Don Lancaster's

Tech Musings

November, 1999

Contact free chargers
Gage and SPS interface
Useful energy resources
Induction heating books
Gauss-Jordan elimination

We do seem to have a mixed bag of stuff for this month. Everything from neat math tricks to new machine tool interfaces to several superb energy resources to induction heating books.

So let's just jump right in…

Contactless Charging

Have you ever noticed there are no electrical contacts found on battery powered toothbrushes? It seems that *inductive coupling* gets used instead. An air core transformer is formed by the charger and your toothbrush. The coupled energy then gets rectified to recharge the internal battery.

The advantages are no contacts to corrode or misalign. Perceived safety gets combined with no battery shorts.

Sadly, you can not get very much low frequency energy through an air core coil. And that energy you can couple drops dramatically with even a slightly increasing air gap. Which is one of many good reasons why you do not put a giant coil around your living room to eliminate line cords on lamps and tv's and such.

TDK has an interesting inductive coupler you might experiment with. As their model IBC-131. Some details are shown in figure one. You have two flat modules roughly one inch in diameter. The transmitter accepts 120 to 190 volts dc, received from a line rectifier and smaller-than-usual filter capacitor. The transmitter consists of a 125 kilohertz oscillator and a coil. This high frequency gives you small size, efficient coupling, and freedom from "growling" or other noise.

Output from the receiver coil gets rectified and sent to your portable or otherwise isolated load. The system delivers 650 milliwatts across a one eighth inch air gap.

The 125 mills output at six volts is more than enough to fully recharge a 600 milliampere-hour battery in six hours. Input current is less than 20 mils and efficiency can approach 60 percent. But, as figure two shows us, your response drops uselessly with increasing air gap, tilting, or axial misalignment. Watch these details.

Let me know any non-obvious uses you can come up with here. Taping your receiver and transmitter together could make a rather interesting plug mounted supply. One much smaller, lighter, and less physically blocking than a typical wall wart.

Going half wave or using two or more receivers for a split voltage or higher outputs also lead to interesting possibilities. This might also be one method to couple low rate data off a moving shaft.

More on Linear Equations

Back in MUSE106.PDF, we looked into ways of solving linear algebraic equations. Such as this fairly simple one which has got three equations in three unkowns…

$$\begin{aligned} 6x + 3y - 4z &= 16 \\ 3x - 2y + 2z &= -3 \\ -2x + 1y - 3z &= 3 \end{aligned}$$

A linear *equation set* might have zero, one, or an infinite number of possible solutions. Most often we are after those having one and only one valid set of results. These are called *linear* equations because your highest power of any variable is unity. These are usually in the form of *n* equations in *n* unknowns.

To yield a unique solution, the number of variables must equal your number of available equations. This example is $n = 3$ since it has three equations in three unknowns.

Solving linear equations comes up over and over again in computers and electronics. Finding the coefficients for digital filters are but one of many examples. We saw a lot more on this specific use back in MUSE105.PDF and MUSE107.PDF

We previously looked at applying *determinants* to solve these kinds of problems. Uh, it turns out there is a stunningly elegant set of tricks called *Gauss-Jordan Elimination* that you can use instead. These tricks let you find linear equation solutions much simpler and faster. Fewer multiplies are involved. Results can also end up more accurate since you are less likely to often bump up against very small or very large numbers.

