by Don Lancaster

Emerging Tech Opportunities II

Way back in *Blatant Opportunist #4*, we checked into several emerging new opportunities. Stuff which was developable on a small scale, which did not go up against any heavy duty competition, had the correct overall vibes, and was sitting right upon some technical, paradigm, or economic breakpoint on its curve.

Looking back, most of my predictions turned out to be right on. As to some others, well, you may have to give them a while longer to develop.

For this time around, I thought I'd throw several newer happenings onto the pile. Stuff that's come up in the two intervening years. Stuff that I am certainly going to be taking a very close look at. Such as...

Dye Based Solar Electricity

Silicon solar cells have pretty much had it. They just don't know it yet. The largest solar cell power plant in the country has recently been torn down and sold to hackers at a yard sale. They found they could make more money by selling off surplus parts to hobbyists than they could by generating any electrical power. *Surplus Traders* is one of many sources for the leftovers.

Sadly, most US solar cell producers have been acquired by major oil companies and then meticulously smothered under layers of bumblingly incompetent management.

You'll find several inherent flaws in silicon solar cells. Silicon is ultra hard, quite brittle, and highly opaque. But worst of all, it only accepts energy in discrete "one size fits all" energy packets. At one near-infrared light frequency, the packets are precisely the right size for a fairly efficient conversion. Lower frequencies become waste heat, and any "spare change" above the key packet size caused by higher frequencies is also blown as waste heat. As a result, the best theoretical sunlight efficiency you could even hope for in a silicon cell is 26 percent. But real world cells do not come remotely near this figure. And efficiency is crucial.

The only tiny little thing that silicon cells had going for them was that they were better than anything else. But this might be changing in a really big hurry, thanks to a newly emerging *dye based solar* technology.

If the sun was a radio star, you would simply build an antenna and a rectifier. Efficient power conversion would be yours. The technology required is ancient and almost trivial. In fact, you would call it a *crystal set*.

Until recently, it has not been all that obvious how to build optical antennas and rectifiers. One earlier attempt was known as *Lumeloid* films from *Advanced Research and Development*. Using microlithography to place submicron antennas and metal barrier diodes on glass.

But it turns out that certain organic dyes can act both as efficient antennas and rectifiers. These dyes are related to those involved in plant photosynthesis. The big difference is that the dyes only raise energy levels of their electrons, while the plants use the raised energy for organic reactions that make cellulose, sugars, and other tasty stuff.

One key paper on dye solar methods can be found in the 1990 *International New Energy Technology Symposium* run by the *Planetary Association for Clean Energy*. And two more appear in the October 24,1991 issue of *Nature*.

A pair of wildly different magazines on solar power use are *Home Power* and the *EPRI Journal*. I've got lots more solar info in my HACK46, HACK49, HACK53, and in newer files at *www.tinaja.com* As well as being available in my new *Hardware Hacker III* hard copy reprints.

Wavelets

There's a genuine revolution coming down in applied mathematics, centered on *Wavelet Theory*. A revolution that is having a stunning impact upon most engineering subjects. From cardiology through seismography. From animal vision through side looking radar. From video compression up through radio spectrum analyzers. From holograms through digital signal processing.

Until recently, all of these topics had one big thing in common: To carry out any useful analysis or advanced development, you had to use *Fourier Analysis*, an ancient tool that everybody loves to hate.

Traditionally, Fourier let you transform the *time domain* into the *frequency domain*. For instance, a square wave will bounce up and down against time, while it will consist of a string of odd harmonics with respect to frequency.

Fourier analysis has several major problems that the wavelets can avoid. Fourier is a "take-it-or-leave-it" sort of *linear* tool. Change anything and you'll change everything. And the edges of your analysis (called *windowing*) need special treatment. Wavelets instead behave as a *log* tool which lets you analyze on a global *and* a local basis.

