

Evaluating energy claims  
CIE Chromaticity diagram  
Superb digital video book  
Innovative auto electronics  
A new current monitor chip

There sure have been several totally bizarre happenings in alternate energy recently. It appears a federal bureaucrat noticed that a thirty cent valve might be needed to keep a solar hot water heater from freezing.

To "solve" this "problem", a costly demo project was built up. One that instead used a solar panel to generate electricity and then used their current to resistively heat water!

Replacing a 95% efficient low tech system with a 6% efficient high tech one. Heating one *fifteenth* the water. In the stupidest possible manner. At many *hundreds* of times the cost.

Which is almost as bad as the time the Feds built up an adsorption solar cooler demo on a Southern school. It did not quite work good enough, so they attached a five ton evaporative precooler to the input.

Then some killjoy asked "How big an evaporative cooler would they have needed *without* using their solar cooler in the first place? The answer:

Only *three* tons!

There's also been bunches of high profile public seminars lately. Aimed at getting individual investors to help develop a low  $\Delta T$  heat engine.

Well, there used to be this "Been there and done that" person by the name of *Sadi Carnot* who once tried to build up an efficient heat engine. Sadly, old Sadi failed miserably. He only came up with a poor design.

The best engine Carnot was able to create had an efficiency equal to the temperature differential divided by the *absolute* source temperature.

For instance, say you have a 125 degree hot well on down your street. What is the best Carnot engine you could build on a 75 degree day?

In absolute Rankine temperature, that's a 598 degree inlet temperature and a 50 degree  $\Delta T$ . The best you can ever hope to do by using a "perfect" Carnot engine is a little over *eight* percent efficiency. Or less than half that in the real world. At least on this particular hot well example.

Carnot had the audacity to call this

poor performer an *ideal heat engine*. He even made it a law. Known as the *Second law of thermodynamics*.

Only a funny thing happened in the two centuries between us and Carnot: *Every* attempt to repeat this law has failed! *Nobody*, but *nobody* has ever been able to build a better-than-ideal heat engine. In fact, *nobody* has ever been able to *match* Carnot's limited engine. Because of a real-world nasty known as *irreversibility*.

Despite the countless thousands of tries and untold billions of research dollars blown to date.

So, I guess you might want to ask exactly what the seminar folks know that Carnot did not. On any gamble, it pays to know the house odds.

## Getting Yourself Energy Literate

Just how can you deal with thuzzy finking in the energy field? Your first step in *any* energy research project is to learn and understand all the basic laws of Thermodynamics. Start with the background tutorial info found in [HACK64.PDF](#) on [www.tinaja.com](http://www.tinaja.com) or in my *Hardwre Hacker* reprints.

Then see if you can't get a copy of Sandfort's old but great *Heat Engines* in the old *Doubleday Science Series*.

From *Amazon Books*.

Next, learn some fundamentals of *engineering economics*. Particularly such concepts as *payback time*.

