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 unknowns…

\[ \begin{align*}
6x + 3y - 4z &= 16 \\
3x - 2y + 2z &= -3 \\
-2x + 1y - 3z &= 3 
\end{align*} \]

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
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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.

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

To use GAUSS-JORDAN ELIMINATION to solve these equations...

\[-3.997w + 2.075x - 0.997y + 1.436z = 29.223\]
\[2.345 - 0.654x - 8.231y + 1.234z = 13.491\]
\[-3.224 + 12.223x - 1.060y + 4.987z = 1.342\]
\[0.334 - 1.653x + 2.724y - 7.003z = -13.365\]

First copy your values into a matrix...

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

Next you should...

1. Force \(w_0\) to unity by scaling.
2. Force \(w_1\) to zero by subtracting.
3. Force \(x_1\) to unity by scaling.
4. Force \(w_2\) to zero by subtracting.
5. Force \(x_2\) to zero by subtracting.
6. Force \(y_2\) to unity by scaling.
7. Force \(w_3\) to zero by subtracting.
8. Force \(x_3\) to zero by subtracting.
9. Force \(y_3\) to zero by subtracting.
10. Force \(z_3\) to unity by scaling.

...to get this ECHHELON FORM matrix...

\[
\begin{pmatrix}
1.000 & -0.519 & 0.249 & -0.359 & -7.311 \\
0.000 & 1.000 & -15.648 & 3.685 & 6.485 \\
0.000 & 0.000 & 1.000 & -0.212 & -0.549 \\
0.000 & 0.000 & 0.000 & 1.000 & 2.176
\end{pmatrix}
\]

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 \(w = -8.012\). Alternatively, you can continue using "Jordan" rules similar to the above to get your matrix into this REDUCED ECHHELON FORM and instantly read obvious answers...

\[
\begin{pmatrix}
1.000 & 0.000 & 0.000 & 0.000 & -8.012 \\
0.000 & 1.000 & 0.000 & 0.000 & -2.899 \\
0.000 & 0.000 & 1.000 & 0.000 & -0.087 \\
0.000 & 0.000 & 0.000 & 1.000 & 2.176
\end{pmatrix}
\]

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...

\[
\begin{align*}
x & = 1 \\
y & = 2 \\
z & = -1
\end{align*}
\]

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
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.


I’ve also just added a big bunch of rather well done algebra videos to my www.tinaja.com/bargo01.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 source code 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 measurements 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.
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 hysteresis 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
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 millilumens.

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 our website.

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

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.

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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. ✦