BY DON LANCASTER

AC and DC Lamp-Dimmer Circuits, and More

THE WEB SURE MAKES ELECTRONICS DESIGN MUCH SIMPLER AND FAR EASIER THAN BEFORE. FOR EXAMPLE, WWW.QUESTLINK.COM CAN ALMOST INSTANTLY PROVIDE YOU WITH ANY AVAILABLE DATA SHEET OR APPLICATIONS NOTE ON just about anything from anyone. There are also a number of newsgroups that anyone into electronics will find handy, including:

- sci.electronics.design
- sci.electronics.equipment
- sci.electronics.misc
- sci.electronics.repair

I have recently added several more key electrical engineering links to my www.tinaja.com/eeweb01.html

Lamp Dimming Fundamentals

Let's assume you have some lamps that you want to cheaply control with a PC, a PIC, or another microprocessor: How would you go about it?

We saw last November (MUSE129.PDF on my Web site) how theaters and concerts use the fancy DMX512 communications standard. Also see RESBN76.PDF on my Web site for information on how home automation often makes use of X-10 dimmer controllers.

Anyway, any incandescent lamp might be brightened or dimmed by changing the DC or rms voltage sent to it. The obvious method involves putting a variable resistor in series with your light. Unfortunately, that technique has big-time inefficiency and heat problems. When you control a 100-watt bulb, as much as 25 watts of heat would have to be burned up in the series controller.

One ancient alternative is to use a Variac, or variable AC transformer. In those, a knob twists a contact to select a changing turns ratio. Early theater lighting controls used ganged banks of motor driven Variacs.

Incandescent lamps can be better brightened or dimmed by changing a duty cycle—the percentage of time voltage is applied. Duty cycling can be very efficient, since the controller is always either on or off. The ratio of on time to off time helps set the brightness. The switching frequency is usually 120-hertz or higher. The thermal inertia from the light bulb's filament and human persistence of vision should integrate or "average out" on and off times, reducing or eliminating flicker.

Your approaches to lamp dimming will differ between AC and DC power systems. The DC routes of Fig. 1 could be used in automobiles, for caving helmets, or in flashlights. In Fig. 1A, a power semiconductor such as a MOS field-effect transistor is placed between lamp and ground. The lamp turns on by making the gate positive by five volts or so. It will turn off by leaving the gate voltage near ground. Very little gate current is needed, so the MOS device acts as a powerful linear or switched "amplifier." One source of white LED caving lights that use those techniques can be found at www.hdssystems.com

In Fig. 1B, a newer style of integrated circuit known as a high-side driver is used. A high-side driver is basically a series power MOSFET with some additional control circuitry. The high-side driving eliminates the need for more than one wire going to the lamp. The return path can be via the vehicle frame or chassis. High-side driver circuits also sense open bulbs, detect other faults, and shut down on short-circuit currents.

One-piece chips that can combine dimming and high-side driving are available. Figure 1C shows how to use the new SGS-Thomson L9830. Its intended use is dimming dashboard lights in an instrument cluster.

The AC dimmers of Fig. 2 all provide a way to switch line-voltage bipolar currents that can be positive or negative. This leaves most power semiconductors out; the exception is a very popular switching device called a Triac.

A Triac has three terminals, called gate, T1, and T2. There is no current between T1 and T2 until a brief and small gate-current pulse is delivered. At that time, the Triac turns on and heavily conducts between T1 and T2. Above a rather small load-holding current, the Triac will latch and stay on. The Triac will stay on until such time as the main current returns to zero. Turn off will usually occur at the next current zero

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Don Lancaster
Synergetics
Box 809-EN
Thatcher AZ, 85552
Tel: 520-428-4073