Which is why you'll worry about

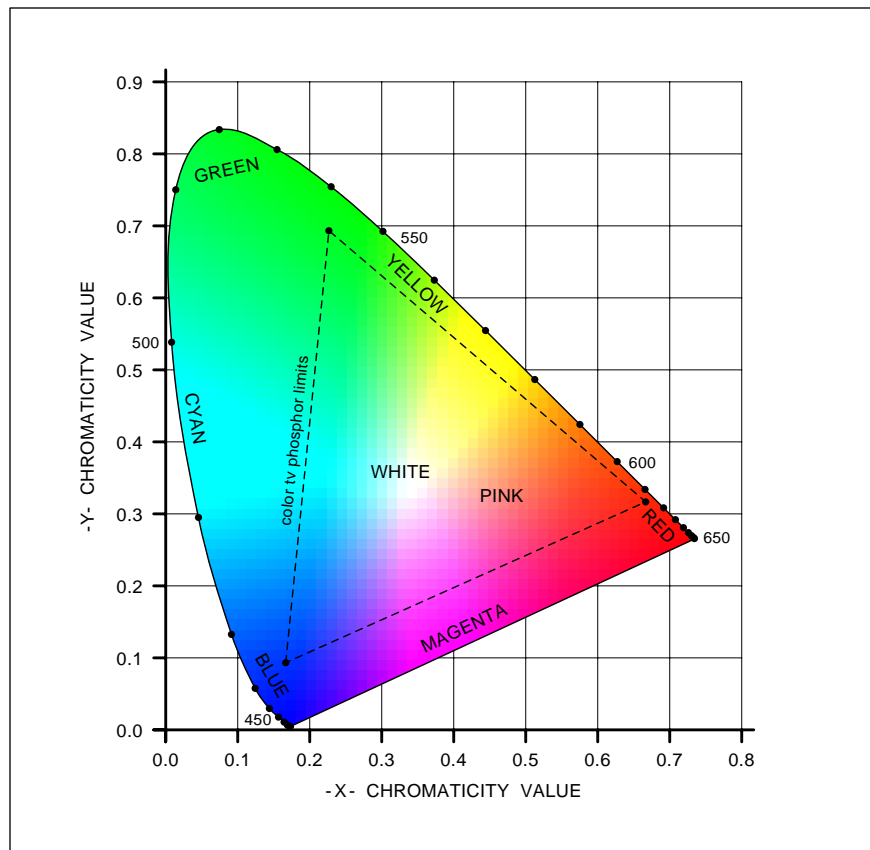


Fig. 1 – THIS CIE CHROMATICITY DIAGRAM is one standard method of specifying all the perceived colors as a pair of -x- and -y- numeric values. Brightness extends out of the page. Outside numbers are saturated color wavelengths in nanometers. NTSC television is only able to show the colors inside the dashed triangle. But most color printing is much worse.

### CIE COLOR –

Measures how much of three "perfect" *tristimulus* colors are needed. Either as *xyz* or *xy* and a white reference.

### RGB Color –

Specifies how much energy from each of three standard red, blue, and green tv phosphors is needed for a given color.

### RGBA Color –

Adds a fourth channel to RGB color. This new channel has production and editing uses that can include transparency or keying.

### GRAYSCALE "COLOR" –

The single gray equivalent for a given color, adjusted for best visual perception. 0.59 green + 0.30 red + 0.11 blue in RGB color space.

### HSB COLOR –

Three independent values specify the *hue* (or shade), the *saturation* (or purity), and the *brightness* (or luminance).

### YIQ COLOR –

Broadcast tv variation on HSB. Brightness is a b/w luminance channel. A subcarrier hue sets phase; while its amplitude sets saturation.

### YUV COLOR –

VCR and PAL variation on HSB having better fidelity. Brightness is a b/w luminance channel. Subcarrier hue sets phase; amplitude sets saturation.

### CMY COLOR –

Standard printer's additive primaries of cyan, magenta, and yellow. Used extensively for three ink process color printing.

### CMYK COLOR –

Adds black overprint to additive CMY color. Normally used to improve color printing, especially for black text. Requires fourth pass.

### HEXCHROME COLOR –

Premium system adds orange and green to additive CMYK color. Gives exceptional color rendition, but demands six precise printing passes.

### MUNSEL COLOR –

A series of standard "paint chips". Often used for soil analysis and related scientific studies. Its popularity is waning.

### PANTONE COLOR –

A series of standard "ink chips". Pretty much an industry standard, especially for printing, textile, and graphic arts.

### TRUEMATCH COLOR –

An electronic equivalent to Pantone or Munsel that gives exact matching of video monitor colors and color prepress.

Fig. 2 – POPULAR COLOR SPACE CONVENTIONS.

efficiency in the first place. Followed by those all important *Uh, compared to what?* factors. Such as thirty cent valves. Or hassle-free grid electricity at eight cents per kilowatt hour. And always look for *elegant simplicity*.

More on this in [HACK86.PDF](#) and [ELESIMP.PDF](#)

### Introduction to Color Spaces

Any electromagnetic energy which has wavelengths between 400 and 800 nanometers is said to be in the *color band*. We subjectively and arbitrarily

call a single frequency radiation near 650 nanometers "red". We can call a frequency that's near 530 nanometers "green". And a single frequency near 470 nanometers "blue".