Video compression is an important new wavelet app, especially for HDTV. Compared to the klutzy and primitive JPEG and MPEG schemes, wavelets offer simpler and more standard circuits, better results, and zero "tiling" artifacts.

Wavelets also can let you work on the big lumps first, quickly giving you a lesser resolution image and adding detail when and as needed. Which can get very important

in animated video and rapid movie scene changes.

To become wavelet literate, start with those intros in *Science* for August 24, 1990, and *EE Times* for November 5, 1990. Then go on to the tutorials in *IEEE SP* magazine for October of 1991, and *Dr. Dobbs Journal* for April of 1992. Your definitive book is *Wavelets and Their Applications*, published by Jones and Bartlett (617) 482-3900.

The folks at *Aware Inc.* (617) 577-1700 do have *Wavelet Explorer* software and several free reprints. I have bunches of wavelet links and books at *www.tinaja.com/wave01.html*

GPS Navigation

Global Positioning Satellites have been called the next major utility. A roving flock of satellites on frequencies of 1227.60 and 1575.20 Megahertz whose spread spectrum differential phase measurements can tell you exactly where you are and how fast you are now moving. Typically to a navigation accuracy of a hundred feet or so. Which is way better than the best topo maps. By carefully going to *differential* techniques, you can often achieve land survey precision of less than an inch.

Your receivers can be wallet sized, including a built-in antenna. Even backpacker's versions are already available. Costs are presently in free fall, with $600 receivers being a typical low end at this writing. Within three years, it is reasonable to expect a $35 chip set and full receivers for under $99. Within five, a $45 *Radio Shack* Navicube.

Uses? What *can't* you do with low cost and universal nav, position, and speed info? Vehicle location. Trucker's dispatch control. Robotics. Land surveying. Not getting lost on a hiking trail. All of that obvious military stuff. Toys. Orienteering. Remotely controlled vehicles. Pipeline work. Well logging. Aircraft nav. Vacation car travel. Altimetry. Drug smuggling. Aerial platforms. Self-positioning maps on CD ROM. Offshore operations. Timber silvaculture. Sailboat racing. Archaelogical digs. Skiing. Ore bodies.

Or anyplace or anytime else you are outdoors and want to see a red dot that says "You are now here, are at this elevation, are going this fast, are headed in this direction, are accelerating at this rate, and the time is now."

A useful intro book on GPS is available from *Trimble Navigation*. The key government document ICD-GPS-200 is provided by *Space Systems Division MZEE*. A primitive and outdated but very informative GPS hacker construction project is offered by *DKD Instruments*. The leading trade journal is *GPS World*. And your better tutorials and most useful ongoing insider info and conferences are provided by the *Institute of Navigation*. Or see my HACK48, HACK51 and newer files in my Navicube library

Spread Spectrum Communications

These GPS satellites are one of many emerging uses for *spread spectrum communications*. Spread spectrum comm sounds almost magic. Self addressing signals which are easily and reliably extracted from unbelievably deep noise and severe interference. Comm which can be highly secure and extremely difficult for most outsiders to detect. Several stations can be on the same center frequency at the same time without interfering with each other. The licensing requirements are also much less of a hassle than traditional comm, since the field strength at any one frequency can end up ridiculously lower.

Most spread spectrum comm is digital and frequency modulated. Each one or zero in your original message gets replaced by a carefully chosen and longer pseudo-random *spreading code*. Chosen such that your final transmitted bandwidth is very much broader than that needed by the original signal. On reception, the spreading codes will very strongly correlate, while much of the noise cancels.

It is sort of like having each and every AM radio station channel broadcasting the same song. By tuning to all of them at once, you can get your song to reinforce, and have most of your background noise cancel out or, at the least, severely reduce itself. Each channel can now operate at far less power. Especially if you already know the tune.

Uses? Military security and bugging devices obviously. And, of course, planetary probe comm. But all the newly emerging and more convivial applications lie in wireless data networks, both local area and city wide. For cellular phones. New pager services. Ham radio. Emergency fire, police, and ambulance comm. Or GPS satellites, where as many as 24 birds are simultaneously broadcasting on the same center frequency. Without interference.