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

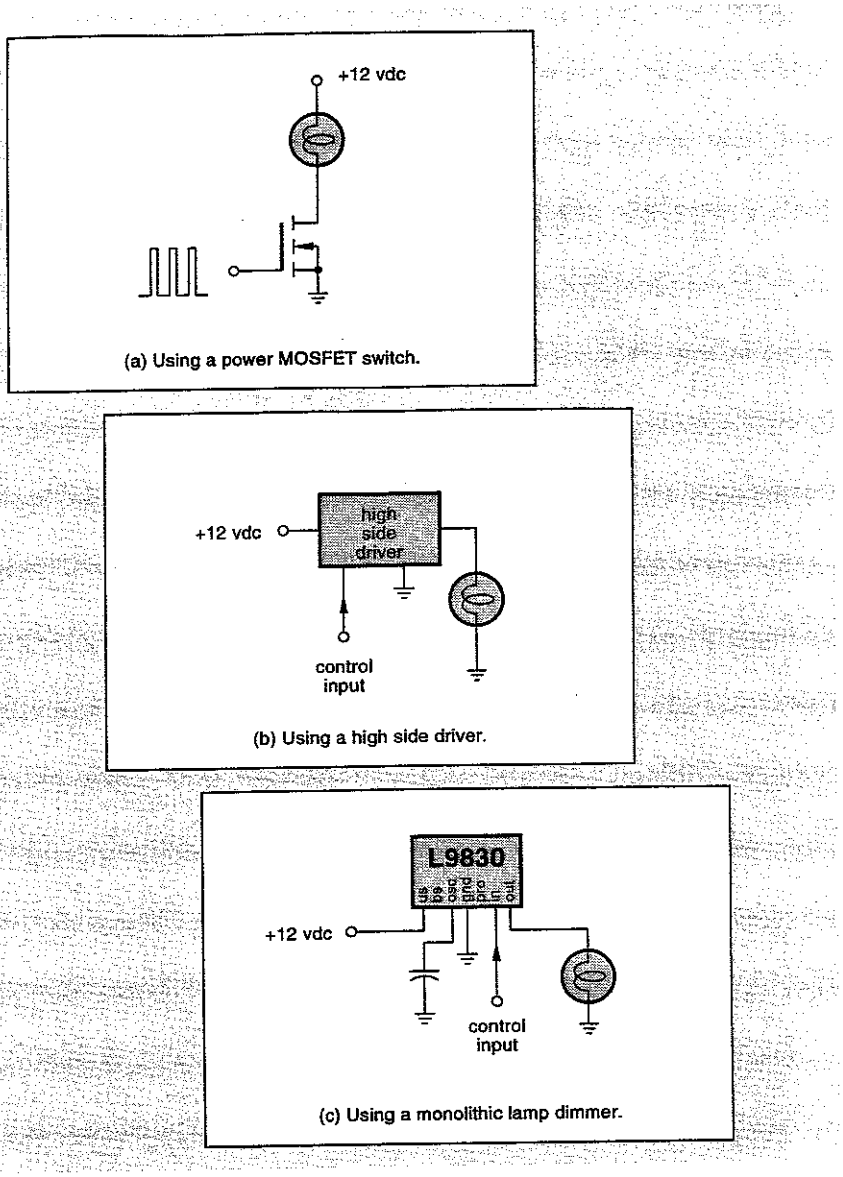

FIG. 1—THREE DIFFERENT APPROACHES to dimming a DC lamp.

crossing of the line AC sinewave.

The simple Triac on-off switching circuit appears in Fig 2A. Closing the switch turns the Triac on; opening the switch will turn the Triac back off just after the next zero crossing. The sensitivity of a Triac's gate changes a little with the changing line and gate polarity. But proper gate drive can switch either polarity load with either polarity gate pulse.

Your classic Triac wall dimmer is shown in Fig. 2B. The diac shown is a bilateral switching diode. A diac turns on whenever its lead voltage exceeds a set amount—often 30 volts or so. Each AC half cycle, the potentiometer starts charging the capacitor. When the capacitor reaches the threshold voltage, the diac will turn on, in turn tripping the main Triac.

The lower the potentiometer's resistance, the earlier in the half cycle that turn on occurs, and the brighter the lamp. The higher the resistance, the later in the cycle that turn on occurs, and the dimmer the lamp. Such a circuit is called a proportional phase control. A second resistor and capacitor (not shown here) will often be added to eliminate any "jumping" problems at very low light levels. You can see the waveforms on this in MUSE108.PDF on my Web site.

