



Circuits for the Hobbyist

by VA3AVR



[Tony's Message Forum](#) Ask your questions here. Someone may answer them.

Circuits

- Active Power Zener
- Active Antenna for AM-FM-SW
- Active Antenna for HF-VHF-UHF
- Active FM Antenna Amplifier
- Aviation Band Receiver **UPDATED** 25C2570 Pin-out: 12-17-2004
- Alternating On-Off Switch
- Audio Booster with 1 Transistor
- Audio Pre-Amplifier #1
- Automatic 9-Volt NiCad Battery Charger
- Auto-Fan, automatic temperature control
- Basic IC MonoStable Multivibrator
- Basic RF Oscillator #1
- Basic LM3909 Led Flasher
- Battery Monitor for 12V Lead-Acid
- Battery Tester for 1.5 & 9V
- Battery (NiCad) Rejuvenator
- Bench Top Power Supply, Part 1
- Bench Top Power Supply, Part 2
- Bench Top Power Supply, Part 3
- Bench Top Power Supply, Part 4 Pics
- Bench Top Power Supply, Auto-Fan
- Bicycle Light with charger (soon)
- Birdie Doorbell Ringer
- Broadcast-Band RF Amplifier
- Bug Detector with Beep
- Car Back-up Alarm **New**
- Car Converter for 12V to 9V
- Car NiCad Charger
- Christmas Lights Tester
- Clock Generator
- Continuity Tester, Low-Voltage
- Continuity Tester, Smart
- Continuity Tester, Latching
- Cut Phone Line Detector
- Dark/Light Activated Relay
- Dazer
- DC Motor Reversing Circuit
- DC Motor Control Circuit
- DSL Filter (phone-line)
- Dual 12V Power Supply
- Fluid-Level Detector
- Fox & Hound, wire tracer
- Gadgets for Radio Control Page
- Gel Cell Charger, I
- Gel Cell Charger, II
- Headlight Alarm
- Heat Sensor -- OFF-LINE (performance problems)
- Lantern Flasher/Dimmer
- Led Flasher, 2 transistor
- Leds Flasher, alternately
- LED Pilot Light (AC or DC)
- Light Sensor With Hysteresis
- Logic Probe(1), with pulse, TTL/CMOS
- Logic Probe(2), with pulse, TTL/CMOS
- Logic Probe(3), Audible, TTL/CMOS
- Micro-Spy with FET's
- Micro-Spy with USW
- Micro-Spy with TTL
- Miniature FM Transmitter #1
- Miniature FM Transmitter #2
- Miniature FM Transmitter #3
- Miniature FM Transmitter #4
- Mini-Drill variable Powersupply
- Missing Pulse Detector (Basic)
- Morse Code Practice Kever, I
- Morse Code Practice Kever, II
- Motor Accu Lader (Dutch language)
- Motorcycle Battery Charger
- No-Hassle Third Brake Light
- Power Supply Converted from a PC (link)
- Practical Intercom
- Pulse Timer, 555
- Pulse Width modulator, 555
- Pulse Width modulator, 4093
- Radio Shack Special - Transmitters by Patrick Cambre
- Relays - Sound Activated
- Relays - Transistor Boosted
- Relays - Delayed Turn-on
- Relays - Automatic Turn-off
- Relays - Long Duration
- Relays - Long Duration--1 to 100 min
- Relays - Long Duration--1 min to 20 hrs
- Relays - Self Latching
- RF Transmitter, light sensing
- RJ45 Cable Tester Modified version (Bruce Marcus) **New**
- ScanMate Your (Radio) scanner buddy!
- Simplest R/C Circuit
- Simplest RF Transmitter
- Simple Transistor Audio PreAmplifier
- Single IC Audio Preamplifier
- Single Cell Sealed Lead Acid Charger - by Søren **New**
- Solar Cell NiCad Charger
- 9-V Op-Amp
- Stun Gun circuits on Chemelec's site
- Third Brake Light Pulser
- Touch Activated Alarm System
- Touch Switch using Transistors
- Two-Tone Trainhorn
- Universal Flasher Circuit
- Variable Power Supply, 1 - 30V @ 1.5A
- Wailing Alarm
- Water-level Sensing and Control
- Waterpump Safety Guard for Fish-pond
- Weller WLC100 Electronic Soldering Station
- Wireless Microphone **New**
- Xmas Lights Tester
- Zip Adapter
- 1.5V Tracking Transmitter
- 4-Transistor Tracking Transmitter **UPDATED**
- 7.2V Field Charger (.pdf file)
- 9-V Stabilized Powersupply
- 9 to 9 pin (Female) Nullmodem Cable
- 12V to 9V with a LM317 **Updated** Amp Booster added
- 30-Meter QRP Transmitter for Morse Code
- 555 DC-AC Inverter
- 555 Timer IC Tester
- 555 Go No/Go Tester More advanced
- Electronic Symbols Template - Paint Shop Pro **Updated** 10-27-2004

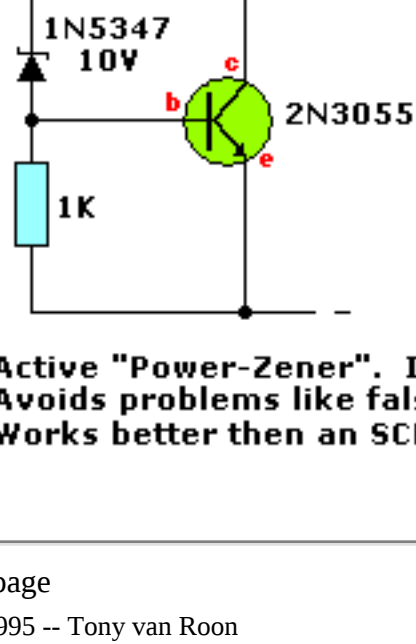
Just in case you're gonna ask: **All drawings are created with Paint Shop Pro**

Info/Data

- Circuits Archive - Older circuits. Most are working, some are not. Could be still useful.
- Tony's Data Sheets - Data Sheet for common Semiconductors
- Data Sheets Archive - Link to tons of data sheets.
- Radio Shack Partnumbers - Most common order numbers for my circuits
- Resistor Value Calculator - By Danny Goodman, A9F **New**
- Tandy Corporation - European/Australian counterpart of Radio Shack
- Transistor 'SM' marking codes by Philips
- TUP/TUN/DUS/DUG European transistor replacement system
- PN100/200 - Data Sheets for the PN100 and PN200
- LF13741 - Monolithic JFET Input OpAmp Data Sheet
- Toroids, RE/EMI Cores - Variety of commonly used toroids, colors, etc.
- Guelph Amateur Radio Club - GARC--Official Homepage
- Jonathan's Electronics Message Forum - More help if you need it! **New**
- Other Interesting Links - Links to other interesting and informative Electronics Websites. **UPDATED** November 1, 2004



DISCLAIMER: I take no responsibility whatsoever for the use and/or implementation thereof, or the misuse leading to damage to equipment, property, or life, caused by the above circuits. Check with local, provincial and federal laws before operating some of these devices. You may also check your life insurance and/or the fact if they cover death by electrocution if you intend to play with Micro-wave ovens and other possible lethal HV devices. Safety is a primary concern when working with high power circuits or con/inverters. Play it safe!



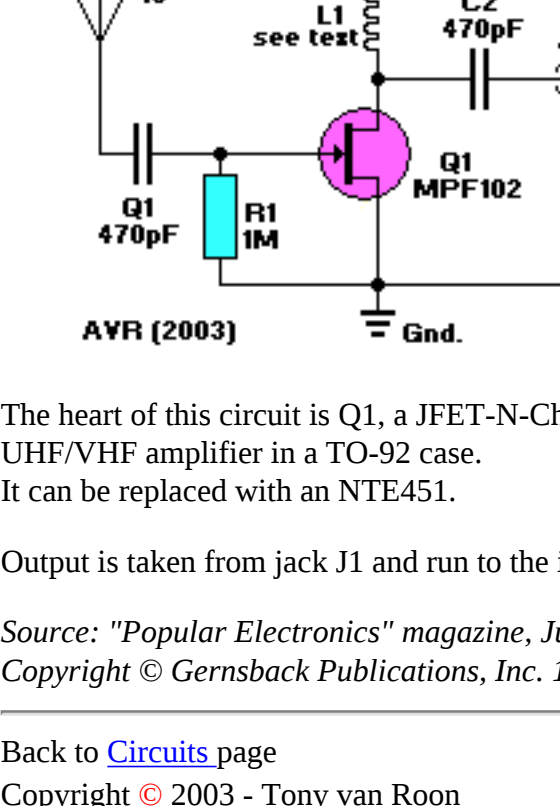
Active Power Zener

"V_Z" = 10.6V

Up to 10 amps

Active "Power-Zener". Install across the supply lines.
Avoids problems like false triggering on spikes.
Works better then an SCR (which has the memory of an elephant).

AM-FM-SW Active Antenna



The heart of this circuit is Q1, a JFET-N-Channel, UHF/VHF amplifier in a TO-92 case. It can be replaced with an NTE451.

Output is taken from jack J1 and run to the input on the receiver.

Source: "Popular Electronics" magazine, July 1989 issue.
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Active Antenna for AM/FM/SW:

This simple little circuit can be used for AM, FM, and Shortwave(SW). On the shortwave band this active antenna is comparable to a 20 to 30 foot wire antenna. It is further more designed to be used on receivers that use untuned wire antennas, such as inexpensive units and car radios.

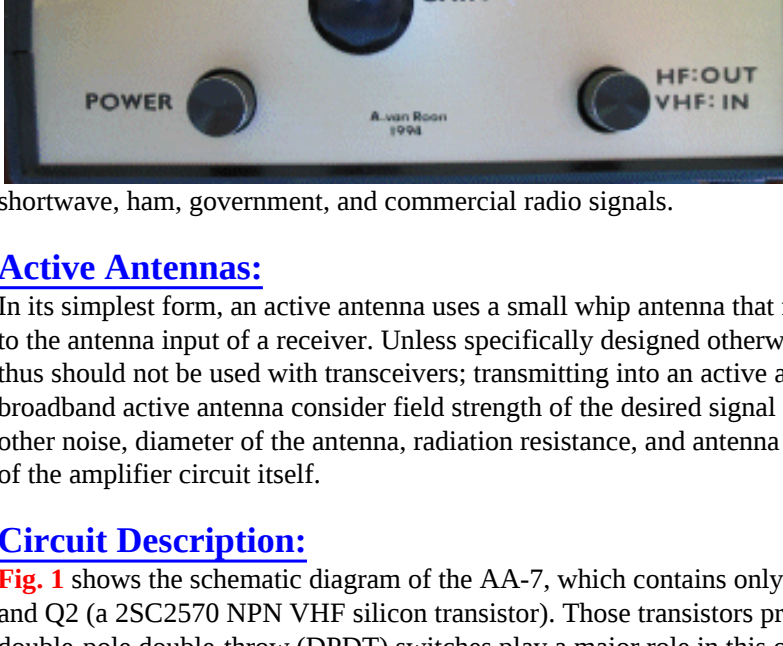
L1 can be selected for the application. A 470µH coil works on lower frequencies and lie in AM, for shortwave try a 20µH coil. This unit can be powered by a 9 volt alkaline battery. If a power supply is used, bypass the power supply with a 0.04µF capacitor to prevent noise pickup. The antenna used on this circuit is a standard 18-inch telescoping type, but a thick piece of copper, bus-bar, or piano wire will also work fine.



Active Antenna AA-7 HF/VHF/UHF, 3 to 3000 MHz

By Fred Blechman

"Lift those hard-to-hear signals out of the mud with this handy receiver accessory."



shortwave, ham, government, and commercial radio signals.

Active Antennas:

In its simplest form, an active antenna uses a small whip antenna that feeds incoming RF to a preamplifier, whose output is then connected to the antenna input of a receiver. Unless specifically designed otherwise, all active antennas are intended for receive-only operation, and thus should not be used with transceivers; transmitting into an active antenna will probably destroy its active components. A well designed broadband active antenna consider field strength of the desired signal (measured in microvolts per meter of antenna length), atmospheric and other noise, diameter of the antenna, radiation resistance, and antenna reactance at various frequencies, plus the efficiency and noise figure of the amplifier circuit itself.

Circuit Description:

Fig. 1 shows the schematic diagram of the AA-7, which contains only two active elements: Q1 (an MFE201 N-Channel dual-gate MOSFET) and Q2 (a 2SC2570 NPN VHF silicon transistor). Those transistors provide the basis of two independent, switchable RF pre-amplifiers. Two double-pole double-throw (DPDT) switches play a major role in this operation of the AA-7. Switch S1 is used to select one of the two preamplifier circuits (either HF or VHF/UHF). Switch S2 is used to turn off the power to the circuit, while coupling the incoming RF directly to the input of the receiver. That gives the receiver non-amplified access to the auxiliary antenna jack, at J1, as well as the on-board telescoping whip antenna. With switch S2 in its power-on position, the input and output jacks are disconnected and B1 (a 9 volt battery) is connected to the circuit. With switch S1 in the position shown in the schematic, incoming RF is directed to the HF preamp circuit built around Q1 (an MFE201 N-Channel dual-gate MOSFET). The HF preamp operates with an exceptionally low noise level, and is ideal for copying weak CW and single-side band signals. When S1 is switched to the other position, the captured signal is coupled to the VHF/UHF preamp built around Q2 (a 2SC2570 NPN VHF silicon transistor), which has excellent VHF through microwave characteristics. With the on-board whip antenna adjustable to resonance through much of the VHF-UHF region (length in feet = 234 divide by the frequency in Mhz), the VHF/UHF mode is ideal for indoor and portable use with VHF scanners and other receivers. Either mode can be used when tuning 3-30 Mhz HF signals. The VHF/UHF preamp offers higher gain than the HF preamp, but also has a higher noise level. You can easily choose either amplifier for copying any signal; of interest—just try both positions. The RF gain control (R5) can be used to trim the output of either amplifier.

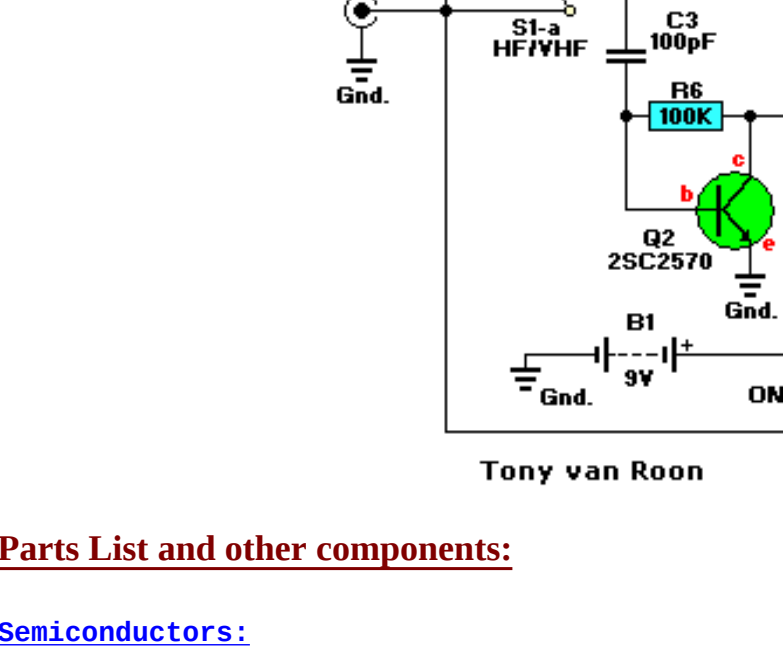
Caution: The AA-7 is *not* intended for transmitting operation (be it Ham, Maritime, or CB); if it is used with a transceiver of any kind, make sure it is not possible to transmit by accidentally pressing a mike button of DW keyer. Transmitting RF into the AA-7 is likely to ruin one of both of the transistors in the circuit.

Construction:

The fact that there are two independent preamplifiers in the AA-7 makes faults easier to diagnose than with many other devices. If a problem occurs, only at one setting of S1, concentrate on that part of the circuit. If the problem is common to both settings, the components and the connections common to both preamps should be checked. Make sure the jumper wires are in place. There are other characteristics or phenomena associated with preamplifiers and active antennas that does not mean that your circuit is malfunctioning. For example, if you have strong AC hum in the HF setting, the antenna is too close to an AC cord or powerline. HF signals may be clearer at the VHF/UHF setting than at the HF setting. Why? Although either preamp may be used for HF, the signal strength will be greater with the VHF/UHF preamp. However, the HF signal-to-noise ration is better with the dual-gate-MOSFET-based preamp. Try both and use the best for your particular receiver conditions. Some portable receivers not enclosed in metal cases may break into oscillation when connected to any RF preamplifier. Try reducing the AA-7's gain and make sure that good grounds are provided with the interconnecting coax cables. A preamplifier will intensify any problems due to poor receiver design: overloading, images, or any other problems with selectivity and image rejection.

If you glow make it obvious when the unit is on.

Although **not** supplied with the kit, a custom plastic enclosure (with front and back panels) or a regular 'hobby' case of some sorts, and knobs for the switches and gain control is offered in the Parts list. The enclosure comes pre-drilled and silk-screened with the appropriate legends for all the circuit controls and connectors, but is not equipped with holes for the whip antenna or the led (if you include one)>



Test and Use:

Prepare coaxial cable to connect the RF output of the AA-7 to the antenna input of your receiver or scanner. One end of the interconnecting cable must be terminated with an RCA phono plug; the other end connector depends on the target receiver or scanner. With some receivers, the only practical connection is to clip the output of the AA-7 to the receiver's antenna, although that connection won't be as effective as conventional (ground-return type) coupling.

To increase signal strength, especially for the lower frequencies, you can connect a simple supplementary portable antenna of any design (a dipole, random-length wire with Earth ground, a bigger vertical whip of some kind, etc.) to the circuit. Just use a small-diameter coaxial cable terminated in an RCA plug for mating with J1. No alignments are required. If you're using the whip antenna, simply connect the output of the AA-7 to your receiver, with the unit turned off (that's the bypass position) and the RF gain control (R5) turned fully counter-clock wise. Turn on the receiver and tune-in a weak station. Switch S2 on, and adjust the gain control clockwise to increase the output signal. Toggle S1 back and forth to see which setting gives you the best results. Don't be surprised if the gain control overloads the receiver; if so, back it off.

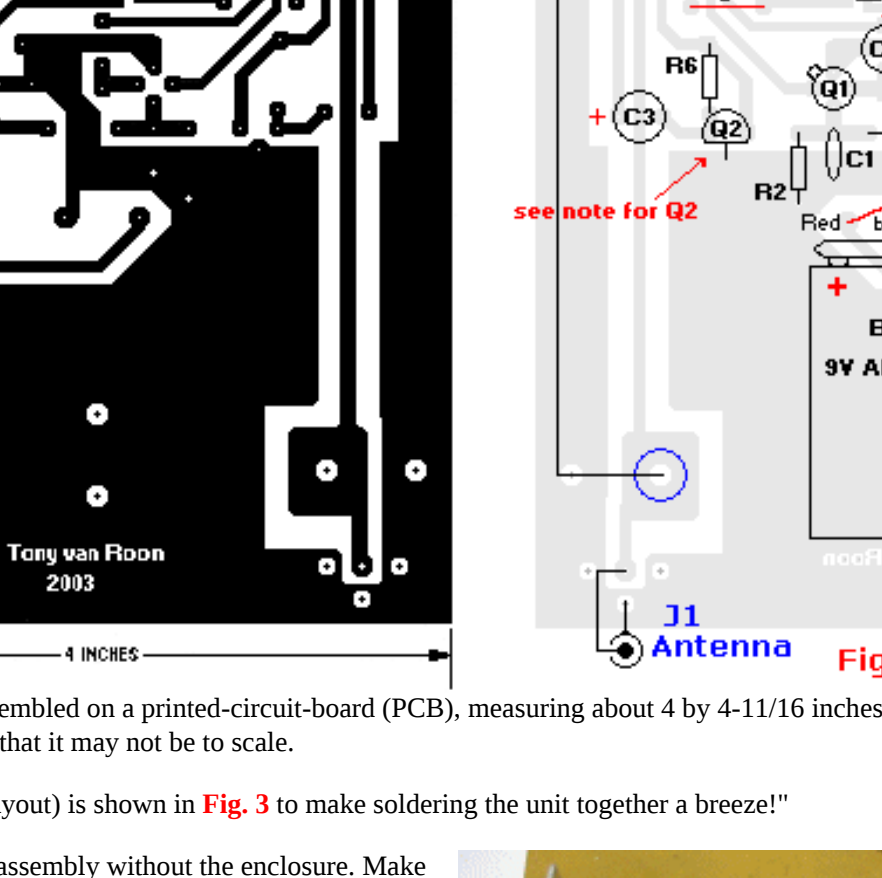
Troubleshooting:

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HF/VHF/UHF Active Antenna



Parts List and other components:

Semiconductors:

Q1 = MFE201, SK3991, or NTE454. N-Channel, dual-gate MOSFET (see text)
Q2 = 2SC2498, 2SC2570, 2N5179, SK9139, or NTE18. NPN VHF/UHF silicon transistor (see text)

Note: If you use the NTE107 as a replacement, make sure to insert it correctly into the pcb. The orientation is different than as shown on the parts layout diagram. (e-c-b seen Frontview for NTE107). See this [Data Sheet](#)

Resistors:

All Resistors are 5%, 1/4-watt

R1 = 1 Mega Ohm
R2 = 220K
R3, R6 = 100K
R4 = 100 ohm
R5 = 10K potentiometer, (pc mount)

Capacitors:

C1, C2, C5, C6 = 0.01uF, ceramic disc
C3 = 100pF
C4 = 4.7 to 10uF, 16WVDC, radial lead electrolytic

Additional Parts & Materials:

S1, S2 = DPDT PC mount pushbutton switch
J1, J2 = PC mount RCA jack
ANT1 = Telescoping whip antenna (screw mount)

MISC = PCB materials, enclosure, enclosure, battery holder and connector, wire, solder, etc.

KIT = NO kit is available at this time. I may supply kits on demand.

Fig. 1. "The AA-7 Active Antenna contains only two active elements: Q1 and Q2 (a 2SC2570 NPN VHF silicon transistor), which provide the basis of two independent, switchable RF preamplifiers."



Fig. 2. "The AA-7 was assembled on a printed-circuit-board (PCB), measuring about 4 by 4-11/16 inches. A template for the printed-circuit-board is shown here. Note that it may not be to scale.

Parts assembly diagram (layout) is shown in **Fig. 3** to make soldering the unit together a breeze!"

Fig. 4. shows the finished assembly without the enclosure. Make sure the antenna-hole in the enclosure is in-line with one on the pcb. On mine I used a stud with thread on both sides to enable me to use different length antenna's; all I have to do is unscrew and screw another antenna back in without taking the AA-7 apart. I used a 9-volt battery tray which allows me to replace the battery without opening up the case, but the regular battery clip and battery works fine. As you can see from the pictures, this is a nice one-evening project.

Types of Active Antennas

The RF preamplifier section of an active antenna may be of several different styles. A fixed-tuned preamp has the greatest gain for the specific frequency of operation, but is limited to only that frequency. A variable-tuned amplifier can be peaked within a range of frequencies, but the circuitry is more complex and expensive and tuning requires constant resetting whenever the receiver frequency is changed. A broadband preamplifier doesn't require any tuning, making it very versatile and easy to use, but has less gain at any specific frequency. The AA-7 described here, for simplicity and low cost, is of a dual broadband design.

I fully support this project, since my unit has been in operation for quite a few years now and still running on the same battery. Power consumption if minimum. Most parts can be obtained via your local electronics store. I will answer all questions but via "Tony's Message Forum" only. This Forum can be accessed via the main page, gadgets, or circuits page.

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Document updates & modifications, all diagrams, PCB/Layout drawn by Tony van Roen.

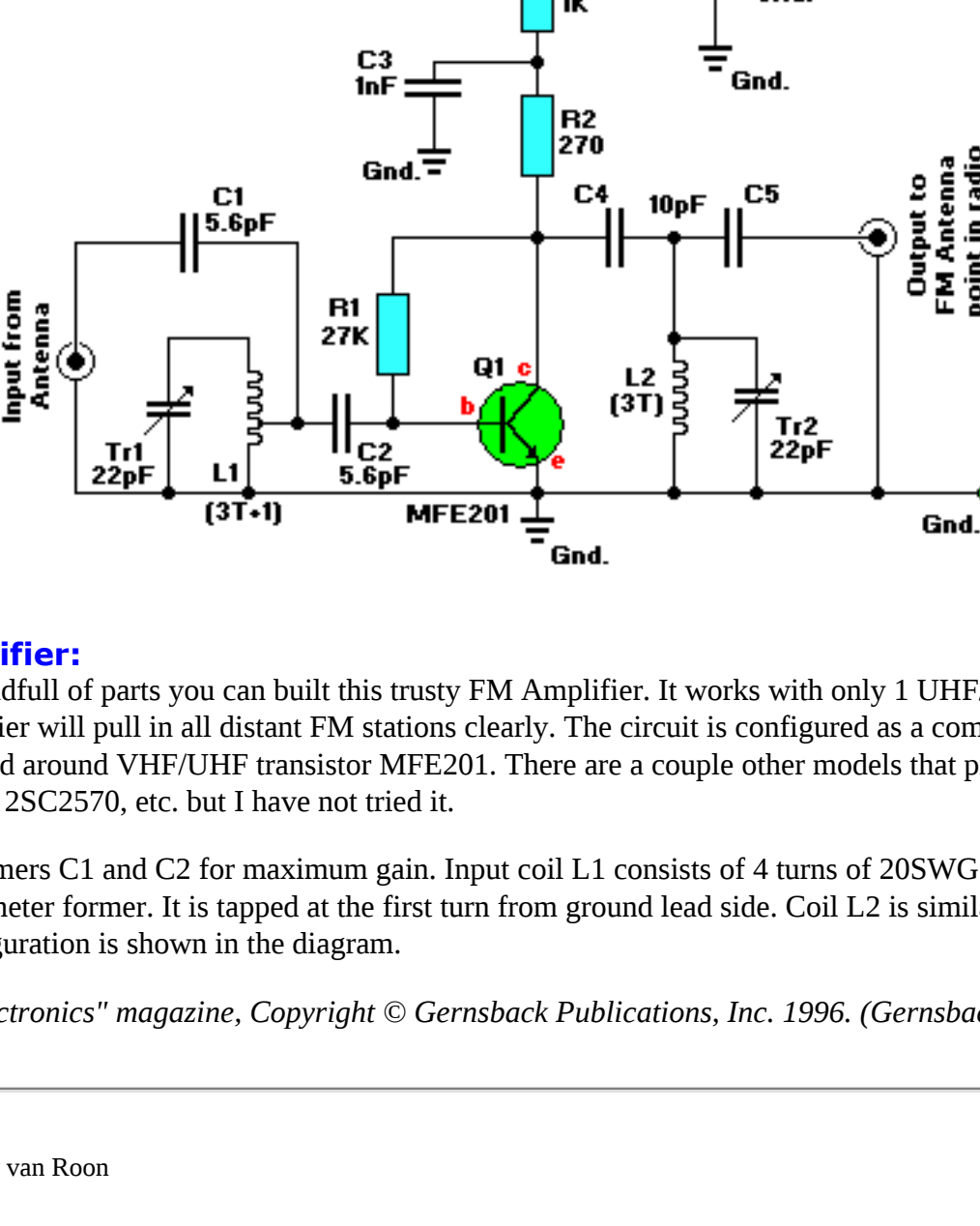
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http://www.uoguelph.ca/~antonio/circ/activant2.html [1/2/05 12:23:42 PM]



Active FM-Amplifier:

With only a small handful of parts you can built this trusty FM Amplifier. It works with only 1 UHF/VHF type transistor, MFE201. This amplifier will pull in all distant FM stations clearly. The circuit is configured as a common-emitter tuned RF pre-amplifier wired around VHF/UHF transistor MFE201. There are a couple other models that probably would work too, like the NTE107, 2SC2570, etc. but I have not tried it.

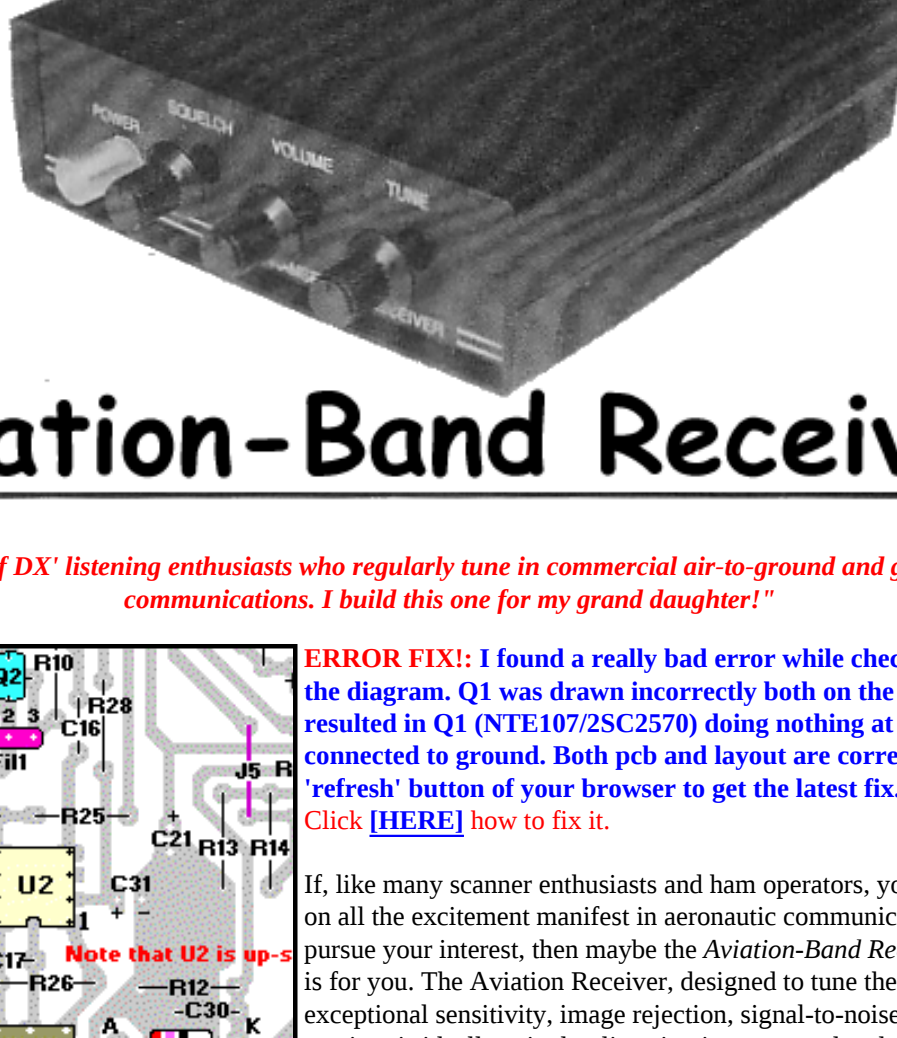
Adjust capacitor trimmers C1 and C2 for maximum gain. Input coil L1 consists of 4 turns of 20SWG enamelled copper wire over a 5mm diameter former. It is tapped at the first turn from ground lead side. Coil L2 is similar to L1, but has only three turns. Pin configuration is shown in the diagram.

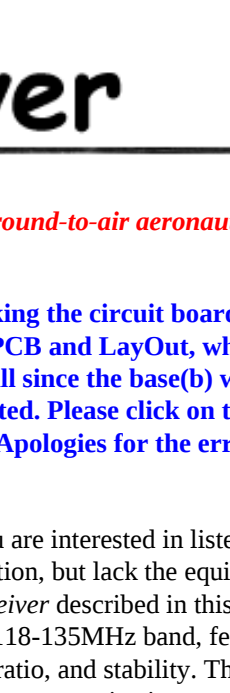
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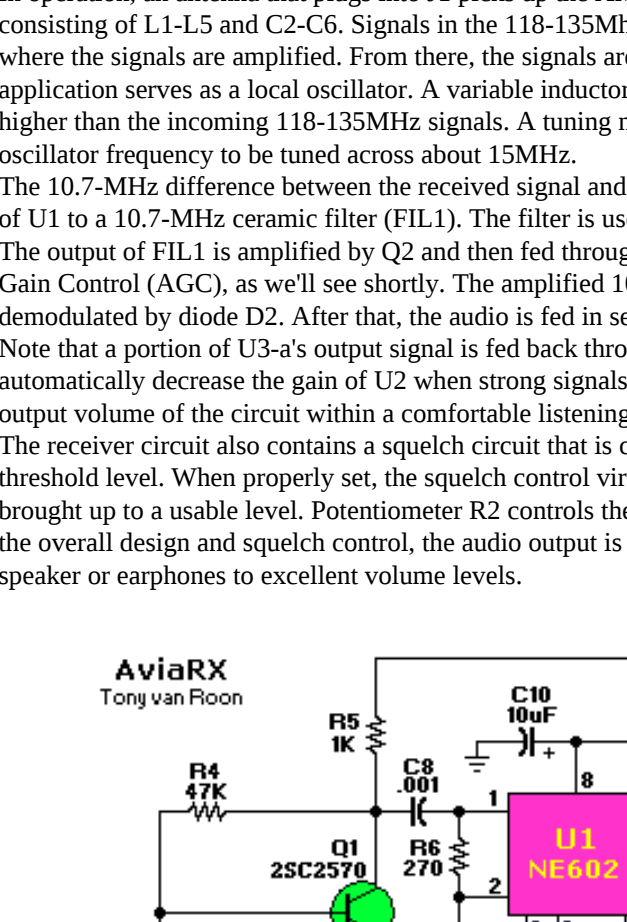
by Fred Blechman





Aviation-Band Receiver

"Join a growing crowd of DX[®] listening enthusiasts who regularly tune in commercial air-to-ground and ground-to-air aeronautics communications. I build this one for my grand daughter!"



