

RS wireless data format
 Exergy and energy quality
 JavaScript's bouncy buttons
 Using Chebycheff polynomials
 Fluxgate & magnetometry books

Because of conservation of energy, a room that has a match in it has exactly the same energy both before and after the match gets struck. So, why would most people value their unlit match higher than their slightly warmer room? The answer lies in...

Understanding Exergy

There's a thermodynamic property known as **exergy** that might give you a measure of the **quality** of energy. The bottom line is that some kilowatt hours of energy are worth a lot more than certain others.

This **Thermodynamic Economics** and other websites tell us that exergy has a precise definition. With liquid fuels, exergy is related to a property called the **Gibbs Free Energy**.

But real-world economics can give you a somewhat looser definition of exergy. Just by asking "how much is this stuff worth?"

For instance, electricity is just about the highest exergy stuff there is, as you can so conveniently move it or efficiently convert it into any other form of energy. Electricity often has a retail exergy value near ten cents per kilowatt hour.

Heat (especially at low temperature differentials) is much lower in exergy due to its gross inconvenience and its inefficiency in conversion to other forms. As we saw way back in

HACK64.PDF, there is a severe and an unavoidable **Carnot Efficiency** limit to what you can do with heat.

Because of this, the kilowatt hours in gasoline have a retail exergy value around three cents per kilowatt hour.

(You can easily get this figure by dividing an average price per liter by the 9000 watt hours per liter you'll normally find in gasoline. Note there are 3.78 liters in a US gallon.)

Thus, a kilowatt hour of gasoline is usually worth less than **one third** of a kilowatt hour of on-grid electricity.

Interestingly enough, you might (with great difficulty) raise or (easily) lower exergy using open systems.

For instance, one system in which you'll pour one gallon of gasoline in the top and get four out the bottom is called "being an oil company". Or a system where you input one kilowatt hour of electricity and output two is called "being an electric utility".

Uh, neither of these are "perpetual motion machines" because they can interact with other entities and can accept other energy inputs.

In your final accounting, a lot of energy *always* gets degraded in exergy in the process of upgrading a little.

Exergy and Electrolysis

Exergy has serious consequences for hydrogen energy electrolysis.

The value of a stored kilowatt hour of hydrogen energy is not very well

established today. Why? Well, first because of extremely limited use. But mostly because the storage and low density and infrastructure problems have yet to get solved. But we know for an absolute fact that it is nowhere as high as that three cents per kwh of gasoline. Since hydrogen has not yet in any way challenged gasoline.

So, something around 0.8 cents per kilowatt hour would seem a ballpark estimate for your value of hydrogen energy today. Which means that use of electrolysis for any bulk hydrogen energy would end up converting (at a hard-to-achieve 50% true efficiency) **two** kilowatt hours of electricity that are worth ten cents per kilowatt hour into **one** kilowatt hour of hydrogen energy worth 0.8 cents...

Electrolysis for bulk hydrogen energy is pretty much the same as converting ~two~ US dollars into ~one~ Mexican Peso!

Now, there are lots of perfect legit uses for large scale electrolysis. Such as for cooling generators, making fat pretty but deadly, filling up research balloons, for precision low energy welding, refining petrochemicals, or generating lab gas.

Nearly all of these successful uses do (A) generate hydrogen **on demand** for immediate use, and (B) generate hydrogen whose immediate use value **greatly exceeds** its stored energy.

