-1/4" H: 3-1/2" WT: 5.5 INTELLIGENT LCD DISPLAY

5	L: 7-3/16"V	V: 1-5/16"T: 3/8"	WT: .2
	STOCK #	DESCRIPTION	PRICE
	5120-OPN	2X40 Display	\$9.95

### **BLUE T-1-3/4 LED**

Cree C470-5T18, Silicon Carbide, Blue LED's. T-1-3/4 Non-diffused blue tinted case. 3.0

VDC fwd drop @ 20mA., Luminous intensity = 3mcd @ 20mA, 470nM peak wavelength. 1" long X .025 sq. leads. wT: .001

WT: .01

WT: .02

CURRENT: .15A

C.F.M:30

NO. OF BLADES: 7

Box fan with plastic frame & blades. Barbarder St. Sq. 3-1/8"

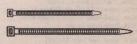
Thk: 1"

WT: .2 Cree C470-5T18, Silicon Car-

STOCK #	DESCRIPTION	PRICE
6678-OPN	Blue T-1-3/4 LED	\$1.50



34. 3-170	TIIK. I	4412
STOCK #	DESCRIPTION	PRICE
7054-FNN	12V 3-1/8" Fan	\$7.95



### TY-RAPS

Natural color Nylon ties sold in packs of

	STOCK #	DESC.	PRI0	CE per 1000
	0199-TYN	4" Ty-wrap	\$1.10	\$9.00
	0200-TYN	5.5" Ty-wrap	\$1.70	\$15.00
1	4529-TYN	7.5" Ty-wrap	\$2.80	\$20.00
	4530-TYN	11" Ty-wrap	\$5.00	\$39.00

### TO-220 HEATSINK

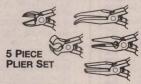


Thermalioy THM6072 Heatsink. Vertical mount, with 2 holes: one 1/2" from top & the other 1/2" from bottom. Holds single or two back to back TO-220 type devices. Solderable mounting clips for pc board mounting

W: 1-3/4" D: 3/8" H: 1-3/4" WT: .013				
STOCK #	DESCRIPTION	PRICE		
7400-HSN	TO-220 Heatsink	\$0.25		



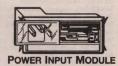
STOCK #	DESCRIPTION	PRICE
6867-NIN	"AA" Ni-Cad	2/\$3.50



Kenwood High output "AA" Ni-Cad cell rated 1.2V @ 800mAH. Insulated outer jacket. Sold in packs of 2 only wr.11

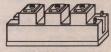
STOCK # DESCRIPTION | Page 1.50 | D

L:5"			WT: .9	
	STOCK #	DESCRIPTION	PRICE	
	5572-TLN	5 Pc. Plier Set	\$9.95	



Potter 7100-0002, snap-in power inlet. Rated: 6A @ 250VAC. Standard male 3 blade IEC cord connector, 6A line filter, fuse holder & input voltage programming card (used to select power transformer taps). UL/CSA listed

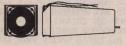
W: 2-3/4" H: 1-1/8" D: 1-3/4" WT: .17				
STOCK #	DESCRIPTION	PRICE		
7313-FHN	IEC Module	\$3.50		



50A BIPOLAR MOTOR DRIVER MODULE

Fuji 2DI-50A-120A Hi-Current NPN 1/2 bridge module. Rated: Ic= 50A, VcE=1200V. VeE = 10. Base Current 3A. 2.5KV Isolation. For motor control, in-

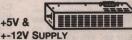
L: 4-1/4" V	V: 1-1/4" H: 1-3/8'	WT: .6
STOCK #	DESCRIPTION	PRICE
7307-QTN	Fuji 50A Driver	\$29.95



### **BAZOOKA SPEAKER**

Plastic tube type case enclosing a 3" mini speaker. Speaker has Ferrite magnet, & a paper cone with foam edge. Rated 6 ohm, 20 Watts. Polyester packing inside. Used to provide full range sound in a small form factor. 24in wire leads

7361-SPN	Tube Speaker	\$4.95		
STOCK #	DESCRIPTION	PRICE		
L: 8-1/2" W: 3-3/4" T: 3-1/2" WT: 1.41				



MFG: TEAPO P/N: TP331B-2 Input: 115 VAC

Input: 115 VAC
Output #1: +5V @ 25A #2: +12V @ 3.5A
ELENCO DC panel meters, Black leg#3: -12V @ 1A

Specifications/Features:
Enclosed switching supply. 18 Pin (2X9)
MOUNTING HARDWARE

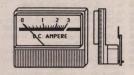
\*3: -127 @ 1A
Specifications/Features:
Enclosed switching supply. 18 Pin (2X9)
.187\* space output connector. IEC power connector, Power on LED & Switch. UL/CSA/TUV Listed.

7365-PSN	Teapo Supply	\$6.95
STOCK #	DESCRIPTION	PRICE
L: 16" V	V: 4-3/8" H: 3-1/4"	WT: 5.4



DC VOLT PANEL METERS

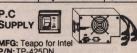
W:2-1/4" H:1-7/8" D:1-1/4" WT:.1 DESCRIPTION PRICE STOCK # 5332-MEN 0-15 Voltmeter \$6.95 5333-MEN 0-30 Voltmeter \$6.95 5334-MEN 0-40 Voltmeter \$6.95



### DC AMP PANEL METERS

ELENCO DC panel meters, Black leg-ends/Red over-range, Plastic case. Back Mounts in 2" X 1-1/8" cutout NO MOUNTING HARDWARE

5336-MEN	0-3A Meter	\$6.95		
5335-MEN	0-500mA meter	\$6.95		
STOCK #	DESCRIPTION	PRICE		
W:2-1/4" H:1-7/8" D:1-1/4" WT:.1				



MFG: Teapo for Intel
P/N: TP-425DN
Input: 110/220 VAC 50-60Hz
Output #1: +5V @ 23A #2: +12V @ 8A
#3: -5V @ 5A #4: -12 @ .5A
220W Switching supply for "AT" P.C.
systems. Standard IEC input power connector, power switch, Female IEC power
connector for monitor. P-1 & P-2 mother
board connectors & 4 molex 4 pin connectors for drives etc. Internal fan. UL/
CSA VDE Listed.

L:9-3/8" W:6" H:5-7/8" WT:7.1				
STOCK #	DESCRIPTION	PRICE		
7349-PSN	P.C. Supply	\$29.95		

# ELECTRONIC TEST EQUIPMENT BOUGHT & SOLD

	BOUGHI	æ 30LD
1	Arbiter 1040A, Meter Calibrator,	HP 8616A, Signal Gen. 1.8-4.5GHz AM/FM/Phase \$200
	AC/DC/Voltage/Current\$1,200 Astrosystems A1202S/R01, Decade Syncro	HP 8620C, Sweeper Mainframe\$250
	Bacharch MV2, Mercury Vapor Detector	HP 86220A, RF Plug-in, 10-1300MHz, for 8620C \$600 HP 86235A, RF Plug-in, 1.7-4.3GHz, for 8620C \$400
	Ballantine 1627A, Scope Calib., with/acc. heads, & Computer \$1,200	HP 86220A, RF Plug-in, 10-1300MHz, for 8620C \$400 HP 86235A, RF Plug-in, 1.7-4.3GHz, for 8620C \$400 HP 86235A, RF Plug-in, 2.8-4GHz, for 8620C \$400 HP 86240B, Sig. Gen. 5-1024MHz, Opt. 1, 2, 3 \$1,800
	Biddle ZM-55/PSM25, Insulation Breakdown Mtr	HP 8640B, Sig. Gen. 20Hz-512MHz Opt. 001/003 \$1,000
	Bruel & Kjaer 2107, Frequency Analyzer\$200	HP 8840B, Sig. Gen. 20Hz-512MHz Opt. 001/003 \$1,000 HP 8654A, Signal Gen. 10-520MHz AM/FM \$500 HP 8654A, Signal Gen. 5.4-12.5GHz AM/WBFM, Pulse \$2,000 HP 87438/018, Reflection Trans Test Set, 2-18GHz \$400 Ithaco 3512, Ratiometer Lin, Log \$250
	Bruno USM-21A, Milliohm Meter, .001-10 ohms \$100	HP 8743B/018, Reflection Trans Test Set, 2-18GHz \$400 Ithaco 3512, Ratiometer Lin, Log \$250
	Chroneucs 1007A, Hemotely Programmable	Imaco 393, Lock-in Ampliner
ı	Cole Parmer 1481-00, Conductance Meter	Krause Storke 5000, Sweeper, 500-1000MHz \$250 Leeds & North 1091, Capacitor Decade, .001uF-1uF \$150
i	Createc SC01, Scope Mtr. 2 Ch., 0-20MHz Dig. Storage \$300 Data Precision 6000, Wave Analyzer, 620 Plug-in \$1,000	Leeds & North 4287-3, Kelvin Bridge
	Datel DVC8500, DC Voltage Calibrator 10uV-10V \$100	Marconi TF2015/2, Signal Gen. 10-520MHz
8	EDC MV106G, DC Voltage Standard, .01uV-10V\$200	Leeus a Notin 420-7, Newti Drillyd Marconi 2022A, Signal Gen. 10KHz-1GHz AM/FM \$2,000 Marconi TF2015/2, Signal Gen. 10-520MHz AM/FM, Mod. \$200 Marconi TF2300A, Modulation Meter, 1000MHz \$350 Micro-Tel SG800, Swept Signal Generator .1-18GHz \$2,500
ā	Exact 627. Funct. Generator, 13MHz 100mV-10V. Digital \$250	Millivac MV-928A, RF Millivoltmeter with Probe Set \$1,00
ì	Fairchild DBMC101, Data Bus Tester \$300 Fluke 332B, DC Voltage Standard 0-1100VDC \$400	Narda 7000A/7202/7206, Microwave Multimtr, .01-18GHz . \$800 Narda 792FF, Attenuator, 2-12.4GHz 0-20dB \$100
ı	Fluke 3330B, DC Voltage, Current Calibrator \$500	North Atl 540/10, Resolver Synchro Bridge \$800
8	Fluke 335A, DC Voltage Standard, 0-1100VDC	Panametrics Epoch 2002, Ultrasonic Flaw Det
ı	Standard HPIB \$1,600 Fluke 540B, Thermal Transfer Standard \$900	Polarad 1105 E-L, Sig. Gen., 1020A Modulator,
	Fluke 750A, Reference Divider\$400	.8-2.4GHz
	Fluke 8010M, Digital Multimeter	Polarad 640-1, Spect. Anyz., .003-18GHz Dig. Storage \$1,200
	Fluke 8506A, Thermal RMS Multimeter HPIB \$1,400	Polarad SPNH, Generator 20Hz 20KHz\$450 Power Designs TW5005D, Dual Output
	Fluke 8921A/03. True RMS Voltmeter	Power Supply/Digital 0-50V
	Fluke 9010A, Micro-System Troubleshooter Opt. 001 \$200 Fluke A90, Current Shunt \$200 Fluke Y8008, Touch Hold Probe \$40	PPM R5, Resistor Standard, 1-111.11K, .1 Ohm Res \$150
	General Radio 1307A/1552B, Oscillator/Sound Level Calibrator \$50	Racal Dana 9035/11A, Computer Counter, Opt. 01/06/55, unused
	General Radio 1422CB. Precision Capacitor	Racal Dana 9515, Universal Counter, HPIB, Opt. 41 \$200
	50-1100 PF, Unused \$350 General Radio 1538A, Strobobtic, Strobe Scope \$400	Schlumberger 7061, Systems Voltmeter, 7.5 Digits \$700 Schlumberger SI-1253, Gain Phase Meter \$1,000
	General Radio 1650A, Impedance Bridge \$200	Sencore TF30, Super Cricket Transistor Tester \$200
	Glow-Mac 20-500, Portable Inertness Analyzer, Unused \$250 Guildline 9152/P4, Standard Cell, Double Oven \$300	Systron Donner 100A, Pulse Generator\$100 Systron Donner 114A, Pulse Gen. 10Hz-1MHz
	Halcyon 520B3, Universal Test System\$500	100V/50 Ohms
	Hiptronics HDA10, Hipto Tester 0-10KV\$300	T.B.E. 208, C, L Meter, 1fF-10uF, 1nH-10H\$300
1	HP 1053h, Quartz Frequency Standard \$600	Tek 114, Pulse Generator \$100
	HP 105B, Frequency Standard, Battery Backup \$600 HP 11049A, Thermal Converter, 3 Volts \$100	Systom Dornier Decay, Counter   12-072, Fire   18-800
	THE FIZUA, ACTIVE FET PRODE KIT, SUUMFIZ	lek 1/8, Linear IC lest Fixture, For 5//
	HP 1122A, Probe Power Supply	Tek 213, DMM Oscilloscope, Portable Battery Oper \$400 Tek 4041, Systems Controller for GPIB \$200
	HP 1200A Scope Dual Trace 1mV-20V	Tek 464, Scope/100MHz Dual Trace, Storage \$500 Tek 465, Scope 100MHz Dual Trace \$400
	HP 11605A, Flexible Arm, Opt.018	Tek 466, Scope, Dual Trace, Storage         \$600           Tek 475, Scope, 200MHz, Dual Trace         \$500
	HP 15453A, Ten Bit Address Probe \$50 HP 15454A, Control Probe Driver \$50	Tek 485, Scope, 350MHz, Dual Trace \$650 Tek 491, Spectrum Analyzer 10MHz-12.4GHz \$600
	HP 15455A, Eight Bit Data Driver, D0-D7\$50	Tek 492, Spectrum Anyz. 50KHz-21GHz Opt 1, 2, 3 \$5,000
	HP 15456A, Eight Bit Data Driver, D8-D15	Tek 624, XY Monitor
	HP 3300A, Function Gen. with 3302A Phase Lock\$150 HP 3320B, Frequency Synthesizer\$250	Tek 7403N, Scope Mainframe, Rack Mount
	HP 3325A, Synthesized Function Generator\$1,800	Tek 7A29, 1GHz Vert. Amp, 7000 Series Mainframe \$450
	HP 3330B, Automatic Synthesizer\$400 HP 3400A, RMS Voltmeter 1mV-300V, 10Hz-10MHz\$150	Tek 7B85, 400MHz Delaying Time Base\$150
	HP 3406A Broadhand Sampling Voltmtr to 1 2GHz \$250	Tek 7CTIN, Curve Tracer Plug-In         \$350           Tek 7D11, Digital Delay Plug-In for 7000         \$100
	HP 3455A, High Accuracy Voltmeter 6.5 Digit\$400	Tek 7L13/7623, Spectrum Anyz. 1KHz-1.8GHz\$2,000 Tek 7L18/7603, Spectrum Anyz. 1.5-18GHz Dig. Storage \$3,000
	HP 3465A, Digital Multimeter\$100	Tek 7S12, TDH/Sampler, No Heads\$400
	HP 3575A, Phase Gain Meter, Opt. 01, Dual Displays \$600	
	HP 3580A, Spectrum Anyz., 5Hz-50KHz, 1Hz Res \$800 HP 3581C, Selective Level Meter \$600	Tek DC503A, Universal Counter, 125MHz TM500 \$200
	HP 3586C, Selective Level Meter, 50 Ohm \$1,000	Tek DM502, Multimeter TM500 Modular System \$100
	HP 428B, Clip on Milliampmeter 1mA-10Amps	Tek FG501, Function Generator\$200
	10MHz/10GHz\$300 HP 435A/8481A, Power Mtr., Cable, Sensor,	lek P6016, Current Probe with Termination
1	10MHz/18GHz \$800 HP 456A, AC Current Probe \$100	Tek P6045, FET Active Probe
	HP 4815A, Vector Impedance Meter \$900	Tek P6201, FET Probe Kit, 900MHz\$350
	HP 5110B, Synthesizer Driver & Cable Set\$300 HP 5300B, 5308A, 75MHz Timer Counter\$200	Tek PS501-1, Power Supply 0-20V, TM500\$150
	HP 5334A, 100MHz Universal Counter, HPIB \$1,500 HP 5340A, Frequency Counter, LEDS & HPIB, 18GHz \$1,000	
1	HP 54200A, Digital Storage Scope, Dual Trace, 200/MG/S \$1,500	Tek S3A, Sampling Head\$150
	HP 7015B, XY Recorder	Tek S53, Trigger Recognizer Head\$350
	HP 741B, DC Voltage Standard/Diff Volt Mtr	Tek SG503, Sig. Gen. 250KHz-250MHz
-	HP 779D, Directional Coupler, 1.7-12.4 GHz \$200 HP 8018A, Serial Data Generator \$300	Tek TM503, Mainframe 3 Slot, TM500
	HP 8405A, Vector Voltmtr with Accs\$400	Tek TR-503, Tracking Gen. 1-1800MHz for 492, 4, 6 \$1,000
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	HP 8443A, Tracking Gen., 100K-110MHz LED Display \$400 HP 8445B, Spectrum Anyz., Automatic Pre-Selector \$400	Wavetek 1002, Sweep/Sig. Gen. 0-500MHz with Markers . \$250
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	1KC-110MHz\$1,000	Wavetek 145, 20MHz Pulse/Function Generator \$300
	HP 8554L/8552B, Spect. Anyz. 141T System, 100KHz-1.2GHz	Wavetek 154, Programmable Waveform Gen.  .001Hz-10MHz\$350
	HP 8555A/8552B, Spectrum Anvz., 141T System,	Wavetek 1910, 12 Inch XY Dual Trace Display\$350
	HP 8557A/180TR, Spectrum Analyzer, .01-350MHz \$1,000	Wavetek 2001, Sweep Generator, 1-1400MHz       \$550         Wavetek 3001, Signal Gen. 1-520MHz, AM, FM       \$600         Wavetek 750, Phase Meter, 10Hz-2MHz, 1mV-340V       \$150
		Wavetek 907, 7-11GHz Signal Generator\$650
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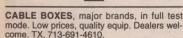
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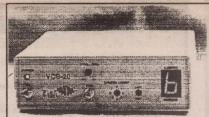
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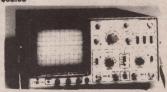
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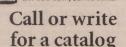


