Don Lancaster's

Tech Musings

Thoughts on brain parity
Impulse radio fundamentals
A "new" bookbinding method
Some Richard Feynman books
MEMS nanotechnology CDROM

April, 1999

What will be the "next big thing" following spread spectrum comm? My best guess is that it just might involve much of the incredible new stuff coming down in…

Pulse Radio

We have seen a number of times before how important it is to relate time and frequency in nearly all of advanced electronics. Seems there was this *Fourier* dude who said that any time or pulse waveform can be made up from bunches of carefully selected sinewaves correctly added together. For instance, a repeating square wave can be built by taking a sine plus a third its third harmonic plus one fifth its fifth harmonic, and so on. We saw a plot of this way on back in MUSE90.PDF.

Let us try this again in figure one. Only this time, I'm going to take ten sinewave harmonics and carefully *weigh* each harmonic to stronger than unusual values. I'll then add them together. We get a fairly nice narrow pulse as our output. The PostScript code which lets you explore this by yourself appears in MUSE135.PSL

What happens here is that all the sinewaves "pile up" or time *correlate* on their pulse peak but pretty much cancel out otherwise.

Yeah, this pattern repeats. There are lots of other pulses "hidden" off the graph. But we could keep adding lower and lower frequency sinewaves to spread the repetitions further and further out in time. And, yeah, that pulse baseline should be shifted on down from zero because the positive energy of a pile of sinewaves has to equal their negative energy on a long term average. But we can get rid of most of this shifting, again by adding enough subharmonics.

Thus, *a single pulse can be built from a large enough pile of carefully arranged sinewaves.*

This is a very simple example of a *spread spectrum* scheme. Note that energy is transmitted *simultaneously* at ten *different* frequencies to build the pulse. Similarly, if we have this pulse, its energy will be spread out over ten different frequencies.

You could think of this pulse as having ten separate transmitters, each on its own frequency channel. Should there be any multipath or interference problems on a channel or two, all the others should fill in as needed.

Figure two shows us a very useful single shape known as a *Gaussian* pulse. Instead of being built up from a few locked harmonics, a Gaussian pulse has energy components of *all possible frequencies*. As you can see, a one nanosecond pulse width uses frequencies that mostly lie below one GigaHertz. One nanosecond is a nice size, since it also equals one foot of radar resolution.

Very nicely, a Gaussian pulse can be produced in an antenna and then transmitted by suddenly changing an antenna's current.

We see that Gaussian pulses have an extremely spread spectrum. Now, *if* we can find some way to suddenly switch Ampere sized or larger signals into a special antenna and *if* we can find some way to build up physically small ultra broadband antennas with decent lf radiation resistance, and *if* we can find some elegant means to move repeating pulses around, then all sorts of exciting things happen.

And that is pretty much what pulse radio is all about.

Using pulse radio, you send out a bunch of Gaussian pulses that repeat in a usefully coded sequence. Either to *radio* communicate by sending out digitized info or to *radar* measure a distance by evaluating path times.

Which just might give us several really big advantages…

no tuning components– Because the system is so broadband, there are no resonant or tuning components. Nor any adjustments. Most parts can get integrated onto a single chip.

effective frequency use– the data or signal rates can go up to 70% or more of the bandwidth. This is far higher than normal.

lower costs– silicon can replace fancy semiconductors because of the lower system frequencies involved.

no multipath– Because the energy is splattered across the entire spectrum, multipath signal problems virtually disappear.

better penetration– Pulse radio does seem remarkably adept at going into buidings, through trees, and even can do limited ground penetration.