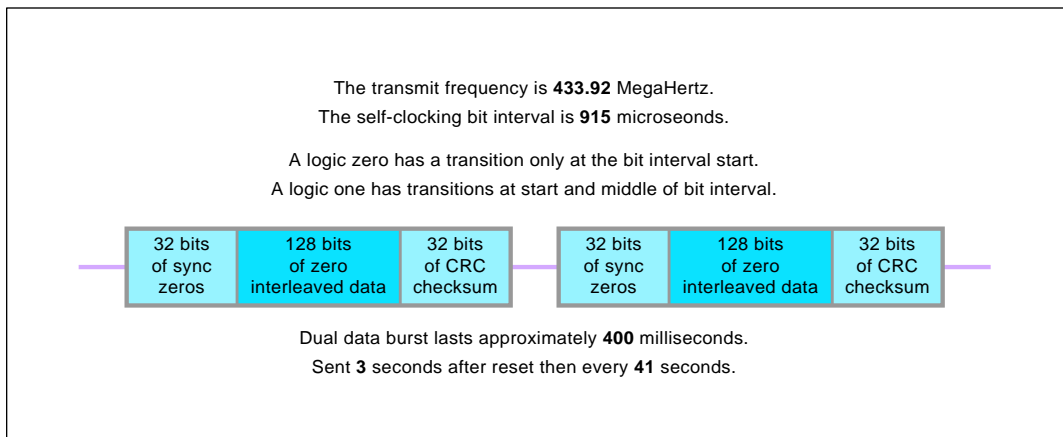


Fig. 1 – DATA FORMAT for the Radio Shack wireless humidity and temperature remotes.

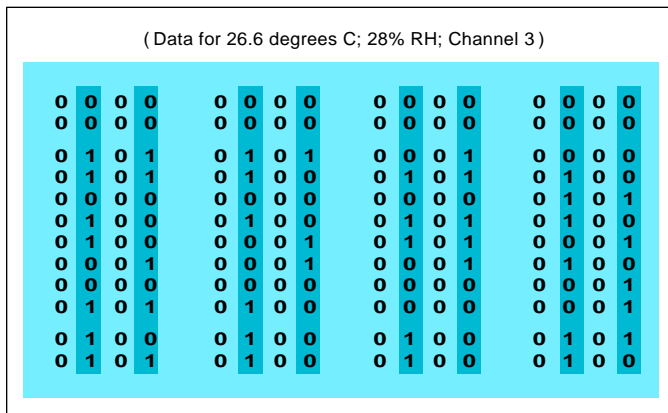


Fig. 2 – ZEROS ARE INTERLEAVED with the "real" data to ease collision detection.

A leading supplier of commercial electrolyzers is [Stuart Energy](#)

But use of electrolysis to produce hydrogen for bulk energy makes no economic or thermodynamic sense at all. At least not for me. Which is why virtually all bulk hydrogen for energy apps is generated by the reformation of methane. But the methane really has to want to reform.

Instead...

Any terrestrial system of making hydrogen for bulk energy apps ~MUST~ very studiously avoid ~EVER~ using grid electricity!

Again, because of that staggering loss of exergy if you go "downhill" from the electrical kilowatt hours to hydrogen kilowatt hours.

Any electrolysis for bulk energy or transportation apps is a really, really dumb thing to do.

More on exergy in our [Hydrogen Energy](#) library page. Also be sure to visit [sci.energy.hydrogen](#).

RS Wireless Weather Data Format

A recent [InfoPack](#) customer asked me to find the data formats for those [Radio Shack](#) weather transmitters. Such as their model 63-1026 used for temperature only or 63-1030 for both temperature and humidity.

Hacking this format opens up all sorts of useful possibilities. Such as custom computer access to your data for recording. Or substituting other external sensors. Such as my [Isopod](#) home energy current sensor. Or for anything else you want to remotely sense, record, or display.

Scoping out the nonobvious data format is tricky, since it flies on by in brief bursts once every 40 seconds. The first DUH! you'll find out is that the unit also transmits three seconds after any forced reset.

Using the "latent persistence" of a newer analog oscilloscope (such as a Tek 2246) and a *totally* dark room can

give you a few frustrating early hints of just what this code is up to.

Although any digital oscilloscope could be used to actually capture the data, I instead went way on back and made a data recorder out of an *Apple IIe* by going into the game paddle port. Sampling the digital input to their transmitter module using a 470 Ohm resistor. Which eased arranging and interpreting the data.

The preliminary viewing capture algorithm I used was...

16x sample {approximately 16 kHz}
the data for 400 milliseconds after you locate the first negative to positive transition.

Write an ASCII "X" for each high or a "." for each low state. Carefully adjust the exact timing to reduce "sample creep". View the memory.

My 6502 sourcecode is available on request. Don't scroll the display!

Their overall scheme is shown in figure one. A burst of coded pulses is transmitted at a frequency of 433.92 MHz, under FCC part 15.231 regs. We did look at these way on back in my [HACK82](#). The modulation scheme is called PAM, as in **Pulse Amplitude Modulation**. Which is nothing but a fancy term for plain old A1 or "gated CW" modulation.

There are two 196 bit bursts of data sent out, separated by a brief quiet time. Giving a total transmit time of roughly 400 milliseconds.