You can easily see these colors by taking the sun or another broadband light source and sending it through a dispersive glass *prism*. Isolating the *fully saturated* rainbow colors.

In their typical *Roy G. Biv* pattern of red, orange, yellow, green, blue, indigo, and violet. Plus everyone in between the named colors.

But where is magenta, salmon, or ecru? Or puce?

It turns out that your eye can not resolve a point source of two or more colors at the same time. Instead, all multiple colors get *blended* into one "new" perceived color. Red and blue together give us *magenta*, a "false" color which does not show up in the spectrum. When you believe you are looking at magenta, you are really seeing a *mixture* that includes blue energy and red energy.

The color "pink" is really nothing but a lot of red energy combined with lesser quantities of blue and green energy. "White" is a strong mix of all the available colors, all radiating or reflecting at once.

To complicate matters, your eye is best at seeing green, so-so at seeing red, and poor at seeing blue. Roughly in a 3:2:1 ratio. We saw more on this in [MUSE95.PDF](#)

Most perceived "colors" are really a mixture of color energies at various wavelengths. You might alternately view magenta as broadband energy that happens to be weak in the green. Thus, magenta *additively* equals red plus blue. Or *subtractively* can equal white minus green.

When you start off with no energy or *black* and add colors, you'll have an *additive* color system. Ferinstance, color tv selects red, blue, and green phosphors to build up the colors by adding energy. One of many possible sets of *additive color primaries* is red, blue, and green. With additive colors, red plus green equals yellow.

If you start with lots of energy or *white* and remove colors, you have a *subtractive* color system. Such as mixing paint or printer's ink. One of many possible sets for the *subtractive color primaries* is cyan, magenta, and yellow. Another is red, yellow, and blue. With the subtractive colors, blue plus yellow equals green.

In order to try and sort all of this out, in 1931 a standards group called the *CIE* created the *standard observer chromaticity diagram* I've shown in figure one. Although this looks kinda bizarre, it is basically a blob of the *gamut* of all perceivable colors in an *x-y* space. *Specifying an x and y will uniquely determine any color.*

Real or imagined.

Pure spectral colors go clockwise

around the top edge of the blob. The "shortcut" across the bottom handles the saturated fake colors you get by mixing varying amounts of red and blue. White is near the blob center, while pastels lie further off axis.

The triangle in figure one shows all the NTSC colors you can get using the three normal RGB tv phosphors. As you can see, color tv can only give you "some" of the color gamut. PAL television is more limited. And typical triple primary printing or dye systems are even worse yet.

But the latest of premium five and six color printing concepts replace the triangle with a larger pentagon or a hexagon and can reproduce nearly all possible colors.

### Color Space Conventions

There are times and places where you will want to standardize colors. But your useful rules will obviously be different for ink on paper, for a phosphor on screen, for additive in food, or for a dye on textile. Thus, there are many different methods to specify any particular color.

Each of these methods might be called a *color space convention*. Each has advantages and disadvantages for its intended use. But since a color is a color, there are precise *transforms* which let you move from one color space to another.

I've shown several popular color space conventions in figure two. Let us summarize them here...

**CIE Color**—Uses the convention of figure one, with the brightness being how high above the *x-y* plot you are. Three *tristimulus* constants set your maximum *white point*. Their ratios set the color and brightness.

**RGB Color**—Specifies how much red energy, how much green energy, and how much blue energy is needed for a given color and brightness.

**RGBA Color**—A variation on RGB color that adds a fourth channel or variable. This extra channel sets the *transparency* of an overlay or allows matte or bluescreen *keying* between two video sources.

**Grayscale "Color"**—A single value monochrome gray for a given color. One popular formula is *gray* = 0.59 green + 0.30 red + 0.11 blue.