ERROR FIX: I found a really bad error while checking the circuit board against the diagram. Q1 was drawn incorrectly both on the PCB and LayOut, which resulted in Q1 (NTE107/2SC2570) doing nothing at all since the base(b) was connected to ground. Both pcb and layout are corrected. Please click on the "refresh" button of your browser to get the latest fix. Apologies for the error. Click [HERE](#) how to fix it.

If, like many scanner enthusiasts and ham operators, you are interested in listening in the aviation band, the excitement manifest in aeronautics communication, but lack the equipment to pursue your interest, then maybe the *Aviation-Band Receiver* described in this article is for you. The Aviation Receiver, designed to tune the 118-135MHz band, features exceptional sensitivity, image rejection, signal-to-noise ratio, and stability. The receiver is ideally suited to listening in on ground and air communication associated with commercial airlines and general aviation.

Powered from a 9-volt alkaline battery, it can be taken along with you to local airports so that you won't miss a moment of the action. And even if you're nowhere near an airport, this little receiver will pick-up all the ground-to-air and vice-versa communications of any plane or ground facility within about 100 miles (160Km)!

Circuit Description:
Figure 1 shows a schematic diagram of the Aviation Receiver—a super heterodyne AM (Amplitude Modulated) unit built around four IC's: an NE602 double balanced mixer (U1), an MC1350 linear IF amplifier (U2), an LM324 quad op-amp (U3), and an LM386 audio amplifier (U4). In operation, an antenna that plugs into J1 picks up the AM signal. That signal is then coupled through C1 to a three-section, tuned-filter network consisting of L1-L5 and C2-C6. Signals in the 118-135MHz VHF (Very High Frequency) range are coupled through C7 to a VHF transistor (Q1), where the signals are amplified. From there, the signals are fed through C8 to the input of U1 (the NE602 double balanced mixer), which in this application serves as a local oscillator. A variable inductor (L6) and its associated capacitor network set the local oscillator frequency 10.7-MHz higher than the incoming 118-135MHz signals. A tuning network, consisting of varactor diode D1 and potentiometer R1, allows the local-oscillator frequency to be tuned across about 15MHz.

The 10.7-MHz difference between the received signal and the local-oscillator frequency (i.e., the Intermediate Frequency or IF) is output at pin 4 of U1 to a 10.7-MHz ceramic filter (F1L1). The filter is used to ensure a narrow pass band and sharp signal selectivity.

The output of F1L1 is amplified by Q2 and then fed through C16 to U2 (an MC1350 IF amplifier), which, as configured, also offers Automatic Gain Control (AGC), as well as see shortly. The amplified 10.7-MHz IF signal is peaked using variable transformer T1. The AM audio is then demodulated by diode D2. After that, the audio is fed in sequence through the four section of U3 (an LM324 quad op-amp).

Note that a portion of U3-a's output signal is fed back through resistor R25 to the AGC-control input of U2 at pin 5. That signal is used to automatically decrease the gain of U2 when strong signals are present or to automatically increase U2's gain for weak signals. That keeps the output volume of the circuit within a comfortable listening range regardless of the strength of the incoming signals.

The receiver circuit also contains a squelch circuit that is controlled by potentiometer R3, which is used to kill random noise below a selected threshold level. When properly set, the squelch control virtually eliminates background noise, so that all you hear are incoming signals that can be brought up to a usable level. Potentiometer R2 controls the overall volume fed through C26 to U4, an LM386 low-voltage audio amplifier. Due to the overall design and squelch control, the audio output is quite low in background noise, and yet it's capable of driving simple communications speaker or earphones to excellent volume levels.

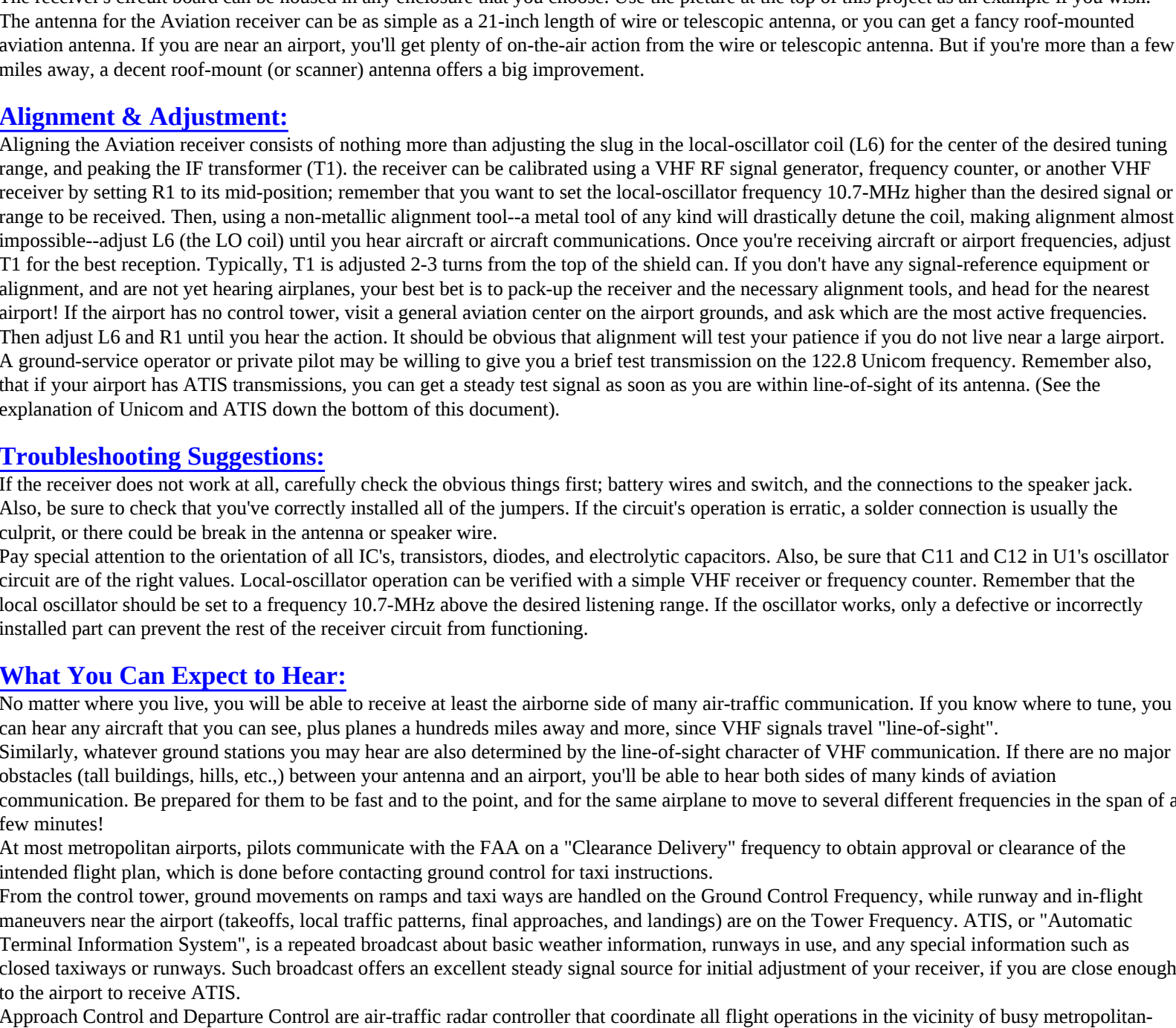


Fig. 1

AviaRX
Tony van Roon

Construction:
The Aviation Receiver was assembled on a Printed Circuit Board, measuring about 4-1/2 x 5-1/4 inches. **Fig. 2** shows a full-size template of that printed circuit board's layout.

Although most of the parts for this project are commonly available through conventional electronic component suppliers, a source for some of the more difficult to find parts is given in the Parts List for those who prefer to do their own shopping. If you opt to gather your own parts or your plan to use what you have on hand, keep in mind that the circuit-board layout was designed to accommodate components of specific dimensions in some cases; jacks J1 and J2, switch S1, transformer T1, and all three potentiometers, for example. However, the potentiometers can be any model if you wish. Just wire them to the board.

Also note that either of the Siemens parts specified in the Parts list for varactor diode D1 will work, but both may be difficult to find from hobbyist sources. However, the second unit (BB505) is available from *Allied Electronics*.

However you go about collecting parts for this project, don't even think about building the receiver circuit without the printed-circuit board. At the frequencies involved, the placement of every wire and part, and even part value is critical for trouble-free performance.

Once you have obtained all of the components and the board for the Aviation Receiver, construction can begin. A parts-placement diagram is shown in **Fig. 3**. When assembling the project, take special care that polarity-sensitive components (electrolytic capacitors [keep leads as short as possible], diodes, and transistors) are installed properly. Just one part installed *backward* can cause grievous harm!

Inductors (Aircorbs) L1,L3,L5 can be made easily on a 5mm drillbit. Before you wind them, scrape the enamel of each end, about 5mm. Then wind the 1.5 turn. I know it can be tricky especially if you have big fingers like me. Begin by installing the passive components, solder bridges, etc. Once you have determined that the circuit has been correctly assembled, it's time to consider the enclosure that will house the receiver.

The receiver's circuit board can be housed in any enclosure that you choose. Use the picture at the top of this project as an example if you wish. Important! If the airport has no control tower, visit a general aviation center on the airport grounds, and ask which are the most active frequencies. Then adjust L6 and R1 until you hear the action. It should be obvious that alignment will test your patience if you do not live near a large airport. A ground-service operator or private pilot may be willing to give you a brief test transmission on the 122.8 Unicom frequency. Remember also, that if your airport has ATIS transmissions, you can get a steady test signal as soon as you are within line-of-sight of its antenna. (See the explanation of Unicom and ATIS down the bottom of this document).

Troubleshooting Suggestions:
If the receiver does not work at all, carefully check the obvious things first; battery wires and switch, and the connections to the speaker jack. Also, be sure to check that you've correctly installed all of the jumpers. If the circuit's operation is erratic, a solder connection is usually the culprit, or there could be break in the antenna or speaker wire.

Pay special attention to the orientation of all acy transistors, diodes, and electrolytic capacitors. Also, be sure that C11 and C12 in U1's oscillator circuit are of the right values. Local-oscillator operation can be verified with a simple VHF receiver or frequency counter. Remember that the local oscillator should be set to a frequency 10.7-MHz above the desired listening range. If the oscillator works, only a defective or incorrectly installed part can prevent the rest of the receiver circuit from functioning.

What You Can Expect to Hear:
No matter where you live, you will be able to receive at least the airborne side of many air-traffic communication. If you know where to tune, you can hear any aircraft that you can see, plus planes a hundreds miles away and more, since VHF signals travel "line-of-sight". Similarly, whatever ground stations you may hear are also determined by the line-of-sight character of VHF communication. If there are no major obstacles (tall buildings, hills, etc.) between your antenna and an airport, you'll be able to hear both sides of many kinds of aviation communication. Be prepared for them to be fast and to the point, and for the same airplane to move to several different frequencies in the span of a few minutes!

At most metropolitan airports, pilots communicate with the FAA on a "Clearance Delivery" frequency to obtain approval or clearance of the intended flight plan, which is done before contacting ground control for taxi instructions.

From the tower control, ground movements on ramps and taxi ways are handled on the Ground Control Frequency, while runway and in-flight maneuvers near the airport (takeoffs, local flight patterns, final approaches, and landings) are on the Tower Frequency. ATIS, or "Automatic Terminal Information System", is a repeated broadcast about basic weather information, runways in use, and any special information such as closed runways or runways. Such broadcast offers an excellent steady signal source for initial adjustment of your receiver, if you are close enough to the airport to receive ATIS.

Approach Control and Departure Control are air-traffic radar controller that coordinate all flight operations in the vicinity of busy metropolitan-airport areas. When you hear a pilot talking with "Jacksonville Center" or "Indianapolis Center", these are regional ATC (Air Traffic Control) centers. The aircraft is really en-route on a flight, rather than just leaving or approaching a destination. A pilot will be in touch with several different Regional Centers" during a cross-country flight.

Airports without control towers rely on the local Unicom frequency for strictly advisory communications between pilot and ground personnel, such as fuel service operators. The people on the ground can advise the pilot what they know about incoming or outgoing aircraft, but the pilot remains responsible for landing and takeoff decisions. Typical Unicom frequencies are 122.8 and 123.0MHz.

The FAA's network of FSS (Flight Service Stations) keeps track of flight plans, provides weather briefings and other services to pilots. Some advisory radio communication takes place between pilots and a regional FSS. If there is an in your local area, but no airport control towers, the FSS radio frequency will stay interesting.

Pilot and Controller Talk:
Just to make sure you have a basic understanding of aviation chat-chat, here are a couple of examples what you may be hearing on your receiver. Don't make the Aviation Receiver if all you hear are short bursts of words that don't make a lot of sense at first. Aviation communication is necessarily and brief, but clear and full of meaning. Generally, pilots repeat exactly what they hear from a controller, so that both know the message or instructions were correctly interpreted. If you are listening in, it's hard to track everything said from a cockpit, particularly in big city areas. Just to taxi, takeoff, and fly a few minutes, all on different frequencies.

Here's the meaning of just a few typical communications:

"Miami Center, Delta 545 heavy out to three zero-five." Delta Flight 545 acknowledges Miami Center's clearance to descend from 30,000 feet to 25,000 feet. The word "heavy" means that the plane is a Jumbo-Jet, perhaps a 747, DC-10, or LT-1011.

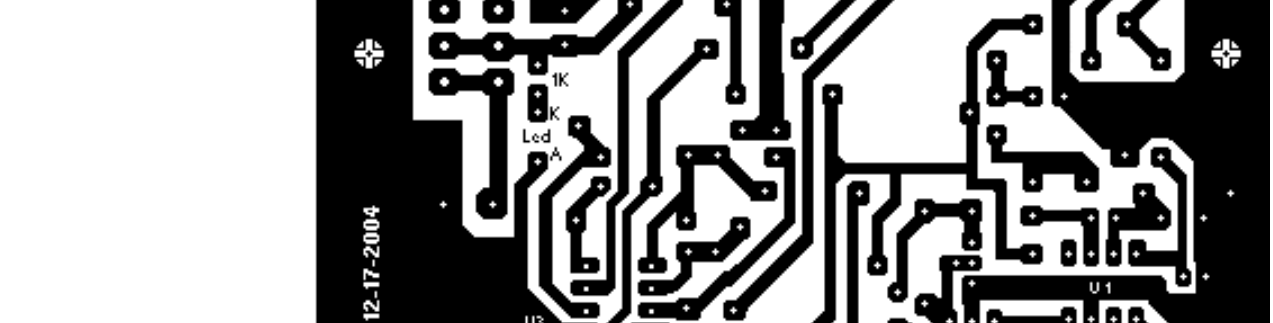
"Seneca 432 Lima cleared to outer marker. Contact tower 118.7" The local Approach Control is saying that the Piper Seneca with the N-number, or "tail number", ending in "432-L" is cleared to continue flying an instrument approach to the outer marker (a precision radio beacon located near the airport), and should immediately call the airport radio control tower on 118.7MHz. That message also implies that the controller does not expect to talk again with that aircraft.

"Cessna 723, squawk 6750, climb and maintain five thousand." The airport controller is telling the Cessna pilot to set the airplane's radar transponder to code "6750", and climb to and level off at the altitude of "5000 feet".

"United 330, traffic at 9 o'clock, 4 miles, altitude unknown." The controller alerts the United Airlines flight of radar contact with some other aircraft off to the pilot's left. The controller immediately calls the unknown plane's altitude is also unknown, both controller and pilot realize that it is a smaller private plane not equipped with altitude-reporting equipment.

Parts List and other components:

- Semiconductors:** KIT available: [\[KIT-1\]](#)
U1 = NE602AN, or SA602AN (see note 1)
U2 = [MC1350](#) or NTE7487
U3 = LM324 or NTE987
U4 = LM386 or NTE223
Q1 = 2SC2570, or NTE107, ([Different Pinouts--Click here!](#)) NPN UHF silicon transistor
Q2 = 2N3904, or NTE123AP, NPN transistor
Q3 = BB405, BB505, (MV2104/NTE612) varactor diode (see note 2)
D2 = [1N270](#), or NTE109, 1N34, etc. Germanium Diode
D3 = 1N914, NTE519, ECG519, or BAX13 silicon signal diode.
- Resistors:** KIT available: [\[KIT-2\]](#)
All Resistors are 5%, 1/4-watt
R1, R2, R3 = 10K PC mount potentiometers
R4, R9, R15, R16, R20, R21, R24 = 47K
R5, R7, R11, R18, R25, R27 = 1K
R6, R28 = 20K ohm
R8, R12, R17, R23 = 10K
R10, R14 = 1 Mega Ohm
R13, R22 = 33K
R19 = 100K
R26 = 22K
- Capacitors:** KIT available: [\[KIT-3\]](#)
C1, C7, C8, C13, C16 = 0.001µF (1nF) ceramic disc
C2, C4, C6 = 32pF, ceramic disc
C3, C5 = 8.2pF, ceramic disc
C9, C17, C19, C20, C28, C30 = 0.01µF, ceramic disc
C10, C15, C21, C25, C26, C31 = 4.7 TO 10µF, 16WVDC, electrolytic
C11 = LM3306 or NTE2101 ceramic disc
C12, C14 = 27pF, NPO ceramic disc
C18, C27, C29 = 100 to 220µF, 16WVDC, electrolytic
C22 = 0.47µF, 16WVDC, electrolytic
C23, C24 = 0.1µF, 16WVDC, electrolytic
- Inductors:** KIT available: [\[KIT-4\]](#)
L1, L3, L5 = 1.5 turns #24 to #30 gauge magnet wire (aircoils),
5mm inner diameter, about 1mm spacing.
L2, L4 = 0.33µH, molded inductor, (DigikKey M9R33-ND, or M7807-ND)
or Miller #9230-08
L6 = 0.1µH, 3.5 turns, slug-tuned coil (DigikKey TK2816ND) or TOKO #E528SN-100061 (peaked using variable transformer T1)
this tiny coil only measures 9x7mm.
T1 = 10.7MHz, shielded transformer (DigikKey 42F123)
F1L1 = 10.7 MHz, ceramic filter (DigikKey TK-2306)



A complete KIT is available for all of the above. [\[KIT-C\]](#)
NO battery-holder or enclosure is included. Shipping to USA and Canada only. email me for details or if you wish to be on the mailing list for updates and modifications: meridian@kitchener.com

Additional Parts & Materials:
S1 = SPST switch, PC mount
J1 = RCA jack, PC mount
J2 = Subminiature phone jack, PC mount
B1 = 9-volt alkaline battery
MISC = PCB materials, enclosure, battery holder and connector,
w1A solder, knob for potentiometers R1/R2/R3, etc.
KIT = Kit is now available.

Printed Circuit Board (PCB) **Fig. 2**, and Parts Assembly diagram (layout) is shown in **Fig. 3** to make soldering the unit together a breeze! Note: PCB pads for the ceramic 10.7MHz filter (F1L1) have been modified. The filter should fit perfectly now. Also, L6 in the parts layout diagram has been updated to reflect the square type TK2816 coil from Toko (PCB updated November 24, 2004).

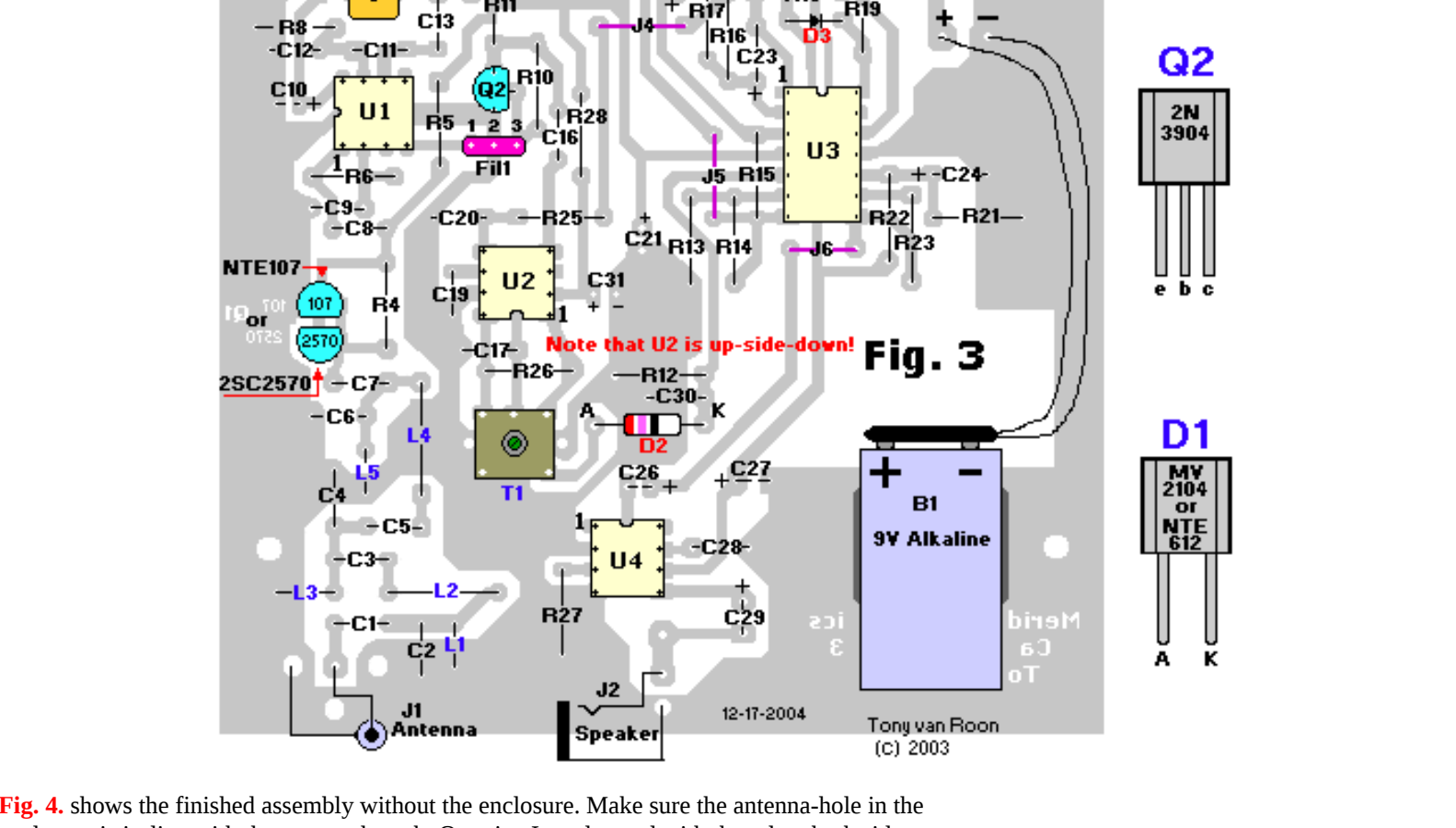


Fig. 2

Aviation Band Receiver

Meridian Electronics
Tony van Roon

Rev. 5-d

[Click here for the pcb](#)



Fig. 3

Tuning Volume Squelch On/Off

Q1 NTE107

Q2 2N3904

D1 9V Alkaline

D2 1N270 or NTE107

12-17-2004 Tony van Roon (c) 2002

Fig. 4 shows the finished assembly without the enclosure. Make sure the antenna-hole in the enclosure is in-line with the one on the pcb. On mine I used a stud with thread on both sides to enable me to use different length antennas; all I have to do is unscrew the antenna and screw another antenna back in place without taking the receiver apart. The connection to the battery holder; you can also just use a piece of the double-sided foam tape if you wish.

Note 1: The SA602AN is an updated version of the NE type (made by Signetics). It is pin-to-pin compatible, and made by Philips. An even newer version is the SA612 and is also fully compatible with better filtering and noise suppression, it just has less gain at 45MHz. The NE602 is a perfect match.

Note 2: The varactor diode (D1) BB405 or BB505 are also difficult to get because they are already obsolete. But I found that the MV2104 is pretty close and can be used instead. I will do some more fine-tuning and tweak shortly.

Note 3: The pin-out for transistor Q1 is very different for either 2SC2570 or the replacement NTE107. So watch out you insert the correct lead into the correct hole on the pcb. Click [\[HERE\]](#) for the diagram.

The following email was received by Matt Hagman to improve the performance:
"I tweaked a few components and managed to improve the sensitivity and tuning stability. I also found that the audio amplifier IC requires an 80hm + 0.047uF load (in a snubber configuration) in order to prevent the tendency to oscillate at high > 300kHz frequencies." Good stuff Matt, thanks!

I will support this project, since my unit has been in operation for quite a few years now and still running on the same battery. Power consumption is minimum, the optional LED indicator will only add about 12mA. Most parts can be obtained via your local electronics store. I will answer all questions but via "Tony's Message Forum" only. This Forum can be accessed via the main page, gadgets, or circuits page.

Below is a picture explaining the importance to make the the coils L1, L3, & L5 as precisely as you can.



Fig. 4



Band Pass Filters

Tuned circuits

Amplified Signal by Q1

1mm spaced

50mm

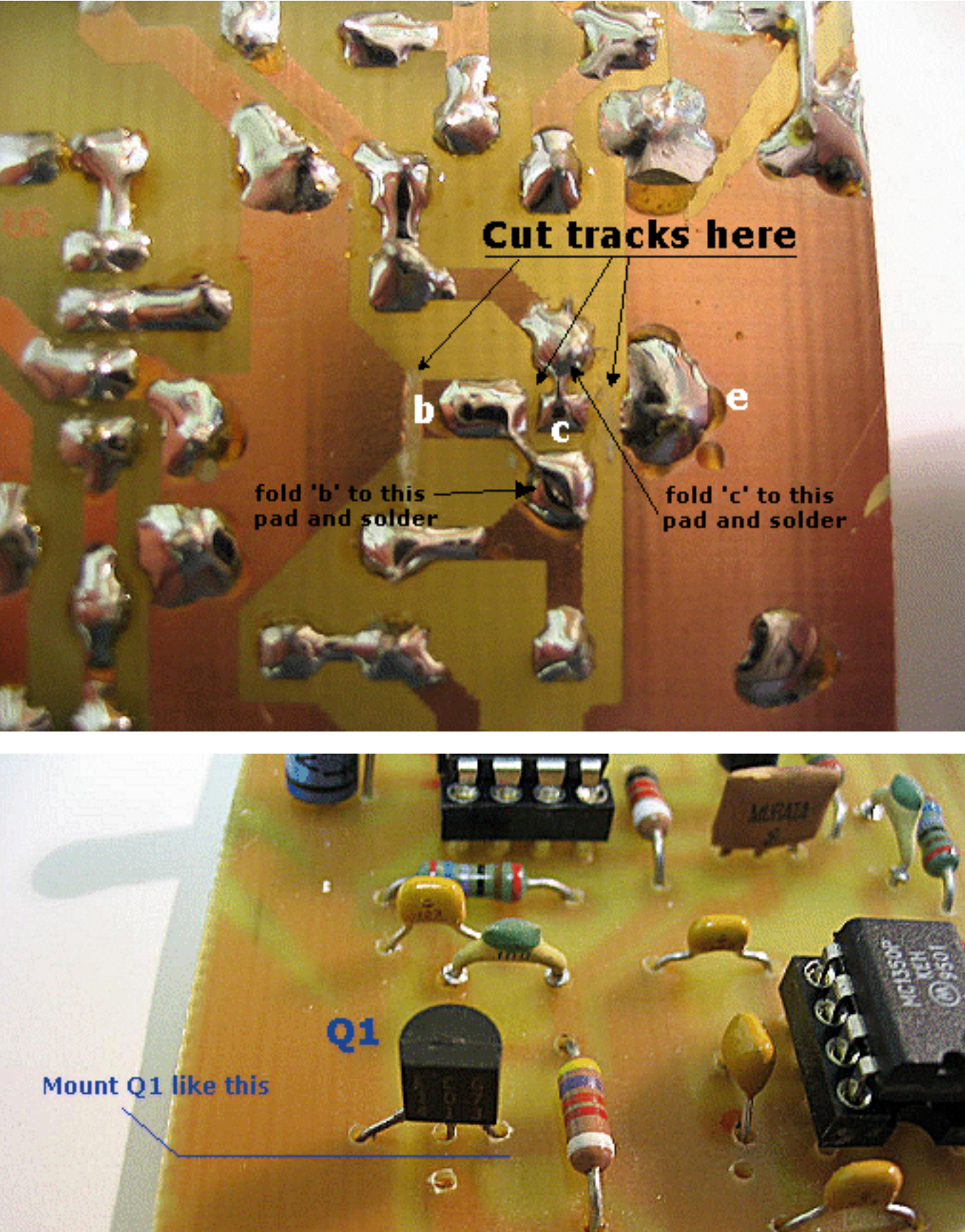
with 82pF = 130MHz

118 135 f (MHz)

Click on the link to see the [\[project and pictures\]](#) of Agustín Sanchez, Canary Islands, Spain. Very nicely done, Agustín!

Some personal pictures showing a different kind of battery holder and a view of [\[Inductors L1/L3/L5\]](#).

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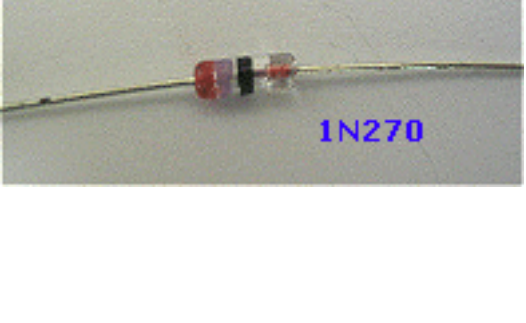


2SC2570



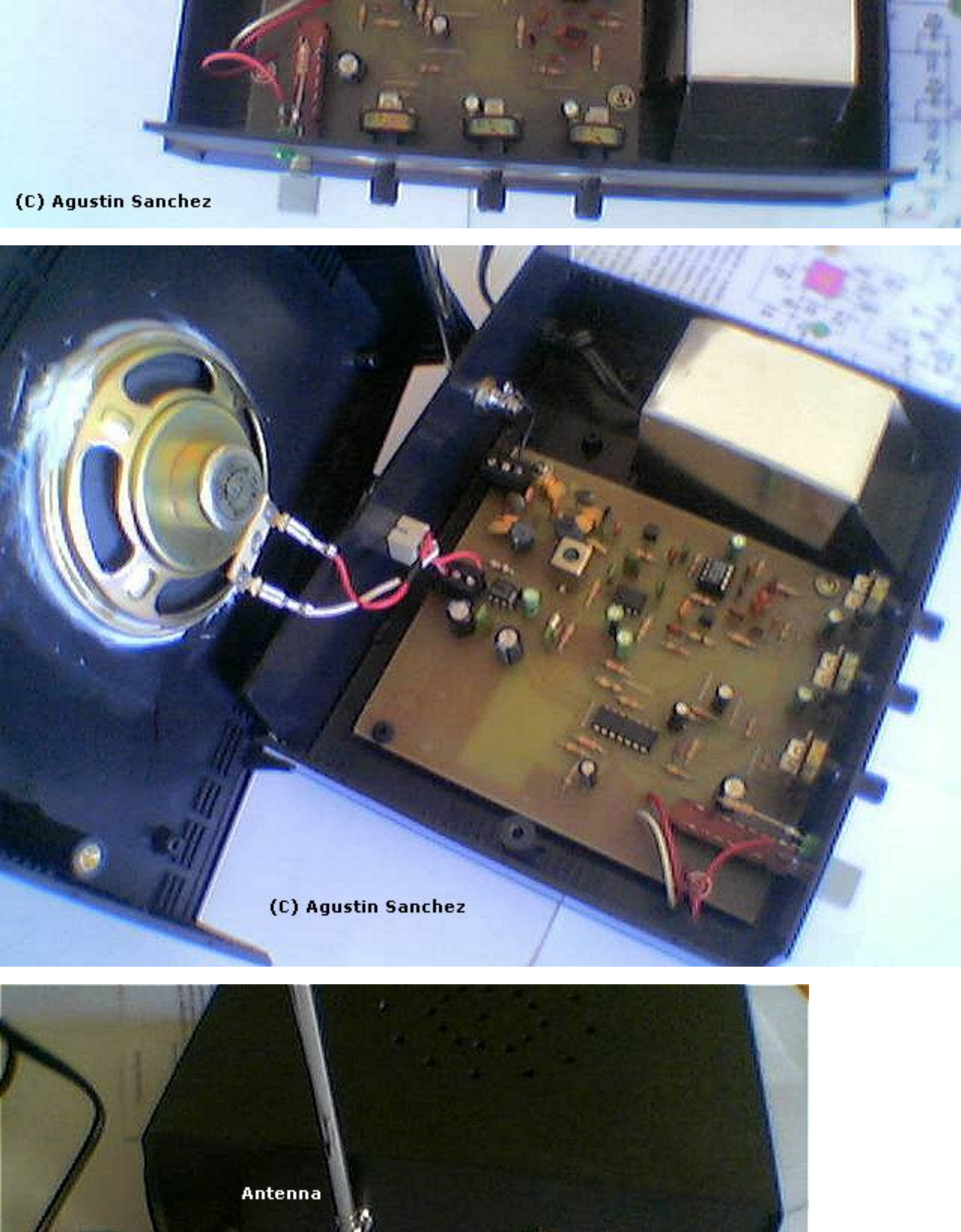
NTE107

Different pinout for 2SC2570 and NTE107
Make sure to insert it correctly on the PCB!

