Don Lancaster's

Tech Musings

May, 1999

Tachometer design basics
"knotty neon" lighting rope
New PIC breadboard source
Some boat anchor resources
Ancient twinkle lights circuit

Let's take a look at something so old and so simple that it just may be new for you. At any rate, this one still makes a seldom-seen and a really fine little homebrew project…

Twinkle Lights

The NE-2 neon lamp is by far your number one electronic component of all time. Yeah, this device is more or less way into retirement, owing to the high voltages and the restricted light output. But you can still get them for a dime or so each at *Radio Shack* and elsewhere. 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 having a tiny amount of low pressure neon gas in it. Two simple pins act as terminals. At voltages below 55 volts or so, your neon lamp is more or less an open circuit. Above this 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. Typically to 45 volts or so. This destructive behavior *must* get externally current limited. Usually with a high value resistor of 100K or more. Conduction continues so long as a current source remains. When and if your current drops down to zero, the neon lamp turns off.

Figure 1-a shows us the standard NE-2 pilot light circuit. Connect this one to 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 this 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 the *hot chassis* detector. Some consumer electronics connects one side of the line cord to an internal chassis. Supposedly, the polarized prongs of the power cord prevent the wrong side from getting connected, but mistakes do happen.

A severe shock hazard can exist when you try to service hot chassis gear. To find out for sure, 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.

Figure 1-b shows us a simple neon lamp *relaxation oscillator*. That two meg 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 voltage gets up to 55 volts, the neon lamp turns on and flashes brightly.

The capacitor then gets discharged to the lamp's turnoff point, and the

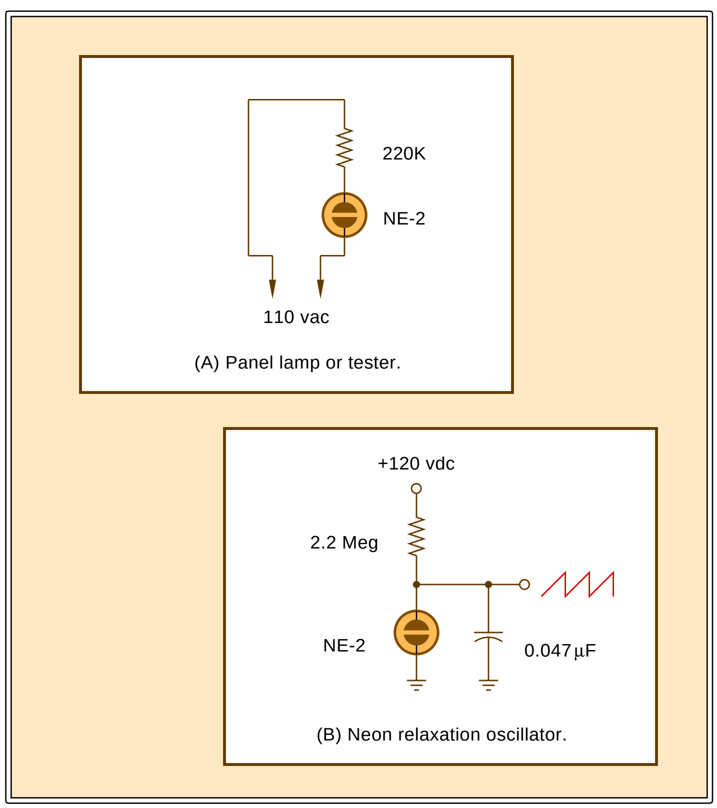

Fig. 1 – TWO NEON LAMP CIRCUITS.

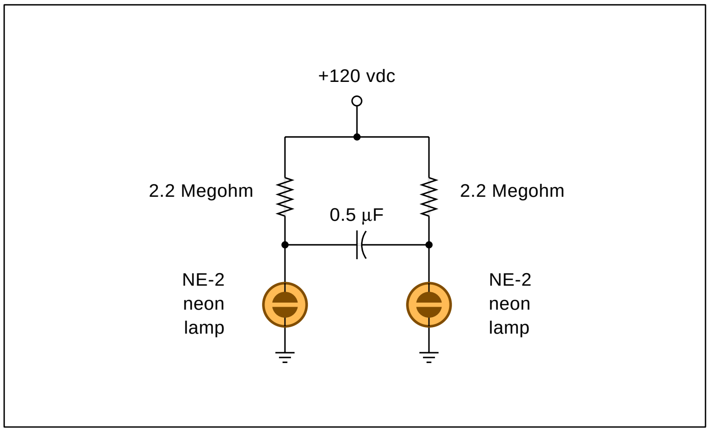

Fig. 2 – A NE-2 SEQUENTIAL FLASHER.

cycle repeats. The lamp flashes at a frequency determined by the RC time constant and the thresholds involved.

A sawtooth-like exponantial wave will appear across the capacitor and can get 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 Figure 2, a pair of neon lamps gets used as an alternating flasher. This was once known as an *astable multivibrator*. The cap first charges right-to-left and then left-to-right as the alternate lamps conduct. The secret to startup involves small stray capacitances inherently around each bulb.