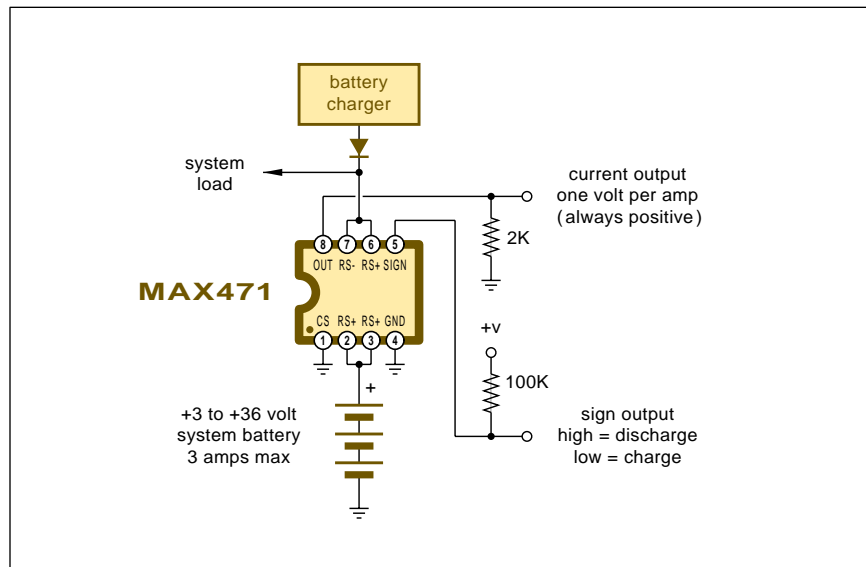


Fig. 3 – THE MAXIM MAX471 is a high side current sensing integrated circuit intended for use in battery "gas gauge" applications.

**HSB Color**—An acronym for *Hue*, *Saturation*, and *Brightness*. The hue can be the angular position around a saturated color wheel. The saturation is how much white gets added to the hue. The brightness ends up as the total generated or reflected energy.

**YIQ Color**—A variation on HSB used by NTSC color. The "Y" is the monochrome brightness. The "I" is a shifted in-phase component of the difference between the white and the selected color. That "Q" is a shifted quadrature component that sets the difference between white and your selected color. Together, I and Q set a vector whose amplitude sets the saturation and whose angle sets the hue of the desired color.

**YUV Color**—A newer variation on HSB used by PAL, VCR, and digital video. "Y" is again the monochrome brightness. "U" and "V" are paired quadrature color difference channels setting hue and saturation.

**CMY Color**—The subtractive print shop primaries of *cyan*, *magenta*, and *yellow*. These are the stock inks used in full color printing.

**CMYK Color**—A fourth or "black" press run added to your print shop primaries. Applied as an additional process color to produce solid blacks and improved legibility in premium printed material.

**Munsel Color**—An older series of standardized and numbered "paint chips" used in soil analysis, textile, and paint industries.

**Pantone Color**—A similar series of fully standardized and numbered "ink chips" used by printing and graphic arts industries.

**Truematch Color**—This one is an electronic equivalent to the Munsel and Pantone systems that is useful for accurate video color displays.

You can not accurately show a CIE chromaticity diagram on any color monitor. Nor on any normal printed page. But I have made up a "fair to middlin" approximation to one and put it in [MUSE111.PDF](#)

I did cheat a little and brightened your center. Unmodified in a "true" display, the same quantity of energy (0.33) that you'll need for a solid red, blue, or green in the corners gives you a rather dark monochrome gray in the middle.

Actually, you might think of the "real" chromaticity diagram as a huge stack of flat layers. The bottom layer is flat black overall. The higher you go, the brighter your color. A corner might range from, say, bright red to black. The middle goes from white on the top, gray in the middle, and black on the bottom.