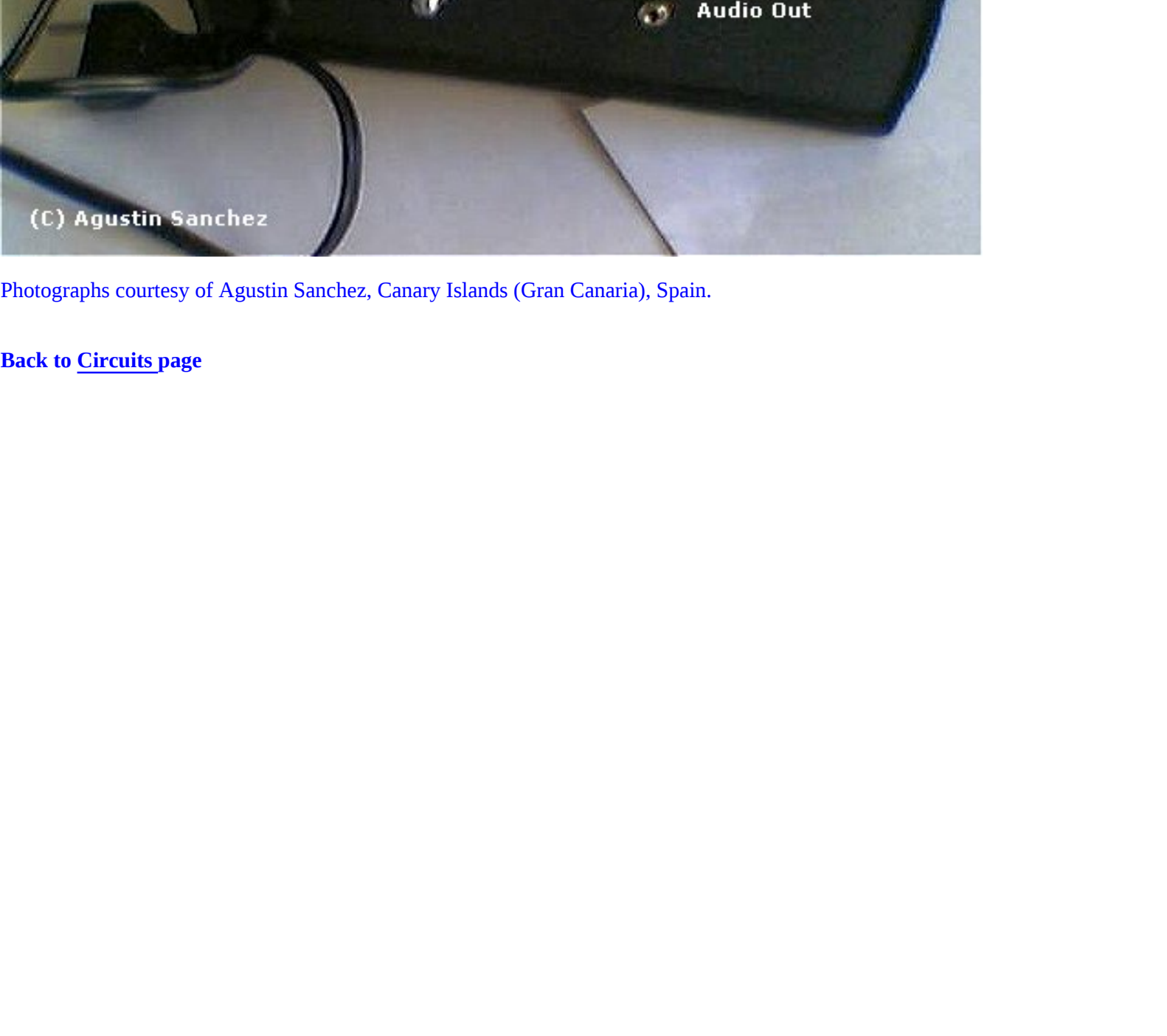




(C) Agustin Sanchez



(C) Agustin Sanchez



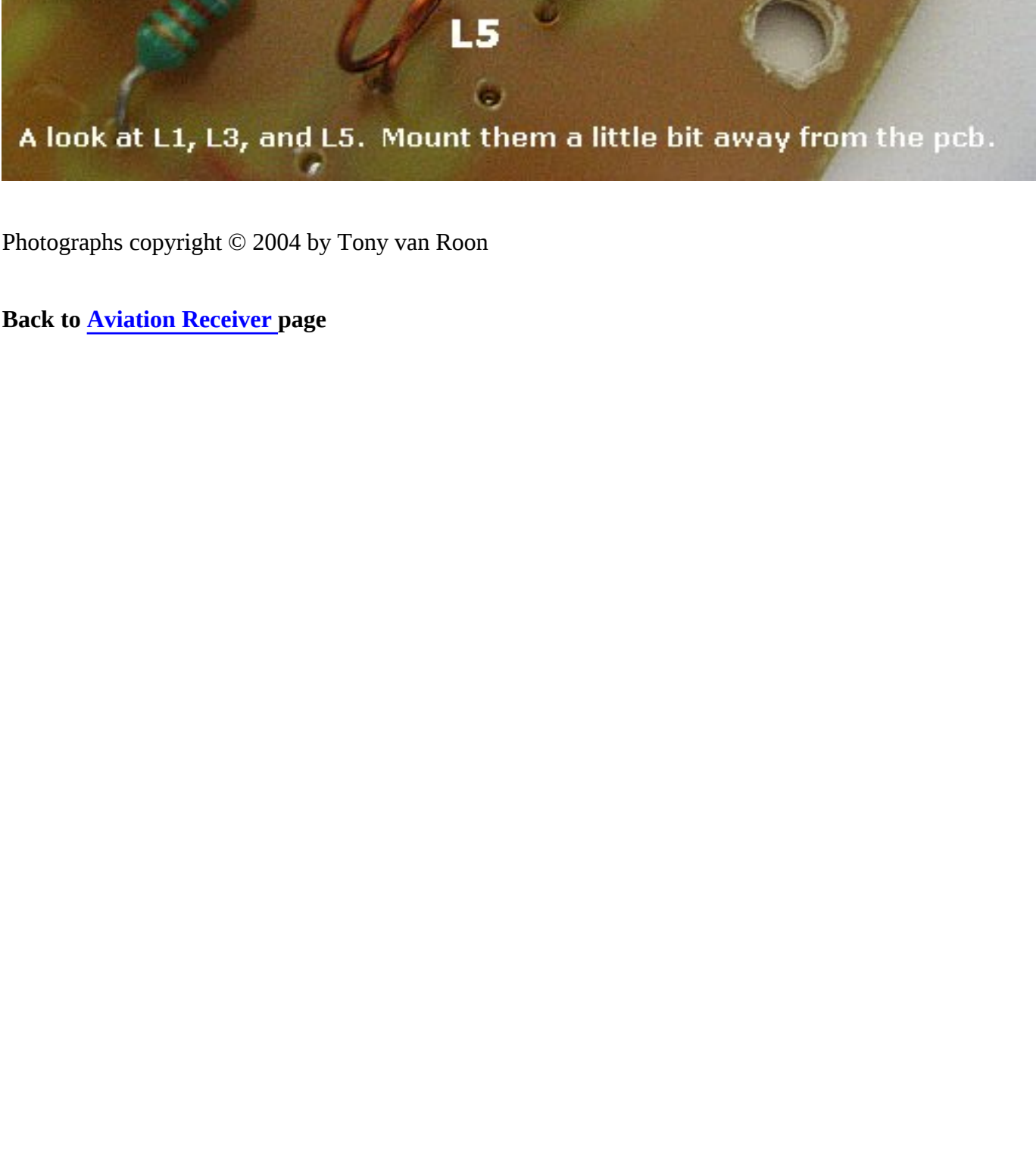
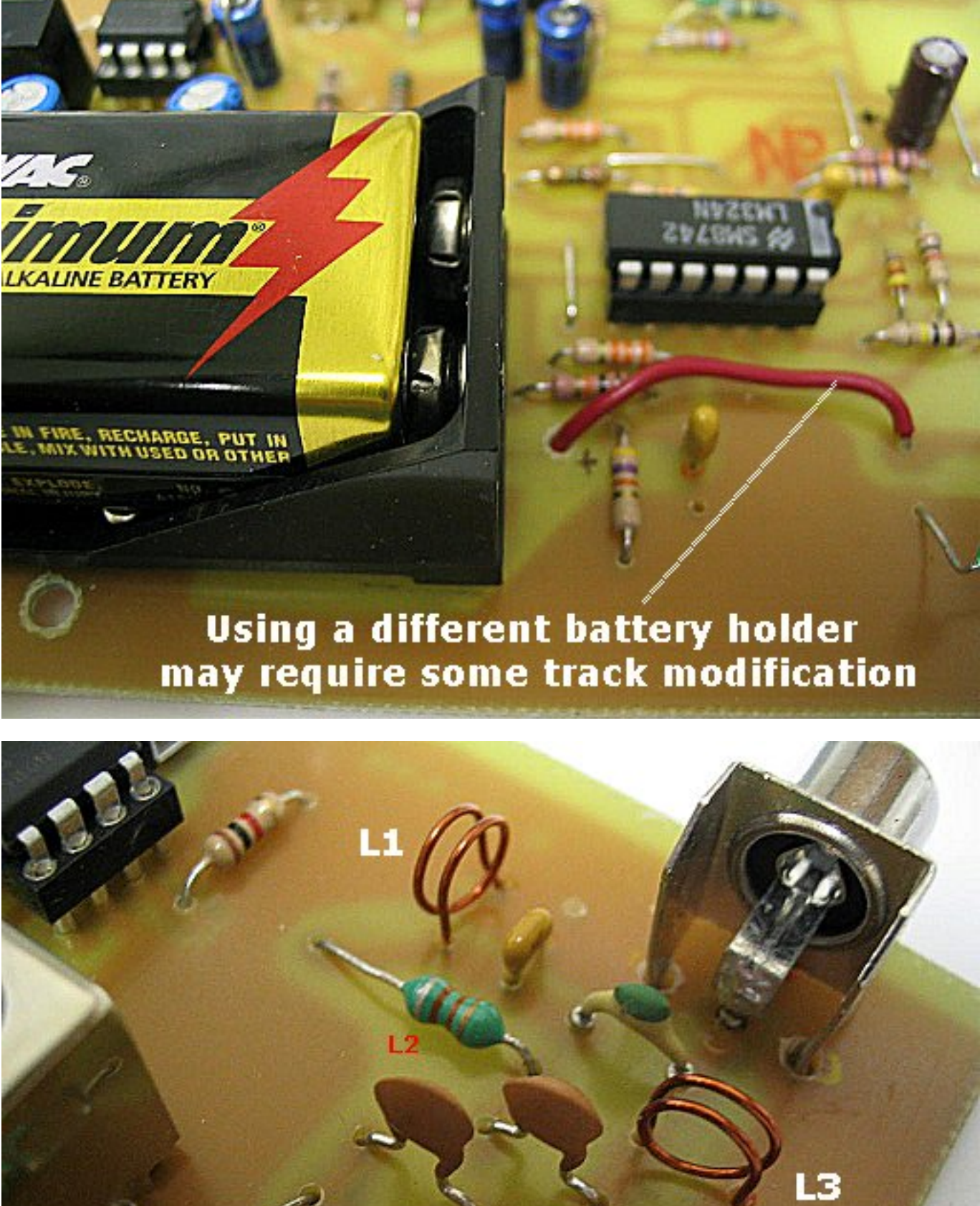
(C) Agustin Sanchez



(C) Agustin Sanchez

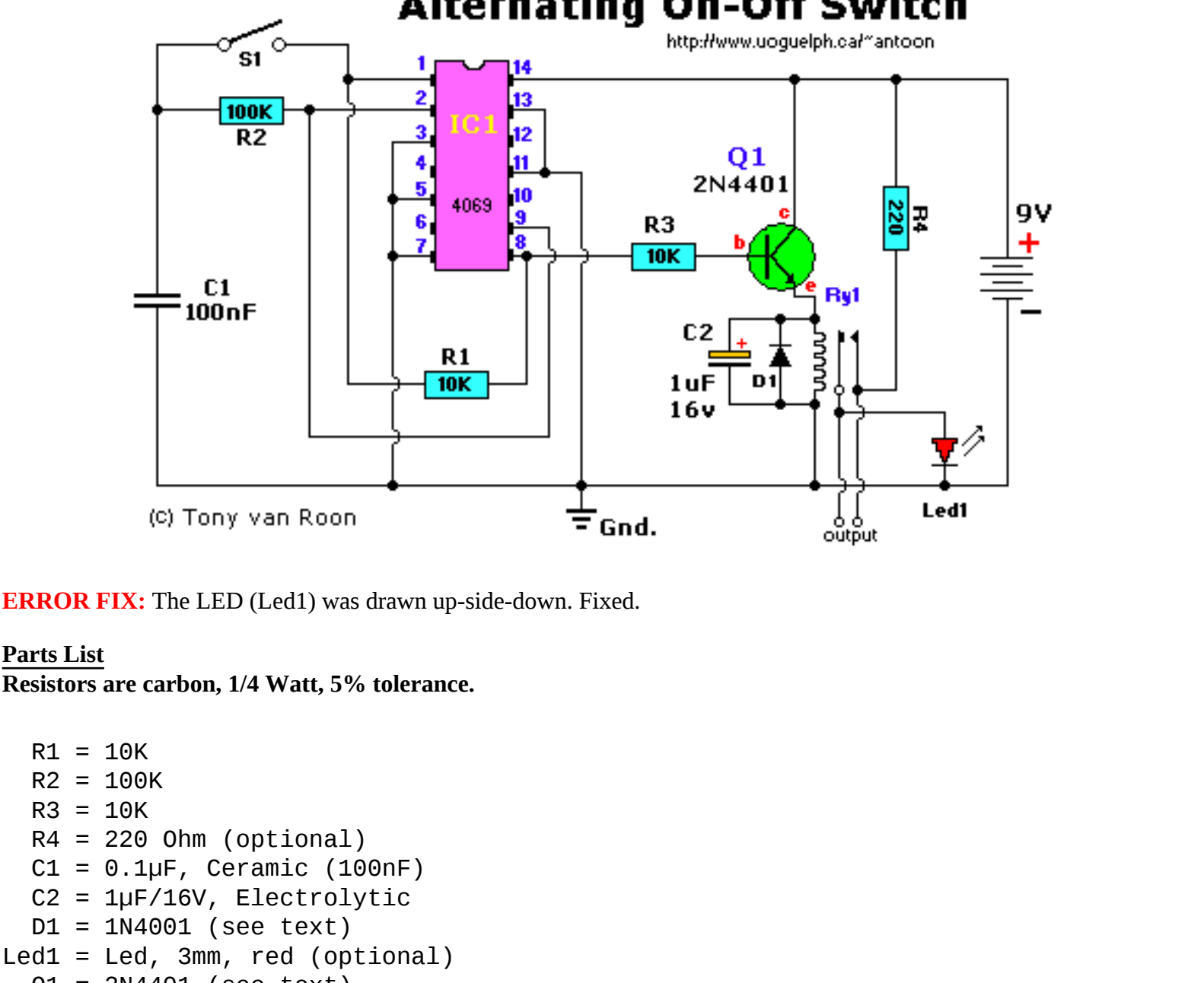
Photographs courtesy of Agustin Sanchez, Canary Islands (Gran Canaria), Spain.

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Photographs copyright © 2004 by Tony van Roon

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ERROR FIX: The LED (Led1) was drawn up-side-down. Fixed.

Parts List

Resistors are carbon, 1/4 Watt, 5% tolerance.

- R1 = 10K
- R2 = 100K
- R3 = 10K
- R4 = 220 Ohm (optional)
- C1 = 0.1uF, Ceramic (100nF)
- C2 = 1uF/16V, Electrolytic
- D1 = 1N4001 (see text)
- Led1 = Led, 3mm, red (optional)
- Q1 = 2N4401 (see text)
- IC1 = 4069, CMOS, Hex Inverter (MC14069UB), or equivalent
- S1 = Momentary on-switch
- Ry1 = Relay (see text)

Use this circuit instead of a standard on-off switch. Switching is very gentle. Connect unused input pins to an appropriate logic level (I used ground). Unused output pins *MUST* be left open!
First 'push' activates the relay, another 'push' de-activates the relay.

IC1, the MC14069 (or 4069) is a regular Hex-inverter type and is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. It will operate on voltages from 3 to 18 volts, but most applications are in the 5 to 15 volts. Although the 4069 contains protection circuitry against damage from ESD (Electro Static Discharge), use common sense when handling this device. Depending on your application you may want to use an IC-socket with IC1. It makes replacement easy if the IC ever fails.

You can use any type of 1/4 watt resistors including the metal-film type.

The type for D1 is not critical, even a 1N4148 will work. But, depending on your application I would suggest a 1N4001 (or similar) as a minimum.

Any proper replacement for Q1 will work, including the european TUN's. Since Q1 is just a driver to switch the relay coil, almost any type for the transistor will do. PN100, NTE123A, 2N3904, 2N2222, 2N4013, etc. will all work.

For C2, if you find the relay acts not fast enough, you can change it to a lower value or use a ceramic cap of around 0.1uF. It is there as a spark-arrestor together with the diode (D1).

For the relay I used a 6 volt type with the above circuit and 9 volt battery. The circuit will work fine with 12 Volt, the only thing to watch for is the working voltage of C2; increase that to 25V if you use a 12V supply.

I added the Led to have a visual indication of being 'on'. For use with 12V supply make R4 390 ohms. The LED and R4 are of course optional and can be left out. Your application may already have some sort of indicator and so the LED and R4 are not needed.

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Audio Booster

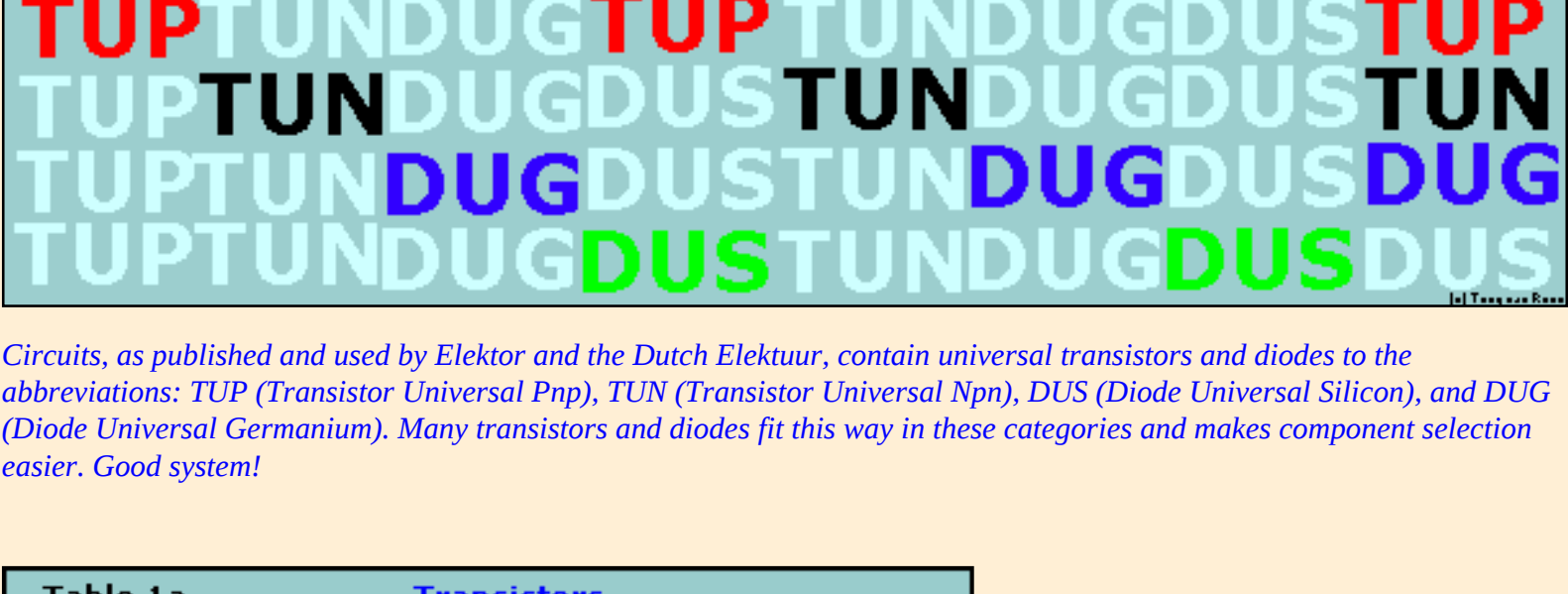
Parts List:

Part	Description	Radio Shack #	DigiKey #	Notes
Q1	2N3392			Transistor, NPN
R1	47K resistor			yellow purple orange gold
R2	10K resistor			brown black orange gold
R3	560 Ohm resistor		560QBK-ND	green blue brown gold
R4	100K potmeter+switch			Linear
R5	270 ohm resistor			red purple brown gold
LED1	LED, red	276-033		Ultra-Bright
C1	Capacitor, .05-.1µF			Ceramic, 50V type
C2	Capacitor, 0.1µF			Ceramic, 50V type
C3	Capacitor, 33µF/25V			Electrolytic

Couple Notes:
The 2N3392 transistor is a low-noise type in a TO-92 housing and can be replaced by a NTE199 or ECG199. If you wish to use a TUN, cross reference the parameters with one of the units from this list: [TUP-TUN](#)
Potentiometer R5 of 100K is a linear type with an on/off switch attached.
The value of C1 may need to be between 0.05µF and 0.1µF (47nF/100nF). Experiment with the value for best performance.

The phone number for [DigiKey](#) is 1-800-Digi-Key.

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Circuits, as published and used by Elektor and the Dutch Elektuur, contain universal transistors and diodes to the abbreviations: TUP (Transistor Universal Pnp), TUN (Transistor Universal Npn), DUS (Diode Universal Silicon), and DUG (Diode Universal Germanium). Many transistors and diodes fit this way in these categories and makes component selection easier. Good system!

Table 1a.		Transistors					
	Type	U _{ceo} (max)	I _c (max)	h _{fe} (min)	P _{tot} (max)	f _T (min)	
TUN	NPN	20Volt	0.1 Amp	100	0.1 Watt	100 Mhz	
TUP	PNP	20Volt	0.1 Amp	100	0.1 Watt	100 Mhz	

The minimum specifications have to be met, in **Table 1a** above, before you can call it a 'TUP' or a 'TUN'.

Table 1b.		Diodes				
	Type	U _p (max)	I _F (max)	I _p (max)	P _{tot} (max)	C _D (max)
DUS	Si	25 Volt	0.1 Amp	1 uAmp	0.25 Watt	5 pF
DUG	Ge	20 Volt	0.035 A	100 uAmp	0.25 Watt	10 pF

The minimum specifications have to be met, in **Table 1b** above, before you can call it a 'DUS' or a 'DUG'.

Table 2.			Table 3.		
TUN	(NPN)		TUP	(PNP)	
BC107	BC208	BC384	BC157	BC253	BC416
BC108	BC209	BC407	BC158	BC261	BC417
BC109	BC237	BC408	BC159	BC262	BC418
BC147	BC238	BC409	BC177	BC263	BC419
BC148	BC239	BC413	BC178	BC207	BC512
BC149	BC317	BC414	BC179	BC308	BC513
BC171	BC318	BC547	BC204	BC309	BC514
BC172	BC319	BC548	BC205	BC320	BC557
BC173	BC347	BC549	BC206	BC321	BC558
BC182	BC348	BC582	BC212	BC322	BC559
BC183	BC349	BC583	BC213	BC350	
BC184	BC382	BC584	BC214	BC351	
BC207	BC383		BC251	BC352	
			BC252	BC415	

In the above tables, **Table 2 & 3**, you can use several different transistor types for a TUP or a TUN. Obviously the tables are not complete. It would be almost impossible to list all available transistor types available today. From the above listed types are all A, B, or C types usable.

Table 4.		
DUS		DUG
BA127	BA318	OA85
BA217	BAX13	OA91
BA218	BAV61	OA95
BA221	1N914	AA116
BA222		
BA317	1N4148	

Several different types of diodes are suitable as a 'DUS' or 'DUG'.

Table 6.		
	NPN	PNP
	BC107	BC177
	BC108	BC178
	BC109	BC179
U _{ceo} (max)	45 V 20 V 20 V	45 V 25 V 20 V
U _{ebo} (max)	6 V 5 V 5 V	5 V 5 V 5 V
I _c (max)	100 mA 100 mA 100 mA	100 mA 100 mA 50 mA
P _{tot} (max)	300 mW 300 mW 300 mW	300 mW 300 mW 300 mW
f _T (min)	150 Mhz 150 Mhz 150 Mhz	130 Mhz 130 Mhz 130 Mhz
F (max)	10 dB 10 dB 4 dB	10 dB 10 dB 4 dB
(A), (B) or (C) added to transistor type: (A) = hfe 125 to 260 (B) = hfe 240 to 500 (C) = hfe 450 to 900		

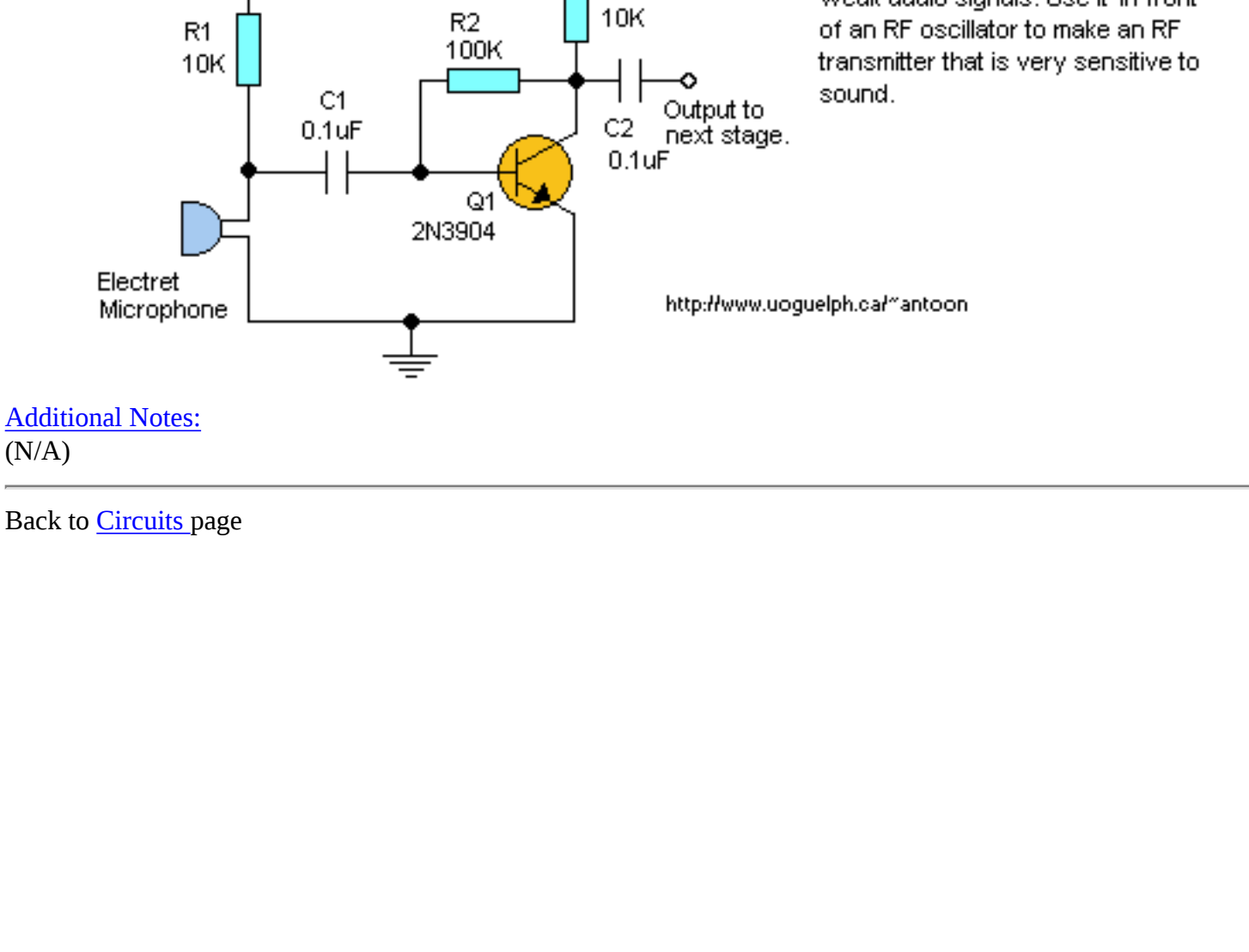
The most important parameters of the BC107...BC109 and the BC177...BC179. These transistors have been chosen as an example of information.

Table 5.			Row 1			Row 2			Row 3				
NPN	PNP	Case Note	NPN	PNP	Case Note	NPN	PNP	Case Note	NPN	PNP	Case Note		
BC107	BC177	 C e	BC317	BC320	 C e	BC467	BC468	 C e	BC467	BC468	 C e		
BC108	BC178		BC318	BC321		BC469	BC469		BC469	BC469			
BC109	BC179		BC319	BC322									
BC147	BC157	 C e	BC347	BC350	 C e	BC167	BC257	 C e	BC167	BC257	 C e		
BC148	BC158		BC348	BC351		BC168	BC258		BC168	BC258			
BC149	BC159		BC349	BC352		BC169	BC259		BC169	BC259			
BC171	BC251	 C e	BC382	BC382	 C e	BC547	BC557	 C e	BC547	BC557	 C e		
BC172	BC252		BC383	BC383		BC548	BC558		BC548	BC558			
BC173	BC253		BC384	BC384		BC549	BC559		BC549	BC559			
BC182	BC212	 C e	BC407	BC417	 C e	BC582	BC512	 C e	BC582	BC512	 C e		
BC183	BC213		BC408	BC418		BC583	BC513		BC583	BC513			
BC184	BC214		BC409	BC419		BC584	BC514		BC584	BC514			
BC207	BC204	 C e	BC413	BC413	 C e	BC261	BC261	 C e	BC261	BC261	 C e		
BC208	BC205		BC414	BC414		BC262	BC262		BC262	BC262			
BC209	BC206		BC415	BC415		BC263	BC263		BC263	BC263			
BC237	BC307	C e	BC437	BC437	C e	http://www.uoguelph.ca/~antoon							
BC238	BC308		BC438	BC438									
BC239	BC309		BC439	BC439									

The letter after the transistor indicates the hfe.
Example: **BC107A**, hfe = 125 ... 260
BC107B, hfe = 240 ... 500
BC107C, hfe = 450 ... 900

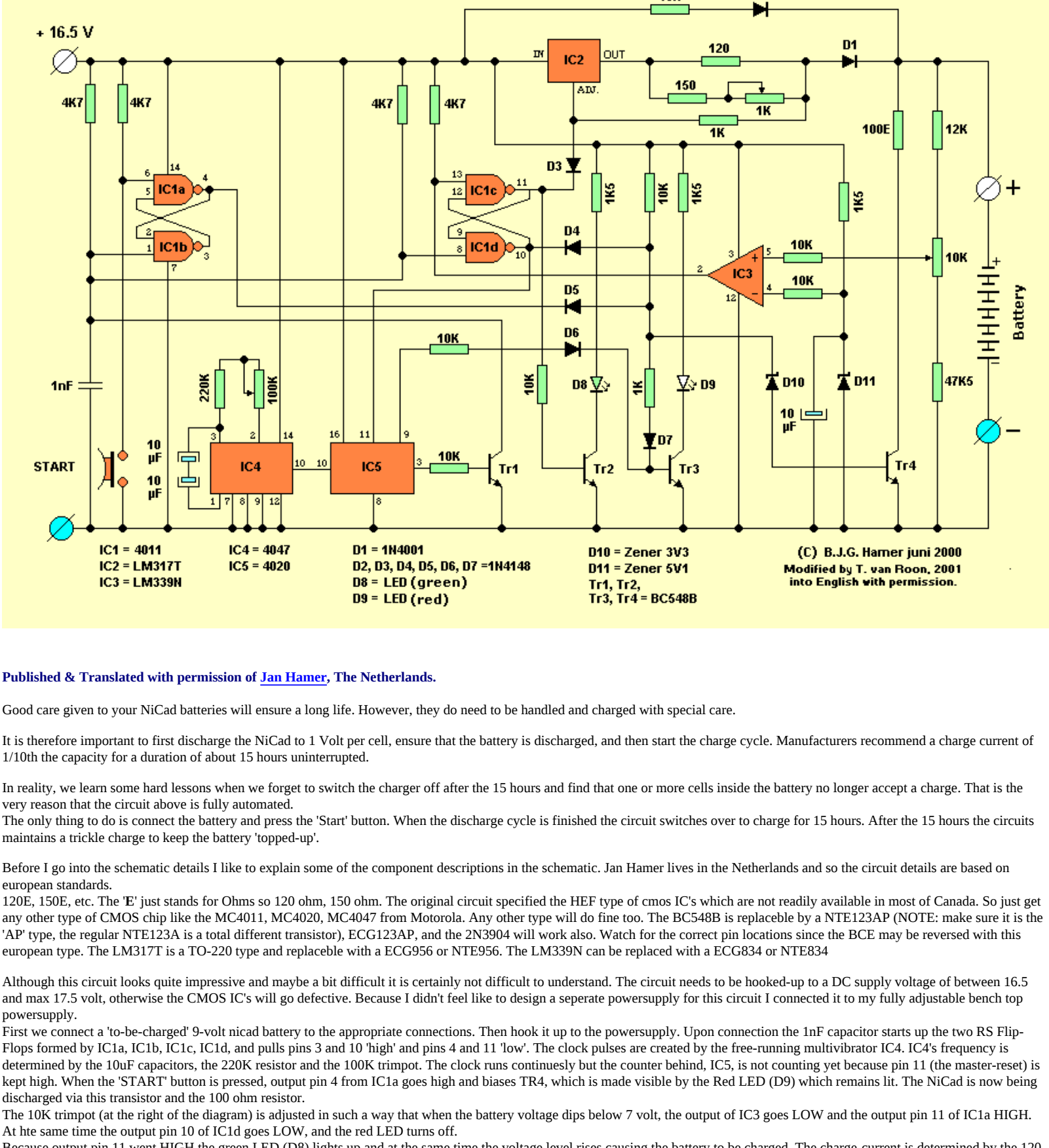
Substitutes within the BC series of transistors are also possible. In Table 6 you see that the transistors are grouped in three. Example, the BC107, BC147, BC317 and BC413 can be substituted with each other, but a BC548 may not be exchanged for a BC107. Why? The BC548 is the second of a group of three. Your choice would be a BC547(A,B, or C).

