BY DON LANCASTER

Twinkle, Twinkle, Little Lights, and More

LET'S TAKE A LOOK AT SOMETHING SO OLD AND SO SIMPLE THAT IT JUST MIGHT BE NEW FOR YOU. AT ANY RATE, THIS IDEA STILL MAKES A SELDOM-SEEN AND A REALLY FINE LITTLE HOMEBREW PROJECT...

Twinkle Lights

In my opinion, the NE-2 neon lamp is by far the number-one electronic component of all time. Yes, the device is more or less way into retirement due to the high voltages needed and its restricted light output. But you can still get them for a dime or so each at RadioShack and elsewhere, and nothing else even comes remotely close to its versatility or its elegant simplicity.

In its prime, that good old NE-2 served as everything from...

- panel lamps
- electronic organs
- surge protectors
- voltage regulators
- polarity finders
- AC-DC voltmeters
- display decorations
- proximity devices
- AND-OR logic
- flash triggers
- strobe lights
- computer memories
- flame monitors
- lamp dimmers
- touch sensors
- signal sources
- flip-flop latches
- frequency dividers
- "hot chassis" checkers
- audio oscillators
- vacuum tube testers
- radiation detectors

...and an awful lot more.

The NE-2 is just a small glass tube with a tiny amount of low-pressure neon gas in it. Two simple pins act as terminals. At voltages below 55 volts or so, the neon lamp is more or less an open circuit. Above that value, the tube "turns on" and starts to conduct, emitting a distinctive orange light.

When conduction starts, the NE-2 becomes a negative resistance. This happens as more current ionizes more gas in the plasma and lowers the drop across the terminals to (typically) 45 volts or so. That destructive behavior requires external current limiting, usually with a high-value resistor of 100K or more. Conduction continues as long as a current source remains. When and if the current drops down to zero, the neon lamp turns off.

A standard NE-2 pilot light circuit is shown in Fig. 1A. Connect that circuit to

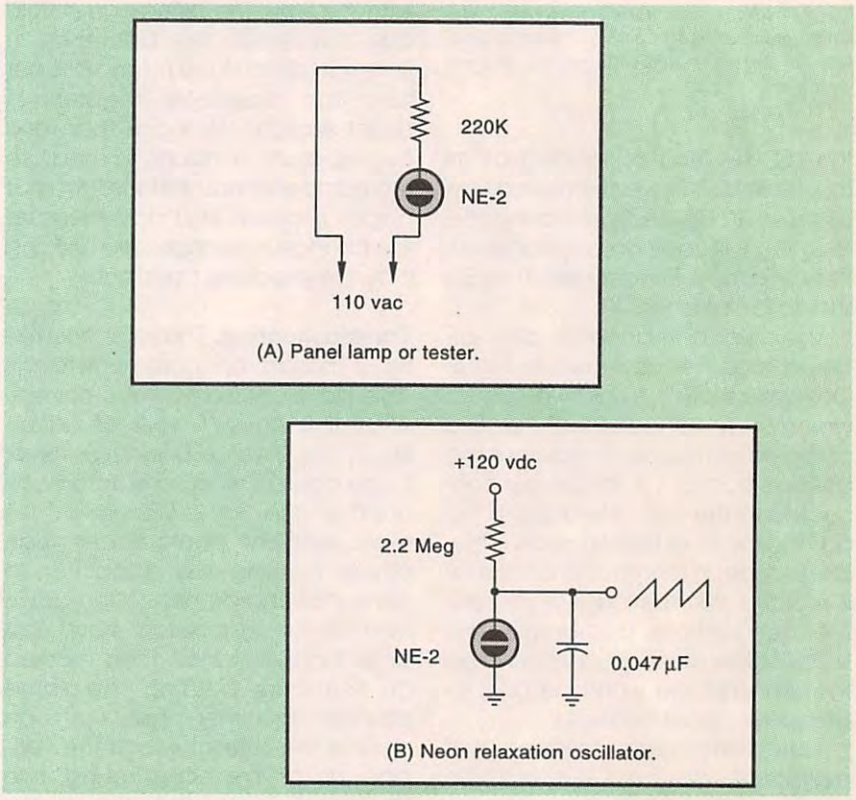

FIG. 1—TWO NEON LAMP CIRCUITS: The one in A is a simple lamp tester; the one in B is a relaxation oscillator.