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SPEAKERPHONE, SUPERB QUALITY Featured in Radio Electronics, November, 1992. Kit uses Motorola chip set and includes all PC electronics, mike, transformer, plated/drilled board, complete step by step, and user mods. \$53 pp. 100s built by stu-dents. Project-Mate, 2727 West Manor Place, Seattle, WA 98199. SASE info. veryone is familiar with the common household lamp dimmer. When you replace an ordinary wall switch with a dimmer, you are able to control the brightness of a lamp or chandelier. In this article, which describes a versatile system of lighting control, a simple and inexpensive modification is

made to the dimmer to allow external control of the brightness. This control can come from a variety of sources such as a simple remote control, a raise/lower touch control circuit, tape recorder interface, or even computer control. The use of dimmers also promotes energy (and electric bill) conservation by delivering only as much lighting power as needed.

Most people have seen the wall type dimmer shown in Figure 1. These units are sold in hardware stores for about three to five dollars. They replace the existing light switch mounted in the wall and can be installed easily in a few minutes with the power off. Figure 1 shows a rotary (dial) type of dimmer, but slide control and toggle types are also very common. Table top units or home-brew devices can be used as well. In most cases, the modification can be built right into the existing dimmer enclosure.

### **How Dimmers Work**

Before going any further, it would be helpful to review some dimmer basics. Lamp brightness is controlled by varying the current flowing through it. One way to accomplish this is to vary the RMS AC voltage applied to the lamp using a rheostat or variable transformer (variac). However, this approach would be extremely expensive and wastes energy in the controlling element.

A better method is to supply the full AC voltage to the lamp, but switch it on and off rapidly. Lamp brightness is then set by the duty cycle, or percentage of the time that the switch is closed. This is how a common dimmer

The schematic of a typical dimmer is shown in Figure 2. The main element which controls the current through the lamp is the triac. A triac is a bi-directional triode thyristor

which means that it allows current to flow in either direction between its main terminals when triggered by a pulse on its gate lead. Furthermore, once triggered, the triac will remain on (like a closed switch) as long as there is current flowing through it. This is shown by the voltagecurrent diagram of Figure 3. For those more familiar with the SCR (silicon controlled rectifier), a triac can be thought of as two SCRs connected in parallel and in opposite directions

For AC operation (as used by dimmers), all that is needed is to trigger the triac sometime during the positive and negative half of each cycle. This will turn the triac on and allow current to flow through the lamp for the rest of that half-cycle until the AC line voltage crosses through zero and the triac turns off again. The

exact point during the cycle at which the triac is triggered will determine what portion of the cycle (i.e., what duty cycle) the lamp receives. Figure 4 shows what the voltage across the lamp would look like for various settings of the dimmer.

The triac is triggered by R1, C1, and the diac. A diac, or trigger diode, is a device which exhibits a high impedance across its terminals until the applied voltage reaches a certain breakover voltage. At this point, the device changes to a negative resistance state (i.e., the voltage across it decreases as the current increases). This is shown by the curve in Figure 5. The diac is used to give consistent triggering from the charging circuit of R1,

Operation of the dimmer is thus quite simple: As the magnitude of the line voltage increases (either negative or positive), C1 is charged through the intensity control R1. The voltage on C1 increases until the breakover voltage (Vbo) of the diac is reached. At this point, a pulse of current flows into the triac gate turning it on. Intensity control

is accomplished by varying the charging resistance and thus the time needed for C1 to reach Vbo. This, in turn, varies the point at which the triac turns on and ultimately the duty cycle of the output.

Figure 2 represents the simplest approach

DIMMERS AND AND CREATIVE LIGHTING CONTROL

by Jeff Mazur

### Improving the Simple Dimmer

The first problem with this simple circuit concerns the initial turn on of the dimmer. If you already have a dimmer installed, try this easy test. Slowly turn the dimmer up until the lamp just turns on. Most likely you may reach

1/4 of the full control range before this happens. Note, however, that this is not the lowest possible setting and that turning the control back down reduces the intensity quite a bit before the lamp is finally extinguished again. This difference in turn on inten-

sity and turn off intensity is a form of hysteresis and is caused by the discharge of C1 as the triac is triggered.

Figure 6 shows what happens when the control is set to the point where the lamp first



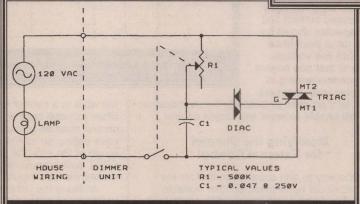
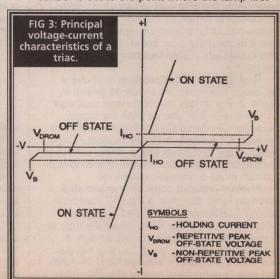
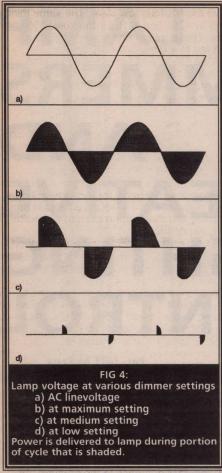


FIG 2: Schematic of a typical dimmer unit and connection to existing lamp wiring. Note that the connections are not polarized; the wires from the dimmer can be interchanged.

to triac lamp dimming and, with few exceptions, is the circuitry used by all dimmers of the type we are discussing. However, there are two major drawbacks to this simple method. Since both can be corrected by adding a few inexpensive parts, they are worth mentioning before delving into additional control schemes.



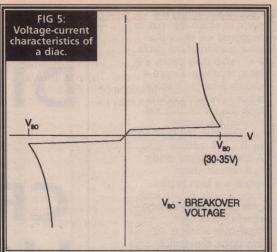


turns on. On the first charging cycle of the capacitor at this setting, the diac (and thus the triac) will fire at point 'a' and the triac will remain on until point 'b.' However, as the triac fires, current is drawn from the capacitor and thus its voltage drops to a lower value Therefore, when the capacitor begins to charge in the other direction, it has a "head start," so to speak, and will reach the opposite breakover point earlier in the next half-cycle (point 'c'). The triac will then conduct between points 'c' and 'd' which is a larger duty cycle. Since the capacitor continues to get this head start on each successive half-cycle, the apparent lamp brightness is set by this larger duty cycle

The control can then be backed down to reduce the triac "on time" and thus lamp bright-ness. Once the triac fails to trigger, as when the control is turned all the way down, the hysteresis has to be overcome again. Because of this, a momentary drop in the line voltage can also extinguish a lamp that has been set to a low level.

One remedy to this problem is to use a two-stage time constant circuit as shown in Figure 7. Put simply, the first stage capacitor C1 stores a higher charge than the trigger capacitor C2. When C2 discharges to turn on the triac, C1 partially restores this lost charge, reducing the hysteresis effect. If fine control at low brightness levels is needed, this modification can make a dramatic difference.

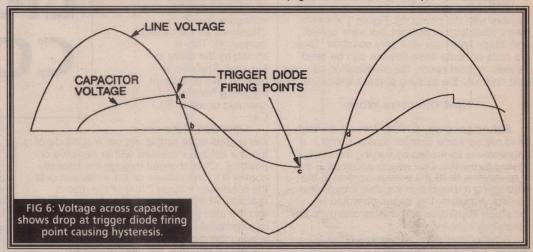
Another problem commonly associated with triac lamp dimmers is the RFI (radio frequency interference) generated by the fast switching action of the triac. When the triac is triggered, the instantaneous line voltage is impressed across the lamp, causing the current to rise rapidly in a step fashion. This current step is composed mainly of higher fre-



and 10.

