

Here's the latest thinking on fluxgate magnetometers: Use the *Magnetics* 80511-0.5D-0015-01 core. Use 200 turns of toroidal wound #34 wire as the excitation. Wrap 150 turns of #34 wire in the *x* sense direction and 150 turns in your *y* sense direction. For minimum feedthrough noise, resonate both of the sense coils to the second harmonic of your drive waveform.

Your power consumption can be dramatically reduced if you do sense when your core goes into saturation and then can suitably alter the drive waveform. Be sure to keep the drive symmetric to block out any second harmonics. Normal drive frequencies are around 20 kHz.

Several helpline callers took strong exception to my negative comments on magnetoresistors. Well, (A) I call 'em as I sees 'em, and (B) After a careful review, I am now even more convinced than ever that today's crop of magnetoresistors end up just plain awful. At least for precision low level field measurement. I do feel these are clearly inappropriate for service in any *Brunton* class digital compass.

The key problems are the linearity, temperature dependence, noise, and sensitivity. Plus the need for external magnetic biasing. Not to mention their nasty habit of flipping out.

On the other hand, IBM researchers discovered a *gross magnetoresistance* effect that promises to quintuple the sensitivity, at least for disk drives.

And there are a lot of brand new techniques in the wind for ultra low magnetic field sensing. Including tiny micromachined fluxgates.

The big-bucks top secret plum that everyone is quietly working towards involves direct and real time imaging for the human heart's magnetic field. Sensitivities of 0.06 gamma are being bandied about.

So watch for a few stunning new mag sensor breakthroughs "real soon now." Meanwhile, fluxgates seem to be the way to go.

Solid state compasses for auto uses have their own unique problems. It

turns out that the magnetic field of the car itself is as much as *ten times* stronger than the Earth's mag field.

Compensating for accurate results can be tricky. Especially if the comp has to be very easy to do.

Current thinking is to use a fancy microcontroller to sense when the car has gone around the block, closing a circle. Correction vectors can then be stored for later use.

One source of low res car compass info is *Dinsmore*. Lower cost hacker magnetometer cores and systems are newly available through *OrthoLogic*. And premium quality magnetometers are offered by *EMDS*.

Much more on these topics in the *Hardware Hacker* reprints and on my *GENIE* PSRT.

Sonoluminescence

How do you spot an emerging new technology *before* it emerges? My usual approach is to review *Science*, *Science News*, and that technology section in the *Wall Street Journal* for

hints of new stuff coming down. Plus, of course, reading hundreds of trade journals. Then, once you have a few magic keywords or the horse's mouth author names, you'll go to *Dialog* or *UMI* for the key papers.

Sonoluminescence (or "light from sound") is one typical example here. This is an emerging research topic having some potentially stunning new uses. Besides the usual school papers and science fair projects, this one also seems cheaply hackable.

The usual sonoluminescence setup is shown in figure one. You take a small flask of water and couple 25 kHz ultrasonic energy into it. Under carefully controlled circumstances, trapped air or other gas bubbles in the water will emit a clear blue light!

Wait, it even gets better. What is apparently happening is that the sonic energy is being spherically focused up to *twelve orders of magnitude* or even higher. That's a million million! The blue light is actually uv centered on 310 nanometers. The water heavily

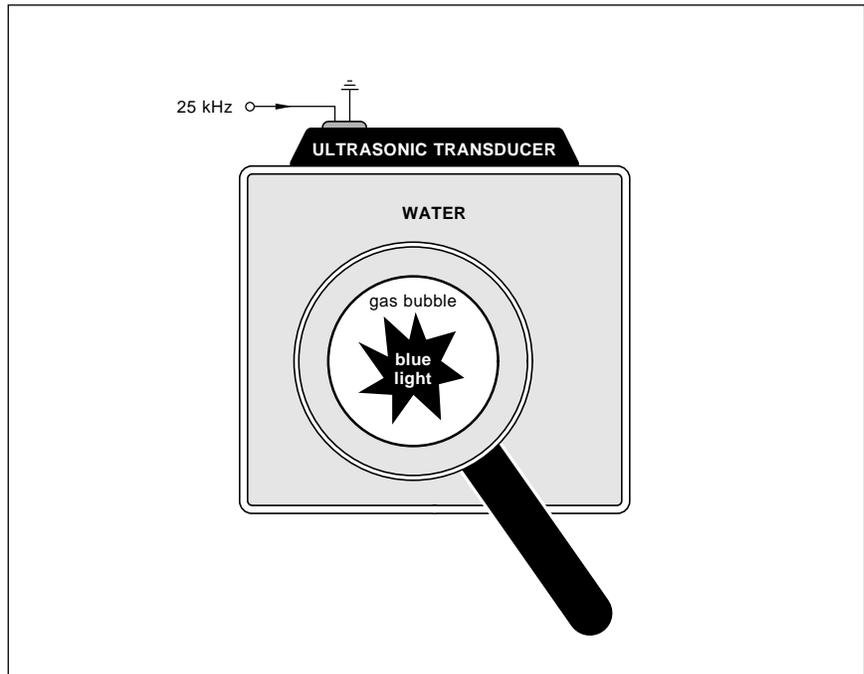


Fig. 1 – SONOLUMINESCENCE results when ultrasonic waves become spherically focused to extremely high intensity. The center of a tiny air or gas bubble may get so hot that it emits ultra-short pulses of blue or uv light!

A Theoretical study of sonoluminescence.

Kamath, V.; Prosperetti, A.; Egolfopoulos, F.N.
Journal of the Acoustical Society of America
vol.94, no.1 p.248-60 July 1993 (49 Refs)

Shock-wave propagation in a sonoluminescing gas bubble.

Wu, C.C.; Roberts, P.H.
Physical Review Letters
vol.70, no.22 p.3424-7 31 May 1993 (13 Refs)

On sonoluminescence of an oscillating gas bubble.

Greenspan, H.P.; Nadim, A.
Physics of Fluids A (Fluid Dynamics)
vol.5, no.4 p.1065-7 April 1993 (18 Refs)

Sonoluminescence spectra of water.

Didenko, Yu.T.; Pugach, S.P.; Kvochka, V.I.; Nastich, D.N.
Journal of Applied Spectroscopy
vol.56, no.4 p.381-5 April 1992 (21 Refs)

The color of sound: shedding light on sonoluminescence.

Scientific American
December 1993, p24-26

Fig. 2 – SOME RECENT references on sonoluminescence.

attenuates the ultraviolet portions, so you only see the blue part.

The light gets produced by literally heating the air at the center of the bubble to beyond 10,000 degrees. And possibly *much* higher.

Even more intriguing, the light is emitted in very brief pulses a mere 50 picoseconds long. These bubbles are usually tiny. They'll oscillate in size from two mils down to a fraction of a mil. Sometimes less.

Just what good is all this? Nobody knows for sure. Yet. It is all too new for commercial apps. Well, *anything* blue should be real handy. Basic laws of physics make generating blue light a real bear. Sonoluminescence should be a low cost source for the brief light pulses needed in laser research and for spectroscopy experiments.

Sonoluminescence can concentrate energy to astonishingly high levels. Possibly this same concept could be adapted to solar energy. It also should be possible to scale up the effect to create a plasma torch that might be used to safely dispose of hazardous materials by vaporization.

The internal sound levels needed are "real loud", comparable to the 110 decibels of a nearby jet engine. But these levels are still within hacking range. Surprisingly, these are actually

much *lower* than the levels required for sonic refrigeration research.

Either a piezo transducer or a plain old tweeter should be useful here.

There are several hundred current papers on sonoluminescence. I have picked five recent samples and put them in figure two. These should be enough to get you started. These do reference dozens of others. As usual, you could get abstracts on all these through *Dialog* and the actual papers themselves either by way of UMI or interlibrary loan.

Let me know what you come up with here.

FM Radio Data Service (RBDS)

FM broadcasters are scrambling all over each other to offer a brand new feature called the *Radio Broadcast Data Service*, or RBDS for short.

What RBDS does is send out short digital messages along with the usual audio program material.

The most obvious RBDS use is to display the name of the song getting aired and who is singing it. But RBDS can also be used to identify the call letters and format of the station. Or used for time, weather, and traffic info. Or other emergency messages. Or for lots of new services previously unthunk of.

RBDS is also apparently used in the cable "CD jukebox" features.

This is all currently at the chicken and egg stage, since few receivers are yet capable of displaying digital data. A related RDS service has been in full operation in Europe for a decade.

Three hot new uses for RBDS are emerging. One is for custom paging services. The second is for *coupon radio* where special discounts can be offered by advertisers *only* to those who are actually listening at any one time. Smart cards are involved.

The third big new use is to provide *differential GPS* correction data. This service could be used to dramatically upgrade the accuracy for all Global Positioning Satellite receivers inside the station's broadcast area. A plain old GPS receiver can be upgraded to a precision one simply by adding some software and the correction data.

The RBDS services are now being co-ordinated by the *National Radio Systems Committee*. Which is a co-op between the *National Association of Broadcasters* and the old *Electronic Industries Association*. Copies of the RBDS standard may be ordered from the EIA for \$20 each.

FM stations are normally at least 200 kiloHertz apart, so there is lots of room in an FM channel for a bunch of services. Figure three shows how a typical station might combine mono, stereo, RBDS and SCA all at once.

At the broadband output of your receiver's FM detector, all of these services could simultaneously appear. The frequencies below 19 kHz will be plain old mono sound. Which is also stereo *left+right* audio. And the only thing you can hear or look at without further processing. The other services are provided on *subcarriers*.

When stereo is present, there is a pilot reference at 19 kiloHertz. The *left-right* stereo information is just below 38 kHz. To produce full stereo, the pilot is doubled in frequency to 38 kHz and then mixed (or multiplied) against the L-R info. The difference term produces baseband audio on a second output. To convert to stereo, a *matrix* technique is used to *add* the two signals to pick up the left channel (L+R+L-R) and subtract the two to get the right channel (L+R-L+R).

The SCA subcarrier services may be provided at higher frequencies.

These are usually fee-based and offer music, news, or stock quotes. The oldest of these is the *Muzak* glop that makes elevators so unpleasant.

SCA services can be demodulated with a bandpass filter and phaselock loop. Popular carrier frequencies are 67 and 92 kHz. But note that doing so is a theft-of-services situation similar to ripping off satellite signals.

Special identifier codes are usually carefully buried in these signals that do make routine criminal convictions trivially easy.

At any rate, the RBDS carrier frequency centers on 57 kHz, the third harmonic of the stereo pilot. The data is plain old 1200 baud serial using a simple frequency shift keying. A digital one is often 1.2 kHz below, and a digital zero is 1.2 kHz above the center frequency. Typical amplitude at the detector is 20 to 200 millivolts.

Four important gotchas for RBDS reception: (A) The FM receiver *must* include wide bandwidth intermediate frequency IF circuitry. Just about any modern receiver does. (B) The signals *must* get extracted directly at your detector or discriminator, *before* any stereo demodulation or audio filtering takes place, (C) You *must* have a full schematic and service info for the receiver being modified. And, finally, if you are doing a computer interface (D) Noise and hum isolation on your data lines is a real good idea.

Fortunately, there is a new, cheap, and elegant single chip solution to RBDS decoding. *Signetics/Philips* has a \$5 device called the SAA6579T. A typical lashup appears in figure four. The chip is basically a high quality bandpass filter, which is followed by a phaselocking digital data detector. It needs only six mils from a five volt regulated supply.

To use the chip, you hang a magic 4.332 Mhz crystal onto its oscillator terminals. You bypass your supply input and the reference output. You capacitor couple the multiplex signal input, and also capacitor couple the filter output to the demod input.

There are three output lines. The data comes out on your data line. A clock output is synchronous with the data and might be useful in simple display circuits. Data is valid on the *leading edge* of the clock.

Presumably, you can route the data

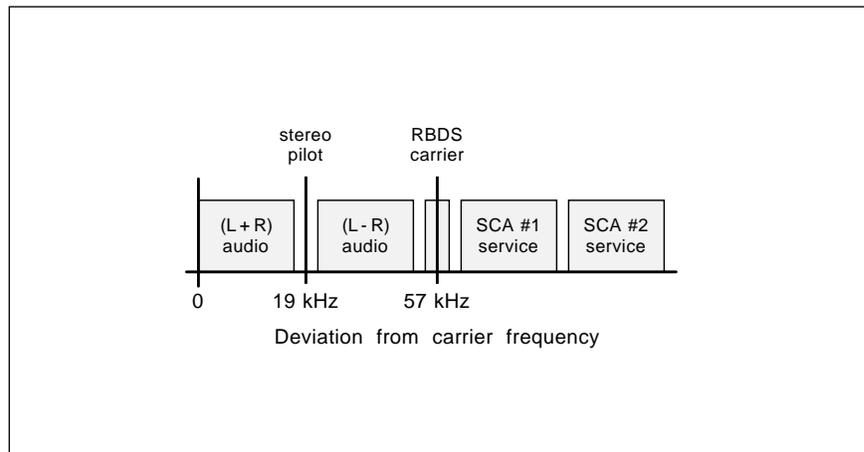


Fig. 3 – FM STATIONS can offer mono, stereo, SCA, and RBDS services all at once. Here is how the received broadband audio spectrum is arranged.

directly into any 1200 baud UART or computer serial port without needing the clock line at all. The final output is a signal quality detector. This pin goes high when valid data is getting received. It stays low if the signal is weak or if RBDS is absent.

The chip is in a miniature SOT162 package, which means you'll have to carefully solder it directly onto your circuit board. Might as well make the other parts surface mount while you are at it. No reason the whole circuit has to be over one square inch, tops. You will want to keep the input lead from the detector very short. Chances

are that you can get away with two inches of shielded input lead.

Your output data leads should be shielded or tightly twisted to prevent them radiating noise back into the rf circuitry. In its simplest use, you go directly into the serial port on your computer. If needed, *Maxim* makes lots of cheap RS-232 converters. But you should already be directly RS423 compatible over short distances.

There is a possibility of a low cost RBDS hacker kit being sold by *PAIA Electronics*. Contact John Simonton there for availability.

RBDS encoders for use by the FM

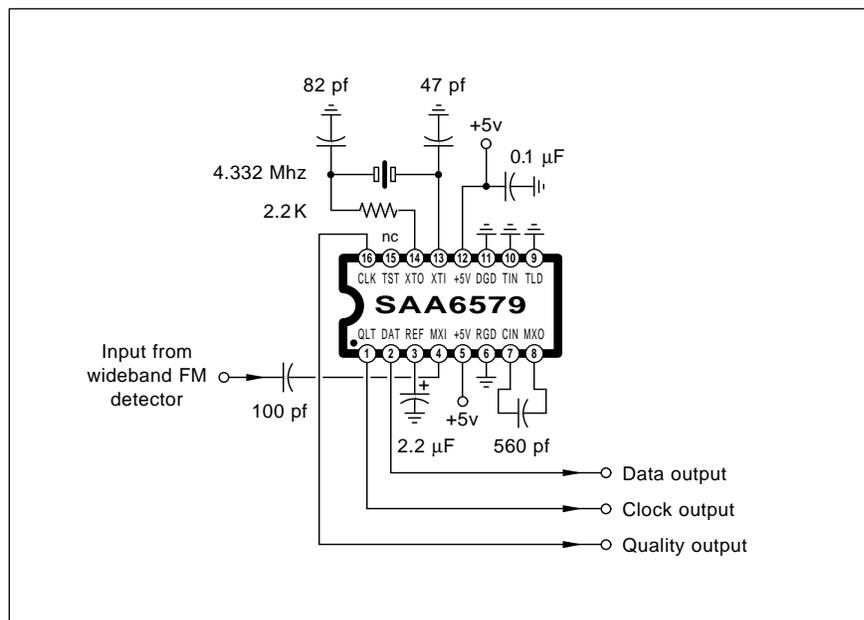


Fig. 4 – THE RBDS DATA STREAM is surprisingly cheap and easy to decode. The Philips SAA6579T chip combines a bandpass filter, a phaselock loop data extractor, and a signal quality detector. See text for kit info.

JUKEBOX RESOURCES

Always Jukin'

221 Yesler Way
Seattle, WA 98104
(206) 233-9460

AMR Publishing Co

PO Box 2007
Arlington, WA 98223
(206) 659-6434

Antique Apparatus

2335 208th Street
Torrance, CA 90501
(310) 328-1306

Electrons Past

851 Enchanted Drive
Midvale, UT 84047
(801) 262-3903

Funtiques

PO Box 825
Tucker, GA 30085
(404) 564-1775

Home Arcade

1108 Front Street
Lisle, IL 60532
(708) 964-2555

Jukebox Central

5540 River Road
Madison, OH 44057
(216) 428-3523 pm

Jukebox Collector

2545 SE 60th Court
Des Moines, IA 50317
(515) 265-8324

Jukebox Junkyard

PO Box 181
Lizella, GA 31052
(912) 935-2721

Jukebox Media

8795-A Corvus Street
San Diego, CA 92126
(619) 271-8294

Jukeboxes Etcetera

223A N Glendora Avenue
Glendora, CA 91740
(818) 914-9434

New England Jukebox

77 Tolland Turnpike
Manchester, CT 06040
(203) 646-1533

Tim Rand

12027 Saint Vrain Road
Longmont, CO 80501
(303) 772-5158

Vern Tinsdale

8402 N 18th Avenue
Phoenix, AZ 85021
(602) 944-8444

Victory Glass Company

3260 Ute Avenue
Waukee, IA 50263
(515) 987-5765

Wurco

908 Niagara Falls Blvd
N Tonawanda, NY 14120
(716) 694-6247

radio stations are available from a number of sources. The leader here appears to be the model 532 from *RE America*. The price of an encoder is around a kilobuck. Pocket change in a typical FM station budget.

One proponent of coupon services is David Alwadish of *Coupon Radio*. This outfit also soon intends to offer ready-to-use receivers and cards.

Several industry insiders feel that RBDS might only form an interim solution, with the higher speed digital transmission systems waiting in the wings. But I can see all sorts of uses where 1200 baud is more than good enough. And it certainly is cheap and simple to provide. And it sure is one worthwhile project to hack.

More news on RBDS as it unfolds is likely to appear in *Radio World*, a trade journal for commercial radio stations. In particular, do check their November 10, 1993 issue.

Jukebox Resources

Several of you have asked where to go for more information on jukebox collecting and parts. For our resource sidebar this month, I have gathered together a large handful of the more important jukebox resources.

The best magazine here is *Always Jukin'* with *Jukebox Collector* being a close second. Both jukeboxes and their collectors are far more common than you might first guess. It's no big deal to get parts for the more popular boxes. Or the mouldy oldie records to go with them.

I have posted more info on other electronic collectibles in NUTS24.PS on *GENie* PSRT. This is also found in my *Resource Bin* reprints.

Electric Autos

I have had several helpline callers ask me for my views on electric cars,

so here's what I think...

All the largest trucks and the most powerful locomotives in the world today are electric. And have been so for decades. So, the key problem is making electric vehicles *more*, rather than less wimpy.

To me, it is completely obvious that the minimum number of motors to use is *four*. One for each wheel. Putting the motors *inside* the wheels eliminates all of the drivetrain parts. Clutches, transmissions, cv joints, or differentials. Gone also is any need to transmit mechanical power between the sprung and unsprung portions of the vehicle. Plus greatly simplified braking. This also allows the vehicle underside to be far more aerodynamic on the road and much less vulnerable when off road.

One motor per wheel gives you the ultimate in continuous positraction, driver safety, and anti-lock braking. True electronic four wheel drive. All terrain, all the time.

What type of motor? You'd want to inside things out with your axle-based stator on the *inside* and your wheel-mounted rotor on the *outside*. Since brushes or commutators would be a bad scene, the best motor type is probably a *switched reluctance* one with high energy permanent magnets on the rotor.

Come to think of it, four motors is probably far too few to use. It might make more sense to provide modular and identical standard snap-on units that would let you add one, two, or up to four motors per wheel. This could let you trade off performance versus economy and range.

The required battery or fuel cell technology will arrive long before it is really needed. Not to worry. For now, the best choice seems to be a hybrid system having a continuous speed gas engine driving a new high efficiency alternator. Plus a limited amount of actual battery storage for acceleration. *Robert Bosch* is one big source for this type of system.

Regeneration? Well, yeah, maybe. Because it simplifies the brakes. But in general, the regeneration will not deliver very much range extension in the real world. Beware of hype and wishful thinking here.

Tellya what. For our contest this month, just send me your views on

electric vehicles. There will be bunch of the usual *Incredible Secret Money Machine II* books going to the dozen best entries, with an all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for two going to the best of all.

As usual, send your *written* entries to me here at *Synergetics* and not to **Electronics Now** editorial.

Lots more stuff on homebrew and low end electric autos shows up in *Home Power* magazine. Other places to look for ongoing developments are the *EPRI Journal*, the *SAE Library*, and, of course, *Dialog*.

New Tech Lit

From *Signetics/Philips* three quite impressive new data manuals. Their *Audio Radio Data Handbook*, which includes info on the RBDS chip that we just looked at. A new *RF/Wireless Comm* data handbook. And a revised *Desktop Video Data Handbook*.

From *SGS Thompson*, their latest edition of their *Designer's Guide to Power Products*.

Analog Devices offers a brochure on *Audio Signal Processing* circuits. Plus their new *Op-amp slide guide*. These folks also do publish their free *Analog Dialog* trade journal.

I have gotten a few requests for simple methods to convert off-the air or cable tv signals down to baseband video. The folks at *Sharp* have a new data book on *RF Components* that includes full info on their RFSP and RFST front end modules. And similar units also sometimes may crop up at *Surplus Traders*.

But since these all require stable external circuits for accurate voltage tuning, you are probably better off adapting a junker VCR instead.

More information on aerogels is now available by way of *Lawrence Livermore Labs*. They do offer a new *SEAgel* product made from seaweed agar that offers densities from balsa wood clear on down to solid foam structures which are actually *lighter* than air. This material is edible, water soluble, an excellent insulator, and a good sound absorber.

A robotics BBS at (214) 258-1832. This announcement from the *Dallas Personal Robotics Group* who have a fine labor-of-love newsletter.

A new Yves Meyer book *Wavelets: Algorithms and Applications* offered

NAMES AND NUMBERS

Analog Devices

PO Box 9106
Norwood, MA 02062
(617) 329-4700

Coupon Radio

10 Rockefeller Plaza
New York, NY 10020
(212) 595-1313

Dallas Personal Robotics Group

%Roger Arrick
PO Box 1626
Hurst, TX 76053

Dialog

3460 Hillview Avenue
Palo Alto, CA 94304
(415) 858-2700

Dinsmore

1814 Remell Street
Flint, MI 48503
(313) 744-1330

Electronic Industries Assn

2001 Pennsylvania Avenue NW
Washington, DC 20006
(202) 457-4900

EMDS

16618 Oakmont Avenue
Gaithersburg, MD 20877
(301) 840-5710

EPRI Journal

PO Box 10412
Palo Alto, CA 94303
(415) 855-2000

GENie

401 N Washington Street
Rockville, MD 20850
(800) 638-9636

Home Power

PO Box 520
Ashland, OR 97520
(916) 475-3179

Lawrence Livermore Labs

PO Box 808
Livermore, CA 94551
(510) 422-6416

Magnetics

Box 391
Butler, PA 16003
(412) 282-8282

National Assn of Broadcasters

1771 N Street NW
Washington, DC 20036
(202) 429-5300

OrthoLogic Corp

2850 S 36th Street, Ste 16
Phoenix, AZ 85034
(602) 437-5520

PAIA Electronics

3200 Teakwood Lane
Edmond, OK 73013
(405) 340-6300

Radio World

5827 Columbia Pike #310
Falls Church, VA 22041
(703) 998-7600

RE America

31029 Center Ridge Road
Westlake, OH 44145
(216) 871-7617

SAE Library

400 Commonwealth Drive
Warrendale, PA 15096
(412) 776-4841

SGS Thompson

1000 E Bell Road
Phoenix, AZ 85022
(602) 867-6259

Sharp

Sharp Plaza
Mahwah, NJ 07430
(201) 529-8757

SIAM

3600 University City Sci Cntr
Philadelphia, PA 19104
(215) 382-9800

Surplus Traders

PO Box 276
Alburg, VT 05440
(514) 739-9328

Synergetics

PO Box 809
Thatcher, AZ 85552
(602) 428-4073

UMI

300 N Zeeb Road
Ann Arbor, MI 48106
(800) 521-3044

by *SIAM* at \$19.50. A review appears in the December 3, 1993 *Science*.

Lots more info on wavelets appears on my *GENie* PSRT. Simply search the library under *wavelets* to get a complete list. And ISODRAW.PS is a new set of simple isometric drawing utilities I've also just added.

Typical downloads cost 21 cents.

For the insider secrets of starting

your own technical venture, do check into my new *Incredible Secret Money Machine II* book, or the ongoing tech resources in my *Blatant Opportunist*.

As usual, most of the mentioned stuff appears in either our *Names & Numbers* or our *Jukebox Resources* sidebars. Be sure to check here before calling our no-charge voice helpline.

Let's hear from you. ♦

Don Lancaster's Hardware Hacker

March, 1994

A sumptun' else contest
Classic oscilloscope book
Federal auction magazines
New cogeneration resources
Fundamentals of SCSI comm

I finally got a closer look at that brand new *Stan Griffiths* book *Oscilloscopes: Selecting and Restoring a Classic*. This one is mostly a well-done guidebook which lists all the older tube-type *Tektronix* scopes, their current values, hidden gotchas, and overall desirability.

A "must have" at \$19.95.

Since *Tektronix* scopes can now be bought for as little as \$50, there is no reason why *every* hardware hacker shouldn't own at least two of them.

Safest bets of the golden oldies: A plain 515A or a fancy 545B with a CA plug in. More on picking a scope in NUTS25.PS on *GENie* PSRT.

Let's go over some more basics...

Fundamentals of SCSI

There is a lot of hacker interest in SCSI devices these days, so I guess it is time for a review.

SCSI stands for a *Small Computer System Interface* and gets detailed in document ANSI X3.131-1986. This is available from the *American National Standards Institute*. While there are improvements, we'll concentrate on the single-ended spec here.

SCSI lets up to eight devices send 8-bit parallel data to each other on an asynchronous info swap. Although any number of these could be hosts, your usual setup is to have only one host that gets served by up to seven peripheral devices. For instance, your host computer might use an internal hard disk, an external hard disk, a CD ROM drive, and a laser printer.

Figure one shows how a SCSI bus is usually arranged. You have up to eight devices connected together with 50 wire cables. All of the devices are daisy chained together. Note that *no other arrangement except the "open" daisy chain is permitted!*

Your cable lengths could be up to *twenty* feet maximum, but *all devices MUST end up plugged into the same grounded ac outlet*. Data rates to 4 Megabytes per second are permitted. Since your data is in parallel, this is equal to a serial data rate around 40 Megabaud! Thus SCSI is potentially

much faster than most of the popular networking schemes.

It's real tricky to move high speed data around in the real world. So, to prevent any noise or line reflections, all SCSI cables lashups *must* be both shielded and properly terminated. For short internal runs, ordinary ribbon cable can get used with every second wire grounded. For longer external runs, special shielded SCSI cables are a must. One good source for these is *Redmond Cable*.

Each end of the SCSI cable system *must* be properly *terminated*. As with any rf cable, termination means doing something to the end of your cable so that standing waves or any reflections are minimized.

Your rules are: *Always terminate both ends of your SCSI cable string. Never leave any extra terminators in the middle of any SCSI string.*

Figure two shows you two methods to terminate a SCSI line. The intended cable impedance is supposed to be 132Ω, but you can usually get by with 100Ω cables. When you do a *passive* termination, you put a 220Ω resistor

to +5 volts dc, and a 330Ω resistor to ground. You'll do this on each and every data and control line.

But note that one side effect is that each of the 18 lines has the equivalent of *two* 550Ω resistors that go +5 to ground. Each of which continuously burns up around 45 milliwatts for a total of nearly two watts. Which is a no-no for low power uses.

Instead, *active termination* is more common these days. If you use active termination, you terminate each line with a single 132Ω resistor that will return to a regulated 3.0 volt source. Since all SCSI lines are either tri-state or open collector, and since most of them do nothing most of the time, an active termination uses less power.

There are also several clever new dynamic switching schemes that play intentional tricks with terminations to further reduce the power and improve data integrity.

Your pin connections for a SCSI connector are shown in figure three. Originally, these were an unshielded dual row header for internal use, or a special shielded and locking external

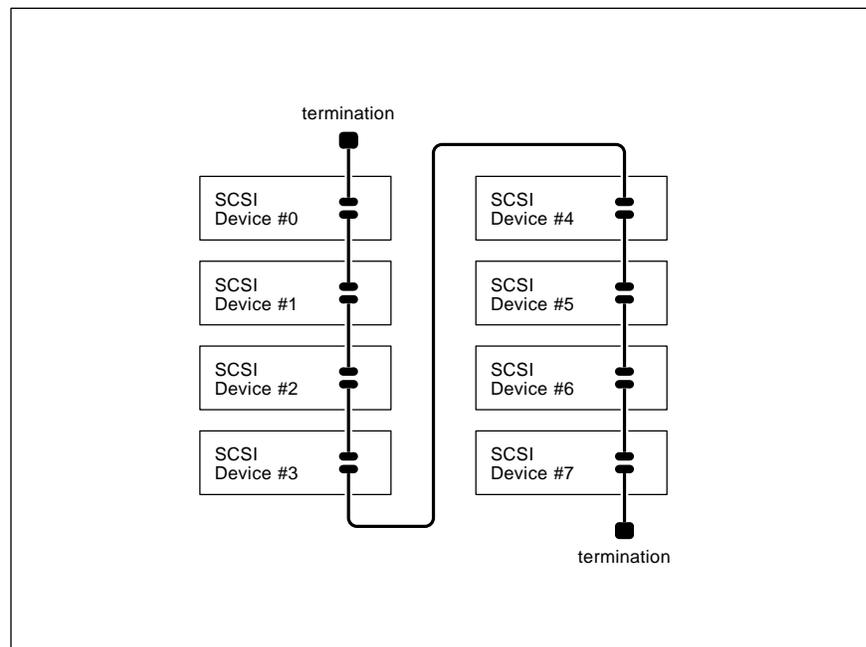


Fig. 1 – SCSI COMMUNICATION allows up to eight devices to talk to each other at high speeds over short distances.

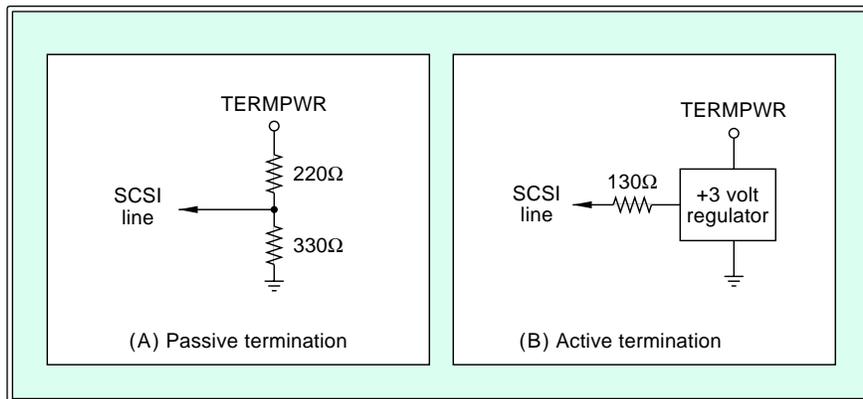


Fig. 2 – BOTH ENDS of each SCSI line must get properly terminated.

connector. The internal connector is a plain old 2 x 25 arrangement on the usual 100 mil centers.

Since the external connectors are so bulky, you'll find some latter day variations. One involves using a plain old DB-25 connector. I do feel this is incredibly dumb because of possibly damaging mixups with serial comm ports. And *Apple* has switched to a small 30 pin rectangular connector, such as they use on their *LaserWriter* Pro 630 and newer Mac's.

You'll find four types of connector lines. First, there are a lot of grounds.

These greatly simplify the shielding, especially on ribbon cables.

Second, there is a TERMPWR lead that outputs a protected +5 volts for termination power. Diodes normally prevent several devices from fighting each other on TERMPWR.

Third, there are eight data lines DB0 through DB7. Data is exchanged as parallel bytes over these tri-state lines. There is also a ninth parity line, but this one is rarely used.

Finally, there are nine control lines that are either tri-state or have open collector drivers. These include BSY

for any bus access, SEL to pick the device, C/D that determines whether the information being sent is control or data, or MSG when a message is being delivered.

The REQ line requests access, and ACK grants it. ATN is a start up call, and RST clears previous actions.

These lines all get detailed in the SCSI spec. They interact with each other to request, verify, and then send data between devices. The devices all take turns, with only one allowed bus access at any given time.

There is a carefully spelled out command order. Most of the time, the SCSI bus should just sit there and do nothing. The action always will start with *arbitration* and *selection* cycles. Then a string of *command* bytes are sent that sets up the size and action of a read or a write or whatever. Next are those data bytes, which are usually transferred in blocks, often of 1024 bytes. The access ends with the *status* and *completion* bus phases.

Each SCSI device has a unique ID number 0-7 associated with it. These match a high on your equivalent data line. The ID numbers appear on the bus during *arbitration* or *selection*.

A very important rule: *Each SCSI device MUST have a unique ID!*

The ID numbers are all prioritized. Device #0 gets your highest priority. The usual custom is to give the main host an ID of zero and your internal hard drive an ID of seven. Printers or CD readers or whatever will often be given mid-range values.

Most of the SCSI peripherals have switches or jumpers that let you pick any ID you choose to. On the other hand, it can be extremely tricky to get a non-zero host ID.

Once again, no duplicate ID's are allowed, and the *lowest* ID always is the one with first dibs.

Your SCSI spec carefully describes the actions which have to take place during each data transfer stage.

Multiple Host SCSI?

There's all sorts of unexplored new SCSI hacking possibilities. One is to come up with any simple and cheap manual A-B switch for SCSI. Believe it or not, commercial units go for as much as \$2200 here.

Hint: The key chips you'll need are available from *Pioneer*, especially as

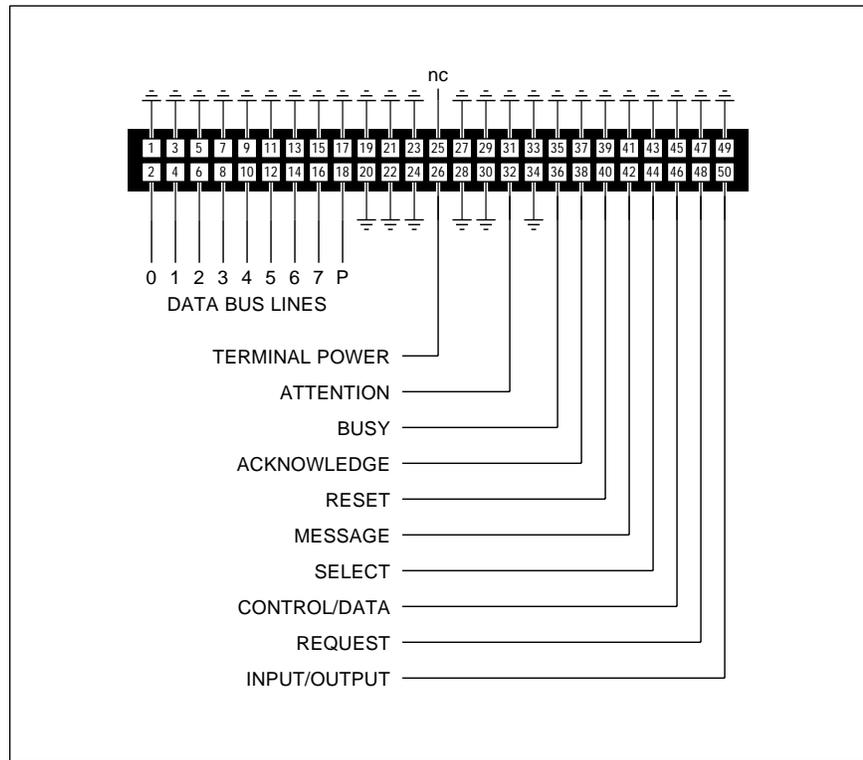


Fig. 3 – PINOUTS FOR A SCSI CONNECTOR. The unshielded internal connector is shown here. External 50-pin connector numbering is the same.

their PIC3383. We will have more on this in a future column.

Another opportunity is to build an even simpler SCSI *ID changer*. In which any SCSI device looks like #6 from one end and #7 from the other. Or #0 versus #1. Which could be a key workaround if two systems insist on keeping their hosts as #0.

Yet another project is to do a plain old SCSI data slurp that looks like a computer's parallel data port. Which lets you send low level commands to outside world devices from inside the SCSI environment. Your real biggie here, of course, is that this lets you use PostScript on any old homebrew CAD/CAM or PC drill or Santa Claus machine or whatever.

Figure four shows you how *shared SCSI comm* works. In which a host and a PostScript printer can share one drive. Such tasks as Book-on-demand publishing run ridiculously faster, as most comm times are eliminated. And the little remaining comm that's still needed happens at serial equivalent speeds as high as 40 Megabaud.

But you do have to get tricky.

The SCSI spec clearly lets you use multiple hosts, where more than one computer could share a hard drive or other peripheral. In fact, you can even have *eight* hosts. Lots of exciting new possibilities here. But there are also some nasty gotchas.

Very ungood things will happen if someone loads a file, somebody else changes it, and the first someone then resaves the old file. These problems are generally called *adjudication*.

Most SCSI systems start out with a *Bus Arbitration* phase that prevents outright conflicts between two hosts which try to grab market share at the same time. So the first thing is to *be sure that both hosts include the SCSI bus arbitration timing cycle*.

A second problem is that SCSI only handles your inner layers of sending data back and forth. It does not spec your *arrangement* or the *partitioning* of the data tracks. This means that *all the host SCSI devices normally MUST share the same operating system*.

A third problem is that most SCSI hosts assume they are da boss. Instead of checking the catalog and directory tracks of the drive each access, they simply keep a copy of these tracks in their *host* memory. Now, if another

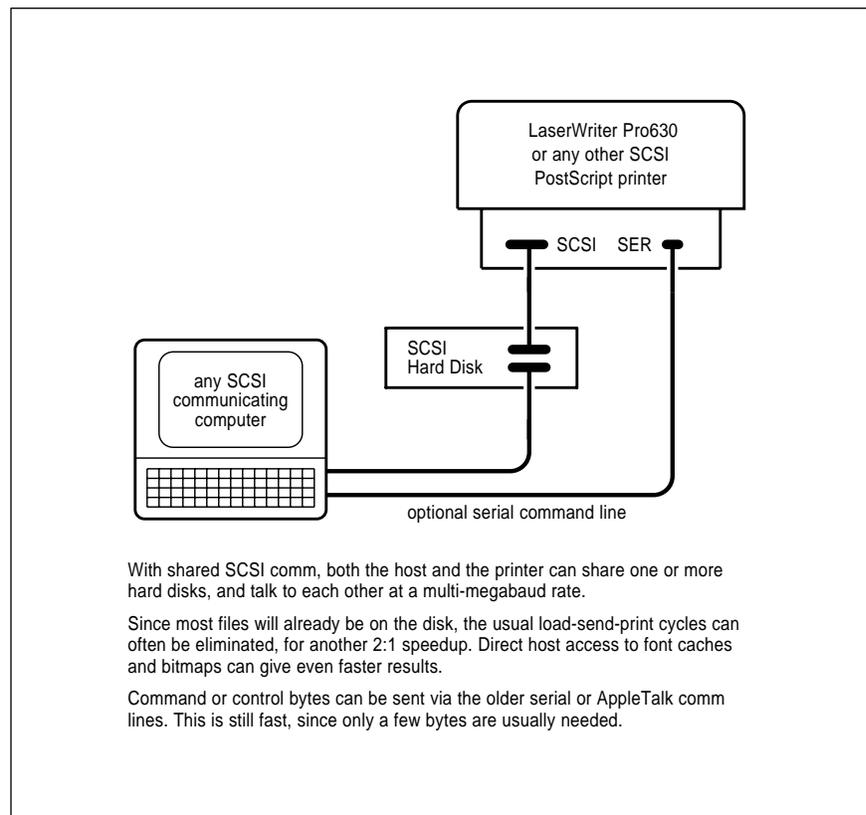


Fig. 4 – SHARED SCSI COMM can dramatically speed up most PostScript laser printing times. But adjudication details will need carefully worked out.

host rewrites your files, the first host will certainly get confused since its internal disk directory copy will now be totally wrong.

One ploy to get around this is to always *mount* and *unmount* drives so that any particular drive is "known" by only one host at any time.

As an example, PostScript has its *devmount* and *devdismount* procs. Presumably *devmount* will read a new directory to the host.

Uh, there is another route that I've been using to let both an Apple IIe and a Mac write to the *internal* hard disk on my LaserWriter. In fact, you could even use this to let IBM and MAC share a common hard disk.

What you do is pick your "main" operating system. In the case of any PS printer, this would be the internal PostScript firmware. So, immediately after you initialize your disk, you'll very carefully define several *dummy files of fixed size and position*.

You can then let your "alien" host use *only* its low level SCSI *read* and *write to track and sector* commands to "force feed" data into the file.

This does get real tricky fast, but it definitely does work.

Let me know your thoughts on new hacker SCSI apps.

Cogeneration Resources

Cogeneration involves producing electricity as a by-product of another activity. If your other activity absorbs most of the cost, the electricity itself can end up surprisingly cheap.

For instance, if a chemical plant or hospital needs lots of steam anyway, they might as well generate most or all of their own electricity while they are at it. Or, if you have a solar panel, it makes a lot more economic sense to use up your waste energy for water or space heating.

A new *Micro-Cogeneration* book from Kirk McLoren of *Independent Power* uses some economic analysis to come to an astounding conclusion: With cogeneration, it can end up far *cheaper* to generate electricity than buy it from the power company!

Especially, if you are, say, rural, half a mile from any power line, have a reasonable home and lifestyle, use a

COGENERATION RESOURCES**Alternative Energy**

205 S Beverly Drive Ste 208
Beverly Hills, CA 90212
(310) 273-3486

Alternative Energy Digests

800 Garden Street Ste D
Santa Barbara, CA 93101
(805) 965-5010

Cogen & Competitive Power

700 Indian Trail
Lilburn, GA 30247
(404) 925-9388

Cogen & Resource Recovery

747 Leigh Mill Road
Great Falls, VA 22066
(703) 759-5060

Dialog

3460 Hillview Avenue
Palo Alto, CA 94304
(415) 858-2700

Energy Conservation Digest

Box 20754
Seattle, WA 98102
(202) 783-2929

EPRI

PO Box 10412
Palo Alto, CA 94303
(415) 855-2000

Home Energy

2124 Kittredge St, #95
Berkeley, CA 94704
(510) 524-5405

Home Power

Box 520
Ashland, OR 97520
(916) 475-3179

Independent Energy

620 Central Avenue N
Milaca, MN 56353
(612) 983-6892

Independent Power Report

1221 Ave of the Americas, 36 Fl
New York, NY 10020
(212) 512-6410

Micro Cogeneration

Independent Power
3309 1/2 Lynn Avenue
Billings, MT 59102

Renewable Energy

660 White Plains Road
Tarrytown, NY 10591
(914) 524-9200

Renewable Energy News Digest

14 S Church Street
Schenectady, NY 12305
(518) 372-1799

Saving Energy

5411 117th Avenue SE
Bellevue, WA 98006
(206) 643-4248

World Cogeneration

84-54 118th Street
Kew Gardens, NY 11415
(718) 847-0230

diesel generator, and pay no road tax on the diesel fuel. And even more so if you can scam the free (but slightly contaminated) diesel fuel sometimes available from local airports.

The trick here involves the utility's line extension costs and the required minimum purchase guarantees on one hand. And on the other, making your generator more efficient by using the waste energy for heating.

For this month's resource sidebar, I thought I'd gather together important places you can go for more info on cogeneration. Both for homebrew and industrial strength needs.

In addition to Kirk's book, be sure to check out *Home Power* magazine. Lots of technical papers and videos are available through *EPRI*. And, of course, for the latest in any technical field, you use the *Dialog Information Service*, available either by way of

Genie or your local library.

World Cogeneration is a free trade journal for commercial and industrial applications of cogeneration. Most of the other resources listed are trade journals or scholarly pubs.

"Sumphun' Else" Contest

One thing I very much like to do is take some product and see just how it can be misapplied for wildly different purposes. Two ferinstances here. An outfit called *Amlan* offers a mini wire duct product by the roll. Which costs around a dollar a foot and is intended to protect communication, alarm, and low voltage wiring.

The channel is made up from an attractive white vinyl and consists of a bottom half that folds up into a "U" shape, and a snap-on cap. The size is either a 5/8 inch square or a 5/8 x 1 rectangle. Predrilled, even.

Now for the neat part: If you chop this stuff up into smaller pieces, you end up with very nice 30 cent cases for handheld projects. Perhaps a laser pointer, remote control, logic probe, bug detector, dog trainer, or signal injector. Free samples are offered.

Or, have you taken a close look at toilet refilling technology lately?

A new version uses a snap-action differential water pressure sensor. It cheaply and reliably replaces older float type switches.

Well, what we really have here is a differential pressure sensor that can respond to a pressure difference of *a fraction of an inch of water*. Last time I checked, that's a sensitivity around 0.01 pounds per square inch!

There simply *has* to be unthunk of hacker and robotics uses for these. Especially for other liquids. Possibly even for air or other gases. Your first hack here would be to couple it to an electrical switch or sensor.

So, for our contest this month, just tell me about any product that can be misapplied to make something totally different. We'll call this a *sumphun' else* contest.

There will be a bunch of the usual *Incredible Secret Money Machine II* books going to the dozen best entries. An all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for two will go to the very best of all.

As always, send all your *written* entries to me here at *Synergetics* and not to **Electronics Now** editorial.

Federal Auctions

Ever since the days of the mythical \$25 Jeep, there's been lots of hacker enthusiasm over buying government surplus. Particularly older military or defense electronics.

To get on military surplus bidding lists, you'll first contact the *Defense Logistics Supply Agency*. You then pick your areas of interest and they will start to mail you auction notices. If you do not actually bid, you have to renew every few months.

General government auctions are handled separately. Many are done through the regional *General Services Agency* offices. For more details, you will have to contact the GSA office in your nearest large city. I've listed the Denver office in this month's *Names & Numbers* sidebar. But the process

anywhere else is the very same: You contact them, tell them your interests, and get on selected bidder's lists.

There are also auctions from other US government agencies, such as the DEA or the Post Office. You contact them directly for more info.

As a reminder, there is a main US government information number up at (800) 359-3997.

But there is now a pair of mags that list upcoming auctions. These can vary much simplify your finding out what is coming down. One of these is the *Federal Auction Locator*, while a second is *Auction Magazine*.

If you are just interested in plain old commercial surplus grunge, the insider secret newsmagazine that the retail surplus dealers and the distress merchandisers all subscribe to is the *ASD/AMD Trade News*. These folks also put on mammoth and incredibly bizarre trade shows.