Details of this useful method are summarized in figure three, while

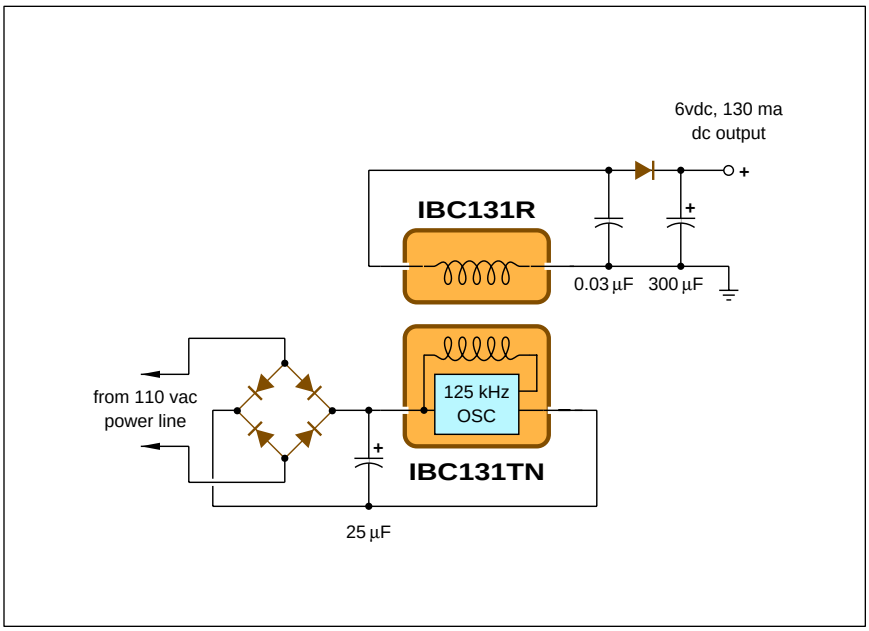

Fig. 1 – TDK CONTACTLESS CHARGER receiver-transmitter pair sends up to 650 milliwatts at 125 kHz across a small air gap.

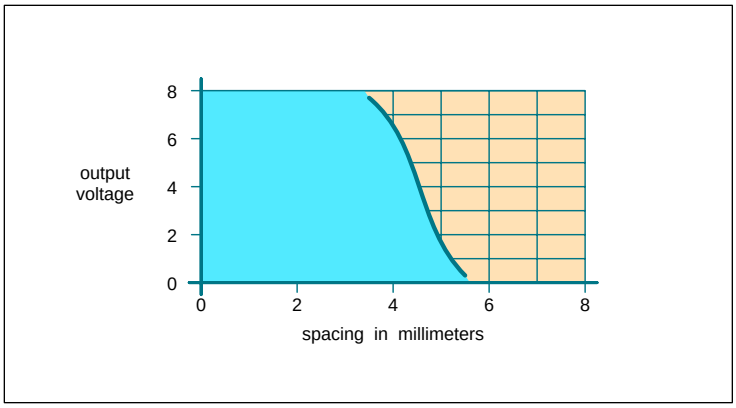

Fig. 2 – COUPLED ENERGY drops dramatically as your air gap increases. The charger circuit is best used well aligned at 1/8 inch or less spacing.

figure four gives you the PostScript solution code to play with on your own. I'll try to add some utilities to *www.tinaja.com/post01.html* or my *www.tinaja.com/math01.html*

PostScript is certainly a fast and fun way to explore math concepts. As I might have mentioned a time or two before, Acrobat Distiller is a great host based PostScript-as language interpreter.

Somewhat similar to determinants, a Gauss-Jordan elimination will first place your equations into a *matrix* like this one…

$$\begin{bmatrix} 2 & 3 & -4 & 16 \\ 3 & -2 & 2 & -3 \\ -2 & 1 & -3 & 3 \end{bmatrix}$$

The variables all go on the left and the constants on the right. These two matrix rules can then get repeatedly applied as needed…

All elements in any matrix row can be multiplied or divided by any non-zero value without changing results.

Any row in any matrix might get added to or subtracted from another row without changing the results.

There's nothing magic about these rules. They're just the same as saying you can multiply every term in any equation by a nonzero constant and not change it. And that you can add or subtract equations of like terms without changing the results.

Your trick is to start at the upper left and apply these two rules over and over again to convert your linear equation's matrix into this special *reduced echelon* form…

$$\begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 2 \\ 0 & 0 & 1 & -1 \end{bmatrix}$$

Note that all the variables are zero except for the ones found on the main diagonal. Once forced into reduced echelon form, you can *immediately* read your results of…

$$x = 1$$
$$y = 2$$
$$z = -1$$

Thus, a little playing around with the coefficients ahead of time greatly simplifies and speeds up solving this type of math problem. Your essential "Gauss" part of the elimination deals with forcing the lower left zeros that are *below* your main diagonal.