One place to get the fundamental CIE color info is in the McGraw Hill

A FEW BATTERY CIRCUIT RESOURCES

**AMP**  
PO Box 3608  
Harrisburg PA 17105  
(800) 522-6752

**Benchmark**  
2611 Westgrove Dr #101  
Carrollton TX 75006  
(214) 407-0011

**Maxim**  
120 San Gabriel Dr  
Sunnyvale CA 94086  
(800) 998-8800

**Power Express**  
14388 Wnion Ave  
San Jose CA 95124  
(800) BATTERY

**Analog Devices**  
PO Box 9106  
Norwood MA 02062  
(617) 329-4700

**Electronic Comp News**  
1 Chilton Way  
Radnor PA 19089  
(215) 964-4345

**Measurement & Control**  
2994 W Liberty Ave  
Pittsburgh PA 15216  
(412) 343-9666

**Sensors**  
174 Concord St  
Peterborough NH 03458  
(603) 924-9631

**Battery Technology**  
5700 Bandini Blvd  
Commerce CA 90040  
(800) 982-8284

**Electronic Products**  
645 Stewart Ave  
Garden City NY 11530  
(516) 227-1300

**Motorola**  
5005 E McDowell Rd  
Phoenix AZ 85008  
(800) 521-6274

**Unitrode**  
7 Continental Blvd  
Merrimack NH 03054  
(603) 424-8610

*Television Engineering Handbook.*

Color spaces and their transforms are easily explored with the general purpose PostScript language. Full details in their *Red Book*. Which is otherwise known as that *PostScript Reference Manual*. And available per my nearby *Synergetics* ad.

**A Great Video Read**

I just received a review copy of the second edition of Keith Jack's *Video Demystified*. Published by *HighText*. This fat volume is chock full of the insider details on most of the popular video formats, compression schemes, MPEG, JPEG, scrambling info, digital processing, encoding and decoding, video conferencing, and lots more.

Among its many useful features, *Video Demystified* explains digital 4-2-2 video in all its gory details.

Like digital RGB (and sometimes called 4-4-4), 4-2-2 has three separate component channels. And similar to YUV, 4-2-2 uses a luminance channel and a pair of chroma channels.

One major difference between the component RGB and 4-2-2 video is that the 4-2-2 colors get sampled only *one-half* as often as your luminance. Put another way, pairs of pixels share the same color values. No big deal since the eye is worse at seeing color changes than brightness changes. But (usually) requiring only 16 bits per pixel instead of 24.

Specifically, 4-2-2 luminance is sampled at a 13.5 MegaHertz rate for 720 pixels per normal res active line, while both chrominance channels are sampled at a 6.75 MegaHertz rate for 360 pixel pairs per line.

And, as you might predict, 4-1-1 video is a somewhat lower consumer grade option where your color info is sampled only *one quarter* as often as the luminance. And needing only 12 video bits per pixel.

Actually, the digital 4-1-1 video is "good enough" for nearly everything. Except possibly for editing and post production. Where generation losses, roundoff errors, and the compression artifacts rear their ugly heads. The 4-1-1 quality differences often seem negligible even to a critical viewer. Especially when they are viewed on a normal television set.

**An Analog Current Monitor**

Those folks at *Maxim* sure have come up with a unique new chip in their MAX471. They call this a *high side current sensing ic*. I have shown this gem in figure three. While the intended use is to simplify "battery fuel gauges" in portable electronics, the chip can do a lot more.

The usual way to measure current is to sense the voltage drop across a small *shunt* resistor that is in series

with your load. In the case of battery systems, you'll often want to do this on the *high side* (usually the positive terminal) of your battery. Besides other reasons, this allows the battery and its charger to share the very same common ground connection.

Here's how the chip works: Your battery voltage can be anything from 3 to 36 volts. There is an internal 36 milliohm shunt resistor.

One end of the shunt goes to the battery. The other end goes to your charger and load. There are two chip outputs. One is a *sign* output which shows you whether your battery is presently charging or discharging. It does this by telling you which way your current is going through the shunt. The second is a *current* output. Typically, this current output gets connected to a 2K load resistor to ground. It outputs a ground based analog signal of *one volt per Ampere* of sensed current.

The chip kinda acts as a "full wave rectifier" in that the output current is *always positive* going with respect to ground. This happens *regardless of the current direction*. The *amplitude* of the current appears on pin eight, while the charge-discharge *sign* of the current appears on pin five.

Thus avoiding any system need for negative voltages.