Audio Pre-Amplifier



Additional Notes:
(N/A)

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Published & Translated with permission of [Jan Hamer, The Netherlands](#).

Good care given to your NiCad batteries will ensure a long life. However, they do need to be handled and charged with special care.

It is therefore important to first discharge the NiCad to 1 Volt per cell, ensure that the battery is discharged, and then start the charge cycle. Manufacturers recommend a charge current of 1/10th the capacity for a duration of about 15 hours uninterrupted.

In reality, we learn some hard lessons when we forget to switch the charger off after the 15 hours and find that one or more cells inside the battery no longer accept a charge. That is the very reason that the circuit above is fully automated.

The only thing to do is connect the battery and press the 'Start' button. When the discharge cycle is finished the circuit switches over to charge for 15 hours. After the 15 hours the circuits maintains a trickle charge to keep the battery 'topped-up'.

Before I go into the schematic details I like to explain some of the component descriptions in the schematic. Jan Hamer lives in the Netherlands and so the circuit details are based on European standards.

120K, 150K, etc. The 'E' just stands for Ohms so 120 ohm, 150 ohm. The original circuit specified the HEF type of CMOS IC's which are not readily available in most of Canada. So just get any other type of CMOS chip like the MC4011, MC4020, MC4047 from Motorola. Any other type will do fine too. The BC548B is replaceable by a NTE123AP (NOTE: make sure it is the 'AP' type, the regular NTE123A is a total different transistor), ECG123AP, and the 2N3904 will work also. Watch for the correct pin locations since the BCE may be reversed with this European type. The LM333T is a TO-220 type and replaceable with a ECG335 or NTE335. The LM333H can be replaced with a ECG334 or NTE334.

Although this circuit looks quite impressive and maybe a bit difficult it is certainly not difficult to understand. The circuit needs to be hooked-up to a DC supply voltage of between 16.5 and max 17.5 volt, otherwise the CMOS IC's will go defective. Because I didn't feel like to design a separate powersupply for this circuit I connected it to my fully adjustable bench top powersupply.

First we connect a 'to-be-charged' 9-volt nicad battery to the appropriate connections. Then hook it up to the powersupply. Upon connection the 10uF capacitor starts up the two RS Flip-Flops formed by IC1a, IC1b, IC1c, IC1d, and pulls pins 3 and 10 'high' and pins 4 and 11 'low'. The clock pulses are created by the free-running multivibrator IC4. IC4's frequency is determined by the 10uF capacitors, the 220K resistor and the 100K trimpot. The clock runs continuously but the counter behind, IC5, is not counting yet because pin 11 (the master-reset) is kept high. When the 'START' button is pressed, output pin 4 from IC1a goes high and biases Tr4, which is made visible by the Red LED (D9) which remains lit. The NiCad is now being discharged via this transistor and the 100 ohm resistor.

At the same time the output pin 10 of IC1d goes LOW, and the red LED turns off.

Because output pin 11 went HIGH the green LED (D8) lights up and at the same time the voltage level rises causing the battery to be charged. The charge-current is determined by the 120 ohm, 150 ohm, and the trimpot of 1K, at the right side of IC2. Actually we could have used one resistor, but the output voltage of different brands for IC2 may differ, by about 1.25 volt. Because the charging current is decided by value of the resistors, with the trimpot the current can be adjusted to the correct value of your own 9-volt NiCad. (In my case, the battery is a 140 mA type, so the charge current should be adjusted for 14 mA (±0.1).

At the same time the LOW of output pin 10 from IC1d starts the counter of the clock. On pin 9 of IC5 square pulses which light up the red LED. This is implemented for two reasons, the clock-frequency can, with the 100K trimpot, be adjusted to the correct value; the red LED has to come ON for 6.59 seconds and for the same duration going OFF and except for that fact the green LED, who indicates the charge current, can be checked if the total charge-time is correct.

When the counter has reached 6192 pulses (± 6.59 = 53965.26 sec = 14.99 hours) the output pin 3 of IC5 goes high again, transistor Tr1 activates and resets the two flip-flops to the start position.

The charging process stops and goes over to trickle charge via the 10K resistor and the D2 diode and keeps the battery topped-up.

The adjustments of the project are really very simple and nothing to worry about. Turn the wolver of the 10K pot in the direction of the 12K resistor, ground connection point of 10K resistodiode D2, like the adjustment pin of IC2, apply a voltage of 7-volt to the battery connection terminals, switch the power ON and slowly turn the pot backward until the green LED starts to light up. Switch OFF the power and take away the connections you made to make the adjustment.

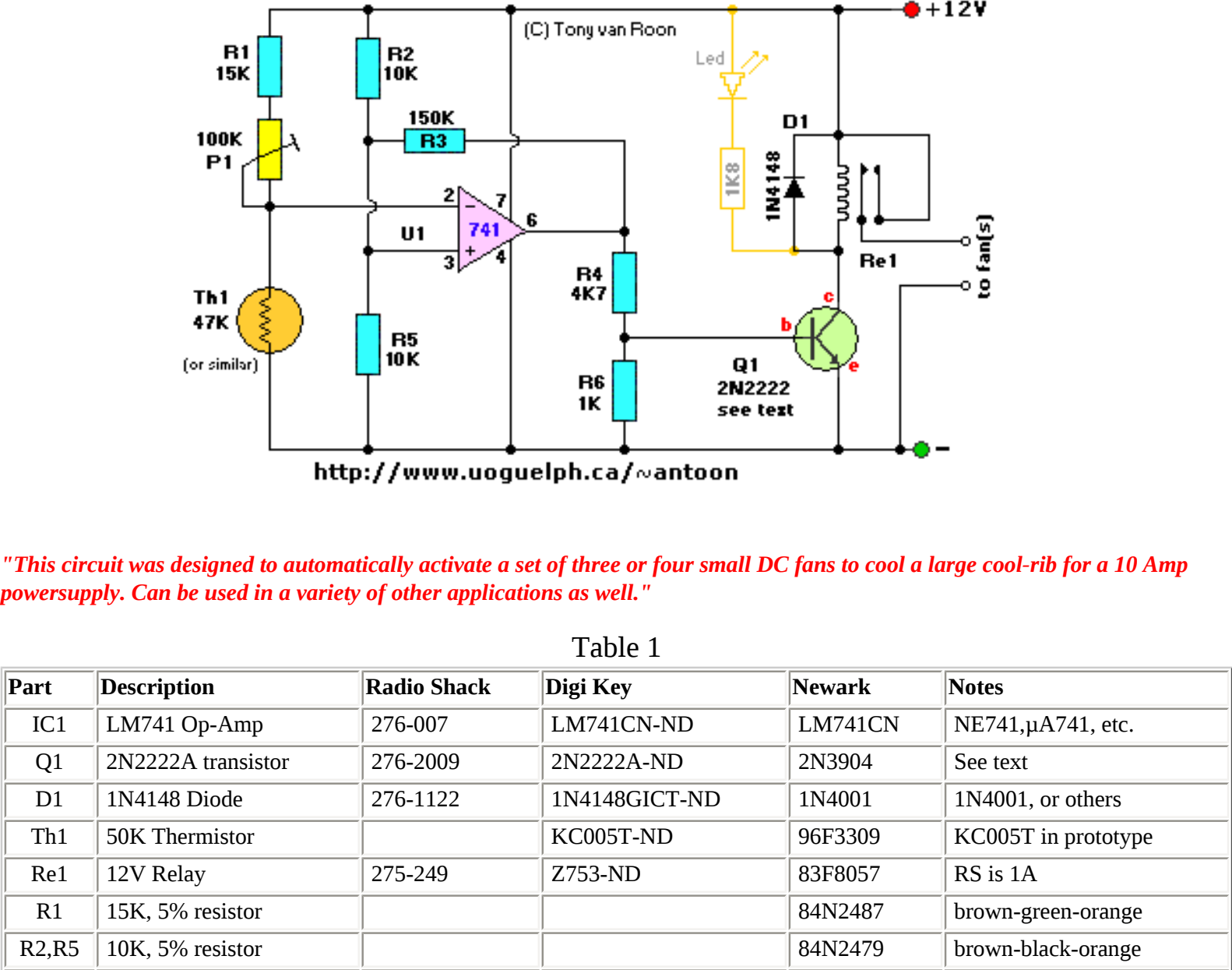
Insert an amp-meter between the battery and the output connection and again switch the power ON. The battery will, in case it is not completely empty, totally discharged (to a safe level) and as soon as the 7 volt margin is reached goes over to the charge cycle. The charge current is at this time adjusted via the 1K trimpot (which is connected in series with the 150 Ohm resistor and in parallel with the 120 ohm resistor) accurately to the desired value.

Addendum: It is strongly recommended to include small 10uF ceramic capacitors over the powersupply lines feeding EACH CMOS IC to keep possible interference to a negligible value.

If you have improved upon or know ways to improve it, Jan Hamer will appreciate your feedback. Click on his name at the top of this page or contact him via his website specified below. Thanks!

Please visit [Jan Hamer's website in the Netherlands!](#)

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This circuit was designed to automatically activate a set of three or four small DC fans to cool a large cool-rib for a 10 Amp powersupply. Can be used in a variety of other applications as well."

Table 1					
Part	Description	Radio Shack	Digi Key	Newark	Notes
IC1	LM741 Op-Amp	276-007	LM741CN-ND	LM741CN	NE741,μA741, etc.
Q1	2N2222A transistor	276-2009	2N2222A-ND	2N3904	See text
D1	1N4148 Diode	276-1122	1N4148G1CT-ND	1N4001	1N4001, or others
Th1	50K Thermistor		KC005T-ND	96F3309	KC005T in prototype
Re1	12V Relay	275-249	Z753-ND	83F8057	RS is 1A
R1	15K, 5% resistor			84N2487	brown-green-orange
R2,R5	10K, 5% resistor			84N2479	brown-black-orange
R3	150K, 5% resistor			84N2485	brown-green-yellow
R4	4K7, 5% resistor	271-1330		50N1628	yellow-purple-red
R6	1K, 5% resistor	271-1321		50N6012	brown-black-red
P1	100K Trimmer Pot		CT94P104-ND	44F3536	Cermet Multi-turn

Replacement Parts:

Th1 = 2N3053, 2N3904, NTE123A, ECG123A, NTE128, ECG128, etc.
D1 = 1N4001, NTE519, ECG519, NTE116 etc.
Th1 = Thermistor, 22K - 100K. Used 50K in prototype.
Re1 = Relay. A reed relay will work too.

Newark Electronics

Digi-Key

Radio Shack/Tandy

Radio Shack's pittyful selection of parts these days is a real headache. So I'm no longer gonna waste my time looking for partnumbers. Unless I'm sure they carry the part. Too bad...

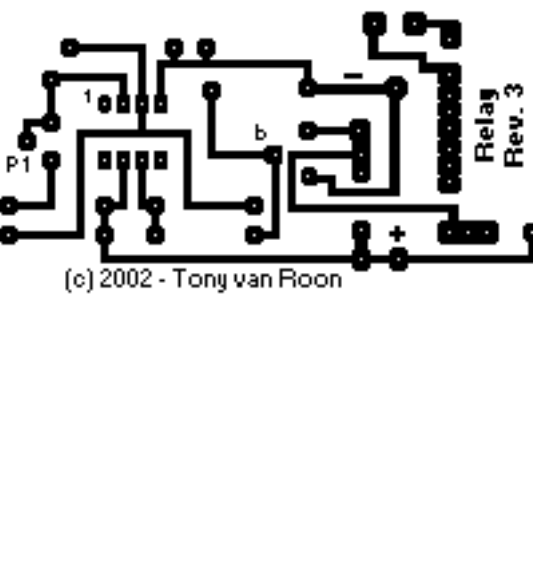
Couple Notes:

P1 is a regular Bourns trimmer potentiometer and adjusts a wide range of temperatures for this circuit. I used the 10-turn type for a bit finer adjustment but the regular type may work for your application.
R1 is a 'security' resistor just in case the trimmer pot P1 is adjusted all the way to '0' ohms. At which time the thermistor would get the full 12 volt and it will get so hot that it puts blisters on your fingers... :-)
R3 feeds a bit of hysteresis back into the op-amp to eliminate relay 'chatter' when the temperature of the thermistor reaches its threshold point. Depending on your application and the type you use for Q1 and Re1, start with 330K or so and adjust its value downwards until you're satisfied. The value of 150K shown in the diagram worked for me. Decreasing the value of R2 means more hysteresis, just don't use more than necessary. Or temporarily use a trimmer pot and read off the value. 120K worked for me.
Transistor Q1 can be a 2N2222(A), 2N3904, NTE123A, ECG123A, etc. Not critical at all. It acts only as a switch for the relay so almost any type will work, as long as it can provide the current needed to activate the relay's coil.
D1, the 1N4148, acts as a spark arrester when the contacts of the relay open and eliminates false triggering. For my application the 1N4148 was good enough since the tiny relay I used was only 1 amp. However, you can use a large variety of diodes here, my next choice would be a regular purpose 1N4001 or something and should be used if your relay type can handle more than 1 amp.

If you like to make your own pcb, try the one below. The pcb is fitted with holes for the relay but may not fit your particular relay. It was designed for a Aromat HB1-DC12V type. The variety and model of relays is just to great. How to mount it then? Well, I left ample space on the pcb to mount your relay. You can even mount it up-side-down and connect the wires individually. Use Silicon glue, cyanoacrylate ester (crazy glue), or double-sided tape to hold the relay in place. Works well. Note that the pcb and layout is not according to the circuit diagram in regards to the hookup of the fans. The PCB measures approximately 1.5 x 3 inches (4.8 x 7.6mm) If you print the pcb to an inkjet printer it is probably not to scale. Try to fit a 8-pin ic socket on the printed copy to make sure it fits before making the pcb...



[Click here for the PCB](#)



Basic IC MonoStable Multivibrator

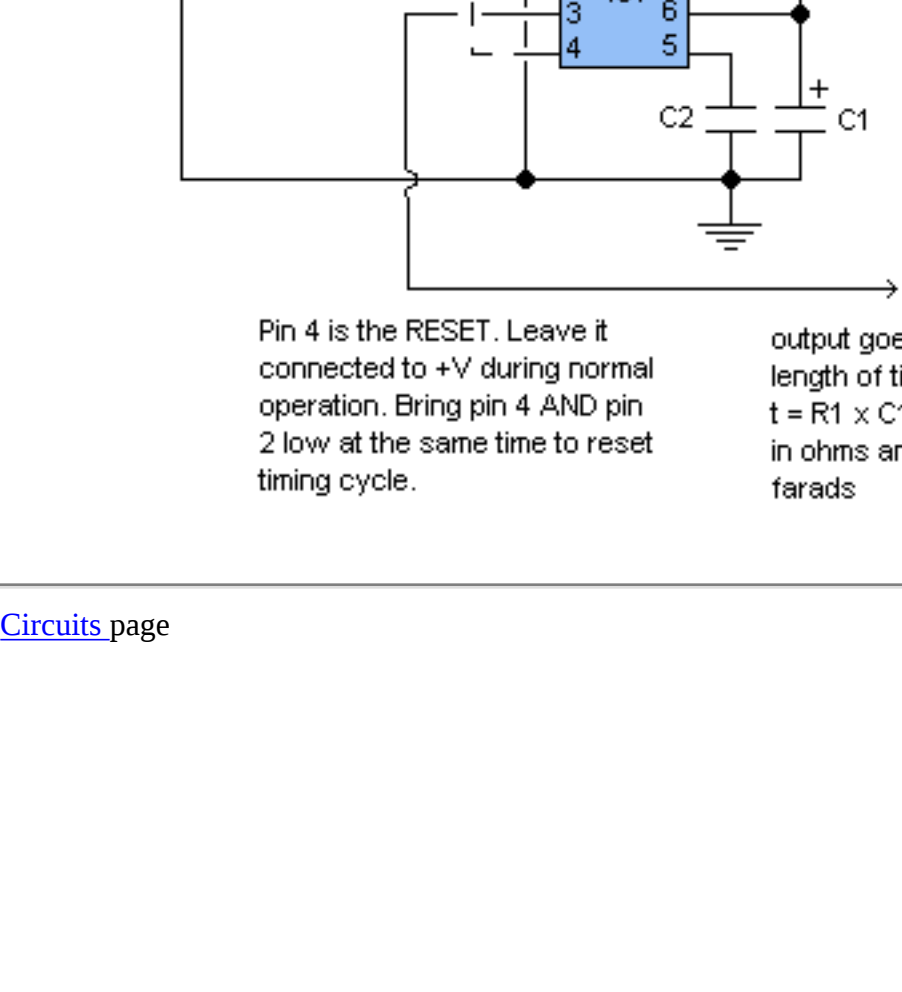
by Tony van Roon

<http://www.uoguelph.ca/~antoon/>

BASIC LM555 MONOSTABLE CIRCUIT

Parts List

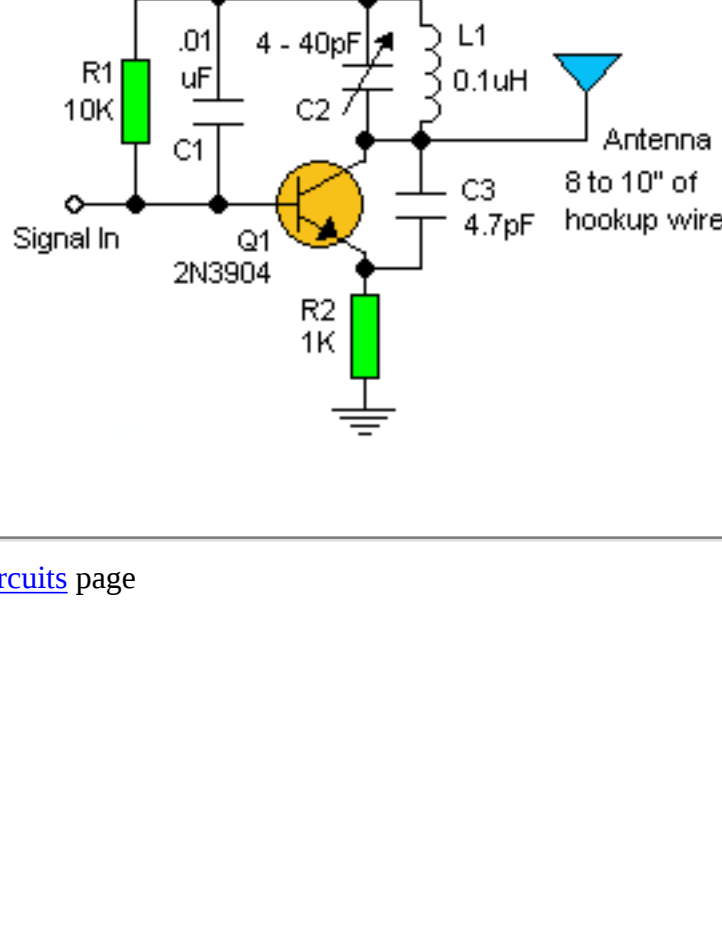
C2 = .01uF
IC1 = LM555 Timer
SW1 = n.o. momentary switch
R1 and C1 determine length of output pulse where $t = R1 \times C1$ and R1 is in ohms and C1 is in farads.



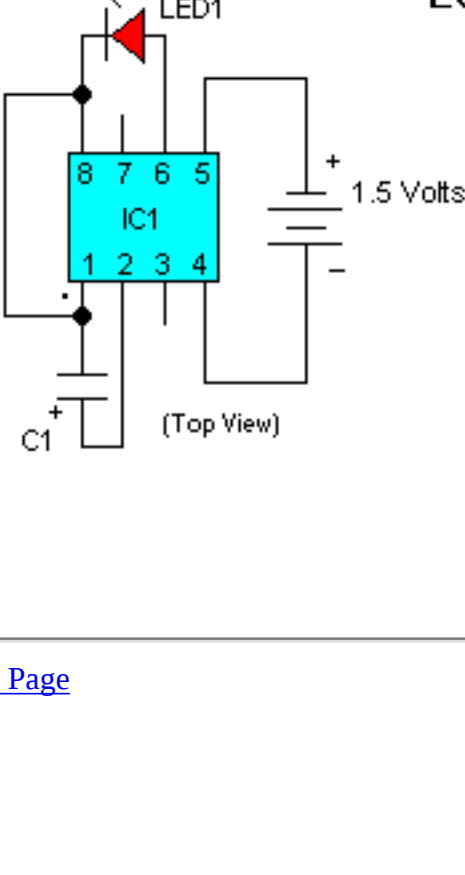
Pin 4 is the RESET. Leave it connected to +V during normal operation. Bring pin 4 AND pin 2 low at the same time to reset timing cycle.

Basic RF Oscillator

<http://www.uoguelph.ca/~antoon>



This basic circuit is easy to build and the components are not critical. Most of them can be found in your junk parts box. The L1 antenna coil can be made by close winding 8 to 10 turns of 22 gauge insulated hookup wire around a 1/4 inch form such as a pencil. You can experiment with the size of the coil and the number of turns to see how it affects the frequency and signal output of the oscillator. You should be able to pick up its signal with a standard FM radio receiver. The "Signal in" should be coupled by a disc capacitor of about 0.1uF to the stage in front of it.



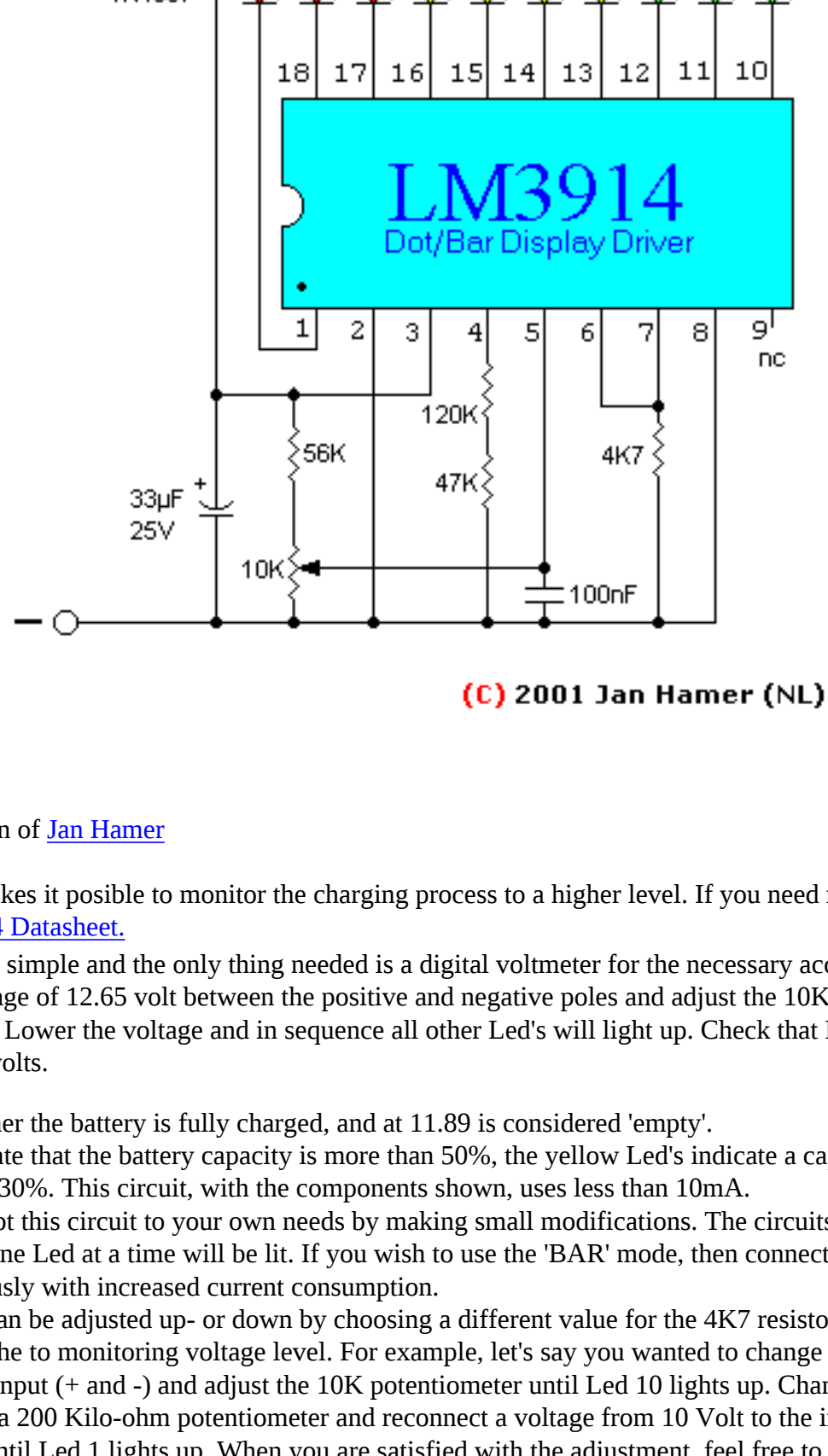
Led Flasher with the LM3909 IC

<http://www.uoguelph.ca/~antoon>

PARTS LIST

C1 = 100uF electrolytic capacitor
IC1 = LM3909 led flasher IC
LED1 = Red LED
Battery = 1.5 Volt AAA

12 V Lead-Acid Monitor



(c) 2001 Jan Hamer (NL)

Posted with permission of [Jan Hamer](#)

This simple circuit makes it possible to monitor the charging process to a higher level. If you need more information then check out the [LM3914 Datasheet](#). Final adjustments are simple and the only thing needed is a digital voltmeter for the necessary accuracy.

Connect an input voltage of 12.65 volt between the positive and negative poles and adjust the 10K trimmer potentiometer until Led 10 lights up. Lower the voltage and in sequence all other Led's will light up. Check that Led 1 lights up at approximately 11.89 volts.

At 12.65 volt and higher the battery is fully charged, and at 11.89 is considered 'empty'.

The green Led's indicate that the battery capacity is more than 50%, the yellow Led's indicate a capacity of 30% - 50% and the red Led's less than 30%. This circuit, with the components shown, uses less than 10mA.

Ofcourse you can adapt this circuit to your own needs by making small modifications. The circuits above is set for 'DOT' mode, meaning only one Led at a time will be lit. If you wish to use the 'BAR' mode, then connect pin 9 to the positive supply rail, but obviously with increased current consumption.

The LED brightness can be adjusted up- or down by choosing a different value for the 4K7 resistor connected at pin 6/7. You can also change the monitoring voltage level. For example, let's say you wanted to change to 10 - 13 volt, you connect 13volt to the input (+ and -) and adjust the 10K potentiometer until Led 10 lights up. Change temporarily the resistors at pin 4 with a 200 Kilo-ohm potentiometer and reconnect a voltage from 10 Volt to the input. Now, re-adjust the potentiometer until Led 1 lights up. When you are satisfied with the adjustment, feel free to exchange the 200K potentiometer with resistors again.(after measuring the resistance from the pot, obviously).

The diode 1N4007 was included to protect the circuit from a wrong polarity connection.

It is however strongly recommended to connect the monitor directly to the battery, in principle a connection to the cigarette lighter would suffice but for reasons unknown at this time the voltage at that point is 0.2 volt lower than the voltage measured directly on the battery. Could be some residual resistance caused by ignition switch and path through the fuse?

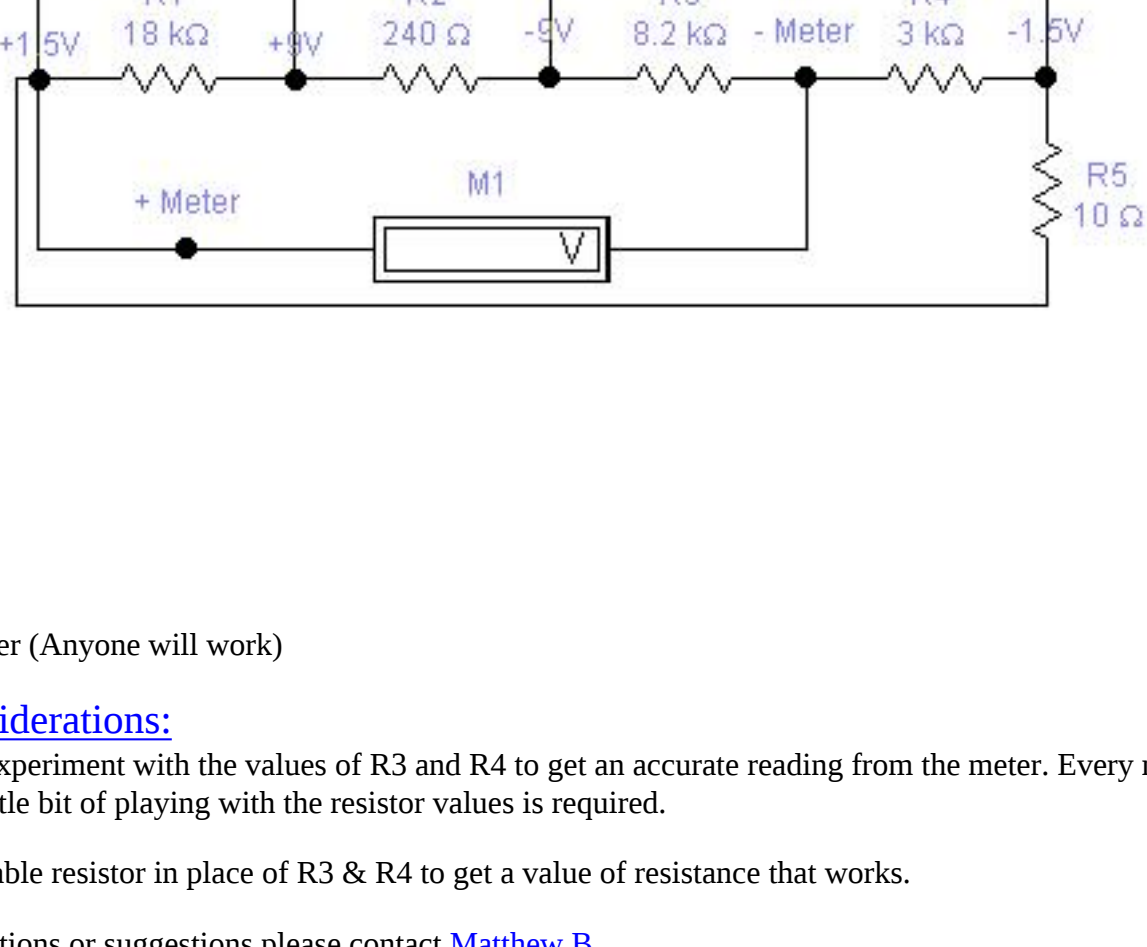
If you have any questions or suggestions, put them to [Jan Hamer](#) in the Netherlands. He does speak and write english.

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Battery Tester for 1.5 and 9V

by [Matthew B.](#)



Parts List:

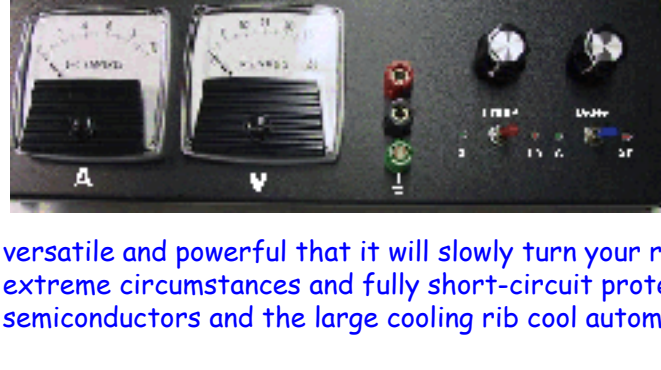
- R1 = 18K
- R2 = 240 Ohm
- R3 = 8.2K
- R4 = 3K
- R5 = 10 Ohm
- M1 = Panel Meter (Anyone will work)

Design Considerations:

You may have experiment with the values of R3 and R4 to get an accurate reading from the meter. Every meter is different, so a little bit of playing with the resistor values is required.