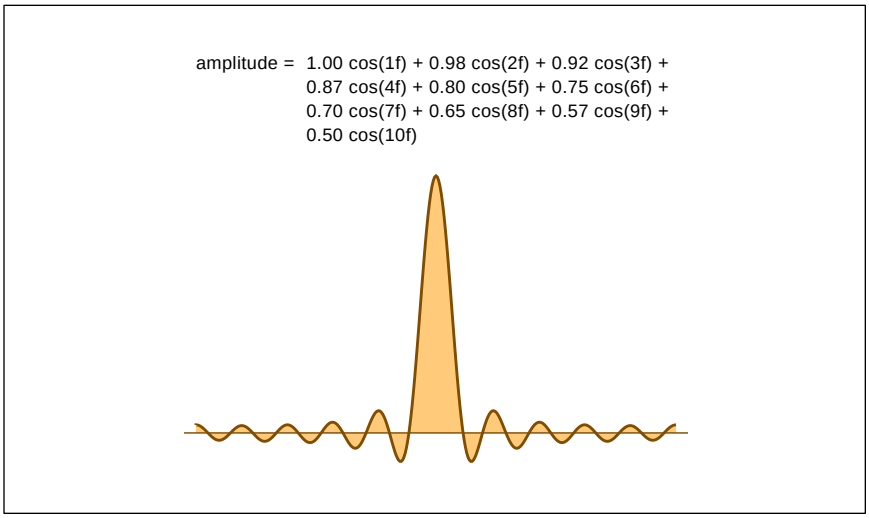

Fig. 1 – A FOURIER PULSE that can be built up from ten sinewave harmonics by using the amplitudes and phasing shown.

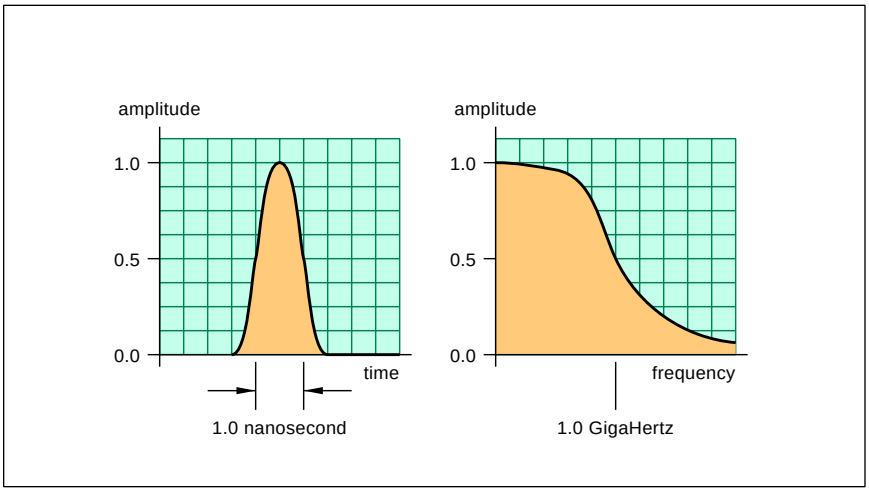

Fig. 2 – A SINGLE GAUSSIAN PULSE is made up of an infinite number of frequencies. Most of the energy in a 1 nanosecond Gaussian pulse lies in frequencies that are below 1 GagaHertz.

highly secure– It seems exceptionally difficult for a third party to intercept pulse radio comm when they do not know the spreading codes.

interference resistant– Jamming an ultra broad band signal is very hard to do if you are using anything this side of a raw spark gap.

high resolution– Distances can now be measured to surprising accuracy for a given cost and bandwidth. Very precise clocks are not needed.

high channel capacity– Hundreds or even thousands of users can share the same region interference free, when codes are properly selected.

long range– Up to several miles are possible at milliwatt power levels.

micropower– Most transmitters and receivers should need far less power. Besides being smaller and cheaper than conventional circuits.

Actually, pairs of pulses known as *impulse doublets* or *monocycles* are usually transmitted by connecting an "H" bridge to its broadband current mode antenna. A logic one gets sent positive pulse first; a logic zero gets sent with negative polarity first. The positioning of the individual pulses sets up an elaborate pseudorandom code with strong self-correlation and very low cross-correlation properties. Different codes let hundreds or even thousands of transmissions in any area that will not interfere.

A simplified block diagram of one possible pulse radio setup appears in figure three. The transmitter is just an H-Bridge driver, usually built up from CMOS. Suddenly flip switches *a* and *d*, and a positive Gaussian pulse will get output from the *current mode* antenna. When you turn *b* and *c* on, a negative Gaussian pulse gets output. Between pulses, the antenna current is given a return path by turning *a* and *b* on. Or else *c* and *d*.

The receiver consists of an antenna and a broadband amplifier. A local *phase lock loop* or a similar circuit keeps track of your expected arriving ones and zeros. An attempt is made to match what you really get against what is expected using a *correlation* technique. Finally, the received data either gets passed on as data (for a modem) or is converted to a distance measurement (for a radar).

We saw more on correlation back in HACK54.PDF

Figure four shows some resource websites and papers that should get you started exploring pulse radio. Your simplest starting point is to just punch "impulse radar" into Hotbot. Use the button at *www.tinaja.com*. Next check the *Ultralab* link farm at *commsci.usc.edu/ulab/links.html*. The leading advocacy group is the *Ultra Wide Band Working Group* found at *www.uwb.org*. Good link lists appear there and *www.tine.domain.com*.