Figure three gives you a cute neon *twinkle light* effect. I have used this many times for dance decorations.

Long ago and far away.

The sequence ends up pretty much random. Owing to the differences in lamp thresholds. 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 caps 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 get 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 meg range are usually a good starting point.

What gets really mind-blowing is that I still know of no way to do the same thing using LED's that can end up remotely as simple, as cheap, or as low in power.

Much more on elegant simplicity apears in ELESIMP.PDF Found on my *www.tinaja.com* website.

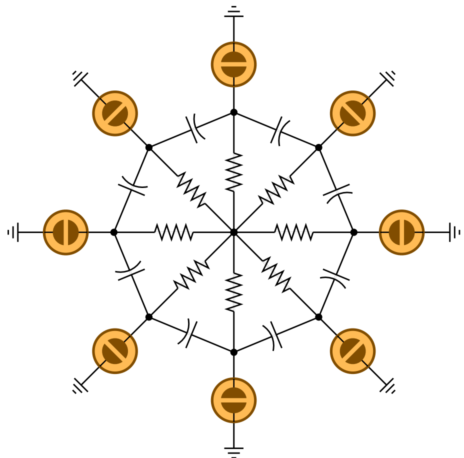

Fig.3 – "TWINKLE LIGHTS" for a dance, show, or display.

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*.

Tachs might be digital or analog. Generally, digital is more accurate but can be *much* harder to read and interpret. Especially during changes. Since there are lots of subtle 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 a "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 gets done magnetically or optically.

Mag 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

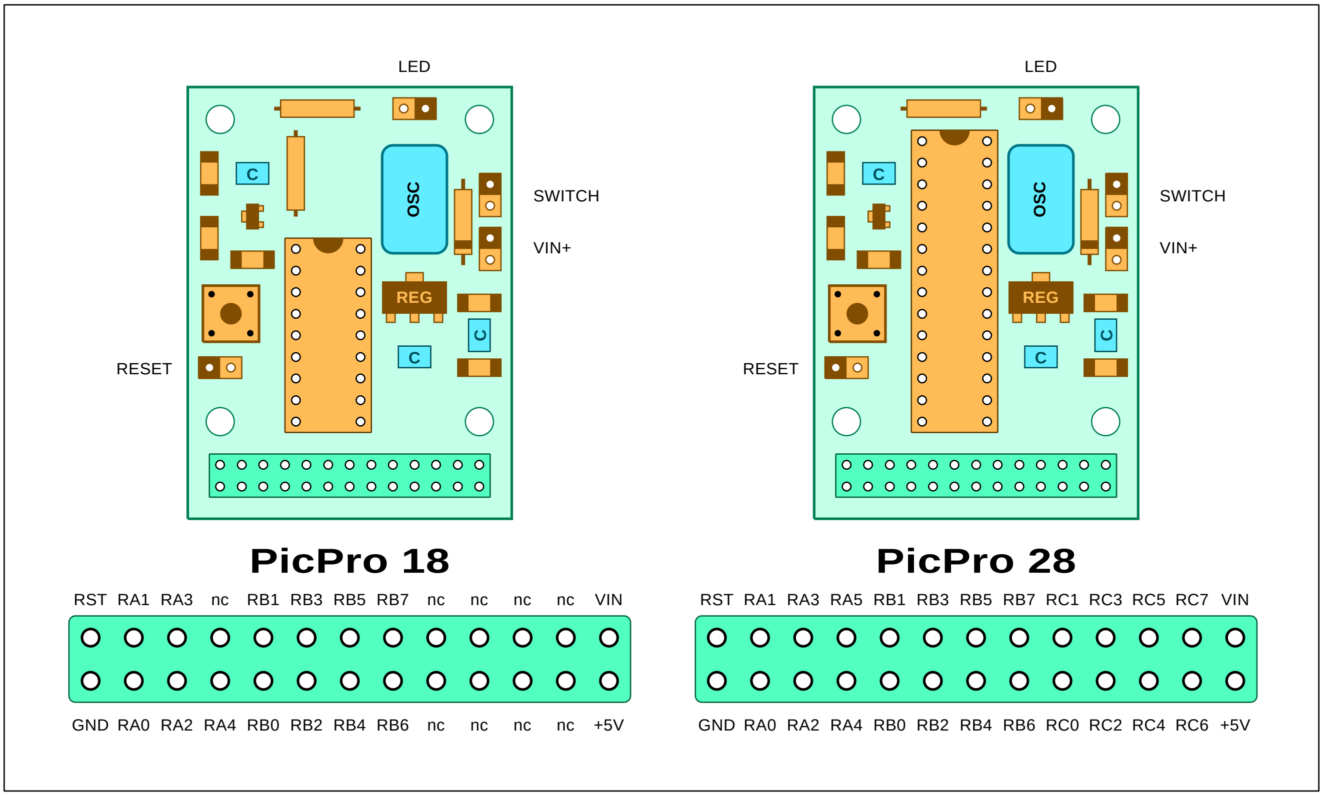

Fig. 4 – THESE PICPRO BREADBOARDS from Technical Works simplify PIC design and interface.