By the way, those WWII military surplus Jeeps always get cut in half before delivery. Except for being a tad oversize, these can make dandy bookends. But be sure to check your local zoning first.

New Tech Lit

A possible major advance towards room temperature superconductivity did appear in the December 17, 1993 issue of *Science*. Pages 1850-1852. It appears a lot more credible than the previous false starts. Temperatures of 250 Kelvin are being bandied about. A balmy Minnesota winter day.

Softwars is a new book by Anthony Clapes that's published by *Quorum Books*. This one is a fairly thorough rundown on the ongoing legal battles involving software protection and the intellectual property rights. While the author does hide his IBM lawyer bias fairly well, his blatant misuse of the term "Hacker" is unconscionable.

Still a good read, though.

Virtual Reality World is a brand new *Meckler Publishing* newsletter.

For something totally different, the *Nomadness Report* gets published by *Steve Roberts*. Who is really big on his bicycle telecomputing, high tech ocean kayaks, and *Internet* surfing. I've posted on-line sample copies of his reports to *GENie* PSRT.

Etchtalk is a useful free company newsletter about glass etching from

NAMES AND NUMBERS

American Nat'l Standards Inst
11 West 42nd Street 13 Fl
New York, NY 10036
(212) 642-4900

Amlan Inc
97 Thornwood Road
Stamford, CT 06903
(203) 322-1913

Armour Products
Box 128
Wyckoff, NJ 07481
(201) 847-0231 FAX

ASD/AMD Trade News
2525 Ocean Park Blvd.
Santa Monica, CA 90405
(800) 421-4511

Auction Magazine
Box 62101-411
Houston, TX 77205
(800) 588-0005

Castcraft
Box 16586
Memphis, TN 38186
(901) 345-5753

CMA
Box 685
Rockaway, NJ 07866
(201) 586-3600

Comus
263 Hillside Avenue
Nutley, NJ 07110
(800) 35-COMUS

Defense Logistics Supply
Box 1370
Battle Creek, MI 49016
(616) 961-4000

Federal Auction Locator
Box 37038
Phoenix, AZ 85069
(800) 977-8889

General Services Agency
Box 25506 DFC B41 R223
Denver, CO 80225
(303) 979-0361

GENie
401 N Washington St
Rockville, MD 20850
(800) 638-9636

Stan Griffiths
18955 SW Blanton
Aloha, OR 97007
(503) 649-0837

Maxim
120 San Gabriel Drive
Sunnyvale, CA 94086
(800) 998-8800

Nomadness Report
Box 2185
El Segundo, CA 90245
(310) 322-1655

Pioneer
2343 Bering Drive
San Jose, CA 95131
(408) 435-0800

Quorum Books
88 Post Road West
Westport, CT 06881
(203) 226-3571

Redmond Cable
17371-A1 NE 67th Ct
Redmond, WA 98052
(206) 882-2009

Virtual Reality World
11 Ferry Lane West
Westport, CT 06880
(203) 226-6967

US Government Information
(800) 359-3997

Armour Products. Interesting casting materials and tech info are available from *Castcraft*. *Comus* appears to be a good source for tilt switches and motion detectors. And information on mechanical cables for robotics and such is offered by *CMA*.

Maxim has announced their new MAX038 function generator chip that generates high frequency triangular, sine, and square waveforms. This one looks like it is going to turn into one rather hot hacker chip. Response is beyond 20 MHz. I'd expect kits to be offered shortly.

If you are at all interested in any

self-publishing, be sure to check out my *Book-on-demand Resource Kit*, per my nearby *Synergetics* ad.

I've also got a brand new catalog with a much larger insider secrets section. You can write, call, or email me at [SYNERGETICS] on *GENie* or SYNERGETICS@GENIE.GEIS.COM on the Internet for your free copy. Or download it directly as SYNCAT1.PS from *GENie* PSRT.

As usual, most of the mentioned stuff appears in either our *Names & Numbers* or *Cogeneration* sidebars. Be sure to check here before calling our no-charge voice helpline. ♦

Don Lancaster's Hardware Hacker

April, 1994

More on RBDS services
Human powered vehicles
Pinball machine resources
Understanding bus switches
Programmable interconnects

Several updates on our earlier stuff: Fluxgate magnetometer construction info appeared in the January 94 *RF Design* on pages 24-32. All that's needed are two low cost ferrite sleeves.

On our RBDS story, it turns out the data format is *not* directly compatible with serial comm. Instead, their data consists of synchronous blocks that eventually become a burst message of 64 characters. Yes, these can get read by any microcontroller. But, no, you can not just shove your data stream through a plain old serial port.

More on this whenever. Delivery is apparently a tad slow on those RBDS specs. Around 150 of the FM stations offer RBDS at this writing, with Las Vegas and Chicago both providing a wide variety of coverage.

Our usual reminder that we have a no-charge helpline per the box below. Where I can try to give you a quick answer for any technical question or a suitable referral. Funding restraints limit this service to US calls only.

Reprints of all these columns are instantly available via *GENIE* PSRT for about twenty-one cents each. This is by far the fastest and cheapest way to pick up this hard-to-find info.

Let's look at a new development of great hacker portent...

Programmable Interconnects

One of the main reasons that we've come so far so fast with computers is *programmability*. Instead of needing custom hardware for everything, you have a "one size fits all" high volume product that can be taught to do many different things.

There are scads of programmable chips out there today. PROMS which let you blow internal fuses. PAL and GAL and PLA logic circuits that have programmable links. Flash memory products which can take non-volatile "snapshots" of their contents. And, of course, microcontrollers with built in EEPROM memory areas.

Wouldn't it be handy if you could *software* program your *entire* circuit as well? No matter how many chips

were involved? Being able to do so would dramatically reduce all of your development times. It would greatly simplify all your testing and debug. Later mods or field upgrading would also be much easier.

Those beginner's hobby electronic labs gave you a full programmability. As did my older *CMOS Microlab* and *Digital Logic Microlab* projects way on back in *Popular Electronics*. So do electronic proto breadboards.

And the whole idea behind wire wrapping is to let you make changes to an existing circuit.

But these all have bad flaws. The connector systems are expensive and demand many hours for manual and mistake-prone hookups. Strays and crosstalk usually end up awful. Your speeds are severely limited. Testing lots of points can be a bear.

Thousands of connections would be needed for even a medium sized project these days. And for every copy of your job, you would have to repeat the entire process.

Instead, there are some brand new concepts that involve *programmable interconnects*. Methods of connecting or changing the wires going *between* dozens or more IC packages.

Let's look at a pair of solutions to programmable interconnect. One is high end. The other one is cheap and eminently hackable.

But before we look at these, lets quickly check into...

Transmission Gates

For a programmable interconnect, what you'll need is a great heaping bunch of ultra cheap simple switches. Ideally, the switches will be a perfect open or a perfect short.

Since you can't get there from here today, a compromise is needed. We will forget about programming all the supply and ground leads. These have to be short and low impedance. And there are not all that many of these anyhow. We'll also forget about any programmable interconnect for high power or extreme speed circuits.

Figure one shows two *transmission gate* circuits. These isolate two lines or else connect them together using a low value resistor.

In 1-A, we simply use a N-channel MOSFET transistor. If your gate is a few volts higher than either line, the transistor turns on and looks like an ordinary resistor. When turned on, we can route digital or analog signals *in either direction*.

There are no saturation effects or direction limitations. Nor is there any difference between input and output.

A single transistor switch can be cheap and compact. Just what we'll need if we want to get serious about putting 25,000 of them (!) inside one

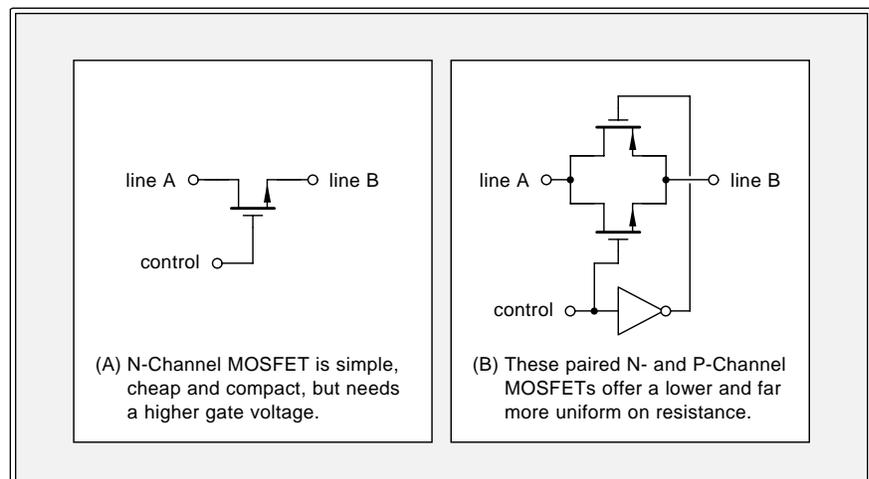


Fig. 1 – TRANSMISSION GATES act as bidirectional switches.

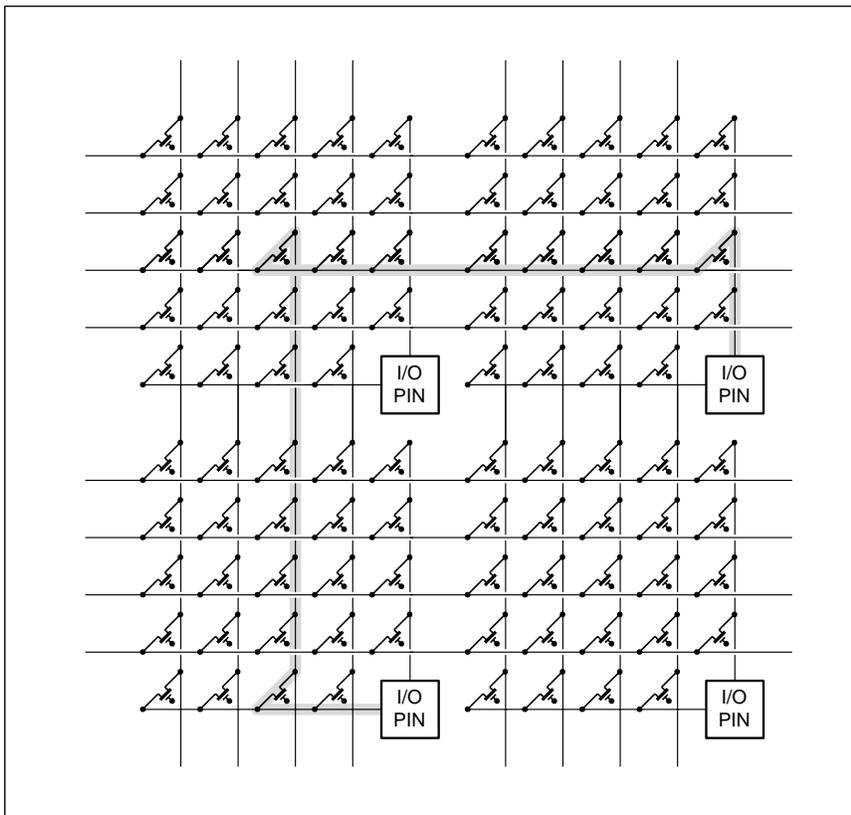


Fig. 2 – AN APTIX FIELD PROGRAMMABLE INTERCONNECT can be thought of as a magic box that lets you instantly connect any of a thousand wires together in any manner you like.

programmable interconnect chip.

A disadvantage is needing a higher voltage supply for your gate. Because currents are low, a charge pump can get used. The resistance values here would be 50 Ohms when on and tens of megohms when off.

A classic CMOS transmission gate is shown in 1-B. Here we place a N channel transistor in parallel with a P

channel one. Your on resistance will be lower and more uniform. We can also eliminate the need for any higher gate voltages, because the N channel device works best when near ground and the P channel device should work best near the positive supply.

Typical CMOS transmission gates are the 4016 and 4066. These have 15 to 60 Ohms of on resistance.

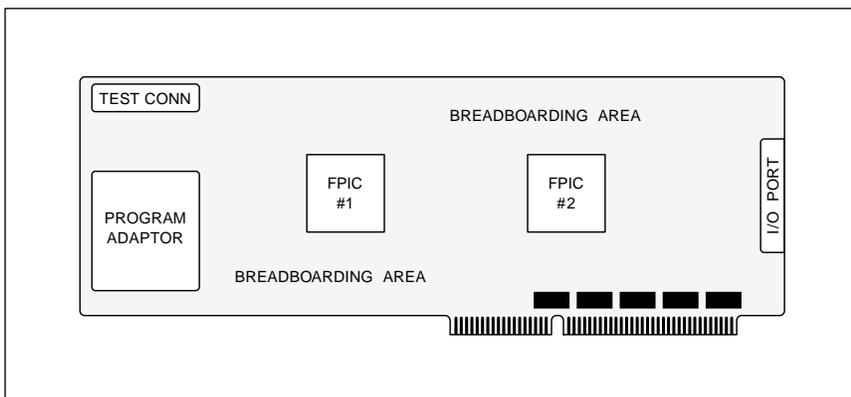


Fig. 3 – THE APTIX FPCB AXB-AT2 is a plug in card for an IBM PC that lets you quickly connect and debug up to 1700 interconnections on 37 square inches of your digital or analog circuitry.

More details on transmission gate fundamentals are shown in my *CMOS Cookbook*.

Godzilla

Aptix has introduced a stunning system of programmable interconnect circuits and breadboards. The key device is their FPIC APX1024D. You can think of this as a package which contains 1000 wires that you could connect together in any combination. 936 of these wires go out the pins on the bottom. You connect these to the other chips in your circuit any way you like. 64 of the wires go out the top to a special ribbon connector.

You normally use these for test and debug. They get connected to *any* of the other wires. On the fly.

At first glance, the obvious way to connect a thousand things together in any combination is to build an array that is 500 wide by 500 high. But this would need a total of 250,000 gates. It is very unlikely that you would ever need this many connections.

Instead, the interconnect system of figure two gets used. Each I/O or test pin has its short vertical stub that can be connected to up to four horizontal routing lines. Each I/O also has its short horizontal stub which can go to four vertical routing lines. Between each I/O pad, four horizontal routing lines can be connected to any of four vertical routing lines. This scheme needs only 24 transmission gates per I/O pad, for a total of 24,000.

Some of the routing lines are long distance "express" ones, while others are "local" ones that short hop only across a few pads. Typically, you'll need *three* series transmission gates for any connection. One to connect your pad to a horizontal routing line. The second to connect the horizontal routing to a vertical one. And a third to connect the vertical line over to the second pad.

Each transmission gate is a simple NPN transistor. That gets driven from either ground (when off) or the +7.5 volt supply (when on). The average three-hop connection should end up around 150 Ohms with 25 picofarads of stray capacitance.

Analog crosstalk will be less than one percent, or 40 decibels down. The pins themselves can handle anything analog or digital within a 0 to +5 volt

range limit.

Although these transmission gates are all bidirectional, there are routing advantages to defining certain pins as input only or output only. There are also methods for the *critical routing* of speed sensitive runs.

A portion of the circuitry gets used as a serial-to-parallel converter. As many as a third of a million bits are received to initialize the chip. Once programmed, the on-off patterns are stored in static RAM.

Their system is volatile, meaning that it forgets what it has been taught on power down. Initialization can be handled by a host computer or with a special stand-alone module.

It is possible to run out of routing lines. Very careful layout can usually find a solution. The same problem is also found with gate arrays and other large programmable chips.

There are many other devices and systems in the line. Their AX1024R is the same device in a cheaper package without the breadboarding connector. Several cards are offered with one or two programmable interconnect chips and lots of breadboarding areas. One of these is the FPCB AXB-AT2. This one is an IBM PC plug in card with programmable interconnects good for 1700 total connections. Included are breadboarding areas, a test and debug connector, and the usual bus driver chips. Dozens to hundreds of IC's can be used for your main circuit.

Lots of additional hard-solder pads are provided for supply and ground connections. With some adaptors, the layout pattern could accommodate just about any shape or size IC. A special area piggybacks a startup device.

Figure three shows us a pictorial of this plug-in card.

At first glance, this Aptix system seems horribly expensive. The chips are in the \$700 range and their fancy breadboards are even higher. But the potential time and dollar savings of programmable interconnects makes this initial cost seem trivial.

We might soon expect some major improvements. Lower costs through both competitive devices and higher sales volume. Lower resistances and strays. And, of course, nonvolatility in the form of internal EEPROM or flash memory is a must. High voltage units for analog design would also be

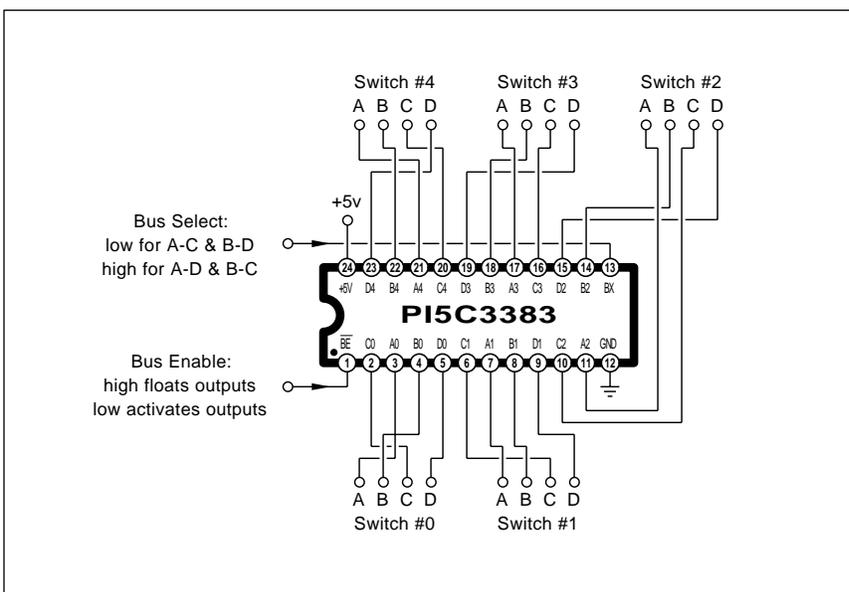


Fig. 4 – THE PIONEER PI5C3383 BUS SWITCH holds five double-pole, double throw bidirectional switches. This one is ideal for SCSI switching.

a nice addition.

And it should eventually dawn on Aptix that smaller hacker offerings without all the bells and whistles and gold plating could be a real big seller. Say solder-in epoxy jobs ferinstance. Possibly a plain old el-cheapo "blow the fuses" EPROM in some sort of a staggered SIP package.

Aptix has a free video, a data book, and other tech info available.

A Low End Solution

Pioneer Semiconductor has some programmable interconnects that are ridiculously cheaper and much more hacker friendly. Albeit at much lower package densities. Costs are as little as \$2.40 each.

Each chip typically offers eight to twenty transmission gates in various arrangements. The gates themselves give a much higher performance with an on resistance of 5 Ohms, and stray capacitance of 6 picofarads.

One model I have been particularly attracted to is the PI5C3383. This one holds five double pole, double throw bus switches. It would appear useful for data switches, especially for those involving SCSI comm.

Details in figure four.

Another use is for an intelligent serial cable setup that can be made instantly configurable on the fly.

A DPDT anything can be tricky to do on a printed circuit board because

of those crossovers. All of the needed crossovers are *internal* to these chips, greatly simplifying layout.

Note that mechanical switches are one big no-no with SCSI. Because of the transients, impedance levels, and those circuit strays.

In use, the *bus select* line picks A to C outputs when it is low and A to D outputs when high. That *bus enable* line tri-state floats the outputs when high and activates them when low.

As before, your bus switches are fully bipolar and can allow digital or analog signals to go either way inside a 0 to +5 vdc range. Switching times are six nanoseconds or so.

A *zero* propagation delay has been claimed, because no amplifying or switching devices are involved. You will, of course, still have the delay of the extra series resistance against all the circuit strays.

Many package options are offered, from a 24 pin DIP down to a quarter size surface mount QSOP.

Now, if we could only convince Pioneer to make much larger chips or Aptix to build much cheaper ones, we would be all set.

A Contest

Tellyawhat. Let's make a contest out of this. Just tell me about some new programmable interconnect uses. Assume that cheaper and mid-sized circuits will shortly be available.

PINBALL RESOURCES

American Coin Machine Dist.

700 SE Clay
Portland, OR 97214
(503) 233-7000

Am Fed of Pinball Collectors

13150 SW Falcon Rise Drive
Tigard, OR 97223
(503) 524-0726

Coin Slot

4401 Zephyr Street
Wheat Ridge, CO 80033
(303) 420-2222

Fabulous Fantasies

12602 Ventura Blvd.
Studio City, CA 91604
(818) 761-2255

The Flipside

Pinball Magazine
81 Carrar Drive
Watchung, NJ 07060

For Amusement Only

315 Belltown Road
Owings Mills, MD 21117
(410) 581-8626

Funtiques

PO Box 825
Tucker, GA 30085
(404) 564-1775

Gameroom

1014 Mt. Tabor Road
New Albany, IN 47150
(812) 945-7971

Marco Specialties

2401 Sunset Blvd.
West Columbia, SC 29169
(803) 796-0265

Mayfair Amusement

60-41 Woodbine Street
Ridgewood, NY 11385
(718) 417-5050

Pinball Lizard

3270 East Fifth Street
Tucson, AZ 85716
(602) 323-7496

Pinball Resource

37 Velie Road
La Grangeville, NY 12540
(914) 223-5613

Pinball Trader Newsletter

PO Box 1795
Campbell, CA 95009
(408) 554-8737

PinGame Journal

31937 Olde Franklin Drive
Farmington Hills, MI 48334
(313) 626-5203

Pinhead Replay

13150 SW Falcon Rise Dr
Tigard, OR 97223
(503) 524-0726

Pintronics

501 Randolph Street
Canton, MA 02021
(617) 961-3012

Play Meter

PO Box 24970
New Orleans, LA 70184
(504) 488-7003

RePlay

PO Box 2550
Woodland Hills, CA 91365
(818) 347-3820

Silverball Express

PO Box 442
Muskego, WI 53150
(414) 422-0600

Steve Campbells Pinball Pages

24309 4th Place West
Bothell, WA 98021
(206) 483-1249

There will be a bunch of the usual *Incredible Secret Money Machine II* books going to the dozen best entries. An all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for two will go to the very best of all.

As always, send all of your *written* entries to me here at *Synergetics* and not to **Electronics Now** editorial.

Pinball Resources

There's a lot of interest in pinball machines these days. As this month's resource sidebar I thought I'd gather together a few places to go for more pinball information.

If you are primarily interested in

machines as an income source, check into *Play Meter* and *RePlay*.

There are a surprising number of labor of love newsletters and mags here. These include *Gameroom*, *The Flipside*, *PinGame Journal*, *Pinball Trader Newsletter*, *Pinhead Replay*, and the *Silverball Express*.

As with any specialized field, there are dozens of useful suppliers. I've shown a random sampling here. But the one with the neatest name has to be *Pinball Lizard*. *Steve Campbell's Pinball Pages* appears to be a good place to go for schematics, manuals, and instructions.

Silverball Express also has a more

extensive resource directory than I've shown here. Included are the leading manufacturers and best books.

Thanks to Marc Mandeltort of his *Marco Specialties* who put me on to many of these resources. Marc is one of our *tinaja quest* winners.

Let me know if we missed any of your favorites here.

New Tech Lit

A free tutorial note on MIDI and wavetable music synthesis is offered by *Crystal Semiconductor*.

Steve Jobs and the NeXT Big Thing is a new book by Randall Stross and published by *Atheneum*. While it is somewhat harsh, the text shows what happens when way too much money and far too much ego get thrown at a non-solution to a non-problem.

You can now make custom printed circuit boards in minutes for pennies. Frank Miller of *DynaArt Designs* has just expanded his line of direct toner printed circuit products. He now has special toner cartridges, his new hot lamination transfer system, and a new gentle wave etcher. More on these if I get a chance to test them out.

Sensym offers free samples of their SDX pressure transducers to qualified potential quantity buyers. Ranges go down to 0-1 PSI. Their 0-5 PSI model looks real useful for measuring water levels to twelve feet.

Free *Fybrglass* brush samples are available from the *Eraser Company*. They are ideal for cleaning PC boards before soldering.

The *Grapevine Group* offers hard to find *Commodore* and *Amiga* parts.

A new low cost scoring system that is ideal for making your own boxes, cardstock models, and book covers is offered by *Martin Carbone*.

Check the Oil is a newsletter for all collectors of antique gas pumps. The *Human Powered Vehicle Association* publishes both a *Human Power* tech journal and a *HPV News* newsletter. Covered is surprisingly sophisticated engineering of bicycles, recumbants, boats, kinetic art, aircraft and even submarines. No spacecraft yet.

Electro- and Magnetobiology is a pricey journal from the *International Society for Bioelectricity*. This one is published by *Marcel Dekker*.

Skin electrodes for brainwave and EKG research are available from *In*

Vivo Metric. Competing ads appear in *Medical Equipment Designer*.

For the fundamentals of integrated circuits, do be sure to check into my classic TTL and CMOS cookbooks.

I've also got a brand new catalog having a much larger insider secrets section. You can write, call, or email me at [SYNERGETICS] on *GENie* or SYNERGETICS@GENIE.GEIS.COM on the Internet for your free copy. Or download it directly as SYNCAT1.PS from *GENie* PSRT.

Speaking of *GENie*, I have newly posted several cute PostScript hacks there. #843 on custom filters, #861 on sneaky server mods, and #868 on my new picojustification scheme.

Picojustification is a new way to stretch the actual characters as well as the spaces and the spaces between characters. This brand new technique can *dramatically* improve the quality of all fill justified text.

This Internet link works more or less one way only. Because PSRT is a commercial service and a for-profit venture. You can send your catalog requests or orders via Internet. You can also send your tech questions, but these will get answered *only* on the PSRT RoundTable.

Once again, most of the mentioned stuff appears in either our *Names & Numbers* or *Pinball* sidebars. Be sure to check here first before you call our no-charge voice helpline. ♦

NAMES AND NUMBERS

Aptix

2890 N First Street
San Jose, CA 95134
(408) 428-6200

Atheneum/MacMillan

866 Third Avenue
New York, NY 10022
(212) 702-2000

Martin Carbone

2519 Bath Street
Santa Barbara, CA 93105
(805) 682-0465

Check the Oil

Antique Newsletter
PO Box 1000
Westerville, OH 43081

Crystal Semiconductor

PO Box 17847
Austin, TX 78760
(512) 445-7222

Marcel Dekker

270 Madison Avenue
New York, NY 10016
(800) 228-1160

DynaArt Designs

3535 Stillmeadow Lane
Lancaster, CA 93536
(805) 943-4746

Eraser Company

PO Box 4961, Oliva Drive
Syracuse, NY 13221
(315) 454-3237

GENie

401 N Washington St
Rockville, MD 20850
(800) 638-9636

Grapevine Group

3 Chestnut Street
Suffern, NY 10901
(914) 368-4242

Human Powered Vehicle Assn

PO Box 51255
Indianapolis, IN 46251
(317) 876-9478

In Vivo Metric

PO Box 249
Healdsburg, CA 95448
(707) 433-4819

Medical Equipment Designer

29100 Aurora Road #200
Solon, OH 44139
(216) 248-1125

Pioneer Semiconductor

2343 Bering Drive
San Jose, CA 95131
(408) 435-0800

RF Design

6300 S Syracuse Way #650
Englewood, CO 80111
(303) 220-0600

Sensym

1804 McCarthy Blvd
Milpitas, CA 95035
(408) 954-1100

Don Lancaster's Hardware Hacker

May, 1994

Tough audio amplifiers
Obsolete semi resources
Air turbine opportunities
More on FM DX reception
Invention marketing scams

New ideas and opportunities are where you find them. So it pays to tune yourself in to the widest possible range of stuff you can. Ferinstance, your local molar mason can be your key to new sources for ultra low cost...

Air Turbines

Dentists are rather concerned over AIDS and related viruses. As a result, a lot of them are switching to newer "single use" tools that minimize risk factors. Which leads us to some new hacking opportunities.

What you call a dentist's "drill" is correctly known as a *handpiece*. One new series of throwaway disposable handpieces are now sold by *Oralsafe*. These have a list price of only \$14 each. These include a plastic handle, a high speed air turbine, and some "gee whiz" fiber optic lighting.

Right out of the box, these make fine printed circuit repair and rework tools. They are also great for model work and mockups. But what is really neat is that you can chop down the device to make a mini air turbine the size and mass of a plotter pen!

Figure one shows you the innards of the Oralsafe air turbine. All you have is a plain old nylon pawl gear that acts as an impeller, the hollow shaft that holds your working tool by friction, two ball bearings, and some simple end seal splash guards.

This one works just like a child's pinwheel. You blow on it. It spins.

An air turbine is inherently a very high speed, low torque device. It is useful for drilling very small holes in printed circuit boards or physically abrading copper foil. This is *not* at all suited for wooden sign routing or for heavy milling of aluminum. But you conceivably could add a gear train to reduce your speed and increase your torque. Odds are that you'd still be way ahead, compared to dragging a moto-tool or whatever around.

Now, compressed air does sound like a complication. But pneumatics can offer some unique solutions. On a CAD/CAM system, the heavier the

device you shove around, the worse the design problem and the higher the final expense. Sort of like ounces of satellite payload needing extra tons of fuel on the pad.

Many hardware hackers already do have shop air routinely available. If you do not, you'll need a compressor, an accumulator (or tank), an optional pressure gauge, and a regulator.

Figure two shows the setup some dentists use.

Normal working pressure at their handpiece is usually around 30 PSI. What a dental office usually will do is have a building shop air supply of around 90 PSI. Which is often a plain old garage compressor. Every work station has a local 60 PSI regulator. A needle valve or other flow restrictor is then used to set the pressure *at the handpiece* to 30 PSI.

Some sort of valve is used to turn the drill on and off. For hacker uses, you could simply close your flow all the way instead. Otherwise, a manual or electric valve can be used. Since the air turbine vents to ambient, only a two-way valve is needed.

Regulators, valves, and gauges are widely available for around \$6 or so

by way of *C & H Sales* or *American Science and Surplus*. Compressors are easily found at yard sales or in most electronic surplus ads. But note that aquarium pumps or spa blowers cannot supply remotely the pressure needed. If all else fails, take a plain old truck tire and fill it to 100 PSI. Or use a Scuba tank. Either should give you many hours of operation.

The Oralsafe package also includes a technological miracle called a "bur ejector." Otherwise known as a nail.

Tellyawhat. Let's make a contest out of all this. Just tell me what you would do with an air motor the size and mass of a plotter pen. Or actually build a low cost something and tell me your experiences using it. As usual, there will be a bunch of my *Incredible Secret Money Machine II* books going to the best entries, plus an all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for the very best.

As usual, send your *written* entries to me here at *Synergetics*, rather than to **Electronics Now** editorial.

Even if these Oralsafe air turbines end up too short-lived or too wimpy for useful work, they seem a superb starting point for solving the hacker's

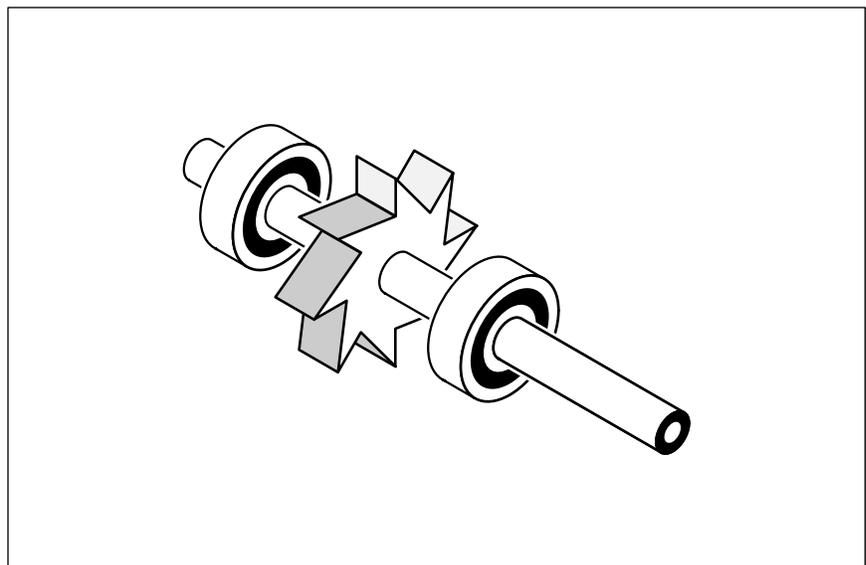


Fig. 1 – THE \$14 ORALSAFE DENTAL HANDPIECE can be cut down to provide an air turbine the size and mass of a plotter pen. Air blown tangentially across the nylon pawl causes the hollow shaft to rotate at high speed.

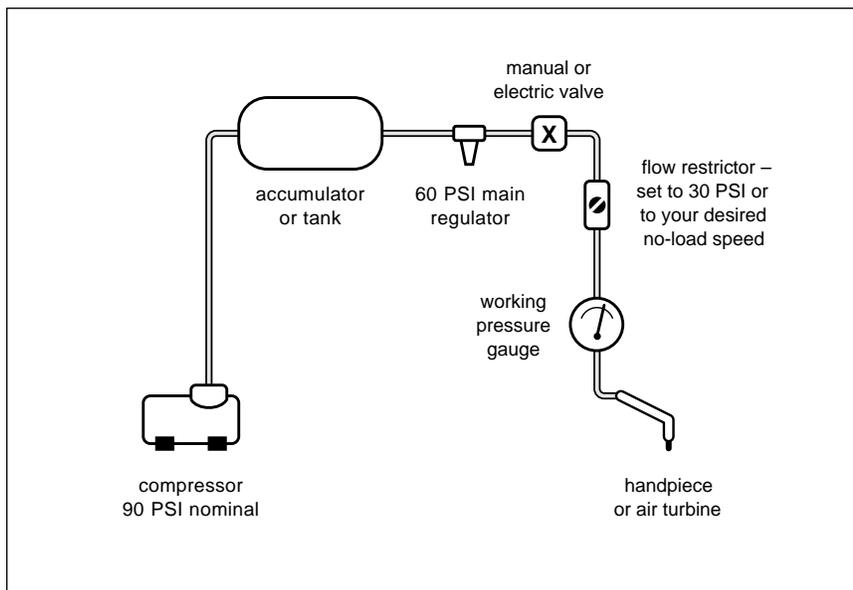


Fig. 2 – A TYPICAL SUPPLY SYSTEM that can be used with air turbines.

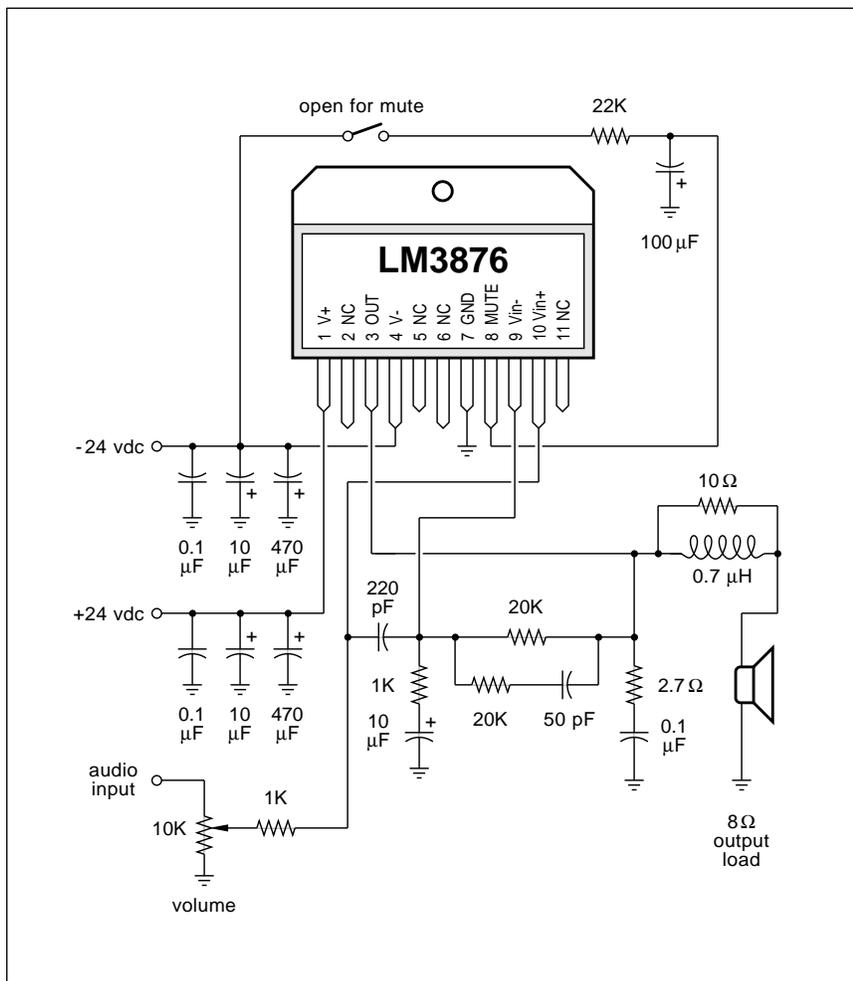


Fig. 3 – NATIONAL SEMICONDUCTOR HAS A NEW LINE of exceptionally rugged Overture audio amplifiers. Here is a typical 40 watt circuit.

CAD/CAM cost hassles. Pneumatics looks like a real winner here.

Disposable handpiece ads appear in the *Dental Products Report* and *Dentistry Today* trade journals. One low cost tubing source is *Hygenic*.

Many thanks to Jim Saline DDS for putting me on to these.

Bulletproof Audio

National Semiconductor has just deluded themselves into believing they have produced an indestructible audio power amplifier. Well, it won't take **Electronics Now** readers long to correct National's thinking here.

But the new *Overture* series audio power amplifiers sure are up into the "fairly sturdy" range. And their specs seem in excess of hi-fi quality. These are also cheap and easy to use. And free samples are sent for letterhead requests. So these do look like great new hacker chips.

Figure three shows us one circuit. They made a pseudocomplimentary integrated bipolar power audio amp and then added some elaborate new *SPiKe* protection circuitry to it.

They call it a 100 watt amplifier, but this really delivers only 40 watts of continuous average output power into your usual 8 Ohm speaker load. The distortion at full power is a scant 0.06 percent and the signal to noise ratio is 95 db.

The protection circuitry is what makes the chip new and exceptional. The chip rapidly shuts itself down on any short, overload, or overtemp. It quickly self-resets.

As a bonus, the amplifier does not start up until the supply voltages are high enough. A mute is also offered. Either of these features can eliminate transients which create annoying and possibly destructive thumps.

National says that you do not need regulated power supplies, owing to their excellent power supply rejection ratio of more than 120 decibels. Such a claim is fraught with peril when told to hardware hackers. You'll still need a solid supply that stays within reasonable maximum and minimum limits and has enough energy storage to prevent dropouts or droop at all power levels.

By the way, *SGS-Thomson* offers a roughly comparable device having MOSFET outputs rather than bipolar

ones as their TDA7294. The pinouts and circuitry are somewhat different. I'm not at all sure which one is your better choice.

FM DX Again

Well, the dust has finally settled on the long distance FM reception stuff we've looked at several times in the past. It did turn out there are lots of genuinely useful products out there, but they sure were hard to find.

A few contest winners pointed out that *too much signal* can cause even more problems than too little. If you reduce the size of your input signals, sometimes you can keep any strong local station from overloading.

So more ain't necessarily gooder.

Radio Shack has some low cost 10 decibel attenuators you can try here for effect.

If you have an exceptionally well designed receiver front end, you can also gain bunches by reducing your receiver's if bandwidth. In just the same way that a comm receiver offers several bandwidth options that trade off selectivity versus audio quality.

In fact, the whole reason for an if strip in the first place is to gain some extra selectivity.

Most modern FM receivers employ ceramic filters that typically have a bandwidth of 270 kilohertz. You can also get very low cost (\$2) filters on down to 90 kilohertz or less. *Murata* is one typical source. These should, in theory, dramatically improve your rejection of unwanted signals. But reworking your if bandpass on any commercial FM receiver is not a trivial task. You have to have special test equipment and know *precisely* what you are doing. And your stereo performance may drop badly.

There is a broadcast quality FM tuner called the *Denon* TU-680 NAB. This one includes a switched narrow band if option that has 75 decibels of rejection a mere 400 kilohertz away from your desired station. The price is around twice that of a better grade home hi fi tuner.

You can also pretend you are a cable tv company and use headend components instead. One leader here is *Cadco*. They offer a rackmount FMP *Broadband FM Processor* that has 35 decibels of RF gain and strong rejection of out-of-band signals.

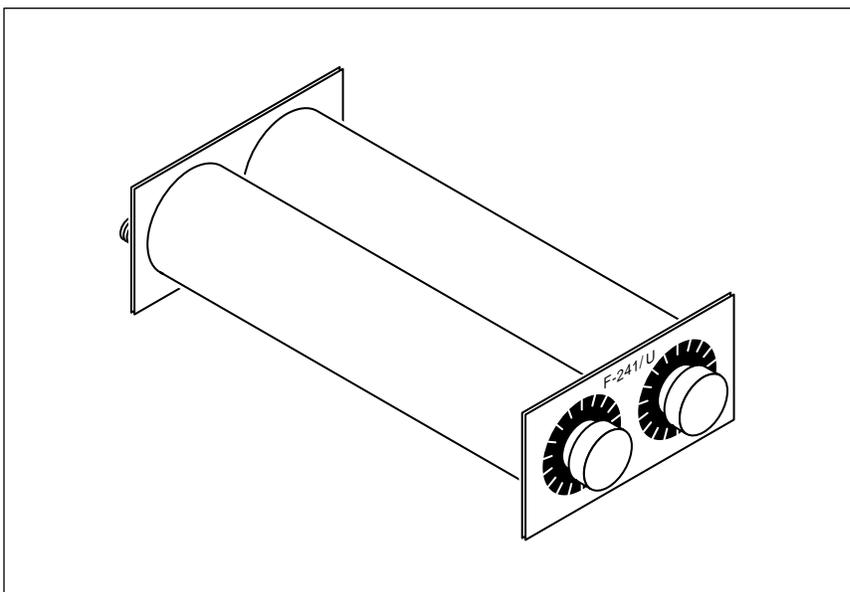


Fig. 4 – SURPLUS F-241/U OR F-243/U TWIN CAVITIES can be easily converted into tuning preselectors to improve distant FM reception.

They have a FME *Broadband FM Equalizer* which includes one dozen premium and passive tunable traps. These let you balance out the signal levels from strong and weak stations. Also offered is a super rugged and no-nonsense FM-SSL-75 antenna with 12 decibels of gain.

Considering that "it don't get any better than this," the costs are not that bad. Around \$300 each.

Speaking of traps, several readers sent me some that just did not work. Sorry, but it is simply not possible to build a single station passive FM trap by using ordinary trimmer capacitors and plain old coils.

Yeah, you can easily trash out the entire FM band. But you can't notch out one single station and still pass a nearby one. Active solutions usually won't work because of crossmod.

Why? Push the numbers. Say you are at 75 Ohms impedance and want a bandwidth of less than 500 kHz at 100 MHz. That needs a loaded Q of 200, which takes an unloaded Q of 600 or higher. Go through the math, and you are talking a tuning capacitance value of a tiny fraction of a picofarad. This is tricky to do in the real world. Not to mention the *extreme* problems you would have with temperature stability or mechanical vibrations.

Yes, you can build or buy narrow 75Ω passive filters. And yes, they can reject single stations. But to do so,

you have to go to exotic techniques such as helical resonators, cavities, or transmission line components.

I did manage to find several good FM trap solutions. The cheapest one is a pair of surplus cavities called a F-241/U and offered for \$22 by *Fair Radio Sales*. Unfortunately, the unit will need modified in a machine shop before it will tune the FM band.

No, a hack saw won't hack it.

There is also a F-243/U unit that is already in the right frequency range. Plug and go. But these are extremely hard to find.

Figure four shows you what these look like.

TX-RX Systems offers bunches of fancy cavity systems that are stable enough to do the job. Responses are offered from variable notches on up through bandpass filters. In general, the larger the cavity, the higher the Q and the greater the stability. These dudes go up to *ten inches* in size!

Pricing of these cavities is in the "Don't ask - Don't tell" range.

A more economical alternative is offered by *Channel Master* as their Model 7008 dual trap. This one uses a pair of vernier helical resonators and lists for around \$80. Insertion loss is only half a decibel.

A second unit would be the *Jerrold* RFT-300 tunable FM trap.

Let me know what else you can come up with in tools and techniques

OBSOLETE SEMICONDUCTOR RESOURCES**Circuit Specialists**

PO Box 3047
Scottsdale, AZ 85271
(800) 528-1417

Digi-Key

701 Brooks Avenue South
Thief River Falls, MN 56701
(800) 344-4539

ECG

PO Box 3277
Williamsport, PA 17701
(717) 323-4691

EEM Master

645 Stewart Avenue
Garden City, NY 11530
(516) 227-1300

Fistells

7023 E Colfax
Denver, CO 80220
(303) 393-6000

Mouser

11433 Woodside Avenue
Santee, CA 92071
(800) 346-6873

NTE

44 Farrand Street
Bloomfield, NJ 07003
(201) 748-5089

Pure Unobtanium

13109 Old Creedmoor Road
Raleigh, NC 27613
(919) 676-4525

RH Electronics

4083 Oceanside Blvd, Ste G
Oceanside, CA 92056
(619) 724-2800

Rochester

10 Malcolm Hoyt Drive
Newburyport, MA 01950
(508) 462-9332

Sunset Silicon

402A Ridgefield Circle
Clinton, MA 01510
(508) 365-6108

Surplus Traders

PO Box 276
Alburg, VT 05440
(514) 739-9328

for longer distance FM reception. A stable dual helical trap would make an interesting low cost construction project. As would specific machining instructions for the surplus cavities.

Obsolete Semiconductors

I sure do get a lot of helpline calls asking for sources of out-of-date or hard to find semiconductors. So, for our resource sidebar this month, I thought we'd run a short list a few of the more obvious sources.

The key thing most callers don't pick up on is that all devices become obsolete for very good reasons.

Usually, there is some far better replacement or a newer approach that caused the obsolescence in the first place. The message here is simple: It is usually a total waste of time to chase after obsolete semiconductors. Especially to build older construction projects or for new product designs. Even when repairing older gear, the chances are that much better stuff is available much cheaper.

Most any really ancient digital integrated circuit can be replaced by a \$2.50 PLA or a PIC microcontroller these days.

Some comments on our listings: *Mouser* and *Digi-Key* stock a wide variety of modern parts; chances are you can locate a replacement here. *Circuit Specialists* tends to offer the unusual and oddball stuff of interest to hardware hackers.

Surplus Traders is likely to end up with just about anything, catch as catch can. *Rochester Electronics* and *RH Electronics* both specialize in warehousing obsolete parts and older MIL spec semiconductors.