A rather useful mag here is Randy Robert's *Spread Spectrum Scene* at *www.sss-mag.com* An essential text is that *Radiation of Nonsinusodial Electromagnetic Waves* by Helman Harmuth. More details on this text at *www.tinaja.com/amlink01.html*

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*

What Good Is It?

Well, modems for openers. Data comm inside of buildings has fewer multipath and interface problems. Outside, you get longer distances on lower power. Comm is more secure, since it is insanely harder to detect by a third party. And Internet ISP's can hang a pulse radio on every tree. Giving you fast, "always connected" net access. And saving them lots of phone bills.

Vehicular safety radars. In front for thruway "safe distance" driving, on the sides as a parking aide, and in the back as a garage wall alarm.

The really big deal in computer animation these days is called *motion capture*. Where a dancer or actor has enough sensors on them that their avatar alter ego can realistically track them. In real time. Things get sticky fast when you have a room full of actors or need enough sensors that are cheap enough for faithful joint renditions. Pulse radio is poised to dramatically lower the costs here.

Prisons are an obvious use, where the location of each inmate can get continuously monitored. The same goes for firemen. Or soldiers on a battlefield where each has their own IFF (Identification Friend or Foe) capability. And by odious big brother extensions, if everybody had to wear one of these, all traditional crimes would surely decrease.

Accurate distance measurements. Inventory control. Otherwise known as *RFID* and an abbreviation for *RF Identification Devices*

Smart highways for vehicle nav.

Pagers. Security and surveillance.

Personal "body" networks. Where you link your worn pager, cellphone, GPS receiver, calculator, wristwatch, EKG monitor, tv set, internet module, email display, Furby, and a coffee grinder together.

Pulse radio offers strong ground penetration properties, given suitable antenna coupling and careful design. This leads to all sorts of apps from measuring the thickness of a glacier; finding the condition of buried steel in a bridge; doing archaeological mapping, utility pipe finding, or land mine recovery; and even treasure hunting. I'm especially fascinated by the possibility of applying lower frequency "holographic" arrays of pulse radio to cave exploration.

Does pulse radio take us back to the time of spark gaps? Where the loudest signal will always win? Not really, because most impulse radio apps will usually be micropower and have strictly limited ranges. But too many impulse radio systems in too small an area clearly will raise the background noise level for all other comm schemes. And a wimpy nearby signal clearly might trash a distant strong one. This one is called the *near-far* problem.

There's a side effect to pulse radio that raises serious SETI exploration questions. We are just beginning to learn that efficient communication is real hard to tell from low levels of noise. Supposedly smart civilizations probably have stopped blasting narrow spectrum radio power into space. Two predictions: (a) today's SETI searches, while admirable, are looking for the wrong signals in the wrong way in the wrong places; and (b) an extremely small but horribly significant portion of what seems to be eltragalactic noise is in fact intelligent communications.

This one may take a while to sort out completely.