When selecting a photocell, the only requirement is that it be able to withstand the peak AC voltage. The 7520 photocell shown in the parts list is a dual unit. By using the two outer leads, both cells are placed in series, increasing the maximum voltage it can withstand. The LED and photocell are placed face to face and joined together with black electrical tape or heat shrink tubing. Since the isolator will be mounted inside the dimmer enclosure, there is no need to make it absolutely light tight. If desired, the control leads can be connected to a two-conductor jack mounted on the front of the dimmer.

Although the dimmer output will be affected by both the external control and the "local" control in the dimmer itself, normally only one will be used at a time. When the external control is disconnected or at its lowest setting (highest resistance of PC1), the local control



quency harmonics which can get into amplifiers and AM radios. Although complete suppression of the RFI may be impossible, the addition of an LC filter, as shown in Figure 8, will usually prove adequate. Make sure that the inductor used will carry the desired current and the capacitor should be rated for at least twice the RMS line voltage.

Now that you have a good understanding of how triac lamp dimmers

work, let's proceed to describe the modification that will enable external brightness control.

### DIAC TYPICAL VALUES 100K R2 15K C1 FIG 7: A two-stage RC triggering circuit reduces hysteresis considerably, values may vary to give smooth range control.

### **Modifying the Dimmer** for External Control

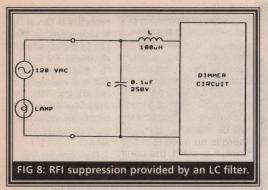
One way to add external control for the dimmer would be to place another variable resistor in parallel with the existing control pot (R1). However, this would place hazardous AC voltage on the control wires, as well as making it difficult to interface to other circuits Therefore, the control circuit needs to be isolated from the dimmer circuit. This is easily accomplished by combining a photocell and LED light source to form an opto-isolator. The LED receives the control current and produces a corresponding light output; this illuminates the photocell which translates the LED intensity into a variable resistance across R1. The complete modification is shown in Figures 9

will work in a normal fashion. Conversely, when external control is being used, the local control must be placed at its minimum brightness setting so as not to interfere with the full range of the external control. For the purist, a SPDT switch could be added to select control resistance (see Figure 9B)

Allowing the lamp brightness to be controlled by an external current opens up a wide range of possible control schemes. The most obvious would be various forms of remote control and automated control. But we'll also show two different ways to control lamp brightness with just a slight touch of your finger.

### **Remote Controlled Dimmer**

The simplest way to generate a control current for the modified dimmer is with a variable resistance and a battery. These then are the makings for a handheld remote control



TO DIAC

JACK

MODIFICATION SHOWN IN BOLD

one plate causes the lamp brightness to gradually increase from totally off to full intensity; likewise, touching the other plate causes the lamp to dim and eventually go off.

Designing a circuit from scratch sometimes brings up interesting choices. There is always more than one way to accomplish the same feat and each approach may have its own pros and cons

Sometimes the main goal of a design is to reduce parts count or cost while other times current drain may be the most important criterion. Often the major design decision is whether to use an analog or digital circuit. Although everything seems to be going "digital" these

TO DIAC

FIG 9: a) Modified dimmer with LED/photocell opto-isolator. A jack may be used to connect the control voltage. In b), optional switch for

selecting internal or external control.

days, sometimes a good old-fashioned analog approach is the best way.

### Analog vs. Digital

The design of a touch-controlled dimmer circuit requires some means of maintaining the control voltage after it has been set. This requirement would

R2 R1 OPTIONAL PLUG = = =0 TYPICAL VALUES (B1 = 9V) FIG 11: Simple wired 50K remote control circuit

unit. The schematic is shown in Figure 11. R1 sets the maximum current for the LED in the dimmer. Its value is determined as follows: Temporarily select R1 for the maximum current that the LED can handle (using the formula R=Vbatt -1.4/Imax). Connect the remote unit to the dimmer. If possible, place an AC voltmeter across the lamp. Starting at its maximum resistance, slowly decrease R2 until there is no further appreciable increase in the lamp brightness or voltage. The lamp should reach normal

brightness (voltmeter showing 100 volts or more). Disconnect the remote control, measure the resistance of R2, add this to the value of the temporary R1, and pick the closest resistor available for the permanent R1. This will allow smooth control and minimum bat-

tery drain.

A

CONTROL

**FIG 10** 

### **Touch Controlled Dimmer**

A more dramatic way to control the dimmer is by touch control. Two conducting plates are mounted in a convenient location (or locations) and connected by fine wires to a control unit. The slightest touch on

seem to dictate a "digital" approach since there is no simple way to accurately maintain an analog voltage for an indefinite period of time. However, there is a "linear" approach of such simplicity and with a unique feature that it is

worth mentioning. The schematic is shown in Figure 12

The raise and lower touch control plates (any piece of metal, aluminum foil, etc.) are connected to the inputs of CMOS inverters IC1a and IC1c. The input impedance of a CMOS gate is so high that the 60Hz AC signal picked up by our bodies is enough to trigger it. Thus, when the "raise" plate is touched, inverter IC1c goes high and low at a 60Hz rate.

This signal is re-inverted by IC1d to pre-

serve the normally low state. The same thing is done by IC1a and IC1b for the "lower" touch plate. These "raise" and "lower" signals are then fed to a ramp and hold circuit.

One half of an LM3900 quad op amp performs this function. The non-inverting and inverting inputs of amplifier IC2a are used to drive the output higher or lower. C1 charges and discharges according to the input and holds the setting between changes.

The voltage across C1 would quickly leak off so IC2b is used to supply a small charging current to offset this leakage. R9 is set to balance out any drift. However, it is impossible to achieve zero drift and, at best, the output will not change appreciably for a couple of hours. For a normal lamp control circuit, this is unacceptable and this is the reason that a digital design is needed.

But a controlled drift can be put to good use. For example, consider turning on a lamp at dusk to about half brilliance. The drift rate control could then be set to slowly increase lamp brightness over some period of time. The lamp would then come up to full brightness an hour or so later when it is completely dark outside. Thus the lamp would be fully on only when needed. Or, a multi-projection special effects show might use several of these circuits to control various lights which are frequently dimming and brightening. If no one lamp must stay at a particular setting for longer than one

hour, then the slow drift will not be noticed.

### The Logical Approach

Referring to Figure 13, let us examine another approach to the problem. As before, CMOS gates are used as touch sensors, but now the 60Hz signal is fed to ripple counter IC2. IC2 can be used to divide by 32, 64, or 128, giving pulses every half, one, or two seconds, respectively. These pulses are gated by IC1c or

d (depending upon which plate is touched) to up/down counter IC3.

The BCD output of the counter is decoded by IC4 into 10 discrete outputs which can be wired to represent 10 different levels of brightness. Outputs of the "0" and "9" count are fed back to the counter inputs to disable the countdown below "0" or count-up above "9.

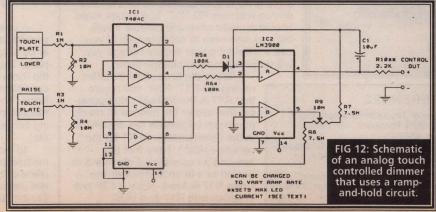
This prevents the "end around" effect that would result if one plate were held too long. Thus when maximum brightness is reached, it will stay there and continued touching of the up plate will have no effect.

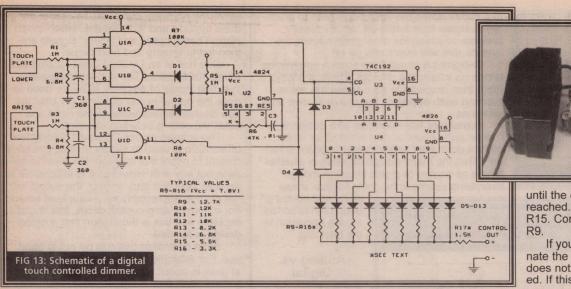
Although 10 distinct brightness levels should be enough for normal applications, a finer degree of control could be obtained by cascading one or more additional

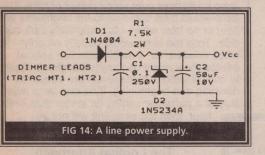
counter/decoder stages.

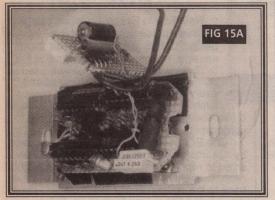
The rate at which the dimmer operates is determined by which output of IC2 is used. At a slower rate, it is easier to control the exact setting to be selected; however, it will require a longer time to reach full brightness

This speed control is useful for another reason. The stray AC picked up by the body is not a clean sinewave (or squarewave. like the CMOS logic would like).











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3) Yonushka, J.V., "Triac Power-Control Applications," RCA Solid State Databook: *Thyristors, Rectifiers, and Diacs*, 1973, pp. 386-393.

Aluminum
foil

Cardboard

Cardboard

Control

Wires

FIG17: a) touch plate made from aluminum foil and cardboard,
b) mount plates where desired, connecting multiple
controls in parallel.

Mount control
where desired

Route wires to
control unit

Additional control
locations simply
wired in parallel

Thus, in some cases, the inverters may be triggered two or three times during each cycle. These extra pulses will speed up the dimmer's operation. After installing the

complete dimmer and touch plates, if the rate is too slow, move the connection point x from IC2 pin 4 to pin 5; if it's too fast, use IC2 pin 3.

### **Setting the Brightness Levels**

Due to the non-linearities of the photocell and light intensity vs. lamp voltage, there is no simple calculation for the LED driving resistors R9-R17. The values listed should provide adequate dimmer levels, but you may wish to set your own (if you use a different power supply voltage you will definitely have to change them).

Here is the procedure for determining R9-R17. First, make sure that R17 is the highest value possible that allows the dimmer to reach maximum brightness (as described in the determination of R1 for the remote control). Note that this requires an operational dimmer connected to a lamp and power line. Once R17 is fixed, place a 50K pot in series with R17 and VCC.

Starting at minimum resistance (level 9), slowly increase the pot to the desired rightness for level "8." Disconnect the pot and measure its resistance. This value (or closest available value) will then be used for R16.

Re-connect the pot and increase the resistance again

until the desired level "7" brightness is reached. Measure the pot again to determine R15. Continue in the same manner for R14-R9.

**FIG 16** 

If you haven't modified the dimmer to eliminate the hysteresis, you may find that the lamp does not come on when the pot is reconnected. If this happens, momentarily short out the

pot to restore the last setting.
To further aid in setting the
brightness levels you may wish to
add a 1K pot in series with R17.
This will allow finer control of the
lower light levels without affecting
the high levels as much. The ultimate solution would be to make R9R16 each a 50K pot. Then each
dimmer step could be adjusted to
precisely the brightness level
desired.

### **Power Supply**

Although an external power supply can be used to run the touch control circuit, the simple zener-regulated circuit shown in Figure 14 will power the circuit directly from the AC line. Normally this would not be a recommended practice, since it connects the ground side of our circuit to one leg of the AC line. But if the entire circuit is placed within the dimmer enclosure as shown in Figures 15 and 16, then no parts

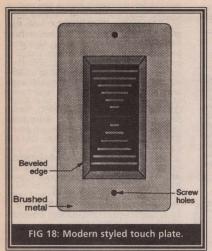
which connect to the line are exposed. Since the touch plates are isolated through onemegohm resistors, they do not pose any shock hazard.

Having said this, it is still very important to be aware of the potentially lethal voltage that is present when working inside the operational dimmer. Whenever the circuit is "hot" be extremely careful not to touch any parts. The old advice of keeping one hand in your pocket will definitely reduce the chances of your receiving a fatal shock.

### Two Way, Three Way, Etc.

A unique property of touch control is that several touch plates can be connected together by simply running the control wire to each plate. Thus light control from several places in the room becomes quite feasible. For easy concealment, use 30 gauge wire for the control leads. The touch plates themselves can be any metallic object. If desired, you could use existing things such as a door knob, lamp frame,

To mount the control on a wall, use a method such as shown in Figure 17. A small piece of cardboard is used as a base to which two pieces of aluminum foil are glued. The foil can be cut into the shape of arrows — one



pointing up, the other down. The control leads are brought through the back, stripped, and taped to the foil before finally cementing to the cardboard. For an even more dramatic look, create your own touch plate like the one shown in Figure 18.

### Sensitivity Adjustment

R2 and R4 determine the sensitivity of the touch controls. If multiple plates and/or long control wires are used, these resistors may need to be changed or replaced with 10M pots. The proper resistance is the lowest value that will allow consistent opera-

### **Further Lighting** Control Ideas

With the modified dimmer as discussed, there are many other

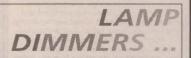
D2

ways to add creative lighting control. The low-voltage control signal can be derived from any computer system using an appropriate D-to-A (digital-toanalog converter). Or by using a V-to-F (voltage-to-frequency converter), varying light levels can be recorded as a variable pitch tone on an ordinary tape recorder.

When played back through a complimentary F-to-V converter, the exact sequence of lighting changes would be repeated. By recording music or narration on one track of the recorder and lighting tones on one or more other tracks, the lights are kept synchronized to the audio

The Bose Corp. designed a fascinating demonstration of their "direct/reflecting" speaker systems using such an approach. As the audio described each of the speakers in the system, spotlights were used to direct the viewer's attention to the area of interest.