If the chip cannot be had at any price, *Sunset Silicon* will be happy to build you brand new devices from scratch. They specialize in buying up old circuit masks for remanufacture. Serious inquiries only, please. Your BMW will be required as a deposit.

The *EEM Master* is your complete directory for most integrated circuits ever manufactured anywhere in the world. *ECG* and *NTE* are your two best houses for consumer electronic replacement semiconductors.

Pure Unobtainium is a labor-of-love hacker operation which stocks problem parts for specific homebrew construction projects. Their catalog is one dollar, cash in advance.

Finally, *Fistells* specializes in old electronic organ chips, especially top octave generators and keyers. They also build modular workarounds for music parts that truly are impossible to get elsewhere.

Let me know if I missed any of your favorites here.

Much more info on pinning down unusual supply sources appears in my *Resource Bin* reprints.

Invention Marketing Scams

I noticed that the February 11, 1994 issue of the *Wall Street Journal* had a column in which the Federal Trade Commission had finally closed down the number one inventor scamming bad guy. What's really amazed me is that inventor scams are now a \$114 million a year industry. What usually happens is that an unsuspecting and misguided "inventor" responds to a tiny classified ad, has his invention lavishly praised, and then typically pays \$5000 or so in up-front fees to license or market his new invention. According to court records, less than one "customer" in 500 ever sees any positive cash flow, and virtually none of them ever make a real profit.

Now, I personally do feel that it is really dumb to refer to yourself as an "inventor" or even act like one. To do so opens you up to every scam in the book, plus a few that haven't made print yet. The playing field is *always* uneven any time the word "inventor" so much as crops up.

On the other hand, there are many hundreds of more or less legitimate inventor organizations who do think they provide useful services. These are often local self-help clubs, school seminars, or the regional "incubator" development programs.

I've posted a long list of these as #538 *INVENORG.PS* to *GENIE* PSRT.

My own thoughts are that you will do vastly better viewing yourself as a *purveyor of risk reduction* rather than as an inventor. This has to do with moving a product or concept as far along to the right on the incredibly steep *idea mortality curve* as you possibly can. Ferinstance, you have absolutely zilch until your product successfully gets out of beta test. The more you internalize your risks, the higher your odds of success. Much more on this in *RISKDOWN.PS*.

Both of these also appear as hard copy in my new *Case Against Patents* package from *Synergetics*.

Midnight Engineering magazine is a useful source of tested and proven smaller scale product development ideas. I've found it infinitely better than the "inventor" magazines.

New Tech Lit

A second source for those bus switches we looked at last column is *Quality Semiconductor*. They have a bunch of low cost and eminently hackable *QuickSwitch* products.

There are now zillions of Internet books coming out of the woodwork. Typically priced at \$300 a dozen or so. Of these, I like the \$2.95 *Internet Public Access Guide* the best.

If you are wondering who issues research grants for what, you might check *The Chronicle of Philanthropy*.

Very heavy matters are routinely covered in the *Weight Engineering* trade journal. Such as scales to find out how heavy airplanes are.

Short Circuit is also the *Newsletter of Engineering Empowerment*. Free samples are offered. This does look like the sort of thing I'd normally be in favor of. Sadly, I feel their writing style totally fails to communicate.

The *Star Tech Journal* is a pub that focuses on insider tech solutions for arcade video game repairs. They also offer a BBS at (404) 631-2928.

If you are now at all interested in starting up your own tech venture, be certain to get a copy of my revised *Incredible Secret Money Machine II*. I've also got a new free catalog when you call or write.

My current Internet address is now SYNERGETICS@GENIE.GEIS.COM. You can send me messages, ask tech questions, or request catalogs over this email link. Any tech questions will get posted to Category 1, Topic 38 of my *GENie* PSRT. ♦

NAMES AND NUMBERS

American Science & Surplus

601 Linden Place
Evanston, IL 60202
(708) 475-8440

C&H Sales

PO Box 5356
Pasadena, CA 91107
(800) 325-9465

Cadco

2405 South Shiloh Road
Garland, TX 75041
(800) 877-2288

Channel Master

PO Box 1416
Smithfield, NC 27577
(919) 989-2205

Chronicle of Philanthropy

1255 Twenty-third Street NW
Washington, DC 20037
(202) 466-1200

Denon

222 New Road
Parsippany, NJ 07054
(201) 575-7810

Dental Products Report

Two Northfield Plaza, Ste 300
Northfield, IL 60093
(708) 441-3700

Dentistry Today

26 Park Street
Montclair, NJ 07042
(201) 783-3935

Fair Radio Sales

PO Box 1105
Lima, OH 45802
(419) 227-6573

GENie

401 N Washington St
Rockville, MD 20850
(800) 638-9636

Hygenic

1245 Home Avenue
Akron, OH 44310
(216) 633-8460

Internet Public Access Guide

PO Box 55549
Seattle, WA 98155
(206) 527-3385

MuRata

2200 Lake Park Drive
Smyrna, GA 30080
(404) 436-1300

National Semiconductor

475 Ellis Street
Mountain View, CA 94043
(800) 272-9959

Oralsafe

43529 Ridge Park Drive
Temecula, CA 92590
(800) 237-8825

Quality Semiconductor

851 Martin Avenue
Santa Clara, CA 95050
(408) 450-8063

SGS-Thomson

1000 E Bell Road
Phoenix, AZ 85022
(602) 867-6259

Short Circuit

PO Box 158
Stuart, FL 34995
(407) 229-5654

Star Tech Journal

PO Box 1065
Merchantville, NJ 08109
(609) 662-1080

Synergetics

Box 809
Thatcher, AZ 85552
(602) 428-4073

TX-RX Systems

8625 Industrial Parkway
Angola, NY 14006
(716) 549-4700

Weight Engineering

PO Box 1043
Alton, IL 62002
(618) 377-9096

I just got this call from a graduate student who is certain they have now proven that the second law of thermodynamics is wrong and what should they do about it? It was something about statistical thermal gradients nailing *Maxwell's Demon* in a driveby shooting. Naturally, the effect is purely theoretical. It is "too small to measure in the lab."

The obvious answer is to go out for some coconut anchovy pizza and then forget the entire incident. But do *not* mention this to your thesis advisor.

Actually, our helpline will average around three second law violations or so per month. So, let us go over the rules one more time: True, the second law of thermodynamics ("you can not break even") has never been proven.

And probably is *not* provable.

But on the other hand, and *without exception*, every attempt to find *any* counterexample that would prove it wrong has utterly and totally failed. At least on the normal everyday scale of things. Literally billions of tests are unintentionally rerun day in and day out that overwhelmingly suggest the law really is true.

Congress is not expected to repeal the second law any time soon.

If this student is convinced he is right, he has two options. He can go the *real science* or the *pseudoscience* route. With the real science route, he has to create some simple and easily duplicated experiment which allows disinterested third parties to get his effect to show up fairly well.

And do so in such a manner that his explanation for what is coming down seems to be the most probable and the most reasonable.

The results *must* end up well above experimental noise floors. After the results are independently duplicated and verified, then his paper can get presented to a credible journal for a peer review and publication.

With the pseudoscience route, he can go to any of the members of the pseudoscience industry press and can instantly get published. Or else could pick slow news days in obscure rural

newspapers for his coverage. Or go to even more obscure semi-scholarly foreign publications of questionable pedigree. But none of these alternate routes will look good on his resume.

I've just posted lots more info on exploring pseudoscience resources as [RESBN26.PS](#) on www.tinaja.com.

Solitons

Outside of a classic ghost town in Colorado's San Juans, there is this free-hanging old mining cable which literally goes up the wall. This beast is nearly a mile long and over an inch in diameter. Which leads us to some utterly fascinating real world and real time physics. If you grab this cable near the low end and shake it once, you can watch a solitary sonic wave running up, reflecting, and returning several seconds later.

What is really amazing is that the solitary return wave is so violent that it will try to rip your arm right off the cable. Something special does appear to be happening.

A century ago, a mathematician decided that certain solitary waves can indeed be special. He was riding his horse along a canal bank and was daydreaming about waves.

A barge suddenly stopped and then launched a single solitary wave. He immediately noticed that this wave was unique in that it kept going much further than ordinary waves. In fact, he followed the wave for miles.

After some analysis, he called this special type of wave a *soliton*.

Today, solitons are an incredibly hot research topic. One big use is for fiber optic communications, where a soliton can go much further between repeating amplifiers. In fact, soliton fiber comm a third of the way around the earth with a 20 Gigabyte data rate has been demonstrated.

Why will any wave die out? You'll find three main reasons. First, your wave will *dissipate* when it does such things as flex a resisting cable or go up against air resistance. Dissipation ultimately transforms all of the wave

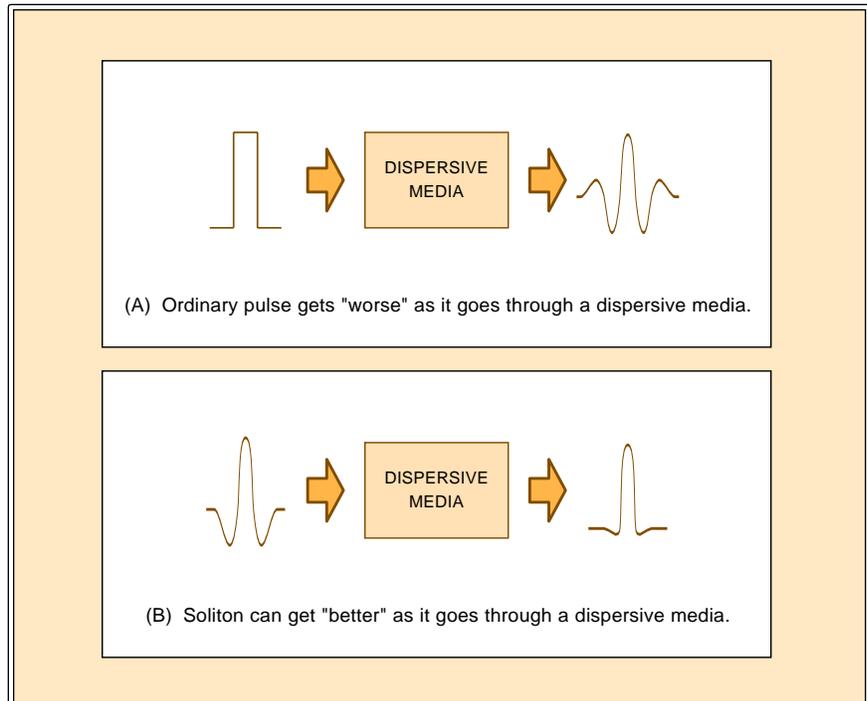


Fig. 1 – SOLITONS are a special class of solitary waveforms that can travel much further than ordinary waveshapes. They are a hot research topic.

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- Solitons, Nonlinear Evolution Equations & Inverse Scattering**, Ablowitz, M.A & Clarkson, P.A. *London Mathematical Society Lecture Note Series*, #149 Cambridge University Press, 1992.
- Soliton Phenomenology**, Makhankov, Valdmir, G, *Mathematics & its Applications, Soviet Series*, Kluwer Ac, 1990.
- Soliton Theory: A Survey of Results**, Fordy, A. P. *Non-linear Science Series*, Wiley, 1992.

Fig. 2 – SOME RECENT SOLITON REFERENCES. There are 8300 more!

energy into low grade heat.

Second, portions of the wave will *reflect* whenever it encounters any changes in the media impedance or uniformity. In the case of that San Juan cable, the end ring is something less than a perfect short, so you don't get everything back.

Finally, and most important for a soliton, the wave will *disperse* if the media lets higher frequency waves go on by faster or slower than lower frequency ones. Usually, your wave energy "stretches out" over time.

Any waveform can be represented as a group of high frequency and low frequency components. If these ever get out of step, your wave shape will change drastically.

As will the detectability.

A different name for one type of dispersion is *group delay distortion*.

For instance, if the frequency for a one in a modem has more delay than the frequency for a zero, you may get times when you've got a one, a zero, *both*, or *neither* at your output.

Obviously, "both" or "neither" are bad news when it comes to extracting useful information.

Figure one shows the essentials of solitons. An ordinary pulse which is sent through a dissipative media gets worse and hard to detect. A soliton sent through the same media actually gets *better* and easier to detect. For the best results, your media has to be known, stable, and fixed length. The soliton shape also has to be designed to match the media.

What a soliton wave tries to do is *predistort* itself so that, by the time it gets sent *through* the media to your intended receiver, the dispersion of

the media and the "undispersion" of your initial waveform cancel out. The fast and later frequency components catch up with slow and early ones.

The soliton wave sort of becomes self-reinforcing.

Your innermost technical secret to self-reinforcement is this: Make the *speed* of a soliton wave proportional to its *height*. Should the wave stretch out, its amplitude will drop and the forward parts of the wavefront slow down to pile back up, re-raising the height. Should the wave become too narrow, its amplitude raises and the forward parts of the wavefront speed up to stretch back out, lowering the height back to where it was.

The effect can be made perfectly self-compensating. Soliton waves are surprisingly common in nature, but they can end up real tricky to do with optics. Special lasers and nonlinear techniques are needed.

Bats and military radars use a more elaborate *chirp* scheme that works in more or less the same way as do the solitons. Send any swept FM signal through any media that has a linear delay versus frequency response, and you get a narrow and high amplitude pulse back out.

Fourier transforms and all.

Another very unusual property of solitons is that they can freely pass through each other without colliding! Ordinary waves often destructively interfere if you attempt this.

When you explore the literature, you will find 8,316 soliton papers on *Dialog* alone! There are also dozens of textbooks. Sadly, many are totally unreadable and involve horrendous math. I have posted a more or less random and rather short sampling of these to figure two. These sources and their end bibliographies should be enough to get you started.

Be sure to let me know if you find any favorite soliton tutorials on your own that are easy to understand. An [Incredible Secret Money Machine II](#) for your trouble.

What good are solitons for all you hardware hackers? Well, obviously, we've got a great subject for science fair projects, student papers, or even thesis topics. But there's a possible new use for solitons that just about anybody can explore. And for which hands-on backyard testing is more

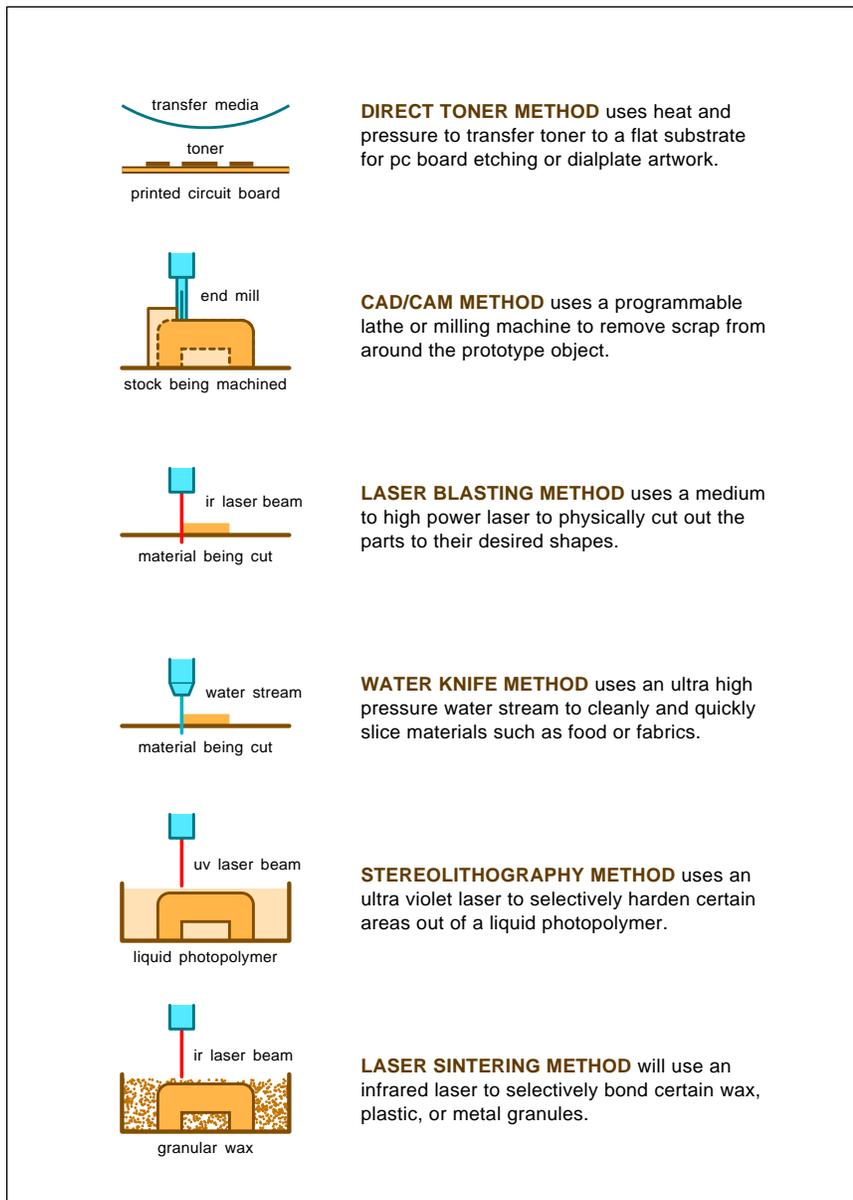


Fig. 3 – SOME CURRENT APPROACHES to Santa Claus Machines.

important than fancy math. One that literally is guaranteed to get your feet wet. Also for which some big bucks just might be made.

Simply answer this question: "Can solitons improve fire streams?"

Between spelunking, *tinaja quests*, and pecan harvests, I am also a city fireman. The deck gun on a pumper has an effective fireground range of slightly over 200 feet. There sure are times and places when that flat out ain't enough. At least theoretically, the solitons should be able to extend this range significantly.

Ideally, all your solitons should be

DIRECT TONER METHOD uses heat and pressure to transfer toner to a flat substrate for pc board etching or dialplate artwork.

CAD/CAM METHOD uses a programmable lathe or milling machine to remove scrap from around the prototype object.

LASER BLASTING METHOD uses a medium to high power laser to physically cut out the parts to their desired shapes.

WATER KNIFE METHOD uses an ultra high pressure water stream to cleanly and quickly slice materials such as food or fabrics.

STEREOLITHOGRAPHY METHOD uses an ultra violet laser to selectively harden certain areas out of a liquid photopolymer.

LASER SINTERING METHOD will use an infrared laser to selectively bond certain wax, plastic, or metal granules.

generated thru water pressure only, using some sort of bolt-on and pass thru flutterwumping adaptor that is in series with the water supply.

But go ahead and use electronics or even high pressure air to prove the idea works. Because of an exciting and an incredibly effective new CAFS foam firefighting technique, certain new pumpers now include a reliable compressed air supply.

Let me know what you can come up with here. Obviously, you can use an ordinary garden hose for all your initial tests. This one appears to be an outstanding hacker opportunity.

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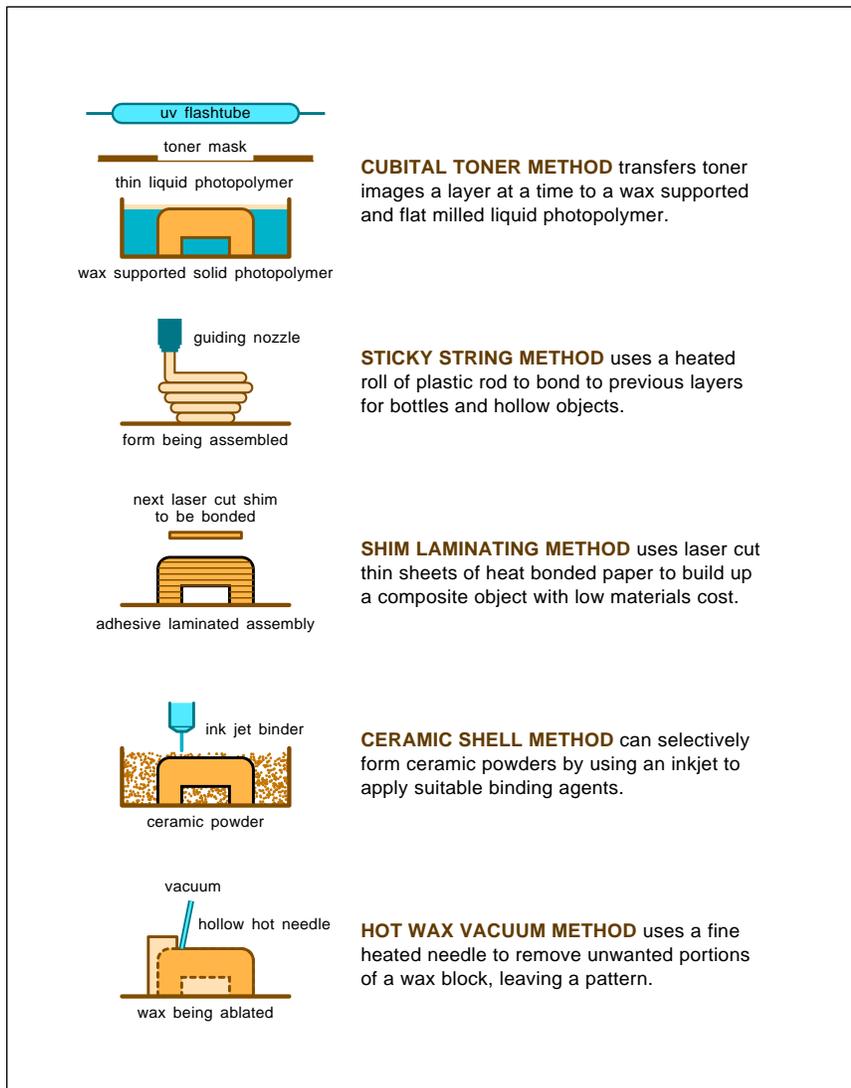


Fig. 4 – ADDITIONAL CURRENT APPROACHES to Santa Claus Machines.

Santa Claus Machines

The science fiction authors called them *Santa Claus Machines*. Magic boxes which could run off a copy of anything – a BMW, a pastrami on rye, a new girlfriend, or a duplicate \$20 bill. Starting with either a sample or a set of software plans.

These days, crude approximations to the Santa Claus machines really do exist. And they literally are getting better every day.

Today, these are often known as *desktop manufacturing* or else *rapid prototyping systems*. The pastrami on rye still leaves this distinctly acrylic aftertaste. But it definitely is low in fat and has zero cholesterol.

There's now a dozen approaches to

Santa Claus machines, so I thought I would once again gather several of the bigger players together into this month's resource sidebar.

Most of the systems we'll look at are outrageously expensive. A house and two cars. But there is no reason the whole kit and kaboodle of them could not be replaced with about \$175 worth of hacker parts, bunches of time, and a lot of imagination.

So there are some incredible new opportunities here. Either for custom systems of your own or as a service bureau for others.

Some of the major approaches to Santa Claus machines are shown you in figures three and four. Let's do a brief rundown of a few of the more obvious possibilities here ...

Direct toner method – This one is the cheapest, the most accessible, and the most hacker friendly. But it is pretty much restricted to two-dimensional work such as instant printed circuits, front panels, or dialplates.

With this method, you PostScript laser print your toner image onto a transfer sheet. The transfer sheet is placed in contact with your printed circuit board or whatever. Heat and pressure is then applied. Your toner transfers to the board and becomes the etch resist. Or the image.

The two leading suppliers here are *DynaArt Designs* and *Techniks*, with the pc supplies sold by *Kepro*.

CAD/CAM – has been around for a while. Which works like an ordinary lathe or milling machine, chewing up scrap to leave the desired object. The difference is software control where you feed it a set of plans and it does the rest by itself. Low end machines have only started to appear here.

While much lower in cost than old "industrial strength" machinery, they still remain obscenely overpriced for most hacker uses.

Typical low end CAD/CAM outfits do include *Roland*, *Techno Isel*, and *Light Machines*. Others advertise in such places as the *School Shop* and *Industrial Education* trade journals.

Custom CAD/CAM bits and pieces are available at *Stock Drive Products*. Two other material sources are *MSC Specialties* and *McMaster-Carr*.

John Rees offers a hacker version here that can let you use ordinary car alternators as power stepper motors.

A CAD/CAM prototyping system can be used with a machinable wax. Instead of metals or plastics. The wax can then become a pattern or a mold for your final items. This is easier on tools, and mistakes can be recycled. Wax is also a good way to practice.

One source of machinable wax is *Freeman Supply*, while *Kindt-Collins* provides a wide range of all sorts of industrial and artistic waxes.

Laser Blasting – The medium power laser is one variation on CAD/CAM that is revolutionizing crafts, model making and smaller parts in general. Parts are cut quickly, accurately, and splinter free. A twenty watt carbon dioxide laser could be used for such things as the precision cutting of doll

house furniture or slicing up parts for model railroad structures.

More info on power laser systems appears in *Industrial Laser Review*, while two hacker friendly sources for lasers are *Meredith* and *MWK*.

Water Knives – are a more or less similar Santa Claus system. An ultra high pressure water stream does all the work. My favorite demo has one of these chopping up a gooey piece of chocolate cake and a four inch thick steel slab at the same time.

Flow International is one source. *Haskell* makes the special pumps.

Stereolithography – The pioneer here is a company called *3D Systems*. With stereolithography, you start off with a vat of a liquid photopolymer. A stage sits very near the vat surface.

A scanning laser then hardens out one layer of photopolymer. The stage is lowered slightly and a new layer is progressively put down.

The process keeps repeating until your part is completed. Virtually any shape can get made, including those impossibly difficult to machine.

The photopolymers aren't all that different from the ones used by the flexographic printing or rubber stamp folks. Two suppliers are *Merigraph* and *Grantham Polly-Stamp*.

Selective Laser Sintering – is a rapid prototyping method that starts with a fine powder of wax, plastic, or even certain metals. The laser selectively melts and bonds portions together in a thin layer by sintering. *Sintering* is melting things just enough that they stick together. Then your part gets lowered, more powder is leveled, and a second layer is imaged, building up the desired prototype.

The final objects are often sturdy enough for use as actual parts. Unlike stereolithography, the materials used are low cost and non-hazardous. The laser is also cheaper since infrared rather than ultraviolet can be used. *DTM Corp* in Austin seems to be the main champion of this method.

Cubital Toner Imaging – This one is related to the direct toner method. An *unfused* toner laser image is contact printed onto a photopolymer. Then your unhardened photopolymer gets sucked up and recycled, as does the toner image. Voids are then replaced

| SANTA CLAUS MACHINE RESOURCES | |
|---|---|
| <p>Cubital America 1307F Allen Drive Troy, MI 48083 (313) 585-7880</p> | <p>MSC Specialties 6700 Discovery Blvd Mableton, Ga 30059 (800) 645-7270</p> |
| <p>DTM Corp 1611 Headway Circle, Bldg 2 Austin, TX 78754 (512) 339-2922</p> | <p>MWK Industries 1440 S State College Blvd 3B Anaheim, CA 92806 (800) 356-7714</p> |
| <p>DynaArt Designs 3535 Stillmeadow Lane Lancaster, CA 93536 (805) 943-4746</p> | <p>Rapid Prototyping Report 841 Turquoise Street, Ste D San Diego, CA 92109 (619) 488-0533</p> |
| <p>Grantham Polly-Stamp 418 Central Avenue NE E Grand Forks, MI 56721 (218) 773-0331</p> | <p>John Rees Route 1 Box 1551 Santee, GA 30571 (706) 865-5495</p> |
| <p>Helisys 2750 Oregon Ct Bldg M-10 Torrance, CA 90503 (310) 782-1949</p> | <p>Roland Digital 7200 Dominion Circle Los Angeles, CA 90040 (213) 685-5141</p> |
| <p>Kepro 630 Axminister Drive Fenton, MO 63026 (800) 325-3878</p> | <p>Soligen 19408 Londelius Street Northridge, CA 91324 (818) 718-1221</p> |
| <p>Light Machines 669 E Industrial Drive Manchester, NH 03103 (603) 625-8600</p> | <p>Stock Drive/Techno 2101 Jericho Turnpike New Hyde Park, NY 11042 (516) 328-0200</p> |
| <p>McMaster-Carr Box 54960 Los Angeles, CA 90054 (213) 692-5911</p> | <p>Stratasys 14950 Martin Drive Eden Prairie, MN 55344 (612) 937-3000</p> |
| <p>Meredith Industries 5035 N 55th Ave Ste 5 Glendale, AZ 85301 (602) 934-9387</p> | <p>Techniks 45 J Ringo Road Ringoes, NJ 08551 (908) 788-8249</p> |
| <p>Merigraph Box 3064 Naperville, IL 60566 (800) 323-1832</p> | <p>3D Systems 26081 Avenue Hall Valencia, CA 91355 (805) 295-5600</p> |

with a suitable wax filling.

The surface is carefully milled flat and another layer is created. Unlike stereolithography, you are rapidly forming an entire layer at once, rather than a single spot. You are also using far less photopolymer, since only a thin layer is used. First developed in Israel, a source is *Cubital America*.

One service bureau here is *Stature Machining Technologies*.

Sticky Strings – Although this looks like a refugee from a special ed arts class, this approach seems well suited for such hollow objects as shampoo

bottles or similar packaging items. A correct name for the process is *fused deposition modeling*, and *Stratasys* is its main source.

In use, a large reel of thermoplastic rod is unwound along a path. The rod is deposited just hot enough that the outside is liquid, causing it to stick to the previous layer of the pattern.

The results are sort of a corduroy, but you could trade off wire diameter versus smoothness. A final polish or filler or solvent spray can be used to improve the surface finish.

Apparently, IBM is working on a variation on these sticky strings that

NAMES AND NUMBERS

Aero/Skyways

15 Crescent Road
Poughkeepsie, NY 12601
(914) 473-3679

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117-A Commercial Drive
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(912) 225-9758

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Van Nuys, CA 91405
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(415) 858-2700

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Sepulveda, CA 91343
(818) 786-4885

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Rockville, MD 20850
(800) 638-9636

The Calculator Collector

Intl Assn Calculator Collectors
10445 Victoria Avenue
Riverside, CA 92503

Morph's Digital Outpost

PO Box 578
Orinda, CA 94563
(510) 238-4545

Polytek Development

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Lebanon, NJ 08833
(908) 534-5990

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Mesquite TX 75149
(214) 324-8741

is a cross between this sticky string method and a hot glue gun. The new process is cheaper than some of the others. Even *chocolate* can be used as a design material with their scheme. Besides the usual plastics and waxes.

Can pizza-on-demand be that far behind?

It appears to me a hacker might easily fake this using a hot glue gun and substituting polyethylene for the glue sticks. We did look at this back in the *Hardware Hacker III* reprints. One obvious use is custom cast house numbers or names.

Laminated Paper Shims – works just like the contour lines on a topo map. It is also known as *laminated object manufacturing*. At the current chosen elevation, a piece of adhesive coated paper of the desired thickness is cut out with a laser.

The latest piece then gets carefully aligned to the previous sheet and then heat set. This process repeats often enough to build up the desired part. A

final surface coating of some sort can eliminate the individual steps.

Materials costs are exceptionally low, and only a lower power laser is needed. This method is particularly good for sand casting. One supplier of these systems is *Helisis*.

Ceramic Shell Casting – Originally developed at MIT, *Soligen* is now the leading proponent of this method. A thin layer of ceramic powder is put down. A scanning head having one or more inkjets passes over the powder, selectively applying a binder.

The part is lowered and repeated, causing layer upon layer of binder to build up in the desired shape.

The final shell can be directly used for the high temperature casting of chrome alloys, aluminum, and even nickel. Hollow items can be done by building up integral cores.

Wax Vacuuming – is a new hacker concept that just might revolutionize jewelry and small art object creation. Picture a hypodermic-like needle that

has a hot tip that can be moved along five or six mechanical axes.

The needle works its way around a block of wax, first melting and then vacuuming all the molten wax away from the pattern. Curved needles can be used for internal details or hard to access points. The intended use is for such things as class rings, and silver ornaments. *John Rees* is one source.

By the way, anytime you are using both X and Y motions, it pays to split up the problem. Move your tool in the X direction and your workpiece in the Y direction. This can convert a thorny two-dimensional problem into simpler one-dimensional ones.

And greatly simplify things.

For more info, there is one pricey industry newsletter called the *Rapid Prototyping Report*. These folks also do directories, conferences, and trade shows. *Batelle* does fancy research on rapid prototyping.

We'll have lots more on this topic as it emerges. Especially the low end hacker stuff. I've just added a new *Santa Claus Library Shelf* to my website. We'll be adding lots of files as time and our *banner advertisers* permit me to.

Finally, many ongoing Santa Claus Machine developments are likely to appear in those *Machine Design* and *Design News* trade journals.

New Tech Lit

There's a mind-boggling UFO and pseudoscience BBS up and running at (214) 638-8369. They've got scads of utterly fascinating files on all of the usual weird stuff. Free access. Their sponsor is *Vanguard Services*.

Morph's Outpost on the Digital Frontier is a unique new multimedia magazine in newspaper format. This one offers the latest inside scoop of multimedia developer happenings.

Two other unusual magazines are *Skyways* and *WWI Aero* for those of you interested in early aviation.

From *Sony*, a new *Computer Audio & Video Multimedia* data book.

A *CD-ROM Selector* from *Save the Planet Software* is a well researched directory of 1600+ CD-ROM titles.

Laser Buddy Document Spray by *Buddy Products* offers Bakerizing in a can. You can spray this glop on any laser printed output and it will get

blackier, smoother, and more durable. The resolution appears to go up and text gets slightly bolder.

Their spray is mostly methylene chloride, acetone, and some isobutyl acetate. Works like a champ. But use this one outdoors only. Watch out for fingerprints. No, it won't help direct toner printed circuit transfers much.

Because of residues.

The *Calculator Collector* is a new labor-of-love newsletter published by the *International Association of Calculator Collectors*.

Lots of telecommunications books are offered by the *Telecom Library*. Some useful multimedia videotapes are sold by *First Light Video*.

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Most of the mentioned items are found in the *Names & Numbers* or *Santa Claus Machine* sidebars. Do be sure to check here first before calling our no-charge technical helpline.

Let's hear from you. ♦

Don Lancaster's Hardware Hacker

July, 1994

PostScript language review
Fundamental research tools
Dowsing and pseudoscience
Recycling EX laser cartridges
Make your own vacuum tubes

Just after last month's column deadline, I did manage to find a real nice tutorial on solitons. See Russell Herman's *Solitary Waves* in the July-August 1992 issue of the *American Scientist*.

Another neat property of solitons: If two ordinary waves crash into each other, they'll self-destruct. But if two solitons crash into each other, they'll transparently pass right on through each other without any damage!

Fundamentals of Research

One recent helpline caller became rather upset when I told him I did not believe in dowsing. His main point was, that if you can buy dowsing rods at *Northern Hydraulics*, that cinches it right there. Don't it?

Well, not so as you'd notice.

Dowsing clearly meets my "looks like a duck and quacks like a duck" pseudoscience definition. It certainly does appear reasonable to approach any pseudoscience topic with a lot of skepticism. It does not make much sense to waste too much time on any stuff that's unlikely to pan out.

On the other hand, it is not fair to categorically dismiss something out of hand you know little about. So, to be fair about this, I decided I'd try and feature dowsing for this month's resource sidebar. And let you decide this yourself. Actually, I needed an excuse to review for you the major research tools I use. Dowsing is as good a topic as any.

There are three types of research, *primary*, *secondary*, and, um, let's call it *tertiary*. Primary research is stuff you do personally by yourself. It can often be the best research of all. Provided, of course, that you do keep any bias in check and use reasonable tools and methods.

And don't get in over your head.

Primary research is important for making sure that any circuit diagrams work as advertised.

Secondary research will go to the published literature. And cites author, chapter and verse. Right down to the mustard stains on the page. But the

quality of secondary research will depend on how thorough you are, the references you cite and their overall credibility and competence.

Other less polite names for tertiary research include *anecdotal evidence*, *hearsay*, *mythology*, *hype*, *National Enquirer journalism*, *hoaxes*, *scams*, *wishful thinking*, *urban lore*, *hidden variables*, *blind faith*, or simply plain old outright lying.

Now, it is not fair to assert that tertiary research will always be dead wrong. But it is fair to say that tertiary research quality will nearly always be very low and highly suspect. You'll need a lot more of it to prove a point. An *awful* lot more. At the very least, *multiple and independent* sources are absolutely essential.

Any and all extraordinary claims demand extraordinary evidence.

Let us see how both primary and

secondary research helps us answer this question of great import...

Is Dowsing For Real?

My primary research experiences here are fairly limited. Way on back, I was given some dowsing rods to play with. I could not get them to work. People I loaned them to who claimed they "believed" also could not get them to work.

I do see my local utility routinely using dowsing rods. On the other hand, I think I know one reason why my utility bills are so high.

I am a caver, and most cavers will aggressively use any tools they can to find new caves. In all of caverdom, not once have I ever seen or heard of anyone successfully dowsing caves.

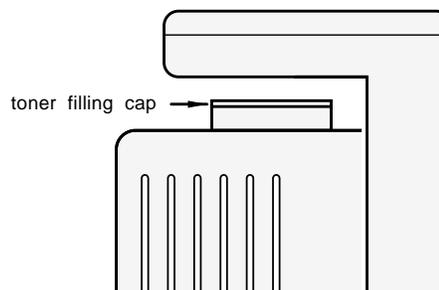
At least not firsthand.

On to some secondary research. First, we should try to find us some

CANON "EX" CARTRIDGE RAPID RECHARGE

NOTE: Use this method only on a cartridge having a good drum and lots of extra room remaining in the spent toner tank. You can usually get three or four refills before the spent toner tank overflows. Drum permitting.

- 1- Set the EX cartridge on its end, top away from you, such that the serial number is up and the "Made in Japan" is down.
- 2- Using a large screwdriver, pop open and remove the large white toner filling cap. Set this cap aside.

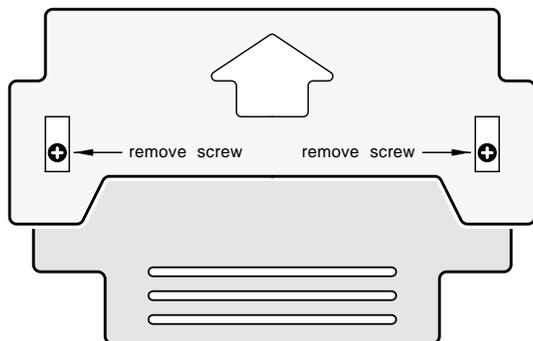


- 3- Pour in a bottle of EX toner, using a bottle with a flexible filling snout. Replace the toner filling cap.
- 4- Carefully vacuum any remaining loose toner and wipe everything with a soft and clean cloth. Run a dozen test pages that alternate white and black sheets to test your work.

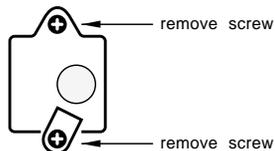
Fig. 1 - EX laser cartridge "rapid recharge" refill.

CANON "EX" TOTAL TEARDOWN CARTRIDGE RECHARGE

- 1- Set the EX cartridge right side up on a cloth surface in an area where toner dust can be safely managed.
- 2- Use a Phillips screwdriver to remove the screws holding the cartridge retainer dogs in place. Squeezing the cartridge frees the dogs. Set these plastic dogs, the screws, and their springs aside. Separate the cartridge halves.



- 3- Carefully set the fresh toner tank half aside. Observe the photo drum retainer bracket on the right side of the spent toner tank half. Remove the two Phillips screws and this bracket. Then carefully remove the photo drum and set it on a soft cloth. Avoid any fingerprints or exposure to strong sunlight.



- 4- Snap the gray cylindrical charging roller out of its holders. Wipe it carefully with a slightly dampened soft cloth to restore its light gray color. Set this charging roller aside.
- 5- Remove the two Phillips screws securing the spent toner wiper blade. Remove the wiper blade and set it aside. Carefully vacuum or dump any toner in the spent toner tank. Reuse of this toner is not recommended.



- 6- Carefully clean the wiper blade with a soft cloth. Replace the wiper blade assembly and its two Phillips screws.
- 7- Snap the toner charging roller back in place. Inspect the old photo drum for scratches while carefully cleaning it with a soft cloth. If you are substituting a new hard drum, do so at this time. Inspect and clean the photo drum retainer bracket. Replace drum, retainer bracket, and two Phillips screws.

more...

Fig. 2A – Using the "total teardown" method for an EX laser cartridge refill.

dowsers. Start with the *Encyclopedia of Associations*, and you'll find the 3500 member *American Society of Dowsers* who also publish *American Dowsers* magazine.

You'll find *Borderlands Research*

and a *Society for the Application of Free Energy* also sometimes having a strong dowsing focus.

The *Skeptical Enquirer* is bound to have touched on this at one time or another. And *Rex Research* has one

or two of his *Infolios* that do provide some dowsing info.

By far my favorite research tool is *Ulrich's Periodicals Dictionary*. But in its 600+ magazine listing on water resources, the *only* one of interest is *American Dowsers*.

Their *Divining Rod* entry is a good example of what researchers call a *false hit*. Pretty nigh but not plumb.

As is typical, the *Thomas Registry of Manufacturers* is of no help at all, since none of their listings will own up to any dowsing supplies. *Northern Hydraulics* does carry rods as stock #15554-384. *American Dowsers* should list other sources of supply.

Books in Print lists no titles under the subject of *dowsing*, but they do suggest you refer to *divining* or to *radioesthesia* instead, where you'll find several dozen titles. I've picked some of these for our listing.

By the way, one of the really big problems in doing any research is getting your keywords right. More often than not, the insiders will be calling things by different names. *It is of utmost importance to find these "correct" names as early in the game as you possibly can.*

The innermost secret to effective research is learning where and how to ask the right questions.

The ultimate heavy weapon in any research work is usually the *Dialog Information Service*. Now offered on *GENie* 24 hours a day. There's around half a *billion* abstracts on line. Last month, we were overwhelmed when a search for the soliton info produced around 8,300 references. How many dowsing references do you suppose they now have on line?

Would you believe *seven*?

Yup. As near as I can tell, there has been darn little serious dowsing research *ever* done. But three of these papers are quite interesting.

The first is a Utah study where a powerful correlation was observed between a big group of dowsers and *something*. The study emphatically points out they were all totally unable to correlate that "something" to either ground water or its related magnetic fields. In any manner whatsoever.

The second one is a British study. Here dowsers were invited to find a big hidden flowing water pipe.

While "something" was apparently

happening, they were totally unable to reliably find the pipe. More telling, professional dowsers did not do any better than amateurs.

The third is a careful analysis of a pendulum. When any pendulum gets driven near its resonance frequency, there is an expected and a normal physical reason why a pendulum will suddenly start bobbing around.

This is in the underlying math of driven oscillators. No further external cause of any type is needed. No, you don't even have to invoke chaos or nonlinear coupling effects.

And that's about as far as I got. The next steps would be a thorough study of the books, back issues of the publications, and attempts to contact the authors of the key papers. Very often the *Science Citations Index* can let you take an older paper and see who references it.

This magic directory is one of the few resources that can let you move *forward* through time, gaining *new* material as it gets published.

Much more on dealing with these pseudoscience resources in general in file NUTS26.PS on *GENIE* PSRT.

Meanwhile, if you have anything useful to add to all this, send it to me. A free new *Incredible Secret Money Machine II* for your trouble.

PostScript Review

I just got a reader letter that was full of dead-wrong misconceptions about the PostScript language. So I guess a review of the fundamentals are once again in order.

I really like PostScript because it is one ideal Hacker's general purpose computing language. It is also superb for the fast and device independent electronic distribution of high quality technical information.

In a new *Hacker Data Format*.

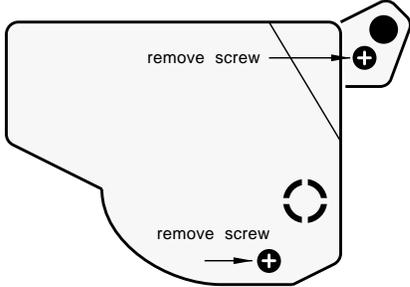
I use PostScript for everything as my primary language. "Everything" includes engineering design; fractals; stock market analysis; printed circuit layouts; video compression; fuzzy data fitting; hot tub controllers; fancy numeric analysis; exotic halftoning; wavelet studies; and direct dedicated homebrew CAD/CAM control.

Plus creating everything you see here and in my other columns.

You simply talk to PostScript with ordinary text files from any old word

EX CARTRIDGE RECHARGE, continued...

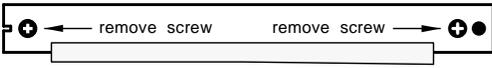
8- Remove the two Phillips screws on the end cap of the fresh toner tank half. Very gently remove this end cap, making sure that none of the three internal gears pop off their posts. Vacuum the gears if needed.



9- Flip up the white lever holding the magnetic pickup roller in place. Carefully remove the magnetic pickup roller. Vacuum it and gently wipe it with a soft cloth. Snap the end cap back in place (without screws) to retain the gears.

10- Make a fixture (such as a cardboard box with a rectangular hole in it) that lets you firmly support this module so that the black magnetic transfer roller area sits horizontally on top.

11- Remove the two Phillips screws holding the fresh toner wiper blade. Remove the wiper blade, and carefully clean it with a soft cloth.



12- If you are changing brands of toner, remove any remaining old toner. Then carefully pour a new bottle of toner into the exposed toner tank. Level the fresh toner as you pour it. Wear a face mask.

13- Replace the fresh toner wiper blade and its two Phillips screws. Carefully remove the end cap. Make sure the gears are all free to rotate. Inspect and clean the magnetic transfer roller supports and snap the roller back into place. Replace the end cap and its two Phillips screws.

14- Note how the two hinge pins hold the two cartridge halves together. Insert the cartridge halves together, squeeze them slightly, and replace the cartridge retainer dogs. Replace the final two Phillips screws.

15- Carefully vacuum any remaining loose toner. Run a dozen test pages that alternate white and black sheets to test your work.

Fig. 2B - The "total teardown" method, continued...

processor or editor. Or let fancy ap packages write the code for you. This is one of the easiest to use and most fun languages I have ever seen. The more you play around with this, the more powerful it becomes.

PostScript is definitely a general purpose computer language. All of the required language features and constructs are in place. As with any general purpose computer language, there are strengths and weaknesses. PostScript does certain jobs better than C++. C++ does some tasks better

than PostScript. PostScript's massive strengths lie in its ability to dirty up otherwise clean sheets of paper.

While doing stunning mixed text graphic and text layouts. Especially those that need lots of transforms or bunches of computation.

Nothing even remotely compares.

Its big weakness lies in its ability to interact with the outside world. For PostScript is often limited to marking up sheets of paper, writing files to disk, returning info over any comm channel, or sending out commands to

external devices.

Absolute proof that PostScript is a general purpose computer language is found in the PSRT RoundTable on *GENie*. Of the 1000+ files now in the library, many employ PostScript for totally non-graphical general purpose computing needs. Or use extensive computations combined with only an incidental graphic output.