Try using a variable resistor in place of R3 & R4 to get a value of resistance that works.

If you have questions or suggestions please contact [Matthew B.](#)



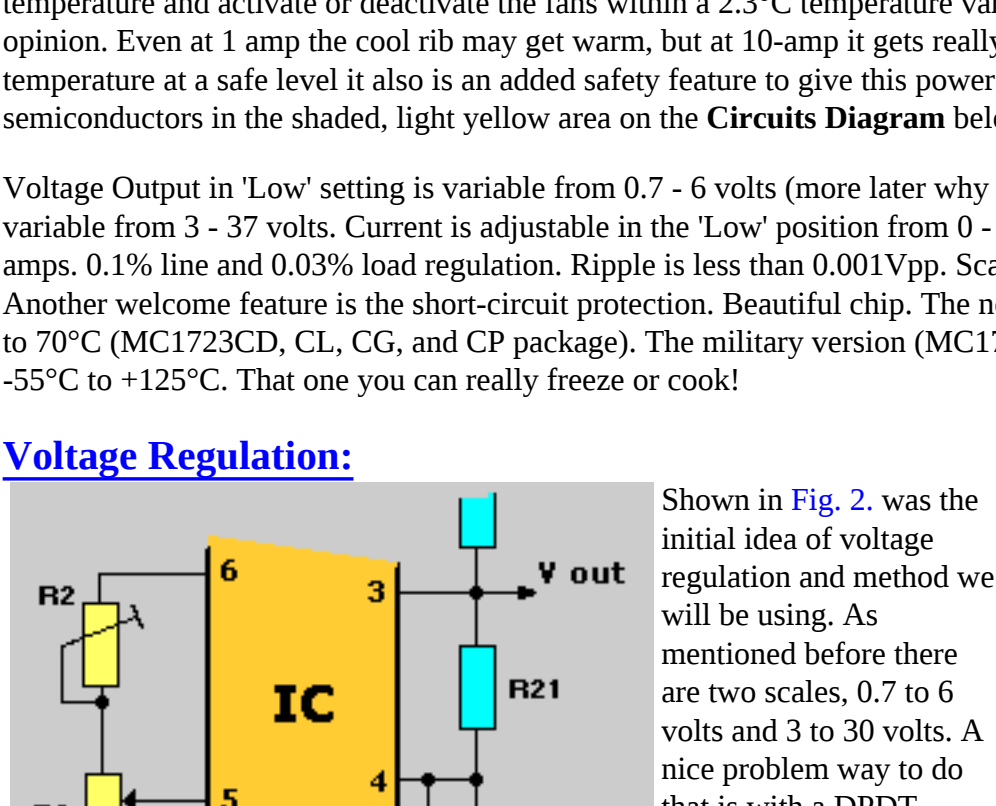
Bench Top Power Supply -- Part 1.

"This 30 volt Bench Top Power Supply is rated at 10 amp, and it is so versatile and powerful that it will slowly turn your regular 115VAC power drill. It was designed to work under the most extreme circumstances and fully short-circuit protected, even in the 10-Amp setting. Cooling fan(s) keep the semiconductors and the large cooling rib cool automatically."

by Tony van Roon, VA3AVR

Introduction:

This "jumbo" power supply is build around the monolithic volt regulator IC from Motorola, the MC1723, which is the cmos version of the old μ A723 from Fairchild Semiconductors. Other versions of this IC, like the LM723 from National and others, and even the old MC723 metal-can will work too. The μ A723 voltage regulator was designed by Bob Widlar and first introduced in 1967, and used ever since. It is a flexible, easy-to-use regulator with excellent performance.

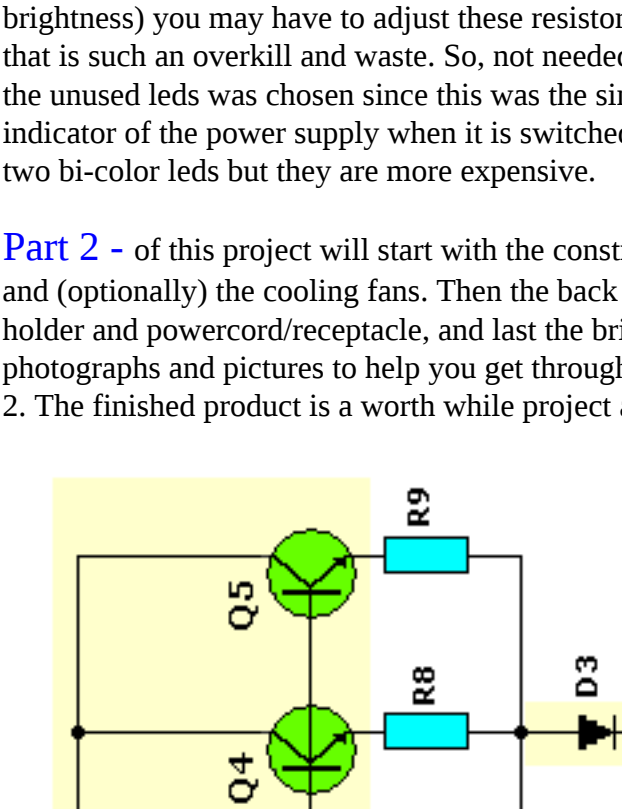


Looking at Fig. 1, this 14 pin regulator is not of your average type. You find this regulator everywhere, in a variety of applications including military. This IC can function both as a positive *or* negative voltage regulator and designed to deliver a load-current of 150mA DC. With external 'pass' transistors the output current can be increased to significant levels, as in our project to about 10 amps (depending on your transformer). A special temperature monitoring circuit (optional) will activate two to four CPU fans (optional) automatically if the temperature of the large cool rib exceeds an adjustable

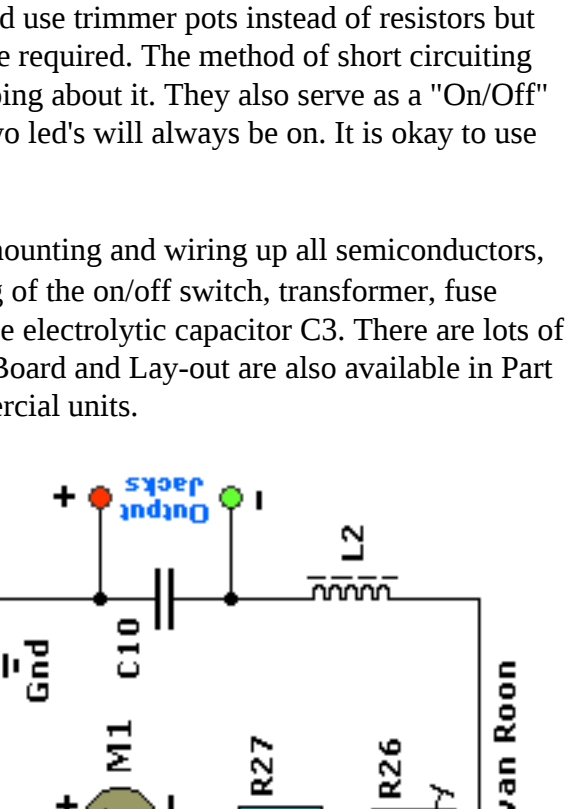
temperature and activate or deactivate the fans within a 2.3°C temperature variation. Pretty good for a 'cool' rib in my opinion. Even at 1 amp the cool rib may get warm, but at 10-amp it gets really hot and so the fans will not only keep the temperature at a safe level it also is an added safety feature to give this powersupply a life-span of at least 30 years! The semiconductors in the shaded, light yellow area on the **Circuits Diagram** below go all on the large cool rib. See Fig. 5.

Voltage Output in 'Low' setting is variable from 0.7 - 6 volts (more later why the 0.7V), in the 'High' setting the voltage is variable from 3 - 37 volts. Current is adjustable in the 'Low' position from 0 - 1 amp and in the 'High' setting from 1 to 10 amps. 0.1% line and 0.03% load regulation. Ripple is less than 0.001Vpp. Scale tolerance Low: 0.2%, High: 0.5%. Another welcome feature is the short-circuit protection. Beautiful chip. The normal commercial temperature range is 0°C to 70°C (MC1723CD, CL, CG, and CP package). The military version (MC1723G or L) can handle a temperature range of -55°C to +125°C. That one you can really freeze or cook!

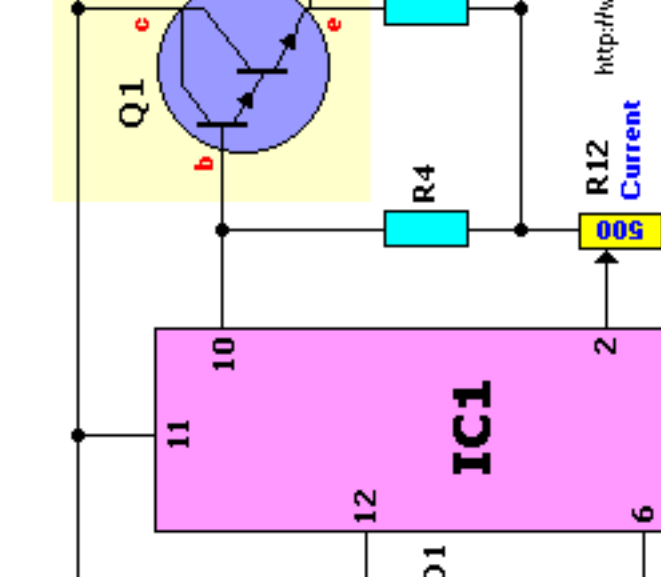
Voltage Regulation:



Shown in Fig. 2, was the initial idea of voltage regulation and method we will be using. As mentioned before there are two scales, 0.7 to 6 volts and 3 to 30 volts. A nice problem way to do that is with a DPDT switch (S2). Plus we will add a LED to indicate which scale we are on. This toggle-switch switches both the volt-scale and the volt-meter.



In Fig. 3, you can see how, by putting one side of S2 to ground via one resistor, the output voltage is in the 3 - 30V scale, and the other side of S2 via another resistor (R-extra) to switch to the 0.7 - 6 V scale. At the same time we switch a parallel resistor with it as a shunt for the panel-meter. If we calculate the value of this resistor to represent the meter R_i for the 6V scale, then everything is a piece-of-cake. A single pole switch is in this scenario sufficient, without limiting any performance. A second pole is used to switch the led-indicators, making S2 a double-pole-double-throw type. The 'Voltage' on the front panel is controlled with potentiometer R3 and the scale adjusted with trimmer pot R2.



The Led indicators have a voltage of between 1.8 and 2.0 volts dc and the current no more then 25mA max. They can also be used to glow on AC, only then an extra diode will be required (see Fig. 4.) which also protects the Led's just in case we accidentally connect them the wrong way. Point 'A' is connected to the same as indicated on the circuit diagram. Leds D6 & D8 are the 30-volt and 10-amp settings but are not lit because they are shorted by the switch S2b and S3b. Resistors R28 to R31 are chosen accordingly to input voltage. A rule of thumb is about 100 ohms per volt input voltage. This means a little less than 10 milliamps per Led and that is enough to light them up.

Depending on the Led type you use (regular, high-, or ultra brightness) you may have to adjust these resistors to suit your needs. You could use trimmer pots instead of resistors but that is such an overkill and waste. So, not needed, just a bit of tinkering may be required. The method of short circuiting the unused leds was chosen since this was the simplest and cheapest way of going about it. They also serve as a "On/Off" indicator of the power supply when it is switched on because a minimum of two led's will always be on. It is okay to use two bi-color leds but they are more expensive.

Part 2 - of this project will start with the construction of the large cool rib, mounting and wiring up all semiconductors, and (optionally) the cooling fans. Then the back panel and the 115VAC wiring of the on/off switch, transformer, fuse holder and powercord/receptacle, and last the bridge rectifier BR1 and the large electrolytic capacitor C3. There are lots of photographs and pictures to help you get through all this. The Printed Circuit Board and Lay-out are also available in Part 2. The finished product is a worth while project and outperforms many commercial units.

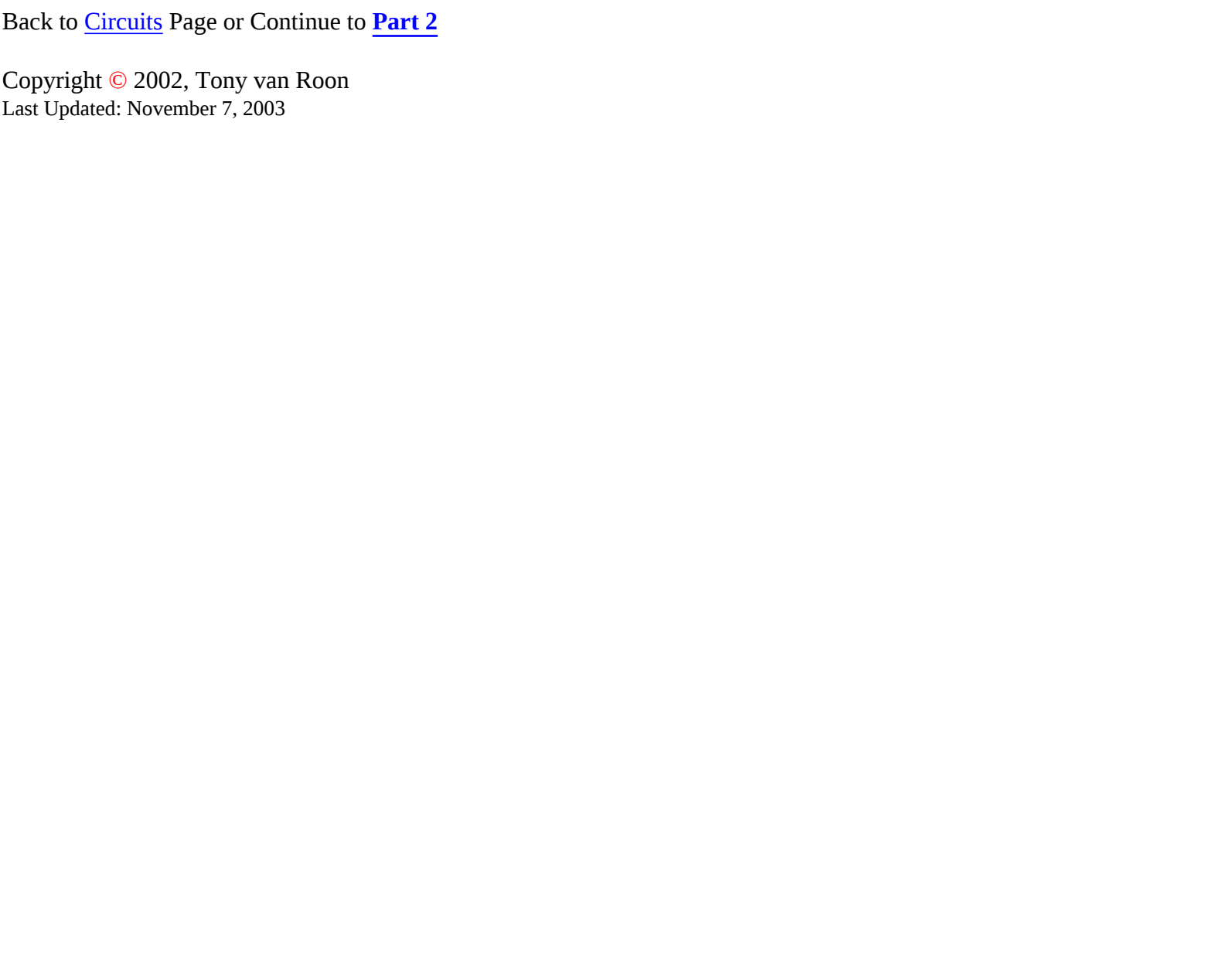
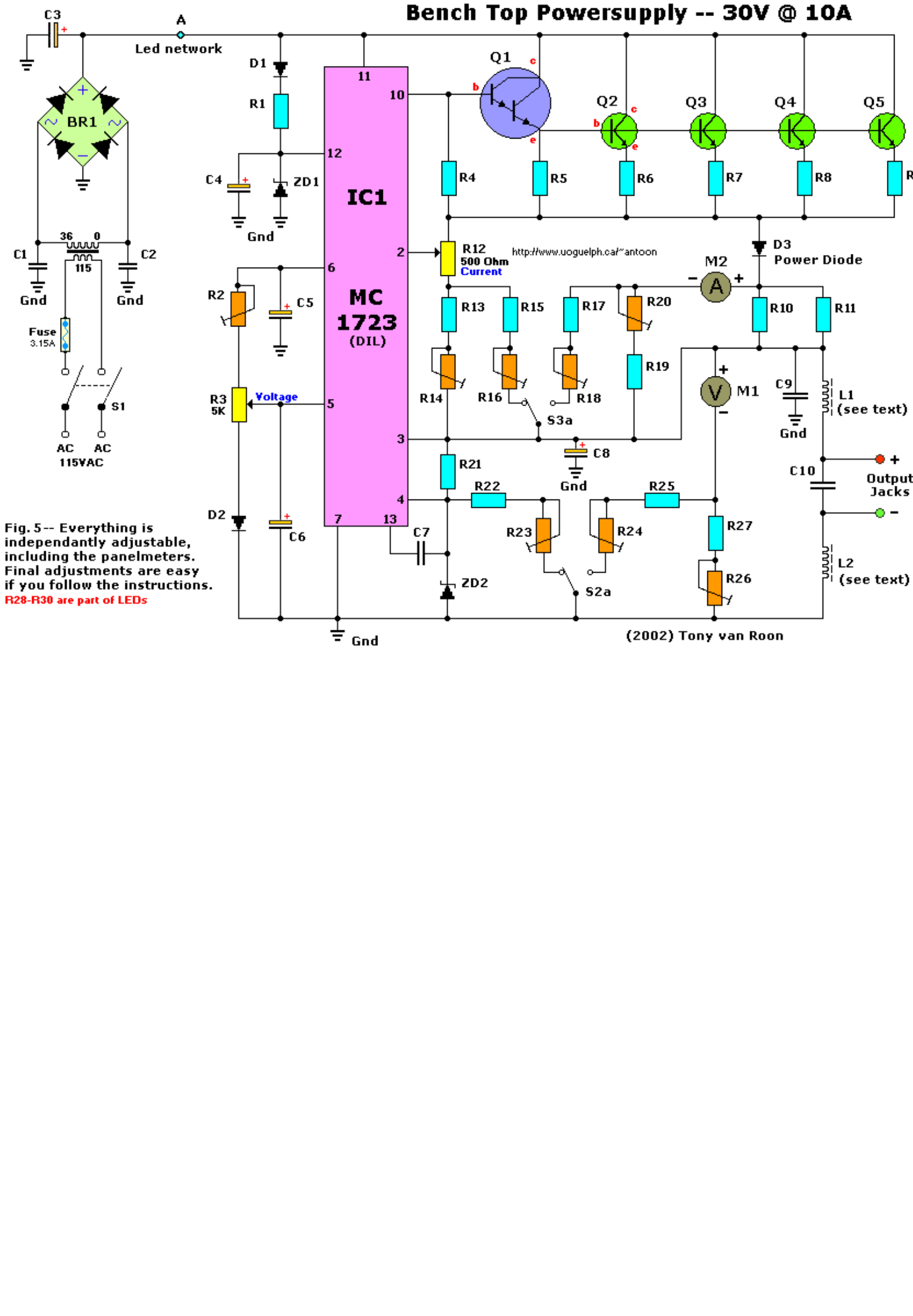


Fig. 5 --- Everything is independently adjustable, including the meters. Final adjustments are easy if you follow the text.

Click [here](#) for a full size version in horizontal view. Only the diagram above prints correctly though.

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Last Updated: November 7, 2003



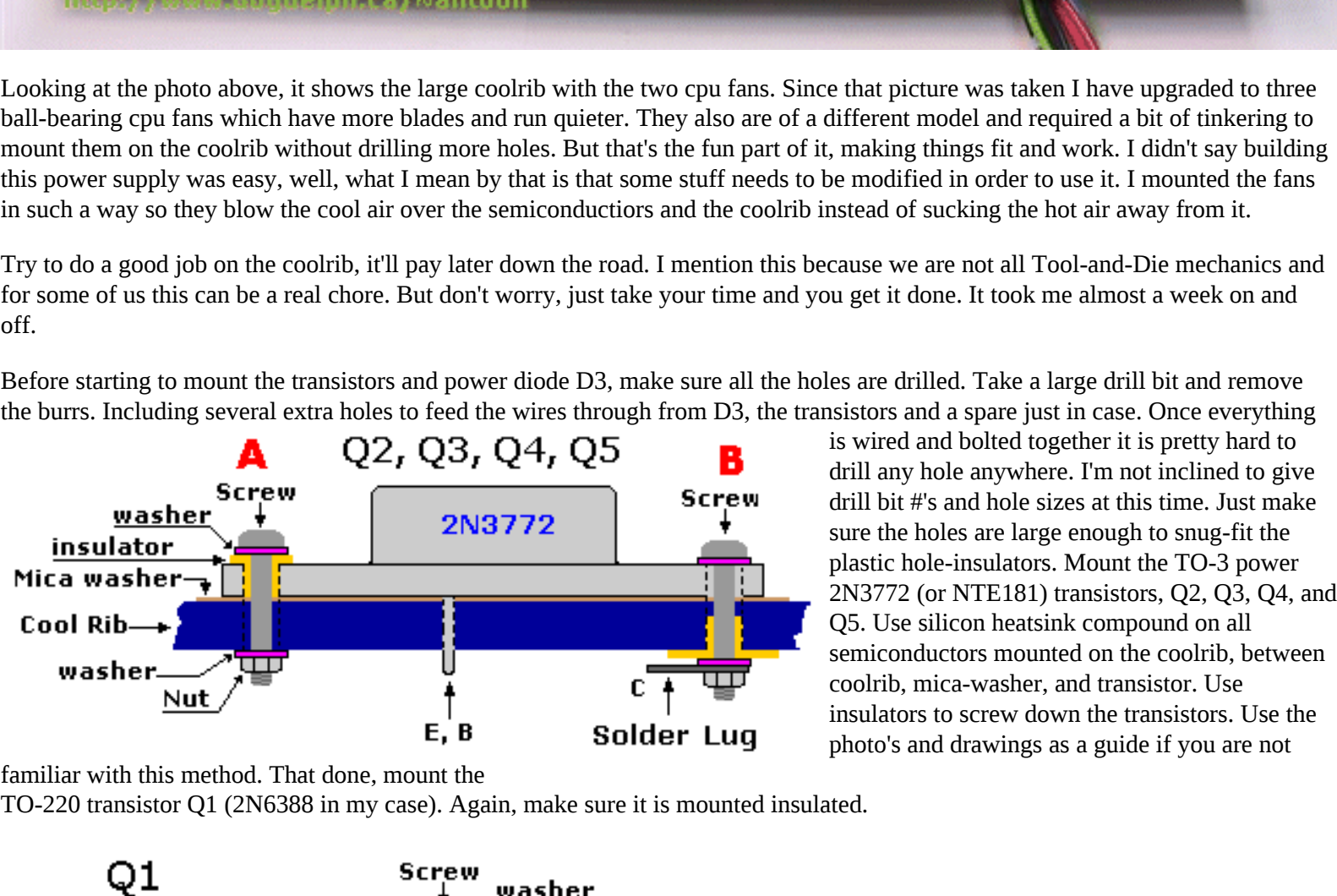
Bench Top Powersupply -- Part 2

"In this second part of the Bench Top Power Supply project we will cover the construction, assembly, and wiring of the large coolrib and the optional Automatic Fan Control circuit. When that is done the transformer T1, 115VAC components, large capacitor C3, and the bridge rectifier will be installed and wired up. There are lots of pictures and photos to help you out. Main thing to remember is to TAKE-IT-EASY, read the explanations and take your time. This is definitely a NO rush job."

by Tony van Roon, VA3AVR

The Large Coolrib:

Building the large coolrib was a lot of fun. I found an old coolrib in one of my parts boxes which measured about 11" x 4-1/8" (28 x 10.5cm) which is perfect because it fitted the back of the Hammond Instrument Case perfectly with room to spare for the AC-side (see photo). The Hammond Instrument Case is not cheap, but is a ventilated, low-profile, series 1426V type with dimensions of about 12x8x4 inches. Make sure **your** transformer fits your instrument case!



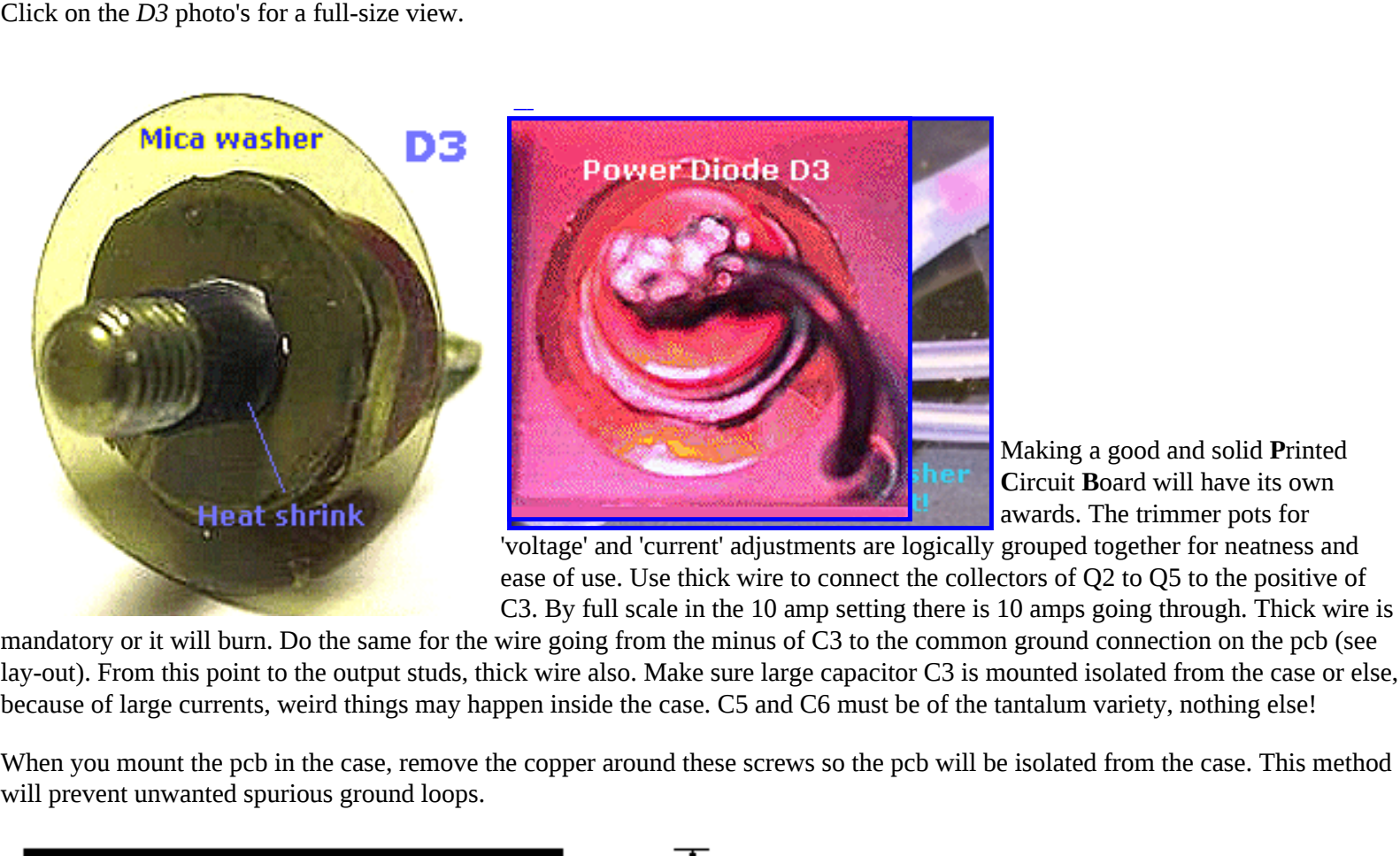
Looking at the photo above, it shows the large coolrib with the two cpu fans. Since that picture was taken I have upgraded to three ball-bearing cpu fans which have more blades and run quieter. They also are of a different model and required a bit of tinkering to mount them on the coolrib without drilling more holes. But that's the fun part of it, making things fit and work. I didn't say building this power supply was easy, well, what I mean by that is that some stuff needs to be modified in order to use it. I mounted the fans in such a way so they blow the cool air over the semiconductors and the coolrib instead of sucking the hot air away from it.

Try to do a good job on the coolrib, it'll pay later down the road. I mention this because we are not all Tool-and-Die mechanics and for some of us this can be a real chore. But don't worry, just take your time and you get it done. It took me almost a week on and off.

Before starting to mount the transistors and power diode D3, make sure all the holes are drilled. Take a large drill bit and remove the burrs. Including several extra holes to feed the wires through from D3, the transistors and a spare just in case. Once everything is wired and bolted together it is pretty hard to drill any hole anywhere. I'm not inclined to give drill bit #'s and hole sizes at this time. Just make sure the holes are large enough to snug-fit the plastic hole-insulators. Mount the TO-3 power 2N3772 (or NTE181) transistors, Q2, Q3, Q4, and Q5. Use silicon heatsink compound on all semiconductors mounted on the coolrib, between coolrib, mica-washer, and transistor. Use insulators to screw down the transistors. Use the photo's and drawings as a guide if you are not

familiar with this method. That done, mount the

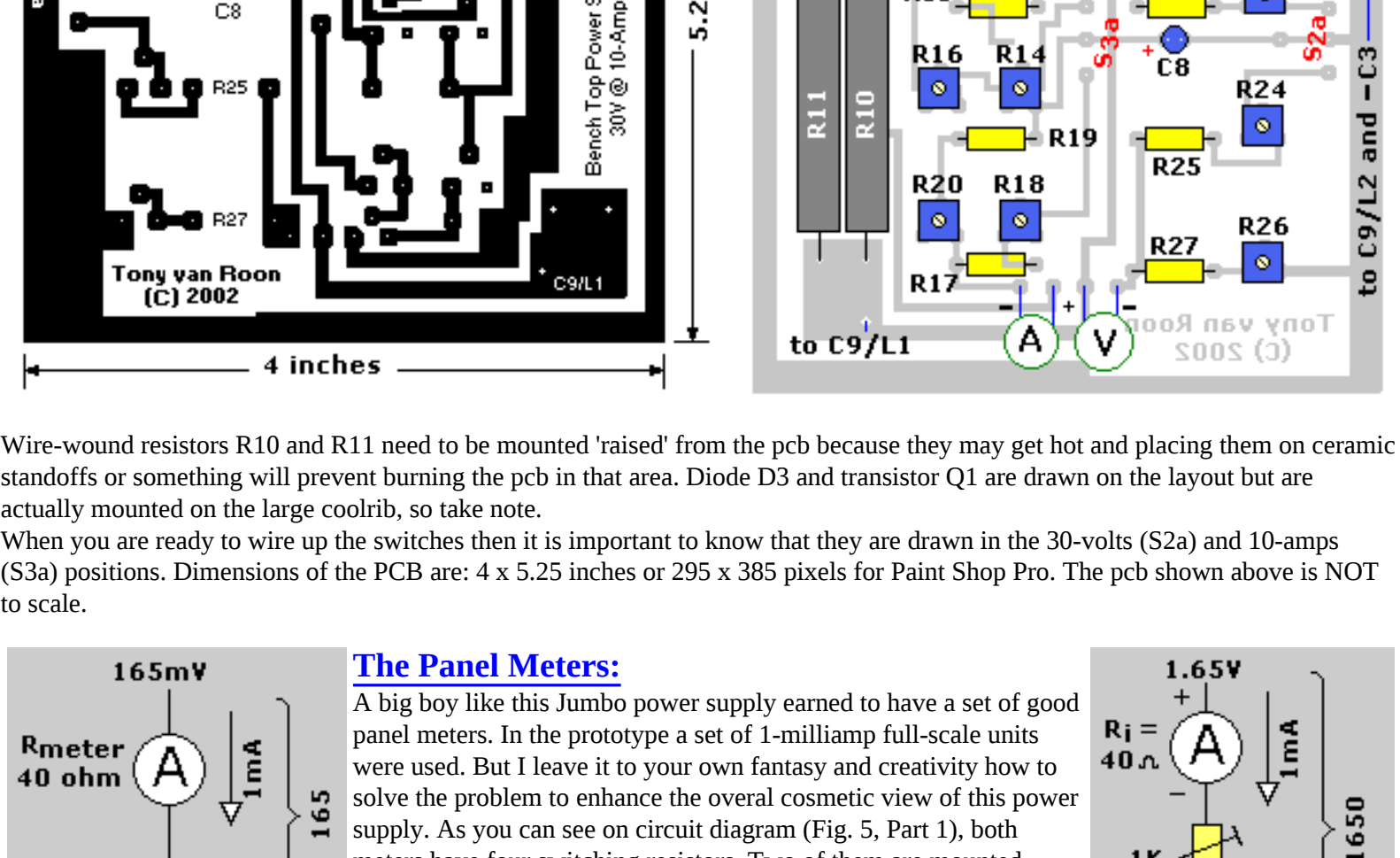
TO-220 transistor Q1 (2N6388 in my case). Again, make sure it is mounted insulated.



power diode D3.