There is no "baud rate". Instead, a self-clocking code running at a base rate just over one kHz gets used. That has a bit interval near 915 µsec.

A logic zero has a transition only at the **start** of your bit interval. A logic one has a transition both at the **beginning** and the **middle** of every bit interval. Note that there could be **two** possible logic one waveforms or **two** possible logic zero shapes. This is one example of what is known as a [Differential Manchester](#) code.

As figure one shows us, each burst lasts 192 bit intervals and is grouped into a 32 bit header, 128 bits of data, and their final 32 bit error correcting checksum. Now for the tricky part: Half of the data bits are real and half are forced zeros! So, **each valid data bit gets separated from its neighbor by a digital logic zero!** This provides

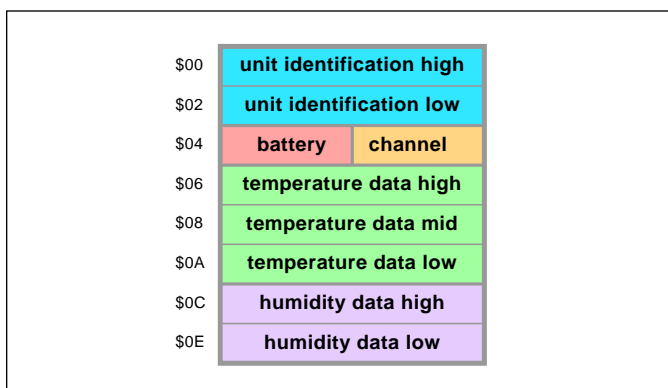


Fig. 3 – ONCE STRIPPED of framing zeros, the actual weather data consists of sixteen four bit bytes. I've arranged them here as 8-bit words.

for sensing collisions caused by any other remote units.

Figure two shows us how the "real" data gets framed by all the collision zeros. Figure three shows you the meaning of the "real" data after it has been stripped of framing zeros.

Their data could be grouped into sixteen four bit words. The first four words are a 16 bit device i.d. that the receiving display can use to verify which sensor just transmitted. Next is their "battery low" detector word, and is all zeros when the battery is still useful. The next word identifies the channel number, and is 1100 for channel "1", 0110 for "2" and 0011 for channel "3".

Six words of 24 bits follow with the temperature data. This is a 24-bit binary number that has been scaled proportionally to temperature. Only the "raw" sensor data is transmitted; there is no conversion to Fahrenheit or Centigrade. Nor any formatting into BCD (binary coded decimal) digits. This straight binary code increases as temperature goes up. All data words are the usual MSB first.

The next four words are 16 bits of humidity data, once again provided in a straight binary format. Note that a lot of excess resolution is available here, because only fourteen bits or so are needed for the temp display and a mere seven bits for humidity. Part of the extra resolution might be used for linearity correction.

The key point is that the available resolution seems well beyond what is really needed. Opening up all sorts of new hacking opportunities.

The CRC checksum consists of 32 bits that are added to the original 128. These allow correction of most reception errors. Which is probably using a **Reed-Solomon** code.

The transmitted (and as received) data is easily intercepted beyond the small superregenerative receiver inside your main unit. Here is one possible "figure eight" detection algorithm to get you from what is received to the actual (but still zero bracketed) ones and zeros...

For 192 iterations of this "figure eight" code...

Seek a pos to neg transition.
Delay 0.617 milliseconds.
Verify state.