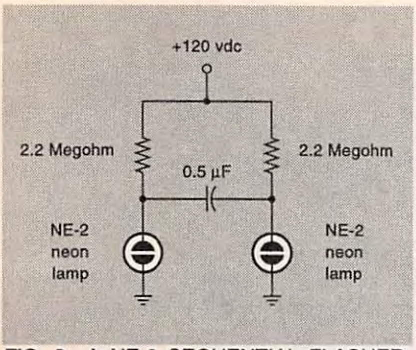

FIG. 2—A NE-2 SEQUENTIAL FLASHER, otherwise known as an astable multivibrator.

110-volts AC and both pins will light up to that characteristic neon orange. Once again, external current limiting must be provided, or a NE-2 will self-destruct. A variation on the circuit is the standard hardware store "circuit tester." Both lamp pins light on AC, but only the positive one does on DC. Thus, you have a simple AC-DC and polarity detector.

Another long-forgotten trick with the circuit checker is to use it as a hot-chassis detector. In some consumer-electronics equipment, one side of the line cord is connected to an internal chassis. Supposedly, the polarized prongs of the power cord prevent the wrong side from being connected, but mistakes do happen.

A severe shock hazard can exist when you try to service hot-chassis gear. To find out if what you are working on is of that type just hold one terminal of a neon tester in your hand and then touch the other to the chassis. If the lamp weakly lights, reverse the power cord or take other suitable precautions. No shock should be felt.

A simple neon-lamp relaxation oscillator is shown in Fig. 1B. That two megohm resistor by itself cannot provide enough current to light the neon lamp in this circuit. So, the lamp remains off, and the capacitor starts charging. When the capacitor charges up to 55 volts, the neon lamp turns on and flashes brightly.

The capacitor is then discharged to the lamp's turnoff point, and the cycle repeats. The lamp flashes at a frequency determined by the RC time constant and the thresholds involved. A sawtooth-like exponential wave will appear across the capacitor; it can be sensed and used as an audio or other signal source.

Neon circuits are also micropower because only a very few microamps are needed from your DC supply.

In Fig. 2, a pair of neon lamps is used as an alternating flasher. This was once known as an astable multivibrator. The capacitor first charges right-to-left and then left-to-right as the alternate lamps conduct. The secret to startup involves the small stray capacitances that are inherently around each bulb.

Figure 3 gives you a cute neon twinkle light effect. Long ago and far away, I used this many times for dance decorations.

Due to the differences in lamp thresholds, the sequence ends up pretty much random—hence your twinkle lights or "little stars." At any given time, one (or rarely two) lamps are lit and provide capacitor charging paths. As the capacitors charge, the threshold for another lamp is exceeded and it fires. Because of a commutation effect, any other lamp turning on should turn off any already lit ones.

For relaxation oscillators to work, the resistors and supply voltage must all be chosen to lie on the negative resistance portion of the NE-2 curve. This usually happens over a rather wide value range. Some cut-and-try may be needed for anything fancy. Resistors in the one to four megohm range are usually a good starting point.

What is really mind-blowing is that I still know of no way to do the same thing using LEDs that can end up being remotely as simple, as cheap, or as low in power. Much more on elegant simplicity appears in ELESIMP.PDF on my www.tinaja.com Web site.

Tachometer Fundamentals

A tachometer is an instrument to measure the speed of a rotating shaft. The results are often shown in rpm, short for Revolutions per Minute.

Tachometers, or tachs, could be digital or analog. Generally, digital ones are more accurate but can be much harder to read and interpret, especially during changes. Since there are lots of subtle

NEED HELP?