The optional "Jordan" part forces upper right zeros *above* your unary

To use **GAUSS-JORDAN ELIMINATION** to solve these equations…

$$\begin{aligned} -3.997w + 2.075x - 0.997y + 1.436z &= 29.223 \\ 2.345w - 0.654x - 8.231y + 1.234z &= -13.491 \\ -3.224w + 12.223x - 1.060y + 4.987z &= 1.342 \\ 0.334w - 1.653x + 2.724y - 7.003z &= -13.365 \end{aligned}$$

First copy your values into a matrix…

$$\begin{bmatrix} -3.997 & 2.075 & -0.997 & 1.436 & 29.223 \\ 2.345 & -0.654 & -8.231 & 1.234 & 13.491 \\ -3.224 & 12.223 & -1.060 & 4.987 & 1.342 \\ 0.334 & -1.653 & 2.724 & -7.003 & -13.365 \end{bmatrix}$$

Next you should …

(1) Force **w0** to unity by *scaling*.
(2) Force **w1** to zero by *subtracting*.
(3) Force **x1** to unity by *scaling*.
(4) Force **w2** to zero by *subtracting*.
(5) Force **x2** to zero by *subtracting*.
(6) Force **y2** to unity by *scaling*.
(7) Force **w3** to zero by *subtracting*.
(8) Force **x3** to zero by *subtracting*.
(9) Force **y3** to zero by *subtracting*.
(10) Force **z3** to unity by *scaling*.

…to get this **ECHELON FORM** matrix…

$$\begin{bmatrix} 1.000 & -0.519 & 0.249 & -0.359 & -7.311 \\ 0.000 & 1.000 & -15.648 & 3.685 & 6.485 \\ 0.000 & 0.000 & 1.000 & -0.212 & -0.549 \\ 0.000 & 0.000 & 0.000 & 1.000 & 2.176 \end{bmatrix}$$

We see by inspection that z = 2.176. You now have your choice of using back substitution to find y = -0.087 x = -2.899 and w = -8.012 Alternately, you can continue using "Jordan" rules similar to the above to get your matrix into this **REDUCED ECHELON FORM** and instantly read obvious answers…

$$\begin{bmatrix} 1.000 & 0.000 & 0.000 & 0.000 & -8.012 \\ 0.000 & 1.000 & 0.000 & 0.000 & -2.899 \\ 0.000 & 0.000 & 1.000 & 0.000 & -0.087 \\ 0.000 & 0.000 & 0.000 & 1.000 & 2.176 \end{bmatrix}$$

Fig.3 – GAUSS-JORDAN ELIMINATION very much simplifies solving linear algebraic equations.

diagonal. Uh, it turns out that plain old ninth grade *back substitution* is usually even faster and simpler than dinking around with your upper right zeros. So the Jordan part may not add all that much for you.

But hey. Whatever works. Either of these schemes behave just fine.

Intimate details on Gauss-Jordan should show up in any modern intro college algebra text. More on math in *www.tinaja.com/math01.html* More on PostScript-as-language secrets in *www.tinaja.com/post01.html*

I've also just added a big bunch of rather well done algebra videos to my *www.tinaja.com/bargos01.html*

These can be a great buy for home study or a charter school.

Gage and SPC Interface

Some key details on what follows did not show up before deadline time, so let's do a bare bones intro:

A few years back, *Mitutoyo*, *Tesa*, *Starrett*, *Brown & Sharpe*, and most other makers of micrometers, height gauges, and similar precise machine shop measuring instruments decided to go digital. Initially by strapping position encoders onto the existing designs. The new large readouts were accurate, and easily viewed.

Errors were greatly reduced.

Data formats became more or less standardized, with a *Mitutoyo format* of their *Digimatic* series leading the pack. Interface was to be by way of a shop-friendly ten pin connector that fit standard 2x5 rectangular headers on 0.1 inch centers.

The data format for a measurement consists of a burst of 13 BCD bytes. The format details, handshaking, and a PIC interface with full sourcecode is found in MUSE145.PDF

This is sometimes called a *DRO* interface as well.

It did not take very long to realize that gathering up these mesurements into computers would have all sorts of big time benefits. Which led to a whole new field called *SPC*, short for *Statistical Process Control*.

Ferinstance, if you could watch the progress of machine tool wear, you can sharpen or replace the tool *before* it got out of spec and started making defective parts.

Better yet, by using feedback, you can get better than expected accuracy and surface finish out of any older or lower cost machines.