One big "gotcha" with Triacs is that they are connected to one side of the AC power line, which creates serious "hot chassis" shock-safety issues.

Figure 2C shows us the standard and safe way of interfacing a Triac to a PIC or a personal computer port. A small and low cost photo-Triac—an optoisolator

with a Triac output—is used. That device is just a light-emitting diode that shines onto a photo-Triac. Pulse the LED with suitably limited current (typically 10 mils) and both the little Triac inside the device and the big main one it drives turn on.

There are a few different ways to use this circuit: You can simply use it for on-off control. Alternately, for heaters and such, you can sense power-line zero crossings somehow and then provide turn on only just after a zero crossing. Such a zero-voltage switch eliminates annoying clicks and radio noise, and it is gentler on both the power line and your load. But note that zero crossing switching is not usable for dimming because the frequency is too low; flicker would be unacceptable.

Instead, you have the option of carefully pulsing the optoisolator's LED on at an exact position inside of each AC half cycle, thus creating a proportional phase control. This gives you a wide flicker-free brightness range.

You can also get combination Triacs and optoisolators. These are called AC solid-state relays and are offered in a wide variety, but tend to be more expensive than going with discrete devices.

A PIC or PC port can also be programmed to do fancy tricks such as slow dimming, stepped brightness, random "somebody is home" security lights, or for theater-lighting scene sequences.

Note that the brightness versus duty cycle is not linear. Why? Because there is more energy at a half sinewave peak than at the "corners". Table lookup software can easily adjust for linear voltage versus current, linear power versus current, log compression for input audio, or can even create flickering "flame" effects. You can find more on those concepts on www.tinaja.com; look for EMERGOP5.PDF and MUSE109.PDF.

Be sure to observe the "backwards" LED connection. Because many computer ports and interface drivers are a lot better at sinking current than they are at sourcing, an active-low scheme is normally used; that turns the LED and the Triac on with a low input and off with a high input—watch that detail.

A Triac that switches in mid cycle could generate severe radio noise and other interference. Series LC filters and suitable shielding is often needed to keep that to acceptable levels.

The leading Triac and optoisolators manufacturers include Motorola, Teccor, and Texas Instruments. A color organ is an older name for psychedelic lighting or audio control of lamps. Design tips and ideas can be found in MUSE108.PDF on my Web site.