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NAMES & NUMBERS

Hitachi
2000 Sierra Point Pkwy.
Brisbane, CA 94005
(415) 589-8300

Home Automation Systems
17171 Daimler Street
Irvine, CA 92614
(800) 367-9836

Home Automator
2258 Sandy Lane
Mebane, NC 27302
(910) 578-9519

Live Wire Enterprises
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Flushing, NY 11367
(718) 544-4400

Maxim
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Sunnyvale, CA 94086
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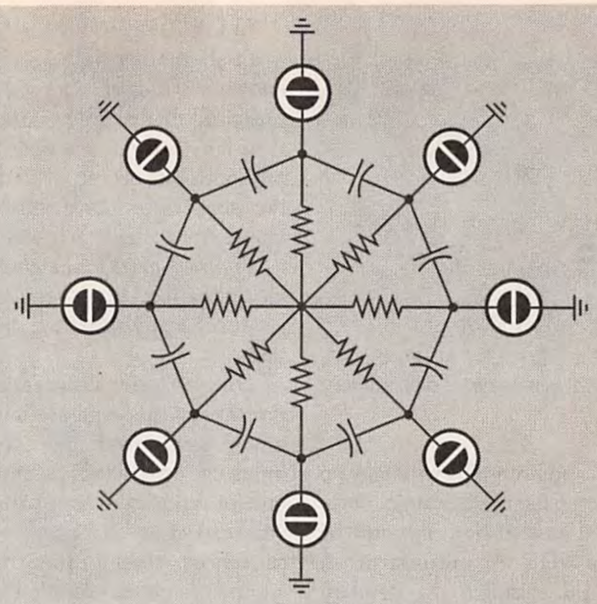

FIG.3—"TWINKLE LIGHTS" for a dance, show, or display.

"gotchas" to tach design, I thought we might go over some fundamentals. Digital tach design can often be split into sensing, conditioning, algorithmic conversion, and display:

Sensing—Sensing involves generating one or more pulses per revolution. In "sensorless" sensing, speed signals are extracted and conditioned directly from the motor's back emf. This has to be tightly integrated into the exact motor and controller in use.

In "sensored" sensing, a device is placed on or near the motor shaft to generate one or more electric pulses per shaft revolution. Sensored sensing most often is done magnetically or optically.

Magnetic sensing is usually done with magnets and Hall Effect devices, or alternately by using ferrous gear teeth and variable reluctance coils. With infrared optics, a bladed vane could interrupt a LED/photodetector pair, or IR light could be bounced off reflective shaft portions.

A third route of very questionable reliability is to use direct mechanical contacts in a commutator setup or a physical gear or roller.

Note that speed can be determined using a single sensor. But when both speed and direction are needed, then a pair of quadrature sensors must be used. These are arranged so that one is in the middle of its sensing activity while the other is at its edge. A dual flip-flop or a computer-logic circuit can extract both speed and direction, as could a somewhat trivial software algorithm. Actual position could be found by adding up or integrating all your speed pulses.

Honeywell and Allegro Electronics are major suppliers for low cost Hall sensors. Optoelectronic providers include Hewlett-Packard, Texas Instruments, Toshiba, Siemens, and QT Optoelectronics.

Conditioning—This just consists of making sure that each sensed pulse ends up as a single clean event. It can be done using hardware, software, or a mixture of both.

Algorithmic conversion—This step usually has to solve several interface problems. It might include numeric translations and reaching acceptable measurement speeds.

At 600 rpm with a single pulse per revolution, you'll have 10 pulses per second. The "10" result from a direct one second measurement must be multiplied by "60" to provide a "600" display. Other scaling factors need to be considered when more than one pulse per revolution is involved, or in automotive applications where each cylinder fires only once for every two revolutions. Note that certain newer cars may fire their cylinders twice to eliminate a distributor—once for real and once at a uselessly wrong time, so watch that detail.