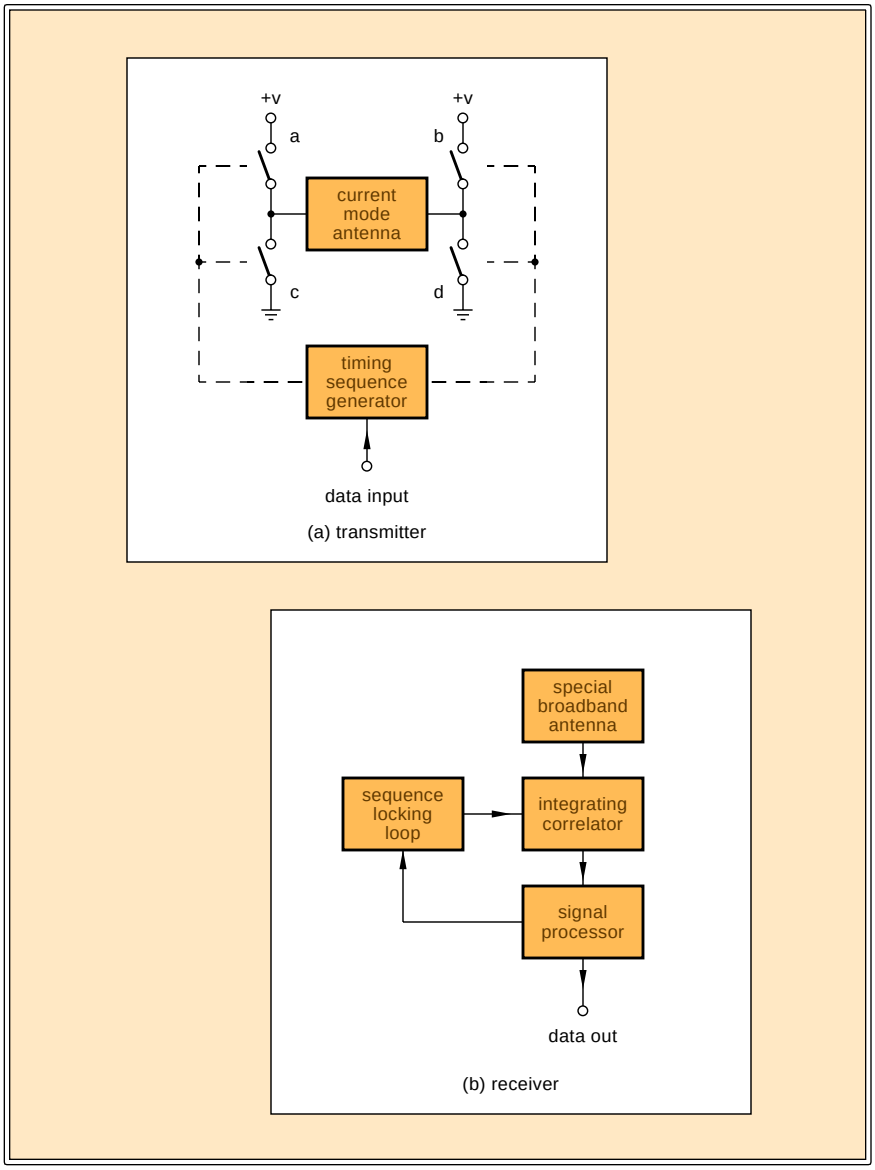

Fig. 3 – SIMPLIFIED BLOCK DIAGRAMS of a typical pulse radio transmitter and receiver. Gaussian pulses are transmitted simply by suddenly changing the current in an antenna. Fancy codes that determine pulse timing convey information or measure distances.

Brain Parity

A few years back, I made the big prediction that we'd have human brain capable computers right about now. Yeah, these aren't a loss leader at *Wal-Mart* quite yet.

The unused "between keystokes" capacity of the web on an average day certainly is a lot larger than humnan brain size. And lots of other examples can be found of specialized computing systems that do go way beyond human abilities.

There's a new "must read" book titled *The Age of Spiritual Machines* by Ray Kurzwell. He convincingly predicts $1000 brain parity machines in less than two decades.

And better machines that routinely will offer 1000X human capability in three or less.

Kurzwell is rather big on neural nets, since this is his bag. My own feelings are that other non-neural architectures should be able do much more much better. The reason being that neural nets came about under severe engineering restraints. Being wetware, slow, and chemical. And, above all, by being forced to evolve gradually. A foremost engineering rule is that *whenever you excessively constrain any parameter, something else has got to give.*

Nonetheless, neural nets certainly should be explored, and developed. Kurzwell's book and his references are a superbly good starting point. He also addresses brain I/O and all the

ULTRA WIDEBAND WORKING GROUP –

This appears to be the main clearing house. Their website is up at **www.uwb.org** You subscribe to their discussion group by sending a message to **fcc_uwb_noi-request@umunhum.stanford.edu** with **subscribe** in the subject line of your email.

OTHER WEBSITE ADDRESSES –

www.aetherwire.com
commsci.usc.edu/ulab/ulab.html
www.com21.com
www.htc.honeywell.com
www.interval.com
www.llnl.gov
www.sensoft.on.ca
www.sss-mag.com
www.tapr.com
www.time-domain.com
www.trw.com
www.uwb.org
www.zircon.com

SEVERAL KEY PAPERS –

Are found at **www.time-domain.com** and also at **www.llnl.gov**

IMPORTANT BOOKS –

Antennas & Waveguides for Nonsinusoidal Waves H. Harmuth
Nonsinusoidal Waves for Radar & Radio H. Harmuth
Propagation of Nonsinusoidal Electromagnetic Waves H. Harmuth
Propagation of Electromagnetic Signals H. Harmuth
Radiation in Nonsinusoidal Electromagnetic Waves H. Harmuth

SOME RESEARCHERS –

Aether Wire & Location
5950 Lucas Valley Road
Nicasio CA 94946
(415) 662-2055

Honeywell Technology Center
3660 Technology Road
Minneapolis MN 55418
(612)951-7226