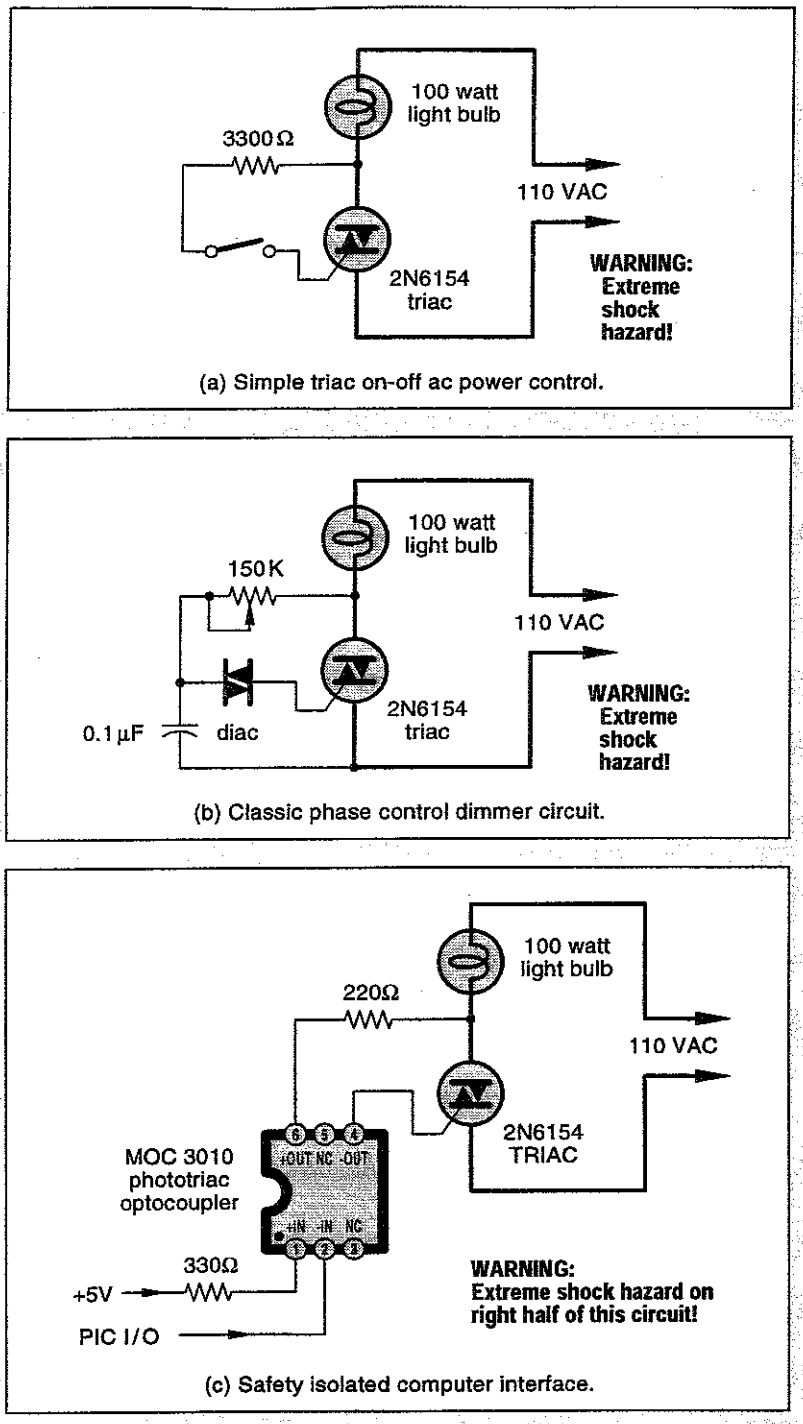

FIG. 2—THREE DIFFERENT line-operated lamp dimming circuits. All are built around a Triac.

A Selection of Dimmer Chips

You have a choice of building up a dimmer from bits and pieces, by use of a PIC or other microcontroller, or by going to new specialized dimmer chips. A surprising variety of custom chips are available and are summarized in Fig. 3.

Two companies that seem to be in the dimmer forefront are Holtek and LSI/CSI. The Basic Stamp from Parallax or the PIC or baby PIC from Microchip Technology are often superb choices. Control can be by way of an up

Holtek HT7620	PIC Controller with Dimmer
Holtek HT7700	Key and Touch Linear Dimmer
Holtek HT7703	Touch Linear Dimmer
Holtek HT7704	Touch Dimmer
Holtek HT7712	Minimum Component Touch Dimmer
LSI/CSI 7234	Touch Control Continuous Dimmer
LSI/CSI 7237	Touch Control Stepped Dimmer
LSI/CSI 7338	Touch Control with Timed ON
LSI/CSI 7314	Multi-level Touch Control Dimmer
LSI/CSI 7534	Up-Down Touch Control Dimmer
Microchip 12C08	Low Cost Baby Programmable PIC
Microchip 16C70	Extra I/O Programmable PIC
SGS L9830	Monolithic DC Lamp Dimmer
Siemens SLB0587	Dimmer IC for Halogen Lamps
Unitrode UC3871	Fluorescent Dimmer Ballast Chip

FIG. 3—A SAMPLER OF some commercial dimmer integrated circuits.