Scaling can be done with hardware or software. These days, software scaling

TACHOMETER RESOURCES

Abbeon Cal 123 Gray Ave. Santa Barbara, CA 93101 (805) 966-0810	**Omega Engineering** One Omega Dr. Stamford, CT 06907 (800) 826-6342
Allegro Microsystems Box 15036 Worcester, MA 01605 (508) 853-5000	**Parallax** 3805 Atherton Rd. #102 Rocklin, CA 95765 (916) 624-8333
Asian Sources 1020 Church St. Evanston, IL 60201 (847) 475-1900	**QT Optoelectronics** 610 N Mary Ave. Sunnyvale, CA 94086 (408) 720-1440
Barbara Arnold Sales 3704 Carlisle Ct. Modesto, CA 95356 (800) 335-4852	**Red Lion Controls** 20 Willow Springs Circle York, PA 17402 (717) 767-6511
Circuit Cellar Ink 4 Park St. #20 Vernon, CT 06066 (203) 875-2751	**Reddington Counters** 130 Addison Rd. Windsor, CT 06095 (860) 688-6205
Scott Edwards 964 Cactus Wren Lane Sierra Vista, AZ 85635 (520) 459-4802	**Sensors** 174 Concord St. Peterborough, NH 03458 (603) 924-9631
Electromatic Equipment 600 Oakland Avenue Cedarhurst, NY 11516 (800) 645-4330	**Siemens Components** 2191 Laurelwood Rd. Santa Clara, CA 95054 (408) 980-4500
Hewlett-Packard PO Box 10301 Palo Alto, CA 94303 (415) 857-1501	**Sunshine Instruments** 1810 Grant Avenue Philadelphia, PA 19115 (800) 343-1199
Honeywell Microswitch 3660 Technology Dr. Minneapolis, MN 55418 (800) 345-6770	**TES Electronics** 57 Jen-Ai Road SEc 2 Taipei, TAIWAN 886-2-2393-9142
Measurement & Control 2994 W Liberty Ave. Pittsburgh, PA 15216 (412) 343-9666	**Texas Instruments** PO Box 655303 Dallas, TX 75380 (800) 336-5236
Microchip Technology 2355 W Chandler Blvd. Chandler, AZ 85224 (602) 786-7200	**Toshiba** 1220 Midas Way Sunnyvale, CA 94086 (800) 321-1718
Frank Murphy Mfg. PO Box 470248 Tulsa, OK 74147 (918) 627-3550	**Veeder Root** 125 Powder Forest Dr. Simsbury, CT 06070 (860) 651-2700

using a PIC or other micro is the preferred choice.

Again, at 600 rpm using a single pulse per revolution, you'll have 10 pulses per second. Six seconds would be required to achieve a ten percent accurate measurement. Much longer times would be required for higher accuracy, especially at lower speeds.

One obvious solution to response times is to have more sensed pulses per revolution. A second solution is to use a phase-locked loop (such as a CMOS 4046) to "multiply" the input-pulse repetition rates by a reasonable selected numeric value. Such a multiplication might also perform the required scaling as well. However, there is an inherent lag in any PLL circuit, which might cause the display to unacceptably fall behind real-time speed changes.

An often optimum workaround is to measure the time period between the sensed pulses instead of counting their frequency. This is known as the EPUT method, as in Events Per Unit Time. The once-horrendous nasty involved here is that a 1/x calculation is required. If your chosen micro has no division instructions, alternates such as a table lookup or a repeated subtraction can be used. Scaling can also be provided internal to your 1/x calculation process.

Another algorithmic consideration is the update time as continuous updates tend to jump around and can be incredibly difficult to interpret or follow. Something near two to four updates per second is often a good choice that optimizes human factors. It's also a very good idea to take the average of as many measurements as practical before displaying them. It is sometimes optimum to round all the display values off to the nearest 100 revolutions per minute.

In certain circumstances, it is best to provide for both an analog and a digital speed display. Use digital for accuracy and analog to interpret any sudden changes.

Display—A PIC or other micro can be used for input conditioning, scaling, and algorithmic conversion. This will often drive an LCD or LED display. An LCD display might typically carry its own very specialized controller chip strapped onto its back.

Some Resources

I've gathered together some tachometer information for you as this month's resource sidebar. Your best starting points are usually the *Sensors* or *Measurements & Control* trade journals. Lab tachs are resold by Omega Engineering, Abbeon Cal, and others.