Interval Research
1801 Page Mill Road #C
Palo Alto CA 94034
(650) 424-0722

Lawrence Livermore Lab
7000 East Avenue
Livermore CA 94550
(925) 422-1100

Sensors & Software
1091 Brevik Place
Mississauga ONT L4W3R7
(800)267-6013

USC Electrical Engineering
Comm Sciences Institute
Los Angeles CA 30089
(213) 740-7832

Spread Spectrum Scene
Box 2199
El Granada CA 94018
(650) 726-6849

Time Domain Corporation
6700 Odyssey Drive
Huntsville AL 35801
(256) 922-9229

TRW Incorporated
One Space Park
Redondo Beach CA 90278
(216) 291-7000

Tucson Packet Radio
8987 East Tanque Verde
Tucson AZ 85749
(940) 383-0000

Xtreme Spectrum
1077 30th St NW #311
Washington DC 20007

Zircon Corporation
1580 Dell Avenue
Campbell CA 95008
(408) 866-8600

Fig. 4 – A COLLECTION OF pulse radio resources.

incredible potential of being able to real time read and write to individual live human neurons. Some of which hints at immortality.

There is definitely a buck to be made here. After all, most any used car salesman would gladly pay $19.95 for a remote control that has three buttons on it. Marked ENTER LOT, BUY and GO AWAY. And the *BMW* dealers might even spring extra for the $29.95 lilac scented and rosewood inlaid version.

A lot more info on *The Age of Spiritual Machines* can be gotten at *http://www.tinaja.com/amlink01.html*

Home Bookbinding

With one glaring exception, home *Book-on-demand* publication has now arrived. Thanks both to *Acrobat* and duplexing PostScript laser printers, you can easily publish all your own books at very low cost. One at a time. On a when and as needed basis. But a lower cost binding solution remains a elusive dream.

I have personally still been using *Unibind* and *Pentabind* products, but sorely would like to use something better. The latest of *Unibind* thermal binders have a steel "U" shaped strip in them. The good news is that the backs always end up solid, wrinkle free, and square. The bad news is that you'll have to carefully match pages and paper thicknesses. Worse yet, you cannot trim these binders using an ordinary paper shear.

Chet Novicki has just published *Perfect Binding Handbook – Making Trade Paperbacks by Hand* Chet found that ordinary hardware store flexible contact cement does make a dandy bookbinding glue. He also has come up with some clamps and a simple process that lets you bind books that look just like the ones in the bookstore.

A 5-1/2 by 8-1/2 cover is often the easiest, usually using some heavier coated stock. The trick is to start with a legal sized cover stock, leaving all of the scrap on the front end of the book. A simple trimming solves the dilemma of needing a spine width over and above the size of a regular folded page.

Besides Chet, the *Paper Plus* chain is one great place to get materials. There's also over a dozen direct mail paper outfits who also sell in small quantities. We looked at many of these back in RESBN66.PDF and in *www.tinaja.com/bod01.html*

Chet can be reached through his *www.gigabooks.net* Besides binding books, he also sells low cost binding machines, materials, supplies, and his consulting services. An extensive listing of bookbinding books appears at *www.tinaja.com/amlink01.html* More on Acrobat at *www.adobe.com* and *www.tinaja.com/acrob01.html* And much more on BOD are in my *Book-on-demand Resource Kit* and at *http://www.tinaja.com/bod01.html*

NAMES AND NUMBERS

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

AeroSence Conference/SPIE
PO Box 10
Bellingham WA 98227
(360) 676-3290

Allegro Micro Systems
Box 15036
Worcester MA 01605
(508) 853-5000

Analog Devices
PO Box 9106
Norwood MA 02062
(800) 262-5643

Ark-Plas Products
Hwy 178 N
Flippin AR 72634
(870) 453-2343

Brand Dielectrics
50 Brigham St
Marlborough MA 01752
(508) 303-8900

Electronics Cooling
1600 Osgood St Rm 21-3D-39
North Andover MA 01845
(508) 960-6443