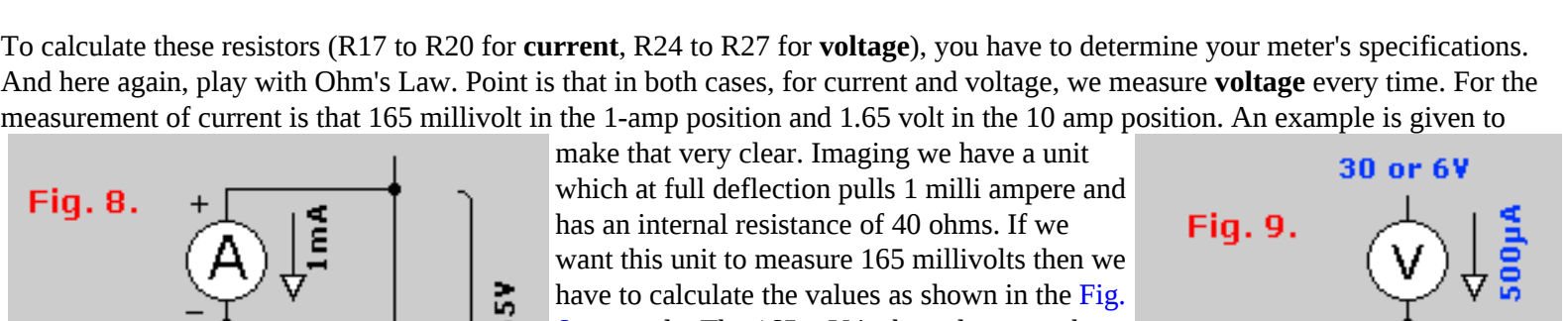
When all semiconductors are mounted, and **BEFORE** starting to wire the whole thing up, take your continuity tester or multimeter and verify that the body of all transistors and the stud of D3 are insulated from the coolrib and each other, meaning **NO** continuity on all of them. One probe on the coolrib and with the other you check the semiconductors if all is well, proceed, if not and you notice continuity somewhere it means that that part is not insulated properly. **Fix that first!** Click on the D3 photo's for a full-size view.

When you mount the pcb in the case, remove the copper around these screws so the pcb will be isolated from the case. This method will prevent unwanted spurious ground loops.



Wire-wound resistors R10 and R11 need to be mounted 'raised' from the pcb because they may get hot and placing them on ceramic standoffs or something will prevent burning the pcb in that area. Diode D3 and transistor Q1 are drawn on the layout but are actually mounted on the large coolrib, so take note.

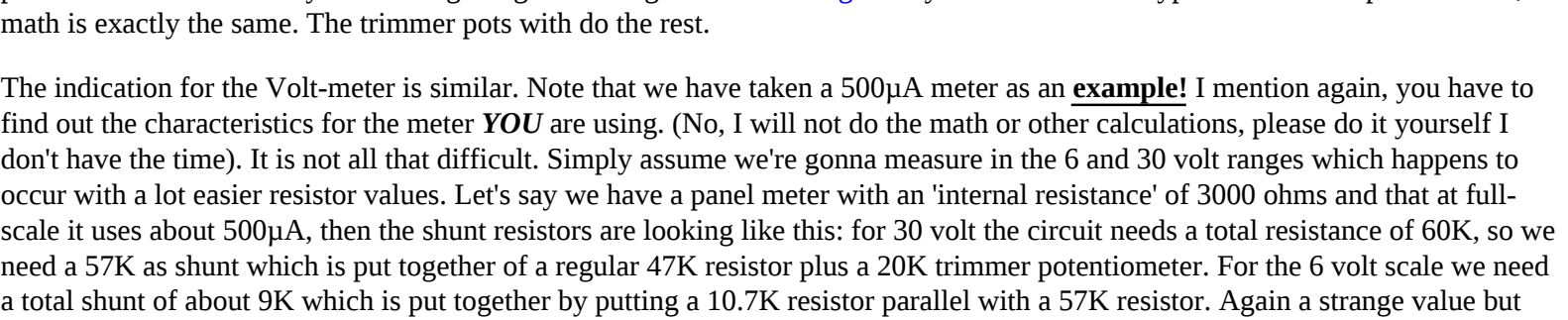
When you are ready to wire up the switches then it is important to know that they are drawn in the 30-volts (S2a) and 10-amps (S3a) positions. Dimensions of the PCB are: 4 x 5.25 inches or 295 x 385 pixels for Paint Shop Pro. The pcb shown above is NOT to scale.



resistance (Ri) which will benefit in the area of current measurement of that particular panel meter.

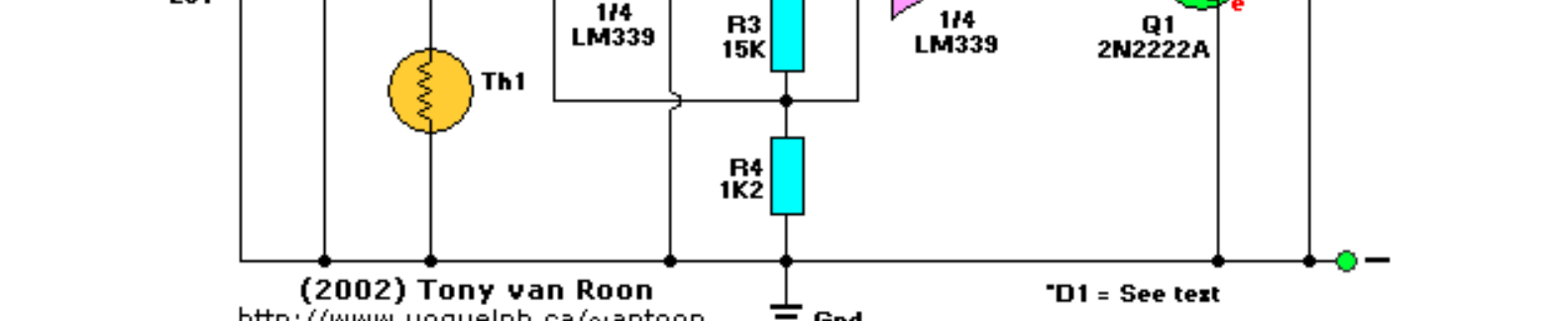
We assume that in the low 0 to 1-amp setting there are only small voltages available over R10-R11 and if all goes to plan is the maximum voltage around 165 millivolt and that is for low-ohm meters feasible. So, try for a model with about 100 millivolt at full-scale. Which means that a 100 millivolt type only pulls 1 milli-amp at full scale. A 100µA type will have a Ri of about a 1000 ohm. Check it yourself with Ohm's Law. For the current panel meter try to get a type with 50 or 100 indicator stripes (or markings). This is less critical for the 'Volt' unit. Basically you can use any model as long as its own power is not higher than a couple milli-amps. The internal resistance or Ri is less important since any type of internal resistor will be removed anyways.

To calculate these resistors (R17 to R20 for **current**, R24 to R27 for **voltage**), you have to determine your meter's specifications. And here again, play with Ohm's Law. Point is that in both cases, for current and voltage, we measure **voltage** every time. For the measurement of current is that 165 millivolt in the 1-mamp position and 1.65 volt in the 10 amp position. An example is given to



in consideration because there are already a couple shunt resistors in series with the meter and those are the components for the 10 amp scale. Looking at the example in Fig. 7, we have to measure there 1.65 volt and that means a resistance value of 1650 minus 40 is 1610 ohms. This weird resistance value can be obtained with a regular 1.2K resistor and a trimmer potentiometer of 1K. The required value of 125 ohm can be acquired by adding another resistor with the funny 1610 ohm one. Doing the math (ohm's law), it turns out the value of this parallel resistor is about 135.5 ohms and that is easily obtainable with a 68 ohm resistor plus a 100 ohm Bourns trimmer potentiometer. And if you're a perfectionist you can even choose a 82 ohm and a 100 ohm trimmer potentiometer. In the end you will be getting something as shown in Fig. 8. If you have different types or values of panel meters, the math is exactly the same. The trimmer pots with do the rest.

The indication for the Volt-meter is similar. Note that we have taken a 500µA meter as an **example!** I mention again, you have to find out the characteristics for the meter **YOU** are using. (No, I will not do the math or other calculations, please do it yourself I don't have the time). It is not all that difficult. Simply assume we're gonna measure in the 6 and 30 volt ranges of 3000 ohms and that at full-scale it uses about 500µA, then the shunt resistors are looking like this: for 30 volt the circuit needs a total resistance of 60K, so we need a 57K as shunt which is put together of a regular 47K resistor plus a 20K trimmer potentiometer. For the 6 volt scale we need a total shunt of about 9K which is put together by putting a 10.7K resistor parallel with a 57K resistor. Again a strange value but 8.2K plus a 5K trimmer potentiometer will make it work. In Fig. 9 I used, where ever I could, metalfilm resistors instead of the regular carbon type. They are more temperature stable. But carbon types will work fine.



Shown above is the circuit diagram for the automatic temperature control switcher. The thermistor, a 1.7K at 70°F model available from Radio Shack (not sure), will keep tab on the coolrib's temperature (adjustable with a 10-turn trimmer potentiometer P1) and activate the cpu fans (or one larger fan) to keep things cool. This circuit is not part of the Power Supply PCB at this time, but (given time) I will change that early in the new year. I played with several different value thermistors; 1.7K, 5K, 10K. They all worked fine after playing with the resistor network a bit.

The D1 diode can be a signal diode like the 1N914 or 1N4148 for micro relays, use a 1N4001 or higher for relays above 100mA. D1 acts like a spark arrestor/filter when the coil is de-energized.

Just in case, here is **another circuit** and this one **Heat Sensor** using the more common 741 op-amp. Good circuits, working fine and a bit cheaper. All parts are available from Radio Shack and Tandy. I found the 741-circuit easier to adjust and there are no capacitors or zener-diode. But, make your own choice. The "Heat Sensor" circuit works great and uses a minimum of easily obtainable parts.

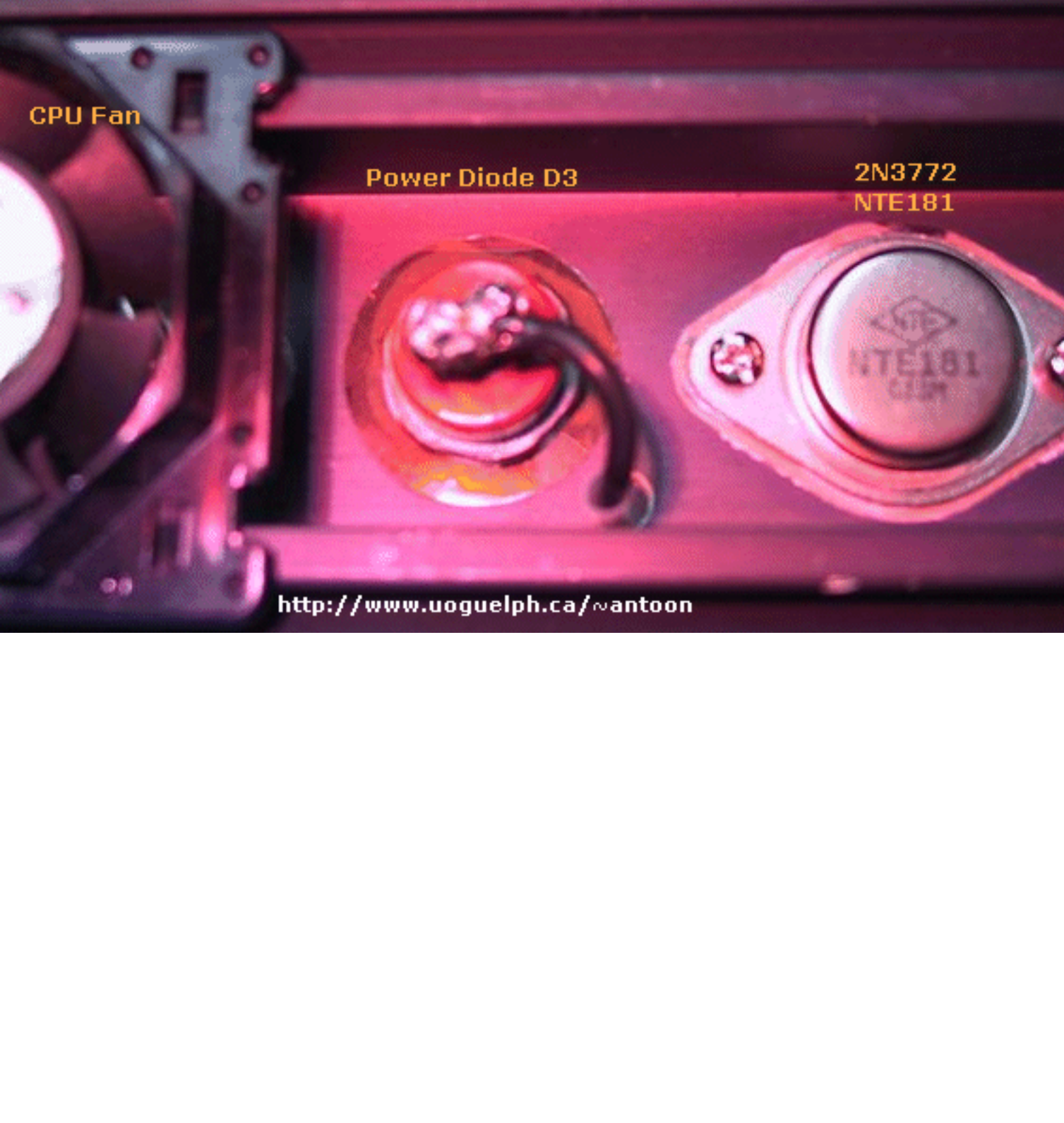
If you have any questions, I'll gladly answer them via "Tony's Message Forum". I regret not answering personal emails!

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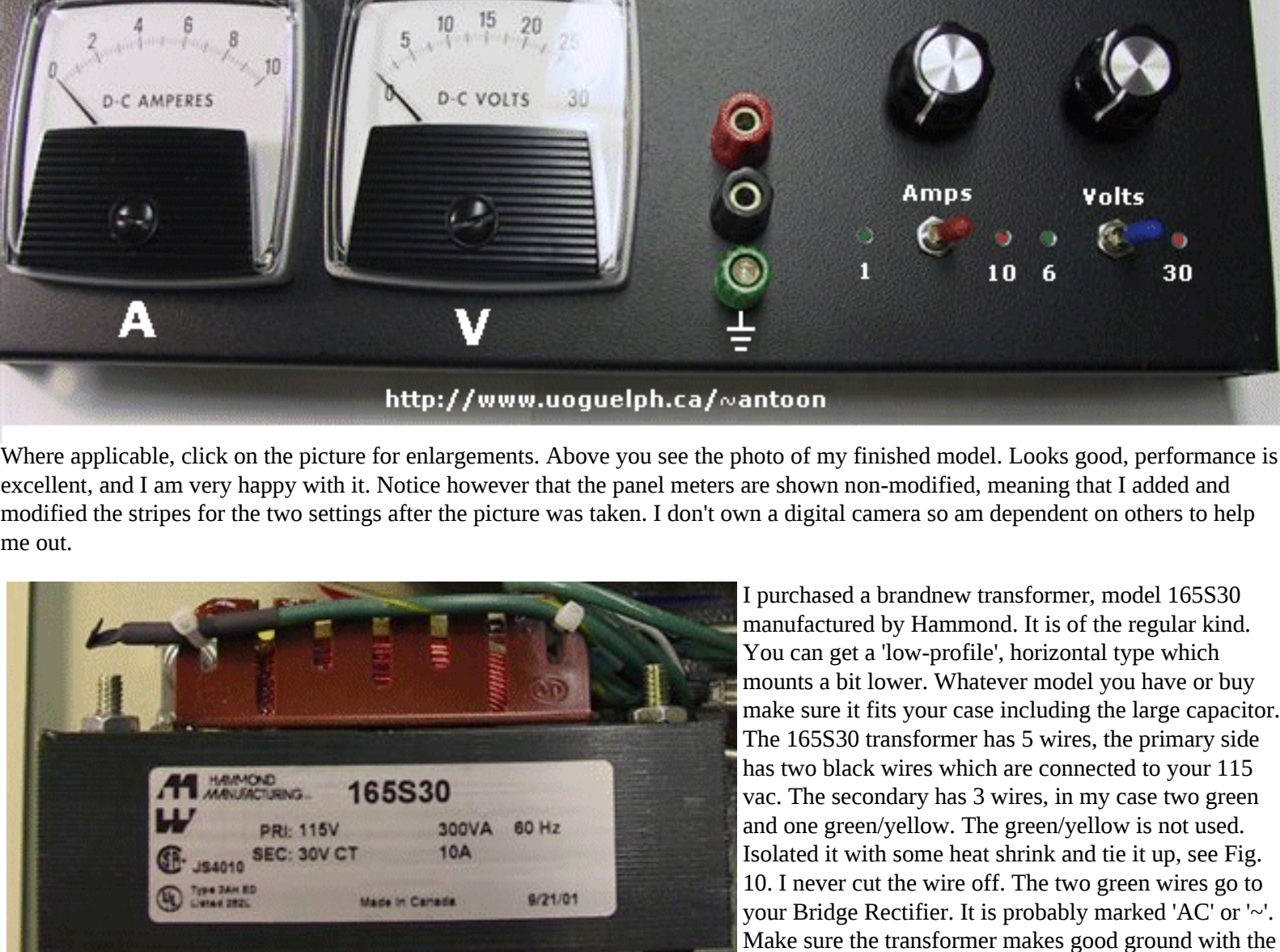
Last Updated: November 4, 2004





Bench Top Power Supply -- Part 3

By Tony van Room.



Where applicable, click on the picture for enlargements. Above you see the photo of my finished model. Looks good, performance is excellent, and I am very happy with it. Notice however that the panel meters are shown non-modified, meaning that I added and modified the stripes for the two settings after the picture was taken. I don't own a digital camera so am dependent on others to help me out.

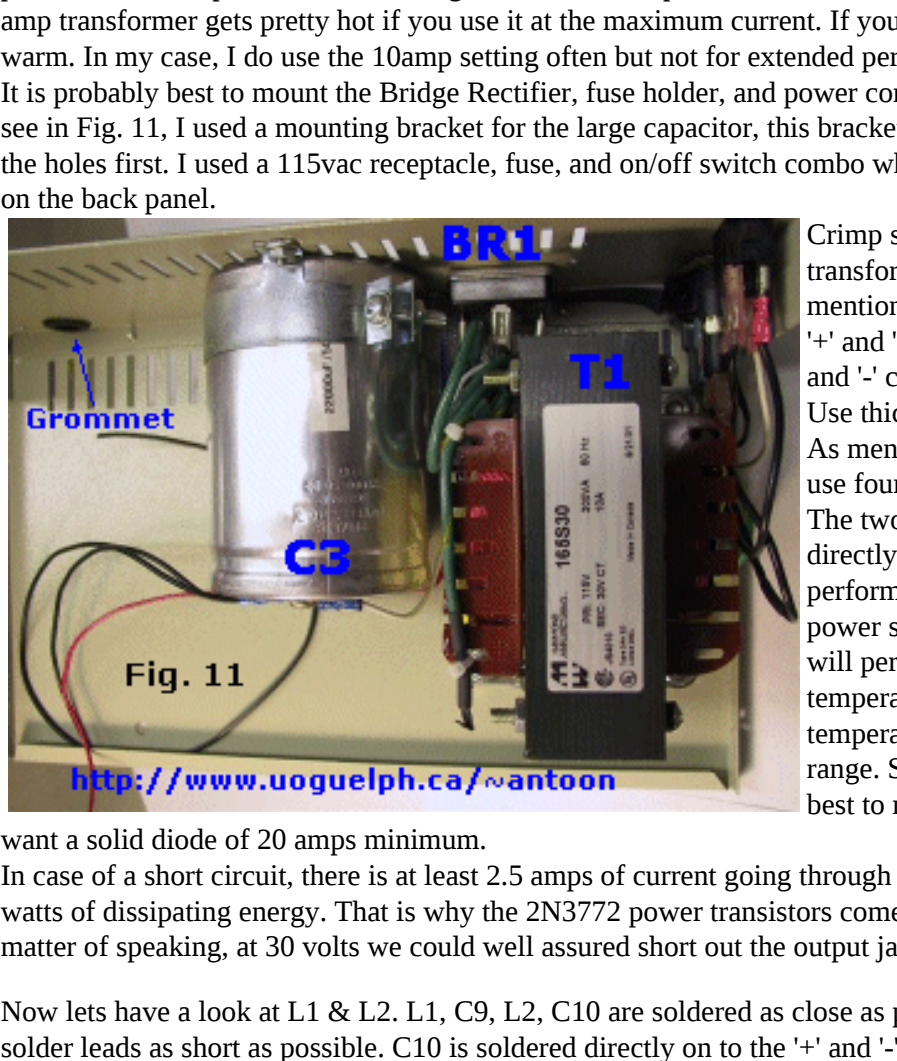


Fig. 10

transformer makes good connection with the chassis of the power supply.
The fuse is a 3.15A slow-blow type to prevent it blows when you switch on the power supply with a bit of load. This transformer is a real heavy one and weighs several pounds. If you're planning to use it with heavy loads, I would suggest to get one which can provide 12-15Amps at a desired voltage, but, the 10-amp transformer listed in the parts list will work. The difference is that the 10 amp transformer gets pretty hot if you use it at the maximum current. If you would have a 12-15 amp type it will only get a little warm. In my case, I do use the 10amp setting often but not for extended periods. A couple hours at best.
It is probably best to mount the Bridge Rectifier, fuse holder, and power cord first before bolting down the transformer. As you can see in Fig. 11, I used a mounting bracket for the large capacitor, this bracket is also mounted on the back panel so don't forget to drill the holes first. I used a 115vac receptacle, fuse, and on/off switch combo which I had laying around and the whole thing is mounted on the back panel.

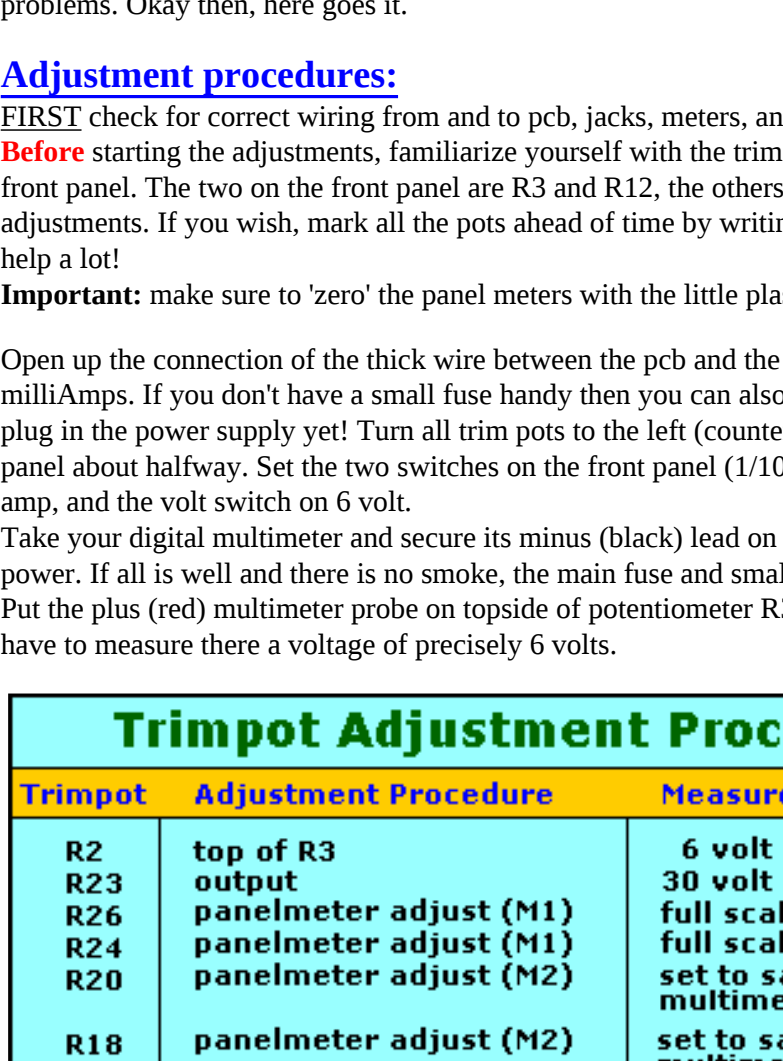


Fig. 11

Crimp spades onto the two secondary green wires and mount the transformer. Connect those wires to the Bridge Rectifier as mentioned earlier. Install the large capacitor and wire up to the '+' and '-' of the Bridge Rectifier. From this point on all other '+' and '-' connections are taken from the large capacitor terminals. Use thick wire.
As mentioned earlier, instead of a Bridge Rectifier you could use four separate 'stud-mount' diodes and make your own bridge. The two anti-rattle capacitors, C1 and C2, should be mounted directly onto the transformer or the bridge rectifier for best performance. Power diode D3 is a very vital component in this power supply and so was chosen a bit over-rated to make sure it will perform satisfactory under all circumstances and temperature changes. You probably already know that a diode is temperature sensitive which is most noticeable in the 0.7Volt range. Since the same D3 also has a job of current limiting it is best to make sure this diode does not get too hot. So, we really want a solid diode of 20 amps minimum.
In case of a short circuit, there is at least 2.5 amps of current going through each power transistor, and that is a lot at about 60 to 70 watts of dissipating energy. That is why the 2N3772 power transistors come in which can dissipate 350 watts or so. And so, as a matter of speaking, at 30 volts we could well assured short out the output jacks and fry an egg on the output power transistors.
Now lets have a look at L1 & L2. L1, C9, L2, C10 are soldered as close as possible to the output jacks. We even have to cut the solder leads as short as possible. C10 is soldered directly on to the '+' and '-' output jacks. C9 is soldered parallel over the L1/C10/L2 network. The two thick wires coming from the printed circuit board are soldered onto each leg of C9. Oh yeah, I mention again that the PCB has to be mounted **isolated** from the case. The common ground connection is connected to the '-' jack via L2. This is a little bit of tinkering but can be done. We are working here with 10 amps so worth all the efforts.

I call the ferrite beads 'pig snouts' because that's what it looks like to me, but hey, call it whatever you want. You need to make two of them. On the circuit diagram they are indicated as L1 and L2. One or two turns of thick magnet wire will do the trick.

By now you must be anxious to try everything out. Well, be patient, we're almost done. We still have to adjust the eight trim potentiometers on the pcb. And you really need to sit down for it and carefully take your time. Look for a time and place when you can do this quietly and undisturbed. The last thing you want is to open this heavy power supply up again and re-adjust it because of initial sloppy adjustments. So, take your time, go slow, and verify each adjustment until you're satisfied.
The adjustments are done in a special sequence and if you keep yourself to this procedure then I doubt you would encounter any problems. Okay then, here goes it.

Adjustment procedures:

FIRST check for connections from and to pcb, jacks, meters, and coolrib. Very important.
Before starting the adjustments, familiarize yourself with the trim pots on the printed circuit board and the potentiometers on the front panel. If you wish, mark all the pots ahead of time by writing the 'R' numbers on a piece of scotch tape or something. It will help a lot!
Important: make sure to 'zero' the panel meters with the little plastic screw attached to the needle movement unit.

Open up the connection of the thick wire between the pcb and the positive of C3 and insert a small fuse of a couple hundred milliAmps. If you don't have a small fuse handy then you can also use a 1/2 watt 10-ohm resistor or something similar. Do NOT plug in the power supply yet! Turn all trim pots to the left (counter-clock-wise) all the way. Set the two potentiometers on the front panel about halfway. Set the two switches on the front panel (1/10A, 6/30V) to the low settings, meaning the current switch on 1 amp, and the volt switch on 6 volt.
Take your digital multimeter and secure its minus (black) lead on the minus output jack. Plug in the power supply and switch the power. If all is well and there is no smoke, the main fuse and small temporary fuse on C3 remain okay, we can continue.
Put the plus (red) multimeter probe on top side of potentiometer R3. This is the position closest to the minus of C4 on the pcb. You have to measure there a voltage of precisely 6 volts.

Trimpot Adjustment Procedures		
Trimpot	Adjustment Procedure	Measured Result
R2 R23 R26 R24	top of R3 output panelmeter adjust (M1) panelmeter adjust (M1) panelmeter adjust (M2)	6 volt 30 volt full scale 30 volts full scale 6 volts set to same value as multimeter reading
R18	panelmeter adjust (M2)	set to same value as multimeter reading
R14 R16	adjust until panelmeter reads 1 ampere adjust until panelmeter reads 10 ampere	control with multimeter control with multimeter

If needed, this voltage can be adjust by turning the R2 pot. Turning the potentiometer (R3) on the frontpanel will move the panelmeter but NOT the multimeter. If you move the red probe to the '+' output jack and you should find a variable voltage (via R3) between 0.7 and 6 Volt. Don't worry about the current meter at this time, it probably will not move at all because there is no current. All you do at this time is adjusting the low-voltage scale.
Leave the multimeter probes connected to the '+' and '-' output jacks and switch the Volt-switch (S2a) on the frontpanel to the

30 Volt position. You will see that the voltage makes a big jump upwards. We adjust R3 all the way to the right (clockwise) and adjust trimmer potentiometer R23 until your multimeter shows 30 volts. We now adjust R26 until the panel meter shows the same, 30 volts. Switch back to the 6-volt position and adjust the panel meter to 6-volt full-scale with R24. If you're done with this and you are satisfied then have beer on me for a job well done. You are half way finished!

Switch off the power, unplug the powercord. Remove the temporary fuse between the positive of C3 and the pcb and re-connect the wire to start adjustments on the current settings.
Switch the panel meters to the 6 volt and 1 amp positions and turn current-limiter R12 on the front panel all the way to the left (counter-clock-wise). Set the volt meter on the frontpanel to 4 volt with R3. Select a setting on your multimeter of 100 or 300 milliamps dc. Take the red probe and insert a resistor of 39 ohms between the red probe and the '+' of the output jack. You will notice that current flows through that resistor. The panel meter also shows a bit of current and at the same time the needle of the panel-voltmeter falls back a little to about 2 volts or even lower. If that is the case you know your current limiter is working properly and you can continue with the adjustment procedures.
Remove the 39 ohm resistor. Switch your multimeter to the highest current setting (preferably 10A) and connect it directly to the '+' and '-' output jacks. The meter should show no more current than with the 39-ohm resistor, even less this time. Carefully open up R12 (front panel) clockwise until you see increased current on both multimeter and panel meter. A good multimeter will go to at least 10 amps, but I guess the job can be done with 2 or 3 amps also. On the other hand it would be actually better to borrow a good multimeter from a friend or rental shop if you don't have one yourself.

Okay, on with it. Open R12, slowly, as far as possible and note the current reading. REMEMBER you are still at the 1A/6V setting! If there are no problems the current reading probably shows 1/2 amp or something in that area. Let it sit in that condition for awhile and observe the temperature of the large cool rib. It should warm up a little bit. If all is okay and still no smoke you can safely assume that the circuitry works correctly.

So far so good. The following adjustments have to be done in the correct sequence. Switch the power supply **OFF**. Set the panel switch to the 10-Amp setting and also the multimeter to as high a current setting as possible. Turn R12 all the way to the left, the multimeter still connected to the '+' and '-' output jacks on the front panel. Turn the power supply **ON**. No should notice almost no current at all. The setting of the 'Volt' potentiometer does not matter much at this time so don't worry about it. Carefully adjust R12 to a high as possible value and stop when it shows about 5 amps on the multimeter. Adjust the panel meter with R20 until it shows the same value as the multimeter. When you're done the panel meter should show half way the 10-A scale. Just make sure that your multimeter can handle 10 amps. If not, then don't exceed that value with R12 or you blow up your multimeter.

Turn R12 again all the way to the left and flick the switch on the front panel to the 1-A setting. Adjust R12 all the way to the right and with R18 adjust the value of the multimeter with the value of the panel meter until they're equal.
In the mean time the coolrib is getting quite hot during all the adjustments in the 10-A settings. But that is done now. You have now adjusted six of the eight trimmer pots and so still two to go.
Remove the multimeter. Turn both potentiometers on the frontpanel (R3/R12) all the way to the left (0 position). Return the switches to the 1-A and 6-V settings. Short out the output jacks on the frontpanel with a piece of wire. Turn R12 all the way to the right and adjust R14 until the 'current' panel meter indicates precisely 1-amp (full scale).
That done, turn R12 back all the way to the left and place the current switch in the 10-A setting. Adjust the full scale of the panel meter with R16 until it shows exactly 10 amps. At this setting the cool rib heats up quickly so keep an eye on the temperature. You are done. Finished. I'll bet you are smiling now. After all, you now have an analog piece of equipment equal or better then the commercial unit and for a fraction of the cost.

Inside the enclosure I keep a little plastic box which contains some spare parts just in case I need it in the future. The parts I use are the 723 IC, the zener diodes, darlington, and one 2N3772 power transistor. Why? Well, just because everything is so-called short-circuit-protected it does not mean it can't happen, for example by a power surge or lightning. Murphy is always on the look-out. But on a safe note, this power supply is almost indestructible and you really have to abuse it to blow a fuse.

Now, what can you do with this power supply? Anything you want. Charge regular NiCad or Lead-Acid batteries, run all kinds of motors, styro-foam cutter, etc. It is limited only by your imagination.