Three examples of handheld tachs include the TouchTach by Barbara Arnold Sales, the Shimpo DT-105 from Sunshine Instruments, and the RM-1500 from TES Electronics.

Ready-to-use digital-tach panel instruments are widely available. A pair of useful sources includes Red Lion and Reddington. Check out the latter's Eagle

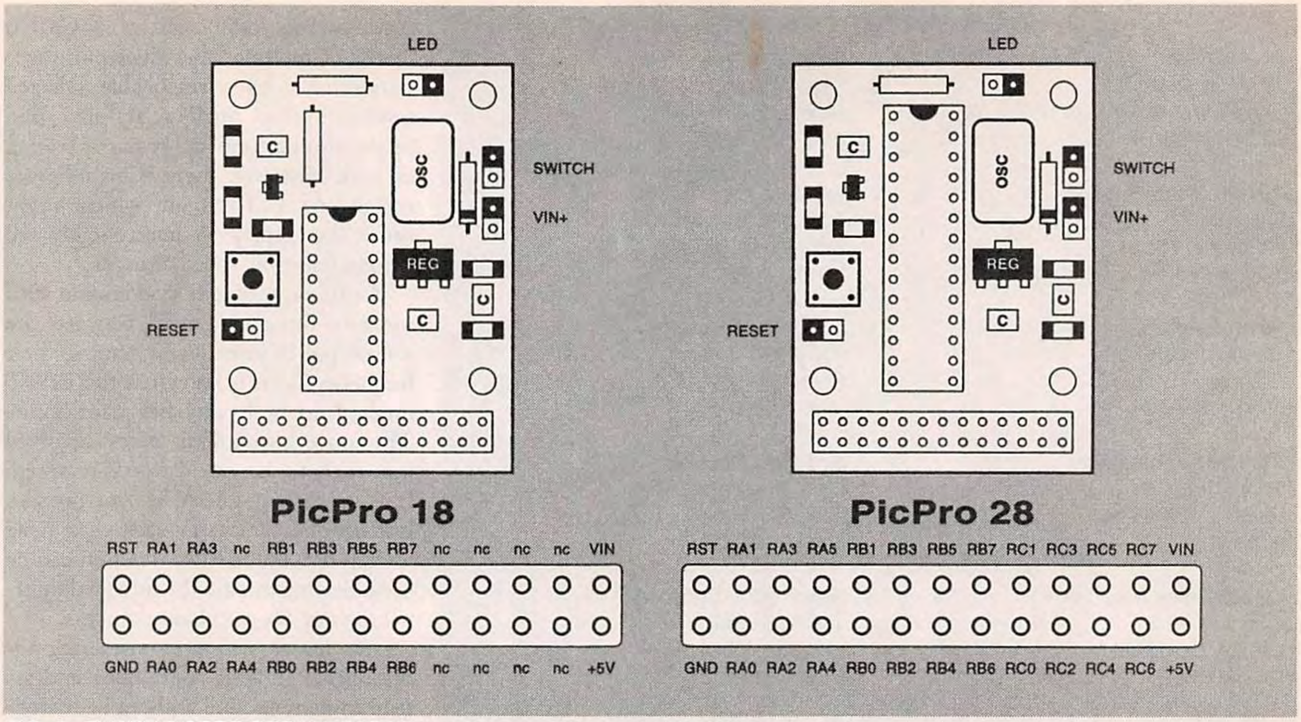

FIG. 4—THESE PICPRO BREADBOARDS from Technical Works simplify PIC design and interface.

Model 53.

One obvious starting point for any custom tachometer is to use the Basic Stamp from Parallax combined with an LCD display module from Scott Edwards Electronics. Later these can be replaced with a custom PIC or a baby PIC design and cheaper display. Microchip Technology is your main PIC supplier. Alternate solutions are offered by Circuit Cellar, as well as in most of the "hobby projects" kit-product lines. But unless you are up to something special, the commercial high volume modules are likely to be a better and cheaper solution than homebrew.