Other schemes can be devised for wireless remote control, sound activated control, etc. And don't forget that dimmers can be used to control many other devices besides lights. Everything discussed here could easily be applied to a heater or soldering iron, for example. Just be aware that most motors, fluorescent lamps, and electronic equipment cannot be controlled by such dimmers. NV



	LED1 PC1	-	PARTS LIST FOR DIMMER MODIFICATION MV5754 LED or equivalent. Clairex 7520 photocell or equivalent. (see text)
THE RESERVE THE PERSON NAMED IN COLUMN TWO IS NOT THE PERSON NAMED IN COLUMN TWO IS	R1, R3 R2, R4, R9 R5, R6 R7, R8 R10 C1 D1 IC1 IC2	-	1 M ohm, 1/4 watt, 5% carbon resistor 10 M ohm, 1/4 watt, 5% carbon resistor 10 M ohm, 1/4 watt, 5% carbon resistor 10.5 M ohm, 1/4 watt, 5% carbon resistor 10.5 K ohm, 1/4 watt, 5% carbon resistor 10.6 K ohm, 1/4 watt, 5% carbon resistor 10.7 M ohm, 1/4 watt, 5% carbon resistor 10.8 M ohm, 1/4 watt, 5% carbon resistor 10.8 M ohm, 1/4 watt, 5% carbon resistor 10.8 M ohm, 1/4 watt, 5% carbon desistor 10.8 M ohm, 1/4 watt, 5% carbon desistor 10.8 M ohm, 1/4 watt, 5% carbon desistor 10.8 M ohm, 1/4 watt, 5% carbon resistor
Statement of the latest of the	R1, R3, R5 R2, R4 R6 R7,R8 R9-R17 C1,C2 C3 D1-D13 IC1 IC2 IC3 IC4 Misc.	PART	1 M ohm, 1/4 watt, 5% carbon resistor 6.8 M ohm, 1/4 watt, 5% carbon resistor 47K ohm, 1/4 watt, 5% carbon resistor 100K ohm, 1/4 watt, 5% carbon resistor 100K ohm, 1/4 watt, 5% carbon resistor 200K ohm, 1/4 watt, 5% carbon resistor 360 pF disc capacitor 0.01 mF disc capacitor 1N914, 1N4148, or equal silicon diode 4011 CMOS quad two-input NAND gates 4024 CMOS seven-stage binary divider 74C192 CMOS up/down counter 4028 CMOS BCD to decimal decoder 30 gauge control wire, touch plates, 5-15 VDC supply.
The last of the la	R1 C1 C2 D1	-	PARTS LIST FOR LINE POWER SUPPLY 7.5 K ohm, 2 watt, 5% carbon resistor 0.1 mF, 250 volt disc capacitor 50 MFD, 10 volt electrolytic capacitor 1N4004 or equivalent silicon diode (400 volt)

IN5234A zener diode (6.2 volt, 500 mW)



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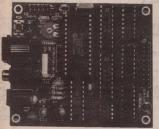
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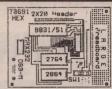
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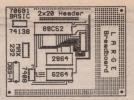
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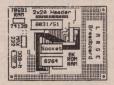


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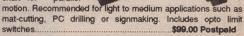
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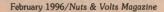
OPT101 Photodiode and Amplifier IC, works with 3V single supply 0.01% nonlinearity. Perfect for color and spot meters and other low level sensing and measuring. 5 pin vertically mounted \$5.00 Postpald

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# wents

### **FEBRUARY 1996**

CANADA - ONTARIO - ST CATHERINES - Niagara Peninsula ARC Hamfest. CONTACT: Marg Sewell 905-680-1211

CA - ANTIOCH - MarketPro Computer Show. CON-

CA - LOS ANGELES - Scientific & Technical

CA - DOS ANGLES - Scientific o Technical Instrument Show. CONTACT: AI 310-476-6277 CA - SANTEE - Ham, Computer & Electronic Swapmeet. CONTACT: Pat 619-561-0052 MA - FTCHBURG - MarketPro Computer Show.

201-265-1075

NH - SEABROOK - Northern Computer Show. CON-TACT: 508-744-8440

TN - KNOXVILLE - The Shriners of Kerbela AR

Service Hamfest. CONTACT: Paul 423-986-9562 TX - AMARILLO - Potter County ARES & Amarillo RACES Hamfest. CONTACT: Ben 806-381-8810

### FEBRUARY 3-4

FL - MIAMI - 36th Annual Dade Radio Club of Miami Tropical Hamboree. CONTACT: Evelyn Gauzens 305-

MS - JACKSON - ARRL State Convention. CON-TACT: Travis Cliett 601-939-9236

### FEBRUARY 4

CA - LANCASTER - MarketPro Computer Show.

CONTACT: 415-388-8893
CA - LIVERMORE - Swapmeet. CONTACT: Noel Anklam 510-447-3857 eves

CA - SANTA ROSA - MarketPro Computer Show. CONTACT: 415-388-8893

MA - ANDOVER - MarketPro Computer Show. CON-

TACT: 201-265-1075

ME - PORTLAND - Northern Computer Show. CON-508-744-8440

MI - SOUTHGATE - Computers & You Computer Show. CONTACT: 313-283-1754

### FEBRUARY 10

CA - FONTANA - Amateur Radio & Electronics apmeet. CONTACT: Bill Gruber 909-822-4138 CA - FRESNO - MarketPro Computer Show. CON-415-388-8893

FL - ARCADIA - Desoto ARC Hamfest. CONTACT: Doug Christ 941-494-5070

FL - PENSACOLA - ARRL Hamfest. CONTACT: Bill

Behrends 904-476-8537
MN - BLAINE - Midwinter Madness. CONTACT: e ARC 612-537-1722

RI - SMITHFIELD - MarketPro Computer Show. CONTACT: 201-265-1075

SC - CHARLESTON - 23rd Charleston ARS Hamfest δ Computer Show. CONTACT: Jenny 803-747-2324 WI - WAUKESHA - Computer Show & Sale. CON-TACT: ComShow 414-961-6003

### FEBRUARY 10-11

MA - WILMINGTON - KGP Computer Show. CON-TACT: 908-297-2526

### FEBRUARY 11

CA - SAN DIEGO - MarketPro Computer Show. CONTACT: 415-388-8893

IL - DES PLAINES - Computer Show & Sale. CONTACT: ComShow 312-665-4817

IN - SOUTH BEND - Computer/Camera Swapmee CONTACT: Roger L. Smith 219-856-3863 VM/FAX

MI - DEARBORN - Computers & You Computer Show. CONTACT: 313-283-1754

NY - STONY BROOK - MarketPro Computer Show. CONTACT: 201-265-1075
OH - MANSFIELD - InterCity ARC Mid-Winter

Hamfest/Computer Show, CONTACT: Pat Ackerman 419-589-7133

PA - LATROBE - Chestnut Ridge ARC Winterfest. CONTACT: Chris Weiss 412-537-6068

### FEBRUARY 16-17-18

FL - ORLANDO - 50th Annual Orlando Hamcation. CONTACT: John Lenkerd 407-645-2026

### FEBRUARY 17

AZ - TUCSON - SouthWest Ninety Niners User Group Fest West '96. CONTACT: Tom 520-886-2460 CA - SANTEE - Ham, Computer & Electronic

Swapmeet. CONTACT: Pat 619-561-0052

CA - STOCKTON - MarketPro Computer Show. CONTACT: 415-388-8893

IN - INDIANAPOLIS - AGI Computer Fair. CON-

MA - MARLBOROUGH - Algonquin ARC Hamfest. CONTACT: Ann Weldon 508-481-4988

MI - LIVONIA - Computers & You Computer Show. CONTACT: 313-283-1754

NY - GOSHEN - Orange County ARC Hamfest. CONTACT: Steve Voorman 914-496-8710

OR - RICKREAL - Salem Repeater Assn & Orange Coast Emergency Repeater Salem Hamfair. CON-

he 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

VA - VIENNA - 20th Annual Vienna Wireless Society

TACT: Evan Burroughs 503-585-5924

TX - SMITHVILLE - Bastrop County ARC Hamfest. CONTACT: Charlie Claiborne 512-237-3817

### FEBRUARY 17-18

CA - VENTURA - MarketPro Computer Show. CON-

GA - AUGUSTA - Computer Show. CONTACT: Richard Stephens 706-868-6814

### FEBRUARY 17-18-19

NJ - EDISON - KGP Computer Show. CONTACT: 908-297-2526

### FEBRUARY 18

CA - SACRAMENTO - MarketPro Computer Show. CONTACT: 415-388-8893

IL - ORLAND PARK - Computer Show, CONTACT: 24-Hour Hotline 708-974-3123

IL - ROCK ISLAND - 25th Annual Davenport RAC

Hamfest. CONTACT: Kent Williams 309-796-0718 MA - TAUNTON - Northern Computer Show. CON-TACT: 508-744-8440

MI - FLINT - Computer Show. CONTACT: Five Star Productions 810-230-0988

MI - LANSING - Computers & You Computer Show CONTACT: 313-283-1754

NC - ELKIN - Briarpatch & Foothills ARC's Hamfest. CONTACT: Dave Nicholson 703-755-4669

### FEBRUARY 19

MA - ROCKLAND - Northern Computer Show. CON-TACT: 508-744-8440

### FEBRUARY 24

CA - MONTEREY - ARRL Hamfest. CONTACT: Max Cornell 408-883-0491

FL - BROOKSVILLE - Hernando County ARA Hamfest. CONTACT: Glenn Brown 904-799-6755 GA - DALTON - Dalton ARC Hamfest. CONTACT:

Harold Jones 706-673-2291

IN - LAPORTE - Mid-Winter "Cabin Fever" Hamfest. CONTACT: LaPorte ARC, POB 30, LaPorte IN 46350 MI - WESTLAND - Great Lakes Computer Expo. CONTACT: 313-416-1015

MI - TAYLOR - Computers & You Computer Show.

CONTACT: 313-283-1754

NY - TROY - MarketPro Computer Show. CONTACT:

VT - MILTON - Radio Amateurs of Northern Vermont Winter Hamfest. CONTACT: WB2JSJ 802-879-6589

### FEBRUARY 24-25

CA - VALLEJO - MarketPro Computer Show. CON-TACT: 415-388-8893

**GA - ATLANTA - ComputerShow. CONTACT:** ComputerShow 770-907-6225

MI - CANTON - Great Lakes Computer Expo. CON-TACT: 313-416-1015 OH - CINCINNATI - ARRL Great Lakes Division 1996. CONTACT: Stan Cohen 513-531-1011

### FEBRUARY 25

CT - CROMWELL - MarketPro Computer Show CONTACT: 201-265-1075

IL - GLEN ELLYN - Computer Central Computer Show. CONTACT: Jay Robinson 708-940-7547
MI - DEARBORN - 26th Annual Livonia ARC Swap N Shop. CONTACT: Neil Coffin 313-261-5486 MI - MADISON HEIGHTS - Computers & You

Computer Show. CONTACT: 313-283-1754
NH - MANCHESTER - Northern Computer Show. CONTACT: 508-744-8440

NY - FREEPORT - Hamfest. CONTACT: Alex 516-

OH - CUYAHOGA FALLS - Cuyahoga Falls ARC Hamfest/Computer Show/Flea Market. CONTACT: Carl 216-497-7047

PA - PITTSBURGH - South Hills ARC Hamfest. CONTACT: Steve Lane 412-341-1043

### Winterfest, CONTACT: Paul 703-560-2779 **MARCH 1996**

### MARCH 2

AL - TUSCALOOSA - Black Warrior Swapfest. CONTACT: Kelly Bruce 205-339-7882

CA - SANTEE - Ham, Computer & Electronic Swapmeet. CONTACT: Pat 619-561-0052

FL - FORT LAUDERDALE - Narisaam Computer Show. CONTACT: 800-436-6707

KY - GLASGOW - Mammoth Cave ARC Hamfest.