Parts List:

Resistors
1/4 Watt, Carbon, 5% (or better), unless otherwise indicated
R1 = 470 ohm, 1/2 watt, yellow-purple-brown
R2 = 2 K, trimmer pot
R3 = 5 K, potentiometer, linear
R4 = 560 ohm
R5 = 47 ohm, yellow-purple-black
R6 = 0.1 ohm, ww, 5%, 1-watt
R7 = 0.1 ohm, ww, 5%, 1-watt
R8 = 0.1 ohm, ww, 5%, 1-watt
R9 = 0.1 ohm, ww, 5%, 1-watt
R10 = 0.33 ohm, ww, 5%, 10-watt
R11 = 0.33 ohm, ww, 5%, 10-watt
R12 = 470 ohm, potentiometer, linear
R13 = 820 ohm, gray-red-brown
R14 = 500 ohm, trimmer pot
R15 = 100 ohm, brown-green-brown
R16 = 150 ohm, trim pot
R17 = See Text
R18 = See Text
R19 = See Text
R20 = See Text
R21 = 5K, metalfilm, 1%
R22 = 820 ohm, gray-red-brown
R23 = 500 ohm, trimmer pot
R24 = See Text (non-variable: 25K trim pot)
R25 = See Text (omit for non-variable voltage)
R26 = See Text
R27 = See Text
R28 = 3.3K, 1/2 watt, 5%, orange-orange-red
R29 = 3.3K, 1/2 watt, 5%, orange-orange-red
R30 = 3.3K, 1/2 watt, 5%, orange-orange-red
R31 = 3.3K, 1/2 watt, 5%, orange-orange-red

C5 = 4.7 µF, 25V, tantalum
C6 = 4.7 µF, 25V, tantalum
C7 = 4.7 nF, ceramic
C8 = 10 µF, 63V, electrolytic
C9 = 1 µF, foil type, see text
C10 = 22 nF, ceramic

Semiconductors

D1 = 1N4004, 1N4005, 1N4007, BY127, etc.
D2 = 1N4148, BAX13, BAX16, etc.
D3 = 1N4389 power diode, 20A+ (see text)
D5,D6,D7,D8 = LEDs, any type (see text)
ZD1 = 1N4754A, Zenerdiode, 1 watt, 39V
ZD2 = 1N4636A, Zener, 250mW, 6.2 or 6.8V
Q1 = TIP140, MJ2501, BD267A, 2N6388, etc.
Q2,Q3,Q4,Q5 = Transistor, 2N3772/NTE181
L1 = Ferrite Bead (see text)
L2 = Ferrite Bead (see text)
IC1 = MC1723, MC723, µA723, LM723
BR1 = Bridge Rectifier (see text)

Miscellaneous

M1 = Panelmeter, see text
M2 = Panelmeter, see text
T1 = Transformer, Hammond 165S30 (30V/10A), or similar
F1 = Fuse, 3.15A, slow-blow
S1 = Toggle switch, ON-OFF, DPDT, sub-mini
S2_{a-b} = Toggle switch, ON-OFF-ON, DPDT
S3_{a-b} = Toggle switch, ON-OFF-ON, DPDT
S4 = For use with one panelmeter: ON-OFF-ON, DPDT
Fuseholder, very large coolrib for the 4 power transistors, Q1, and D3 (isolated), wire, solder, 2 knobs, instrument case, power cord, etc. The meter scales are re-scaled with rail-on lettering.

Possible Component Substitutes:

D1 = 1N4004, 1N4005, 1N4007, BY127, NTE116, NTE125
D2 = 1N4148, BAX13, BAX16, NTE519
D3 = Possible types: MUR2510, MUR3010CT, NTE6246, NTE6247, etc.
ZD1 = 1N4754A, NTE5086A, ECG5086A
ZD2 = 1N4636A, NTE5071A
Q1 = BD267A, TIP140, MJ2501, NTE623, NTE270
Q2 = NTE181
IC1 = µA723, LM723, NE723, NTE923D

Last Minute changes and other info:

- At the right you see the AC stuff I used. Came of another defective unit. It contains the on/off switch, fuse, and receptacle. Works just beautiful. Click on the picture for an enlarged view. The cool rib is a little smaller in width then the enclosure so was just a nice opportunity to get a more professional look. Click on the picture for an enlarged view.



- If you decide to use the older 'metal-can' version of the 723, the pin out is shown at the left.
- For the Led's I personally choose green for the low scales (0-6V/0-1A) and red for the high scales (1-30V/1-10A). But hey, use whatever preference you have. High-brightness types is what I'm using, but again, use whatever you like.
- The bridge rectifier is one with a metal part attached for mounting on a coolrib. You can use 4 separate stud-mount diodes of 75V/12-15A minimum. They **MUST** be mounted isolated on a coolrib.



- Powerdiode D3: I used an older 'stud-mount' type of 35Amps because I had it available and it has to go onto the coolrib assembly. But use whatever you have laying around, just keep in mind it needs to be cooled and needs to be a minimum of 20A.
- Don't forget to mount R10/R11 a little bit away from the PCB. I used 1/4" (5mm) ceramic stand-offs.
- Capacitor C3: Big sucker, but needed. Mine is a computer-grade 22000µF at 50V. Came from a powersupply out of an old 'floor-model' tape-drive. You can buy them new but you pay the price, around \$35.00 CAN in my area. Keep in mind, if you are thinking of combining two or more capacitors that their working voltage must be the same and that you may need a larger enclosure.

- Panel meters: I decided to stick with the analog panel meters. I like to see exactly what I'm doing and in this project they are just as accurate. The 'Volts' panelmeter will most likely be a 100-millivolt type with 30 or 60 scale stripes. The 'Amps' meter will probably be a 1-mA type with 50 or 100 stripes on the scale. The internal resistance (RI) of the meters is not at all important since anything with a build-in resistor or resistance wire will be removed anyways.
- Cooling Fans: After some experimenting I decided to increase the 2 cpu fans with one more making the total 3. I also decided to exchange the cpu fans, depicted in the photograph, for a different type which is a bit larger and has more fins. The whole cooling circuit with the fans now work like a charm. I will likely modify the circuit and use a more common op-amp such as the 741, and create a printed circuit board and parts layout for ease of use. Most types of thermistors will work so don't worry too much. You just have to play with the series resistance a bit. No big deal.

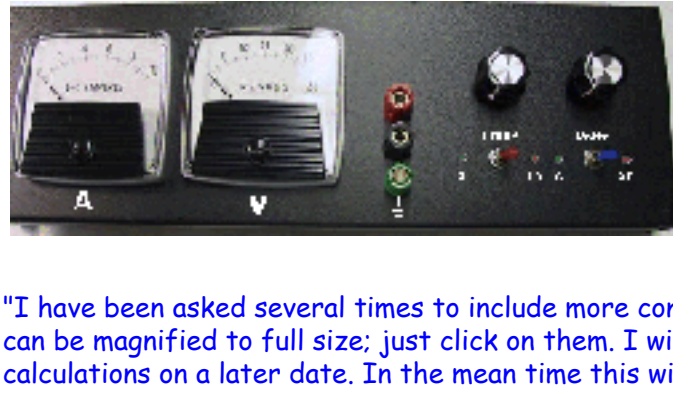
- Optional Led (yellow 3mm) and 1K8 resistor for the automatic fan control. Added this later after the front panel was already finished. Although you may be able to hear the fans when they kick in, I prefer a visual indicator as well. Secondly, I like bells and whistles...grin).

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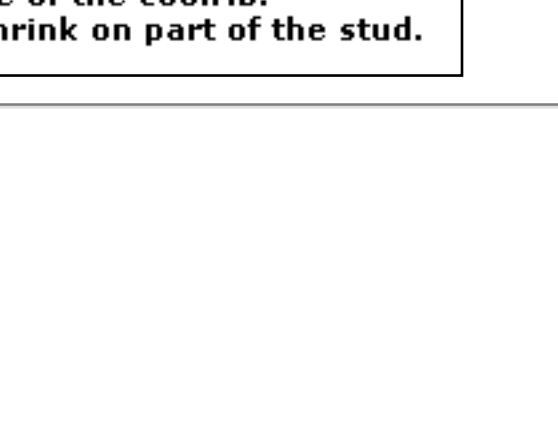
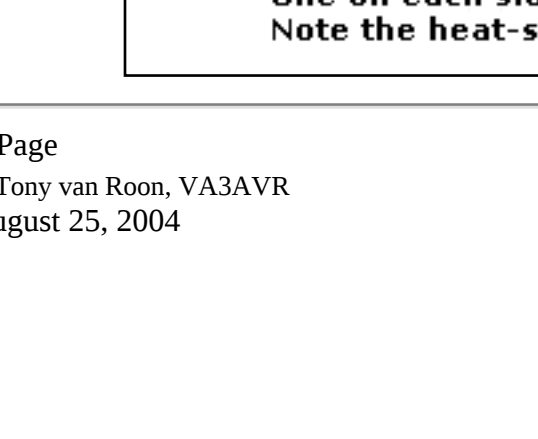
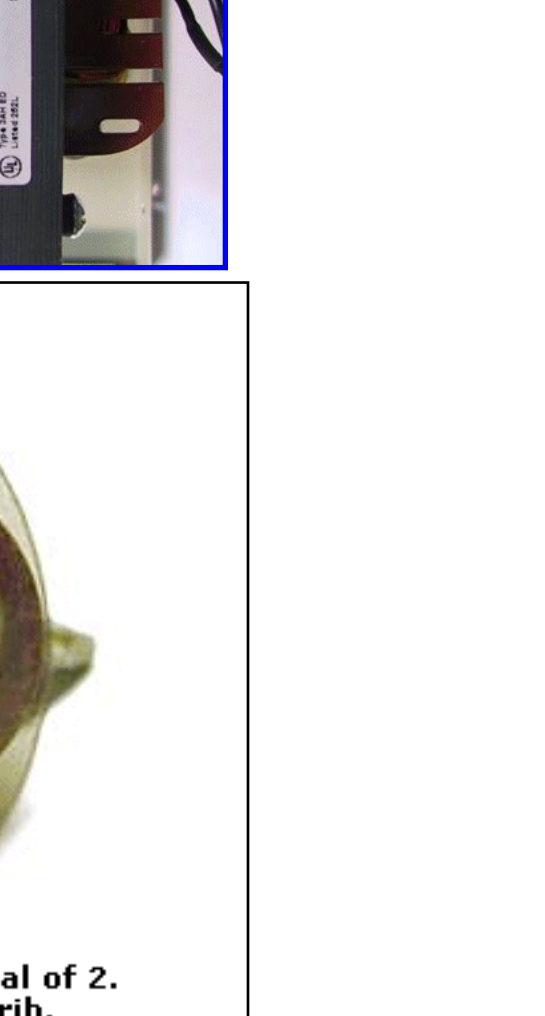
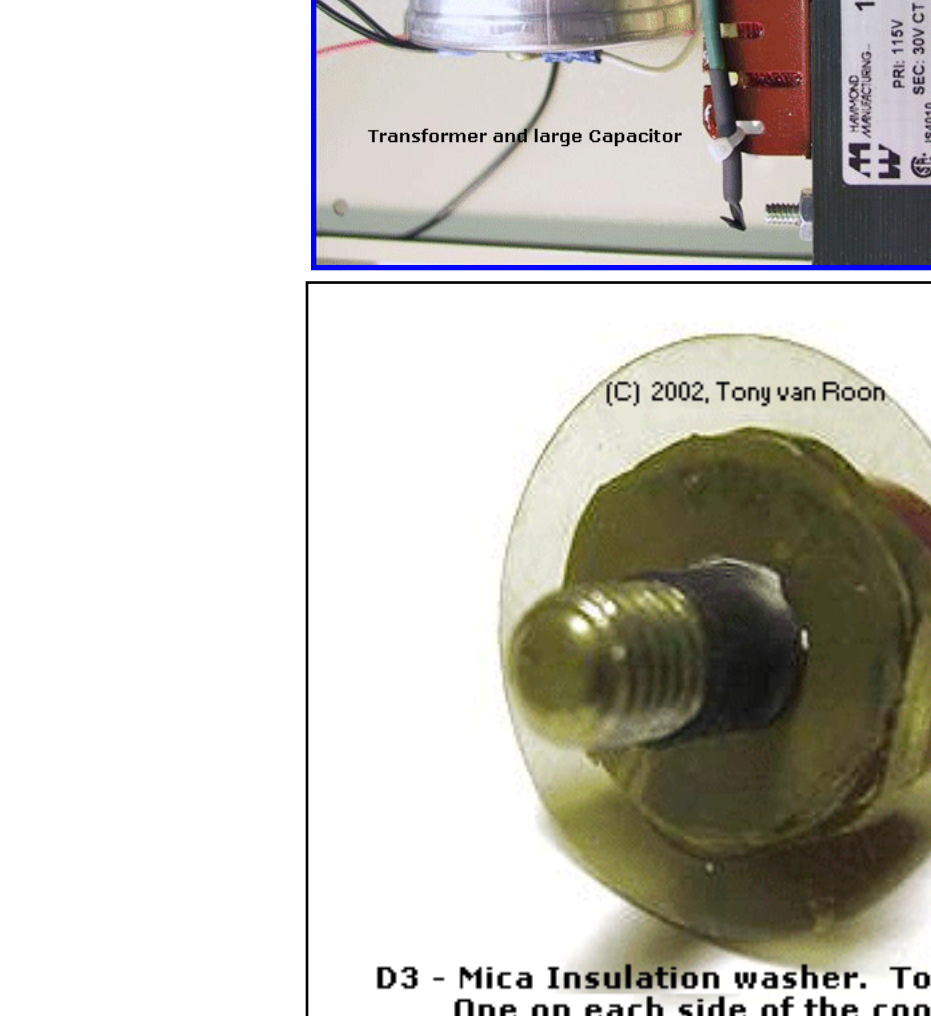
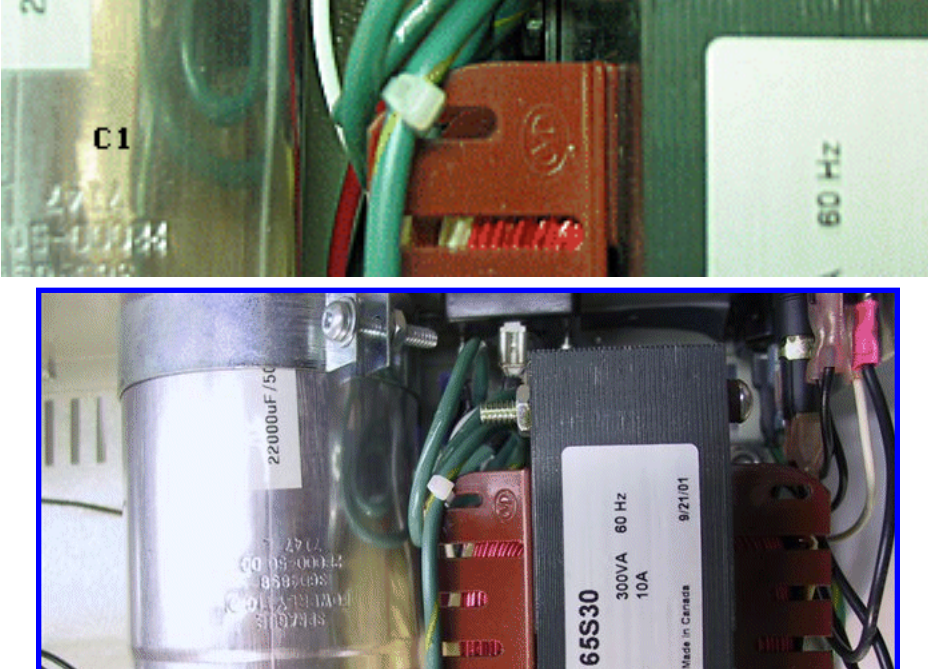
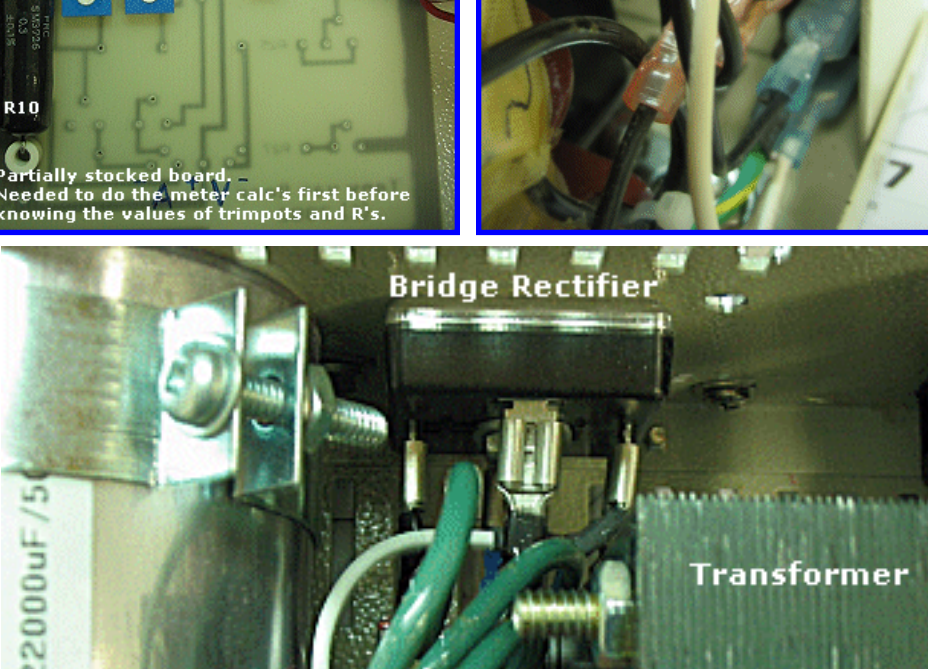
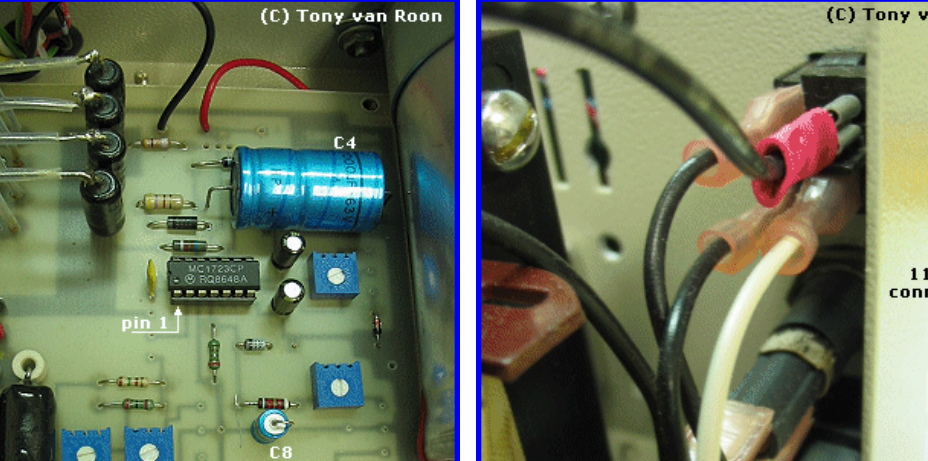
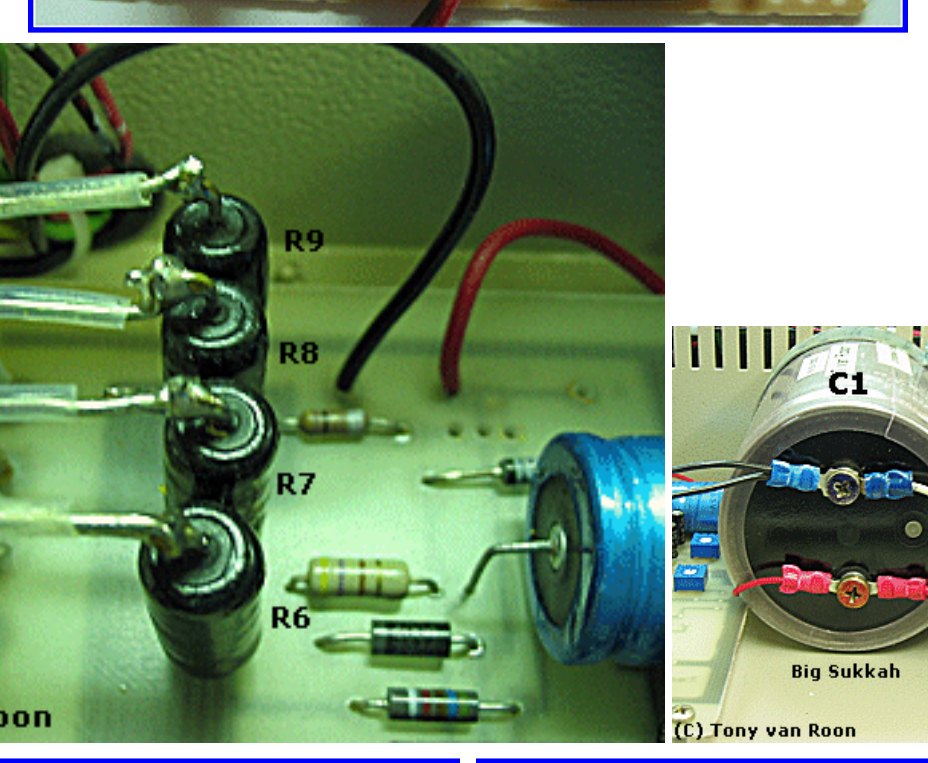
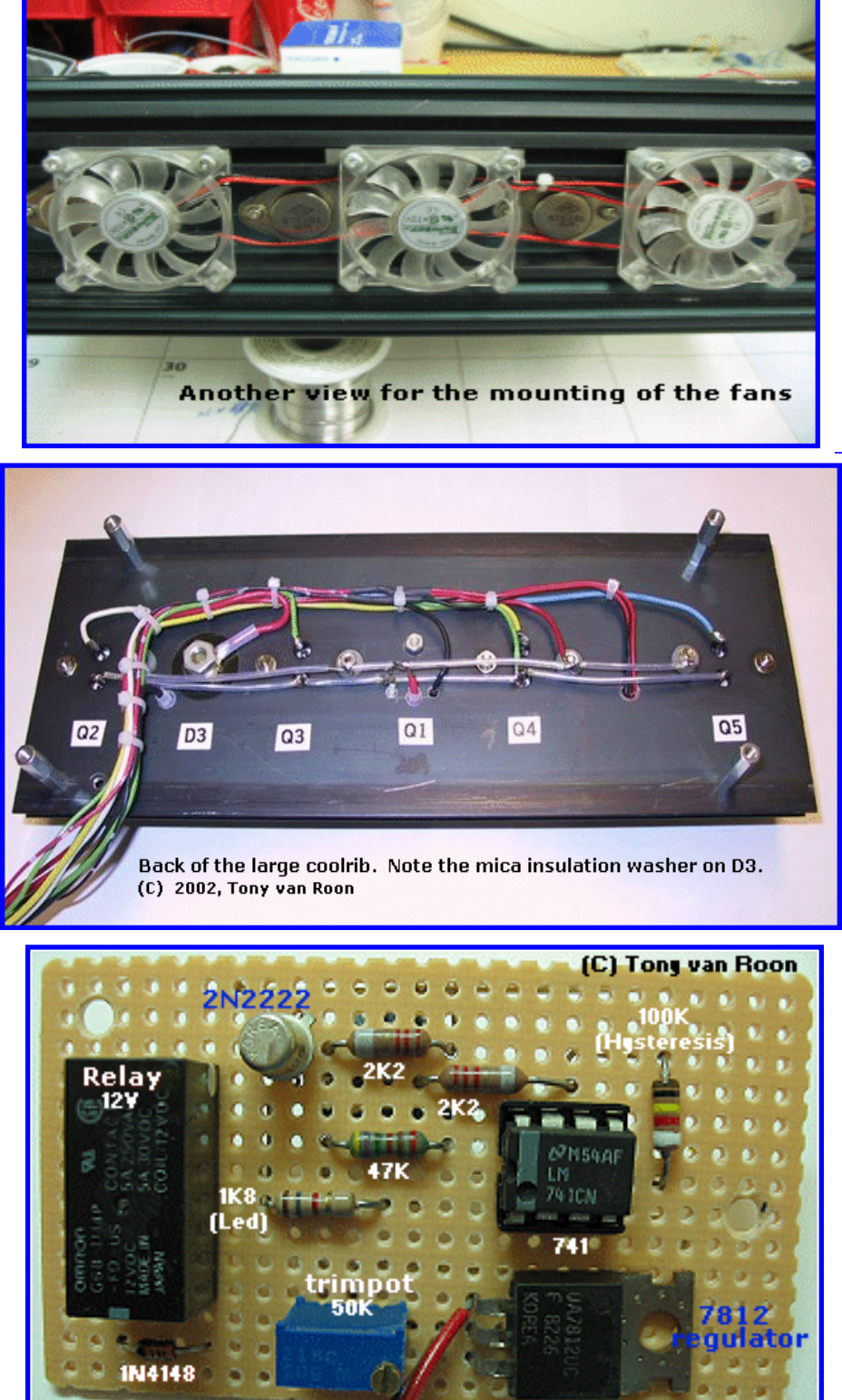
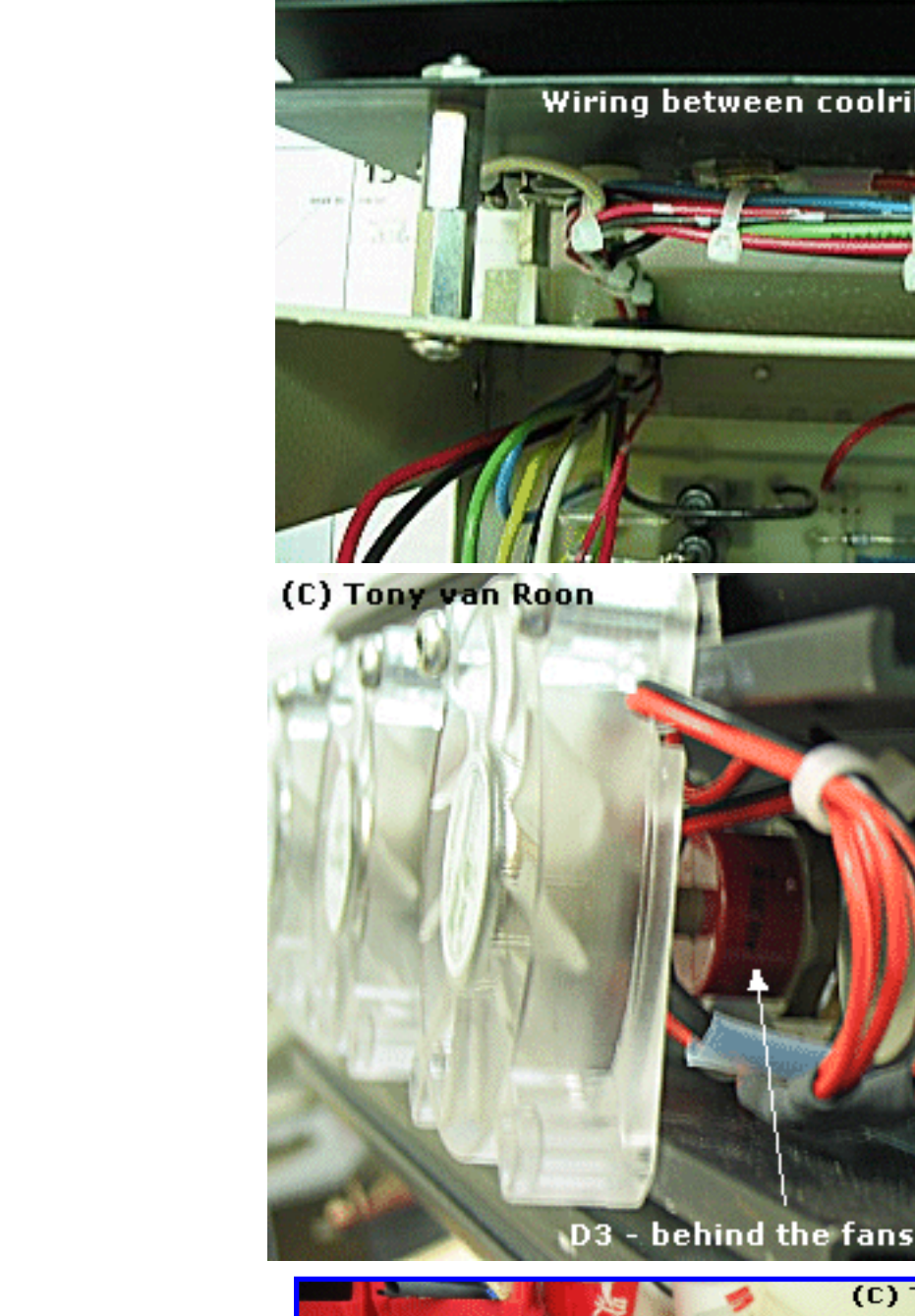
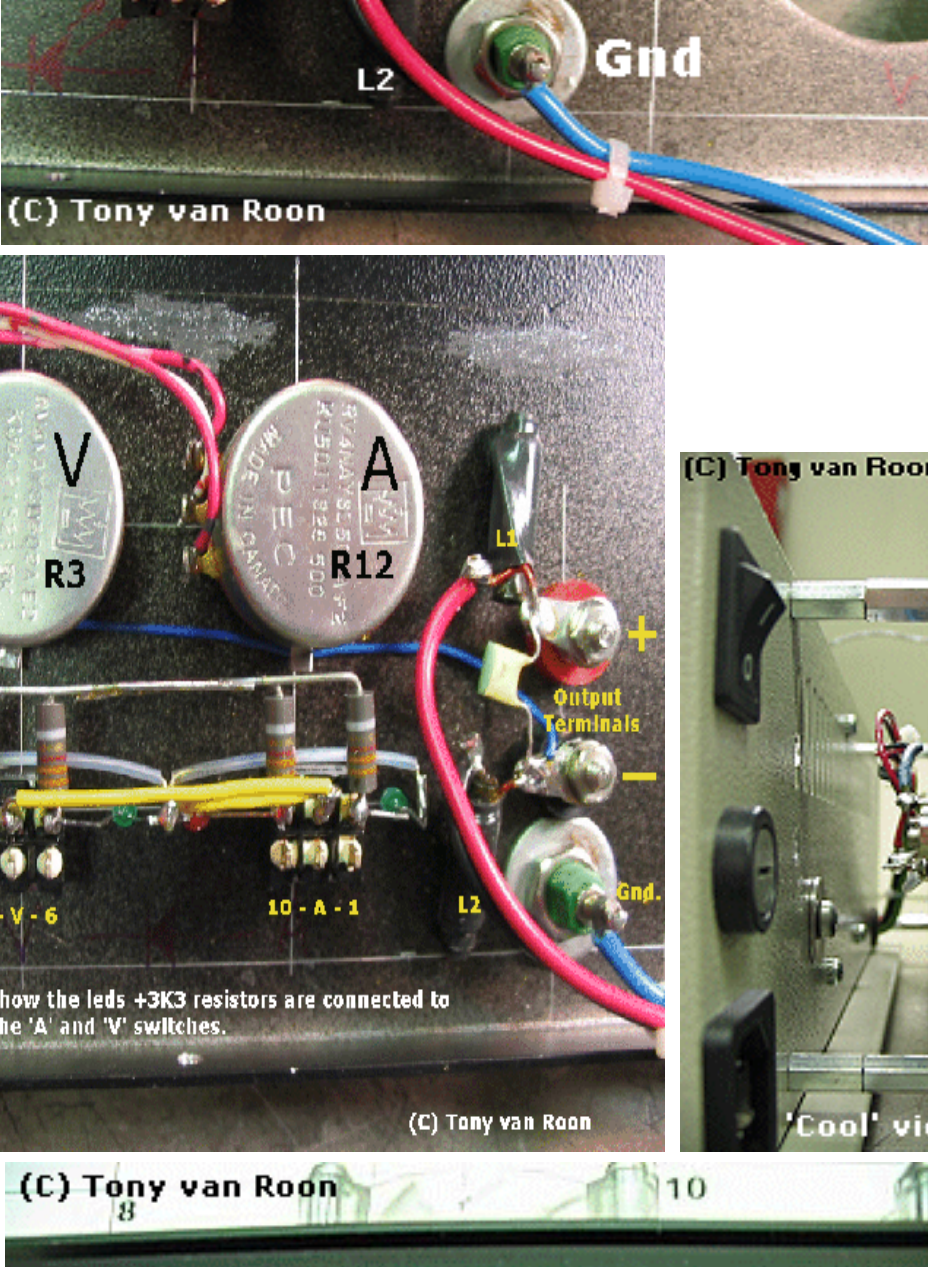
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Bench Top Power Supply -- Additional Construction Photos.

"I have been asked several times to include more construction pictures and photos. Well here they are. A couple of them can be magnified to full size; just click on them. I will add photos of the shunts for the panel meters and associated calculations on a later date. In the mean time this will get you going for a while."