Many books on SPC can be found at *www.tinaja.com/amlink01.html*

Your usual way to route gage data into a PC or microcontroller has been via serial RS-232-C Since this older standard was one-on-one, a smarter interface gets used to let many gages share the same input.

```
% PS LINEAR EQUATION SOLVER FOR N=4  LINEQ04.PS
% ==============================================

% Copyright c 1999 by Don Lancaster and Synergetics, Box 809, Thatcher, AZ, 85552
% (520) 428-4073 don@tinaja.com http://www.tinaja.com
% Consulting services available per http://www.tinaja.com/info01.html

% All commercial rights and all electronic media rights fully reserved.
% Personal use permitted provided header and entire file remains intact.
% Linking is welcome. Reposting expressly forbidden.

% This utility demo shows how to use PostScript to solve linear algabraic equations
% by use of Gaussian elimination. It is easily extended to higher orders.

% Define or capture your data. To avoid any div0 problems, preplace your largest
% absolute values on your principle diagonals...

/w0 -3.997 store /x0 2.075 store /y0 -0.997 store /z0 1.436 store /a0 29.223 store
/w1 2.345 store /x1 -0.654 store /y1 -8.231 store /z1 1.234 store /a1 -13.491 store
/w2 -3.224 store /x2 12.223 store /y2 -1.06 store /z2 4.987 store /a2 1.342 store
/w3 0.334 store /x3 -1.653 store /y3 2.724 store /z3 -7.003 store/a3 -13.365 store

/solven04 {

% normalize w0 to unity...
/a0 a0 w0 div store /z0 z0 w0 div store /y0 y0 w0 div store /x0 x0 w0 div store /w0 1.000 store

% force w1 to zero...
/a1 a1 a0 w1 mul sub store /z1 z1 z0 w1 mul sub store /y1 y1 y0 w1 mul sub store
/x1 x1 x0 w1 mul sub store /w1 0 store

% normalize x1 to unity...
/a1 a1 x1 div store /z1 z1 x1 div store /y1 y1 x1 div store /x1 1.000 store

% force w2 to zero
/a2 a2 w2 a0 mul sub store /z2 z2 w2 z0 mul sub store /y2 y2 w2 y0 mul sub store
/x2 x2 w2 x0 mul sub store /w2 0 store

% force x2 to zero...
/a2 a2 a1 x2 mul sub store /z2 z2 z1 x2 mul sub store /y2 y2 y1 x2 mul sub store /x2 0 store

% normalize y2 to unity...
/a2 a2 y2 div store /z2 z2 y2 div store/y2 1.000 store

% force w3 to zero
/a3 a3 a0 w3 mul sub store /z3 z3 z0 w3 mul sub store /y3 y3 y0 w3 mul sub store
/x3 x3 x0 w3 mul sub store /w3 0 store

% force x3 to zero
/a3 a3 a1 x3 mul sub store /z3 z3 z1 x3 mul sub store /y3 y3 y1 x3 mul sub store /x3 0 store

% force y3 to zero
/a3 a3 a2 y3 mul sub store/z3 z3 z2 y3 mul sub store /y3 0 store

% solve by back substitution
/z a3 z3 div store /y a2 z2 z mul sub store /x a1 z1 z mul sub y1 y mul sub store
/w a0  z0 z mul sub   y0 y mul sub   x0 x mul sub store

% report the results
(w = ) print w 10 string cvs print (\n) prin(x = ) print x 10 string cvs print (\n) print
(y = ) print y 10 string cvs print (\n) print (z = ) print z 10 string cvs print (\n) print
            } def

% this actually does it
solven04
```

Fig. 4 – SOME N=4 POSTSCRIPT CODE to handle the "Gauss" portion of Gauss-Jordan elimination. The plain old back substitution shown here is often quicker and simpler than the Jordan method. To use this code, change your data values and send it to Acrobat Distiller or GhostScript.