At one time, spread spectrum comm looked obvious for voice and appliance data carriers routed over home power lines. But so many spike and noise filters are now in use that hopes are rapidly dimming for this particular ap. The radio frequency impedance of home and industry power lines have dropped dramatically in the last decade. Many power lines now offer an essentially dead short at low radio frequencies. So this particular hound may not hunt. But the rest of the pack is clearly off and running.

Something possibly off-the-wall: Possibly not. Spread spectrum is ideal for transmitting long distances through extreme noise. Would it not be a totally obvious choice for extragalactic communications? With multi-level codes, the dummies out there could determine that something was up, while the bright ones could receive the full set of plans in the same message. A multi-level marketing scheme which clearly beats sending out prime numbers forever.

I haven't yet gotten around to any really heavy duty research into spread spectrum, but here's a few resources to get you started: Just about all scientific publishers offer at least one book on spread spectrum theory. Dixon's *Spread Spectrum Systems* from *Wiley* being typical. The *ARRL* publishes a *Spread Spectrum Sourcebook*, mostly for ham radio applications. One major patent is #4,455,651. A new labor of love newsletter called the *Spread Spectrum Scene* promises to deliver lots more on this topic.

The May 92 issue of *Microwaves & RF* offers a current applications update. Also try the *EE Times* trade journal. A wireless book list is at *www.tinaja.com/amlink01.html*.

Calling Party Identification

Many telephone operating companies are starting to set up a new group of CLASS services. By far the most popular one of these is *calling party identification*, or *caller id* for short. Caller id is just plain wonderful. Among its many overwhelming benefits, when you come back from lunch, you have a free and no-hassle list of every one who tried to call you, with an asterisk beside anyone who was antsy enough to have called twice.

A very vocal, totally irrational, badly misinformed, and negligibly small minority has now thrown out some legal

EMERGING TECHNICAL RESOURCES

Advance R&D
359R Main Street
Athol, MA 01331
(508) 249-4696

Aware Inc
One Memorial Drive
Cambridge, MA 02142
(617) 577-1700

Cermetek
1308 Borregas Avenue
Sunnyvale, CA 94088
(408) 752-5000

Dallas Semiconductor
4350 S Beltwood Parkway
Dallas, TX 75244
(214) 450-0400

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

DKD Instruments
1406 Parkhurst
Sima Valley, CA 93065
(805) 581-5771

Dr Dobb's
411 Borel Avenue #100
San Mateo, CA 94402
(415) 358-9500

EPRI Journal
5310 Derry
Agoura, CA 91301
(800) 638-2581

Galco
26010 Pinehurst Drive
Madison Heights, MI 48071
(800) 521-1615

GPS World
PO Box 10460
Eugene, OR 97440
(503) 343-1200

Grainger
2738 Fulton Street
Chicago, IL 60612
(312) 638-0536

Hello Direct
140 Great Oaks Blvd
San Jose, CA 95119
(800) HI-HELLO

Home Power
PO Box 130
Hornbrook, CA 96044
(916) 475-3179

IEEE SP
445 Hoes Lane
Piscataway, NJ 08855
(908) 981-0060

Institute of Navigation
1026 16th Street NW #104
Washington, DC 10036
(202) 783-4121

Jones & Bartlett
20 Park Plaza
Boston, MA 02116
(617) 482-3900

Lindsay Publications
PO Box 538
Bradley, IL 60915
(815) 935-5353

Motion Control
800 Roosevelt Road E-408
Glen Ellyn, IL 60137
(708) 469-3373

PCIM
2472 Eastman Avenue #33-34
Ventura, CA 93003
(805) 658-0933

Planet. Asso. Clean Energy
191 Promenade du portage
Hull PQ CANADA J8X 2K6
(819) 777-9696