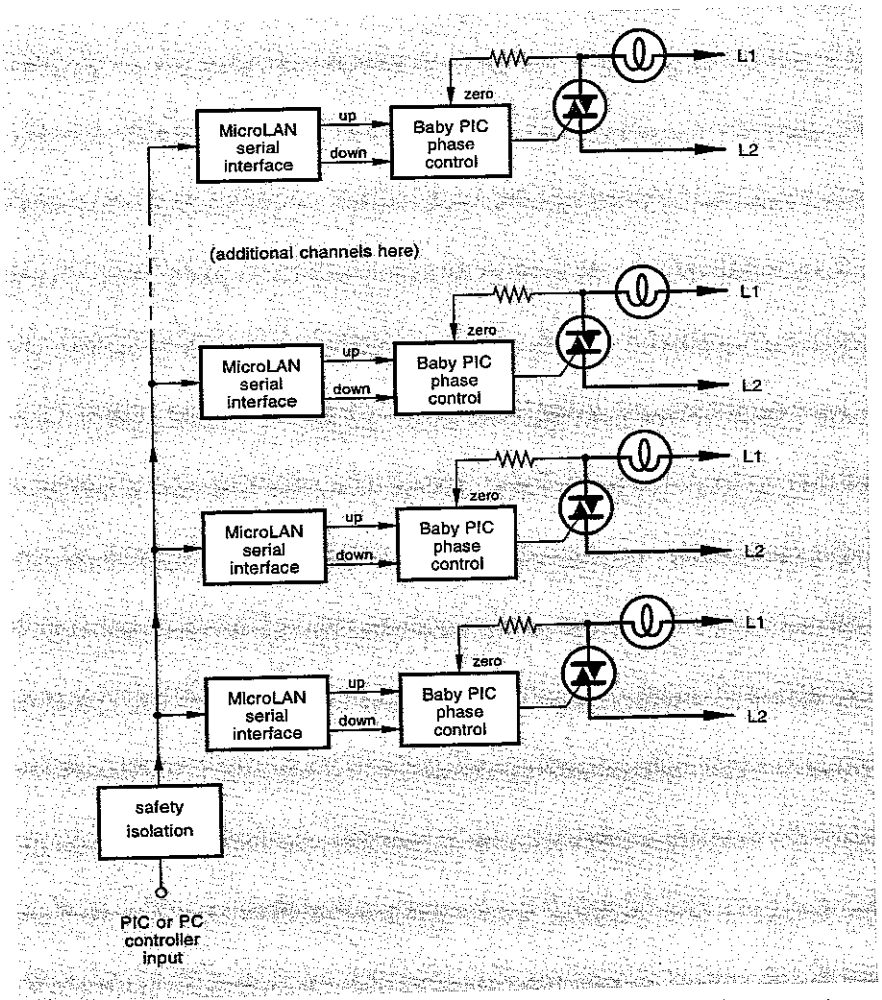

FIG. 4—ONE POSSIBLE SCHEME to remotely dim many lamps using only a single interconnecting wire.

and down pair of input pins, by a resistor going to an A/D converter, parallel "set level" inputs, serial data, or an analog voltage.

A number of useful PIC-dimmer applications notes are downloadable directly from Microchip Technology. To download, use the Questlink listings or the links at www.tinaja.com/picwb01.html

One very interesting combination for multiple control of lots of lamps would be to drive a slew of up-down PICs with several of the new Dallas DS2407 dual addressable switches (from their MicroLAN series). That would let you cheaply and independently control dozens or even hundreds of lamps using a one-wire simple networking system. Each PIC would test every so often to decide if the brightness needed to be changed. With 64 brightness levels, the slew rate from full off to full on would be just over half a second with half cycle sampling if the elaborate MicroLAN comm scheme could be made fast enough. Each addressed up or down command would be carefully synchronized and adjusted to last for a precise line-cycle interval. Levels would be synchronized either with a master reset or simply by supplying enough down commands in a row to guarantee everything is off.

A possible block diagram for this appears in Fig. 4. Should the best data rates of a MicroLAN end up too slow, a second baby PIC might be used instead of turning to higher baud rates.

Even simpler might be a "one long serial word" setup. Your first six bits go to lamp 1, the second six bits go to lamp 2, and so on. Sort of a "mini" DMX512.