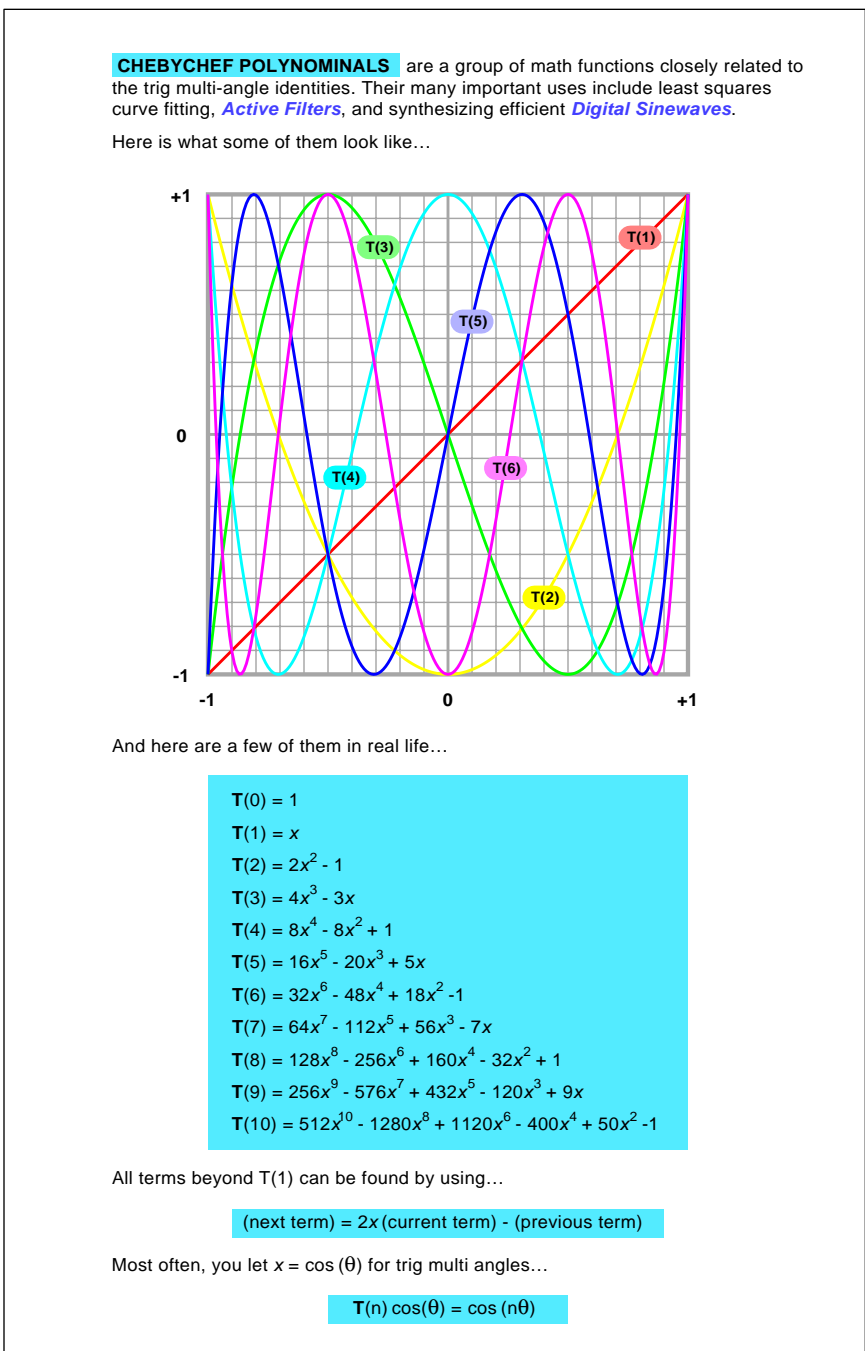


Fig. 4 – SOME DETAILS of first kind Chebycheff Polynomials.

If state is positive, write a 0 to the display device and seek next pos to neg transition.
If state is negative, write a 1 to the display device and seek next neg to pos transition.

Seek a neg to pos transition.
Delay 0.617 milliseconds.
Verify state.
If state is negative, write a

0 to the display device and seek next neg to pos transition.
If state is positive, write a 1 to the display device and seek next pos to neg transition.

To prevent lost data or dropouts, **do not let the display device scroll!** Or do anything else that takes more than a few tens of microseconds of housekeeping.

```

% JAVASCRIPT BOUNCY BUTTONS
% =====
% Copyright c 2001 by Don Lancaster & Synergetics, Box 809, Thatcher, AZ, 85552
% (928) 428-4073 Email: don@tinaja.com Website: http://www.tinaja.com
% Consulting services available per http://www.tinaja.com/info01.html
% All commercial rights and all electronic media rights fully reserved.
% Linking welcome. Reposting expressly forbidden. Version 1.2
% These JavaScript code fragments show you how to get a button or other web
% page to change its appearance when a mouse cures over it.
% First, create images of the pressed and unpressed buttons, and make them
% website available. Such as these BARRO and BARROX examples.
% Second, add this JavaScript module near the beginning of your HTML or
% ASP code...

<SCRIPT LANGUAGE="JavaScript1.1">function sl
(imgName, type){if (type == "x"){glotz =
"barrox.jpg"} else {glotz = "barro.jpg"}
document.images[imgName].src = glotz
return false </SCRIPT>

% Third, code your button positions as follows...

<TD ALIGN=CENTER WIDTH="60" BGCOLOR="#FF9966">
<A HREF="http://www.tinaja.com/glib/muse150.pdf"
onMouseOver="return sl('b1j','x')" onMouseOut=
"return sl('b1','n')"><IMG SRC="barro.jpg"
NAME="b1" BORDER=0 HEIGHT=34 WIDTH=37 ALIGN=BOTTOM>
</A></TD>

% This code assumes the button is the only element in a HTML table cell.
% Note that each and every button ~MUST~ have a unique NAME
% More examples in BOUNCY.PDF. Some JavaScript Books
% are found here. For InfoPack consulting: don@tinaja.com