CONTACT: Mark Woodcock 502-651-8777
ND - BISMARCK - 6th Annual Hamfest. CONTACT: Central Dakota ARC, POB 7162, Bismarck ND

NH - TWIN MOUNTAIN - North County ARC & Littleton ARK Ham Radio/Computer Flea Market. CONTACT: Richard Force 603-788-4428

NJ - ABSECON - Shore Points ARC "Springfest '96". CONTACT: SPARC, POB 142, Absecon NJ

OH - CINCINNATI - Computer Fair. CONTACT: Mark Hanslip 513-263-3378

CA - LIVERMORE - Swapmeet. CONTACT: Noel Anklam 510-447-3857

FL - WEST PALM BEACH - Narisaam Computer Show. CONTACT: 800-436-6707

MA - BRAINTREE - South Shore ARC Ham Radio

Flea Market, CONTACT: William 617-288-6906 MA - SWANSEE - Northern Computer Show. CON-TACT: 508-744-8440

### MARCH 8-9-10

LA - LAFAYETTE - Acadiana ARA Hamfest, CON-TACT: Nolen Griffith 318-989-9039

NE - NORFOLK - ARRL State Convention. CON-TACT: Patrick Adams 402-371-7295

AZ - SCOTTSDALE - Scottsdale ARC Hamfest. on Reynolds 602-240-0473

CA - FONTANA - Amateur Radio & Electronics Swapmeet. CONTACT: Bill 909-822-4138 eves

FL - LAKE WORTH - West Palm Beach ARC Semi-Annual Free Flea. CONTACT: Marvin 407-683-2930 KS - COLBY - Trojan ARC Hamfest, CONTACT: Jim Robison 913-462-4548

KY - HAZARD - Kentucky Mountains ARC Hamfest. CONTACT: John Farler 606-436-5354

ND - FARGO - Red River Radio Amateur's Amateur Radio/Computer Fair. CONTACT: 701-282-2876 TX - VICTORIA - Swapfest 1996. CONTACT: Victoria ARC 512-573-0821

WA - PUYALLUP - Electronics Fleamarket. CON-TACT: Mike & Key ARC, 637 2nd Ave S, Kent WA

### MARCH 9-10

NC - CHARLOTTE - Mecklenburg ARS Hamfest. CONTACT: Mary Hunt 704-841-4267 NJ - PENNSAUKEN - KGP Computer Show. CON-TACT: 908-297-2526

### MARCH 10

IL - ORLAND PARK - Computer Show. CONTACT: 24-Hour Hotline 708-974-3123

OH - CIRCLEVILLE - Teays ARC Computer/ Hamfest, CONTACT: Roy Ulko 614-477-2771 OH - CONNEAUT - 10th Annual Conneaut ARC Hamfest. CONTACT: Jack Martilla 216-593-3353 WI - WACKESHA - Sewfars Swapfest. CONTACT: Southeastern Wisconsin FM ARS 414-789-1034 All listing information should be sent to **Nuts & Volts Magazine** 

**Events Calendar** 430 Princeland Court Corona, CA 91719

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### MARCH 12-13-14

CA - LOS ANGELES - Computer Telephony Conference. CONTACT: 212-691-8215

### MARCH 15-16

AR - LITTLE ROCK - Hamfest & ARRL State Convention. CONTACT: Jim 501-246-6734

### MARCH 16

CA - SANTEE - Ham, Computer & Electronic Swapmeet. CONTACT: Pat 619-561-0052

Swapmeet. CONTAC. 1: Pat 619-961-0032

FL - ENGLEWOOD - Englewood ARS HAMCOM '96.
CONTACT: Dennis Babcock 941-698-0248

GA - MARIETTA - Kennehoochee ARC Hamfest.
CONTACT: Margaret Durham 770-977-4405

MI - MARSHALL - 35th Annual Crossroads Hamfest.
CONTACT: SMARS 616-979-3433

NJ - PHILLIPSBURG - Micro Mart Computer Show. CONTACT: 609-924-2344

### MARCH 16-17

FL - FORT WALTON BEACH - Playground ARC Ham/Swapfest. CONTACT: Scott 904-244-3182 GA - PERRY - Middle Georgia ComputerShow. CON-TACT: ComputerShow 770-907-6225

NJ - WAYNE - KGP Computer Show. CONTACT: TX - MIDLAND - Midland ARC Hamfest, CONTACT:

### Larry Nix 915-699-5441 MARCH 17

MI - FLINT - Computer Show. CONTACT: Five Star

Productions 810-230-0988 MI - NOVI - Great Lakes Computer Expo. CONTACT:

OH - MAUMEE - Toledo Mobile Radio Assn's 41st Annual Hamfest/Computer Fair. CONTACT: Brian Harrington, 4463 Holly Hill Dr, Toledo OH 43614 OR - MILTON-FREEWATER - Walla Walla Valley

ARC Hamfest. CONTACT: David 509-525-2529

PA - DOVER - 9th Keystone VHF Club York Springfest. CONTACT: Ted Rodes 717-259-8063, FAX 717-259-7870

PA - MONROEVILLE - Two Rivers ARC Hamfest/ Computer Fair. CONTACT: TRARC, POB 225, Greenock PA 15047

### WI - JEFFERSON - Tri-County Arc Hamfest. CON-TACT: TCARC 414-563-6502 eves

MARCH 23 FL - MARTIN COUNTY - 20th FREE Hamfest. CON-MCARA, POB 1901, Stuart FL 33495

**FL - SEBRING** - 3rd Annual Highlands County ARC Hamfest. CONTACT: Clyde 941-453-7181 IN - INDIANAPOLIS - AGI Computer Fair. CON-TACT: 317-299-8827

MI - CANTON - Great Lakes Computer Expo. CON-TACT: 313-416-1015

MO - KANSAS CITY - Ararat AR Shrine Club Hamfest. CONTACT: Roger Bessmer 816-842-0400 NJ - WEST ORANGE - Irvington-Roseland AC Hamfest. CONTACT: Jim Howe 201-402-6066

### MARCH 23-24

AL - HUNTSVILLE - ComputerShow. CONTACT:

ComputerShow 770-907-6225 Hamfest & ARRL Section Convention. CONTACT: Merlin 918-272-3081 PA - FORT WASHINGTON - KGP Computer Show. CONTACT: 908-297-2526

### MARCH 24

IL - GLEN ELLYN - Computer Central. CONTACT: 708-940-7547

IL - STERLING - 36th Annual Sterling-Rock Falls ARS Hamfest. CONTACT: Lloyd 815-336-2434 MI - ANN ARBOR - Colossal Computer Sale. CON-TACT: 313-971-0990

MI - MIDLAND - Computer Show, CONTACT: Five

Star Productions 812-230-0988

NJ - TRENTON - Hamcomp '96. CONTACT: Delaware Valley Radio Assn Hotline 609-882-2240
NY - YONKERS - WECAfest. CONTACT: Thomas Rafaelli 914-741-6606

PA - ASTON - Camera & Video Show. CONTACT: Adam Rifkind 610-527-5903

OH - MADISON - Lake County ARA Hamfest. CON-TACT: Roxanne 216-256-0320

WV - CHARLESTON - ARRL Hamfest. CONTACT: Jimmie Hewlett 304-768-1142

### MARCH 29-30

GA - COLUMBUS - Columbus ARC Hamfest. CON-TACT: Randy Hancock 706-596-8820

### MARCH 29-30-31

CO - GOLDEN - 5th Annual ENTCOM. CONTACT: Midnight Engineering Magazine 719-254-4558

### MARCH 30

CT - WATERFORD - Radio Amateur Society of Norwich's Ham Radio Auction. CONTACT: Tony 203-

IN - COLUMBUS - Columbus ARC Hamfest, CON-TACT: Marion Winterberg 812-342-4670

KY - ELIZABETHTOWN - 17th Annual Lincoln Trail ARC Hamfest. CONTACT: LTARC, POB 342, Vine Grove KY 40175

MI - MICHIGAN CITY - Michigan City ARC Hamfest & Computer Flea Market. CONTACT: Ron Stahoviak

MI - WESTLAND - Great Lakes Computer Expo. CONTACT: 313-416-1015

NJ - UPPER SADDLE RIVER - Chestnut Ridge Radio Club Flea Market. CONTACT: Andy 201-261-3783, FAX 201-261-1038
TN - TULLAHOMA - Middle Tenneessee ARS

Hamfest. CONTACT: Ernest Moore 615-728-9473

### MARCH 30-31

GA - NORCROSS - Atlanta Area ComputerShow. CONTACT: ComputerShow 770-907-6225 MD - TIMONIUM - Baltimore ARC Hamboree/ Computerfest & State Conv. CONTACT: William Dobson 410-426-3378

### MARCH 31

CA - SANTA ANA - ACP Swapmeet. CONTACT: Mary Russo 714-558-8813

CT - SOUTHINGTON - Southington ARA Flea Market. CONTACT: Chet 860-628-9346

IL - GRAYSLAKE - Libertyville/Mundelein ARS

LAMARSFEST '96. CONTACT: Frank Avellone 708-234-4124

NC - KINSTON - Down East Hamfest. CONTACT: Jean DuPree 919-524-5724

### **APRIL 1996**

AL - ALBERTVILLE - Marshall County ARC MountainFest. CONTACT: Buddy Smith 205-593-2516

CA - SANTEE - Ham, Computer & Electronics Swapmeet. CONTACT: Pat 619-561-0052 CO - LONGMONT - LARCFEST. CONTACT Longmont ARC, POB 86, Longmont CO 80502-0086
PA - PHILADELPHIA - Micro Mart Computer Show. CONTACT: 609-924-2344

TX - WICHITA FALLS - Wichita ARS Hamfest. CONdson 817-586-0215

VA - VIRGINIA BEACH - Chesapeake ARS Hamfest. CONTACT: Preston Ipock 804-543-4610

### APRIL 7

CA - LIVERMORE - Swapmeet. CONTACT: Noel Anklam 510-447-3857

### APRIL 12-13

MS - TUPELO - Tupelo, Booneville & Monroe County ARC's Hamfest. CONTACT: Jack Ellis 601-842-7255

OK - LAWTON - ARRL State Convention & Hamfest. CONTACT: Robert Morford 405-355-6120

### APRIL 13

CA - FONTANA - Amateur Radio & Electronics Swapmeet. CONTACT: Bill 909-822-4138 eves Swapmeet. CONTACT: Bill 909-022-4130 eves
KY - BOWLING GREEN - Kentucky Colonels ARC
Hamfest. CONTACT: Leon Garrett 502-842-5307
ME - PORTLAND - Portland Amateur Wireless Assn Hamfest. CONTACT: Ronald Levere 207-846-9090 MO - JOPLIN - Joplin ARC Hamfest. CONTACT: Andy Gabbert 417-673-8371

PA - FREDERICKSBURG - Appalachian AR Group Hamfest. CONTACT: Mark Schropp Jr 717-754-7700 WA - SPOKANE - Inland NW Hamfest. CONTACT: Al Lafky 509-924-3475

### APRIL 13-14

TN - NASHVILLE - ComputerShow. CONTACT: ComputerShow 770-907-6225

NC - RALEIGH - Raleigh ARS Hamfest, Convention & Computer Fair. CONTACT: Rollin Ransom 919-269-4406

NJ - NEWARK - Micro Mart Computer Show. CON-TACT: 609-924-2344

WI - MADISON - Madison Area Repeater Assn Hamfest. CONTACT: Jim Waldorf 608-245-8890

### APRIL 19-20-21

CA - VISALIA - ARRL Int'l DX Convention. CON-TACT: Don Bostrom 818-784-2590

### APRIL 20

CA - SANTEE - Ham, Computer & Electronic eet. CONTACT: Pat 619-561-0052 MI - MUSKEGON - Muskegon County ARES/RACES Hamfest. CONTACT: Tom Vander Mel 616-733-2963

### APRIL 20-21

GA - ATLANTA - ComputerShow. CONTACT: ComputerShow 770-907-6225

NJ - WEST WINDSOR - 21st Trenton Computer Festival. CONTACT: TCF '96 717-529-6134

DE - NEWCASTLE - Penn-Del ARC Hamfest. CON-TACT: Hal Frantz 302-798-7270

IL - ARTHUR - Moultrie ARK 34th Annual Hamfest. CONTACT: Ralph Zancha 217-873-5287 IL - ORLAND PARK - Orland Park Computer Show. CONTACT: 24-Hour Hotline 708-974-3123 MA - CAMBRIDGE - MIT Flea Market. CONTACT:

Nick 617-253-3776 MI - FLINT - Computer Show. CONTACT: Five Star

Productions 810-230-0988

### APRIL 27

KY - OWENSBORO - Owensboro ARC Hamfest. CONTACT: Suzzie Young 502-684-5157
MI - WESTLAND - Great Lakes Computer Show.

CONTACT: 313-416-1015 MT - BUTTE - Butte ARS Hamfest, CONTACT: Bob

Evans 406-494-3066 OR - ROSEBURG - Ham Radio & Computer Show. CONTACT: UVARC 503-673-1310

WA - VANCOUVER - Clark County ARC Hamfest. CONTACT: Wayne Schuler 360-896-8909

FL - GAINSEVILLE - 9th Annual Hamfest & Computer Show. CONTACT: Bill Wells 904-454-3105 KY - LOUISVILLE - Computer Fair. CONTACT: Mark Hanslip 513-263-3378

MI - GROOSE POINT WOODS - Southeast MI ARA Hamfest. CONTACT: Thomas Orlicki 313-527-3497
NY - POUGHKEEPSIE - Mt. Beacon ARC Hamfest. CONTACT: Ken Akasofu 914-485-9617
OH - ATHENS - Athens County ARA Hamfest. CONTACT: Drew McDaniel 614-592-2106

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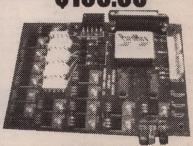
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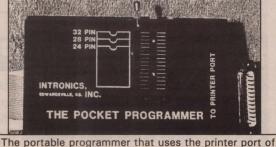
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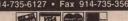
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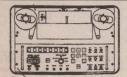
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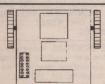
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NV-5750	. \$319	\$299	CALL

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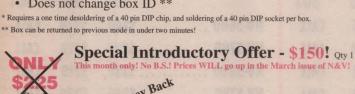
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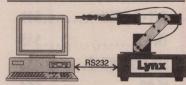


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HEATH COMPANY is selling photocopies of most Heathkit manuals. Only authorized source for copyright manuals. Phone: 616-925-5899, 8-4 ET.