Yes, a PIC can directly drive a Triac gate. That would eliminate the cost of your Triac-output optoisolator. But the extreme shock hazard would have to be addressed at other points in your circuit or system.

Zero-crossing detection could be simplified by sensing only positive, zero-going transitions and deriving turn on pulses for both half cycles. For further consulting and design information, see www.tinaja.com/info01.html

What About Fluorescents?

Fluorescent lamp-dimming needs special circuits. Ordinary dimmers must definitely not ever be used with fluorescents! But new concepts are available that let you dim from full brightness down to as low as four percent.

NAMES & NUMBERS

Advance Transformer
10275 W Higgins Rd.
Rosemont, IL 60018
(708) 390-5000

Argonne National Lab
9700 S Cass Ave.
Argonne, IL 60439
(800) 627-2596

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

Dallas Semiconductor
4401 Beltwood Pkwy. S
Dallas, TX 75244
(972) 450-0400

Data Storage
10 Tara Blvd., 5th Fl
Nashua, NH 03062
(603) 891-0123

Galco
26010 Pinehurst Dr.
Madison Heights, MI 48071
(800) 575-5549

Holtek Technology
1342 Ridder Park Dr.
San Jose, CA 95131
(408) 573-8050

Horizon MapInfo
3990 Ruffin Road
San Diego, CA 92123
(800) 828-2808

Jameco Electronics
1355 Shoreway Rd.
Belmont, CA 94002
(800) 536-4316

JKL Components
13343 Paxton St.
Pacoima, CA 91331
(800) 421-7244

Levy/Latham
6263 N Scottsdale #371
Scottsdale, AZ 85250
(602) 367-1100

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

LSI/CSI Systems
1235 Walt Whitman Road
Melville, NY 11747
(516) 271-0400

Map One
PO Box 999
Dewey, AZ 86327
(520) 632-8774

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

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

Planetary Society
65 N Catalina Ave.
Pasadena, CA 91106
(818) 793-5100

SGS-Thomson
1000 E Bell Rd.
Phoenix, AZ 85022
(602) 867-6259

Siemens Components
2191 Laurelwood Rd.
Santa Clara, CA 95054
(408) 980-4500

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

Teccor Electronics
1801 Hurd Dr.
Irving, TX 75038
(214) 580-1515

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

One source of suitable ballasts is Advance Transformer, while useful chips and applications notes can be found at Unitrode. Small laptop fluorescents and suitable dimming technique information is offered by JKL Components.

We just might look at fluorescent dimming further in a future column. Meanwhile, do not try it unless you really know what you are doing!

Magnetic Recording Books

A list of magnetic recording books shows up for this month's resource sidebar. More information on any of these is available at www.tinaja.com/amlink01.html A useful new trade journal on this topic is *Data Storage*.

Custom research into any technical field is available at surprisingly low cost at www.tinaja.com/info01.html. This is especially useful in gathering essential broad-based primary and background material on any emerging or unfamiliar tech topic you might want to get into big time.

Surplus Update

At present, the administrative expenses of selling military surplus electronics seem to be running something like $1.60 for each dollar in public sales. Thus, your tax dollars are being used to pay people to haul away surplus bargains. Your best defense here is to recycle your tax dollars by grabbing some of these for yourself!

To improve their bottom line, the Feds appear to be experimenting with DRMO office closures; "term" sales (in which you agree to accept a full year's worth of stuff); other new types of sales; and privatization. An asset-management outfit by the name of Levy/Latham is now doing a few of the Fed's surplus sales—so far mostly big-ticket items like machinery and boats. Supposedly a lot more of this will be done in the future. For more details on getting involved, you can visit www.levylatham.com

Although seldom advertised, most DRMO sites stock lists of people and firms who will photograph, bid, pack, and ship items for you. These lists are usually available on request. The type and quality of their services offered seems to vary with the base and who happens to live nearby. The major problem here is triage, where you literally will want to lighten up a lot before you ship.