```

Fig. 5 – JAVASCRIPT CODE to generate bouncy buttons.

Highly detailed service manuals including full schematics are offered by **Radio Shack** on these, but certain stores seem to have trouble admitting they exist. Let me know what you can come up with in the way of new or unusual apps for these unique remote data transmitters.

Chebyshev Polynomials

Don't panic. These do end up a lot simpler than they may seem at first. **Chebyshev Polynomials** are just a group of unique math functions that offer a few rather useful properties. They are especially handy at building

sharp cutoff analog filtering, at doing least squares data fitting, or creating ultra efficient **Magic Sinewaves**.

A curious Cheby property is that if it is good for something, it is often the **best possible** solution you can have. Ferinstance, you cannot build a filter with a steeper cutoff slope than Cheby if your filter has got passband ripple and all stopband zeros are at infinity. And it is extremely likely that you can not synthesize a digital sinewave that gives you more low harmonics zeroed out for any given number of switching events than by using Chebycheff.

Driving the Cheby to the Leby.

A **polynomial** is just some power expression. Such as...

$$T(5) = 16x^5 - 20x^3 + 5x$$

This particular example is said to be of order five, since the fifth power is the highest involved. Not all lower powers have to be nonzero, as in the "missing" second and fourth here.

Polynomials can often be found that have useful properties for certain tasks. A **Butterworth** Polynomial is the flattest one you could possibly build. Or a **Bessel** polynomial is the one that can give you the smoothest possible time delay.

Cheby polynomials are intimately related to the cosine trig function and its harmonics. A cosine wave is like a sine wave except it starts out at max amplitude at zero degrees. The *third harmonic* cosine wave does the same thing, except it spins around three times as fast. A fifth should go around five times as fast, and so on. More harmonics in **MUSE90.PDF**.

Instead of directly working with a third harmonic, you often will go to the **identities** section of nearly any trig book to find out that...

$$\cos(3\theta) = 4\cos(\theta)^3 - 3\cos(\theta)$$

Similar (but uglier) polynomials do exist for all higher harmonics. Now, it does turn out that certain first kind **Cheby polynomials are primarily just a list of all of your available multi-angle cosine trig identities!** Once you let $y = \cos(\theta)$. Or, as you'll find out by digging deep enough into a fat enough math handbook...

$$T_n \cos(\theta) = \cos(n\theta)$$

Figure four shows us what these

FLUXGATE & MAGNETOMETRY BOOKS

J.A. Jacobs, **Geomagnetic Micropulsations**
W.F. Stuart, **Geomagnetic Observatory and Survey Practice**
D. Orr, **Geomagnetic Pulsations**
P. Savage, **Giant Magnetoresistance : Technology & ...**
Ed Ramsden, **Hall Effect Sensors : Theory and Application**
Wallace H. Campbell, **Introduction to Geomagnetic Fields**
David Jiles, **Introduction to Magnetism and Magnetic Materials**
R. A. Lange, **The Magnetic Field of the Earth's Lithosphere**
U. Hartmann, **Magnetic Multilayers & Giant Magneto...**
Pavel Ripka, **Magnetic Sensors and Magnetometers**
Wallace Campbell, **Magnetism : A Guided Tour**
R. O'Handley, **Modern Magnetic Materials**
John R. Jensen, **Remote Sensing of the Environment**

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

NAMES AND NUMBERS

Abbeon Cal, Inc.
123 Gray Avenue
Santa Barbara, CA 93101
(800) 922-0977
www.abbeon1.com