SAMS PHOTOFACTS 511 to 1950. \$4 per folder in lots of ten or more. Will sell complete set negotiable. Call: JBRD Hess & Assoc., 212 E. Main, Braidwood, IL 60408. 1-800-458-0083.

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	13.8 VOIT D	CPOWE	R SUPPLI	ES
	Amps	Amps		Unit
Part #	Constant	Surge	Wattage	Price
PS-6	4	6	90	\$35.95
PS-8	6	8	140	\$39.75
PS-10*	10		320	\$172.70
PS-12	10	12	200	\$65.90
	20			\$119.90
• P:	S-10 ADJUSTA	ABLE OTO	20 VDC	
· Al	I HAVE DUA	METERS	S FXCFPT #F	S-8 & PS-8

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Mis-Cyn Electronics 7211 Olde Salem Cr. Hanover Pk. IL 60103



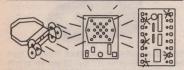


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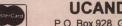
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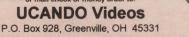
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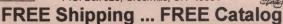


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MANUALS WANTED for amateur, audio, test equipment, TV, VCR. A.G. Tannenbaum, Box 386, Ambler, PA 19002. 215-540-8055, FAX 215-540-8327.

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

WANTED: MANUAL copy for Hickok 1805A scope (Tek 545 copy), and type 1823A plugin (CA copy). Harold Hagen, 2428 SW Myrtle St., Seattle, WA 98106. 206-768-1043.

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WANTED: CLEAN used copy of "Power Line Filter Design for Switched Mode Power Supplies" by Mark J. Nave. Book must be complete and in good condition. Please contact, J.D. Wexler at 310-391-4093.

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CHEAP RECEIVERS! Motorola tone/voice pager boards. Complete, less case. Experiment, use for radio control, etc. Choice of 35MHz, 43MHz, 152MHz, or 450MHz. Order part #NZ525, Wt 3 oz., \$6 ea., 5 for \$25 + UPS. MDM Radio, Ltd., 7112 W. Roosevelt Rd., Oak Park, IL 60304. Tel. 708-848-4310. 848-4210

FOR SALE: KLM 10-30MHz 7el log periodic, cost \$1,000, sell \$500 or trade? John, 2175 Wagner Dr., Caro, MI 48723. 517-673-4312. WA8CKT.

TUBES, NEW, unused. Send self-addressed, stamped envelope for list. Fala Electronics, Box 1376-3, Milwaukee, WI 53201.

CNC BUILDERS: stepper motors, machines, linear rails, several sizes of stepper motors, some servo motors and misc. drivers. Industrial equipment removals. Price list. Jim DuBois, 330 State Road 101, Amherst, NH 03031. 603-673-3645.

# RESOURCE BIN

number forty-nine

# **Fundamentals of Nutting and Volting**

ur 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

A portion of my PSRT RoundTable on GEnie has also been set aside for you Nuts & Volts readers. This is the place you go for instant tech answers. Among the many files in our library, you will find complete reprints for all the Resource Bin columns.

I did manage to wrangle one super special sign-up deal for you Resource Bin readers. Ten free hours

GEnie now offers far lower daytime rates, a direct Internet access, plus a Windows graphics interface, so it's an even better deal than ever.

See the trailer blurb for details.

### **Nutting and Volting**

Um, somehow we got up to column #49 and the start of our fifth year. So I guess it might be time to review just where we're at and where we seem to be heading.

Our two-fold charter has always been "finding places to get stuff." And "finding places to learn stuff." If it is unusual, oddball, or off-the-wall, so much the better.

I've always gone on the theory that if it interests me, it just might interest others of a technical bent.

All of my previous columns are now offered online on GEnie PSRT. They are also available in bound hard copy from my Synergetics Press. I'm in the process of wrapping some super powerful search engines around my entire library. By using Adobe's great Acrobat Search and Catalog features. I am also hoping to put all of this on a CD-ROM. Real soon now.

Let's start off with ...

### Magazines

It appears rather insulting to call them "hobby" or "popular" magazines. For they often have the best technical content and often the most genuinely useful information. They also seem to care a lot more about all their readers than the trade journals do.

You obviously know about Nuts & Volts, since you are reading this. Here are several of my other

Electronics Now is the largest and oldest of newsstand electronic mags. Publishing fairly advanced technical content. I have a Tech Musings column here. Their sister publication is called Popular Electronics and tends to focus on simpler and easier projects. Note that this is not the original PE of Carl and Jerry fame.

Steve Ciarcia still publishes a great Circuit Cellar magazine. It's got mostly advanced projects on microcontrollers and on home automation.

Richard and Karen Perez publish Home Power. This is the source for info on everything from rural solar energy to electric cars to alternate

### **NEXT TIME:** Don looks at prototyping plastics and injection molding

And have also got a definitive new solar reference CD.

A number of special interest tech magazines are published by The Audio Amateur. Besides their flagship title, these include Speaker Builder and Glass Audio. The journal for the rabid fringe of the tube set is Sound Practices.

I particularly like their "definitive midrange to upper register sonority" when talking about certain brands of type 80 rectifier tubes. The key secret for vacuum tube sound is simply to add hum, noise, and distortion to an otherwise clean audio channel.

There are quite a few ham radio magazines that we did review back in NUTS17.PDF.

Midnight Engineering is one superb and hog-on-ice independent journal on small scale technical startups. I do a Blatant Opportunist col-

So much for the obvious. What else do I read? A lot, actually, since I now subscribe to over 600 magazines and trade journals. I guess my favorite of all is Whole Earth Review whose access to tools mandate does seem to closely follow my elegant simplicity goals.

That Wall Street Journal, of course. Especially their Technology section that usually appears on page B4. And Science magazine for their very latest ongoing developments in everything. Actually, *Nature* is better, but I can't afford both of them.

I kinda like Skeptical Inquirer, since pseudoscience bashing is a fiendish hobby of mine. More pseudoscience in NUTS18.PDF and in NUTS26.PDF. And especially FactSheet Five which reviews thousands of labor-of-love 'zines each

### **Trade Journals**

By far your best way to get techliterate on any subject is through the trade journals. These are littleknown, largely advertiser-driven mags which tightly target specific interests. They never appear on newsstands and only rarely show up in any but the largest of technical libraries.

There are over 85,000 trade journals being published today. Most of them are free to "qualified" subscribers. You "qualify" by telling them what they (and all their advertisers) wish to hear on all their qualification cards. It does help to have a registered trade name and a laser printed

letterhead. Both of these are

trivial these days.

The best place to find out all about trade journals is the Ulrichs Periodicals Dictionary. Available online through GEnie or on the reference shelf of your library. There is also an International Standard

Periodicals Dictionary.

Let's see. For electronics, your best trade journals are Electronic Design, E.E. Times, EDN, Electronic Products, and Electronic Component News. Such specialty publications as R.F. Design, Sensors, Measurement & Control, and PCIM are also highly

Of those mechanical trade journals, my two favorites are Design News and Machine Design. But your best freebie sample offers usually appear in New Equipment Digest.

The Industrial Market Place is a big industrial surplus shopper. Primarily scads of great mechanical buys. With some computers and electronics.

There are great heaping bunches of trade journals. Some random samples I have found handy: GPS World, Fire Engineering, Video Toaster User, Foiled Again, Powder

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mentality of mergers and acquisitions, IRS rules that pay publishers to shred books, and the

zines, and online resources. Between the blockbuster

22 week turnover economics of chain bookstores, the end reader has been left completely out of the loop. The bottom line is that it's real hard to conveniently find any fairly priced technical book that can exactly meet your needs

At any rate, we looked at the best of the best back in NUTS11.PDF. Many of you felt that The Art of Electronics by Horowitz, my CMOS Cookbook classic, and that Radio Amateur's Handbook are the "must have" starting points.

About the worst possible place to find a technical book is some mall chain storefront which has a sign that says "Bookstore" outside it. Instead, seek out larger technical booksellers. Especially those in and around main universities. A few favorites of mine do include Computer Literacy, Op-Amp Books, and the Stanford Bookstore.

But your best bet by far is to go to those direct mail resellers who offer specialty book services. All of the best titles in any narrow field. With all the dregs and dogs removed.

Let's see. Lindsay Books for antique electronics, craftsman machine shop stuff, and general-

obscure how-to. The MIX Bookshelf or everything audio and video. That Audio Amateur for hi-fi, speakers, and tube audio. SAE Library for most automotive. AEE for energy books. Mondotronics for robotics. And Navtech for GPS and navigation.

Telecomm Books for anything in and around the phone network. Electronic Servicing for repair titles. Coriolis for its Windows and PC titles. And Media Magic for comput-

ers in science or art. Or my own Synergetics for only the very best of all PostScript titles. I've also just picked up a great heaping batch of used technical books at very low prices. You can write, E-Mail, or call for a complete list.

Jukin, Horsetrader, Converting, Recharger, and Telecom Sources. Typical computer trade mags

lately seem to be jammed full of overhyped drivel. They appear to go out of their way to deprive their end users of any useful technical content.

& Bulk Solids, Printwear, Always

Especially anything that empowers end users or saves them money. Or is critical of their advertisers. But I do find InfoWorld to be one highly useful exception. And MacWeek to usually be fairly informative.

By far, the best buys in computers show up in Comp-U-Mart, Computer Reseller, and Computer Hotline.

Much more on trade journals can be found in NUTS08.PDF.

### **Online Resources**

Getting yourself online-literate is essential these days. An obvious route is the Internet with its humongous collection of primarily public domain material. The overwhelming majority of which is sorry drivel and diffuse dregs. Not to mention the obnoxious flamers and uninformed time wasters. All of which you will have to wade on through to get at the buried gems.

Alternately, there's the commer-

cial online services that provide higher quality and more tightly focused info. But at higher cash-and-carry prices.

Of the commercial services, America Online, CompuServe, and the Microsoft Network are your three largest. I still like Genie the best of all, though. First, because they pay me to say things like that. And second, because GEnie still has the finest in the area of quality technical downloads and third party games.

And - get this - they are in the black. Mostly by avoiding the insane overpromotion and overhyping of the big three. Last count, I've received ninety-four AOL sign-up disks.

All services offer free sign-up trials and free software on their floppy or CD-ROM mailings.

A third route is to use your local labor-of-love BBS independents. But the best of these are rapidly moving onto the net. And the rest may need long distance phone surcharges. More details in Boardwatch magazine.

There's two approaches to Internet access. All of the commercial services offer Internet gateways. These can be your best-of-both worlds. Except that their hourly costs will eat you alive if you spend more than 20 hours a month on the net.

The commercial services are

also a good way to sample the net without fully committing yourself.

The other route is to go through a local Internet service provider. Their typical charges these days are around \$25.00 per month. With surcharges for extra storage or excess access hours. One example of a local provider is ZEKE@ZEKES.COM

The latest of Internet services let you make phone calls to anywhere in the world for the price of a local call.

There's lots of Internet directories. Printed (the Gale Guide to the Internet Databases), on CD-ROM, or online. The highest profile online search service is YAHOO.COM

As secure petty cybercash becomes available, the quality of the Internet content should dramatically improve. Vastly better reference materials can be offered at 20 cents a download than they can with "free" distribution. Expect to see a convergence between net charges and commercial services.

I have posted a listing for the top electrical engineering Internet sites to MUSE94.PDF.

Tech books place a distant fourth behind trade journals, maga-

### **Learning Electronics**

Sadly, a lot of community colleges are now dropping their electronics programs. Even sadder, there is far more money to be made in selling off their surplus lab stuff than there ever was teaching for them.

In one case, electronics got dropped because the football team needed the money. Seems they were paying the spectators \$58.00 each to attend the home games and it just wasn't enough.

### RESOURCE BIN

To me, this is shooting your seed corn in the foot. Or, more bluntly, it is pissing in the soup.

If your community college still has an electronics program, grab it before it folds! This is often your most cost-effective choice towards learning and understanding tech fun-

These days, your finest technical education will be a mix of traditional electronics with computer software and programming. That formal BSEE with a masters in computer science seems like a winning route to me. But beware of corner cutting. I feel the BSEET technician degree is largely a cost-ineffective ripoff. That locks you into second rate positions. Especially in more traditional firms.

Yeah, Heathkit is still in business. They have superb technical education and self-study courses. They just cost a lot more than they used to and have a much lower profile. They are still by far your best

home study bet.