PostScript is an example of a stack and dictionary oriented, extensible, threaded, interpretive, and reentrant language. Using a *Reverse Polish* or *postfix* notation. It is a second cousin to *Forth*, three times removed and five times disowned.

Important features of PostScript include its total device and resolution independence and its ability to handle graceful curves and work with sparse data descriptions.

Yes, you can easily and cheaply get yourself a lower cost PostScript host interpreter. Your most popular one is known as *GhostScript* and is available for the downloading. From many BBS sources, including PSRT. *GhostScript* also provides on-screen previewing on *any* host platform. Full source code is available. Again for the downloading.

Other host PostScript interpreters include various forms of Adobe's CSPI, an acronym for a *Configurable Software PostScript Interpreter*. And there are dozens of other third party interpreters offered.

But PostScript is best used inside a dedicated computer created from the ground up to meet its needs.

Most of these dedicated PostScript computers usually have an obscenely misleading and a horribly restrictive label wrongly placed on them. These awful labels say "printer" on them.

Instead, I prefer to call all of these HUCC's, which is short for *Hacker's Universal Coprocessing Computer*. I feel this is by far most outstanding emerging opportunity for *Electronics Now* readers that I know of.

For instance, I'll routinely use the 68030, the twelve megs of RAM, and the hundred meg hard drive of my *LaserWriter Pro630 HUCC* as a fine "mother's little helper" co-processor for the 6502 in my Apple IIe. Sort of a silicon *Au Pair* girl.

One that lets me powerfully and profitably explore non-obvious stuff

in non-traditional ways. Without a lot of unneeded baggage.

You can easily compile PostScript. The simplest example is the PS *bind* operator that more tightly links your commands with bare metal code.

Intermediate is PostScript's *binary object format*. Some highly profound compiling involves PostScript's *form capabilities*. A cached form gives you major runtime speedups.

External compilers are also offered which greatly improve the efficiency and speed of runtime code. Examples include Adobe's *Distillery* and their *Acrobat Distillery*, or my *Maudedoc* and *Triple Distilling* techniques.

Yes, PostScript is strongly object oriented. But only if you want it to be. The centermost keys to an object oriented language are modules that have one single input, one output, a controllable reach, and that perform one well-defined task.

Otherwise known as a PostScript proc inside of a PS dictionary.

Check into any Acrobat output for examples of PostScript object use. Or check out PostScript's *execuserobject* and related commands.

For more on PostScript, start with Adobe's red and blue books. And my files STARTUP.PS and SPEEDUP.PS on *GENie* PSRT. Or write or call for more help.

Toner Cartridge Reloading

Brand new toner cartridges used in popular laser printers might cost as much as \$140 each. You can easily refill toner cartridges several times at a refill cost as low as \$4.25. And do so in a minute or two.

The primary reason for cartridge refilling is economics. New carts give you per-page toner costs around one nickel a page, which is much higher than jiffy printing. The toner recycled carts give you per-page toner costs as low as 0.1 cents per page side. A 50:1 cost reduction which can completely blow away old line printing. Not to mention making Book-on-demand publishing super attractive.

Refill toner can also be better than the factory original. Or give you such options as blacker graphics, longer cartridge life, color, check printing MICR magnetics, or thermal dye sub for Tee shirt printing.

A typical toner cartridge includes a

fresh toner tank, the magnetic feed roller, a photosensitive drum, and a spent toner holding tank.

In general, there are a number of reasons why a toner cartridge fails. The most common is simply running out of toner. A plain old quick refill takes care of this problem.

The second most common problem involves drum defects. Factory drums appear to be intended to fail shortly after one tank of toner is used. They may drop in sensitivity, or pick up scratches or dropouts. There's now a lively third-party *hard coated drum* industry today. Swapping to one of these hard drums can let your cart be recycled dozens or more times.

The third most common cartridge problem is overflowing your holding tank. This typically will happen after three or four refills on newer types of cartridges. The obvious fix here is to empty the tank before it overflows. Recycling the recovered spent toner is *not* recommended.

We have seen how to recycle the older *Canon CX, SX, and LX* carts in previous columns. The step-by-step details also appear in the *Hardware Hacker II*, that *Intro to PostScript* video, and on *GENie* PSRT.

This month I thought we'd look at how to recycle the popular *Canon EX* cartridge. As used on such machines as the *Hewlett-Packard LaserJet 4M+* or in the *Apple LaserWriter Pro630*. This EX cart is much easier to recycle than the earlier ones.

There's two recycling methods I'll show you here. The *Rapid Recharge* method of figure one just adds toner. Pop the cap, pour it in, replace the cap. This works *only* if the drum is still good and the spent toner tank is nowhere near full. You can make up a special flexible snout refill bottle to ease getting the toner into the tank. A piece of shrink tubing works fine.

The *Total Teardown* recharge of figure two takes longer, but can fix nearly any cartridge problem. On the other hand, this can cause you more problems than it solves.

Such as stripped screws, dropped parts, loose wipers, fingerprinted or light flashed drums. And can easily *raise* your per-page toner costs.

Removing two screws causes the EX cartridge to split into two pieces. The toner tank half can be refilled by

the rapid recharge method. Or else two screws can be removed to access the entire bottom of the tank. Mixing brands of toner is *not* a good idea.

The other half can get a new hard coated drum installed by removing two screws. Try to avoid fingerprints, scratches, and strong light exposure. The spent toner tank is also on this half. Removing two screws lets you access the bottom of the tank.

Cartridge recycling is best done outside or in a hooded area having a vacuum cleaner available. Use of a face mask is recommended.

By the way, it pays to carefully monitor and label the history of each cart. I use brand new carts only for my camera-ready art. Prime recycled carts get used for my BOD production and catalogs. And problem carts get used for in-house work.

If you start up your own cartridge recycling service, one key rule is to have a seven mile service limit. Just like pizza. Go beyond that, and your pizza gets cold and you will get into big arguments over the anchovies. As soon as you get into the commercial shipments and unknown sources and histories of carts, your problems will go up and your profits will go down. So will your customer satisfaction.

Be sure to personally hand carry all your carts to your customers. Each customer also gets his own cart back, each and every time. In some market areas, you can charge as much as \$15 to \$19 for a cartridge refill.

Several big printer suppliers offer "recycling" programs. This is really a blatant attempt to *prevent* personal or third-party cartridge recycling. And is ecopornography at its very worst. If you ever get a prepaid recycling pack from any printer supplier, put a brick in it and send it back.

The leading trade journal for the toner recycling industry is *Recharger* magazine. Here you will find lots of ads for the toner, drums, tools, and services. This industry has matured, with many outfits now offering first quality products. But there still are some scams and flakes on the fringe, so always ask around about a supplier before you lose lots of money.

It does *not* pay to buy toner in bulk unless you are recycling over 2000 cartridges per month. Use the refill bottles instead.

DOWSING RESOURCES

Associations:

American Society of Dowsters
Brainerd Street Box 24
Danville, VT 05828
(802) 881-7165

Borderland Sciences
Box 429
Garberville, CA 95440
(707) 986-7211

Free Energy Application Society
1315 Apple Avenue
Silver Spring, MD 20910
(301) 587-8686

KeelyNet BBS
Box 1031
Mesquite, TX 75149
(214) 324-3501 (BBS)

Rex Research
Robert Nelson
Box 19250
Jean, NV, 89109

Skeptical Enquirer
Box 703
Buffalo, NY 14226
(716) 636-1425

Books:

- William Barrett, *Divining Rod*, Carrol pub, University Books, 1967.
Gabriele Blackburn, *Science & Art of the Pendulum*, Idylwild Books, 1984.
Bill Cox, *Techniques of Swing-Rod Dowsing*, Life Understanding, 1971.
R. Davies, *Dowsing: The Art of Finding Hidden Things*, Aquarian Press, 1979.
Harvey Howells, *Dowsing for Everyone*, Viking Penguin, 1979.
R. Simmons, *Professional's Complete Dowsing Course*, Dowsing Institute, 1978.
Robert Steffy, *The Dowser's Primer*, Halldin Publishers, 1980.
Evon Vogt, *Water Watching USA*, University Chicago Press, 1979.

Critical papers:

- F.E. Irons, *Concerning the nonlinear behaviour of the forced spherical pendulum*, European Journal of Physics, vol.11, no.2, p.107-15, March 1990.
B. Walti & U. Jenzer, *Dowsing and electromagnetic fields*, Bulletin de l'Association Suisse des Electriciens v.75, #15 p.903-6, 4 Aug. 1984.
Ian Killip, *Geophysical dowsing*, Civil Engineering for Practicing Engineers, vol 4, n 4, p 343-360, Apr 1985.
O. Vyzkumu, *Proceedings of the Conference on Psychotronic Research*, Joint Publications Research Service, Arlington, VA, 227p, 6 Sep 74.
Duane G. Chadwick, *The Detection of Magnetic Fields Caused by Groundwater and the Correlation of Such Fields with Water Dowsing*, Utah Water Research Lab, 65 p., Jan 71.

A superb source for laser printer repair and maintenance training is *Don Thompson*. Who now offers his seminars worldwide. And low cost replacement parts and modules.

New Tech Lit

The SAE is now offering the third edition of the 840 page *Robert Bosch classic Automotive Handbook*. \$29 for nonmembers. Includes new coverage of sensors, driver info systems, GPS comm and navigation.

NewTek has just introduced their stunning new video nonlinear editing system they call a *Video Flyer*. This uses hard disks instead of videotape to give you random video access.

This totally eliminates most of the

overpriced junk previously associated with serious video post production. While offering broadcast quality that is free of any generation loss. Demo videos are offered.

The *Bell Jar* newsletter continues to offer exceptional info for those of you interested in any high vacuum techniques. A recent issue shows you how to build your very own scanning electron microscope.

Speaking of vacuum concepts, new make-your-own vacuum tube *kits* are offered by George Schermund of *Science Resources*. After you create your own vacuum tube triode, you use it in a regenerative receiver.

More on RBDS shows up in *Radio World* for April 20, 1994. Including a

NAMES AND NUMBERS

Adobe Systems

PO Box 7900
Mountain View, CA 94039
(800) 833-6687

American Scientist

Box 13975
Research Triangle, NC 27709
(919) 549-0097

Appliance Service News

PO Box 789
Lombard, IL 60148
(708) 932-9550

The Bell Jar

35 Windsor Drive
Amherst, NH 03031
(603) 429-0948

Robert Bosch

38000 Hills Tech Drive
Farmington Hills, MI 48331
(313) 553-9000

Computer Hot Line

15400 Knoll Trail Drive, #500
Dallas, TX 75248
(800) 999-5131

Deep Vision 3-D

6457 Santa Monica Blvd
PO Box 38386
Hollywood, CA 90038

Dialog

3460 Hillview Avenue
Palo Alto, CA 94304
(415) 858-2700

Digital Video

80 Elm Street
Peterborough, NH 03458
(800) 441-4403

GENie

401 N Washington St
Rockville, MD 20850
(800) 638-9636

Global Micro-Parts Depot

11151 Denton Drive
Dallas, TX 75229
(800) 325-8488

Magnets in Your Future

PO Box 250
Ash Flat, AR 72513
(501) 856-3877

NewTek

215 SE 8th Avenue
Topeka, KS 66603
(800) 765-3406

Northern Hydraulics

PO Box 1499
Burnsville, MN 55337
(800) 533-5545

Radio World

5827 Columbia Pike #310
Falls Church, VA 22041
(703) 998-7600

Recharger

3340 Sunrise Avenue #102
Las Vegas, NV 89101
(702) 438-5557

SAE

400 Commonwealth Drive
Warrendale, PA 15096
(412) 776-4841

Science Resources

1260 Liberty Way, Ste B
Vista, CA 92083
(619) 727-6933

Service News

38 Lafayette Street
Yarmouth, ME 04096
(207) 846-0600

Synergetics

PO Box 809
Thatcher, AZ 85552
(602) 428-4073

Tapeswitch

100 Schmitt Blvd
Farmingdale, NY 11735
(516) 694-6312

Don Thompson

6 Morgan #112
Irvine, CA 92718
(714) 855-3838

list of currently active FM stations.

Super cheap red and green glasses for 3-D video experiments are offered by Steve Gibson of *Deepvision 3-D*. Touch switches and driveway sensors are offered by *Tapeswitch*. One new desktop mag is *Digital Video*.

Several good servicing resources: *Global Micro-Parts Depot* is big on replacement oven parts, both regular and microwave. *Appliance Service News* covers the small appliance and tv repairs in depth. *Service News* is a trade journal for computer service and support now in its fourteenth year. And the all-ads *Computer Hot Line* has lots of sources for printer, hard disk, and monitor parts. Mostly mainframe dino stuff, though.

One monthly pseudoscience pub is *Magnets in Your Future*. This one is intended for you motors-and-magnets perpetual motion enthusiasts. Quite costly and even more outrageous than most. Very strange indeed.

More on BOD publishing appears in my *Book-on-demand publishing kit* from *Synergetics*. I have also got a brand new catalog for you having a greatly expanded insider technical secrets section. You can write, call, or email me for a free copy.

Plus a reminder that ten free hours of *GENie* are available to you per the details in that *Need Help* box.

You might also send me technical questions, new catalog requests, and orders to SYNERGETICS on GENie or SYNERGETICS@GENIE.GEIS.COM via the Internet.

Most of the mentioned items are found in the *Names & Numbers* or *Dowsing Resources* sidebars. Be sure to check here first before calling our no-charge technical helpline.

Let's hear from you. ♦

Don Lancaster's Hardware Hacker

August, 1994

A \$39 laser pointer
Cold fusion update
Video driver circuits
Computer I/O boards
Transmission line use

I very much do like to look into unusual or controversial topics. Mostly because they are there, I guess. In past issues, we have looked into such genuine scientific wonderments as sonoluminescence, aerogels, magnetic refrigeration, and solitons. And at such pseudoscience subjects as perpetual motion, UFO resources, and dowsing.

Today, there's one topic that seems neither fish nor fowl. So I guess its time we asked...

What Ever Happened to Cold Fusion?

Uh, the answer to this one depends on who you ask. So, I will give you several current points of view and let you draw your own conclusions. You will find a summary in figure one.

Many thousands of individuals and hundreds of firms worldwide tried out the cold fusion experiments. But after early excitement, most of them were unable to get anything to work.

As of today, the number one and number two researchers are getting paid to stay in France. By Japan. Er, number three has now withdrawn his modest claims. And number four got caught with his hand in the alchemy cookie jar. Big time.

At the very least, cold fusion is now clearly in chaotic disarray.

Several leading scientific journals flat out refuse to publish anything on cold fusion at all. Many feelings are widespread that cold fusion is simply *pathological science* in which most researchers see anything they want to. Just like that *polywater* fiasco a few decades back.

Or yet another example of what research insiders call the *Utah Effect*. Clearly, a lot of people learned the hard way that calorimetry is a very precise science. One which involves a lot more than glancing sideways at a thermometer.

Your best starting place is that critical summary review found in the January 7, 1994 *Science* on pages 105 and 106. Of the five major popular books on this topic, the latest and the

best appears to be *Bad Science: The Short Life and Weird Times of Cold Fusion*. By Gary Taubes.

On the other hand, the cold fusion research does continue.

Mostly by highly vocal mavericks well out of the scientific mainstream. Who are often discredited out of hand by *Big Science* establishment types. At times unfairly and unreasonably. Ongoing info on this work is likely to show up in *Cold Fusion Times* or in *Cold Fusion Magazine*.

My own feelings are these: Yes, there seem to be real circumstances where excess heat *appears* to result from lab experiments. But, no, I have not seen so much as one credible shred of evidence that a new atomic process is clearly involved.

I do feel the majority of excess heat results are still caused by bad labwork. Of those that remain, I feel that several mundane explanations should eventually crop up. None of which are very likely to lead to a new

or useful energy source.

For instance, one very little noted paper cropped up in *Science* smack in the middle of the cold fusion fiasco. A Bell Labs researcher figured out how to make a fuel cell that lets you *premix* the gases. Something that is now thoroughly verifiable but was previously thought impossible. His work looks amazingly similar to the cold fusion setups the researchers are now using.

Transmission Line Review

At dc, audio, and other very low frequencies, we usually assume that the signal we send into one end of a wire will promptly arrive at the other end. Identically and instantaneously. If we use cables at all, it is mostly for their shielding effects.

Video and RF users do not have this luxury. Instead, they have to use *transmission lines*. In a transmission line, you send a signal down one end of a cable so it can arrive somewhere

Books:

F. Close, *Too Hot to Handle*, Princeton University Press, 1991.

G. Taubes, *Bad Science*, Random House, 1993.

J. Huizenga, *Cold Fusion: The Scientific Fiasco of the Century*, University of Rochester Press, 1992.

E. Mallove, *Fire From Ice*, Wiley, 1991.

D. Peat, *Cold Fusion: The making of a scientific controversy*, Contemporary Books, 1989.

Critical summary book review:

Richard Crooks, *Cold Fusion Revisited*, *Science*, v. 263, Jan 1994, p105-6.

Journals & Magazines:

Cold Fusion,
70 Route 202 North, Peterborough, NH 03458, (800) 677-8838.

Cold Fusion Times,
Box 81135, Wellesley Hills, MA 02181, (617) 239-3383.

Fusion Technology,
555 N. Kensington Avenue, La Grange Park, IL 60525, (708) 352-6611.

Journal of Electroanalytical Chemistry,
Box 882, Madison Square Station, New York, NY 10159, (212) 989-5800.

Fig. 1 – Some current cold fusion readings. The entire field has largely been discredited. Mostly because of "not even wrong" labwork.

else sometime later. If you are not *very* careful with your transmission lines, you can get reflections, echos, or standing waves. At the least, these effects can very badly distort what you are trying to transmit. Or change the signal size and delivered power. At worst, they can literally destroy a high power transmitter.

When do you need to worry about transmission lines? Besides radio and video uses, they also get important in networks, in SCSI comm, and even in routing address and data lines on high speed computers.

The rule is this: *Use transmission lines if the distance you need exceeds one tenth of a wavelength at your highest frequency of interest. Another rule: Electrical signals travel around a foot per nanosecond in free space.*

Or travel around eight inches per

nanosecond on most wires.

Let's say we have a lossless coax cable that is so long we don't have to worry about what is coming down at the far end. A cable is an example of a *distributed* network, where all the inductance and the capacitance will change in small increments. We can go to a *lumped* or *discrete* model of figure two.

But you can't just use this as a plain old network. Instead, you have to go to the differential equations of a propagating wave. When you use this advanced math to calculate the input impedance of your cable network, you will find an amazing result. You end up with an input impedance that looks like a pure *resistor* of constant value. Over all frequencies.

We'll call this the *characteristic impedance* of the cable. As far as the

source is concerned, this looks and behaves just like a "real" resistor.

As long as our uniform cable is so long that nothing ever returns from the far end.

The characteristic impedance of free space is 377 Ohms. All physical cables are lower than this. Twin lead is 300 Ohms. Cable tv and most video cables are usually 72 Ohms. Hams and broadcast people often use 50 Ohm cables. Lower impedances are preferable for higher powers.

Since any infinitely long piece of cable looks like a resistor, we can replace any portion of it with a real resistor. This is known as properly *terminating* a cable.

A rule: *All cables must be properly terminated in a resistor whose value equals its characteristic impedance!*

Another rule: *Always* use cables in a *series* daisy chain, going from unit to unit, with *only* your farthest unit terminated. *Never* connect cables in parallel or in any star configuration. Unless each one has its own private distribution amplifier.

What if you forget to terminate a cable? What happens? Say you have some ultra short cable and purposely short circuit the far end of it. The input still looks like a short circuit. Your signal goes down to the end, bounces off your short and returns. Nearly immediately.

Things get real interesting in a big hurry if the cable is longer. The *time delay* of the cable will cause a *phase shift* in the return signal. If you have a cable *one-quarter* wavelength long, the short returns to your input as a very *high* impedance.

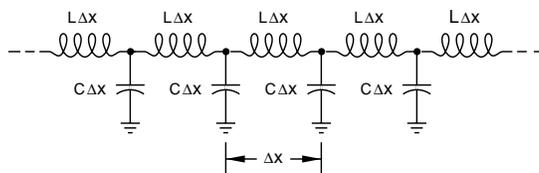
Looking at things another way, the incoming signal and the reflected one *reinforce* each other.

Should the shorted cable be *half* a wavelength long, the short returns to the input as a very *low* impedance. The incoming signal and the reflected one *cancel* each other.

A shorted cable looks *inductive* for lengths of zero to just under a quarter wavelength. It will appear *capacitive* for lengths slightly over one quarter wavelength to half a wavelength.

The opposite is true of an open termination. An open will appear as a short a quarter wavelength away and as an open at half a wavelength. But you can not do an open termination

Any long and lossless transmission line (or coaxial cable) forms an example of a distributed network, made up of many tiny series inductors of L Henrys per unit length and shunt capacitors of C Farads per unit length...



You cannot simply analyze this as a low pass network; instead you have to take a tiny piece from the middle and ask what happens as a wave passes through it. Doing this leads to a messy differential equation. In the solution, the design factor $\sqrt{L/C}$ pops up in several places.

Specifically, the velocity of the wave turns out to be $1/\sqrt{L/C}$ meters per second and the impedance of the rest of the cable will turn out to be exactly $\sqrt{L/C}$ Ohms. A *constant* resistance that is *independent* of frequency.

This magic resistance value is called the *characteristic impedance* of the cable. To a source driver, a very long or otherwise properly terminated cable will appear the same as a physical resistor of equivalent value.

For cables to work properly:

- (1) All cables *MUST* be terminated in their characteristic impedance at their far end.
- (2) Cables must *NEVER* be used in parallel or in a "star" configuration. Unless they have separate drivers.
- (3) Cables may be daisy chained from one point to another. But they must *NEVER* have mid-line terminations.

Fig. 2 – Some transmission line and coax cable fundamentals.

of any cable in the real world.

Because of the radiation, coupling, and whatever.

Any cable termination mismatch will reflect some energy and create *standing waves* along your cable. The strength of these standing waves is known as the *voltage standing wave ratio*, or the VSWR. The ideal VSWR value is 1.0, meaning that there aren't any standing waves at all.

A higher VSWR limits how much power you can deliver to your load. This also causes excessive voltages and currents along your cable. At worst, it can make your input look like a short and overload your source. Or blow up your transmitter.

A mismatched antenna is one way to pick up a high VSWR.

So, if your main goal is delivering a signal to a load, you *always* want to use proper cable termination. On the other hand, you can purposely exploit shorted cables as very high Q circuit elements. Ones shorter than a quarter wavelength look like inductors. Ones longer than a quarter wavelength but less than half a wavelength look like capacitors. The cycle then repeats.

Purposely mismatched end-shorter cable stubs could get used for tuning, impedance matching, trapping, and filtering. At higher frequencies, you can use a *Smith Chart* design aid.

Print-your-own Smith Charts are available on *GENIE* PSRT as file #367 SMITHCHT.PS.

Video Op-amps

Most video cables require proper termination. The rule is that five or more feet for high quality video and twelve or more feet for tv quality signals *must* be properly terminated at the far end of the cable. And *only* at your far end. Once again, video cables *must* be daisy-chained unless each has its own distribution amp. Mid-points on the cable string *not* be terminated. Usually a "high-Z" switch on your monitor or whatever gives you this choice.

What driver impedance should you use on your cable? If the far end is terminated properly and there are no standing waves, there will be nothing to reflect off your near end. So, you could theoretically drive your cable from any impedance source. If you are delivering high power to a radio

transmitter or whatever, your obvious choice is to make your source driver impedance as *low* as you possibly can. To maximize your efficiency.

Much of today's video will use a different scheme. This is called *back termination* and is shown in figure three. With back termination, you'll drive your cable by way of a series resistance *equal* to the characteristic impedance. This further helps cancel any reflections, and also is optimum from that maximum power transfer point of view. As a side benefit, back termination also protects your driver against shorted cables.

Uh, there is a minor gotcha with back termination. Half your power gets burned up in the input resistor. And, because of the voltage divider, *you only get one-half the signal level at the far end of the cable*. To beat this, you'll normally set up a video distribution amplifier with a gain of +2 or higher. The amp *doubles* your signal level. Your back termination resistor cuts it back down to size.

When using back termination, you also have to be sure you terminate the far end of the cable. Otherwise, your video levels will be far too high and might overload.

Video distribution amps are no big deal these days. Even *Radio Shack* has several off-the-shelf models. But it is tricky to do one without using a negative power supply.

Suitable video driver chips are now available through *Maxim*, *National*, *Burr-Brown*, *Liner Technology*, and

Analog Devices, among others. My favorite here is *Maxim*, who has lots of free samples available.

National also has some samples available on their new LM6181 high performance video op-amp. This one employs current, rather than voltage feedback to give you a 50 MegaHertz back-terminated bandwidth plus a 2000 volt per microsecond slew rate. A demo circuit board is also offered, per the schematic in figure four. This one also is an excellent plug-and-go video driver. It also lets you evaluate competing op-amps.

Both the chip and the evaluation board are available free to qualified requests. Their technical support is provided via (800) 272-9959.

"Forgotten Lore" Contest

Let's have us a different kind of contest this month. One for you real old timers out there. Just tell us about some long forgotten electronics lore. Tips and techniques that fell through the crack somewhere along the way. But still remain fairly useful.

For instance, there's not too much point in reminding anyone that you can service a classic record changer outside of its case by setting it on three quart ginger ale bottles. But these three tips still *are* very useful: (A) A *tiny* amount of beeswax on a screwdriver tip makes a very useful screwdriver; (B) One single thread from a pad of #000 steel wool can often replace the super expensive and hard-to-find low amperage fuses used

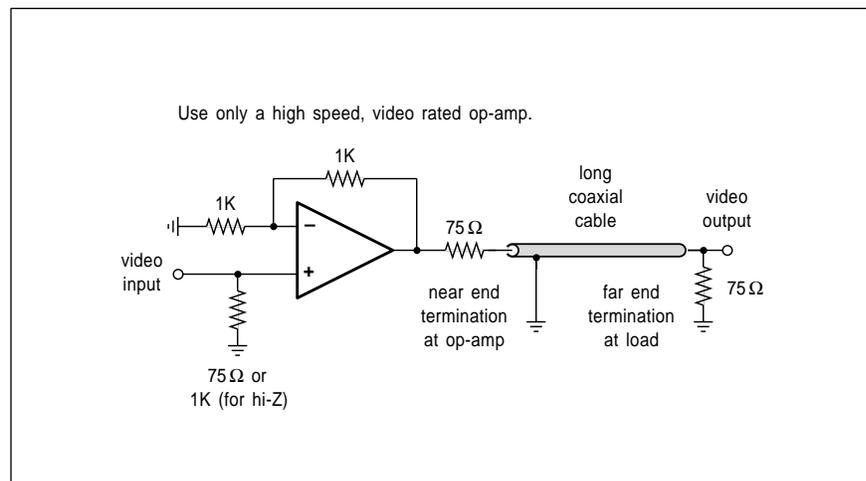


Fig. 3 – "Back termination" is a popular method of driving video cables. It is short circuit proof and minimizes reflections. But an amplifier with a gain of at least +2 is needed. Unterminated outputs may overload badly.

to protect microammeters; and (C) A neon test light still makes a great "hot chassis" tester. Just hold one tester lead and touch the other one to the suspect area. If the lamp dimly lights, you have a hot chassis and a severe shock hazard. No shock is perceived during this test.

There will be a dozen of the usual *Incredible Secret Money Machine II* books going to the better entries, with an all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for two going to the very best of all.

Be sure to send all of your *written* entries to me at *Synergetics*, rather than to **Electronics Now** editorial.

Metrologic's \$39 Laser

I've been waiting for the price of laser pointers and the solid state laser diodes they use to drop for several years now. It seems that *Metrologic* has turned the corner with a complete ready-to-use 3 milliwatt laser pointer for \$39. Model ML-211. At long last, no-nonsense lasers for hacking are cheaply and conveniently available.

The spot size is around half an inch at thirty feet. Presumably the beam could be further collimated by using external lenses. The 675 nanometer red is visible in bright daylight.

Feedback stabilization is used for maximum safe output. Battery life is eight hours continuous with a pair of alkaline AAA cells. And much longer with lithium cells.

A safety slider on the pocket clip prevents unintended use. You could defeat this with a rubber band safety, or else use two component clips for remote control. Simply short one end of the pointer to the other.

My only complaints were that the delivery was very slow and that their batteries wobble badly. This wobble is bound to ultimately cause damage when bouncing around long term in, say, a toolbox or glove compartment. A strip of cloth cures this.

Yes, you can do all the usual "red string" laser stuff. But forget about holography. First, there isn't nearly enough power. And second, the light beam almost certainly runs in higher order optic modes, so the light isn't totally coherent.

Monochromatic yes, coherent no. Their brightness should be more than enough for most uses. But as a fireman, I was disappointed by its fireground performance. It turns out that a freshly burned black is black indeed. And simply does not reflect light. One possible solution would be a push-button higher power mode.

A dozen experiments come with the pointer. Obviously, you can strap this onto a level or bounce it off a mirrored loudspeaker. My favorite is annoying cats. It drives them bonkers in a darkened room.

Computer I/O Interface

A lot of construction projects have

been published right here in EN that plug into your PC or other computer and give you real-world I/O. Two other fairly useful sources for hacker computer interface include *John Bell Electronics* and *Circuit Cellar*.

There's also lots of commercial I/O card offerings. Cards which do data acquisition, A/D or D/A conversion, signal conditioning, power interface, fancier comm, and whatever. While these tend to be expensive, they are plug-and-go and usually do include warranties, tech help, and all of the needed software.

For this month's resource sidebar, I've gathered together a few of the major players in the industrial PC I/O arena. Most of these offer fat and free catalogs that include useful ap notes and similar tech info.

New Tech Lit

From *Siemens*, a new *Hall Effect Integrated Circuits Data Package* on automotive applications. And from *RF Micro Devices*, the new *RF and Wireless Comm* data book.

Motorola has two free directories. Their *Technical Literature Guide* and the *Applications Literature Guide*.

A new catalog from *Small Parts*. An essential source for everything your hardware store never heard of, besides being the greatest hacker robotics store in the world. They also custom cut metal and plastics.

Two additional special interest bookstores: *The Working Library* by *ST Publications* on screen printing, sign painting, graphic layout, neon, and pinstripping. Or the *Firefighter's Bookstore* on fire science books and videos. Of the dozens of firefighting trade journals, I personally like *Fire Engineering* the best.

Hundreds of "C" language public domain software programs are now offered by the *C User's Group*.

Hewlett-Packard has just started shipping out their new *LaserJet 4M+* printers. At a first glance, this one looks like a routine upgrade with a few minor improvements.

Genuine Adobe PostScript Level II, a bolt-on-duplexer, enhanced 600 DPI resolution, 12 pages per minute, refillable carts, all service manuals available, efficient memory, multiple trays that can hold nearly a thousand pages, and stunning new photo grays.

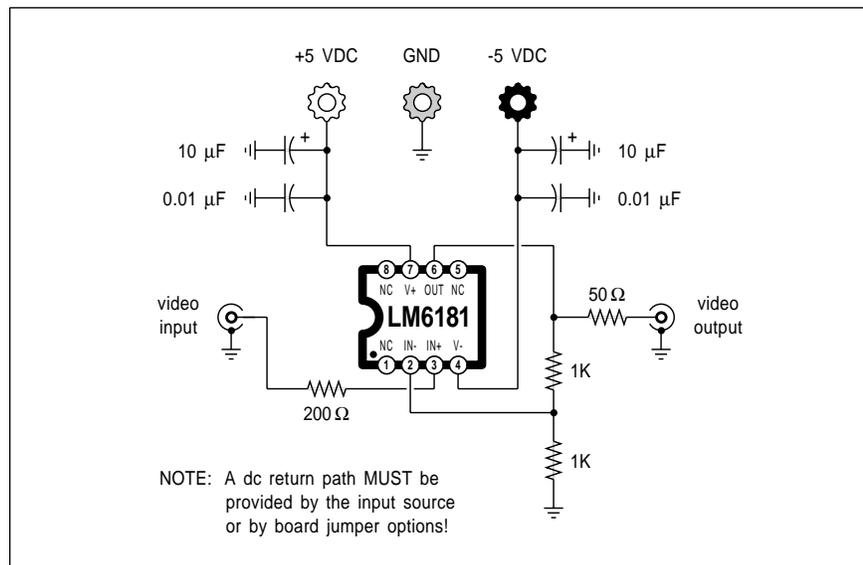


Fig. 4 – National's high speed op-amp evaluation board can be used as is as a superb video cable driver. It is also very handy for op-amp testing.

COMPUTER I/O BOARD RESOURCES

Aptix

2890 N First Street
San Jose, CA 95134
(408) 428-6200

John Bell

1381 Saratoga Street
Minden, NV 89423
(702) 267-2704

Blue Earth

165 West Lind Court
Mankato, MN 56001
(507) 387-4001

Circuit Cellar

4 Park Street Ste 20
Vernon, CT 06066
(203) 875-2751

ComputerBoards

125 High St
Mansfield, MA 02048
(508) 261-1123

Data Translation

100 Locke Drive
Marlboro, MA 01752
(617) 481-3700

Industrial Computer

PO Box 23058
San Diego, CA 92193
(800) 523-2320

Intelligent Instruments

1141 W Grant Road, MS131
Tucson, AZ 85705
(602) 623-9801

IOtech

25971 Cannon Road
Cleveland, OH 44146
(216) 439-4091

Keithley

440 Myles Standish Blvd
Taunton, MA 02780
(800) 348-0033

National Instruments

6504 Bridge Point Parkway
Austin, TX 78730
(800) 433-3488

PAIA Electronics

3200 Teakwood Lane
Edmond, OK 73013
(405) 340-6300

Parallax

3805 Atherton Rd
Rocklin, CA 95765
(916) 624-8333

Pro-Log Corp

2555 Garden Road
Monterey, CA 93940
(408) 372-4593

At an \$1800 street price.

But, all of a sudden, this is *the* machine that will *completely* blow away ink based black-and-white jiffy printing. At least for 5000 or fewer copies, this new beast now gives you higher quality at lower cost than ink printing. With *zero* makeready and much less scrap. And infinitely more convenience. The photo grays have to be seen to be believed. There's 120 gray levels at 106 spots per inch.

A major threshold clearly has been crossed with this machine. One that opens up an incredible number of new hardware hacking opportunities. A new era has clearly been defined.

One in which you could publish your own top quality books off your own kitchen table. As good as or better than anything in bookstores today.

The only negative on the 4M+ is its appalling lack of a supporting hard disk. But such a monumentally dumb omission almost certainly will soon be fixed. And you can temporarily workaround this by sneaky use of full page PostScript forms.

Additional info and support on this incredible new machine on *GENie* PSRT. And in my *Book-on-demand Resource Kit*.

For most hardware hackers most of the time, any patent involvement is

absolutely certain to result in a net loss of time, energy, money, and sanity. Thoroughly tested real-world alternatives do appear in my *Case Against Patents* package, which also includes my *Incredible Secret Money Machine II* as a bonus book.

Per my nearby *Synergetics* ad.

A reminder that ten free hours of *GENie* use are still available, per our "Need Help" box. As usual, most of the resources I've mentioned appear in the *Names & Numbers* and in the *Computer I/O Resources* sidebars. Be sure to check here before calling our no-charge technical helpline.

Let's hear from you. ♦

NAMES AND NUMBERS

Analog Devices

PO Box 9106
Norwood, MA 02062
(617) 329-4700

Burr-Brown

6730 S Tucson Blvd
Tucson, AZ 85706
(602) 746-1111

C Users Group

1601 W 23rd St Ste 200
Lawrence, KS 66046
(913) 841-1631

Fire Engineering

PO Box 1289
Tulsa, OK 74101
(918) 835-3161

Firefighters Bookstore

18281 Gothard #105
Huntington Beach, CA 92648
(800) 727-3327

GENie

401 N Washington St
Rockville, MD 20850
(800) 638-9636

Hewlett-Packard

PO Box 10301
Palo Alto, CA 94303
(415) 857-1501

Linear Technology

1630 McCarthy Blvd
Milpitas, CA 95035
(408) 432-1900

Maxim

120 San Gabriel Drive
Sunnyvale, CA 94086
(800) 998-8800

Metrologic

Coles Road @ Route 42
Blackwood, NJ 08012
(800) ID-METRO

Motorola

5005 E McDowell Road
Phoenix, AZ 85008
(800) 521-6274

National Semiconductor

2900 Semiconductor Road
Santa Clara, CA 95052
(800) 272-9959

RF Micro Devices

7341-D West Friendly Ave
Greensboro, NC 27410
(910) 855-8085

Science

1333 H Street NW
Washington, DC 20005
(202) 326-6400

Siemens

2191 Laurelwood Road
Santa Clara, CA 95054
(408) 980-4500

Small Parts

PO Box 4650
Miami Lakes FL, 33014
(305) 557-8222

ST Publications

407 Gilbert Avenue
Cincinnati, OH 45202
(513) 421-2050

Synergetics

PO Box 809
Thatcher, AZ 85552
(602) 428-4073

Don Lancaster's Hardware Hacker

September, 1994

Binary chain code secrets
Major SETI developments
Battery charging resources
New shaft encoder designs
Light-to-frequency circuits

There seems to be another new manufacturer making those programmable interconnects we looked at several columns back. A startup known as *Atesla* now offers what they call *programmable wiring* crosspoint arrays.

These are dense chips, fairly low in cost, and have good high frequency performance. They are only one-time programmable. Sizes go from 13 x 13 up to 101 x 101.

Any and all pins can be connected together in any combination without limit. These all can handle digital or analog to 30 volts of either polarity. Their final interconnects are purely passive and draw *zero* current.

One warning on these: Beware of *sneak paths*. If you connect 2 to 6 and 6 to 7, you've also connected 2 to 7. Whether you like it or not. Since you have low value resistance fuse links between pins, any pin can be either an input or an output.

But a hacker friendly, non-volatile, cheap, dense, and reprogrammable wiring chip has yet to be offered.

More Thoughts on SETI

Some very interesting things have come down lately in the search for extraterrestrial intelligence.

After a number of false reports, extremely convincing evidence exists that several planets do orbit a remote Pulsar. Discovered by Penn State's Alexander Wolszczan and published in *Nature* for February 24, 1994.

French astronomer Pierre Lagage may have found a different planet or two in a totally different part of the galaxy. Per *Science News* for June 25, 1994. Orbiting Beta Pictoris.

Both observations do clearly imply that planets are *not* unique to our solar system. And strongly suggest planets are as common elsewhere as they are here. This also shores up a weak element in the *Drake Equation* that predicts the number of intelligent civilizations lurking around.

Even more intriguing, amino acids have "most likely" been verified near the galactic center. Per page 1668 of

the June 17, 1994 copy of *Science*. At a distance of 30,000 light years, the Glycine spectrum is not likely to be bread crumbs that blew away from a family picnic.

Amino acids, of course, are the key precursors to protein and to life itself. Should you want to build your own kangaroo, you'll start off with several key amino acids. The complete set of kangaroo plans appears in a machine language code called DNA.

Free copies are available at your nearest zoo. Some skill is needed for compilation and assembly.

Meanwhile, federal funding for a major SETI search has been dropped. But I suspect this will be beneficial in

the long run. Individual and creative private research ultimately beats out the feds every time. I expect a loose network on Internet will more than pick up the slack. With a network of dishes and computers the Feds could not even remotely dream of.

Real soon now.

But the major SETI setback seems to be our own fault. All of a sudden, we are a lot less dumb about comm than we used to be. We've found out that 5 watts up on a satellite is better than 50,000 watts on a tower. And a mere 5 milliwatts on a fiber can end up even better yet.

We have also found out that it is really dumb to reserve unique radio

A binary chain code is a long series of ones and zeros that keeps repeating.

A chain of length "n" will have 2^n bits in it. What makes binary chain codes interesting is that any short sample of n bits will define a unique position in the chain. All possible n-bit words get used precisely once.

For instance, \$09AF is a four bit binary chain code. Expand it into a series of ones and zeros...

0 0 0 0 1 0 0 1 1 0 1 0 1 1 1 1

Add a few extra bits so the sequence goes round and round...

... 0 1 1 1 1 0 0 0 0 1 0 0 1 1 0 1 0 1 1 1 1 0 0 0 0 1 ...

Now repeat the sequence sixteen times. Note how each n=4 bit sample defines a unique position in the sequence...

... 0 1 1 1 1 0 0 0 0 1 0 0 1 1 0 1 0 1 1 1 1 0 0 0 0 1 ...
... 0 1 1 1 1 1 0 0 0 0 1 0 0 1 1 0 1 0 1 1 1 1 0 0 0 0 1 ...
... 0 1 1 1 1 0 0 0 0 1 0 0 1 1 0 1 0 1 1 1 1 0 0 0 0 1 ...
... 0 1 1 1 1 0 0 0 0 1 0 0 1 1 0 1 0 1 1 1 1 0 0 0 0 1 ...
... 0 1 1 1 1 0 0 0 0 1 0 0 1 1 0 1 0 1 1 1 1 0 0 0 0 1 ...
... 0 1 1 1 1 0 0 0 0 1 0 0 1 1 0 1 0 1 1 1 1 0 0 0 0 1 ...
... 0 1 1 1 1 0 0 0 0 1 0 0 1 1 0 1 0 1 1 1 1 0 0 0 0 1 ...
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... 0 1 1 1 1 0 0 0 0 1 0 0 1 1 0 1 0 1 1 1 1 0 0 0 0 1 ...
... 0 1 1 1 1 0 0 0 0 1 0 0 1 1 0 1 0 1 1 1 1 0 0 0 0 1 ...
... 0 1 1 1 1 0 0 0 0 1 0 0 1 1 0 1 0 1 1 1 1 0 0 0 0 1 ...
... 0 1 1 1 1 0 0 0 0 1 0 0 1 1 0 1 0 1 1 1 1 0 0 0 0 1 ...

Fig. 1 – BINARY CHAIN CODES are self-positioning. This makes them an exciting new tool for robotics sensing and data base management.

to most binary chain codes.

Figure one shows us what's unique about a binary chain code: *Any n bit sample can immediately and uniquely tell you its exact position in the total sequence.* Thus, if you know only six recent bits in your code, you know *exactly* and *uniquely* where you are in the 64 bit long sequence.

Figure two shows us sample binary chain codes for some lower *n* values. Check any of these, and you will find that any sample that is *n* bits long is uniquely positioned.

No, the positions are not revealed in numeric error. But a simple table lookup is all you need to find where you are at any particular time.

The binary chain codes are neither super rare nor very common. As an example, you should find 67,108,864 possible simple binary chain codes of length six. On the other hand, there are 18,446,744,073,709,551,616 total possible *different* code sequences of length six. Randomly stumbling into a chain code ain't gonna happen.

Several properties of simple chain codes: The number of ones and zeros are equal. There will be one black run of *n* bits and one white run of *n* bits. On a basic six bit chain code, there will be a total of...

- 1 - black run of six bits
- 0 - black runs of five bits
- 1 - black run of four bits
- 2 - black runs of three bits
- 4 - black runs of two bits
- 8 - black runs of one bits

Plus an identical number of white runs in the same pattern. The total number of black runs will be *one quarter* of *n*. So will the total number of white runs. Thus, there will only be 32 black stripes on any *seven* bit encoder. And that 1-0-1-2-4-8-16-32... sequence will continue for a higher number of bits.

Now to have us some fun. Figure three shows you PostScript code that will generate *any* radial pattern of ones and zeros on a disk. All you do is throw it a string having ones and zeros in it, and it builds the pattern for you. This is even smart enough to ignore spaces and carriage returns.

Just route this code to most any PostScript printer or view it by using *GhostScript* shareware.

This is yet another example of the

general purpose computing stuff that is trivial with PostScript but difficult to do otherwise.

As an example, figure three also shows you a simple seven bit binary chain code encoder disk. Unlike the conventional absolute encoder disks, your photo sensors fit *tangentially* along the disk. By measuring seven bits, you will know your position in the sequence at all times.

But despite the seemingly simple pattern, this is an *absolute* encoder that tells you *exactly* where you are. Not an *incremental* one that is only able to count pulses.

Out in the real world, some extra

refinements can be added. You can purposely *oversample* to produce ten to twelve bits of position accuracy from a seven bit wheel. Part of this can be a simple interpolation as the pattern moves across the sensor face.

Oversampling can also solve those "hairy edge" problems common to all "non-Gray" encoders.

Note that a wheel having only 32 stripes on it can measure an absolute position to an accuracy of one part in 1024 or even one part in 4096!

Compared to the usual Gray code position encoder, the binary chain encoder is simpler and cheaper and allows much sloppier tolerances. The

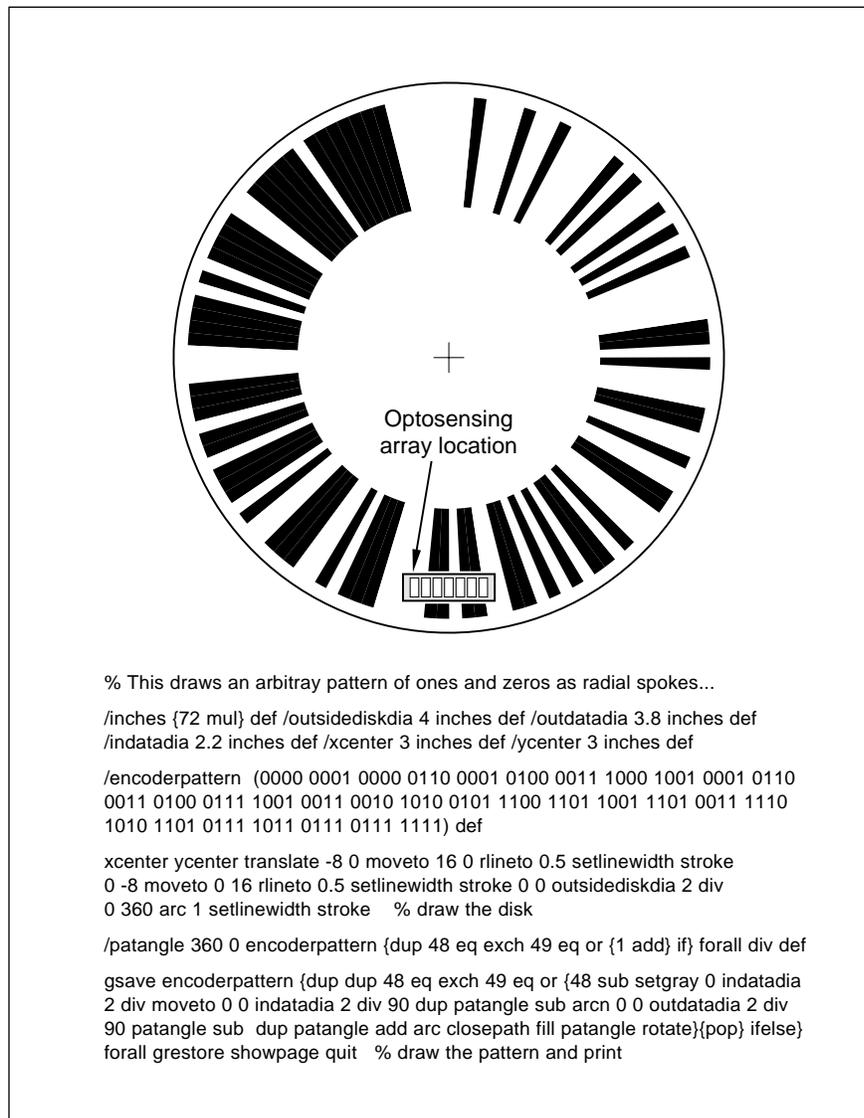


Fig. 3 – BINARY CHAIN CODE encoder disk and the PostScript code needed to generate it. Despite the mere 32 stripes, this is an absolute position sensor that can provide as much as a 10- or even 12-bit accuracy.

main negative is that a binary chain encoder ends up somewhat slower in its processing times.