Delvies Plastics
133 West Haven Ave.
Salt Lake City, Utah 84165
(800) 533-5843
www.delviesplastics.com

Industrial Arts Supply Co
5724 W 36th Street
Minneapolis MN 55416
(888) 919-0899
www.iasco-tesco.com

PNI Precision Navigation
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Santa Rosa, CA 95403
(707) 566-2260
www.pnicorp.com

Radio World
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Falls Church, Virginia, 22041
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www.rwonline.com

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Miami Lakes, FL 33014-0650
(800) 220-4242
www.smallparts.com

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www.tfcbooks.com

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Lima, Ohio 45801-3196
(800) 809-4217
www.usplastic.com

Cheby polynomials do look like and how simple it is to generate them. It turns out that $T(0) = 1$ and $T(1) = x$. From there you use this stunningly simple rule...

$$(\text{next term}) = 2x(\text{current term}) - (\text{previous term})$$

... to generate as many of these values of figure four as you need.

Cheby can be used to simplify the notation. Or ease your calculations. Or to show how something works. Or prove that something is optimum.

Many math packages give you the ability to directly work with these unique math tools.

Some Cheby tutorial material can be found in my [STEPSYNT.PDF](#) More detailed examples are located on my [Magic Sinewaves](#) Library Page. More on active filters is in my [Active Filter Cookbook](#)

JavaScript bouncy buttons

I have been looking at JavaScript lately and have newly uploaded some [JavaScript Books](#) to our website.

JavaScript complements PostScript in several ways as it is interactive and has more accurate math.

One of the first things most folks want to do with JavaScript is get their

buttons dynamically moving on their web pages as they mouse around.

A simple example appears in figure five. A more detailed tutorial appears as [BOUNCY.PDF](#)

Fluxgates and Magnetometry

Its been a while since we looked at this topic, so I have just uploaded a group of recommended [Fluxgate and Magnetometry](#) books up to my [Book Access](#) page. A summary is nearby.

Basically, the problem of building accurate compasses was solved a few years back by [Precision Navigation](#) as we saw back in [MUSE104.PDF](#).

Their variable permeability cores are simpler than fluxgates and do offer more than comparable performance.

NEED HELP?

Phone or email all your US Tech Musings questions to:

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Thatcher, AZ, 85552
(928) 428-4073

US email: don@tinaja.com
Web page: www.tinaja.com

And are quite a bit more sensitive than Hall Effect devices and far more stable than magnetoresistors.

Two other resources include the classic *Recent Advances in Fluxgate Magnetometry* from IEE Transactions on Magnetics MAG8.1 1972. Plus a newer *A Review of Magnetic Sensors* from the Proceedings of the IEEE, 78-6 1990, p.973.

New Tech Lit

The CFA Crossfield antenna fiasco we looked at back in [MUSE138.PDF](#) apparently refuses to die. As does its CTHA companion See ongoing issues of [Radio World](#) (especially issue June 20, 2001) to follow the neverending saga of what to me sure appears like badly misguided researchers who are still chasing completely bogus goals. Their latest excuse for not testing is mad cow disease!

Permits aside, *if* this was for real, somebody somewhere surely would have run a brief late night and lower power test in a remote area and word would have surely gotten out.

I may be going way out on a limb here, but I predict that Maxwell will emerge unscathed. I also predict that their test results will be ambiguous, allowing this absurdity to continue to the next level.

More in [BASHPSEU.PDF](#) and on our [Pseudoscience Library](#) page.

Tesla titles and the new *Feedline* newsletter are newly available from [Twenty First Century Books](#). Our own Tesla Book recommendations appear on our [Book Access](#) web page.

One summary on plastics suppliers appeared back in [RESBN50.PDF](#). Two "must have" industrial arts suppliers catalogs from [Delvies](#) and [Iasco](#). Plus [United States Plastics](#), [Abbeon-Cal](#), and, of course, [Small Parts](#).

Check these out.

A reminder that many outstanding [Surplus Bargains](#) can be found [here](#), and are offered on [eBay](#) as well.

For all the fundamentals of digital integrated circuits, be sure to study copies of my *TTL Cookbook* and *CMOS Cookbook*. You can find both these at www.tinaja.com/amlink01.asp

And a final reminder about our cash-and-carry InfoPack consulting at www.tinaja.com/info01.asp.

Let's hear from you. There are lots of new opportunities here. ♦

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