I can't emphasize enough just how important your trade journals are in becoming electronics-literate. These should be the first and foremost route towards all technical education. And are by far the most costeffective.

### **Research Fundamentals**

How can you find out everything about anything? Once again, the trade journals are one good starting point. Closely followed by the online search services. But the best way I've found is with the Dialog Information Service. Yeah, it's expensive. But it instantly gives you the very latest and best on any technical subject.

Dialog is available by the minute at your local library. Or cash-and-carry on GEnie and other online services.

At the local library, try Ulrich's, the Encyclopedia of Associations, the Thomas Registry, or the Science Citations Index. And, if you do not personally own a copy yet, the Business Phone Book CD. Or one of their competitors.

To get a reprint on any reasonable story, go to UMI, formerly University Microfilms. They've also opened a new division called The Information Store, from where you can pick up the really oddball and tricky-to-find stuff. Like conference proceedings and such.

Many government documents are available retail in a national chain of US Government Bookstores. I've listed one in the N/V sidebar. An instant, but pricey, source for most standards is Global Engineering Documents.

More on research fundamentals are found in my NUTS30.PDF. Standards organization info in HACK47.PDF.

### **Building a Data Library**

A good way to build up a technical data library is to start with the trade journals and then use the bingo cards to score data books and applications manuals. There's lots of free technical information out there. Full names and numbers appear in NUTS20.PDF.

And, of course, you will want to collect all of the mail order catalogs. Especially the electronic biggies such as Mouser and Digi-Key. Maybe even old line full service distributors such as Allied or Newark. Plus Grainger.

Then get my surplus favorites that do include American Science & Surplus, C & H Sales, and Surplus Traders. Plus, of course, good old Edmund Scientific and Fair Radio

Do aim for a bare minimum of 100 lineal feet in your data library. This is just barely enough to let a rank beginner squeak by.

### Starting a Lab

We reviewed what you'll need in

test equipment in NUTS25.PDF. You'll want a volt-ohm-milliammeter. either digital or analog. Along with a decent lab power supply or two.

If you are at all serious about what you are doing, a good oscillocope is a must. Your three choices are simple - Tektronix, Tektronix, or Tektronix. As brand new; as aerospace recycled 465 era instruments; or as the classic Tek doghouses such as the 545, and found in most markets for around \$150.00. Stan Griffiths has written a great Selecting Restoring a Classic Oscilloscope.

His sequal on the newer Tek scopes is supposedly in the works.

The first thing to do with your lab, of course, is get your Basic Stamp up and running. The PIC is the chip of the decade. No matter what your project, you can make it faster, cheaper, and better by adding a PIC to it.

Start with the Microchip Technology data books, all the Stamp documents from Parallax, and those Scott Edwards Tools. I've got most of the stamp ap notes and Scott's reprints up on GEnie PSRT. More PIC in MUSE98.PDF.

If you get into repairs at all, you might find Electronic Servicing to be of major interest. The usual sources for replacement semiconductors include ECG and NTE. Your best place to get really obsolete or out-ofdate chips is Rochester Electronics. More on obsolete semis in NUTS02.PDF. And more on electronic servicing in NUTS27.PDF.

I've got some great buys in surplus test gear. Especially on Heath digital logic breadboards. Call or write for a free catalog. Or you can grab this as SURPCAT1.PDF on GFnie PSRT

### **Your Own Tech Venture**

The fun really starts when you try to convert your tech interests into a paying venture. Once again, Midnight Engineering is your finest bimonthly magazine for this sort of thing. My Incredible Secret Money Machine II and my Case Against Patents should be of help, as well. I also run a US technical helpline on start-up topics.

Details per the end blurb.

### This Month's Contest

For our contest this month, just tell me about anything that seemed to be missing from our previous columns. Or tell me about anything new which you'd like to see in the way of secret insider resources.

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 allexpense-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.

To be fair to everyone, all entries must be written and mailed. NV

icrocomputer 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 now the sysop of GEnie PSRT, where a special Resource Bin topic has been reserved for Nuts & Volts readers. For modem access: (800) 638-8369. When prompted, enter JOINGENIE. When asked for an offer code, enter DMD524.

You can also reach Don at Synergetics, Box 809, Thatcher, AZ 85552. Or send any messages to his US Internet address of SYNERGETICS@GENIE.COM

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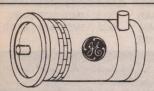
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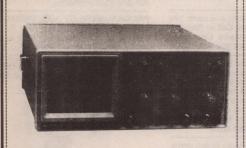
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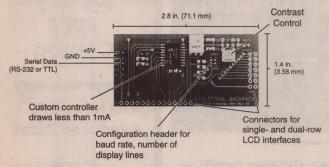
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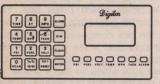
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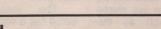
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# Build A Mini Quad Video Switcher



### by Michael Davenport

his project is a platform that allows the 16C55 and 16C57 microcontrollers to switch up to 10 signals (in pairs) onto two separate buses. It does not have to be a quad video switcher. The microcontroller socket is like a little "Borg Interface" already connected up to the real world, just waiting for a new microprocessor configuration to come along and be "assimilated." The PC Board is only 2-3/4 by 3 inches so it should fit easily inside a wide variety of applications.

Since this circuit uses the 4066 quad bilateral switch, it could also be used to switch between five stereo audio inputs, although all the "sequencing business" is a bit unnecessary. You could write a PIC for serial control of the switching. Since the 16C55 has 20 input/output pins, it could be used to control 10 pairs of stereo audio inputs with no fancy pin matrixing. Each control line and each input line could have its own pin. Ah, the luxuries of modern convenience. Instead of becoming smarter, we will just have more and more I/O pins on our microcontrollers.

Of course, the 4066 which does the actual switching does not need much explaining. It is simple as dirt to use, yet precious as gold. The signal comes in on one pin and goes out on another when you put the juice to the control pin. There are four of these in a single 4066. U2 (see schematic, Figure 1) switches the VCR inputs onto the two buses and controls VCR muting, U3 switches the four audio inputs onto the audio bus, and U4 switches the four video inputs onto the video bus.

The thing is controlled by a routine that handles four blocks of code, each representing a camera or input.

# (That's Really a General Purpose Signal Control Platform for PIC's 16C55 & 16C57)

Each block is executed in turn if a bit is detected (LED turned on) at bit 5 (pin 6) of port RC. This pin is turned on both during initialization of the program (so the unit comes scanning after power up) and by pressing the "Auto" button. If an individual camera or the VCR is selected

this bit is wiped out and the routine jumps the "blocks" and continues scanning the input pins for a change.

The "Skip" switches connect to pins RA0-3 which are normally pulled high (as are all of the input pins). Grounding a pin causes the routine to skip the respective input. If you like, the DIP switch can be left

out and wires run to an alternate location, like the front or rear panel. Alternatively. these four I/O lines can be used for almost anything if you write and program your own controller.

The reset circuit has a voltage detector IC (U6) which holds U1, pin 28, low (in reset) until the supply voltage reaches a workable level, preventing stalls on power up.

This switcher features a "muting" circuit which is missing in a couple of the commercial units. On some switchers when you select "VCR" and the VCR is

in the stop mode, a video feedback of flashing white horizontal bars appears on the monitor screen. The signal is removed from the out to VCR pins (pin 1 and pin 4 of U2) when the VCR is selected as an input. Little NPN transistor Q1 inverts the high VCR select signal present on pins 6 and 12 of U2, and grounds the control pins (5 and 13) for the out

to VCR signal which are normally held high (ON) by pull-up resistor R21.

Also featured is a front panel pushbutton speed control. The speed is changed by sampling the respective input pin and adding to (slower) or subtracting from (faster) a variable that controls the number of trips through a delay routine.

### Construction

Drill a lot of holes in a box. Solder the electronic parts onto the board. Mount the board in the box.

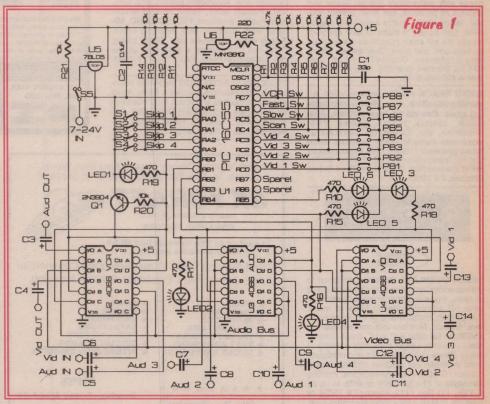
In place of RCA phono jacks you could use phone jacks, BNC connectors, DB-9/25, or bare wires hanging out of a hole in the back of a box. The templates for the "642" box (Figure 2) are at the correct scale when the hole centers (excepting the DC power jack) are on exactly half-inch centers in the vertical and hori-

work (R11-14) has a dot at one end. This end goes toward the outside edge of the board as seen on the component layout (Figure 4).

The wire location chart (Figure 5)

Learn how to program PICs and upgrade the bejeebers out of them.

indicates the board hole to use for each switch, LED, or I/O jack. It is easiest to solder all of the wires into the circuit board holes first, then mount the board and solder the wires to the box components (see photo). Be sure and leave your wires long enough. If you are careful, you can plan your wiring so that it is possible to pull the board out enough to work on it. I use 24 gauge telephone wire



zontal directions.

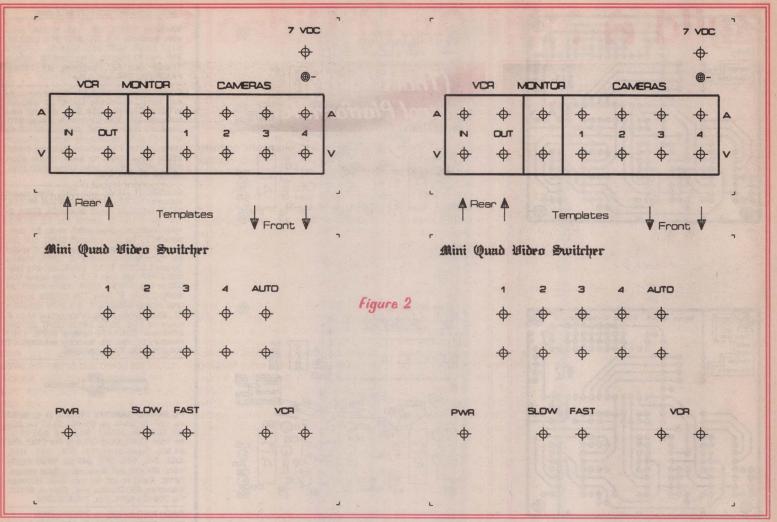
In the interest of making a simple one-sided board (see foil pattern, Figure 3), there are a few (nine) jumpers. All of the jumpers can be easily eliminated if you want to make a two-sided board. Note jumpers J1 and J3 share a hole near U2. All resistors should be stood on end.

Note that the SIP resistor net-

for most of my projects because it is inexpensive and works fine. Using shielded cable grounded at both ends for all connections can increase isolation between inputs for the connoisseur.

### Connection

Select a value of coupling capac-



itor (C3-14) or resistor that is appropriate for your application; 4.7 uF is a good value for general purpose audio coupling. A 47 to 100 uF capacitor will effectively pipe aboard your video signals while providing isolation from DC offset between stages. Some video applications use resistors in the range of 60 ohms to 10K ohms in place of the capacitors. Also, you may need to add a 75-ohm resistor connecting the signal inside of the capacitor/resistor (not the 4066 side) to ground for each of the video inputs to match the impedance of the video line. You can solder these resistors on the foil side of the board if you need them. (This will make your PC board look like a real VCR part!) Experiment with your application to find out if you need the 75-ohm loads.

#### Operation

After power-up, the switcher begins switching the four sets of inputs onto their respective buses, one at a time. If you press one of the four "Camera" switches, or the "VCR" switch, the unit will stop switching and stay on that selection. Pressing the "Auto" button resumes automatic camera selection. The switcher starts scanning at a rate of about one camera each three seconds.

When you adjust the scan speed with the "Fast" and "Slow" buttons, the four camera LEDs give you an indication of where you are in the speed adjustment. Each time you press the "Slow" button the scan jumps to camera 2, one LED left of center. When you reach the lower limit of the speed settings, the scan jumps to camera 1, far left of center, each time you press the "Slow" button. The "Fast" button operates conversely. Each press of the "Fast" button jumps the scan to camera 3, one position right of center, and once you reach the upper speed limit, the scan jumps to camera 4, the far right, with each press.

#### Upgradeability

Socketing the PIC provides for easy upgradeability. Since the switcher is already microprocessor controlled, it could be upgraded to provide such things as external serial control, timer or event control, front panel programmability using existing LEDs and buttons, etc., all by replacing IC1 and the simple addition of a resistor and/or jack if anything. There are still two I/O pins left over! (Shame.) A smarter microprocessor could come along and make this little

Some applications might include remote serial control of PA, musical

instruments, digital signals. Computer control of multiple computer internal audio sources.