PIC Development Boards

Speaking of PICs, Brad Mock of Technical Works has just come up with something that has long been needed—some small printed circuit breadboards that hold your choice of popular PIC chips, along with all the necessary regulator, oscillator, reset circuitry, and related goodies. Unlike the Basic Stamp from Parallax, these conveniently let you work directly in ultra fast PIC machine language. Two current models are for the 18- and 28-pin PIC chips; other sizes are in the works.

The list prices will be $17.95. His special introductory price of $14.95 is available for readers of this column. Several more details on these PicPro devices are shown in Fig. 4. Lots more PIC information can be downloaded at www.tinaja.com/picup01.html.

New Tech Lit

From Texas Instruments there's Radio Frequency Solutions and Video Solutions for PC Platforms mailers. From Maxim comes the latest release of a Data Catalog CD. The new reference library CD from Hitachi is about their SuperH RISC Engines

There is a new freebie catalog out from Home Automation Systems. And *Home Automator* magazine remains your first choice for useful help in this field. A home-automation tutorial is at www.tinaja.com/resbn01.html.

I came across two interesting new books this month. First, be sure to check out *When Things Start to Think* by Neil Gershenfeld. This text is mostly on ongoing projects by the MIT Media Lab. Neil makes heavy predictions for the widespread use of low-cost distributed intelligence: everything from erasable digital paper to smart shoes. This title meshes nicely with *The Age of Intelligent Machines*, which we looked at last month.

There is also a superb *Planetary Astronomy* text by a Ronald Schorn. This appears to be a highly readable and a definitive history of our solar system discoveries as written by a NASA insider. Lots of references and a detailed and annotated bibliography are nicely included.

More on these titles can be found at www.tinaja.com/amlik01.html. A very useful database for astronomy teaching materials can be obtained from www.aas.org/~education/index1.html.

An intriguing "Knotty Neon" lighting and display material is now available. These are basically knottable "ropes" of electroluminescent light. There's ten colors with lengths up to 600 feet. The colors are somewhat adjustable by changing the applied frequency from a 12-volt AC control unit driven by a wall wart supply. The supplier is Live Wire Enterprises. I was unable to locate their Web site (if one exists). They are mentioned at www.led.com and at www.lightsearch. com. Trade journals that target this sort of neat stuff include *Signcraft*, *Sign Business*, *POP and Sign Design*, and *Point of Purchase*.

There sure is a bunch of interest in boat anchors—pieces of ancient military surplus communications or test gear that are outrageously huge and heavy—these days. They sure don't make them like this any more. I will try to do an in-depth survey sometime, but for now, check into the link farm at nashville.net/~badger/millist. Or to find "straight from the horse's whatever" information, try out FM 24-24 at www.gordon.army.mil/doctrine/2424, plus, of course, good old Surplus Al at mh105.infi.net/~surplsal/.

Speaking of boat anchors, I just happen to have a stunning buy on a neat 60-kilowatt load bank. AC or DC, single or three phase, 12 to 440 volts. You use this one for generator testing, student power-lab loads, or wind energy research. It also makes toast. And, no, there is no way you can call this one a white elephant—it is a perfectly normal gray elephant in color and size. Contact me via e-mail at don@tinaja.com or see www.tinaja.com/bargte01.html.

For all the fundamentals of digital integrated circuits, be sure to check into my *TTL* and *CMOS Cookbooks*, either by themselves or as part of my bargain priced *Lancaster Classics Library*. See my nearby Synergetics ad for full details. And for all your other book needs, see www.tinaja.com/amlink01.html.

The latest Web-site additions to my Guru's Lair found at www.tinaja.com include a tutorial on Supraluminal Dowsing for Brown's Gas in Roswell. Your key secret, of course, is to be sure to use an overunity water-fueled black helicopter.

Our Consultant's Network is newly expanded and greatly improved at www.tinaja.com/consul01.html. And lots of surplus bargains are found at www.tinaja.com/barg01.html.

As usual, most of these mentioned items should show up in our Names & Numbers or Tachometer Resources sidebars. Check here before calling our no-charge US technical helpline shown in the nearby box.

Let's hear from you.

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