Sierra Semiconductor
2075 N Capitol Avenue
San Jose, CA 95132
(408) 263-9300

Space Systems Div MZEE
LA Air Force Base, POB 92960
Los Angeles, CA 90009
(310) 363-0125

Spread Spectrum Scene
PO Box 2199
El Granada, CA 94018
(510) 278-3157

Springer-Verlag
175 Fifth Avenue
New York, NY 10010
(212) 460-1500

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

Synergetics
Box 809
Thatcher, AZ 85552
(520) 428-4073

Trimble Navigation
585 North Mary Avenue
Sunnyvale, CA 94086
(800) TRI-MBLE

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

challenges that have caused a general slowing of the rate at which caller id is becoming universally available. But the service already covers around a third of the country. Full coverage should take place within two years.

Production caller id receiver modules should soon be available from Hong Kong for under $9. So your straight hardware opportunities are limited. But the software and applications possibilities are wide open. Especially when interactively combined with CD ROM or data bases.

Your actual caller id pulses are related to modem tones and are provided between the first and second telephone ring. Note that an ordinary unmodified modem can *not* be used to extract these tones. Because of the formatting.

In general, telephone information is available through their free *Bellcore 1992 Catalog of Technical Information*. The key document you need is TR-TSY-0030, while papers TR-TSY-00391 and FSD-02-1051 yield useful info.

The two largest caller id chip houses are *Motorola* and *Sierra*. Dr. Moto has a MC14557 chip and a MC145460EVK evaluation kit. Sierra offers their new SC11212 chip and several useful ap notes. Although Motorola is making the most noise, I overwhemingly prefer Sierra's SC11212. Two companies offering the preapproved Type 68 interface circuits required for caller id are *Dallas Semiconductor* and *Cermetek*. *Hello Direct* offers several ready-to-use caller id stand alone products as stock items.

I've already run quite a bit of background tutorial info on caller id. See my HACK43, HACK49, and HACK50

Switched Reluctance Motors

Most of the innovation in electromechanical power has long since been coming down outside of the United States. Ferinstance, for over five years now, Japan has routinely offered air conditioners that are twice as efficient as ours, with SEER ratings of 16 and higher. With more comfort.

The efficiency secrets do include a variable speed scroll compressor, a variable speed air handler, and multiple zone control through fuzzy logic. Your local HVAC contractor refuses to sell these to you because of "code" problems, telling you that there is "no demand."

"Sides, it ain't in mah *Grainger* catalog."

By the way, the *HVAC News* trade journal is one fairly useful source for info on most current US antiquated air conditioning technology.

OK. We've got these beasties known as *ac induction motors*. Which were a stupendously great idea when Telsa first thunk them up. And still do remain the most popular type of appliance motors in use anywhere in the world. But most ac induction motors suffer from what is turning out to be a fatal flaw. They only run over an undesirably high and quite narrow speed range. For instance, your typical quarter horse motor might run properly only over a speed range of 1725 to 1800 revolutions per minute.

These days, a high energy efficiency is becoming super important. For energy efficiency, you'll want to vary your input speed to get precisely the level of tail twisting you need. The centermost key to appliance energy efficiency is often a widely ranging and an exactly controllable variable speed motor. One that runs at useful slower speeds without any mechanical reduction.

Although pulse modulation and vector controllers are slowly being offered for ac induction motors, these systems remain costly and quite complex. These controllers have to change both the frequency and the supply voltage. And they still operate only over a rather limited speed range. Many of them are also extremely noisy, producing strong harmonics in the mid audio range. Tweeeee. They also can cause turf fights with the starting mechanism.

The bottom line is that it is long past time to flush the ac induction motor since it is inherently a single speed machine. The heir apparent replacement is the *switched reluctance motor*. While widely used in Europe, they are only being newly rediscovered here in the US.

A switched reluctance motor uses groups of simple half pitch windings on the stator. The rotor is just a rotating magnet in smaller sizes, or soft iron salient poles in larger

ones. A companion speed and position sensor is needed, and can be done with optics or Hall Effect sensors.