To build a battery gauge similar to a gas gauge, you'll send these two signals on to further analog or digital processing. This further processing typically calculates Ampere hours in versus Ampere hours out. And then relates charge and discharge totals to the actual battery properties.

**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](mailto:don@tinaja.com)  
Web page: [www.tinaja.com](http://www.tinaja.com)

**NAMES AND NUMBERS**

**Amazon Books**  
Box 80387  
Seattle WA 98108  
(800) 201-7575

**Aura Systems**  
2335 Alaska Avenue  
El Segundo, CA 90245  
(310) 643-5300

**Automotive Industries**  
PO Box 2056  
Radnor PA 19080  
(215) 964-4876

**The Bone Room**  
1569 Solano Avenue  
Berkeley CA 94707  
(510) 526-5252

**Hewlett-Packard**  
PO Box 10301  
Palo Alto CA 94303  
(415) 857-1501

**HighText Publications**  
PO Box 1489  
Solana Beach CA 92075  
(619) 793-4141

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

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

**Microchip Technology**  
2355 W Chandler Blvd  
Chandler AZ 85224  
(602) 786-7200

**Moments in Time**  
330 State Rd 101  
Amherst NH 03031  
(603) 673-3633

**Pantone**  
590 Commerce Blvd  
Carlstadt NJ 07072  
(201) 935-5500

**Rohm Corporation**  
2150 Commerce Drive  
San Jose CA 95131  
(408) 433-2225

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

**Texas Instruments**  
PO Box 809066  
Dallas TX 75380  
(800) 336-5236

**Thomson Industries**  
2 Channel Drive  
Port Washington NY 11050  
(800) 554-8466

**Versa Tech Electronics**  
PO Box 18476  
Boulder CO 80308  
(303) 440-5590

Note that *Amperes* multiplied by *time* will equal *Ampere Hours*. The process of summing things against time is called *integration*. Analog op-amps or digital accumulators are great at this sort of thing.

Your maximum sensed current is three amps. You could connect two chips in parallel for six amp service. Supply current is 60 microamps when active and five when the shutdown pin is brought high.

An extra 36 milliwatts of power is consumed by the shunt when sensing a one amp load. This loss is usually well under one percent of your total battery capacity. And is comparable to other wiring losses. Note also that the *sign* output is open collector. An external pullup resistor must always be provided.

There is also a MAX472 chip that lets you use your own shunt and gain resistors. One good method to build a cheap shunt is to use a narrow part of

a printed circuit trace. A second is to use a segment of paper clip. Both of these ploys need calibration and are somewhat temperature sensitive.

I can think of a dozen other uses for either device. Which I have now summarized in figure four. I have also shown several other sources of battery related ic chips and info as this month's resource sidebar.

**Names & Numbers**

From *Texas Instruments*, a new databook on *Low Voltage Logic* ic families. From *Rohm*, a *Short Form Catalog* on unusual and underutilized integrated circuits and sensors. From *Unitrode*, a similar *Product Selection Guide*. From *International Rectifier*, a *Power Solutions* product digest.

From *Microchip*, the PIC12C5XX data book on their baby PIC's.

Speaking of which, that *FBASIC TICkit* is a new series of PIC projects and software offered by *Versa Tech*

**new from  
DON LANCASTER**

**ACTIVE FILTER COOKBOOK**

The sixteenth (!) printing of Don's bible on analog op-amp lowpass, bandpass, and highpass active filters. De-mystified instant designs. **\$28.50**

**CMOS AND TTL COOKBOOKS**

Millions of copies in print worldwide. THE two books for digital integrated circuit fundamentals. About as hands-on as you can get. **\$28.50** each.