One possible sensor would be the new TSL213 from *Texas Instruments*.

You could also conjure up *linear* position sensors that use binary chain codes or some variant of them.

Many thanks to mathematician Jim Fitzsimmons for his help in finding these codes and understanding their unique properties.

More on generating and using your own binary chain codes do appear in both #899 BINCHAIN.TXT and #902 MORCHAIN.TXT up on *GENIE* PSRT. Including programs to generate your own. More on digital codes in general in my *Micro Cookbook I*. Of which only a scant few copies remain.

One source of ready-to-go chain encoders is *Photocraft*. Additional encoder construction details appeared in that April 1994 issue of *Sensors* magazine. More on the geodata chain code uses appears on *Dialog*.

Light to Frequency Converters

Texas Instruments has had a real sleeper product for over two years now. One having outstanding hacker potential. This is their TSL230 light to frequency converter. You put in light and you'll get out a frequency

proportional to light intensity.

Ridiculously simplifying opto to computer interfaces. All in a clear 8-pin minidip that costs under \$5 in singles. Half that in quantity.

You can use this one for nearly any light task. Just measuring the output frequency can give you dusk-to-dawn controls, colorimetry systems, auto brightness, or exposure meters.

Integrating (or counting) the output pulses gives you a total dosage. For such things as measuring total solar irradiance at a site. Or automating a photo dodge and burn.

And differentiating (or monitoring changes) in the output pulse rate can be used for light-to-voice or light-to-music applications, as well as various solutions for light beam telemetry.

Figure four shows how simple the circuit is. You apply +3 to +5 volts of supply power. Pick some hardware jumper options, and route the output to a computer port or whatever. For quick and dirty experiments, you can even use a headphone or audio amp on the outputs. Even a speaker with a series 100 ohm resistor will work.

Jumpers let you change sensitivity and the frequency range. There are apparently three silicon photodiodes used, with relative areas of 1, 9, and 90. Which gives you four sensitivity

options of zero (off), one, ten, and one hundred.

Similarly, you will find four output frequency options. The fastest gives one Megahertz pulses at max light. Typical pulse width is one third of a microsecond. You can also get output square waves that divide the output by 2, 10, or 100.

The choice of photodiode area can give you an electronic shutter or a variable F-stop. The choice of output scaling gives you the equivalent of a variable shutter speed.

There normally are two different ways of measuring frequency. If you have a high frequency, you can count cycles for a specified time interval, say one tenth of a second. This gives you *events per unit time* and directly measures frequency. Which is great for fast stuff. But lower frequencies may need hundreds or thousands of seconds for accurate results.

For lower frequencies, you can use one cycle of the frequency itself to start and stop a high speed reference. This is known as the *pulse period* or *stopwatch* method. You can precisely measure a 5 Hertz square wave in a tenth of a second by using this pulse period method.

But the pulse period method has a price. Your answer does *not* measure frequency. Instead, it measures *time period*, or the *inverse* of frequency. Instead of 440 Hertz, you get 0.00227 seconds. A division or a table lookup will be required when you really are interested in the actual frequency. Do note that any inverse is always some nonlinear curve.

The pulse period method also is noise sensitive. Any deviations on the particular cycle you are measuring may trash your results. One obvious trick is to average the pulse period method over several input cycles.

Which is trivial with just about any microcontroller these days.

Supply current is two mils active and ten microamps when your output enable pin is high. Accuracy varies from five to twenty percent, per chip options. You can custom calibrate if you need better accuracy.

Be sure to keep your chip clean!

The spectral response is your usual silicon curve that is weak in the blue and very strong in the infrared. Temp comp is good over the visible light

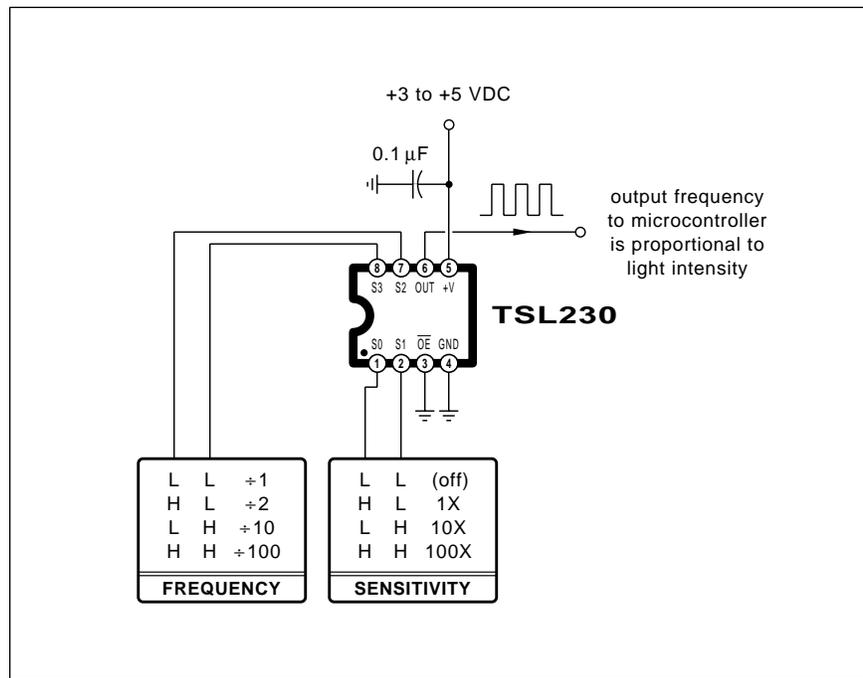


Fig. 4 – TSL230 LIGHT-TO-FREQUENCY CONVERTER is a simple and low cost way of interfacing light intensity to any microcomputer.

range, but any near ir heating of the chip causes bad frequency errors.

A fan or a heat filter is probably a good idea for solar aps.

The dark current gives you around half a Hertz at full area. Compared to saturated light at 1 Megahertz. This gives you a 66 db dynamic range. The jumpering options let you center this dynamic range on the intensity range you need.

Battery Charging Resources

There are some real exciting new products coming down in the battery charging arena these days. Mostly new chips that allow faster and safer charging of high tech batteries. Often using careful temp measurement and precise cell monitoring.

For this month's resource sidebar, I thought I would gather together the major sources.

One of the bigger players here is *Dallas Semiconductor*, who have a new battery charging data book out. Along with bunches of sophisticated yet quite low cost chips. Some fully programmable. You also might want to pick up a copy of that *NiMH and NiCD Battery Management* ap note from the *Philips* folks.

As to the batteries themselves, you ain't seen nuthin' yet. Research to date on electric car batteries has been mostly "smoke and mirrors" hype.

Crammed full of hidden agendas, wishful thinking, and sorely limited funding sources.

But the laptop battery people have an *immediate* and a *hassle-free* new multi-billion dollar market begging for new cell designs. Cells that pack stored energy into minimum volume at minimum weight.

Solve the laptop energy problem and the electric car problem becomes a trivial sideshow.

My own guess right now is that a thinly sheeted, polymer-based, fast rechargeable lithium system should end up with all the marbles. Lithium is light and cheap and has a high energy density. Lithium's reactivity is fast becoming managable through brand new developments. Lithium is easily mined from seawater.

This Month's Contests

Uh, let's have us a *really* far out contest for this month. Say you are a

BATTERY CHARGING RESOURCES

Benchmark

2611 Westgrove Dr #109
Carrollton TX 75006
(214) 407-0011

Burr-Brown

6730 S Tucson Blvd
Tucson AZ 85706
(602) 746-1111

Dallas Semiconductor

4401 Beltwood Pkwy S
Dallas TX 75244
(214) 450-0400

Electronic Power Technology

6400 Atlantic Blvd Ste 130
Norcross, GA 30071
(404) 449-1104

EnChip

434 Ridgedale Ave Ste 11-327
East Hanover NJ 07936
(201) 328-2049

International Rectifier

233 Kansas St
El Segundo CA 90245
(310) 322-3331

Linear Technology

1630 McCarthy Blvd
Milpitas CA 95035
(408) 432-1900

Maxim

120 San Gabriel Dr
Sunnyvale CA 94086
(800) 998-8800

Philips/Signetics

PO Box 3409
Sunnyvale CA 94088
(800) 234-7381

Siliconix

2201 Laurelwood Rd
Santa Clara CA 95054
(800) 554-5565

Teledyne Semiconductor

1300 Terra Bella Ave
Mountain View CA 94043
(415) 968-9241

Unitrode

580 Pleasant St
Watertown MA 02172
(617) 926-0404

high tech hardware hacking native of some fairly laid back planet orbiting *Gamma Gallinas*.

Your specialty is radio astronomy and you have been observing a third rate star some 40 light years away that suddenly became a radio source a few grumpids ago.

So far, you've discovered strongly suspicious VHF spectral distributions and have applied the latest in PDSP (psychic digital signal processing) techniques to them.

Up on the virtual monitor viewer from your latest run suddenly pops a twelve second clip of *Roller Derby*. Superbly clear. For our contest this month, just send me a copy of the report you will send your supervisor. Also your next Intergalactanet post.

Yes, you do have witnesses and archival backup copies.

There'll be the usual dozen or so *Incredible Secret Money Machine II* books going to the best entries, plus an all expense paid (FOB Thatcher, AZ) *tinaja quest* for two going to the finest of all.

Be sure to send all your *written* entries to me here at my *Synergetics*, rather than to **Electronics Now**.

As a second and more down to earth contest this month, just tell me

about a new and hacker friendly use for the TLS230 opto chip.

New Tech Lit

From *Raytheon*, a 1994 *Data Book* on fancy video and multimedia chips. From *Hitachi*, a new *Semiconductor Technology for Wireless Comm*.

From *Apple Computer*, the *Power Macintosh Software Directory*.

From *Motorola* a new *Power Scene* newsletter on power electronic MOS products and such.

And from *Texas Instruments* again, a new \$98 (!) digital signal processing breadboard. Called the *TI DSP Starter Kit*. For more specifics, call up TI at (800) 477-8924, extension 3651.

Several helpline callers have asked about TIFF files. These are simply an older method of describing a bitmap image. Short for a *Tag Image File Format*. Copies of the Rev. 5.0 spec are available from *Aldus*. A *Guide to the Tag Image File Format* is also offered by *HP Peripherals*.

But observe that PostScript's *image* operator is a vastly better way to deal with bitmapped data.

Adhesive & Sealants Industry is a trade journal that's not afraid to deal with sticky subjects.

Computer Telephony is a new mag

NAMES AND NUMBERS

Adhesives & Sealants

PO Box 400
Flossmoor IL 60422
(708) 922-0761

Aldus

411 1st Ave S #200
Seattle WA 98104
(800) 685-3614

Apple Computer

20525 Mariani Ave
Cupertino CA 95014
(408) 996-1010

Atesla

2890 N Frist Street
San Jose CA 95134
(408) 428-6250

Black Range Films

Star Rt 2 Box 119
Kingston NM 88042
(505) 895-5652

Computer Telephony

12 West 21 Street
New York NY 10010
(212) 691-8215

DynaArt Designs

3535 Stillmeadow Ln
Lancaster CA 93536
(805) 943-4746

GENie

401 N Washington St
Rockville MD 20850
(800) 638-9636

HP/Peripherals Group

16399 W Bernardo Dr
San Diego CA 92127
(619) 592-8333

Hitachi

2000 Sierra Point Pkwy
Brisbane CA 94005
(415) 589-8300

Home Systems Network

Box 3006
Edmond, OK 73083
(405) 330-0718

Internet World

11 Ferry Lane West
Westport CT 06880
(203) 226-6967

Motorola

5005 E McDowell Rd
Phoenix AZ 85008
(800) 521-6274

Photocraft Inc

PO Box 408
Geneva IL 60134
(815) 786-2885

Planetary Society

65 N Catalina Ave
Pasadena CA 91106
(818) 793-5100

Raytheon

350 Ellis St
Mountain View CA 94043
(800) 722-7074

Sensors

174 Concord St
Peterborough NH 03458
(603) 924-9631

SETI Institute

2035 Landings Dr
Mountain View CA 94043
(415) 961-6633

Synergetics

Box 809
Thatcher AZ 85552
(602) 428-4073

Texas Instruments

PO Box 809066
Dallas TX 75380
(800) 336-5236

on phone modem networking. And *Internet World* is an ongoing pub on Internet access and use.

Three unique videos on straw bale home construction are newly offered by *Black Range Films*. And a half hour home automation video titled *Living with an Intelligent Home* has been released by the folks at *Home Systems Network*.

Frank Miller of *DynaArt Designs* just sent me a bunch of his brand new tools and materials for direct toner printed circuit boards. More on this when I complete testing. Meanwhile, you can pick up free details on this exciting new method to quickly and simply make your own printed circuit boards by giving Frank a call.

To pick up the fundamentals of digital integrated circuits, check into my CMOS and TTL Cookbooks. Also available as part of my *Lancaster Classics Library*.

A reminder that electronic reprints of all my columns, along with instant tech help, are available on *GENie* PSRT. I've managed to arrange ten free *GENie* hours for your use. As shown in the help box.

Free catalog requests and technical questions you want answered here or on PSRT can also be sent me via my SYNERGETICS@GENIE.GEIS.COM Internet address.

As usual, most of these resources I've mentioned appear in the *Names & Numbers* or else in that *Battery Charging Resources* sidebar. Be sure to check here before calling our no-charge tech helpline.

Let's hear from you. ♦

NEED HELP?

Phone or write your Hardware Hacker questions to:

Don Lancaster
Synergetics
Box 809-EN
Thatcher, AZ, 85552
(602) 428-4073

For fast PSRT access, modem (800) 638-8369, then an HHH. Then JOINGENIE. On keyword prompt, enter DMD524.

Internet email access link: SYNERGETICS@GENIE.GEIS.COM.

Don Lancaster's
Hardware Hacker

October, 1994

More on dowsing tests
 Reprints and standards
 Using helical resonators
 Scientific method review
 New laser service manual

There sure were a lot of you that responded to our recent dowsing contest. Several of you revealed detailed info on new controlled studies.

All having highly negative results. Several others genuinely and truly believed in dowsing, but presented their case on blind faith alone.

Check the *Skeptical Enquirer* #4-1 p16-20; #6-4 p34-37; #8-1 p138-140; and #15-3 p386-397 for lots of further negative evidence. Or the *Untapped Technology in Review*, Spring 1994 p 4-7 for a bizarre sampling of current pro-dowsing thought.

See the newsstand "treasure" mags for dozens more.

Thanks to bunches of you readers, I've now received mountains of info. Virtually all of it totally devastating to the dowsing cause. The *Skeptical Enquirer* will pay \$10,000.00 cash to anyone who can use a dowsing rod to detect any buried flowing pipe in a properly controlled test.

There's also a dead wrong popular myth about finding water wells. As a spelunker, I can assure you that any rapidly flowing underground rivers are *extremely* rare items.

Instead, a well simply taps into a *permeable* (or porous) layer above an *impermeable* (or solid) layer. Sort of like a straw in a bowl of oatmeal.

Except near the *cone of depression* of an *existing* and flowing well, the water pretty much just sits there. *The usual flow rate is zero.* Any device (scientific *or* pseudoscientific) that searches for flowing water will be of no use in finding new wells.

Over the years, we've had lots of questions about those long distance "electrostatic" treasure finders. One industry expert dissected a \$2500 unit and discovered less than \$6 worth of surplus parts. Klutzily arranged in a very simple and highly questionable circuit. Apparently these are nothing but a high tech coat hanger.

The intent seems to be making a dowsing rod look like an induction balance treasure finder.

Their "unconditional guarantees"

are used to try to ward off the FTC.

Much as I am a fan of the *scientific method*, though, this is *only* a belief system. With *any* belief system, some things are unknown and others stay *inherently* unknowable.

Thus, you can *not* use the scientific method to disprove dowsing. All you could do is show that repeated tests fail, making any dowsing credibility more and more unlikely.

Which brings us around to...

The Scientific Method

Uh, exactly what is this "Scientific Method" stuff all about anyhow? The scientific method is a belief system that feels that observed effects have underlying physical causes. And that the relationship between cause and effect has rational mathematical *and* experimental bases supporting it.

Typically, something has happened and you want to know *why*. Or you

want to cause something to happen and you want to know *how*. In either case, you'll make an educated guess called a *theory* or a *premise*.

You'll then attempt to perform the simplest possible lab experiment or else work the simplest possible math analysis that will test your theory for real-world accuracy.

This is known as a *model*. Your model's goal is to get your intended effect to show up fairly well.

You'll then tell others about your results, inviting them to duplicate them. Should enough independent outsiders duplicate the results many times over, the theory gets upgraded to "law" status. A "law" is just some theory that nobody has been able to convincingly disprove.

For the scientific method to work, there has to be a *balance* between lab experiments and math theory.

Too much of either will *always* be

| HP MANUAL | HP PRINTER | APPLE PRINTER | QMS PRINTER |
|----------------------------|---------------------------------|---|--|
| 02686-90920 (CX Engine) | LaserJet I | LaserWriter LaserWriter Plus | PS800 Smartwriter 80+ |
| 33449-90906 (SX Engine) | LaserJet II LaserJet III | LaserWriter NT LaserWriter NTX LaserWriter F LaserWriter G | PS810 & Turbo PS820 & Turbo PS815-MR PS825-MR |
| 33459-90906 (SX Engine) | LaserJet IID LaserJet IIID | ----- | ----- |
| 33481-90951 (LX Engine) | LaserJet IIP | Personal LW NT Personal LW NTR | PS410 PS420 |
| C2010-90939 (NX Engine) | LaserJet IIIsi LaserJet IVsi | ----- | PS1700 |
| C2001-90940 (EX Engine) | LaserJet 4 LaserJet 4M+ | LaserWriter 600 LaserWriter 630 | ----- |
| C2005-90988 (PX Engine) | LaserJet 4ML LaserJet 4MP | ----- | ----- |
| ----- (BX Engine) | ----- | (Fall 1994) | Hammerhead 860 |

Fig. 1 – HEWLETT-PACKARD MANUALS can be used to repair most popular laser printers from dozens of manufacturers. Here's the latest update.

suspect. Underlying *hidden variables* or *alternate causes* must get strictly and rigorously eliminated. All of the observed effects also have to obey the statistical laws of large numbers. Having something happen once won't hack it. It has to be repeated many times in many ways. Until the results are beyond a shadow of a doubt.

One of the things that pops up over and over again using the scientific method is that most effects obey a *square law* or higher dropoff as you increase distance.

Thus, any *action at a distance* is an *extremely rare* physical phenomenon. And *always* one which will be *highly* suspect. Note that in most "radar" or "treasure finder" situations, *both* the illuminator *and* the target emissions drop off *at least* as a square law. The sensitivity of such devices drop off as the *fourth power* of distance.

Usually *much* higher.

Another unavoidable feature of the Scientific Method is the *noise floor*. There is a certain limit below which things are unobservable. Caused by inherent sources of interfering signals which are stronger than those you are trying to measure. One example is the thermal emission noise inherent in anything not at absolute zero.

Yes, certain tricks can be pulled to reach well down into noise. Such as filtering, integration, or correlation. But the noise floor *always* will set an ultimate limit.

Enter Heisenberg and Company

The bane of the Scientific Method is an even more fundamental gotcha known as the *Heisenberg Uncertainty Principle*. This one tells us that *you cannot measure something without disturbing it*. At the lowest level, if you try to extract information from a system, you alter its entropy.

Let's look at two wildly different examples. Say you want to verify Ohm's law by measuring the current through some 2.2K resistors. Seems simple enough. Just apply a one volt source. Then observe something like a 455 microamp current.

But even with such "pure physics" stuff, you can easily get into lots of trouble. Why? Any current measuring device has a voltage drop across it. And any voltmeter draws current.

Causing inherent *instrumentation errors*. Dissimilar contacts generate thermocouple voltages. The resistor might be photosensitive. Power line hum or the local radio station may be getting into the works. You may have forgotten to calibrate or ground your scope probe. Or other energy sources may cause resistive currents.

Even your test current can cause a *self-heating* that shifts values.

Somebody may have painted the wrong stripes on the resistor. Or you might be color blind.

Now, thinking "positive psychic thoughts" at your resistor is unlikely

to change the results. But trying to please your boss just might. As might trying to get through your school lab report. Or daydreaming about a giant clockwork armadillo instead.

But all this is largely manageable. One way or another.

Suppose, instead, that you want to prove that *L-Carnitine* is a cheap and safe cure for heart disease. Now the uncertainties and the hidden variables get ugly in a big hurry.

Most psychic effects do tend to be highly controversial. But one psychic phenomenon which has strong proof of its validity is the *placebo effect*. It has now been observed time and time again that *a patient who wants to get well and who feels they are taking positive steps towards that goal is significantly more likely to do so*.

But just watching someone taking L-Carnitine won't hack it. Chances are they are taking other stuff too. Or doing other things that'll make their problem better or worse. So, for the scientific method to work here, you have to go to *double blind testing* of thousands of patients.

In which *neither* the patient *nor* the doctor knows whether the real stuff or a placebo is currently being used. Actual selection has to be done on a totally random basis by a third party. Otherwise, unavoidable visual clues and other hidden variables will trash out the test results.

Similarly, the only credible way to raise or lower the apparent validity of dowsing or any other psychic effect is by large scale double blind testing. All of the dowsing tests I know about seemed to have failed.

Totally and without exception.

Once again, it is not very fair to discredit anything you know nothing about. But from all of my research to date and from what you've all told me, though, dowsing now appears to me to be an outright scam.

The "dowsing reaction" appears to be something the dowser wants to see happen. Or else is chaotically driven.

A Correction or Two

Whoops. I apparently said some things that were just plain wrong two issues ago in our transmission line story. What you thought I said isn't what I thought I meant.

A *shorted* transmission line will

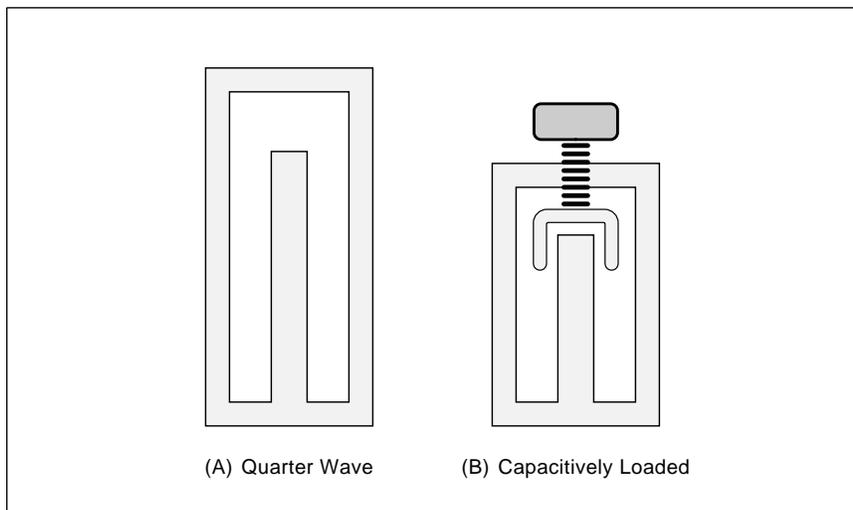


Fig. 2 – A CAVITY is any conductive enclosure that can support resonance. These are widely used at microwave frequencies. Energy can be coupled in or out with magnetic loops, electric probes, or electron beams. Here are cross sections of two examples of simple coaxial cavities.

appear as a short at zero length, as an open at *one quarter* of a wavelength, and back to a short at *one half* of a wavelength. Neglecting losses. The line will appear inductive at *less* than one-quarter wavelength and appears capacitive at *more* than one-quarter (but less than one-half) wavelength.

Note that a round trip on a quarter wavelength stub is actually one half of a wavelength long. And that any short inverts reflections.

An *open* transmission line appears as an open at zero length, as a short at *one quarter* of a wavelength, and on back to open again at *one half* of a wavelength. Your line should appear capacitive at *less* than one-quarter wavelength and inductive at *more* than one-quarter wavelength.

These changes have been picked up in HACK79.PS on GENie PSRT.

New Laser Training Manual

Don Thompson has just released his new volume on *Mastering Laser Printer Service*. Detailed step-by-step technical info on repairing all of the Canon series engines as used in the most popular printers from Apple, Hewlett-Packard, QMS, and many dozens of others.

You'll find hundreds of pages of proprietary "from the trenches" info not available elsewhere. It includes such insider secrets as the zero cost cure for those flakey connectors on the SX engine, rapid repair shortcuts, and much more. Plus nuts-and-bolts info on running a repair service.

I particularly like the dozens of printouts of the actual page problems. And his unique "pie chart" method of breaking down probable causes. All based upon thousands of actual real world case histories.

As a small sample of its contents, figure one shows you a listing of the little known HP manuals which are real handy to repair just about any major laser printer from nearly any source. Any and all of these can be ordered from *HP Manuals*.

Don has set up a special offer for *Hardware Hacker* readers. Contact him directly for further details.

Helical Resonators

At the frequencies above 100 Mhz, traditional coils and capacitors create serious design problems. Your circuit

strays often dominate, and unwanted coupling becomes bad news. Your Q values tend to drop and your stability becomes a big problem.

The usual solution is to go to some *distributed* network of some type, in which the inductance and capacitance is "spread out" all over everywhere, rather than being in distinct lumps. If the network can be self-shielding, so much the better.

A *cavity* is your stock solution at microwave frequencies. A cavity is simply any *conductive enclosure*. A cavity can resonate at many possible frequencies. What you do is look at the field equations. Any situation where you do not have an E-field *across* a conductor or an H-field *into* a conductor will resonate.

Normally, you use the simplest and most obvious solutions to your field equations. These are called *low order resonance modes*.

Figure 2-A shows us a *coaxial* cavity. It is simply a sealed cylinder that has a rod inside it. If the rod is precisely a quarter wavelength long, it can support resonant energy. With resonant current a maximum at the shorted bottom and resonant voltage a maximum at the open top.

The resonant frequency depends on the length of the inside rod. The Q is determined by surface conductivity

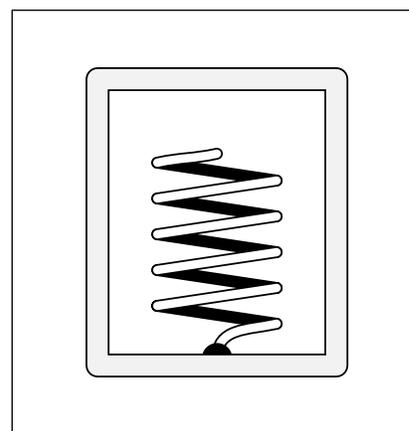


Fig. 3 – A HELICAL RESONATOR is a cavity variation that can be more suitable for VHF and UHF circuits. These can be easily built up from house wire and pc board stock.

and your diameter ratios. In general, the larger the cavity and the better its surface conductivity, the higher the Q. One piece cavities machined from solid blocks are usually better than built-up units.

In figure 2-B, we *capacitive load* a cavity. Which gives a more compact size and a tuning option. Sometimes a plain old machine screw or two is all you need for tuning. Other times, an actual variable capacitor or a varactor diode will get used.

Energy can be coupled into or out

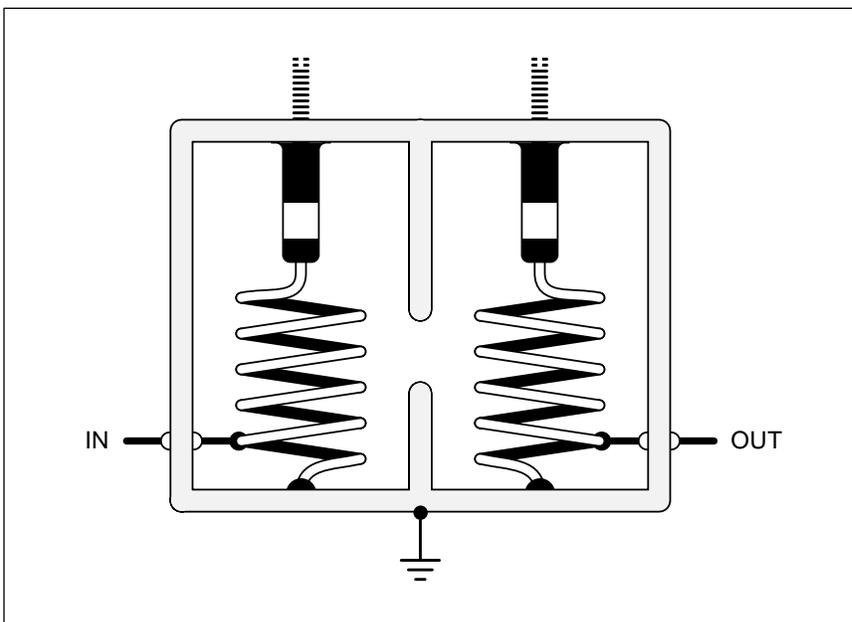


Fig. 4 – TWO-STAGE FILTER made from helical resonators. Energy gets coupled between resonators by the hole in the wall. The input and output taps serve as impedance step-up and step-down transformers.

RESOURCE RESOURCES

Books in Print

121 Chanlon Road
New Providence NJ 07974
(908) 464-6800

R.R. Bowker

121 Chanlon Road
New Providence NJ 07974
(908) 464-6800

Dialog Information Services

3460 Hillview Avenue
Palo Alto CA 94304
(415) 858-2700

Encyclopedia of Associations

835 Penobscot Bldg
Detroit MI 48226
(313) 961-2242

Factsheet Five

R. Seth Friedman
PO Box 170099
San Francisco CA 94117

Gale Research

835 Penobscot Blvd
Detroit MI 48226
(313) 961-2242

Global Engineering Documents

15 Inverness Way East
Englewood CO 80112
(800) 854-7179

Information Store

500 Sansom Street Ste 400
San Francisco CA 94111
(415) 433-5500

Intl Standard Periodicals Guide

150 Fifth Avenue #202
New York NY 10011
(212) 741-0231

KeelyNet BBS

Box 1031
Mesquite TX 75149
(214) 324-3501 BBS

Oxbridge

150 5th Ave #202
New York NY 10011
(212) 741-0231

Rex Research

Robert Nelson
PO Box 19250
Jean NV 89019

Science Citation Index

3501 Market Street
Philadelphia PA 19104
(215) 386-0100

Thomas Registry Mfrs

1 Penn Plaza
New York NY 10119
(800) 222-7900

Ulrichs Dictionary

121 Chanlon Road
New Providence NJ 07974
(908) 771-7714

UMI

300 North Zeeb Road
Ann Arbor MI 48106
(800) 521-3044

this way. Tuning can still get done with a variable capacitor.

Note that you do *not* just have a plain old series L-C circuit here. Most of the resonating capacitance is from coil to wall. In a distributed and time-sensitive transmission network.

Figure four shows us a two stage helical filter. Energy is coupled into the first stage from a suitable tap. Sort of like an impedance step-up transformer. A "hole in the wall" can provide your interstage coupling. And energy finally gets tapped out of the second stage. The size and the other details vary with what you want your filter to accomplish.

You could easily make your own helical resonators up out of soldered printed circuit board and heavy wire. Avoid any supports on the "hot" end of the helix as they will dramatically lower your Q. Some fancy math may be needed. Along with quite a bit of experimental cut-and-try.

More info on cavities in general in *Reference Data for Radio Engineers*, the *Radio Engineer's Handbook*, and in most microwave texts. One source for surplus cavities is *Fair Radio*.

Your "horse's mouth" paper on the helical resonators showed up in the December 1959 *Proceedings of the IRE*. Reasonably priced helical filters are manufactured by *Toko*. They are stocked by *Digi-Key*.

Please let me know if you find any newer and readable papers on helical filter and resonator designs. A free *Incredible Secret Money Machine II* for your trouble.

Resource Resources

I just got a new *UMI* catalog, so I decided it is high time to gather the most significant of my fundamental research tools into one sidebar. *UMI* (formerly *University Microfilms*) is the place to pick for hard copies of most any magazine story or journal paper. Sadly, those free *Interlibrary Loan* services of many libraries are being discontinued. Others seem to be getting slow and unreliable.

UMI is now associated somehow with *The Information Store*. These folks sell all the "hard to get" stuff such as standards or conferences.

Major standards associations were listed in *Hardware Hacker II* and in HACK47.PS on *GENie* PSRT. Another

of a cavity in several ways. A wire loop can get used for *magnetic* or "H-field" coupling. Or a wire probe for an *electric* or "E-field" coupling. Simply leaving a hole in the side of the cavity can also let energy in or out. Carried to an extreme, a very long cavity intended to move energy is called a *waveguide*.

The position of the probe or the size of the hole defines the ratio of unloaded versus loaded Q and thus the bandwidth of the resonator. The low frequency equivalent would be a tap on a coil.

Cavities can be temperature and humidity sensitive. Temp comp can be done by the choice of the cavity base metal, with a small bellows, or by purposely adding components that drift in the opposite direction. Or by using active AFC feedback. The best base material is *Invar*, which has a near zero tempco. One sledgehammer way to get around humidity problems is to hermetically seal the cavity in a

vacuum or dry nitrogen.

The Q of a cavity is very sensitive to the conductivity of its walls. While hardware hackers can often get by with soldered printed circuit boards, the highest Q cavities should be gold or silver plated. Q values of several thousand are easily reached.

Microwave ovens use a cavity in their *magnetron* rf oscillator. As do many radar speed detectors. In fact, just about all microwave applications use one or more cavities. But at VHF and UHF frequencies, cavities tend to end up big and expensive.

Enter the *helical resonator*, stage left. A cross between cavities and discrete L-C circuits. And one that is cheap and effective for everything from improved FM reception through ham television to wireless cellular.

Figure three shows you a helical resonator. All you do is take some ordinary coax cavity and twist your center conductor, making a helix out of it. The final size gets a lot smaller

one-stop but pricey place to pick up most standards is *Global Engineering Documents*.

Seems to me I have mentioned the *Ulrich's Periodicals Dictionary* a time or two before. As your single most important Hacker resource ever. Their competition is the *International Standard Periodicals Dictionary*.

Other library resources include the *Encyclopedia of Associations*, that *Thomas Registry of Manufacturers, Books in Print*, and the *Science Citation Index*. This last gem lets you move *forward* through time, finding newer and newer material.

The major publishers of reference directories are *Gale*, *Oxbridge*, and *Bowker*. Check any library.

My favorite online resource to find out *anything* from *anywhere* is the *Dialog Information Service*. And now available 24 hours a day as a *GENie* service. They have a surcharge-free Dialog practice area. Dialog is the broker for hundreds of info sources. Three of major interest to hardware hackers are INSPEC, MATHSCI, and COMPENDEX.

And then there is the Internet. All zillion terabytes of it. Chances are you can instantly talk to an expert, once you figure out *which* of those zillion terabytes to access. Lots of guides are now available.

Of the alternative resources, my two favorites are *Rex Research* for pseudoscience stuff, and *Factsheet Five* for little known reviews. That *KeelyNet BBS* is another weird and wondrous pseudoscience resource.

If you have any research favorites of your own, please be sure to let me know about them.

New Tech Lit

From *Philips*, a fat and free new *80C51 Application Notes* manual. And from *Samsung* free samples of their new *microMOSFETs*. These are very small high current switches.

New lasers that literally could be *painted* onto most any substrate are detailed in the *Photonics Spectra* for August 1994, p119-124. Included is a good bibliography.

Computer Video is a brand new trade journal from the *Radio News* folks. Free, with a surprisingly good mix of tech info. Two leading sources for most video products are *B&H* and

NAMES AND NUMBERS

B&H Photo-Video

119 West 17th Street
New York NY 10011
(800) 947-9901

Bell Jar

35 Windsor Drive
Amherst NH 03031
(603) 429-0948

Computer Video

5827 Columbia Pike 3rd Fl
Falls Church VA 22041
(703) 998-7600

Fair Radio Sales

PO Box 1105
Lima OH 45802
(419) 227-6573

GENie

401 North Washington Street
Rockville MD 20850
(800) 638-9636

Hewlett-Packard Manuals

19310 Pruneridge Avenue
Cupertino CA 94014
(800) 752-0900

Loose Change

1515 South Commerce Street
Las Vegas NV 89102
(702) 387-8750

Markertek Video Supply

4 High Street, Box 397
Saugerties NY 12477
(800) 522-2025

Neon News

PO Box 668
Volcano HI 96785
(808) 967-7648

Philips/Signetics

2001 W Blue Heron Blvd
Riveria Beach FL 33404
(407) 881-3200

Photonics Spectra

PO Box 4949
Pittsfield MA 01202
(413) 499-0514

Ragtime

4218 Jessup Road #AB
Ceres CA 95307
(209) 668-9704

Rough & Tumble Engineers

Box 9
Kinzers PA 17535
(717) 442-4249

Samsung Semiconductor

3725 N First Street
San Jose CA 95134
(800) 446-2760

Skeptical Inquirer

PO Box 703
Buffalo NY 14226
(716) 636-1425

Don Thompson

6 Morgan, #112
Irvine CA 92718
(714) 855-3838

Toko

1250 Feehanville Drive
Mt Prospect IL 60056
(708) 297-0070

Untapped Technology Review

PO Box 5185
Mesa AZ 85211

Markertek Video Supply.

Loose Change is a magazine for slot machine restorers and rebuilders. From the *Mead Publishing Company* who also have lots of *Pictorial Guide* repair manuals for popular vintage slots. Most states now allow private ownership of classic slots as antique collectibles. But check first.

Stupendously major breakthrough! I finally found out where to go to find *real* steam calliopes! Check out the *Rough and Tumble Engineers Historical Association* in Kinzers, PA. Who have year-round events. Meanwhile, modern replica air calliopes remain available from *Ragtime*.

The *Neon News* is a newsletter for the neon sign trade. Many thanks to Steve Hansen for this info. As I've said before, Steve publishes the *Bell Jar*, a superb labor-of-love newsletter

on homebrew high vacuum.

For the insider secrets on forming your own tech venture, check into my *Incredible Secret Money Machine II*.

A reminder that electronic reprints of all my columns, along with instant tech help, are now offered on *GENie* PSRT. I've managed to arrange ten free *GENie* hours for your use. As shown in the help box.

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Let's hear from you. ♦

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Hacker questions to:

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Box 809-EN
Thatcher, AZ, 85552
(602) 428-4073

For fast PSRT access, modem
(800) 638-8369, then an HHH.
Then JOINGENIE. On keyword
prompt, enter DMD524.

Internet email access link:
SYNERGETICS@GENIE.GEIS.COM.

Cyborg cosimano helmets
Long range remote control
Unique direct toner decals
Powerful new PIC software
Virtual ways CAM machine

There's lots of exciting new developments for this month, ranging from Scott Edwards' powerful new PIC tools, to an incredibly versatile hacker remote control, a stunning new *virtual ways* breakthrough in CAM tooling, better hacker printed circuits, and even your very own techno-shamanistic cyborg cosimano helmet....

Long Range Remote Controls

The FCC has long been fussy over unlicensed transmitters. Most of the time, what you are allowed to use just barely misses being useful. But there is one class of unlicensed transmitters the FCC permits that lets you use *ten times* the usual power.

Mark Gottlieb and the rest of the folks up at *Design Tech International* have come up with a new "E" series of remote control modules which cry out for hardware hacking.

While intended mostly for several channels of on-off control, they have a reliable and effective range as far as 300 feet. They easily work through a car windshield or house walls.

Back to the basics. The full set of FCC regulations appear as Title 47 in the *Code of Federal Regulations*.

You will find several hundred parts to the regulations, usually offered in four or five volumes. They are found at most larger libraries, or can get ordered through the *US Government Bookstore*. We saw much more on FCC regulations in my [HACK45.PS](#) on www.tinaja.com.

Our main interest here is Part 15, which covers unlicensed radiations. In particular, check section 15.231. It is summarized in figure one.

A special class of service exists for *periodic* operation. This is defined as a transmitter that is never on for more than one second, nor repeats at more than a three percent duty cycle. The two most popular uses are automatic garage door openers and "where's my car?" keychain vehicle locators.

Operation is allowed in a narrow band around 40 MHz and anywhere above 70 MHz. At 330 MHz, a very

generous signal of 7000 microvolts per meter is allowed.

The allowable bandwidth is 0.25 percent, which translates to a highly useful 800 kiloHertz.

You are not supposed to transmit voice or music. Data is limited to id code sequences. Control of toys is specifically excluded.

"Scheduled" or timed non-random operation is also a big no-no. These restrictions are eased at lower power levels. In reality, if you are using one of these devices for personal and intermittent use, you are unlikely to get caught if you don't bend the rules too blatantly.

More Details

The "E" system consists of a few receiver and transmitter modules.

The three transmitter modules are electrically identical, except that the number of buttons on them varies from one to three channels. These are conveniently keychain sized.

In operation, pressing a transmitter button sends a repeating 24 bit AM pulse modulated signal at 330 MHz. Power is from a long lasting pair of internal lithium cells.

Codes are factory programmed to one of the 16 million possible values, selected at random. The codes are generated by a 16C54LP PIC micro from *Microchip Technology*, running at an 8 MHz clock rate.

A 3-transistor transmitter powers

an internal small loop antenna that is capacitively trimmed. Battery power is only required when a button gets pressed. A light emitting diode cutely lights red, yellow, or green as the selected channel gets activated. The surface mount construction does all this in slightly over *one square inch* of circuit board space.

Your transmitter should be held horizontally. Operation is best over an unobstructed path.

Figure two shows you most of the receiver schematic. It measures two by three inches. This was originally intended as a long range retrofit for existing garage door opener systems. A new power jack has been added for general purpose hacker uses.

For hacker uses, you power the device from a 12 volt *negative tip* DC wall mounted power supply, such as a *Radio Shack* 273-1652 unit. The sensitivity drops off markedly if you try using a lower supply voltage.

Each receiver has a single relay in it, rated one amp at thirty volts. *Do not try to control 110 volt ac power with these contacts!* Use an external relay or triac instead.

Your receiver can respond to *four* different codings. The relay contacts close for a half a second.

You will find two portions to the circuit, digital and analog. Both have their own supply regulators. 8 volts for the receiver, and the usual 5 volts for the digital part. A preregulator

The allowable frequencies of operation are 40.66 through 40.70 MHz or any frequency above 70 MHz.

Maximum transmitter "on" time is one second with a three percent duty cycle. Minimum time between shorter retransmissions is ten seconds.

Allowable signal strength at 330 MHz is 7000 microvolts per meter. Up to 12,500 microvolts per meter are permitted above 470 MHz.

Bandwidth is restricted to 0.25 percent below 800 MHz.

Data transmission is restricted to identification codes.

Music, voice, control of toys, or scheduled operations are not permitted.

Fig. 1 – THE FCC ALLOWS UNLICENSED OPERATION at ten times normal power for "periodic" transmitters. Here's a part 15.231 summary.

limits input voltage peaks to 24 volts. The receiver portion is a fancy and hot superregenerative detector. Made from six transistors and an op-amp chip. The single tuning coil sets the center frequency. A six inch vertical wire serves as the input antenna.

Any amplifier that is on the verge of oscillation can exhibit incredible gain, due to positive feedback. One older type was called a *regenerative* detector. But these end up extremely touchy. Too little feedback, and you get low gain and bad selectivity. Too much and you oscillate.

The old superregenerative detector scheme beats this by purposely going into and out of oscillation. This gets done by a signal known as the *quench frequency*. The quench frequency is normally several tens of kiloHertz. It "saws" the detector in to and out of

oscillation. The circuit averages to an optimum sensitivity.

On any superregen detector, it is quite important to have a properly designed rf stage between it and the input antenna. Otherwise, you'll end transmitting garbage.

The output of your receiver is a repeating digital code, matching that of the activated transmitter.

The digital portion of the circuit consists of a second 16C54LP PIC micro, a small electrically alterable EEPROM serial memory chip, and a 2N2222 relay driver.

This microcomputer works in two modes. In *normal mode*, when one of four proper codes gets received, the relay closes for half a second. The red LED also lights. A *click-clack* can be heard as the relay activates.

In the *program mode*, you teach

the receiver to recognize the codes of additional transmitters. Up to a total of four. To do this, you'll press your *program* button and then activate your transmitter from several feet away. Your LED flashes two times when it goes into program mode, and three times when complete. This is pretty much similar to programming a universal TV/VCR remote.

Figure three summarizes costs and availability. Other more specialized units are available that do have more control outputs.

There are two ways you use this receiver, known as *garage mode* and *hacker mode*. In garage mode, a 24 volt ac or dc control loop is assumed. From which ten mils of current can be pirated *without* activating the main door relays. The receiver gets put in parallel with the manual switch.

During the off times, the receiver steals around ten mils of standby supply current. The 1000 microfarad capacitor stores enough energy to power your receiver during the brief "on" time when the relay shorts the main control line. See figure four.

Not all older garage door openers are compatible. Sometimes swapping the two leads will work. Other times, you'll have to go to hacker mode.

In hacker mode, an external 12 vdc *negative tip* supply gets plugged into a standard jack. You may want to alter the circuit slightly to isolate the relay contacts from the power supply. Details vary with your application.

Each transmitter comes from the factor permanently preprogrammed as one, two, or three unique codes out of 16 million. Each receiver can be taught to recognize any of four codes, all of which close the relay.

Considering the sophistication and performance of these units, they are surprisingly low in cost.

Get the #^\$*% Phone!

I had an immediate use for an "E" remote just as soon as it showed up. My *Synergetics* operates out of my home, helped along by Bee and a few associates. The building is kinda "L" shaped and usually full of such noise generators as coolers, printers, rock music, dehumidifiers, and cat-dog philosophical discussions.