C1 and R1 are the external RC clock components. If you have a frequency counter that needs playing with, connect it to unused pin 3 of IC1. This signal is the oscillator (clock) frequency divided by four. At +5.03 volts supply, my pin 3 is reading about 721.3K which x 4 is the oscillator frequency of 2.89 MHz. Since our circuit does not need to be synchronized with anything else or make measurements, then this clock is accurate enough. You will want to use a crystal timebase if you are going to build an accelerometer for the space shuttle, though. It would take a rocket scientist just to change the light bulb in it. Isn't electronics fun?! NV

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#### Where do these things come from?

nspiration for this circuit came from several sources. Nuts & Volts reader Rick Halchuck, from Woburn, MA recognized the need for a cheap video switcher in the Jun. '95 issue. Rick, you wanted a design from a rocket scientist, but how about one from a chicken farmer instead? Thank you, Don Lancaster for turning me on to the 4066 in your Dec. '94 Resource Bin, "The Greatest Electronic Parts of All Time." (This article is what electronics is all about!) Scott Edward's excellent work, "The PIC Source Book" has been a great frame of reference for learning how to accomplish specific tasks with a microcontroller. Finally, thanks to Nuts & Volts Magazine for bringing us all together, one big happy family!

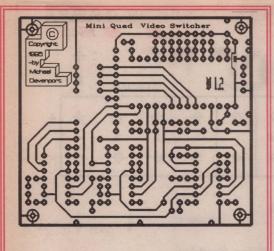
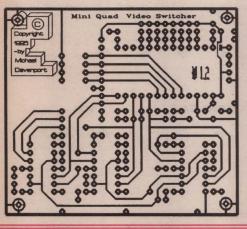


Figure 3



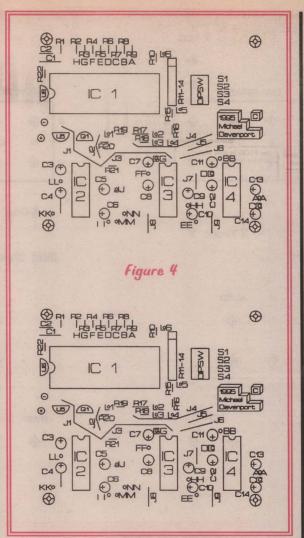


Figure 5 WIRE LOCATIONS			
Symbol	Wire to:	Symbol	Wire to:
A	Vid 1 Sw	AA	Vid 1 IN Jack
В	Vid 2 Sw	BB	Vid 2 IN Jack
С	Vid 3 Sw	СС	Vid 3 IN Jack
D	Vid 4 Sw	DD	Vid 4 IN Jack
E	Scan Sw	EE	Aud 1 IN Jack
F	Slow Sw	FF	Aud 2 IN Jack
G	Fast Sw	GG	Aud 3 IN Jack
Н	VCR Sw	НН	Aud 4 IN Jack
THE STATE OF	APPLICATION OF THE PROPERTY OF	II	VCR V IN Jack
L1	VCR LED +	JJ	VCR A IN Jack
L2	Vid 1 LED +	KK	VCR V OUT Jack
L3	Vid 2 LED +	LL	VCR A OUT Jack
L4	Vid 3 LED +	ММ	Monitor V Jack
L5	Vid 4 LED +	NN	Monitor A Jack
L6	Scan LED +	S1	Skip Vid 1 Sw
Side and	New Indiana and	S2	Skip Vid 2 Sw
+	DC Power Pos	S3	Skip Vid 3 Sw
30.00	DC Power Neg	S4	Skip Vid 4 Sw

#### Semiconductors

U1: PIC16C55 microcontroller programmed with Mini Quad Switcher firmware

(see sources) U2,U3,U4: CD4066B quad bilateral switch U5: 78L05 voltage regulator

(Mouser# 333-78L05A) U6: MN1381Q reset circuit

(Digi-Key# MN1381-Q-ND) Q1: 2N3904 NPN transistor

LED1-LED6: panel mount LEDs

#### Resistors

R1: 4.7K R2-R9, R20-R21: 10K R10, R15-R19: 470

R11-14: SIP resistor network, 10K

(Mouser# 592-6S-10K)

#### Capacitors

C1: 33 pF C2: 0.1 uF C3,5,7,8,9,10: 4.7 uF C4,6,11,12,13,14: 47 uF

#### Miscellaneous

S1-S4: 4 gang DIP switch

(Mouser# 106-1204)

\$5: mini SPST toggle switch

PB1-PB8: SPST momentary pushbutton switches

J1-J14: RCA phono female or BNC female iacks

J15: 5.5mm DC input jack Metal enclosure: LMB MDC-642

(Mouser# 537-MDC642-BI)

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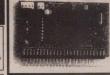
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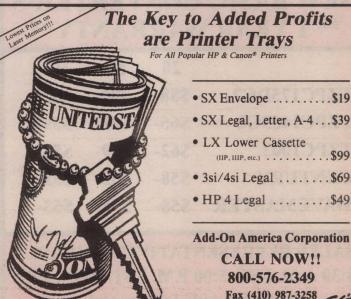






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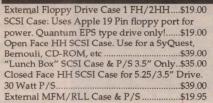
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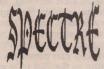


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Tom G. - FL Excellent Service, fast and quick. The only bad thing about this company is they don't sell Cable Boxes. We hope someday they will....

David P. - CA We called around for help on filters and nobody had any answers except one, call the "THE FILTER COMPANY" we did and had an answer in a matter of minutes...

John B. - IL Our company buys in the 100 quantities and needs a large selection of different channels. "The Filter Company" was the only one who was able to supply.....

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Continued from page 5

nating little catalog, and prompted me to add "Fantastic Electronics" to my growing library of lovine titles. By all means, continue work on your biological articles. If *Nuts & Volts* is not the most suitable forum for publication, submit them elsewhere. Nuts & Volt's readers will be the poorer for the loss.

W.T. Gay

Dear Nuts & Volts: Further to your Sept. '95 article on hardware to allow a FAX machine to act as a scanner for a PC, written by Fred Blechman, and the follow-up letter from John Soltesz (Nov. '95) which simplified

the approach, I offer the following:
I used the same approach as
suggested by reader Soltesz, but
simplified his modular phone adapter. I wired two RJ11 modular phone connectors (the type with 4" leads) back-to-back, using only the red and green wires, making a "cross" connection from red to green, and green to red, from one connector to the other.

With this simple and cheap adapter (cost approximately \$2.00), I was able to use my FAX machine as a scanner to my PC with no problems, using the approach suggested by Soltesz.

My FAX machine does not need a dial tone to start sending, which simplifies the adapter. Making a temporary parallel connection to a phone line, as suggested by reader Soltesz, would resolve this. Perhaps another reader can provide a sim-pler solution to the dial tone requirement.

Thanks to Blechman for raising this concept in Nuts & Volts, and particularly to Soltesz for pointing out a more economical way of accomplishing the FAX scanning

> **Steve Roberts** La Jolla, CA

Dear Nuts & Volts:

I support the Secret Service's attempts to catch criminals engaged in cellular phone fraud or credit card fraud, and have no problems with stings, computer based or otherwise. However, the E-Mail messages Mr. D. Thorn received from pmf@cyberspace.com meet my definition of attempted entrapment and are unethical in any event. If pmf@cyberspace.com was willing to persistently try to induce someone who had already demonstrated that they had no intention of committing a crime, what inducements were used on those parties that they caught? Regardless of pmf's specific role with the Secret Service, he had sufficient involvement with them that his inducements color their prosecutions. While I understand the need for law enforcement entanglements with criminals, we cannot allow the ethics of law enforcement to become subvert because technically the entrapment was not done by law enforcement. We all lament when criminals are released on technicalities; should we allow tainted convictions to stand on more ludicrous technicalities? Mr. Thorn seems certain that this sting was conducted properly - except with regards to the attempts to ensnare him. What if he had chosen to cooperate, but not provided any material he considered illegal only to discov-er that the Secret Service felt differently about the nature of his contributions? I am happy that the Secret Service does not seem to have engaged in many of the other ignorant idiocies that law enforcement seems to engage in when they enter the computer frontier.

**Dave Lynch** 

Dear Mr. lovine:

I sure learned a lot about stepper motors from your two articles in Nuts & Volts (Jul. '95 and Aug. '95). I ordered a stepper motor kit from Gateway (advertised as "learn theory"), but the IC's tops were sanded off, and had no schematic. What's to be learned(?) (returned).

Thanks for having filled this knowledge void of mine.

P.J. Allen Mountain View, CA

Checks only to:

Radio School, Inc. in

California

#### TECH FORUM

Continued from page 65

memo-minders. Messages can be recorded and instantly played back as many times as desired. The message is stored in an "analog EEPROM" nonvolatile memory cell array inside the IC. This EEPROM storage technology allows analog data to be written directly into a storage memory cell without the need for A/D or D/A conversion. Thus, the recorded message remains intact even when power to the chip itself is removed from the circuit. A +5 volt only, 28-pin DIP package chip is manufactured by ISD (Information Storage Devices) under the name ChipCorder. They have several varieties available including the ISD1416 and ISD1420 which I have used. The first can record up to 16 seconds of voice and the other part up to 20 seconds at a somewhat lower quality (the tradeoff for an additional four seconds of record time). A message retention time of 100 years is claimed together with 100,000 record cycles before failure. The limited lifetime is due to the EEPROM technology used (all EEPROM devices have this limitation and are therefore used to backup information periodically, but never continuously as with ordinary bipolar or CMOS RAM devices). The 100 K cycle limitation should not present a problem since this represents recording 50 new messages every day of the year for over five years. The number of message playbacks is indefinite. The record time is currently limited to the 16 or 20 seconds mentioned, but newer devices with 45, 60, 75, and 90 second record times are planned. There is also a loop mode that the chip can be placed into continuously play back a recorded message. Some external components are required for operation, as well as a small microphone, speaker, battery, and record/play pushbuttons. An LM386 is recommended, as well for audio amplification. Price for the parts are \$8.00 each in quantities of one and are available from Premier Technical Sales, Irvine, 714-262-0522. Additional spec sheets and app notes are available from ISD at 512-263-5600. Greeting card manufacturers purchase large quantities of the actual chip die from ISD and bond them onto a small PC board using the familiar epoxy blob method used in digital clocks and wristwatches. This makes for a very small package, but is unsuited for experimenters unless you have a bonding machine! Drawbacks to this part are its currently short recording time, difficulty in recording and accessing multiple messages on the same chip (it is better to use separate chips for this), and its rather high price even in

large quantities. However, its unique analog storage method and message non-volatility make it a fun part to play

> Jay Rabkin Pasadena, CA

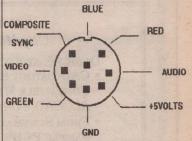
#### **ANSWER TO #12958-DEC 1995**

In reference to the request for a smart serial switch to switch incoming data between two different Web servers for load balancing: You can't do this, and you don't want to anyway. The question assumes that the people wanting access to your Web servers will dial your web site. They will actually be connected to the Internet, and will access your web site across the Internet. To have a web site (server) you will need to have a full-time connection to the Internet. To provide any kind of functionality you will need to have at least a 56 KB line. This is an engineered dedicate line and has a high start-up cost. Under no circumstances will modems work for this function. The descriptions of the computers are not very descriptive; however, if you can find web server software that will run on the computer, the computer will vastly out-perform the connection to the Internet and so no load balancing is necessary.

A better solution is to get with any Internet provider who will host the site on their server. My provider has such a system. Provided you don't have too large files or have a too busy site, the right to set-up and publish a web site is part of the monthly fee. If you need extra storage, or are lucky enough to have a high-usage site, the fees for this are highly reasonable.

**Ray Todd Stevens** Bedford, IN

#### ANSWER TO #129518-DEC 1995



Glad I kept that drawing all these years! I don't have a Nintendo, but I used to run my Genesis into a video monitor. The drawing shows the pins as you are looking into the DIN connector on the back of the Genesis box. The game outputs in both RGB and composite video.

**Lyndon Walker** Seymour, CT

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TYPE or PRINT your ELECTRONICALLY RELATED ad copy CLEARLY (not all caps) on a separate piece of paper. Spell out words when submitting handwritten 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:

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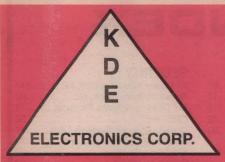
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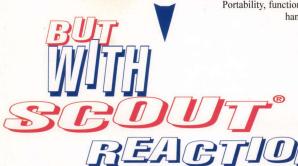
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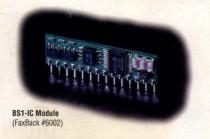
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OUT2	2	15	OUT0
OUT3	3	14	SERIN
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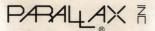


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Marvin Green (first row, 2nd from left) uses BASIC Stamps in his Explorer Scouts robotics classes in Hillsboro, Oregon. These are some of his students with their Explorer-Bots, which are small Stamp-based robots that follow a light source while playing a tune



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