SOME SELECTED ULSTRASONIC BOOKS

Basics of Induction Heating (L. Schmerr)
Conduction and Induction Heating (E.J. Davies)
Encyclopedia of Polymer Science: Dielectric Heating (H. Mark)
Elements of Induction Heating (S. Zinn)
Heat Treating: 1997 Conference (A.S.M.)
Heat Treating (R. Wallis)
Induction Heat Treatment of Steel (S. Semiatin)
Induction Heating Handbook (John, Davies)
Industrial Applications of Induction Heating (M. Lozinskiaei)
Radio Frequency Heating in the Timber Industry (J. Pound)
Skin Effect Heating of Pipelines and Vessels (I.E.E.E.)
Soil Vapor Extraction: Radio Frequency Heating (D. Daniel)

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

Typical products here include the *GagePort* by *Fowler* or (long ago) by *Observational Systems*, or *GageNet* by *Qualitron Sysstems*.

These small plug-in modules often slurp their needed power directly off the interface, and will often accept two or four gage inputs. Some also provide for and condition low level analog inputs from strain gauges and such. Additional inputs are gotten by *mulltiplexing* the modules into a small backplane.

Typical older gage interfaces are dipswitch programmable. The newest ones can intelligently evaluate what is connected to them.

One distributor for off-the-shelf gaging products is *Elisha Penniman* found at *www.elishapenniman.com*

PIC's from *Microchip Technology* or *Basic Stamps* from *Parallax* or are obvious choices for your homebrew designs here. More info on these is at *www.tinaja.com/picup01.html*

Also obvious, the USB *Universal Serial Bus* is a much better way to go these days. Because you can connect as many gages as you want to hassle free. But machine shops tend to be a tad on the conservative side, so older RS232 interfaces are more than likely to stay around for a while.

But use USB for anything new.

One commercial website having useful info here is *www.fowler.com*. Many more can be found by using the *Hotbot*, *Alta Vista*, and other search engines. You can conveniently link these and many more sites at *www.tinaja.com/webwb01.html*

Trade journals such as…

CAD Systems
Control Engineering
Design Engineering
Design News
Industrial Equipment News
Machine Design
Manufacturing Engineering
Modern Machine Shop
New Equipment Digest
Quality and Participation

…all should have useful gage interface product info in them. Many more can be quickly located by using that convenient OXBRDG button on my *www.tinaja.com* home page.

If you do have any insider info on pinouts and exact formats, let's hear from you. The big opportunity here, of course, is PIC wireless.

I will try to work up more specific details on all of this. Possibly into an upcoming RESBN94.PDF. The actual pinouts and data formats seem to be inordinately difficult to find.

Meanwhile, I've got these great buys on GagePorts, multiplexers, and digital height gages newly up at my *www.tinaja.com/bargte01.html*

Induction Heating Books

Induction heating is a scheme to use coils to couple alternating current or radio waves into conductive items to precisely heat them. Non-magnetic targets heat through eddy currents, while magnetic ones heat up through hystersis losses and eddy currents.

Because of the precise control, no need for actual contact, the efficient object-only heating, the possibility of operating under vacuum or special atmospheres, and low contamination, induction heating sees a wide variety of industrial uses. Such as for shrink fitting, heat treating, brazing, surface hardening, chemical processing, and warming. Or even the special pans on those new "cool" stovetops.

A related *dielectric heating* uses insulators instead of conductors for such tasks as setting glue in plywood panels. We looked at induction and dielectric heating in MUSE106.PDF

A recommended list of induction heating books appears for you this month's resource sidebar. You can get more details on any of these titles at *www.tinaja.com/amlink01.html*

Trade journals such as *Industrial Heating* and *Process Heat* sometimes touch upon these topics. As does that *Industrial Electronics Transactions* by the *IEEE*.

Partially because induction heating is such an arcane backwater, some of these titles may be a tad hard to find. The best and most accessible I have located is the old but superb Volume Two from Chester Tudbury's *Basics of Induction Heating*. As far as I can tell, this text is only available by way of the *InductoHeat* folks.

New Tech Lit

An incredibly useful special issue on energy is the focus of *Science Magazine* for July 30, 1999 Volume 285 number 5247. The bibliographies make this a great reference. A paper on eventually approaching hydrogen sustainability starts on page 687.

Details on a new solid state utility power transformer design from Scott can get newly requested by way of *emil_venere@uns.purdue.edu*.

These could dramatically improve

NEED HELP?