Getting me to the phone has been a real hassle. Because of the rooms and

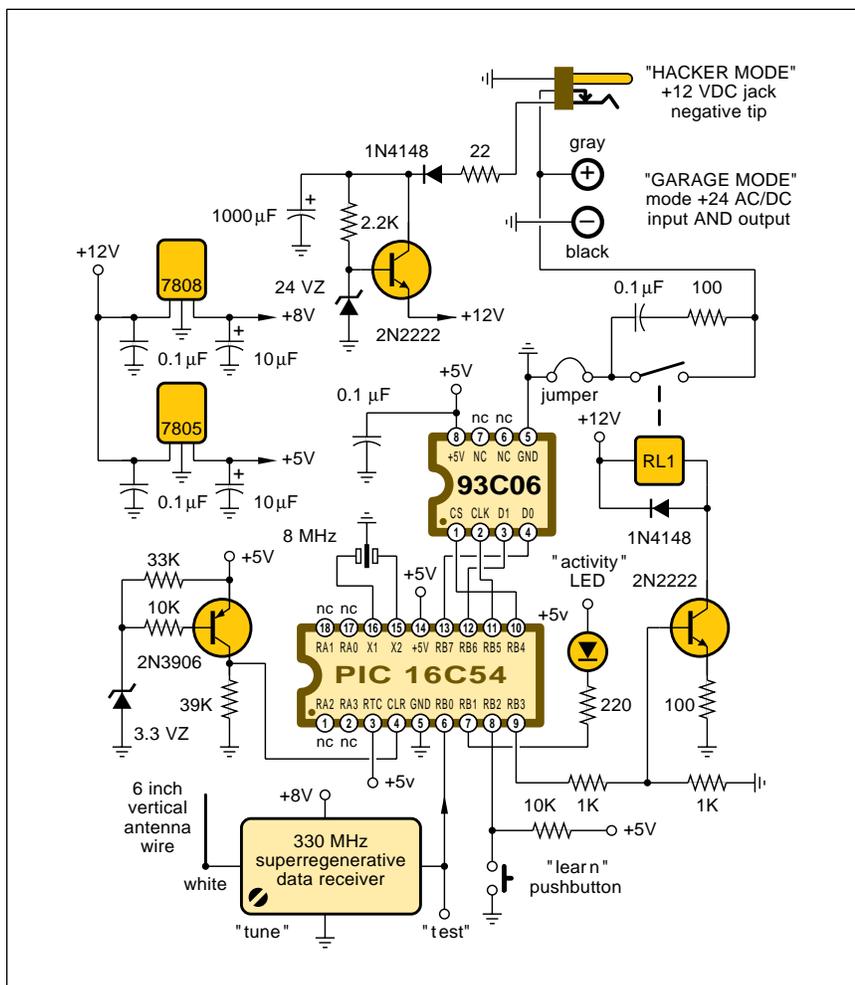


Fig. 2 – PARTIAL SCHEMATIC for the E-series universal hacker remote control receiver. Note the dual supply options. It can be taught up to four new input codes by pressing "learn". There are 16,772,216 possible codes.

walls, no way will any ultrasonic or infrared remote hack it.

Figure five shows how I modified the receiver to drive a piezo speaker. The receiver gets stashed in my usual lair, and the phone answerers all get to use the remotes.

Offhand, I could think up hundreds of hacker uses for this really great system. Robotics, construction sites, any long driveways, fire departments, farms, and security access. But why not tell me instead? As part of...

This Month's Contest

Just tell me about a new or unusual use for a fairly secure medium range wireless remote control. There'll be a dozen or so of my *Incredible Secret Money Machine II* books going to the better entries, with one all expense paid *tinaja quest* (FOB Thatcher, AZ) for two going to the best of all.

In addition, development units may be awarded to the most interesting or most unusual new apps.

Electronic Decals

Frank Miller of *DynaArt Designs* has just dramatically expanded his offerings for prototype and hobby printed circuits. He has got bunches of innovative wave etchers, shears, laminators, and support products.

Many of them optimized for his improved version of the *direct toner method*. Which lets you cheaply and quickly create all your own printed circuit boards at home.

A free catalog is offered.

I thought I'd zero in on a little known use for Frank's products. His direct toner transfer sheets can also be used to create high quality decals. In black and white *or* in full color. Obvious uses include panel artwork, dialplates, custom audio apps, antique restorations, and board callouts.

There are two decal methods you might like to try. One cold and one hot. Frank's *toner transfer film* is the key to both. The film carrier has a thin layer of a high temperature water soluble glue applied to it.

You create a *reverse* of your art and then run this paper through your PostScript speaking laser printer. The transfer film then gets placed against the panel or circuit board material you want the final image on.

You then apply heat and pressure.

The safest and surest way to apply exactly the right pressure for the right time is by using Frank's laminator.

The heat and pressure melts the toner and bonds it onto your circuit board or front panel or whatever. You then soak the panel in warm water for a minute or so, dissolving the glue out from under the transfer sheet.

You could also use a *Canon* color copier for stunning effects.

The cold method is more suited for traditional decals, such as you might need on a model railroad layout.

As before, you'll PostScript laser print your artwork onto a transfer sheet. This time, you print frontwards or "right reading". You then apply three *light* coats of ordinary art store lacquer over your sheet. Next, you cut out your artwork, while leaving a small margin all around.

You then soak the decal in water and slide it off the transfer sheet and onto wherever you want it. Just like plain old decals. The careful use of a Q-tip can get rid of any air bubbles. Once dry, you can optionally remove the lacquer film with alcohol.

Polyethylene in the toner makes

The following are available from DesignTech International, 7401 Fullerton Road, Springfield VA, 22153, (703) 866-2000 (voice), (703) 866-2001 (FAX):

#20051-E one code transmitter \$44.95; #30021-E one relay, four code receiver \$49.95; #30020-E factory matched transmitter-receiver pair \$79.95; #20061-E three code transmitter \$49.95.

Fig. 3 – PRICES & AVAILABILITY on the E-series universal remotes.

the actual hot method bond. This is fairly rugged. With the cold method, a water soluble adhesive does your bonding, and is less durable. Either can be protected with suitable clear epoxy overcoats.

An HO gauge railroad layout uses a scale of 87:1. With a 600 DPI laser printer, the simplest "five-dot" letters would equal a scale three-quarters of an inch high. Say two inches or so for fancy fonts that need more dots for accuracy. Thus, an incredible amount of detail is easily picked up with this technique. A single 600 DPI line is equal to a scale *one-seventh* inch.

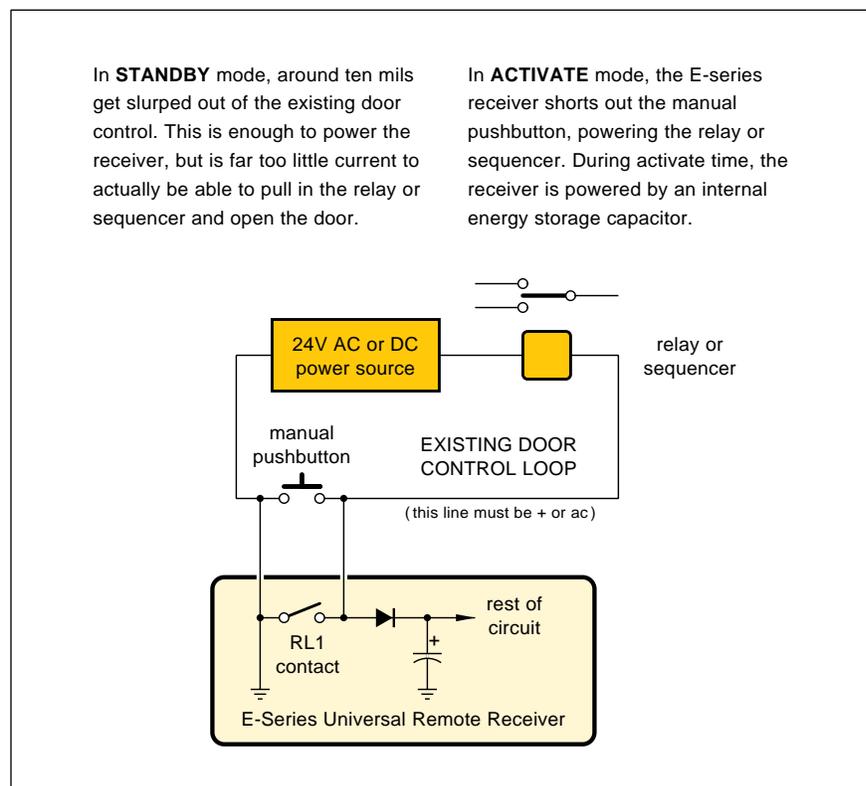


Fig. 4 – WHEN IN "GARAGE MODE", the E-Series receiver uses a two wire hookup that pirates its supply power from the main system.

PSEUDOSCIENCE RESOURCES

Borderland Research
PO Box 429
Gaberville CA 95542
(707) 986-7211

Electric Spacecraft Journal
73 Sunlight Drive
Leicester NC 28748
(704) 683-0313

Free America Network
PO Box 777
Frederick CO 80530
(303) 833-4895

High Energy Enterprises
PO Box 5636
Security CO 80931
(719) 475-0918

Intl. Guild Advanced Sciences
255 N El Cielo Road #565
Palm Springs CA 92262
(619) 327-7355

Intl. Assn New Science
1304 S College Ave
Fort Collins CO 80524
(303) 482-3731

KeelyNet BBS
Box 1031
Mesquite TX 75149
(214) 324-3501 BBS

Lor'd Industries Limited
Box 156
Hancock WI 54943
(715) 249-5611

New Energy News
PO Box 58639
Salt Lake City UT 84158
(801) 583-6232

Phaedra Enterprises
PO Box 1241
San Bruno CA 94066
(415) 359-0432

Planetary Assn. Clean Energy
191 Promenade du portage
Hull PQ CANADA J8X 2K6
(819) 777-9696

Rex Research
Robert Nelson
PO Box 19250
Jean NV 89019

Skeptical Inquirer
PO Box 703
Buffalo NY 14226
(716) 636-1425

Smithsonian Institution Press
470 L'Entant Plaza Ste 7100
Washington DC 20560
(202) 287-3738

Space Energy Newsletter
PO Box 11422
Clearwater FL 34616

Super Science
101 E Stroop Rd
Kettering OH 45429
(513) 298-7116

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Box 121873
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(805) 646-3371

Untapped Technology Review
PO Box 5185
Mesa AZ 85211

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LOTS OF OTHER GOODIES

| | |
|-------------------------------|----------|
| Ask the Guru I or II or III | \$24.50 |
| Hardware Hacker II, III or IV | \$24.50 |
| Micro Cookbook I | \$19.50 |
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| PostScript Show and Tell | \$29.50 |
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| PostScript Reference II | \$34.50 |
| PostScript Tutorial/Cookbook | \$22.50 |
| PostScript by Example | \$32.50 |
| Understanding PS Programming | \$29.50 |
| PostScript: A Visual Approach | \$22.50 |
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SYNERGETICS
Box 809-NV
Thatcher, AZ 85552
(520) 428-4073

And a whole new world opens up for the PostScript language. You can call or write for more details.

Much more on direct toner printed circuits is found in [HACK54.PDF](#) and [RESBN31.PDF](#) on www.tinaja.com Along with great heaping bunches on PostScript as language.

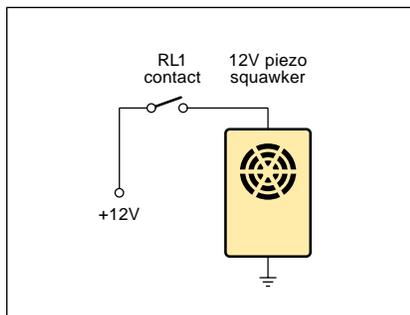


Fig. 5 – WIRELESS ANNUNCIATOR made up by modifying an E-series receiver in its Hacker mode.

Pseudoscience Marches On

There sure is still a lot of ongoing helpline interest in pseudoscience topics. Since there's several major new products from the pseudoscience industry this month, I thought we'd do a current update for this month's resource sidebar.

Pseudoscience is best defined as "Tain't likely McGee" beliefs which miss tests of scientific credibility and reproducibility. Often involving "not even wrong" labwork. And typically including hefty doses of conspiracy and paranoia.

Why bother with pseudoscience? Many of you do continue to demand more coverage. I certainly do like to encourage people to seek out oddball topics. And most of pseudoscience reading is highly entertaining and wondrously bizarre fiction.

These also can be a "reality check" of how close to "the edge" I get with my own designs and explorations. It definitely is fun to research. Often, the closer you get to those original source documents, the worse things totally unravel.

And finally, I'd like to take all of pseudoscience and pile it up on a center stage somewhere, and shine a bright light on it. Then have you all objectively conclude "Yup, that sure is a big pile alright."

Let's start with *Watch the Skies! A Chronicle of the Flying Saucer Myth*. By Curtis Peebles and published by the *Smithsonian Institution Press*. It traces the evolution of UFO lore on through time, elegantly showing what came from where. His premise is that not one credible shred of true hard evidence exists anywhere.

Although obviously thorough and scholarly, much seems missing. Such as the Gulf Breeze scams and the ongoing crop circle hoaxes. The big intergalactic happy face on Mars is absent. The biggest international flap – Billy Meier – has but the briefest of mentions. And I personally felt that the crown jewels for all of UFOdom – Roswell 1947 – were dismissed far too lightly. For differing viewpoints, see *The Roswell Incident* or the brand new *Roswell* videos.

The best guide to the UFO industry is David Belevin's *Almanac of UFO Organizations*. From *Phaedra*.

New Energy News is an ongoing newsletter from the *Institute for New Energy*. Their focus is on cold fusion developments, new free space energy generation, and rotating "over unity" machines. They seem best at their book reviews and conference listings. They also mention the *Space Energy Newsletter*, a *Free America Network*, or the *Electric Spacecraft Journal*.

Several helpline callers have asked exactly what molecular frequency discriminators are. These are just a plain old power audio oscillator, a matching transformer and two ground injection probes.

Supposedly you can set these to "magic" frequencies for gold, silver, platinum, etc... and then use normal dowsing techniques to find what you are looking for.

I know of no credible scientific basis for such a machine. Even if it

NAMES AND NUMBERS

Altera

2610 Orchard Pky
San Jose CA 95134
(408) 894-7000

Anton/Bauer

One Controls Drive
Shelton CT 06484
(203) 929-1100

AP Professional

6277 Sea Harbor Dr
Orlando FL 32887
(800) 313-1277

Scott Edwards Electronics

964 Cactus Wren Lane
Sierra Vista AZ 85635
(602) 459-4802

Design News

44 Cook St S210
Denver CO 80206
(303) 388-4511

DesignTech International

7401 Fullerton Rd
Springfield VA 22153
(703) 866-2000

DynaArt Designs

3535 Stillmeadow Ln
Lancaster CA 93536
(805) 943-4746

Focal Press

313 Washington Street
Newton MA 02158
(617) 928-2500

GEnie

401 N Washington St
Rockville MD 20850
(800) 638-9636

Growing Community

1118 Round Butte Drive
Ft Collins CO 80524
(303) 490-1550

Intel Corporation

2200 Mission College Blvd
Santa Clara CA 95052
(800) 548-4725

Maxim

120 San Gabriel Dr
Sunnyvale CA 94086
(800) 998-8800

Media Magic

PO Box 598
Nicassio CA 94946
(800) 882-8284

Micro Linear

2092 Concourse Dr
San Jose CA 95131
(408) 433-5200

Microchip Technology

2355 W Chandler Blvd
Chandler AZ 85224
(602) 963-7373

Radio World

5827 Columbia Pk #310
Falls Church VA 22041
(703) 998-7600

Science/AAAS

1333 H St NW
Washington DC 20005
(202) 326-6400

US Government Bookstore

720 N Main St
Pueblo CO 81003
(719) 544-3142

works, these \$4000 systems could be replaced by \$5 circuits such as the *Maxim* MAX238 or else the ML2035 from *MicroLinear*.

The KEELYNET BBS has scads of files on pseudoscience topics. And more or less objective trashing of the entire field often shows up in the *Skeptical Inquirer*.

Last but not least, I have located the ultimate pseudoscience treasure trove. The mother lode, fer sure. The *International Guild for Advanced Sciences* offers hundreds of books and videos on everything from alien contacts to perpetual motion up to techno-shamanistic radionics.

Neatest of all, though, are their antigravity machines, the time travel devices, teleportation systems, and even a cyborg cosimano helmet full of psychic energy amplifying magic crystals. Off the shelf hardware, no

less. Also off the wall.

Their free catalog is a must read.

Much more on these topics in the *Hardware Hacker* reprints and in the [HACK57.PDF](#), and [RESBN26.PDF](#) now up on my www.tinaja.com

New Tech Lit

The PIC Source Book is a brand new \$39 book and software package from *Scott Edwards Electronics*. It is for anyone who wants to go beyond the *Basic STAMP* in developing their own fast machine language code for the incredibly superb PIC series of low priced hacker microprocessors from *Microchip Technology*. This one is just about essential to design ultra low cost PIC circuits such as the "E" series remotes we just looked at.

Two new sets of free development software for the programmable logic devices: *FirstStep* from *Altera* and

PLDshell Plus from Intel.

New light emitting diodes that are *ten times* more efficient get described on page 943 of the August 17, 1994 issue of *Science*. Microcavities are the secret. Since the best of current LED lamps are newly approaching incandescent efficiency, this is truly a major development.

Any color you want. Even white!

A revolutionarily new *virtual ways* machine tool technology appears on pages 58-61 of the August 15, 1994 issue of *Design News*. Unlike older conventional mills or lathes, *there's nothing that slides!* Only plain old bearings and six ordinary jackscrews or linear steppers are involved. There are zero bending moments anywhere in the machine.

All stresses are simple tension or compression, leading to outstanding stability and precision. And this one looks great for hacker CAM.

More on RBDS data broadcasting

NEED HELP?

Phone or write all your US Tech Musings questions to:

Don Lancaster
Synergetics
Box 809-EN
Thatcher, AZ, 85552
(520) 428-4073

US email: don@tinaja.com
Web page: www.tinaja.com

by FM stations appears in the July 27, 1994 *Radio World*. Included is a list of over a hundred stations in 32 states and in-depth receiver reviews.

Two sources for multimedia books and software are *Media Magic* and *AP Professional*. Free catalogs.

The *Growing Community* is a well done newsletter on alternate and high tech intentional communities. Mostly in the Western US and mostly off of

the utility power grid.

A 46 page *Video Battery Handbook* is available from Anton/Bauer.

A new book by John Huntington is now titled *Control Systems for Live Entertainment* and published by the *Focal Press*. It covers the basics of theater, concert, and amusement park systems for lighting, sound, F/X and even pyrotechnics. Including MIDI time and show codes, SMPTE, and even SDX systems.

These days, it's a simple and easy matter to self-publish your own high quality books. Or set up a service bureau to instant publish for others. Full details are in my newly updated *Book-on-demand Resource Kit*. Per my nearby *Synergetics* ad.

Also a reminder that reprints and preprints of all my columns, my free insider secrets catalogs, and instant tech help is found on www.tinaja.com per the *Need Help?* box.

Let's hear from you. ♦

I have run across several recent books that are worth a mention. *Who Owns Information?* from Anne Branscomb (Basic Books, 1994) covers everything from Internet to the Dead Sea Scrolls. Focusing on all those radical changes now tearing traditional copyright laws asunder.

While thorough, it is mostly from the viewpoint of a very conservative lawyer. This one would be far more balanced with more input from, say, the *Free Software Foundation*, *Wired Magazine*, or whoever.

For a totally different take on a related topic, read Winn Schwartau's *Information Warfare; Chaos on the Electronic Superhighway* (Thunder's Mouth Press, 1994).

I've long been a Richard Feynman fan. Who was one of my great heros. *No Ordinary Genius: The Illustrated Richard Feynman* has been newly released by Richard Phillips (W. W. Norton, 1994).

A "life and times of" summary that adds to such titles as James Gleick's *Life and Science of Richard Feynman* (Pantheon, 1992).

Or Feynman's own *Surely You're Joking Mr. Feynman* (W.W. Norton, 1985) and *What Do You Care What Other People Think?* (1988).

My other heros? Well, since you asked: Perry Ferrell, Bucky Fuller, Ed Abbey, P.T. Barnum, and William M. Gaines. The last of whom was the greatest philosopher of the twentieth century. Bar none.

Plus, of course, Scrooge McDuck and Gyro Gearloose.

Science Versus Pseudoscience? is an important and easy to read Nathan Aaseng book (F. Watts Press, 1994). One that clarifies several topics we have kicked around here quite a bit. My own definition of pseudoscience is pretty much one of "Looks like a duck – Quacks like a duck".

When you've been at the research game for a while, the pseudoscience stuff gets painfully and laughingly obvious. Such as those dreary chain letters that spend five pages telling you they are not chain letters.

Aaseng is much more specific. In that he lists ten crucial tests to tell the differences between pseudoscience and real science. I've excerpted them here as figure one. The only thing I'd personally append to his list is this: *Science requires that extraordinary claims demand extraordinary proof.*

A second pseudoscience trashing text is *The Hundredth Monkey*, edited by Ken Frazier (Prometheus Books, 1991). Mostly on psychic phenomena and related wonderments.

Magnetic Measurements Handbook is a smallish 95 page self-published book by J. M. Janicke and offered by *Magnetic Research*.

Included are hard-to-find magnetic fundamentals. Along with bunches of construction projects for fluxmeters, Helmholtz coils, and similar stuff.

Magnetic Research also does sell fluxgates and Hall probes.

But note that the Hall devices are *totally* unsuitable for most compass and nav uses. And so is the currently abysmal batch of magnetoresistors. Today, a fluxgate is the *only* way to go. A competing low cost source for fluxgate coils useful for homebrew compass use is *OrthoLogic*.

More on electronic compasses in my *Hardware Hacker* reprints.

Vector-to-step Conversions

Say you want to mill a diagonal cut on a CAD/CAM machine which can only step north-south or east-west. How do you do it? Or you want to show a slanty line on a raster scan display? Or do the same in a laser printer's bitmap? Or wish to map a tumbling 3-D object using rendering animation software?

All of these require *vector-to-step* conversions. One of your most basic and most important needs in all of computer graphics. So, I thought we would review the fundamentals here in figure two.

A *vector* is simply a number that expresses two or more values. As an example, walking ENE for 10.2 miles is a vector quantity.

Vectors can be *resolved* into their underlying components. Ferinstance, going 10.2 miles ENE gets you to the same end point as going 9.4 miles due east and 3.9 miles due north.

Trig can be used to resolve vectors. As an example, ENE is at an angle of 22.5 degrees counterclockwise from east. 10.2 times the *cosine* of 22.5° gets you the 9.4 east component. And 10.2 times the *sine* of 22.5° gets you the 3.9 mile north component.

1. Science is logical and rational.
2. Science makes well-defined claims.
3. Scientific hypotheses are falsifiable.
4. Scientific experiments are repeatable.
5. Science requires that claims be examined by peers.
6. Science views unexplained gaps in theories with suspicion.
7. Science requires caution in examining evidence.
8. Science requires objectivity.
9. Science does not accept coincidence as proof.
10. Science does not accept anecdotal evidence as proof.
11. Extraordinary claims demand extraordinary evidence.

Fig. 1 – NATHAN AASENG lists these ten key criteria in his *Science Versus Pseudoscience* book. I've appended a popular eleventh test here.

Obviously, your 10.2 mile "direct route" is shorter. And probably a lot easier. A CAD/CAM machine that cuts only east and then travels only north would miss by a country mile in the middle of your path. The trick is to find a set of rules that let just

enough north and east steps be taken in just the right order to approximate the path as closely as you can.

A position in space is said to be absolute if it is measured from some 0,0 reference axis point. A position is relative if it gets measured from the

current point, or from your last used or referred position in space.

A 10.2 mile straight line hike is absolute when you end up 10.2 miles from home. It is relative if today's travel on a one week backpack took you 10.2 straight line miles from this morning's start. Typically, absolute positioning is used for the first point in any path, while relative position is used for all points that follow.

Your first step in a vector-to-step conversion often will be to correct your vector. Usually, you'll want to go from where you thought you were to where you desire to be. But you probably are not where you thought you were. Why? Roundoff errors will change your actual current position from your desired current position. If you do nothing about these errors, they will pile up on you.

Which is one reason you take topo maps on a hike.

Instead, you'll correct your input vector so it routes from where you know you now are to where you want to be. This needs a measurement or else a transform from current device space back into user space. The net result is that your input vector will change slightly in size and direction. Thus "swallowing" previous position errors. Correcting on the fly.

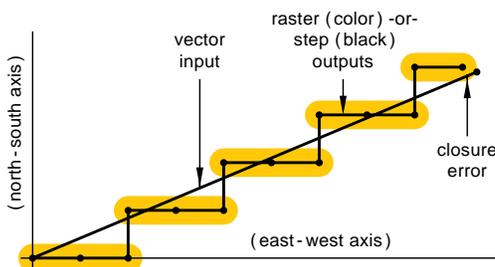
We'll next note that there are eight possible vector-to-step cases. Each of which can end up "alike but different somehow". Let's call east-west our x and north-south our y components. Now, x could be positive or negative. And y could be positive or negative. And the length of x can be greater or less than that of y. Giving us eight total possibilities.

Our next step is to decide which of the eight cases we currently have on hand. Then, we pick the correct case and use it for our actual conversion. If your computer or microcontroller and your available processing time allows you the luxury of "real" trig, you could find the arctan, or "angle whose tangent is", and then integer divide by 45 to get a 0-7 case.

When speed is essential or if your microcontroller isn't too bright, you instead test the signs of x and y plus the absolute lengths of x compared to y. To pick one of the eight cases. The selected case then gets run.

Let's assume the math coordinate

The goal of vector-to-step conversion is to change a diagonal tool path or a slanty line on a screen or printer bitmap into discrete unit steps that travel only in north-south or east-west directions...



First, you correct your input vector so it starts at your actual initial position. This prevents closure errors from piling up. If not already done, you then resolve your input vector into its x and y components. For a vector of length Z and an angle of θ ...

$$x = Z \cos(\theta) \quad \text{and} \quad y = Z \sin(\theta)$$

Next, calculate the slope y/x and save it for later use. Then round x and y off to the nearest integer values to get the actual steps needed. Compare the signs of x and y, and the absolute sizes of x and y to find an octant...

| | | | | |
|----|----|-----|-----------|----------------------|
| x+ | y+ | x>y | octant #0 | (000 to 045 degrees) |
| x+ | y+ | x<y | octant #1 | (045 to 090 degrees) |
| x- | y+ | x<y | octant #2 | (090 to 135 degrees) |
| x- | y+ | x>y | octant #3 | (135 to 180 degrees) |
| x- | y- | x>y | octant #4 | (180 to 215 degrees) |
| x- | y- | x<y | octant #5 | (215 to 270 degrees) |
| x+ | y- | x<y | octant #6 | (270 to 315 degrees) |
| x+ | y- | x>y | octant #7 | (315 to 360 degrees) |

If you are in octant #0, you always step by +x and sometimes step by +y. To determine whether a +y step is needed, multiply the total number of x steps so far by the slope. If the current y total is more than 0.5 steps under this value, also add a new y step.

Here are the rules for the other octants...

- In octant #0, always step by +x and sometimes step by +y.
- In octant #1, always step by +y and sometimes step by +x.
- In octant #2, always step by +y and sometimes step by -x.
- In octant #3, always step by -x and sometimes step by +y.
- In octant #4, always step by -x and sometimes step by -y.
- In octant #5, always step by -y and sometimes step by -x.
- In octant #6, always step by -y and sometimes step by +x.
- In octant #7, always step by +x and sometimes step by -y.

For the maximum possible speed, replace on-the-fly calculations by table lookups, compiling, special hardware, or similar techniques.

Fig. 2 – VECTOR-TO-STEP CONVERSION is one of the most fundamental tools in computer graphics. Here is how do it. Details vary with end use.

orientation, rather than the *geography* one. With east being 0 degrees, north at 90, west at 180, and southeast at 315 degrees. Let's also call any of the eight cases an *octant*. A vector of 10.2 miles ENE is in octant zero.

Now, in octant zero, x absolutely *must* be positive and absolutely *must* be larger than y . And y also *must* be positive. Otherwise, we'd be in some *other* octant. So, in octant zero, we simply use the rule "always step by x and *maybe* step by y ".

Let's assume your corrected vector has been resolved into $x = 9.4$ and $y = 3.9$ components. Since we are only allowed whole *integer* steps, we are not allowed to take 9.4 unit steps. In this case, we will *round down* to nine steps. Thus, we know we want nine x steps. And we want four y steps. The question is *when* to add the y steps to get *closest* to our original vector.

Should the rounding down give you an x value of zero, you exit. The little missed piece gets picked up on the next vector. Exiting on a zero length also gets rid of the possible divide-by-zero in the next step.

Next, you calculate the *slope* or the "slantocity" by dividing the little y number by the bigger x one. Or, in this case y/x . Save this value.

You then step along your x axis, *always* taking one x step. After each x step, you will *compare* your actual y against your desired y position. The desired y position gets obtained by multiplying x times the slope. Any time you end up more than half a step (or 0.5) low, you throw in a y step. Continue this for each needed x step.

Reviewing: For any vector-to-step conversion, you'll first correct your vector so it travels from where you really are to where you want to be. You then pick one of eight octants, based on the size and sign of the x and y components. You'll then pick octant specific code that *always* steps along x but only *sometimes* will step along y . Or vice versa.

Getting Fancy

There are several refinements we can add here. Testing for an 0.5 unit error gets less accurate the slantier you get. But 0.5 is more than good enough for most uses. For the really best fit, you should instead use 0.5 times the *cosine* of the slant angle.

If you can't "afford" a real cosine, $1 - (\text{angle in radians})^2/2$ could fake it pretty good. Cruder useful fakes are $0.5 - (\text{angle in degrees})/300$. Or even letting 0.44 split the difference.

Some CAD/CAM applications will let you move your x and y steppers simultaneously. This is called *stepper phase interleaving*. And means you can travel *east* or *northeast* in octant zero. What you have done is *combine* an east step with a north step into a single northeast one. Eliminating a sharp corner in the process.

Which dramatically improves your resolution, speed, and smoothness of your actual cuts. Figure three shows you the improved results.

But why calculate the obvious over and over again? The foremost rule of all high speed computing is to *never calculate what you can look up!* Any of several *table lookup* techniques can dramatically speed things up for you. But these are hard to understand and are very device specific.

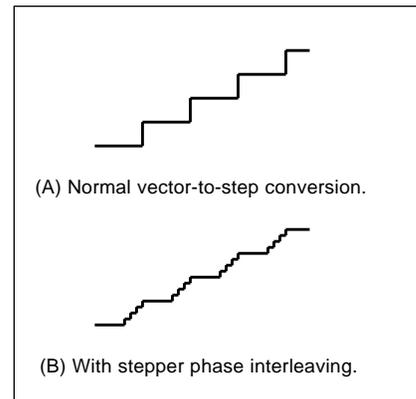


Fig. 3 – CAD/CAM SYSTEMS could apply an -x- and -y- stepper phase interleaving to dramatically improve their apparent resolution.

A PostScript Example

There are all sorts of variations on these vector-to-step schemes. It all depends on the speed required.

In some cases (such as computer animation), your rendering speed is

```
% PostScript Vector-to-step student demo algorithms.

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% (602) 428-4073. All commercial rights and all media rights fully reserved.
% Additional support via GENIE PSRT. Consulting services also available.
% Personal use permitted so long as this header remains present and intact.
% Two-way host recordable comm is required.

/curxpos 0 def /curypos 0 def % running output currentpoints

/oct0 {2 copy exch dup 0 eq (0.00001 add) if div /slope exch store pop cvi /#incs exch store 0
0 1 #incs 1 sub (/posn exch def (E) print /curxpos curxpos 1 add store posn 1 add slope mul
0.5 sub 1 index ge {1 add (N) print /curypos curypos 1 add store} if} for pop} def

/oct1 {exch 2 copy exch div /slope exch store pop cvi /#incs exch store 0 0 1 #incs 1 sub
{/posn exch def (N) print /curypos curypos 1 add store posn 1 add slope mul 0.5 sub 1 index
ge {1 add (E) print /curxpos curxpos 1 add store} if} for pop} def

/oct2 {exch 2 copy exch div neg /slope exch store pop cvi /#incs exch store 0 0 1 #incs 1 sub
{/posn exch def (N) print /curypos curypos 1 add store posn 1 add slope mul 0.5 sub 1 index
ge {1 add (W) print /curxpos curxpos 1 sub store} if} for pop} def

/oct3 {2 copy exch div neg /slope exch store pop cvi /#incs exch store 0 0 1 #incs 1 sub
{/posn exch def (W) print /curxpos curxpos 1 sub store posn 1 add slope mul 0.5 sub 1 index
ge {1 add (N) print /curypos curypos 1 add store} if} for pop} def

/oct4 {2 copy exch div /slope exch store pop cvi abs /#incs exch store 0 0 1 #incs 1 sub
{/posn exch def (W) print /curxpos curxpos 1 sub store posn 1 add slope mul 0.5 sub 1 index
ge {1 add (S) print /curypos curypos 1 sub store} if} for pop} def

/oct5 {2 copy div /slope exch store cvi abs /#incs exch store pop 0 0 1 #incs 1 sub (/posn
exch def (S) print /curypos curypos 1 sub store posn 1 add slope mul 0.5 sub 1 index ge {1
add (W) print /curxpos curxpos 1 sub store} if} for pop} def

/oct6 {2 copy div neg /slope exch store cvi abs /#incs exch store pop 0 0 1 #incs 1 sub (/posn
exch def (E) print /curxpos curxpos 1 sub store posn 1 add slope mul 0.5 sub 1 index ge {1
add (E) print /curxpos curxpos 1 add store} if} for pop} def

/oct7 {2 copy exch div neg /slope exch store pop cvi abs /#incs exch store 0 0 1 #incs 1 sub
{/posn exch def (E) print /curxpos curxpos 1 add store posn 1 add slope mul 0.5 sub 1 index
ge {1 add (S) print /curypos curypos 1 sub store} if} for pop} def

/findectant {2 copy exch 2 copy 0 eq exch 0 eq or {pop 0.000001} if atan cvi 45 idiv
[{oct0}{oct1}{oct2}{oct3}{oct4}{oct5}{oct6}{oct7}{oct0}] exch get} def

/vectortostep {findectant exec flush } def % main control loop

% //// demo - remove or alter before reuse ////
9.4 3.9 vectortostep quit % should return EENEENEENEENE
```

Fig. 4 – A STEP-TO-VECTOR CONVERTER written in PostScript.

PROGRAMMABLE INTERCONNECT RESOURCES

Aptix
2890 North 1st St
San Jose CA 95134
(408) 428-6200

Atesla
2890 North First Street
San Jose CA 95134
(408) 428-6250

EDN Magazine
275 Washington St
Newton MA 02158
(617) 964-3030

EE Times
600 Community Drive
Manhassat NY 11030
(516) 365-4600

Electronic Component News
1 Chilton Way
Radnor PA 19089
(215) 964-4345

Electronic Design
611 Rt #46 West
Hasbrouck Heights NJ 07604
(201) 393-6060

Electronic Products
645 Stewart Ave
Garden City NY 11530
(516) 227-1300

I-Cube
2328-C Walsh Avenue
Santa Clara CA 95051
(408) 986-1077

Lattice Semiconductor
5555 NE Moore Court
Hillsboro OR 97124
(503) 681-0118

Pioneer Semiconductor
2343 Bering Drive
San Jose CA 95131
(408) 435-0800

Quality Semiconductor
851 Martin Ave
Santa Clara CA 95050
(408) 450-8063

Synergetics
Box 809
Thatcher AZ 85552
(602) 428-4073

everything and you have to use every machine language trick you possibly can to make things happen real quick like. Elsewhere (such as CAD/CAM), a more leisurely pace is acceptable, and a powerful and friendly higher level language works just fine.

I have found the general purpose *PostScript* computing language to be ideal for medium speed conversions. Especially for real time CAD/CAM.

Figure four shows you *PostScript* code that can do these conversions for you. This is a very simple tutorial example that can be (and has been) significantly improved.

With table lookup code, speeds in the 13,000 steps per second range are easily hit. Your results can also get recorded and then be sent out later at arbitrarily high speeds.

Most CAD/CAM systems are cutter head limited to much slower speeds than these. Thus *PostScript* speed is in *no way* a limiting factor.

The key point is that you can now easily apply genuine *PostScript* for ultra low cost homebrew hacker apps. Superbly better than any other way I know of. Particularly for such tricks as microsizing and compensating for tool paths and diameters.

Just how can you use *PostScript*'s

graceful curves and fancy lettering? Curves are simply broken down into lots of individual straight line vectors which are short enough to meet your accuracy goals. *PostScript*'s *charpath* and *flattenpath* operators get used for curve-to-vector conversions.

More examples of vector-to-step conversions are in my [POSTVECT.PS](#), [FLUTWUMP.PS](#) and [FLUTOOLS.PS](#) on www.tinaja.com I've also got some exciting new products in the works that use these concepts. Give me a call if you need advanced details or help with your own project.

The Halogen Cycle

I've gotten several helpline calls over early fusion lamp failures on Canon EX laser engines. Such as the 4M+ or Pro630. The symptom is a darkening of the bulb before it blows. Well, I got some theories here...

A quartz halogen lamp sits inside that bottom roller. And intermittently turns on and off. The light heats the roller, maintaining a regulated 375 F surface temperature.

Despite the fancy name, a quartz halogen lamp is still just a plain old incandescent bulb. It still has a more or less ordinary tungsten filament. The only difference is it gets run

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much *hotter* for more efficiency. The quartz bulb is more resistant to heat shock than ordinary glass. And some wondrously magic chemistry known as the *halogen cycle* is supposed to make the filament last longer.

Tungsten readily forms compounds with any of the halogen gases. Such as tungsten hexachloride or tungsten hexafluoride. These gases are stable at lower temperatures, but dissociate at very high temperatures.

Now, one big problem with high temperature filament life is that the tungsten literally boils off. This both weakens the filament and blackens the glass, leading to early failure.

Here is how that halogen cycle works: Near the hot filament, ejected tungsten mixes with the dissociated halogen. Away from the hot filament, the two merge to form a stable halide gas. And when the lamp gets turned off, much of the dissociated tungsten deposits *right back* onto the filament! Normally, there is little chance for bulb darkening.

However, there are two important rules for quartz halide lamps: *Never touch them!* and *Always cool them completely!*

Any fingerprints can cause a high temperature spot on the glass, leading to mechanical stress and a possible darkening. And the cooling-off time is *mandatory* for that halogen cycle to complete itself.

So, there might be a supplier or quality control problem. Or maybe somebody who doesn't know better is handling the lamps during assembly or service. But I have the following hunch: That "green" lower energy operation of new laser printers seems *dead wrong* for the halogen cycle!

The *worst* thing you can do to a quartz halogen lamp is to repeatedly and briefly cycle it!

Possible solutions: Run the lamp continuously for an hour every now and then. Maybe even at 120 percent of voltage. See if it lightens up any. Outside of the printer, of course. And in an area where a kilowatt of heat can be safely disposed of. And, of course, *keep fingerprints away!*

Or design a new lamp technology *specifically* for the new green energy cycles. Instead of using a plain old stock copier bulb. Or go to some type of PTC self-regulating beastie.

NAMES AND NUMBERS

Access to Energy

Box 1250
Cave Junction OR 97523
(503) 592-4142

Accu-Weather

619 W College Avenue
State College PA 16801
(814) 234-9601

Basic Books

10 East 53rd Street
New York NY 10022
(212) 207-7057

Bergquist

5300 Edina Industrial Blvd
Edina MN 55439
(612) 835-2322

Design Toscano

17 East Campbell Street
Arlington Heights IL 60005
(800) 525-0733

EITD

2057-2 Aurora Road
Twinsburg OH 44087
(216) 425-9000

Extraordinary Science

PO Box 5636
Colorado Springs CO 80931
(719) 475-0918

Lindsay Publications

PO Box 538
Bradley IL 60915
(815) 935-5353

Magnetic Research

122 Bellevue Avenue
Butler NJ 07405
(201) 838-6348

Motorola

5005 E McDowell Rd
Phoenix AZ 85008
(800) 521-6274

MultiFAX

Route 1 Box 27
Peachland NC 28133
(704) 272-9028

W. W. Norton

500 Fifth Avenue 6th Fl
New York NY 10110
(212) 354-5500

OrthoLogic Corp

2850 S 36th St #16
Phoenix AZ 85034
(602) 437-5520

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Buffalo NY 14215
(716) 837-2475

Seismo-Watch Newsletter

PO Box 18012
Reno NV 89511
(800) 852-2960

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11011 N Torrey Pines Rd
La Jolla CA 92037
(800) 424-5444

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PO Box 500
Beaverton OR 97077
(800) 426-2200

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632 Broadway 7th Fl
New York NY 10012
(212) 780-0380

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New York NY 10016
(212) 951-2650

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40 Washington Street
Westborough MA 01581
(800) 876-1232

Programmable Interconnect Resources

The next logical feature beyond programmable integrated circuits is fully *programmable systems*. Where all of the wires *between* chips can be conveniently and quickly rearranged. Obvious uses are for breadboarding, development, and field upgrades.

An ideal interconnect would be dense and cheap, allowing arbitrary connection of anything to anywhere. Connections would permit analog or digital signals to move out in either direction without delays.

Both the "on" resistance and any crosstalk would end up very low. And these devices should consume

zero to little power. They would have to remember all their connections between power downs *and* be fully reprogrammable at any time.

As you might imagine, the semi houses are scrambling to offer new programmable interconnect chips. I have tried to list the key players in this month's resource sidebar.

Unfortunately, nearly all devices offered today miss and miss badly on one or more goals. *Aptix* seems to be at the top of the heap. Their devices are quite dense, extremely flexible, bidirectional analog/digital, and have low on resistance and crosstalk. But they are expensive and have to be reprogrammed each time your power is applied to the system.

Pioneer and *Quality* offer very low cost and easy to use bidirectional bus switches. But their density is very low. Programming is external. *Atesla* has arrays of fuse-blowable direct interconnects. Medium low cost and bidirectional analog/digital. But once blown, the results are permanent and cannot be changed.

Apparently, those programmable logic device folks are relabeling their existing PLA and PLD variations to claim they are interconnects. While dense, reprogrammable, and cheaply priced, the results are often digital

only and one way only. There's also prop delays involved.

One brand new source is *Lattice Semiconductor* with their *Generic Digital Switch* shown in figure five. Densities are offered up to 11 by 11. Any lead can be taught to be an input or a tri-state digital output that can be its input, the complement of its input, a one or a zero. Reprogrammable.

But any A-side input/output can only be routed to B-side pins. These are ideal as dipswitch replacements.

Meanwhile, *I-Cube* is offering what they call FPID devices, short for

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Web page: www.tinaja.com

Field Programmable Interconnect Devices. While mostly a PLD style beastie, these *do* also provide for high impedance analog.

Crossbar architecture is used with densities as high as 320 by 320. Since this is static RAM based, it must be reprogrammed every time your power is disconnected. Each pin can be taught to have *eight* different functions. It can be non-buffered for analog signal pass-through. Digital inputs can be buffered or latched. Outputs can be buffered, registered, or held either high or low.

Info on newer devices which are likely to overcome all of the obvious defects of this current crop should show up in the usual places, such as *E.E. Times*, *EDN*, *Electronic Design*, *Electronic Component News*, and in *Electronic Products*.

Programmable logic devices could even be used to downgrade double sided circuit board layouts into single sided ones.

Let's have your thoughts on new hacker uses for these exciting parts. The usual *Incredible Secret Money Machine II* book rewards for your contributions.

New Tech Lit

From *Motorola*, their new *Master Selection Guide*. One unique chip of theirs is the new MC144143 tv closed caption decoder.

Tektronix has a bunch of videos and ap notes that you just may be interested in. One video is on *The VectorScope*, a crucial tool for color tv broadcasting and video production. There's also a pair of vids on *Cable Measurement*, plus others on such specialized topics as *Cable TV Sweep Systems*. Of their many ap notes, you might find their *Spectrum Analyzer*

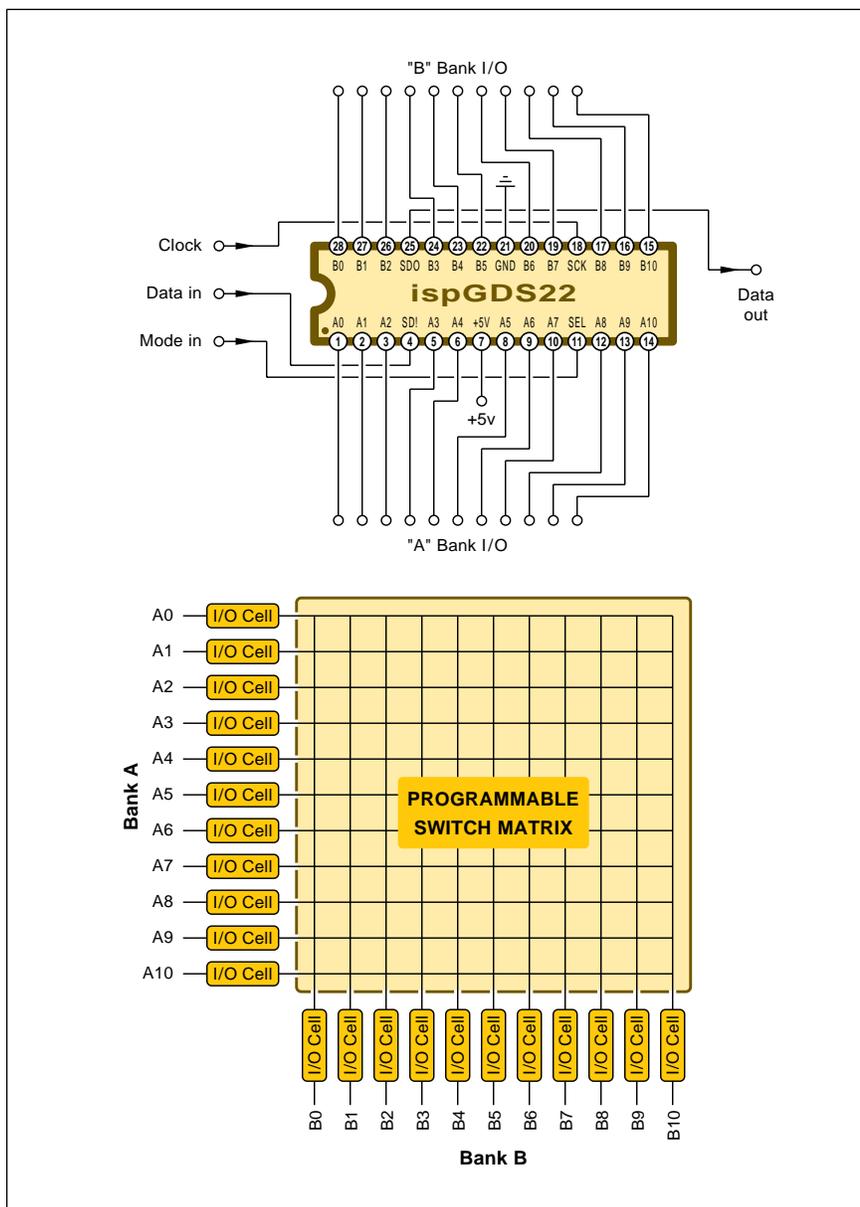


Fig. 5 – GENERIC DIGITAL SWITCH from Lattice Semiconductor can offer medium density programmable interconnects.