**INCREDIBLE SECRET  
MONEY MACHINE II**

Updated 2nd edition of Don's classic on setting up your own technical or craft venture. **\$18.50**

**LANCASTER CLASSICS LIBRARY**

Don's best early stuff at a bargain price. Includes the CMOS Cookbook, The TTL Cookbook, Active Filter Cookbook, PostScript video, Case Against Patents, Incredible Secret Money Machine II, and Hardware Hacker II reprints. **\$119.50**

**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
- PostScript Beginner Stuff . . . . . \$29.50
- PostScript Show and Tell . . . . . \$29.50
- Intro to PostScript Video . . . . . \$29.50
- 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
- PostScript Program Design . . . . . \$24.50
- Thinking in PostScript . . . . . \$22.50
- LaserWriter Reference . . . . . \$19.50
- Type 1 Font Format . . . . . \$16.50
- Acrobat Reference . . . . . \$24.50
- Whole works (all PostScript) . . . . . \$380.00
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- Technical Insider Secrets . . . . . **FREE**

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A complete collection of all Don's Nuts & Volts columns to date, including a new index and his master names and numbers list. **\$24.50**

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

### **BATTERY FUEL GAUGE –**

Use analog or digital techniques to integrate current versus time to get amp hours in versus amp hours out. Relate to battery characteristics.

### **SOLAR ENERGY MONITOR –**

Place in series with solar panel to monitor the incoming solar radiation and the total watt hours of energy recovered.

### **HEADLIGHT TESTER –**

Use threshold logic on current levels to determine "open", "short", or "normal" headlight current consumption.

### **LOUDSPEAKER PROTECTOR –**

Monitor floating speaker outputs and shut down anytime output currents approach a danger level.

### **CHARGE LIFE EXTENDER –**

Can you get more total energy and life out of a battery by continuously pulse recycling a fraction of the discharge energy?

### **DATA MULTIPLEXER –**

Send both power and data over the same line by changing the load current for a one or zero. Sense the current change as data.

### **ELECTRONIC CIRCUIT BREAKER –**

Monitor load currents and then provide a shutdown or foldback any time the drawn current goes over or under set limits.

### **FLASHLIGHT BULB SAVER –**

Prevent turn-on lamp surges or set your overall brightness by sensing and then limiting the total delivered lamp current.

### **CURRENT HISTORY LOGGER –**

Use the current output to record long term current history for industrial processes, replacing a chart recorder.

### **SHORT FINDER –**

Isolate circuit board and integrated circuit short circuits by applying and monitoring safe test current levels.

### **BATTERY OVERCHARGE DETECTOR –**

Prevent overcharging or fault currents by monitoring charging current and total charge time. Shut down on excess.

### **CABLE TESTER –**

By creative use of binary weighted resistive loads, multiple cable lines can be tested simultaneously.

### **LOAD RELAY –**

By sensing the current in one system, a second can be turned on or off. Such as autpowering a monitor only when computer is active.

*Electronics*. Included are a compiler, debugger, console, and launcher.

Incredibly innovative automotive developments are now offered on a custom basis from *Aura*. Including a combination head gasket and triple spark plug that greatly improves your flame front; their electromechanical direct valve scheme; plus a combo flywheel, starter, and alternator.

One source of info on similar firms is *Automotive Industries* magazine.

Flutterwumpers and related X-Y table surplus bargains are stocked in depth by *Moments in Time*.

If there aren't enough skeletons in your closet, contact *The Bone Room* for immediate assistance. They have a free catalog.

The free video on *Nyliner* bearings from *Thomson Industries*. Another free video and a pair of demo/tutorial CD's on the superb 5SiMX PostScript printer from *Hewlett Packard*.

For the fundamentals of starting up your own tech venture, check out my *Incredible Secret Money Machine II*. Autographed copies available singly or as part of my bargain *Lancaster Classics Library*.

Per my nearby *Synergetics* ad.

I've also just reorganized parts of my [www.tinaja.com](http://www.tinaja.com) website. Newly included are gateway access to *PIC*, *Electronic Engineering*, *PostScript*, *Pseudoscience*, and *Webmastering* Internet sites. Along with scads of technical and nontechnical favorites. Plus a new library shelf on wavelets.

As usual, most of these mentioned resources show up in the *Names and Numbers* or in that *Battery Control Resources* sidebar. Be sure to check these out first before you visit my [www.tinaja.com](http://www.tinaja.com) website or call our US technical helpline. ♦

Fig. 4 – A BAKER'S DOZEN uses for the MAX471.