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 get found by adding up, or *integrating* all your speed pulses.

Honeywell and *Allegro Electronics* are major suppliers for low cost Hall sensors. The optoelectronic providers will 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 needs to 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.

Watch this detail.

Scaling can be done with hardware or software. These days, a software scaling 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 lock loop (such as a CMOS 4046) to "multiply" your 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*. Your 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 your update time. For 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

SOME USEFUL TACHOMETER RESOURCES

Abbeon Cal
123 Gray Ave
Santa Barbara CA 93101
(805) 966-0810

Allegro Microsystems
Box 15036
Worcester MA 01605
(508) 853-5000

Asian Sources
1020 Church St
Evanston IL 60201
(847) 475-1900

Barbara Arnold Sales
3704 Carlisle Ct
Modesto CA 95356
(800) 335-4852

Circuit Cellar Ink
4 Park St #20
Vernon CT 06066
(203) 875-2751

Scott Edwards
964 Cactus Wren Lane
Sierra Vista AZ 85635
(520) 459-4802

Electromatic Equipment
600 Oakland Avenue
Cedarhurst NY 11516
(800) 645-4330

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

Honeywell Microswitch
3660 Technology Dr
Minneapolis MN 55418
(800) 345-6770

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

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

Frank Murphy Mfg
PO Box 470248
Tulsa OK 74147
(918) 627-3550

Omega Engineering
One Omega Dr
Stamford CT 06907
(800) 826-6342

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

QT Optoelectronics
610 N Mary Ave
Sunnyvale CA 94086
(408) 720-1440

Red Lion Controls
20 Willow Springs Circle
York PA 17402
(717) 767-6511

Reddington Counters
130 Addison Rd
Windsor CT 06095
(860) 688-6205

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

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

Sunshine Instruments
1810 Grant Avenue
Philadelphia PA 19115
(800) 343-1199

TES Electronics
57 Jen-Ai Road SEc 2
Taipei, TAIWAN
886-2-2393-9142

Texas Instruments
PO Box 655303
Dallas TX 75380
(800) 336-5236

Toshiba
1220 Midas Wy
Sunnyvale CA 94086
(800) 321-1718

Veeder Root
125 Powder Forest Dr
Simsbury CT 06070
(860) 651-2700

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 a LCD or LED display. A LCD display might typically carry its own very specialized controller chip strapped onto its back.

Some Resources

I've gathered together some tach info 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*, by *Abbeon Cal*, and others.

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

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* Model 53.

One obvious starting point for any custom tachometer is to use the *Basic Stamp* from *Parallax* combined with that 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 those "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 PIC's, Brad Mock of his *Technical Works* has just come up with something which 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. Figure four shows you several more details on these *PicPro* devices. Lots more PIC info can be downloaded at *www.tinaja.com/picup01.html*

NEED HELP?

Phone or email all your US Tech Musings questions to:

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

US email: *don@tinaja.com*
Web page: *www.tinaja.com*

New Tech Lit

From *Texas Instruments*, a *Radio Frequency Solutions* and their *Video Solutions for PC Platforms* mailers. From *Maxim*, the latest release of a *Data Catalog* CD. The new reference library CD from *Hitachi* 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, do check out *When Things Start to Think* by Neil

NAMES AND 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
PO Box 670081
Flushing NY 11367
(718) 544-4400

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

P-O-P & Sign Design
7400 Skokie Blvd
Skokie IL 60077
(708) 675-7400

Point of Purchase
6225 Barfield Rd #200
Atlanta GA 30328
(404) 252-8831

Sign Business
1008 Depot Hill Office Pk
Broomfield CO 80020
(303) 469-0424

SignCraft
PO Box 06031
Ft Myers FL 33906
(813) 939-4644

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

Technical Works
PO Box 3692
Albany GA 31706
(912) 787-3000

Texas Instruments
PO Box 655303
Dallas TX 75380
(800) 336-5236

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* that 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/amlink01.html* A very useful data base for astronomy teaching materials can be gotten from *www.aas.org/~education/index1.html*

An intriguing *Knotty Neon* lighting and display material is now available. These are basically knottable "ropes" of electrolumnescent light. There's ten colors with lengths up to 600 feet. The colors are somewhat adjustable by changing your applied frequency from a 12 volt ac control unit driven by a wall wart.

Supplier is *Live Wire Enterprises*. I was unable to locate their website. 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* these days. Pieces of ancient military surplus comm or test gear that are outrageously huge and heavy. They sure do not make them like this any more. I will try to do an in-depth survey sometime.

But for now, check into that link farm at *nashville.net/~badger/millist* Or to find "straight from the horse's whatever" info, 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 do happen to have a stunning buy on a neat-o 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. Nope, there is no way you can call this one a white elephant. It is a perfectly normal gray elephant color.

And size.

Email me at *don@tinaja.com* or go to *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 book needs, see *www.tinaja.com/amlink01.html*

The latest website additions to my *Guru's Lair* found at *www.tinaja.com* do 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 up 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 US technical helpline. ✥