An external microcontroller is required. As any pair of coils are excited, the rotor will try to align itself, either by magnetic attraction or else by trying to minimize the reluctance of a magnetic path. By properly sequencing the windings, a continuous rotation at any speed in either direction for any reasonable loading is easily gotten. Speed and torque regulation are inherent.

When compared to an induction motor, you gain higher efficiency, reversibility, self-starting, double peak power, and an incredibly wider speed range.

For a good background tutorial, try *High Performance Switched Reluctance Drives* in the February 1992 issue of *Motion Control* on pages 50-55. Besides this trade journal, additional developments are likely to appear in the *PCIM*, *Motion*, and *MotorTechniques* trade journals, along with the IEEE transactions on *Energy Conversion* and *Industrial Applications*. Plus *Dialog* and *UMI*.

Now for the neat part: *Any car alternator is very easily converted into a switched reluctance motor!* And these are available in junkyards for as little as $5, especially if you don't care which make or model, can use one with a blown diode or two, can remove it by yourself, and don't need the regulator that usually goes with it.

At high speeds you can use the alternator as a motor; at lower ones as a three phase stepping motor. I've seen some videos of some outstanding homebrew three axis wooden sign routers built up out of junk alternators.

Naturally, the results probably will not be as good as properly designing a switched reluctance motor up from scratch. But the economics certainly make sense.

To start, the internal wye connection is brought out as a common terminal giving you three phases of windings. The windings are best rewound spanning single slots, with high ampere turns being the name of the game here. But don't saturate the iron. The rotor and slip rings are simply run as a rotating electromagnet. For motor use, external speed and positioning sensing has to be added. When used as a low speed stepper, no special sensing is required.

An ABC sequence runs you in one direction; ACB in the other. You are thus fully reversible.

Power MOS transistors make good drivers, with *Galco* being one useful source. For your initial experiments, a Commodore-64 or some other older microcomputer should work out just fine as an economical controller. Eventually, you would substitute an embedded microprocessor.

For more of the fundamentals on modifying alternators, see RESBN07, HACK44 and newer files on *www.tinaja.com*. A good book source on traditional alternator rewinding is *Lindsay Publications*.

Aerogels

What if they gave a new form of matter and nobody came? The stuff is called an *aerogel*. These are solids that look like solidified smoke. Solids that have the density of air or even less. In fact, all that prevents certain of these aerogels from floating away are all of those air molecules stuck inside. Aerogels can transmit light, but block heat, electricity, and sound.

Inorganic aerogels can be made from plain old sand. I'd guess that copper mine tailings dumps would be an ideal raw material source. Organic aerogels can be made from seaweed and are actually edible. The process starts out as an ordinary liquid gel followed by sort of a medium tech freeze drying. The final aerogel consists of solid and gas, rather than the solid and liquid found in Jell-O.

The obvious potential uses include high performance insulation, new packing materials, and energy absorbing structures. Plus new composite materials with unheard of strength to weight ratios. The nonobvious apps could range from diet foods to novel weaponry. If some third world empire gets out of line, you simply foam the whole country in place. Camels and all.

It is not clear how to make any bucks on this just yet. Especially on a small scale and low budget. But the stuff is so new and so exciting that it somehow doesn't seem to matter all that much.

Two good aerogel papers appeared in the February 16, 1990 and February 21, 1992 issues of *Science*. Bounce these backwards through the *Science Citations Index*. There's also an *Aerogels* book offered by *Springer-Verlag* ✦

Microcomputer pioneer and guru Don Lancaster is the author of 35 books and countless articles. Don maintains a US technical helpline you'll find at (520) 428-4073, besides offering all his own books, reprints and consulting services.

Don has a free new catalog crammed full of his latest insider secrets waiting for you. Your best calling times are 8-5 weekdays, Mountain Standard Time.

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