A pair of tutorials on military-surplus bidding insider secrets can be found at www.tinaja.com/resbn01.html Hot buttons on my home page take you directly to the various DRMS access pages. Examples of the actual surplus bargains available these days are up at www.tinaja.com/barg01.html

New Tech Lit

You are invited to participate in a new SETI extraterrestrial intelligence search. An ongoing quest that needs zillions of net-linked computers. For info, see setiathome.ssl.berkeley.edu or pick up the summary invitation in the October 30, 1998 issue of *Science*. Meanwhile, you also might follow the separate Planetary Society billion-channel extraterrestrial assay in real time at seti.planetary.org

Volume 9, #4 of the *Tech Transfer Highlights* by the Argonne National Lab describes some magic new ionic conductor filters. One can be used to extract oxygen from air. Another can separate hydrogen from gas streams.

USGS topographic maps are at long last finding their way onto the Web and CD-ROM. Although not yet in full resolution, full quality, or in the zoomable and compact Adobe Acrobat format, at

SOME MAGNETIC RECORDING BOOKS

Complete Handbook of Magnetic Recording (Finn Jorgensen)
Ferromagnetic Materials: Structure and Properties (R. A. McCurie)
Ferromagnetism (Richard Bozorth)
The Foundation of Magnetic Recording (John Mallinson)
Handbook of Electromagnetic Materials (Perambur Neelakanta)
Magnetic Disk Drive Technology: Heads... (Kanu Ashar)
Magnetic Measurements Handbook (J.M. Janicke)
Magnetic Storage Handbook (Eric Daniel)
Magneto-Resistive Heads: Fundamentals... (John Mallinson)
Modern Recording Techniques (D. M. Huber)
The Physics of Magnetic Recording (C.D. Mee)
Practical Recording Techniques (Bruce Bartlett)
Theory of Magnetic Recording (Neal Bertram)
Theory of Magnetism (Kei Yosida)
Troubleshooting and Repairing Audio & Video... (Homer Davidson)

least they are continuous without page breaks. One low cost CD-ROM source in my neighborhood is Map One found at www.bslnet.com/map1 Included will be 64 seven-minute quads to TIFF quality, three reference maps, and a viewer for $16!

MapInfo, a division of Horizons Technology, has a much more pricey new Web and CD-ROM-based service. Check their Web site at www.horizons.com/suremaps These two are obviously the first two early tricklings of a deluge. I'd predict free viewing of USGS topographic maps routinely provided on hundreds of Web sites within a year or so, and snap-in GPS receiver modules within two.

From Jameco comes the latest electronic components catalog 984. Get this one free by clicking on their banner on my Web site. From Galco, their latest industrial electronics catalog. Galco specializes in high-power electronics.

Nomadics, human-scale transport, and energy efficiency are all nicely covered by Steve Roberts through his Microship site at www.microship.com Grab his free e-zine newsletter.

Free samples this month include a TLC5615 ten-bit serial D/A converter from Texas Instruments, along with plastic fittings, tubing, and such from the folks at Ark-Plas Products.

The latest of "new-old" books by Lindsay Publications now include the *Harper's Aircraft Book*, *Manufacture of Wireless Components*, and *Electrical Designs*. All of these are unique turn-of-the-century reprints. *The Ultimate Modem Handbook* is a Cass Lewart book from Prentice Hall. More details on all these titles at www.tinaja.com/amlink01.html

For most individuals and smaller scale startups most of the time, any involvement with patents is virtually certain to result in a net loss of your time, energy, money, and sanity. Find out why, along with proven and tested real-world alternatives in my *Case Against Patents* package as per my nearby Synergetics ad.

The latest Web site additions at my www.tinaja.com include an expanded PIC libary, lots more classic Blatant Opportunist uploads, plus improved layout and navigation. The newest surplus bargains that you will now find at www.tinaja.com/bargte01.html include mystery cryogenics, military tube testers, distortion analyzers, superb luminance probes, radiosondes, and much more.

As usual, most of the mentioned resources show up in the Names & Numbers or the Magnetic Recording sidebars. Always check here before using our US technical helpline that is shown in the nearby box.

Let's hear from you. EN