Phone or email all your US Tech Musings questions to:

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NAMES AND NUMBERS

Amacoil
2100 Bridgewater Rd
Aston PA 19014
(800) 252-2645
www.amacoil.com

ASIS
PO Box 1409
Alexandria VA 22313
(703) 519-6200
www.asisonline.org

Boston Turning Works
120-R Elm St
Watertown MA 02472
(617) 924-4747

Brown & Sharpe
200 Frenchtown Rd
N Kingstown RI 02852
(800) 648-4640
www.bwnshp.com

Elisha Penniman
586 New Park Ave
W Hartford CT06110
(860) 233-1104
www.elishapenniman.com

Fowler
66 Rowe St
Newton MA 02466
(899) 788-2353
www.fvfowler.com

HDS Systems
PO Box 42767
Tucson AZ 85733
(520) 881-2632
www.hdssystems.com

Home Power
PO Box 520
Ashland OR 97520
(916) 475-3179
www.homepower.com

Hewlett-Packard
PO Box 10301
Palo Alto CA 94303
(415) 857-1501
www.hp.com

Inductoheat
32251 N. Avis Drive
Madison Heights MI 48071
(800) 624-6297
www.inductoheat.com

Industrial Heating
Box 2600
Troy MI 48007
(313) 362-3700
www.bnp.com

Mitutoyo/MTI
965 Corporate Rd
Aurora IL 60504
(630) 820-9666
www.mitutoyo.com

Nichia America
3775 Hempland Rd
Mountville PA 17554
(717) 285-2323
www.nichia.com

Parallax
3805 Atherton Rd #102
Rocklin CA 95765
(916) 624-8333
www.parallaxinc.com

Process Heating
3150 River Rd #101
Des Plaines IL 60018
(708) 297-3450
www.bnp.com

Qualitron Systems
71-T Park Dr
Troy MI 48083
(248) 616-8001
www.qualitron-sys.com

Starrett
121 Crescent St
Athol MA 01331
(978) 249-3551
www.lsstarrett.com

Synergetics
Box 809
Thatcher AZ 85552
(520) 428-4073
www.tinaja.com

power quality, do significant power factor correction, simplify billing, handle load shedding, eliminate big harmonics, and even save core loss electricity during inactive times.

Besides ultimately being lighter, smaller, and cheaper.

Check out those new white LED's from *Hewlett Packard* you'll find in their HLMP-CW-30 data brochure. These blue+phosphor units appear similar to older *Nichia* devices but have brightnesses levels as high as an astonishing 5500 millicandelas.

An interesting place to get more LED test info is at Don Klipstein's *www.intermarket.net/~don/ledx.html* Where we find that some new LED's are already way more efficient than incandescents (ridiculously so when batteries age!) and might eventually approach the fifty Lumens per Watt range of fluorescents and other better lighting solutions. One source for ready-to-go premium super reliable LED lamps is *HDS Systems*. Reach them by clicking through on their banner on my website.

From *Home Power* magazine, their latest *Solar IV* CD. With 1200+ pages

of PDF format reprints on alternate energy and working offgrid solutions. Access them at *www.homepower.com* or click on my website link.

A free linear drive video is offered by *Amecoil* This is a new scheme to use angled rollers to provide all sorts of fancy motion solutions that work on plain old round shafts.

A wide variety of insider security books is offered by ASIS, short for the *American Society of Industrial Security*. Lots of titles here.

For a quick check on the list prices of most anything tool or mechanical, visit *www.mcmaster.com* For a fine final word on fineals, be sure to look into *Boston Turning Works*.

Top quality custom research done at surprisingly low charges have long been available on most *Tech Musing* items and similar topics. Please see *www.tinaja.com/info01.html* and my *www.tinaja.com/consul01.html* to pick up full details.

Collected info on Book-on-demand publishing is available per my nearby *Synergetics* ad.

The latest website additions to my *Guru's Lair* at *www.tinaja.com* now include tutorials on antenna resources and PostScript robotics. Lots of new "scanner method" photos have been newly added to all our bargain pages. Tutorial training and custom "photo" work of this type is newly available by emailing me at *don@tinaja.com*

As usual, most of the mentioned items can be found in our *Names & Numbers* or *Induction Heating Books* sidebars. Always do check these first before calling our no-charge US tech helpline shown in the nearby box. Be sure to include your US email address if you need a personal reply. ✦