Fundamentals to be handy.

Real live human neurons are now offered by *Stratagene* per their inside cover ad in the September 2, 1994 issue of *Science*. If I understand this correctly, these can be hot wired for direct electrical to biological neuron computing experiments. But do not connect these to your cat!

Three weather satellite resources: *MultiFAX*, *Accu-Weather*, and *ZFX*.

From *Harris Publishing*, their new *1995 Electronic Industry Telephone Directory*. If it is not already in my *Synergetics Master List*, the EITD is where I'll always go first.

Access to Energy is a labor-of-love venture that bills itself as a high tech,

free enterprize monthly newsletter.

A freebie *Sil-Pad Sample Kit* from *Bergquist* includes several thermally conductive insulators that are useful for power heatsinking.

A free issue of the *Seismo Watch Newsletter* is available. This covers weekly earthquake info.

The *Extraordinary Science 1995 Resource Guide* is a new catalog of both real science and pseudoscience books, videos, and reprints. Among other strengths, they now stock a definitive Tesla collection. They also now seem to be stocking a lot of the *Lindsay Publications* texts.

A well done collection of Griffins and Gargoyles are newly available

from *Design Toscano*.

For the fundamentals of digital integrated circuits, check into my classic *TTL Cookbook* and my *CMOS Cookbook* texts. More details in my nearby *Synergetics* ad.

Also a reminder that reprints and preprints of all my columns, my free insider secrets catalogs, and instant tech help is on www.tinaja.com

Free catalog requests and technical questions you want answered here or on my web site can also be sent me via my don@tinaja.com email.

As usual, most of these resources I've mentioned appear in the *Names & Numbers* or in the *Programmable Interconnect Resources* sidebars. ♦

Don Lancaster's

Hardware Hacker

January, 1995

Unique scientific resources
Commercial Online services
Automotive computer basics
Servicing tough intermittents
"Mystery Band" opportunities

There's a pair of brand new scientific resources you may have some interest in. One is Shawn Carlson's new *Society for Amateur Scientists*. This one is intended as a collaboration between amateurs and professionals, offering some new methods for individuals to do credible research.

Carlson says "We are preparing to support amateur projects with grants, awards, equipment and expert advice. Our philosophy is to focus on people and let the science largely take care of itself."

Meanwhile, Carl Helmers of early *Byte Magazine* fame is starting up a new *SETIQuest* magazine. Included are bioastronomy tutorials, amateur microwaves and optics, reviews, and "do-it-yourself" participation.

Only recently have really useful SETI power tools for serious amateur research become available.

Car Computers

I recently had this unpleasant and outrageously expensive experience which involved a "factory certified" mechanic at a major dealership. Who could not even *find* my car's engine computer, let alone repair it. In the process, I learned a lot more than I wanted to about car computers and servicing intermittents.

A gasoline engine basically mixes aromatic hydrocarbons with air. It then compresses them, and ignites the mixture using an electrical spark. In general, you have real time control over how much air, how much gas, how much load, and when the needed sparks arrive.

The purpose of a car computer is to optimize this control process to give knock-free power and fuel economy while minimizing pollutants. Figure one shows a typical setup.

In any chemical reaction, there is some optimum mix of components. If you use too much gas, you'll end up *rich* and have leftover hydrocarbons in the exhaust.

If you have too much oxygen from the air, you'll end up *lean*. Leftover

oxygen is not bad by itself. But, at those high cylinder temperatures and pressures, it readily combines with all the unused nitrogen in the air to form highly polluting NO_x nitrogen oxides. Forming smog.

A *stoichiometric* mix gives just the right chemical inputs such that zero inputs will remain when the reaction completes. Combining 14.7 parts of air with one part of gasoline results in a minimum pollution. On the other hand, a mix of 12.6:1 gives you max power and 15.4:1 gives you best fuel economy. But there is surprisingly little worsening of fuel economy at a minimum pollution point.

One of the two main goals of a car

computer is to set up a *closed loop system* that continuously adjusts your fuel and air to maintain an optimum stoichiometric mixture. One that's not too rich nor too lean.

An *oxygen sensor* is a device that generates some output voltage in the *absence* of oxygen and no output in its presence. Figure two shows you its typical output.

The oxygen sensor normally sits in the exhaust stream just *before* your catalytic converter and muffler. The voltage output of an oxygen sensor gets A/D converted and routed to the engine computer. The computer then adjusts the gas/air mix to one that has low pollution and good economy.

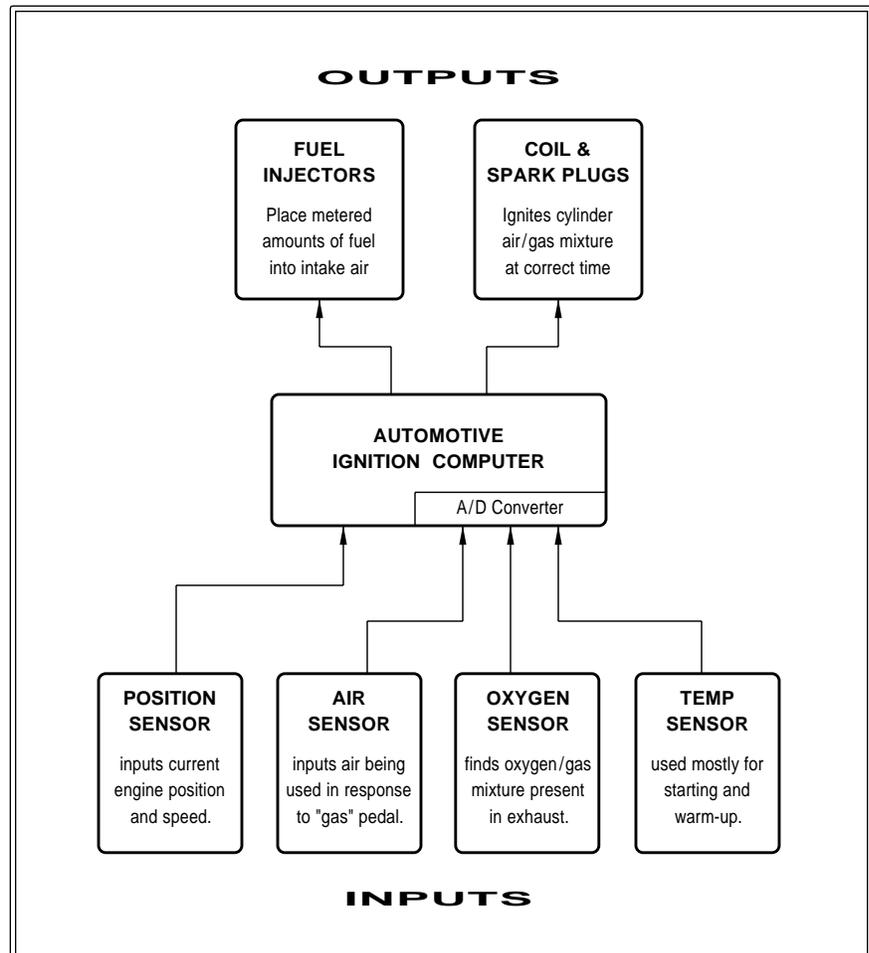


Fig. 1 – THE TWO MAIN TASKS of an auto ignition computer are to optimize the air to gas ratio and to control the spark timing.

Figaro is one resource for oxygen sensor info.

How does your computer adjust its gas/air mixture? The precise details shift with your system. And change with any newer technology. What I'll describe is an older *Bosch* system that uses an airbox, individual pulsed fuel injection, and a horribly dated "electronic over mechanical" ignition distribution.

In such a system, the throttle (or "gas" pedal) controls the *air* going into the engine, *not* the gas.

The quantity of air you select has to be measured and converted into a A/D computer input. An *airbox* vane drives a fancy potentiometer whose resistance changes with the airflow. Air temperature also is measured.

Newer systems use a more accurate *mass air flow* sensor instead. These work by measuring the differential cooling rates of heated wires. Either way, an analog voltage is generated, A/D converted, and sent to a digital engine computer.

The gas gets pressurized to 29 PSI or so by using an electric fuel pump and a pressure relief valve. The gas then gets routed to the fuel injectors which intercept the air paths. One per cylinder, near the intake valves.

In this system, the injectors are *not* locked to individual cylinder timing.

They are *all* driven identically. But in other systems, there is one master injector. Or individual high pressure injectors that replace input valves.

An injector is just a solenoid valve. Pulse duty cycle modulation sets the amount of gas metered. The engine computer uses feedback from the air flow and oxygen sensors to adjust the injector duty cycles.

Helped along by other inputs like engine temperature, idle stabilization, and startup "choke" enrichment.

Once again: As you step on your "gas" you will increase your *air*. The increase in air gets compared against your *previous* gas/air mixture. The computer then adjusts the amount of injected fuel.

The second major role for any car ignition computer is for adjusting the *timing*, deciding precisely *when* your compressed mixture gets ignited.

Spark too early and you will lose power; too late and you'll cause an erratic and power-robbing *knock*. The optimum timing gets determined by engine speed, mixture, load, and the temperature. Traditionally a *vacuum advance* was used to physically rotate the points as speed increased.

In this Bosch system, the points got replaced with a solid state *Hall Sensor* that pulsed somewhat *before* the time a cylinder actually needed

sparked. The set of rules that decide how much to advance your spark is called an *ignition map*.

The rule map is stored in a digital read-only memory whose addressing is controlled by speed, load, mixture, temperature and other factors. The output of the map sets a timing delay. After the timing delay, the computer pulses a triac switch that discharges an energy storage capacitor into the coil and spark plugs.

Unlike classic systems, the delay (amount of advance) and the pulse width (dwell time) are independently controllable. In fact, the dwell time is set by capacitor energy storage.

By today's standards, my own car computer seems rather primitive. A 6805 and an EPROM mostly, helped along by a grunt multi-channel A/D. A triac drives the coil. A Darlington for the injectors. A transistor for the fuel pump. An internal regulator.

One book on all this is *Bosch Fuel Injection and Engine Management* by Charles Probst. Other titles appear in the *SAE Library*.

Two major auto publishers include *Robert Bentley* and *Chilton*. Also see *Automotive Industries* magazine.

Servicing Intermittents

Back to our horror story. My 1987 *Synchro* 4WD van started showing an intermittent and a total loss of power. Naturally, I did not suspect for an instant that all those 138,000 off road desert miles I put on it had anything to do with the problem.

Cleaning up the airbox, checking connectors, and swapping the fuel filter did not help. Hauling it off on a 350 mile trip to my nearest factory authorized service center cost me an outrageous bill.

For zero improvement.

In all fairness, it *is* hard to fix an intermittent when it doesn't show up on demand. But as soon as I started treating this as an electronic service problem, rather than an auto problem, the cause became obvious.

I next sent out for a shop manual, something I should have done years ago. The *Robert Bentley* manuals are really outstanding.

Meanwhile, I decided I had to try and catch this intermittent in action. While driving down the road.

So, I hooked up an oscilloscope.

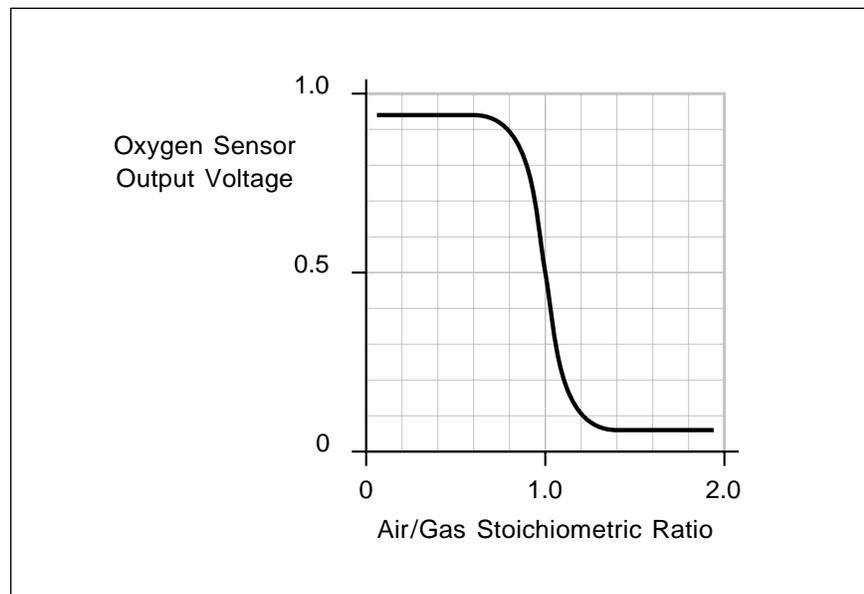


Fig. 2 – AN OXYGEN SENSOR outputs a voltage in the absence of oxygen. Placed in the vehicle exhaust, it forms the key feedback element to maintain a gas/air mixture which is neither too rich nor too lean. And one which has neither excess polluting hydrocarbons nor nitrogen oxides.

My first guess was the Hall Sensor, so I monitored the green wire from the sensor by using a temporary test pin I have shown in figure three. The sensor output was continuous, even during a dropout.

Finally, a stroke of blind luck. I hit the computer with my fist and the engine died! Something I should have thought about long before. Something which that mechanic *certainly* should have tried.

Cleaning the connector didn't help, so I resoldered the computer. The culprit was this bad solder joint on a steel lead power resistor. Aging and corrosion caused the failure.

In hindsight, the tachometer would drop to *zero* during failure, with the engine obviously still stumbling over. Because the tach connects directly to the coil primary, the problem almost *had* to be the computer or wiring.

Interestingly, there is this newer wiring harness/filter that's supposed to eliminate the very same *symptom* that is apparently caused by the steel lead on that big computer resistor not being solder wettable. I suspect they never found the real problem at all.

And still haven't got a clue.

All of which did get me thinking about servicing intermittent problems in general. So, figure four gives you a set of my rules that should get you started. The key points are to *always* have documentation on hand; to be *certain* to get the problem to actually show up; to divide-and-conquer by finding out where the problem is *not*; to attack probable causes first; and to think logically, paying attention to *all* of the symptoms.

Yeah, there are fairly low cost data loggers out there. But nobody has yet come up with a universal intermittent "flight recorder" that a car mechanic, a cardiologist, or an air conditioning repairman would fight over. There's a bunch of opportunities here.

Many thanks to real-world auto expert Bob McKnight for his superb help on this matter.

Some Contests

There sure is a lot of interest in car computers on our helpline. The big problems in getting straight answers lie in traditional automotive secrecy. Plus a "swap the module" mentality. And the fact that the EPA has made it

a felony to *reduce* the emissions from any car by tampering with it.

Still, I'd really like to put together a set of car computer resources. As our first contest this month, just tell me about any useful book, service, publication, or online resource that can be of help here.

As our second contest, please find me a clean late model Synchro. Or else tell me about *any* old substitute vehicle that is a mid sized, rugged, economical, skidplated, 22 MPG, high clearance, posi, granny-gear full time 4WD *van*. A van that sleeps six cavers, Bowseretta, and a full sheet of plywood.

There'll be all the usual *Incredible Secret Money Machine II* books for the dozen or so better entries, with an all expense paid (FOB Thatcher, AZ) *tinaja quest* for two going to the very best of all.

The "Mystery Band"

How far is it from radio to heat? Both are electromagnetic phenomena whose frequencies and wavelengths differ only in size. How far apart are they, spectrum wise?

Figure five tells all. Between radio and heat lies what I will label as the

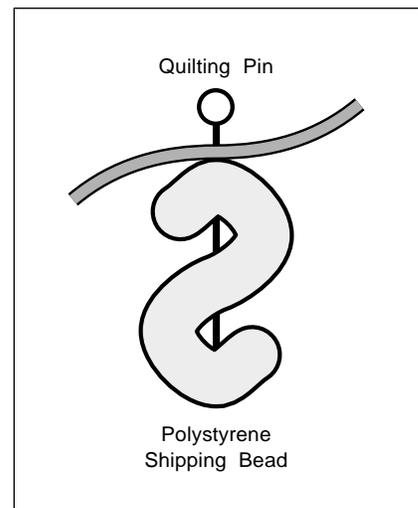


Fig. 3 – A QUILTING PIN makes a safe test point along stranded wires.

mystery band. Otherwise known as the *submillimeter wavelengths* or the *quasi-optical frequencies*.

A 32:1 frequency range whose 8.7 Terahertz bandwidth can easily hold 1,600,000 HDTV television signals. A band which is totally unlicensed and unregulated. With incredible future hacker potential.

Reviewing, the *frequency* of any signal is simply how many full lumps

1. Make certain the problem is real.
2. Have *all* service manuals on hand. *Read them!*
3. Make the problem show up. Collect data *during* the fault.
4. Divide and conquer. Find out where the problem is *not*.
5. Assign probable causes. Look, smell, touch, and listen.
6. Associate mechanical problems with connectors; time ones with solder joints; temperature ones with memory chips.
7. Cause the patient no harm. *Never* hot plug!
8. Isolate temperature problems with fans, cold, or hot boxes.
9. Pay attention to *all* symptoms. Be willing to change tactics.
10. Hit it with your fist or otherwise apply *controlled* shock.
11. Attack the disease, not the symptom. Things "burn out" for a reason. Find and fix that underlying reason.
12. Reduce the system to the simplest possible.
13. If all else fails, try to make the problem *worse*.
14. When possible, compare against an identical working unit.
15. Back off and give it a rest; let your subconscious do the work.

Fig. 4 – INTERMITTENTS CAN BE A BEAR TO SERVICE. Cause iffen it ain't broke, it certainly can end up hard to fix. Here's several attack guidelines.

COMMERCIAL ONLINE BBS RESOURCES

| | |
|---|---|
| <p>Apple eWorld Box 4493 Bridgeton, MO 63044 (800) 776-2333</p> | <p>Dialog Information Services 3460 Hillview Avenue Palo Alto, CA 94304 (415) 858-2700</p> |
| <p>America Online 8619 Westwood Center Drive Vienna, VA 22182 (800) 827-6364</p> | <p>GEnie 401 N. Washington St Rockville MD 20850 (800) 638-9636</p> |
| <p>CompuServe 500 Arlington Centre Blvd Columbus, OH 43220 (800) 848-8199</p> | <p>Prodigy Services 445 Hamilton Avenue White Plains, NY 10601 (914) 448-8811</p> |
| <p>Delphi Internet Services 1030 Massachusetts Avenue Cambridge, MA 02138 (800) 695-4005</p> | <p>The Well 65 N. Gate Five Road Sausalito, CA 94965 (415) 332-4335</p> |

go by per second. The *wavelength* is the inverse of a frequency. And the distance along the wave it takes to get back to exactly the same *phase* point you started at.

For instance, an X-band speed radar has a frequency of 10 *Gigahertz* or GHz. Its wavelength is 3 centimeters, or 30,000 micrometers.

A warm human body radiates at a frequency of 30 *Terahertz*, or THz, otherwise known as 30,000 GHz. Its wavelength is 10 micrometers.

If this mystery band is so great, why doesn't anybody know about it

or use it very much? Until recently, there's been no decent amplifiers or oscillators in this range.

The high end microwave electronic devices listed in *Wireless Design & Development, Microwaves & RF* and similar pubs tend to run out of steam at 100 GHz or thereabouts.

At the other end, most ir detectors can't handle anything longer than 10 micrometers. Although a few costly ir sensors from *EG&G Judson* can get near 50 micrometers. That's way on down to a mere six Terahertz!

New advances in *nanotechnology*

should soon bring about all sorts of new low noise, high gain, high power devices that can combine the best of microwave and optical techniques. So should parametric amplifiers.

This mystery band does demand line-of-sight transmissions. Or, better yet, pipe or fiber waveguides. While extremely high gain antennas can be small and compact, these also need extreme precision.

Sadly, the atmosphere in the 0.3 to 10 THz frequency range changes from murky to totally opaque.

At best, you'll have something like a decibel per kilometer attenuation. At its worst, the molecular absorption (notably oxygen and water vapor) flat out sops up everything. Thus, rain could be a total disaster for outdoor Terahertz comm.

Hot objects could also cause grief. Although a warm human body has a peak energy wavelength of 30 THz, there is a long tail that drags on down into the mystery band. Hotter objects have even more mystery band energy. Even though their *peak* wavelengths are much higher.

Some applications demand cooling to cryogenic temperatures. At very least, an awareness of possible heat interference is important.

What good is the mystery band? For now, radio astronomers are about the only users. But wireless modems and mice are an obvious possibility. As are other forms of personal comm or short haul telemetry.

I'll also predict that the mystery band will turn out to be important for new SETI research.

You could make a lot of friends in a really big hurry by hacking up a \$5 mystery band device having 20 db of gain, a 2 decibel noise figure, and 100 milliwatts of output power at 3 THz. Even at \$6.42 it would still sell.

The best mystery band info comes down in the *International Journal of Infrared and Submillimeter Waves*.

Near ground, atmospheric mystery band attenuation may be poor. But the radio astronomers have to look up through the *entire* atmosphere. For most of the mystery band, the full atmosphere is uselessly opaque.

But there are lots of interesting windows. One at 680 GHz has around 70 percent loss and a second at 760 GHz offers a 60 percent loss. Dirty

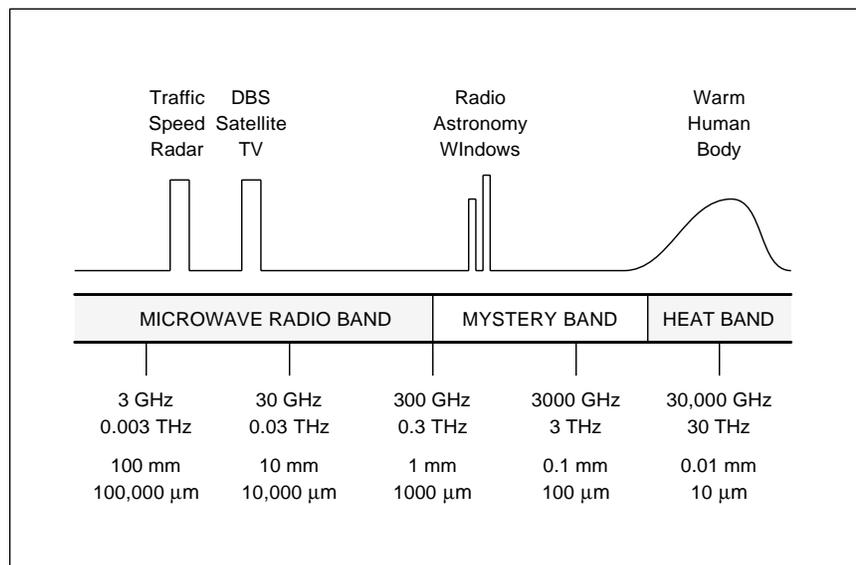


Fig. 5 – THE MYSTERY BAND of submillimeter wavelengths between "radio" and "heat" is five octaves wide and offers an incredible bandwidth. This band is unregulated and unlicensed. Yet its many opportunities still go begging.

windows yes, but still useful.

In a September 1994 *IJISW* story (on p.1465-1481), authors Harris and Schuster describe a major noise floor breakthrough in a cooled receiver for 680 GHz radio astronomy.

The best strategy when you don't have any decent amplifiers available is to "Get out of Dodge." Do a first stage downconversion to less hostile frequencies.

The authors built up a hand crafted niobium Josephson tunnelling mixer diode. For their local oscillator, they started out by using a 110 GHz Gunn diode source. And then tripled it and doubled it to hit 660 GHz. The mixer difference gets extracted as a medium microwave frequency.

With their new technology, they managed to get their input noise temp down to 800 degrees, compared to an older 2400 degree model that used a Schottky diode. While much better, a lot more can be done.

Another resource for the mystery band is the *Society of Amateur Radio Astronomers*.

As a third contest this month, just dream up some new hacker use for mystery band frequencies. Or maybe send me a sample amplifier having the specs mentioned above.

On-Line Resources

Naturally, it is totally *unthinkable* to attempt *any* technical research or idea development without aggressive use of online resources. Not getting online is almost as dumb as not using a personal computer.

These days, everybody wants to get on the Internet. Personally doing so in the past often meant expensive and snotty services, phone charges, arcane commands, and –org– having to become UNIX literate.

By the time you read this, all of the major commercial BBS services will be offering fast, powerful, and very friendly direct Internet access. At low hourly rates as a local call.

I have listed the commercial BBS biggies in our resource sidebar this month. Of the more useful services, *CompuServe* is the largest, *America Online* is the friendliest, and *GENie* has the most and best in the way of technical downloads.

Obviously, I like *GENie* the best. On my *GENie* PSRT RoundTable, you

NAMES AND NUMBERS

Automotive Industries

PO Box 2056
Radnor, PA 19080
(215) 964-4876

Robert Bentley

1033 Massachusetts Avenue
Cambridge, MA 02138
(617) 547-4170

BKL

421 Fehely Drive
King of Prussia, PA 19406
(610) 277-2910

Chilton

Chilton Way
Radnor PA 19089
(610) 964-4000

EG&G Judson

221 Commerce Drive
Montgomeryville, PA 18936
(215) 368-6900

Figaro Engineering

Box 357
Wilmette IL 60091
(708) 256-3546

Fuzzy Systems Engineering

12223 Wilsey Way
Poway, CA 92064
(619) 748-7384

GENie

401 N Washington St
Rockville MD 20850
(800) 638-9636

Jnl Infrared & Millimeter Waves

233 Spring Street
New York NY 10013
(212) 620-8495

Master Bond

154 Hobart Street
Hackensack NJ 07601
(201) 343-8983

Maxim

120 San Gabriel Dr
Sunnyvale CA 94086
(800) 998-8800

Microwaves & RF

611 Rt #46 West
Hasbrouck Heights NJ 07604
(201) 393-6286

Old Colony Sound Labs

PO Box 243
Peterborough NH 03458
(603) 924-6371

Railbike Newsletter

3502 Buckskin Road
Coeur d'Alene, ID 83814
(208) 765-2831

Redmond Cable

15331 NE 90th Stret
Redmond WA 98052
(206) 882-2009

SAE Library

400 Commonwealth Dr
Warrendale PA 15096
(412) 776-4841

Soc. Am. Radio Astronomers

247 N Linden St
Massapequa NY 11758
(516) 798-8459

SETIQuest Inquiries

174 Concord Street
Peterborough, NH 03458-0874
(603) 924-9631

Society for Amateur Scientists

1549 El Prado
San Diego, CA 92101
(800) 873-8767

Wireless Design & Dev

301 Gibraltar Dr
Morris Plains NJ 07950
(201) 292-5100

will find preprints and reprints of all my *Hardware Hacker* and my other columns. Along with unique design tools not found elsewhere. I've just added new features, including major *Acrobat* support, Steve Hansen's high vacuum *Bell Jar* and the *Nomadic Notes* from Steve Roberts.

Internet email tech questions asked to PSRT get answered in Category 1, Topic 33. Often in two hours.

I've often been asked to post my files, reprints, and research studies directly to some Internet site. But the askee never seems to get around to explaining exactly how this would be funded. But, if they can get *Safeway*, *Texaco*, and the *Purina Doggy Chow*

folks to offer all their products free over the Internet, I'll be most happy to do so also.

New Tech Lit

From *Maxim* a 1995 *New Releases Data Book*. Lots of great video stuff, waveform generators, and *RF-to-Bits* comm chips. Maxim is quite liberal with engineering samples and offers a toll free order hotline.

Much more on sonoluminescence in Robert Heller's story in the Oct. 14, 1994 issue of *Science*.

I guess I'm kinda down on fuzzy logic. The wildly ludicrous claims of early proponents gave the entire field a bad name. *Anything* you could do

NEED HELP?

Phone or write your Hardware Hacker questions to:

Don Lancaster
Synergetics
Box 809-EN
Thatcher, AZ, 85552
(602) 428-4073

For fast PSRT access, modem (800) 638-8369, then an HHH. Then JOINGENIE. On keyword prompt, enter DMD524.

Internet email access link:
SYNERGETICS@GENIE.GEIS.COM.

with fuzzy logic you can also do just as fine without.

Still, there are times and places where concepts such as "short" or "tall" or "cold" or "warm" could form useful system inputs. A reasonably hype-free new book is *Fuzzy Logic; A Practical Approach*. Through *Fuzzy Systems Engineering*. They also have *Fuzzy Thought* software.

Product MB6A from *Master Bond* is an effective epoxy stripper.

Electroluminescent panel kits are available for \$45 from *BKL*.

For custom and stock cables and interfaces, including *Nintendo* and *Sega*, try out *Redmond Cable*.

Lots of audio and other tech books in a new catalog from the *Old Colony Sound Labs*.

A *Railbike Newsletter* from Dick Smart. Adaptor kits are shown in the 1908 *Sears-Roebuck* catalog, but may no longer be in stock.

I've just picked up a great heaping bunch of classic Apples, including rare and collectable Apple III's. And II+ and IIe computers cheap enough to use as dedicated BASIC controllers or for general lab apps. Give me a call if you want a complete list.

A reminder that unique downloads, freebie insider secrets, catalogs, and technical help are available on *Genie* PSRT. A ten hour free trial offer per the *Need Help?* box.

As usual, most of these resources I've mentioned appear in the *Names & Numbers* or in that *Commercial BBS Resources* sidebars. Be sure to check here first before calling our no-charge tech helpline.

Let's hear from you. Especially on all of those automotive resources.♦

Obvious things these folks might try if they feel they have this problem are to see if extended time in a cave can make any difference. Or attempt long term herbal remedies such as *Ginko Biloba* or *CoEnzyme Q10*.

Now, it is real easy to dismiss such claims out of hand. At first glance, they seem about as likely as Saddam Hussein's bar mitzvah. But I don't like to discourage most off-the-wall

topics, regardless of how bizarre. At least not until I find out what "real" science and "real" engineering have to say about the subject. If, *after* my careful research, the topic obviously becomes a "useful adjunct to porcine cleanliness", then so be it.

Well, the amazing answer is that implants are routinely available! As off the shelf stock items. At modest costs. But the most popular models

only hold your net worth and Social Security Number. They only measure how hot you are under the collar.

And they only have a useful range of several inches.

Most uses are totally unlicensed and unregulated.

I strongly feel that one of the next major hardware hacking arenas will involve the direct computer-to-brain interface. First and foremost, because direct access offers the prospect for immortality. At least as far as your thoughts and feelings go.

Typical used car dealers would gladly pay \$44.95 for a box with three buttons on it that are marked "enter lot", "buy", and "leave". Politicians would spring ten bucks extra if the same box had a 100 mile range.

Historians would appreciate the "instant replay" features. As would crime investigators. Most medical pros would definitely welcome new routes towards effective cures.

Especially for addictions.

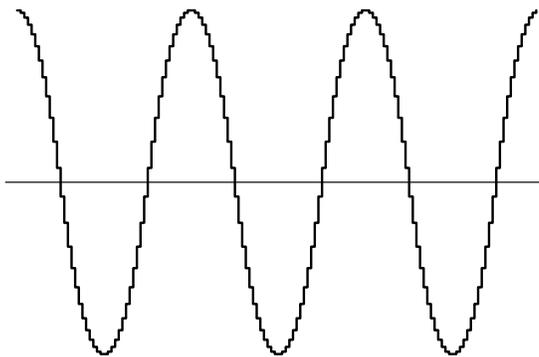
The more conservative elements of society are bound to be horrified at the prospect of direct personal access to brain pleasure centers. "Press one for psychedelics; two for sex; three for rapture; or four for a coconut anchovy pizza." This would instantly obsolete most of the more popular forms of entertainment.

The obvious current problems with direct access are the I/O scheme and understanding the brain's operating system and its instruction set. But there's bound to be a system monitor in there somewhere. Can't be any worse than UNIX. But the solutions to these problems are a lot closer than you think. And clearly solvable.

The leading manufacturer of new implants is *Bio Medic Data Systems*. Their DAS series is intended mostly for lab animals. They normally go in the back or shoulder, rather than the brain. These have a read, record, and write capability, with stock models logging body temperature. The usual range is normally only a few inches. One major supplier for implantable chips is *Dallas Semiconductor*.

Significant trade journals in this area include *Identification Journal*, *Automatic ID News*, *Access Control*, and *I.D. Systems*.

Clearly, the human brain is sure to become the ultimate hack.



THE ALGORITHM:

1. Initialize a SIZE stash to a magic value.
2. Initialize a SPEED stash to zero.
3. If SIZE is positive, decrement SPEED.
If SIZE is negative, increment SPEED.
4. Add SIZE to SPEED to get the new SIZE.
5. Use your digitally generated sinewave.
6. Repeat steps 3-5 as required.

POSTSCRIPT DEMO:

```
% Draw a 48 step digital sinewave...
200 300 translate           % set position on page
/steps 48 def               % set steps per cycle
/size 72 def                % set zero to peak size
/speed 0 def                % initialize speed
0 size moveto               % move to starting point
1 1 size {                  % start a for loop
  /val exch store           % save position
  /speed speed size 0 gt {-1}{+1} % do the algorithm
  ifelse add store
  /size size speed add store
  1 0 rlineto               % draw horizontal step
  val size lineto           % draw vertical step
} for                       % complete loop
stroke showpage            % draw it and print it
```

Fig. 2 – AN AMAZINGLY EFFICIENT digital sinewave generator. As few as six machine language bytes are required! On magnification, the slight "hydrogenated" waveshape fattening reveals a four percent distortion.

Another Contest

For this month's contest, just tell me in 175,000 words or less all the possibilities and consequences of the "real soon now" direct brain access that is almost certainly to occur.

There will be a dozen or so of my *Incredible Secret Money Machine II* books going to the better entries, with an all expense paid (FOB, Thatcher, AZ), *tinaja quest* going to the very best of all. Entries must be *written* and sent to me here at *Synergetics*.

Sinewaves Old and New

A "new" algorithm for generating digital sinewaves showed up in the December 94 *Byte* on pages 217-218. This is one of the finest examples of elegant simplicity I have ever seen. Amazingly, it takes only *two* registers and *six* bytes of working 8-bit code to implement on PIC micros!

I have repeated their algorithm in figure two. Along with some simple PostScript code which could let you interactively explore, model, analyze, or plot this "new" sinewave scheme. This method is extremely attractive for small microcontrollers.

Before we look into the details, I thought it would be a good idea to review many of the standard methods for generating sinewaves. I've long been both a student and developer of sinewave sources.

In the *bandpass filter* method, you wrap an amplifier having unity loop gain around a resonant coil and cap. If you tap the coil for feedback, you have a *Hartley* (or "hardly") circuit for your oscillator. Tap the capacitor instead, and you'll end up with a *Colpitts* (or "polecats") circuit.

A *Wein Bridge* uses a R-C network that can be thought of as overlapping highpass and lowpass filters. Put just enough gain around this one, and you get a sinewave out. For "just enough" gain, you have to go to some sort of amplitude stabilization scheme.

Such as the nonlinear resistance of a pilot lamp.

Most any old repetitive waveform consists of a fundamental sinewave and several harmonics. In the *filter* method, you generate a waveform and then lowpass or bandpass filter to extract the fundamental wave. Using symmetric waveforms gets rid of all

THE ALGORITHM:

1. Initialize a SIZE stash to magic value #1.
2. Initialize a SPEED stash to zero.
3. Select a magic value #2 for CLIP.
4. If SIZE is positive, decrement SPEED.
If SIZE is negative, increment SPEED.
5. Set FIX to SPEED.
If FIX > +CLIP, then FIX = +CLIP
If FIX < -CLIP, then FIX = -CLIP
6. Add SIZE to FIX to get the new SIZE.
7. Use your digitally generated sinewave.
8. Repeat steps 4-7 as required.

A POSTSCRIPT UTILITY:

```
% Calculate a 48 step low distortion digital sinewave...
/steps 48 def                % set steps per cycle
/size 64 def                 % set zero to peak size
/speed 0 def                 % initialize speed
/clip 8 def                  % initialize clip
1 1 size {                   % start a for loop
  /val exch store            % save position
  /speed speed size 0 gt {-1}{+1} % start the algorithm
  ifelse add store
  speed dup clip gt          % clip a copy of speed
  {pop clip} ifelse
  speed dup clip neg lt
  {pop clip neg} ifelse
  /size exch size add store  % finish the algorithm
  % use your sinewave here
} for                         % complete loop
```

Fig. 3 – A LOW DISTORTION variation that requires a few more bytes. The third harmonic can sometimes be eliminated entirely.

the even harmonics. Particularly that troublesome second.

While square waves are an obvious starting place, the third harmonic is a horrific 0.33 of the fundamental and is only ten decibels down. A triangle wave's third harmonic is only 0.11 of the fundamental and can be a lot easier to deal with.

Filtering can get tricky fast if the frequency changes by much.

Those *triangle games* methods all start with a triangle wave and then play around with it. If you softly clip the "points", you'll get a sinewave out. Or, you can add a new triangle wave that has 3X the frequency and 1/9th the amplitude to cancel out the original third. Leaving that easily dealt with fifth at -1/25th down.

The horribly obsolete *breakpoints* method is related to triangle games,

and builds up an analog sinewave by straight line approximations.

The *double integrator* seems the purest form of sinewave generator. Take any old waveform "S". Add up, or continuously *integrate* your *area* under "S" to produce a new waveform "C". Then integrate "C" and invert it. Make this inverted and integrated "C" output your "S" *input*, and you've got yourself a pure sinewave.

Guaranteed.

Why? Because you just set up a big old hairy piece of math called a *differential equation*. Whose solution is *always* a pure sinewave. And "S", stands for the *sine*. And "C" for the quadrature (90 degree phase shifted) *cosine*. This is sometimes called the *analog computer* method.

More on the double integrator in my *Active Filter Cookbook*. One of

| steps per cycle | peak amplitude | clipping level | dc offset present? | 3rd harm. distortion | total harm. distortion |
|-----------------|----------------|----------------|--------------------|----------------------|------------------------|
| 8 | 2 | none | no | 5.74% | 9.76% |
| 12 | 4 | 2 | no | 0% | 2.72% |
| 12 | 5 | none | yes | 4.92% | 5.32% |
| 16 | 8 | 3 | yes | 1.79% | 2.18% |
| 16 | 8 | none | no | 4.33% | 4.65% |
| 20 | 10 | 3 | yes | 1.56% | 2.11% |
| 20 | 12 | none | yes | 4.09% | 4.29% |
| 24 | 16 | 4 | no | 0% | 1.08% |
| 24 | 20 | none | no | 3.96% | 4.12% |
| 28 | 22 | 5 | yes | 0.96% | 1.25% |
| 28 | 24 | none | yes | 3.89% | 4.03% |
| 32 | 28 | 5 | yes | 0.90% | 1.42% |
| 32 | 32 | none | no | 3.84% | 3.98% |
| 36 | 36 | 6 | no | 0% | 0.94% |
| 36 | 40 | none | yes | 3.8% | 3.94% |
| 40 | 46 | 7 | yes | 0.67% | 1.03% |
| 40 | 50 | none | no | 3.79% | 3.81% |
| 44 | 52 | 7 | yes | 0.63% | 1.19% |
| 44 | 60 | none | yes | 3.81% | 3.89% |
| 48 | 64 | 8 | no | 0% | 0.90% |
| 48 | 72 | none | no | 3.77% | 3.88% |
| 56 | 76 | 9 | yes | 0.51% | 0.94% |
| 56 | 84 | none | yes | 3.76% | 3.87% |
| 56 | 86 | 9 | yes | 0.49% | 1.08% |
| 56 | 98 | none | no | 3.75% | 3.86% |
| 60 | 100 | 10 | no | 0% | 0.88% |
| 60 | 110 | none | yes | 3.74% | 3.85% |
| 64 | 116 | 11 | yes | 0.41% | 0.91% |
| 64 | 128 | none | no | 3.74% | 3.84% |
| 68 | 126 | 11 | yes | 0.41% | 1.02% |
| 68 | 138 | none | yes | 3.76% | 3.84% |

Fig. 4 – SOME DATA VALUES for the more interesting and useful digital sinewave generators. Both "regular" and "low distortion" schemes are shown.

the variations on this is known as a *state variable filter*.

All these sinewave generators so far can be done analog or digital. The advantages of digital methods are that they offer frequencies that are both stable and easily changed. They might be instantly swept with ease, usually without any nasty transients. No large, costly, and field-sensitive coils are needed. Amplitude is easily controlled and inherently stable.

Distortion products are precisely known. So is phase.

Today, digital is smaller, cheaper, better, and lower in power.

The *walking ring* is one older but still rather cute example of a hybrid sinewave generator. Take a walking ring counter, and connect carefully chosen summing resistors to *all but one* of those output phases. Input a

digital clock and out comes an analog sinewave having a surprisingly low distortion. Full details in my *CMOS Cookbook*.

Table lookup is the most popular "pure" digital method in use today. Start with some direct input or an up-down counter and route it to an EPROM or other read only memory that simply looks up the sine of the counter state representing the current angle. This is very fast, but needs lots of memory for any decent accuracy. Symmetry and interpolation tricks can be used to ease memory needs.

A frequency synthesizer might use a *phase accumulator*. Which is just a phase adder put in front of a lookup table or two.

Most any old waveform could be represented by a *power series*. For instance, the cosine of x could get

calculated by $1 - x^2/2! + x^4/4! + \dots$

Up to sixty degrees or so, you can usually get away with the square term only. But more terms may be needed for higher angles. The power series calculations do take time and do have precision limits.

Variations on these power series methods get applied in most math coprocessor chips. Sinewaves can be related to exponentials and similar functions. The details get hairy real fast. There is also the obscure and quite slow *rate multiplier* scheme to generate digital sinewaves, but this one seems to have long ago fallen by the wayside.

The "New" Method

My first reaction when I saw the code was "That can't work!" There simply can *not* be any overlooked fundamentally new sinewave method in this day and age. That would be about the same as discovering a new trig identity.

So, it does turn out what we really have here is an extremely fast and compact (but very slightly flawed) variation upon the double integrator method. You can alternately look at it as a *numeric sequence generator* that happens to trace out something that's roughly akin to a real sinewave.

Take an 8-bit stash and call it *size*. Take a second 8-bit stash and call it *speed*. Select a magic initial value for *size*. Say decimal 72. Set *speed* to zero. Now use the following rules: If *size* is positive, *decrement* the *speed* value. If not, *increment* your *speed* stash. Finally, add *speed* to *size* to find your new *size* value.

The method does *not* generate a true sinewave. Instead, it creates a "partially hydrogenated" cosine wave having a little extra fat on its leading edges. Out of the box, your third harmonic distortion is typically in the four percent range. Which may or may not be acceptable. Four percent just barely shows on a visual plot, but its harshness is easily spotted when you listen to it as audio. Many apps cannot tolerate this level.

Thankfully, there are *zero* even harmonics. Often, there will be zero dc offset. The cause of the distortion problem is that *speed* is supposed to be a cosine wave, and the algorithm builds a triangle wave instead.

Improving it

Naturally, I could not leave well enough alone. This beast is highly obsessive. Like the old shop joke of Machinist #1 drawing out the world's thinnest wire. Well, Machinist #2 then drilled the world's smallest hole down through it. Finally, of course, Machinist #3 tapped it.

It turns out there's a simple mod you can make that can dramatically reduce the distortion. You sometimes can *completely* eliminate the third while significantly stomping on the rest of them. All those higher odd harmonics are usually easy to filter. Of course, there might be a modest speed and code length price.

Exact details will vary with the implementation.

Once again, the cause of all the original distortion is generating a triangle wave but calling it a cosine wave. Admittedly, real cosines get tricky when you are only allowed to use six bytes worth of small integers. But if you chop the top and bottom off your triangle, you can come an awful lot closer to perfection. As I have shown in figure three.

Any repetitive waveform can be analyzed by use of *Fourier Series* techniques. Naturally, the general purpose PostScript language is ideal for this sort of thing. We'll get into all the details some other time. But figure four reveals several magic amplitude and distortion values for both algorithm versions.

If a dc offset is present in the listed values, it's half a step one way or the other. Capacitor coupling can get rid of this. When permitted.

Note that *none* of the 128 or higher amplitude sequences are realizable as single 8-bit words. Because of state zero and negative values, 257 or more states are involved. PostScript, of course, handles these higher values with ease and aplomb.

There are several other possible amplitudes. These either have extra dc in the output or else have worse distortion present.

I am fairly sure I've shown all possible 8-bit steps-per-cycle values. These are just four times your max unclipped *speed* value.

I've also gone ahead and gilded the lily. An ultralow distortion variant is

NAMES AND NUMBERS

Access Control

6151 Powers Ferry Rd NW
Atlanta GA 30339
(404) 955-2500

Amateur Seismologist

2155 Verdugo Blvd #528
Montrose CA 91020
(818) 249-1759

American Laboratory

30 Controls Drive
Shelton CT 06484
(203) 926-9300

Antique Automobile Radio

700 Tampa Road
Palm Harbor FL 34683
(800) 933-4926

Antique Radio Classified

PO Box 802
Carlisle MA 01741
(508) 371-0512

Automatic ID News

7500 Old Oak Blvd
Cleveland OH 44130
(216) 243-8100

Bio Medic Data Systems

255 W Spring Valley Avenue
Maywood NJ 07607
(800) 526-2637

Jim DuBois

330 State Road 101
Amherst NH 03031
(603) 673-3645

GENie

401 N Washington St
Rockville MD 20850
(800) 638-9636

GeoSpace

7334 N Gessner
Houston TX 77040
(713) 939-7093

Handmade Electronics

1825 Roth Ave
Allentown PA 18104
(610) 432-5732

Horn Speaker

PO Box 1193
Mabank TX 75147
(903) 848-0304

ID Systems

174 Concord St
Peterborough NH 03458
(603) 924-9631

Identification Journal

2640 N Halsted St
Chicago IL 60614
(312) 528-6600

National Semiconductor

2900 Semiconductor Rd
Santa Clara CA 95052
(800) 272-9959

NewTek

1200 SW Executive Dr
Topeka KS 66615
(800) 847-6111

Microchip Technology

2355 W Chandler Blvd
Chandler AZ 85224
(602) 963-7373

RF Design

6300 S Syracuse Way #650
Englewood CO 80111
(303) 220-0600

Signetics/Philips

PO Box 3409
Sunnyvale CA 94088
(408) 991-2000

AG Tannenbaum

PO Box 110
E Rockaway NY 11518
(516) 887-0057

shown in figure five. Which offers a mere 0.24 percent distortion, virtually all of which is that easily stomped *seventh* harmonic. But this does take a few extra bytes of code. And has limited sets of useful values. There is an aesthetically unsatisfying wrinkle in the sine plot as well.

In one variation, the fifth is 62 db down. *Before* any filtering!

A much more detailed analysis, full sequences, and ready-to-run code appears in my files FOURIER.PS and NEWSINE.PS on *GENie* PSRT.

New Tech Lit

Also from *Signetics/Philips*, new editions of their *Audio/Radio*, and *Wireless* data handbooks. Or from

Analog Devices, the incredibly fat new *Design-In Reference Manual*.