InsideFinishing
PO Box 12090
Portland OR 97212
(503) 331-6221

International Rectifier
233 Kansas St
El Segundo CA 90245
(310) 322-3331

Linear Technology
1630 McCarthy Blvd
Milpitas CA 95035
(408) 432-1900

MEMScaP
50, allee des Dauphins
ZAC du Pont Rivet
38330 St Ismier FRANCE

Chet Novicki/Gigabooks
PO Box 90674
Honolulu HI 96835
chet@gigabooks.net

Paper Plus
4101 McEwen #800
San Antonio TX 75244
(888) PAPERPLUS

Plastikoil
Northgate Dr
Warrendale PA 15086
(800) 665-7884

Smart Card Allert
300 S Wacker Dr Ste 1800
Chicago IL 60606
(312) 913-1334

Society Amateur Scientists
4735 Clairemont Dr #179
San Diego CA 92101
(800) 873-8767

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

Texas Instruments
PO Box 655303
Dallas TX 75380
(800) 336-5236

Unibind/Pelsaer
4125 Prospect Dr
Carmichael CA 95608
(916) 967-6401

Vision Systems Design
98 Spit Brook Road
Nashua NH 03062
(603) 891-0123

Richard Feynman

I've long been a Richard Feynman fan. Who discovered fundamental quantum mechanics. In all his spare time, he built the atom bomb, made physics understandable to legions of students, solved the Challenger space accident, cracked safes, infuriated all security personnel, while he expertly played bongo drums.

I've gathered a few of the better books in the nearby listing.

New Tech Lit

From *Analog Devices*, the *Winter 1999 Short Form Catalog*. And by *Texas Instruments*, a *Convert Analog* CDROM about analog-to-digital and digital-to-analog conversions. From *International Rectifier*, a new data book on power semiconductors.

From *Linear Technology*, Design Note 161 on "smart rock" micropower transponders. And from *Allegro Microsystems*, their free CD ROM dataguide on chips, sensors, and power drivers.

The *MemScap MEMS* Universe is a freebie new data CD. Subtitled *The Power of a Small World*, this one is on microminiature nanotechnology. Stuff like micro mirrors, resonators, comb fingers, electrostatic motors,

BOOKS ON OR BY RICHARD FEYNMAN

Feynman (James Glick)
The Meaning of it All: Thoughts of a Citizen... (Richard Feynman)

The Beat of a Different Drum (Jagdish Mehra)
The Character of Physical Law (Richard Feynman)
Feynman Lectures on Computuation (Richard Feynman)
Feynman Lectures on Gravitation (Richard Feynman)
Feynman Lectures in Physics I-III (Richard Feynman)
No Ordinary Genius (C. Sykes)
Photon-Hadron Interactions (Richard Feynman)
QED: The Strange Theory of Light & Matter (Richard Feynman)
Quantum Electrodynamic (Richard Feynman)
Six Easy Pieces (Richard Feynman)
Statistical Mechanics: A Set of Lectures (Richard Feynman)
Surely You're Joking Mr. Feynman (R. Feynman)
Theory of Fundamental Processes (Richard Feynman)
What Do You Care What Other People Think? (Richard Feynman)

For more details, see ***www.tinaja.com/amlink01.html***

tiny inductors, and even unbelievably small hinges. You can pick up more details at *www.memscap.com*

I finally found the definition for ISO 9001. Which is just an insider's secret term for "no wrinkles on the Duck tape"

The *AeroSence* conference will be held April 5-9, 1999 at the Orlando World Center. Sponsored by *SPIE*, there's an incredible variety of laser sensing, wavelet, unmanned vehicle, neural networks, and infrared comm offerings here. Contact *www.spie.org* for more details.

Free samples this month include plastic "wire" binding samples from *Plastikoil*, and expandable sleeving from *Brand Dielectrics*. Featured trade journals do include *Electronics Cooling*, *Vision Systems*, the pricey *Smart Card Alert* newsletter, and that *Inside Finishing* all about hot stamp technology.

The *Society of Amateur Scientists* publishes their *Amateur Scientists Bulletin*, besides running forums and other useful activities. You can visit them at *wwww.sas.org*.

For most individuals most of the time, any involvement with patents is almost certainly going to result in a monumental loss of time, energy, money, and sanity. Find out exactly why, along with tested and proven real world alternatives, in my *Case Against Patents* package. As per my nearby *Synergetics* ad. Or check out *www.tinaja.com/patnt01.html*.

I just made some major upgrades to both my *Acrobat Library* and my *webmaster library* shelves found at *www.tinaja.com/acrob01.html* and *www.tinaja.com/weblib01.html* *See www.tinaja.com/info01.html* for lots of instant research solutions and my *www.tinaja.com/barg01.html* for some incredible surplus electronic bargains.

As usual, most of the mentioned items are in our *Names & Numbers* or *Feynman Books* sidebars. Always check here first before calling our no-charge US helpline shown in the service box. ✦