Fancy new *molecular* computers based on using strands of DNA are described in the November 11, 1994 issue of *Science*, on pages 993 and 1021-1023. In a Leonard Adleman paper. One calculation related to the traveling salesman problem gets done a thousand times faster than the best supercomputer. Needing only a tiny fraction of the space and energy. The secret lies in using *billions* of parallel coprocessors.

Outstanding buys for precision CAD/CAM steppers, X-Y tables, and similar bits and pieces are offered by *Jim DuBois*. Mostly as one-of-a-kind used and surplus.

```
% Copyright c 1995 by Don Lancaster and Synergetics, Box 809, Thatcher, AZ,
% 85552. (602) 428-4073. All commercial and all media rights fully reserved.
% Personal use permitted so long as this header remains present and intact.
```

```
% Variation #1 has 60 steps per cycle and a 96 peak amplitude.
% The DC term and harmonics 2,3,4,6,8,9,10, and 12 are ZERO!
```

```
% The fifth harmonic distortion is 0.061%. Total distortion is 0.342%.
```

```
/size 96 def
/speed 0 def
```

```
0 1 60 {
  /val exch def
  /speed speed size 0 gt {-1}{+1} ifelse add store
  /size size speed dup 10 eq {pop 6} if dup -10 eq {pop -6} if
  dup 10 gt {pop 10} if dup -10 lt {pop -10} if add store
  % use your sinewave here
} for
```

```
% Variation #2 has 60 steps per cycle and a 97 peak amplitude.
% The DC term and harmonics 2,3,4,6,8,9,10, and 12 are ZERO!
```

```
% The fifth harmonic distortion is 0.162%. Total distortion is 0.247%.
```

```
/size 97 def
/speed 0 def
```

```
0 1 60 {
  /val exch def
  /speed speed size 0 gt {-1}{+1} ifelse add store
  /size size speed dup 10 eq {pop 7} if dup -10 eq {pop -7} if
  dup 10 gt {pop 10} if dup -10 lt {pop -10} if add store
  % use your sinewave here
} for
```

```
% Variation #3 gives you 48 steps per cycle and a 62 peak amplitude.
% The DC term and harmonics 2,3,4,6,8,9,10, and 12 are ZERO!
```

```
% The fifth harmonic distortion is 0.149%. Total distortion is 0.241%.
```

```
/size 62 def
/speed 0 def
```

```
0 1 48 {
  /val exch def
  /speed speed size 0 gt {-1}{+1} ifelse add store
  /size size speed dup 8 eq {pop 6} if dup -8 eq {pop -6} if
  dup 8 gt {pop 8} if dup -8 lt {pop -8} if add store
  % use sinewave here
} for
```

Fig. 5 – ULTRALOW DISTORTION digital sinewaves use Guru black magic.

A mind-boggling breakthrough in micropower receivers appears in the December, 1994 *R. F. Design*. Check pages 32-44. These easily extend the max range for *legal* and *unlicensed* transmitters to 1000 feet and beyond. The key secret to this TRF variant is to have two cascaded high gain rf amplifiers, *only one of which gets*

switched on at any time!

The performance greatly exceeds the finest of superregens or single conversion superhetrodynes. There are zero radiation or image hassles.

The *Amateur Seismologist* offers fairly low cost earthquake detectors and PC support software. Meanwhile, professional geophones are available

NEED HELP?

Phone or write your Hardware Hacker questions to:

Don Lancaster
Synergetics
Box 809-EN
Thatcher, AZ, 85552
(602) 428-4073

For fast PSRT access, modem (800) 638-8369. On prompt, enter JOINGENIE. When asked for the keyword, enter DMD524.

Internet email access link: SYNERGETICS@GENIE.GEIS.COM.

from the *GeoSpace* folks.

Some antique radio resources: The *Horn Speaker* is a new labor-of-love tabloid alternative to *Antique Radio Classified*. Hard to find classic repair manuals and *Photofacts* are offered by *A. G. Tannenbaum*.

Who also, wonder of wonders, has *Radiotron Designer's Handbooks* in stock at \$15. The 1945 edition.

Replacement auto radio vibrators are offered by *Antique Automobile Radio*, while vacuum tube audio parts are sold by *Handmade Electronics*.

The key secrets for starting your own technical venture appear in my *Incredible Secret Money Machine II*, available per my nearby *Synergetics* ad. I've also now got great heaping bunches of classic Apples and parts, cheap enough to use for dedicated controllers. Write, email, or give me a call for a complete list.

A reminder that unique downloads, freebie insider secrets, catalogs, and technical help are available on *GENIE* PSRT. A ten hour free trial offer per the *Need Help?* box.

As usual, most of these resources I've mentioned appear in the *Names & Numbers* sidebar. Be sure to check this sidebar first before calling our no-charge tech helpline.

Let's hear from you. ♦

Hardware Hacker

March, 1995

The DNA computer language
Some wavelet book resources
Magic digital sinewave codes
Engineering economics review
Hot new fringe FM RBDS tuner

As you might guess, I do get more than my share of high profile nastygrams. Lately, some of them seem to reveal a dismal ignorance of a fundamental engineering topic that nobody talks about too much. So, I guess it's way past time we took a look at...

Efficiency and Engineering Economics

Otherwise known as the bang for the buck. *Efficiency* is simply how much of something you get back compared to what you put in. Physical systems *never* return more than you put in.

But an enterprise or a tech venture sometimes has an *apparent* efficiency well above 100%. This can happen if your rearrangements of the physical inputs and your personal value added causes the *perceived value* of your out-the-door products or services to exceed the cost of the parts, time, and effort that went into them.

Engineering economics is simply finding out exactly what the bang for the buck is. Get more than one buck back, and you'll have a "profit" or a "winner". Less than a buck back, and you probably should have been doing something else.

E&EE tells us why 6% efficient solar cells are useless electric power generators *at any price*. Even if free. Or why thermoelectric coolers simply *do not work* at power levels beyond eight watts or so.

Or why most solar space heating is impractical in much of Arizona. Or why it makes perfectly good sense to pour \$20,000 worth of electricity into the Gila River each year.

Or, for that matter, why it is totally insane to try and patent any million dollar idea. Or how I can easily win any one mile race. You in your BMW and me on my *Fuji* bicycle.

Some Details

Say you want to start a technical venture. You first borrow a thousand dollars for your tools and materials. Today, the actual *time value of money* of those dollars will be somewhere

around ten percent. Thus, simply to break even, your venture has got to generate more than \$100 per year and do so forever.

But your tools and materials won't last forever. If they last for ten years, then your venture must generate more than \$270 per year to *amortize* your initial expense and the time value of money over the effective life. With a five year lifetime, your venture must generate more than \$329 per year.

Just to break even!

If your *total* cost is less than the returns, then you have an economic loss. The total costs must include all parts, labor, and your time value of money. Plus great heaping bunches of intangibles.

Not to mention taxes and inflation.

Paying cash does not make much difference. Since there's other things you might be doing with the money that gives better returns.

Sadly, any "hacker economy" that

substitutes time and energy for cash will only *shift* the viability breakeven points. Often by a lot less than you'd first guess. Even when you factor in entertainment, ego, and enjoyment.

A hacker economy does not in any way eliminate those fundamentals of engineering economics. And there's likely to be subsidies involved. Both subtle and obvious.

Another name for E&EE, of course, is a simple *reality check*.

Let's go back to our examples of really bad engineering economics:

The amount of electricity *per unit area* a six percent efficient solar cell produces cannot *ever* pay for all the installation, structure, interest, land, and operating expenses. The energy recovered is simply too diffuse. The longer you run it, the more it is going to cost you.

Besides their unreliability, this is what makes amorphous solar cells such dismally poor performers. Their

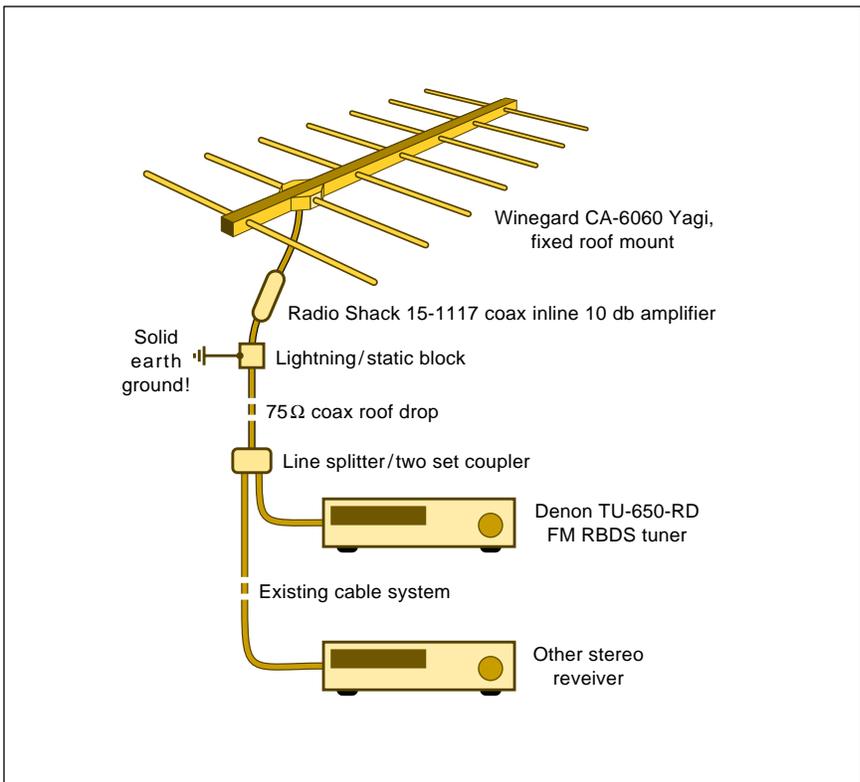


Fig. 1 – MY TEST SETUP for ultra-fringe FM and RBDS.

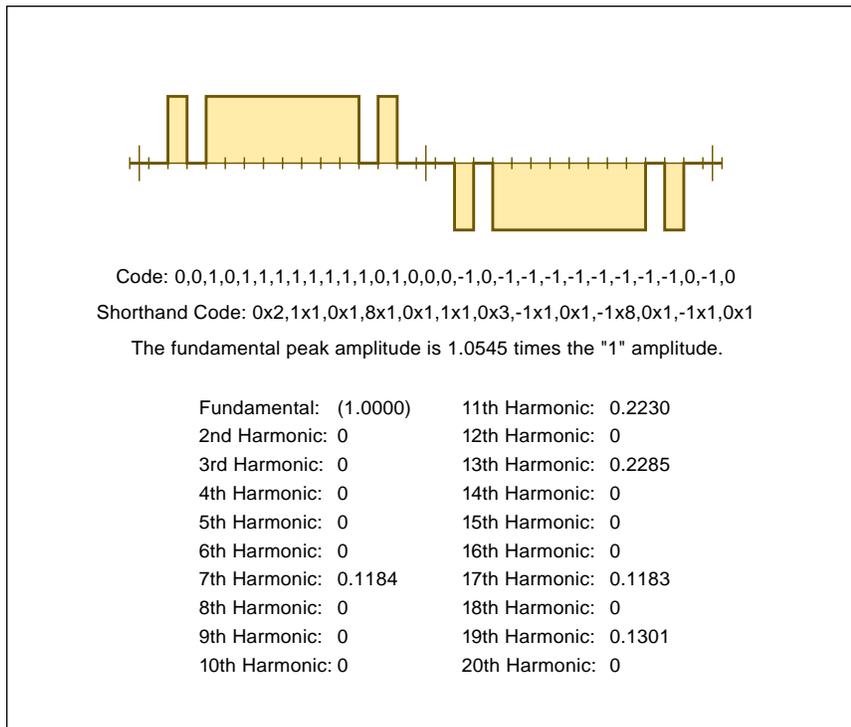


Fig. 2 – A "MAGIC" 30-BIT WAVEFORM for generating power sinewaves.

low efficiency is perilously close to economic breakeven. Which is also why commercial solar electric power plants are being chopped up and sold to hackers at yard sales. There is a lot more profit to be made in selling junk than there is in selling solar power from deteriorating cells.

In the Arizona desert, there are too few winter degree days to make solar space heating economical. It's hard to compete with \$10 worth of propane or a few sticks of wood.

Because of the gross inefficiency of thermoelectric coolers, your heat sink typically has to deal with six or more times your cooling power. At high power, the heat rise across your heatsink exceeds your cooling drop provided by the modules.

Making your "cooler" a heater!

Recovering that \$20,000 per year of Gila River electricity from a hot well down my street would demand a low delta-t plant. One whose design time, operating expenses, and time value of money would exceed income.

Especially in a flood plain.

Patenting your million dollar idea makes no sense at all. Why? Because there are not enough profits from a million dollar idea to begin to cover the costs of getting and successfully

defending a patent.

Your breakeven is roughly *twelve* million dollars in gross sales. At that 12 mil level, it is still a toss-up as to whether a patent is or is not worth all of the obscenely mind-rotting hassles involved. Much more on this in my WHEN2PAT.PS on www.tinaja.com.

Oh yeah. My bicycle race. You do, of course, have to include the time you spent working to pay for the part of the vehicle you used up during the race. Say you earn \$12 per hour after expenses. And it costs one dollar per mile to run your Beemer. Even if the BMW covers the mile at Mach 3, your minimum race time will end up five minutes or more.

Are there times when efficiency and engineering economics aren't of crucial importance? Only if nobody else can come up with a good answer to "Uh – Compared to What?"

Ferinstance, inefficient solar cells seem wonderful for calculators but useless for power generation. Peltier thermoelectrics are great for cooling a microscope slide, dewpoints, or an infrared detector. But worthless for making ice.

Solar hot water works really fine in the Arizona desert, but solar space heat does not.

Wavelets Update

There's sure been a lot of interest in *wavelets* recently. These can be a super performing replacement for the older Fourier analysis techniques that relate time and frequency. Important usage areas include everything from video compression schemes to human vision to seismography.

Advanced math is required.

The field is maturing and there are now dozens of books available. I've listed several of the more popular of them in our resource sidebar.

The best tutorial paper is probably by Rioul and Vetterli in *IEEE Signal Processing Magazine*, vol 8, #4, Oct 1991 pp 14-38. Also check that Dec 1993 issue of their *IEEE Transactions on Signal Processing*. Note that these are two different pubs.

Yes, we have wavelet shareware up on www.tinaja.com

Hot New FM Tuner

In past issues and in the *Hardware Hacker* reprints, we've been looking at ultra-fringe FM reception as well as those new FM RBDS data services. The folks at *Denon* were kind enough to loan me one of their superb new TU-650-RD premium FM tuners. At \$375 list, \$299 or so street.

RBDS is a 1200 BPS data subcarrier service. An early intro shows up as HACK73.PS on my www.tinaja.com. Along with do-it-yourself circuits. The most common RBDS use is to show the call letters and station format. Other uses are for song, singer, traffic, weather, emergency alerts, GPS corrections, and coupon radio promotions.

Sadly, most FM stations have yet to pick up on this great new suite of services, all cheaply provided. The latest *Radio World* listing shows only 220 or so stations on line.

Besides showing the station call letters, this *Denon* receiver lets you search on format. Like asking it to scan only for classic rock.

There are now only a few Arizona stations offering RBDS. But several came in just fine. Even though most of them only provided the format and call letters so far. It seems the usual chicken-and-egg problem. Nobody wants RBDS if only a few stations have it; the stations do not want to

spend money on a service nobody is yet using very much.

But all the benefits are definitely there. Especially for car radios.

Scottsdale KSLX (100.7), Kingman KZZZ (94.7), and Cottonwood KZGL (95.9), broadcast the GPS corrections. Which upgrades position accuracy down to several feet.

The theory in *differential GPS* is that you have one known and *fixed* location at the radio station. Over several dozen miles, the errors at the radio station will be pretty much the same as the error in your instrument. You just subtract the two to pick up a lot more accuracy.

More on these techniques in *GPS World*. Two major RBDS resources include *Differential Corrections* and *Coupon Radio*.

The Denon receiver would have to be slightly modified to receive GPS. This is a custom and encrypted fee based commercial service.

There are several unique features that make their TU-650-RD a good ultra-fringe receiver. A fully shielded super hot front end design. And an optional narrow band if filter that blocks most co-channel interference. Yes, you can still receive stereo and RBDS in the narrow mode.

Figure one shows my current test setup. A high fixed mount *Winegard* CA-6060 ten element Yagi on the roof pointed due west. A lightning block and ten decibel *Radio Shack* 15-1117 amplifier on the antenna. A two-set coupler in the living room driving the TU-650-RD. And on back through the previous cable system going to the second and lower quality receiver in the computer room.

Performance? First and foremost, KDKB comes in like a champ. You can arc weld with their signal. Which is all that really matters to me. There are some 40 FM stations of listenable quality. At an *average* distance of over 105 miles!

Their if filter is incredible. Weak Tucson alternate radio KXCI at 91.3 gets easily separated from the much stronger Phoenix KJZZ at 91.5.

The rule on a bandpass filter is to try it and see. If the station *changes*, or the noise goes *up*, you have got co-channel problems. But any weak signal by itself might come in better with or without the filter. In general,

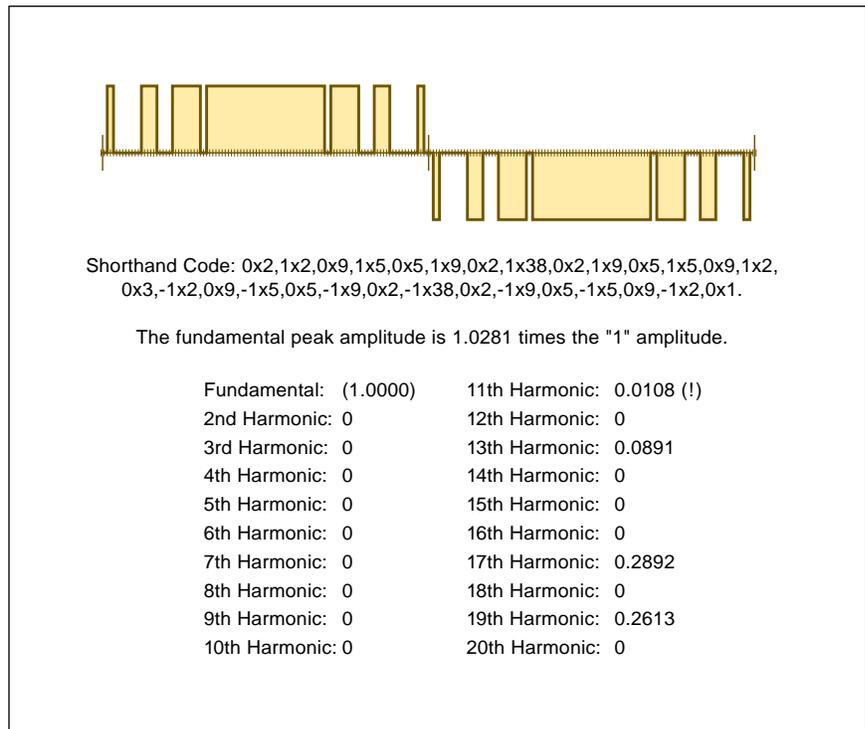


Fig. 3 – AN "EVEN MORE MAGIC" power sinewave waveform of 210 bits.

the filter only makes a difference on a few stations.

But what a difference.

Does it make sense to add a lower quality booster at the antenna ahead of an ultra hot receiver? A modest 10 db boost at your antenna gives your antenna a fixed impedance to work into and makes up for both line and distribution losses.

The slightly higher signal level is enough to override the "no stereo on weak signal" feature. Which lets you switch by yourself rather than using the factory preset. Naturally, mono is cleaner for marginal signals.

But any preamp also adds to your cross mod and can cause overloading. Which was only observable at half a

channel away from a nearby station. If you use a preamp, be sure to use an inline coax version which is totally shielded. Providing you with only the bare minimum gain needed.

Does a fixed antenna make sense? Fixed is cheaper and more rugged. And there's not too much east of me because of this slight rise that some folks call the Continental Divide.

But Bee does not get her classic Tucson KUAT very well. Despite its strong reception on the car radio in the driveway. Some sniffing around with an unboosted cheap fringe-but-not-ultra *Radio Shack* 15-1636 FM antenna led to a big surprise.

A large number of FM stations appear to now use *vertical* or *circular* polarizations. Their apparent aim is to improve nearby auto reception at the cost of distant coverage.

For KUAT, flipping the antenna to the vertical dramatically improved the reception in Thatcher.

The ultimate solution is antenna height. Which conquers all. At the top of the two mile high mountain in my front yard, I can take a \$4 pocket FM receiver and tune it to 93.3. By pointing the whip antenna in one of three directions, I can get KDKB in Phoenix, KKOB in Albuquerque or a

NEED HELP?

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(520) 428-4073

US email: don@tinaja.com
Web page: www.tinaja.com

WAVELET BOOK RESOURCES

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- G. Wornell, *Wavelet-Based Signal Processing with Fractals*, P-H, 1994.
- R.K. Young, *Wavelet Theory & Its Applications*, Kluwer Ac, 1992.

Mexican station from the south.

Tuning on the TU650RD is every 100 kiloHertz, giving you one stop *between* channels. This could reduce co-channel interference or might be useful for some homebrew wireless broadcaster that is off frequency. It also helps the channel six tv sound near 87.8 MegaHertz.

One strange restriction: This tuner is so hot you'll have to activate the internal rf attenuator to prevent any overload on cable systems. For some reason, you can only do this from the remote. I suspect this may have been an afterthought when the design was nearly completed.

Because there is a microcontroller inside, you'll find all sorts of unusual features. You can manually teach any *non*-RBDS stations their call letters and formats. Or store other messages

of 13 or fewer characters.

You can scan for all of the classic rock stations, all the news stations, or any of 20 other formats. Since there is no keyboard as such, you use the *up/down* button to select any of the 66 characters. Which is not quite as bad as it sounds.

There are 30 station presets. These are bright enough to remember the RBDS or manually entered data, AM versus FM, the rf attenuator setting, and the filter bandwidth.

There is a panel light dimmer. All presets get saved during power down.

The power consumption is only 12 watts. Being a component tuner, an external stereo amplifier is needed.

I'd sure like to see a "raw" RBDS output jack on this product.

The next step here is obvious. A monthly updated plug in card, chip,

or modem line that stores *all* of the stations in North America with all of their formats and the operating hours. Which would be most useful for long auto trips.

More "magic" Waveforms

High power sinewaves are quickly becoming one hot hardware hacker topic. For such uses as car battery power inverters, UPS computer power supplies, telephone ringers, electric autos, line conditioning, and variable speed induction motor drives.

Most of these apps *demand* fairly decent sinewave outputs. Square or other sloppy waveforms could cause inefficiencies, heating, resonances, cogging, or severe audio whine.

Analog solutions which use power amplifiers will not hack it because of their lousy efficiency.

A microcontroller oriented digital solution is the *only* route to use these days. Especially when stability, wide range, easily adjusted voltage, or a constant speed is involved.

You'll also want to minimize how many power switches you use. And you'll want your switch currents to be reasonably efficient.

So, the trick is to find a "magic" single train of fixed amplitude ones and zeros that could fake a decent variable voltage sinewave. Often, you will pick a RZ or *ternary*, or PWM pulse width modulation scheme that has states of +1, 0 and -1.

Figure two shows a wonderfully "magic" 30 bit waveform for power sinewaves. When you go through *all* possible binary sequences for 36 or less bits per word, there is *no* other code that even comes close.

The "top" half of your waveform is 00101111111010. The "bottom" half gets repeated with -1 values. Note that you mirror top-to-bottom but *not* right-to-left! Giving you the 30 bit word. Or a 1800 Hertz clock for 60 Hertz line power. The 30 bit length nicely taps out by tens if you need three phase power.

Believe it or not, this elegantly simple "magic" word has a *zero* dc term. It has *zero* second, third, fourth, fifth, sixth, eighth, ninth, and tenth harmonics! The peak fundamental is around five percent *above* the "1" value, for nicely behaved switching currents. The seventh harmonic ends

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4401 South Beltwood Pkwy
Dallas TX 75244
(214) 450-0400

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(201) 575-7810

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10121 Miller Avenue #201
Cupertino CA 95014
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401 North Washington Street
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(800) 638-9636

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Eugene OR 97440
(503) 343-1200

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Piscataway NJ 08855
(908) 981-0060

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Radio World
5827 Columbia Pk #310
Falls Church VA 22041
(703) 998-7600

Science/AAAS
1333 H Street NW
Washington DC 20005
(202) 326-6400

Synergetics
Box 809
Thatcher AZ 85552
(520) 428-4073

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27 Gate Five Road
Sausalito CA 94965
(415) 332-1716

Winegard
3000 Kirkwood Street
Burlington IA 52601
(319) 754-0600

up around 11.8% amplitude, which will translate to 1.39% power.

Uh, there are a few minor points over this one, though. There's flat out no way you are going to get all those fancy square corners with nothing but a fundamental sinewave and a weak seventh harmonic.

So, all the 11, 13, 17, and 19 teen harmonics are sorta gruesome. But no worse than the third in any plain old square wave. They end up mid-audio with 60 Hertz power. But these are usually easy to filter out. Even the winding inductance of a motor acts as a low pass filter.

Still, you will definitely need some low pass filtering and you will have to watch for system resonances.

Note that the "-1" state can simply be a reversed current. With a bridge driver, only a single supply is needed for both current directions. Another option is to use a *pair* of oppositely phased windings.

Details vary with the use and your intended application..

Naturally, the fine general purpose PostScript computer language is *the* quick and fun way to interactively analyze waveforms. I've written a new [FOURIER.PS](#) tutorial exploration utility and my [ZEROHARM.PS](#) code finder to www.tinaja.com

I'm currently checking out 210 bit words using PostScript. One highly interesting 210 bitter is shown in figure three. Whose very first nasty harmonic is the *seventeenth*.

A library of low harmonic codes with listings of different fundamental amplitudes can be used to provide variable output voltage from a fixed supply. Call me for details.

At longer bit lengths, you do have to think smarter rather than harder to quickly get any useful answers. But PostScript does explore any high bit count words with aplomb. The key secret is to represent your words by ones and zeros *in a string*. And then manipulate the strings.

Many thanks to mathematician Jim Fitzsimons for his help on this.

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New Tech Lit

From *Crystal Semiconductor* a new *Audio Databook*. On digital audio products, particularly low distortion delta-sigma A/D converters.

From *Dallas Semiconductor*, a *System Extension Data Book*. This book includes digital potentiometers and electronic thermostats.

From *National Semiconductor*, a *Power IC's Databook*. Full of linear and switching regulators, motion controls, and power drivers.

That November 24, 1994 issue of *Science* proves something that has been completely obvious to me for some time. That 97% of so-called "junk" DNA is really a sophisticated

computer language! Or, at the very least, passes all the exact tests in the same ways that *all* current human and computer languages do.

Details on page 1320.

If you want to make a real quick buck on this, just publish the pocket reference card for the DNA language. And maybe show us how to access a utility subroutine or two.

At long last, the *Millenium Whole Earth Catalog* is shipping. A "must have" essential resource on access to tools. Don't miss this one.

I've just newly reissued my classic *Active Filter Cookbook* and do have bunches of autographed copies on hand. And I do still have scads of classic Apple computers, monitors,

cards, and drives on hand. Cheap enough for use as a programmable controller. Even rare and collectible Apple III's. Write, call, or email me for more details.

A reminder that unique downloads, freebie insider secrets, catalogs, and technical help are available on my www.tinaja.com. More info per the *Need Help?* box.

Please note that my area code has just changed to 520. Be sure to update any earlier catalogs or whatever I may have sent you.

As usual, most of these resources I've mentioned appear in the *Names & Numbers* or *Wavelets* sidebars. Be sure to check here first before you call our no-charge tech helpline. ♦

Way on back in the seventh grade, I got this brilliant idea on how to "improve" VHF radio vacuum tubes by *eliminating* all of their internal interelectrode capacitance!

The scheme was to arrange the cathode and plate planar beside each other. Then place the grid up at right angles. The reasoning was that there would be zero capacitance among the three. Magnets got vaguely assigned to somehow bend the e-beam from cathode through grid to plate.

I even sent this idea to RCA.

Sorry, but electrical capacitance *always* exists *everywhere*. Separate a conducting point from another with an insulator, and you got a capacitor. Period. All that my scheme did was reduce it slightly. Obviously, I had never heard of *transit time*, *electron ballistics*, or *parasitics*. Or any of the other crucial gotchas important for any high frequency design.

Naturally, it never dawned on me for an instant that similar ideas might have occurred to RCA's hired help.

Uh, history seems to be repeating itself. First as a tragedy and then as a farce. So we need to talk about...

"Too Good to be True" Results

Let's see. One caller has this zero inductance scheme that is remarkably similar to my zero capacitance one.

There's all of the usual motors and magnets perpetual motion folks.

Another has information traveling faster than the speed of light. One believes that a ridiculous amount of spark advance is all you need for a super efficient gas engine.

Yet another claims an ultra small satellite antenna.

I would really like to reply to all of these people "You are wrong." The outcome is not now and never was in doubt. All that remains is deciding whether you want to find out *how* or *why* you made your error.

Well, figure one shows you my guidelines for dealing with "too good to be true" results.

If you have *any* conductor routed

between two points in space, you *do* have inductance. Period. All that a non-inductive winding does is make the inductor physically *larger*.

Nobody, but nobody who has ever stayed awake during the Physics 101 lecture would even dream of trying perpetual motion. Without exception, *each* and *every* attempt to date has failed spectacularly. There is *not one shred of evidence* that such a thing is even remotely possible.

On extreme spark advance, there are few dead horses that haven't been whipped as thoroughly as this one. Try the *SAE Library* for more info.

I got the impression the antenna person never even heard of Doctor Maxwell's silver hammer. Nor read chapter twelve of H. Jasik's *Antenna Engineering Handbook*. Nor have they appreciated the zillions of small antenna failures and outright scams littering all of TVRO history.

An antenna has an *effective area*. There is a specified amount of input energy flux going into that area. You can do no better than grab it all. But even *trying* to grab it all will lead to a bad scene with ugly *sidelobes*.

You want a smaller antenna, raise

your frequency and up your transmit power. That's how the DBS folks do it for their new services.

I very much do like to encourage people to think about things and then come up with new ways of looking at problems. And, yes, new or improved antennas are certainly possible.

But results that are "too good" are *always* suspect.

New BASIC Stamps

Lance Wally of *Parallax* just sent me a few samples of his brand new BS1-1C *BASIC Stamp Module*. This is an *entire* computer measuring 0.4 by 1.4 inches. At \$29 each. Figure two shows you this stamp's actual size. The schematic for the new stamp is shown in figure three.

Just in case you've come in late, there's a new microcontroller on the block called a PIC chip. These are now clearly *the* hacker component of the *decade*. Under one dollar in large quantities. Dozens of PIC projects already have appeared in print. With hundreds more on the way.

Thanks to an unusual architecture and a minimal RISC instruction set, PIC's *completely* blow away *all* of

0. They are.
1. The primary cause of an outrageous result is an outrageous mistake.
2. The secondary cause of an outrageous result is not having enough tools and skills to understand the problem.
3. Outrageous results *demand* that you make heroic efforts to thoroughly *disprove* them.
4. It is trivially easy to be "not even wrong".
5. Have others ever thought about this problem? When? How?
6. Have you completed a thorough DIALOG search? Do you personally subscribe to most of the industry trade journals? Are you aggressively using online resources?
7. What do you know that "they" do not?
8. What are you bringing to the table that is genuinely new?
9. Is hubris a factor?
10. Extreme paranoid secrecy or obsessions with patent "protection" are *certain* to cost you dearly in the long run.
11. If the result *still* looks legit, reduce the effect to its most fundamental terms. Then create a simple and reproducible experiment that some disinterested outsider can verify or disprove.

Fig. 1 – MY GUIDELINES FOR results that are "too good to be true".

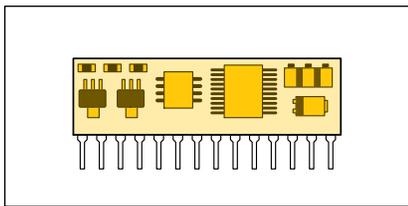


Fig. 2 – NEW \$29 BASIC STAMP is a superbly versatile microcontroller. It is shown here full size.

the earlier microcontrollers. Usually with 3X or even higher performance. The same unusual architecture makes it possible to distribute any problem among two or more PIC chips.

The PIC chips are far easier to use than, say, a 555 timer. And lead to *far* lower cost products.

If your circuit has *eight* or more parts in it and if one of them is any active device, then you most likely should use a PIC instead.

As we saw last month, you can easily perform such PIC tricks as a complete digital sinewave generator using only *six* bytes of code.

But the really great thing about PIC chips is that they are simple and fun to use. *None* of the traditional micro hassles remain.

You can easily hand code these without ever going even remotely near an assembler or an emulator. In fact, I strongly recommend that you write *at least* your first 1200 lines of PIC code *by hand*.

For those of you that don't want to jump in with both feet, the BASIC Stamps make becoming micro literate quite easy. After a few of the stamp projects, you can step up to "real" PIC projects with blazing speed.

No matter where you look in the PIC universe, amazing and elegant hacks show up. Note the apparent misprint in figure three, where a logic output becomes the supply pin for another chip. This is in fact a cute power saving trick.

If you aren't immediately using a chip, disconnect it.

I'll get into these a lot more in future columns. But for now, you get started by picking up the free catalog from *Parallax*, the "must have" free *Microcontroller Handbook* and *PIC Applications Manual* from *Microchip Technology*, and the really unique *PIC Tools and Stamp Extenders* from *Scott Edwards Electronics*.

As our resource sidebar for this

month, I've listed several more key sources for PIC info and applications support. Don't miss this one!

AC Motor Drives

Induction motor speed controls and electric auto drives are both of major hacker interest these days. In both cases, your key secret is to come up with a variable voltage and a variable frequency power sinewave.

Cheaply and conveniently.

Sadly, a plain old linear amplifier will not hack it. Because there's no known linear amplifier scheme that offers any decent efficiency.

Instead, we might want to go to one of the routes of figure four. A dc power supply gets connected to one winding of an ac motor through a pair of switches. These switches are often called a *bridge drive*.

The trick is to flip the switches just right so that your motor thinks it is seeing a variable voltage and variable frequency pure sinewave.

What gets hairy fast is that we'll want to minimize motor *harmonics*. Because harmonics cause power loss, whine, cogging, and even instability. You'll also want to flip your switches as *few* times as possible *per cycle*. Because each flip costs you dearly in *transition losses*.

A classic method of dealing with power sinewaves is known as PWM, short for *pulse width modulation*. A high frequency carrier becomes duty cycle modulated with the sinewave.

The fundamental is *not* present at first. It only appears after you *sum*, or *integrate* up your PWM waveform. Fortunately, the inductance of the motor winding forms a low pass filter which doubles as an integrator. Thus converting the duty cycle variations into a fundamental sinewave.

There'll be no low harmonics if the carrier frequency is high enough.

But PWM does have some nasty habits. Nonlinearities, quantization, or dc offset in the modulation shows up as output distortion. And the high frequency carrier amplitude is *always* larger than the fundamental.

Gruesomely so for low amplitude fundamentals. And there is all that higher frequency energy to contend with. Also ugly are the high number of transitions per cycle.

By using the *magic code* method,

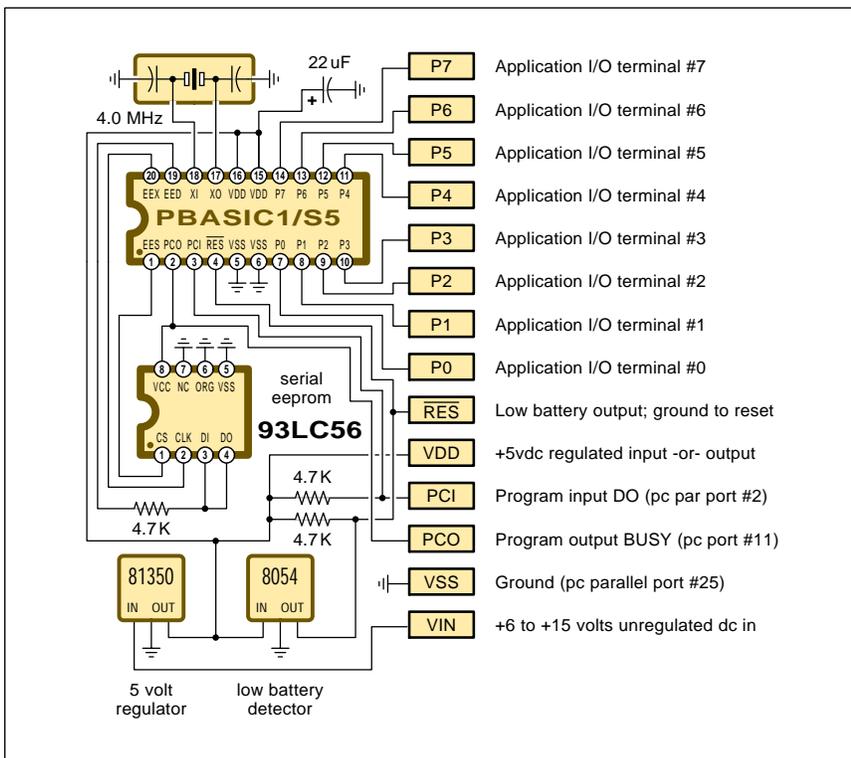


Fig. 3 – BS1-IC BASIC STAMP schematic. This is the first microcomputer that is faster and easier to use than a 555 timer.

you come up with a switch flipping pattern that looks like a fundamental sinewave. The waveform shown is one of the simplest you can build that has a strong fundamental, zero even harmonics, and a zero third. It has very few transitions per cycle. On the other hand, there's only one value available. And it's got a fairly strong fifth and seventh.

Do note that classic PWM changes *both* sides of the bridge at the same time. Even for a comparable number of transitions per cycle, PWM has *twice* or more the losses.

In our simple example shown, the magic code requires only *four* single transitions per cycle, compared to *twenty-four* double ones for PWM. While we can't claim this is "twelve times more efficient", we certainly might say that those high frequency transition losses are only 1/12th as much. And PWM often uses *much* higher frequencies for even worse performance.

Fewer losses, of course, let us use cheaper drivers, lower temperatures, and smaller heatsinks.

Thus, the magic waveform method would seem to be better. *If* we can locate some having lots of different amplitudes and low harmonics.

We saw last month that a magic half waveform of 00101111111010 has no dc term, no even harmonics, no third and fifth, and a fairly weak seventh.

To pick up the other half, you use a code of 00-10-1-1-1-1-1-1-10-10. Do this by reversing your bridge to run your current *backward* through the motor winding.

All of which is a good start. Go through the 30-bit math, and you'll also find that 000110111101100 has around 83 percent amplitude and that 000101011010100 has got around 62 percent amplitude. Equal to 69 and 38 percent power. While still keeping a zero third and fifth. Plus, of course, good old trivial 000000000000000 for the zero amplitude.

Which gives us four amplitudes to work with at 30 bits. For many apps, you'll want a lot more than this. The obvious thing to do is increase the number of bits in your word. It turns out that words that are *products* of low harmonics can force all of those harmonics to zero.

The most obvious next stopping point is a 105-bit half word. Because $3 \times 5 \times 7$ equals 105. Now, there are a *lot* of possible 105 bit words. Rows and rows of them even. But it turns out that only a mere 2219 or so of them end up with zero third, fifth, and seventh. These also have zero ninth, fifteenth, twenty-first, and such. Plus no dc term and no evens. Which means that harmonics 0,2,3,4, 5,6,7,8,9,10,12,14,15,16,18,20,21, and 22 are all zero.

And that ain't half bad.

Some of the magic sinewaves will have too much distortion. Others will have too many transitions. And yet others won't hit the amplitudes we want. Or cause amplitude jitter.

But if you go through the list, you can pick out 103 or so magic sines per our list in figure five. These give you roughly one percent amplitude control. And have far fewer losses than PWM.

To use this list, you "unfold" the strings to get magic words of length 210. You then stash these in a table lookup memory somewhere. Pick a

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magic word for an amplitude. Pick a selected delay for a frequency. And that's all there is to it.

If really needed, the few "missing" words in figure five can be gotten around by going to 420 bits.

Howdidyadoit?

With PostScript and an Apple IIe, of course. How else are you going to exhaustively explore all possible 210 bit binary words?

As always, I've found PostScript's friendly interactivity to be *the* way to solve a seemingly sticky problem.

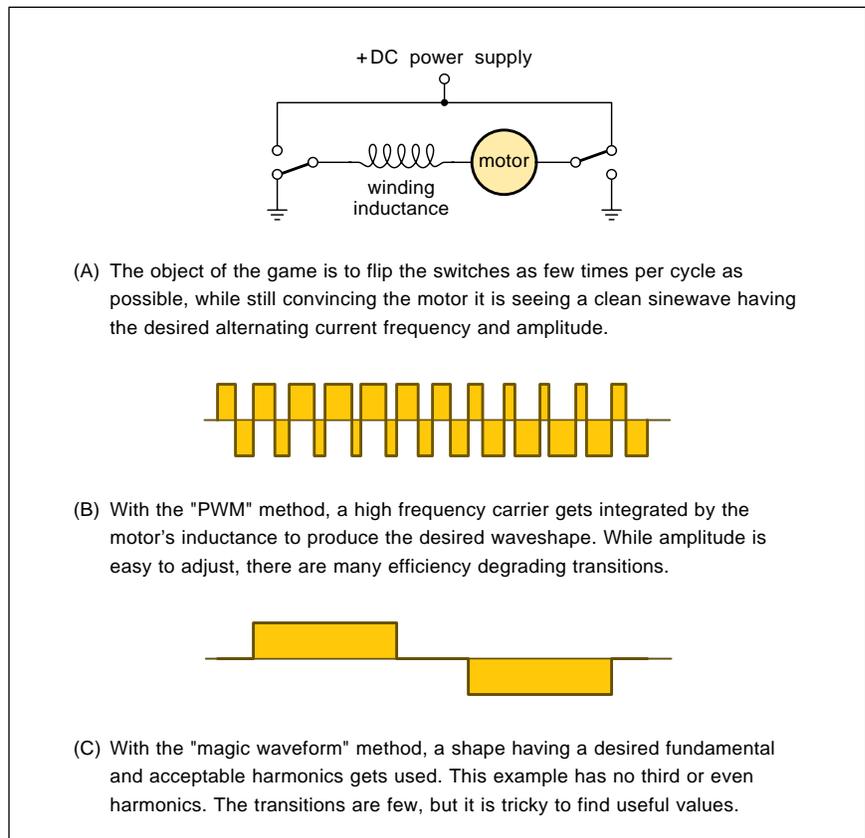


Fig. 4 – TWO APPROACHES to high power adjustable sinewaves.

PIC MICROCONTROLLER RESOURCES

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for a zero seventh. 34 equations in 52 unknowns should, in theory, reduce to one equation in 18 unknowns.

262,144 states or so.

Which still might need a break or two for coconut anchovy pizza.

Instead, we think smarter and not harder. These are *general* equations. But *all* of our inputs and *all* solutions have to end up *binary* ones and zeros. You can thus eliminate some of these words immediately and test for the rest. Which quickly generates all the 2219 possible candidates.

You then run your Fourier Series only on the good ones. Leaving you with a few hours work at most.

Full details are on www.tinaja.com in [FOURIER.PS](#), [ZEROHARM.PS](#), and [SN210CAT.PS](#). Plus a few others.

Many thanks to math genius Jim Fitzsimons for his valuable inputs on all this. Yeah, we've got consulting services available for this exciting new hacker topic. A kit or two may also be in the works.

Surely others have plowed some of this ground before. If you know of

any tech papers on power waveform harmonics, please send them to me.

For a free *Incredible Secret Money Machine II* book copy.

Now, the real challenge is to find the improved 440 bit magic word list. Which should give us fewer losses, lower distortion, and more choices. Yet still keep reasonable 26.4 kHz switching frequencies.

This one might take a tad longer, though...

New Tech Lit

From *Sony*, a bunch of new data books. Including their *Multimedia Computer Audio/Video*, *CCD Area Sensors*, *CCD Linear Sensors*, and *Radio Communications IC's*.

From *Motorola*, a new *Rectifier Applications Handbook*. It includes some mind numbingly obsolete filter design info.

They completely missed the fact that you can *instantly* design any 60 Hertz full wave filter cap simply by memorizing this factoid: In an 8300 microfarad capacitor, your *volts* of

ripple equals the *amps* of current.

Marvin Simon's *Spread Spectrum Communications Handbook* offered by *McGraw Hill* does seem to be the definitive tome on the subject.

All 1228 pages of it.

This textbook clearly shows the military jamming heritage of spread spectrum comm. For it takes them until page 1186 or so to get around to mentioning that there *might* be some commercial uses for this stuff. For a totally different approach to the same subject, check out Randy Robert's *Spread Spectrum Scene*.

From Dave Strom, a new *Power Up* book on making battery adaptors for military surplus radios. Pub by *CRB Research*.

That *Scientific American* mag for January 1995 has a great project on sonoluminescence. In their *Amateur Scientist* section. Costs are in the hundred dollar range. Useful results should be obtainable in any fairly advanced home lab.

The fusion energy potential for sonoluminescence is talked about in

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Science of December 16, 1994, p1804. Sonoluminescence can routinely hit a million degrees C and a 100 million atmospheres. All in a flask.

Of course, I did tell you all about sonoluminescence long ago. More in [HACK73.PS](#) on www.tinaja.com.

Lots of info on *bright* blue light emitting diodes in the January 6, 1995 *Science* on pages 51-55.

Few people are aware that LED's are potentially five to ten *times* more efficient than an incandescent lamp. As auto taillights, LED's are also *much* safer. That quarter second or so turn on risetime of an incandescent lamp translates to *twenty feet* of delayed warning at thruway speeds!

For info on speech synthesis and recognition, check into the *AVIOS*, or

American Voice I/O Society. Their next applications conference will be Sept. 12-14 in San Jose, CA. Journals, proceedings, and vendor's directories are also offered.

The *Electric Spacecraft Journal* is one interesting pseudoscience pub. There is also an *Anomalous BBS* on related off-the-wall topics.

Historically Brewed is that unique magazine offered from the *Historical Computer Society*. \$3 trial issues.

Free *P-Nut* connector samples are available through *Kleinhuis North America*. These are a long overdue improvement to wire nuts.

For most hardware hackers most of the time, patents are an utter and total waste that is *guaranteed* to cause you a net loss of time and money.

The reasons behind this along with fully tested and proven real-world alternatives now appear in my *Case Against Patents* package. Which also includes my *Incredible Secret Money Machine*. Details are found in my nearby *Synergetics* ad.

A reminder that unique downloads, freebie insider secrets, catalogs, and technical help are available on my www.tinaja.com Details in that *Need Help?* box.

As usual, most of these resources I've mentioned appear in the *Names & Numbers* or that *PIC Resources* sidebars. Be sure to check here first before you call our no-charge US technical helpline.

Let's hear your comments on some of these new opportunities. ♦