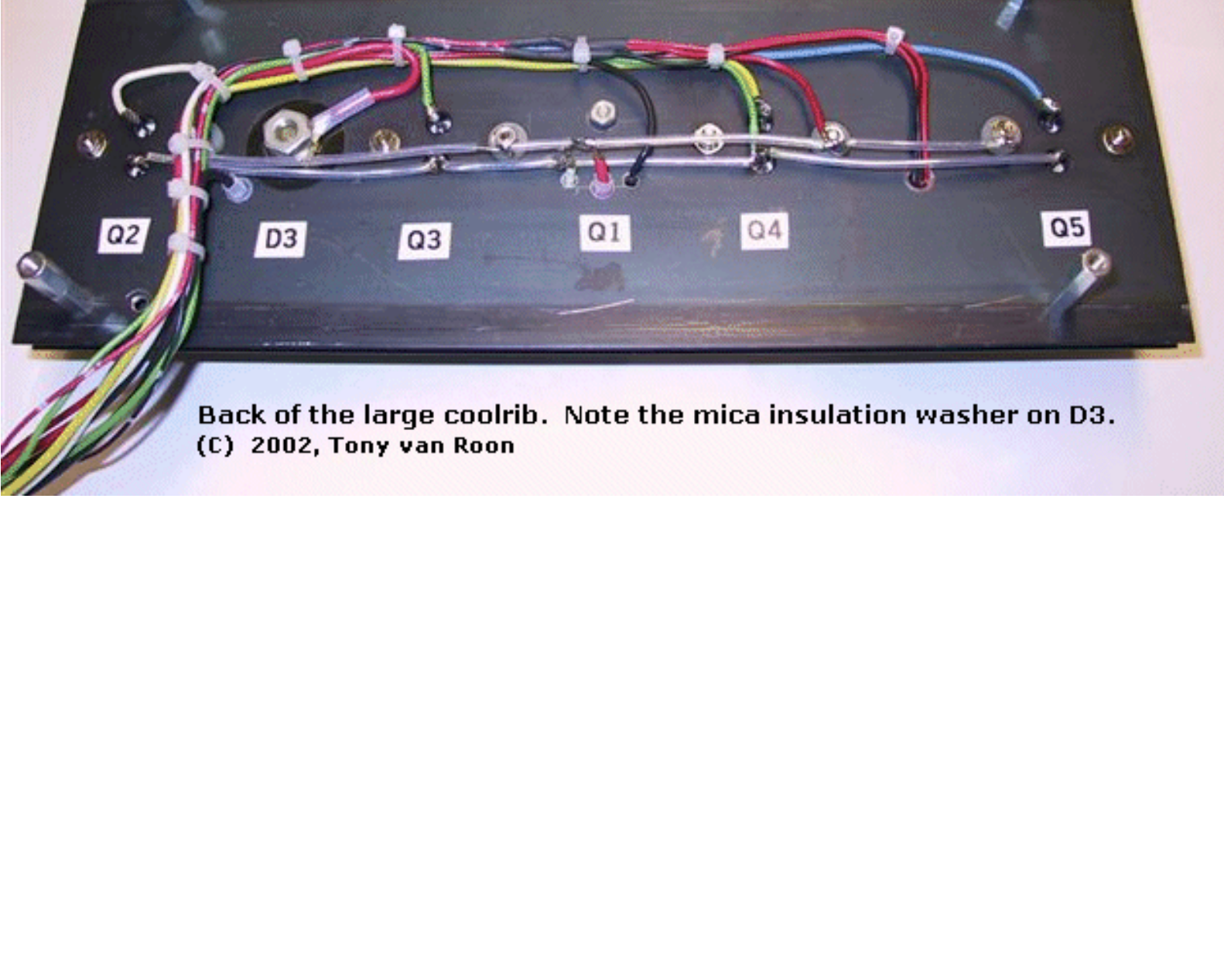
by Tony van Roon



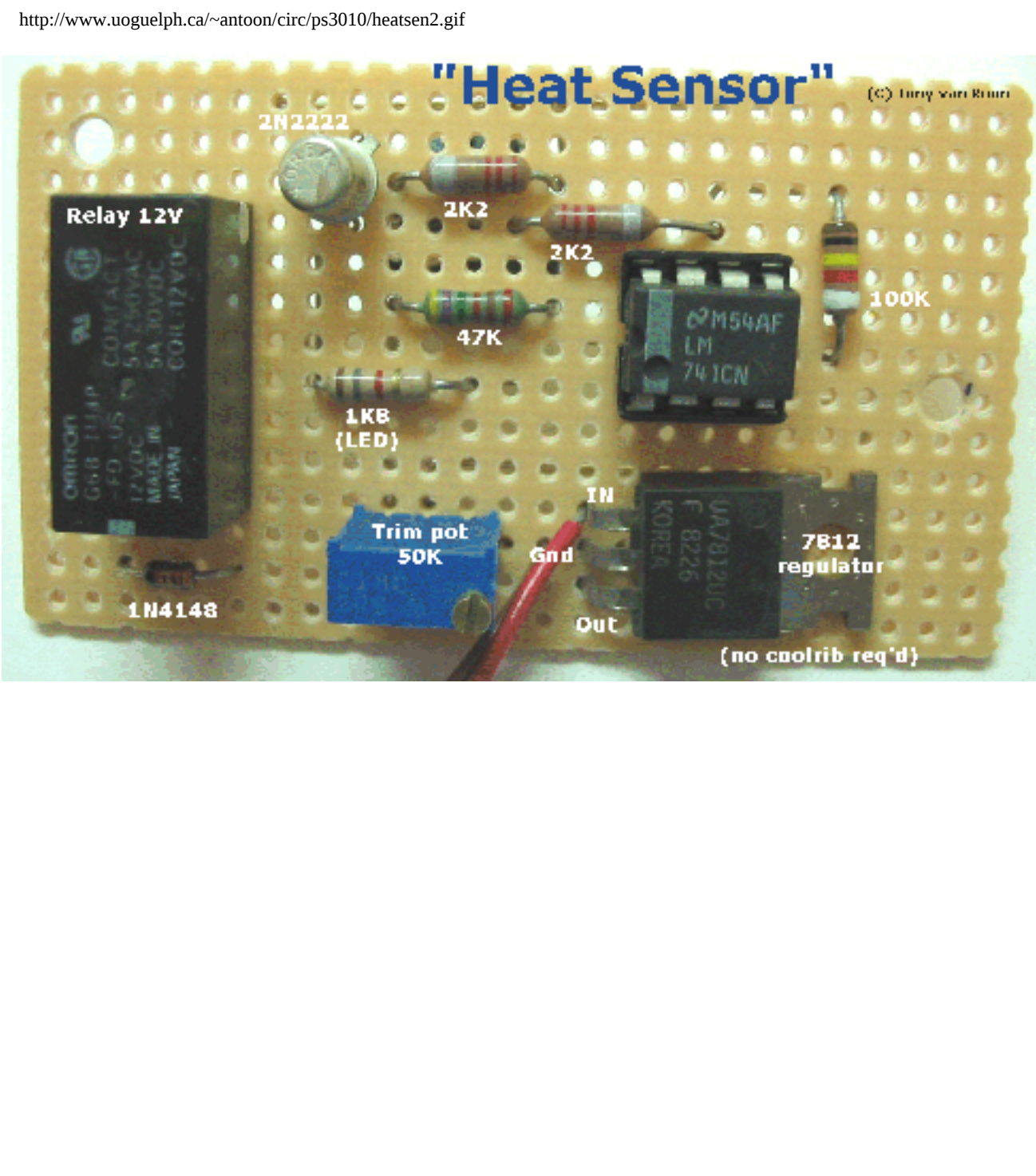


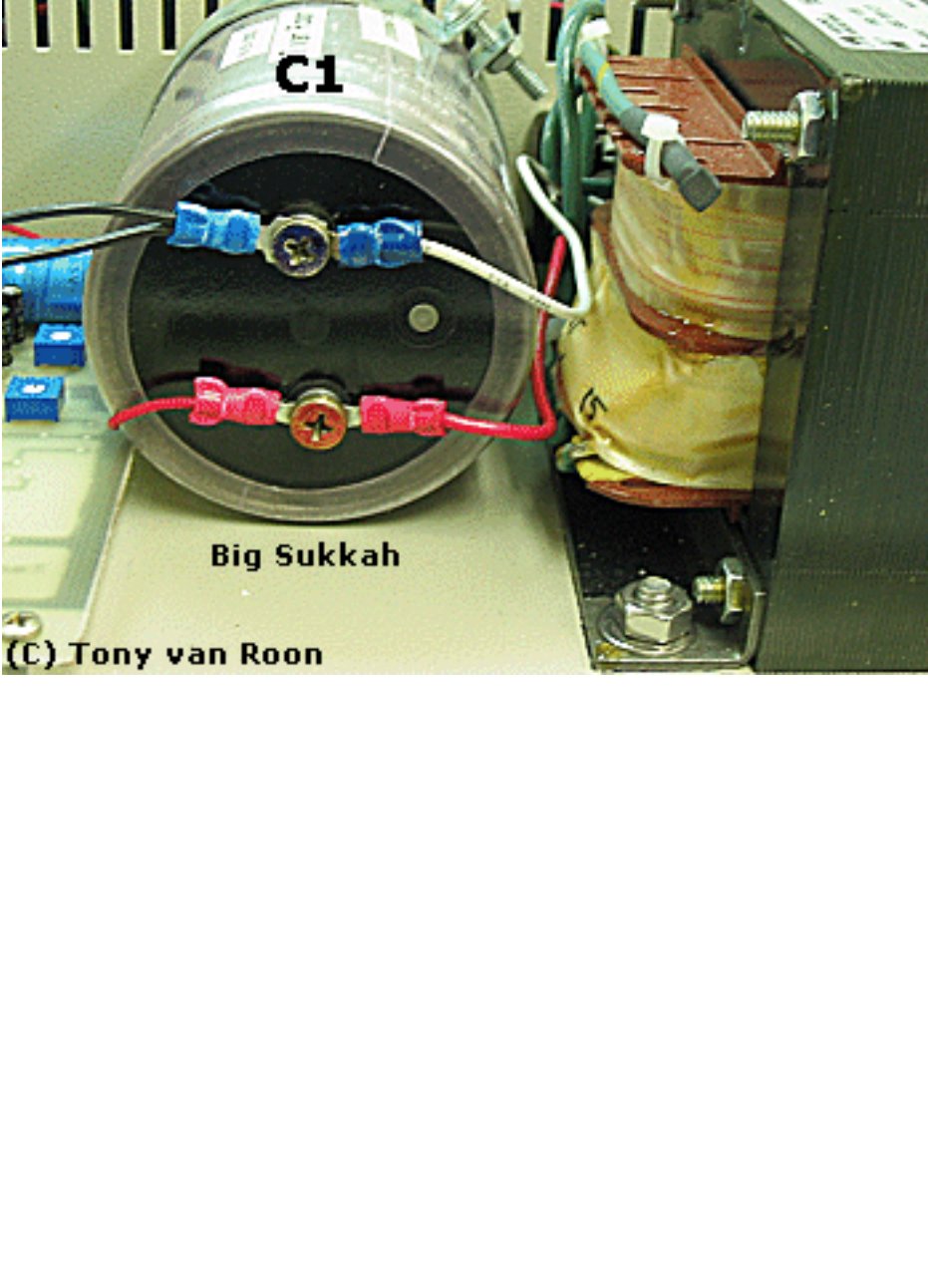
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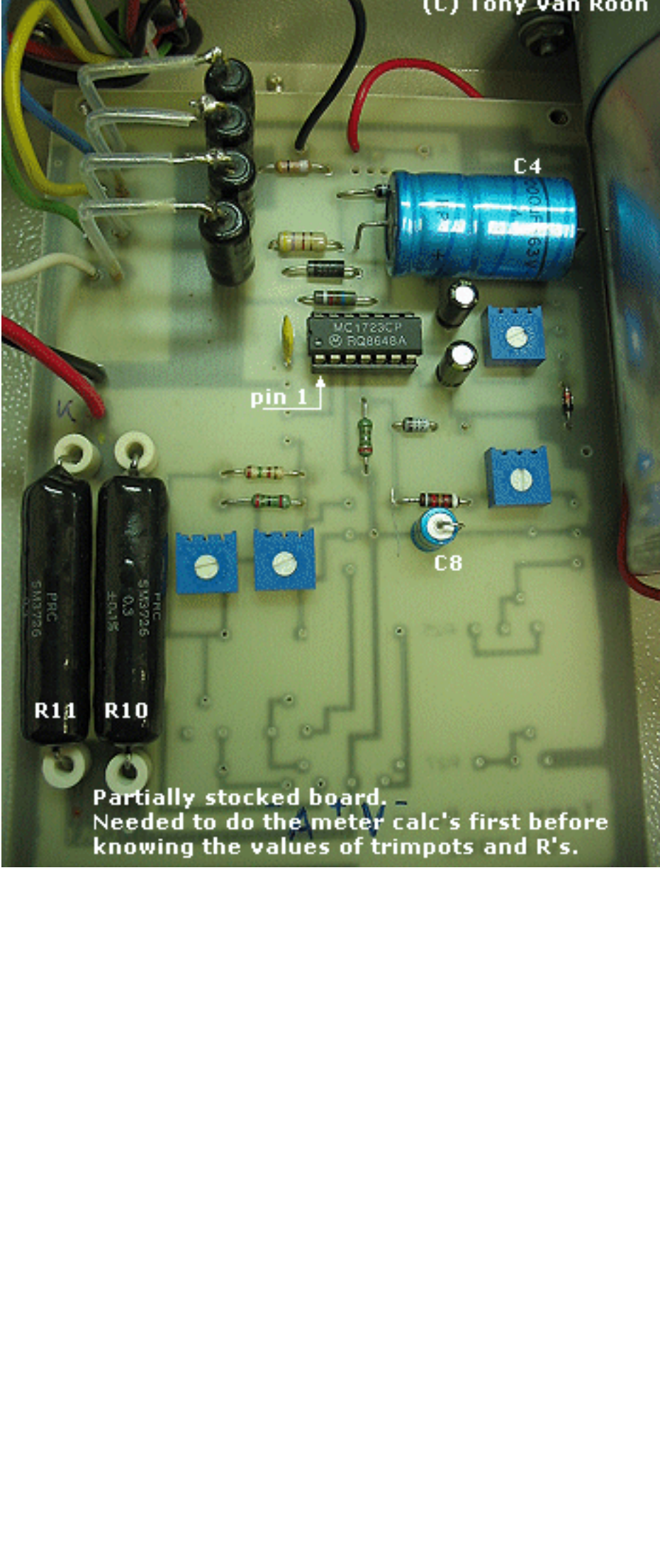


Back of the large coolib. Note the mica insulation washer on D3.
(C) 2002, Tony van Rooy

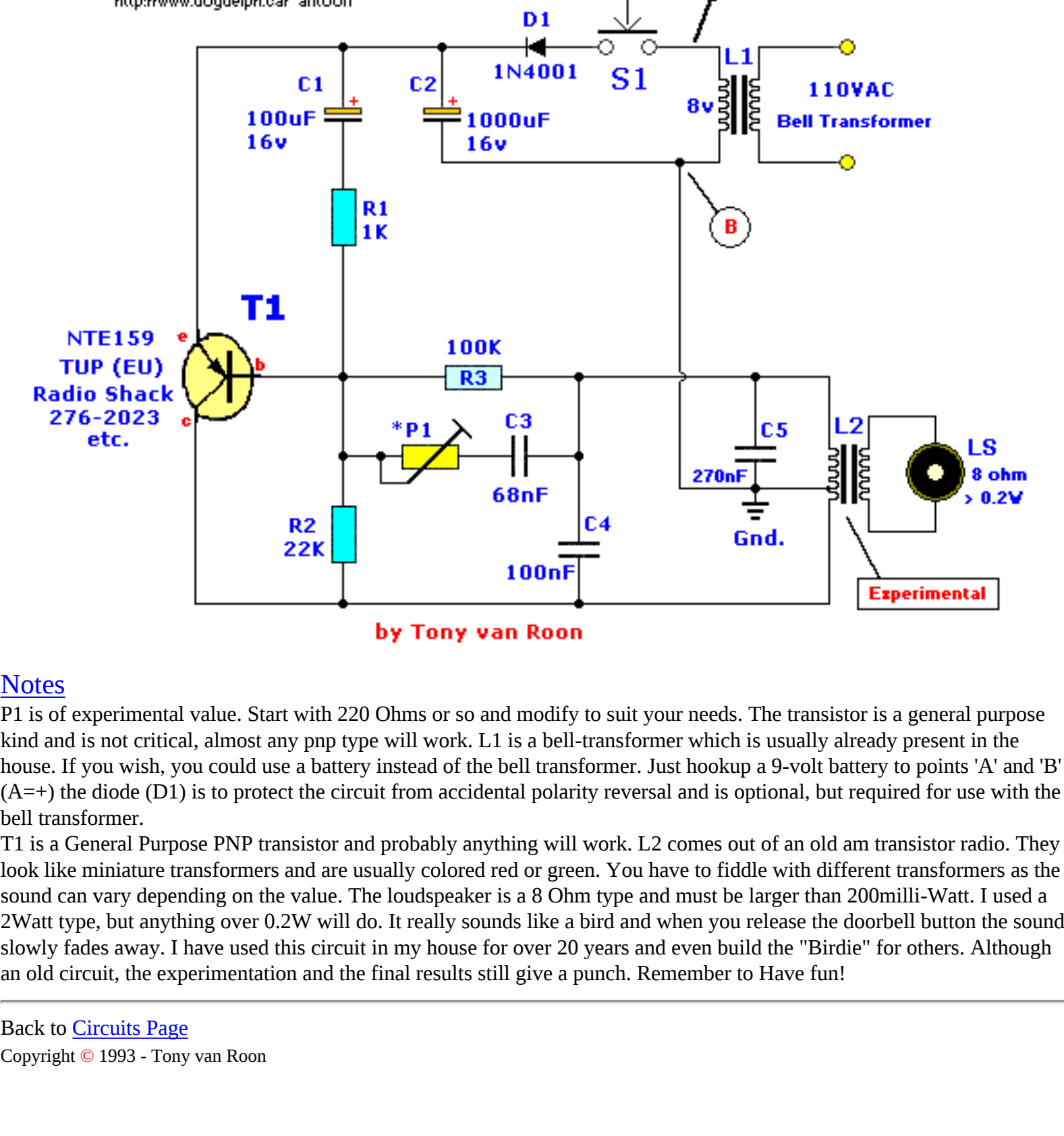




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[Notes](#)

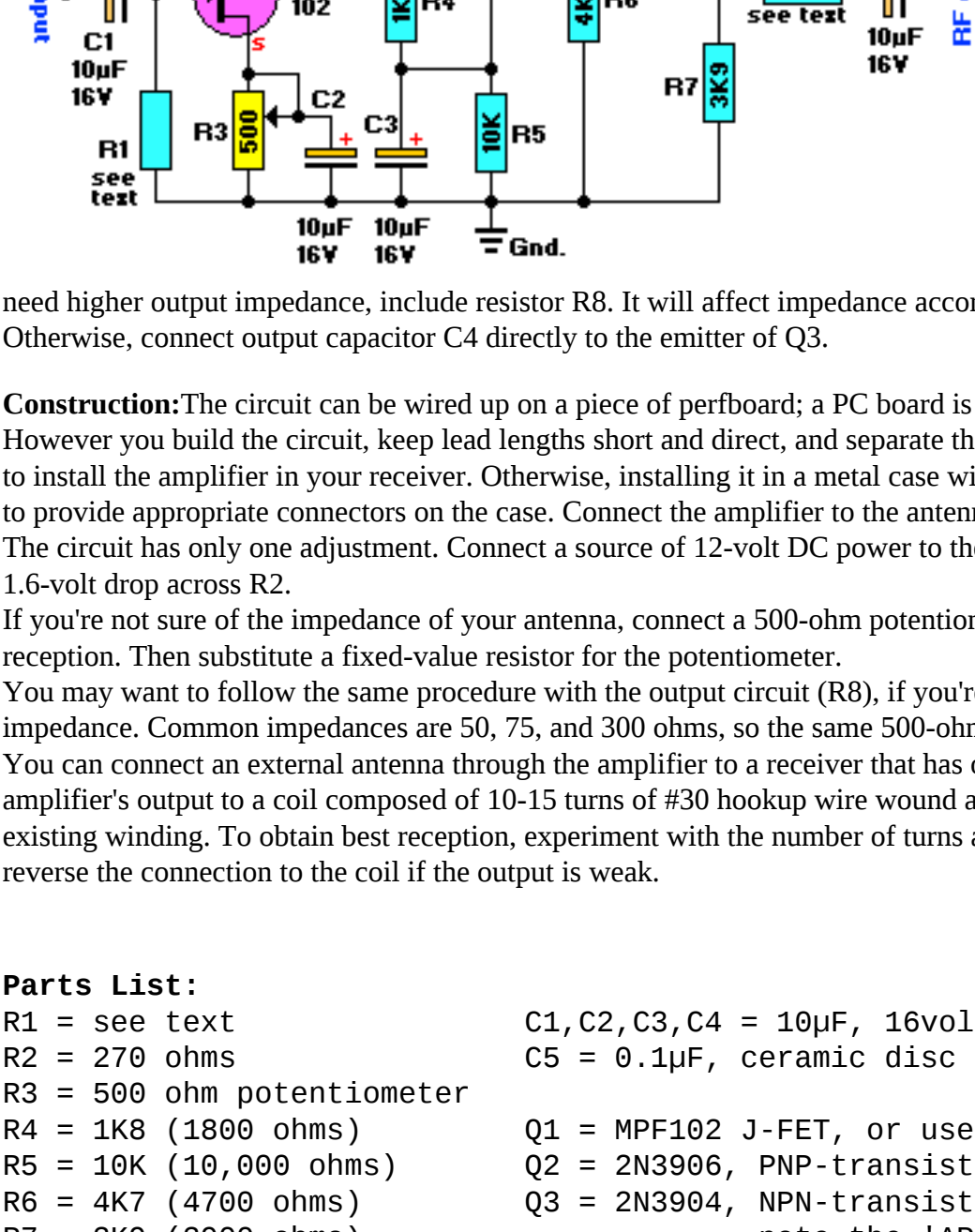
P1 is of experimental value. Start with 220 Ohms or so and modify to suit your needs. The transistor is a general purpose kind and is not critical, almost any pnp type will work. L1 is a bell-transformer which is usually already present in the house. If you wish, you could use a battery instead of the bell transformer. Just hookup a 9-volt battery to points 'A' and 'B' (A=+) the diode (D1) is to protect the circuit from accidental polarity reversal and is optional, but required for use with the bell transformer.

T1 is a General Purpose PNP transistor and probably anything will work. L2 comes out of an old am transistor radio. They look like miniature transformers and are usually colored red or green. You have to fiddle with different transformers as the sound can vary depending on the value. The loudspeaker is a 8 Ohm type and must be larger than 200milli-Watt. I used a 2Watt type, but anything over 0.2W will do. It really sounds like a bird and when you release the doorbell button the sound slowly fades away. I have used this circuit in my house for over 20 years and even build the "Birdie" for others. Although an old circuit, the experimentation and the final results still give a punch. Remember to Have fun!

Broadcast-Band RF Amplifier

By Tony van Roon

"Unless you own a top of the line receiver or car radio, your AM reception may be as good as it should be. The reason is that few low-to mid-price receivers and radios include RF amplifiers. By adding on yourself, however, you can improve reception at minimal cost. The RF amp shown here uses readily available parts, has wide bandwidth, and is very stable. In addition, by varying the values of several resistors, you can match the amplifier's input impedance to your antenna, and its output impedance to your radio."



How it Works: The complete schematic is shown in **Fig. 1**. The circuit has frequency response ranging from 100Hz to 3MHz; gain is about 30dB. Field Effect Transistor Q1 is configured in the common-source self-biased mode; optional resistor R1 allows you to set the input impedance to any desired value. Commonly, it will be 50 ohms. This signal is he direct-coupled to Q2, a common-base circuit that isolates the input and output stages and provides the amplifier's exceptional stability. Last, Q3 functions as an emitter-follower, to provide low output impedance (about 50 ohms). If you need higher output impedance, include resistor R8. It will affect impedance according to this formula: **R8 ~ Rout - 50**. Otherwise, connect output capacitor C4 directly to the emitter of Q3.

Construction:The circuit can be wired up on a piece of perfboard; a PC board is not necessary, although one can be used. However you build the circuit, keep lead lengths short and direct, and separate the input and output stages. You may have to install the amplifier in your receiver. Otherwise, installing it in a metal case will reduce stray-signal pickup. You'll have to provide appropriate connectors on the case. Connect the amplifier to the antenna and radio using short lengths of coax. The circuit has only one adjustment. Connect a source of 12-volt DC power to the circuit, and adjust R3 so that there is a 1.6-volt drop across R2. If you're not sure of the impedance of your antenna, connect a 500-ohm potentiometer for R1, and adjust it for best reception. Then substitute a fixed-value resistor for the potentiometer. You may want to follow the same procedure with the output circuit (R8), if you're not sure of your receiver's input impedance. Common impedances are 50, 75, and 300 ohms, so the same 500-ohm potentiometer can be used. You can connect an external antenna through the amplifier to a receiver that has only a ferrite rod antenna. The amplifier's output to a coil composed of 10-15 turns of #30 hookup wire wound around the existing ferrite core, near the existing winding. To obtain best reception, experiment with the number of turns and their placement. You may need to reverse the connection to the coil if the output is weak.

Parts List:

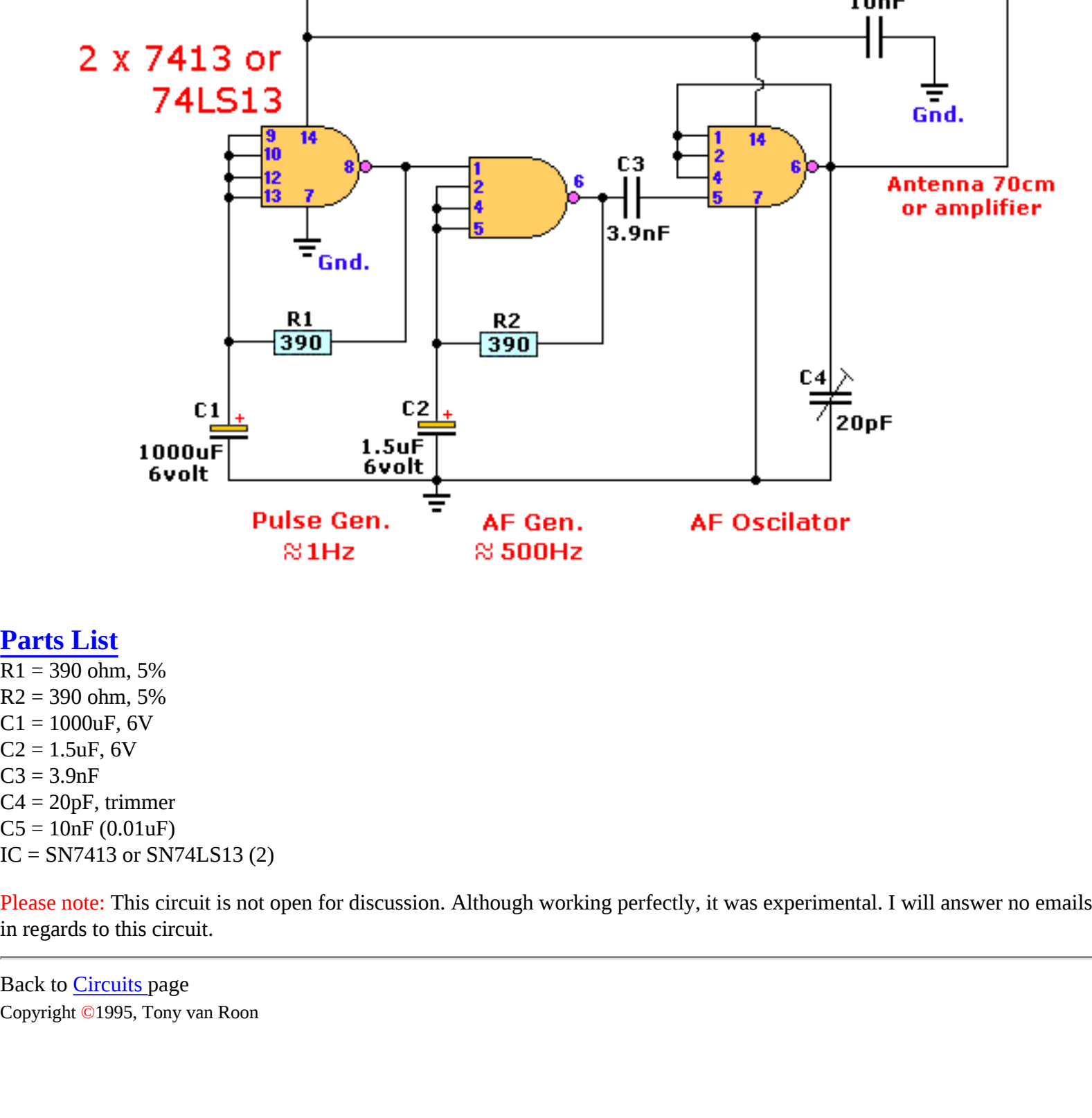
- | | |
|----------------------------|---|
| R1 = see text | C1, C2, C3, C4 = 10µF, 16volt |
| R2 = 270 ohms | C5 = 0.1µF, ceramic disc |
| R3 = 500 ohm potentiometer | |
| R4 = 1K8 (1800 ohms) | Q1 = MPF102 J-FET, or use NTE451 |
| R5 = 10K (10,000 ohms) | Q2 = 2N3906, NPN-transistor (or use NTE159) |
| R6 = 4K7 (4700 ohms) | Q3 = 2N3904, NPN-transistor (or use NTE123AP) |
| R7 = 3K9 (3900 ohms) | note the 'AP' extension. |
| R8 = see text | |

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Bug Detector with Beep

by Tony van Roon



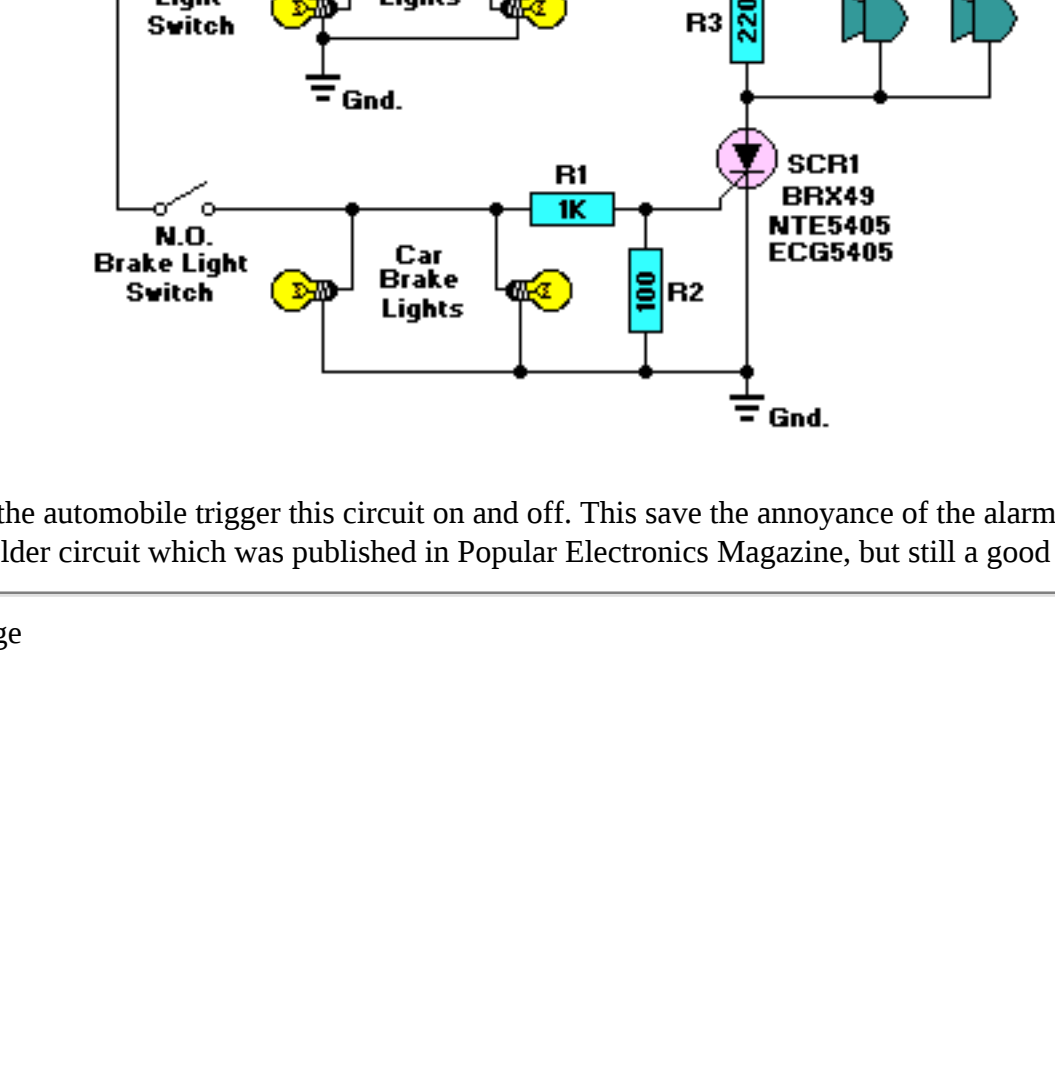
Parts List

- R1 = 390 ohm, 5%
- R2 = 390 ohm, 5%
- C1 = 1000uF, 6V
- C2 = 1.5uF, 6V
- C3 = 3.9nF
- C4 = 20pF, trimmer
- C5 = 10nF (0.01uF)
- IC = SN7413 or SN74LS13 (2)

Please note: This circuit is not open for discussion. Although working perfectly, it was experimental. I will answer no emails in regards to this circuit.

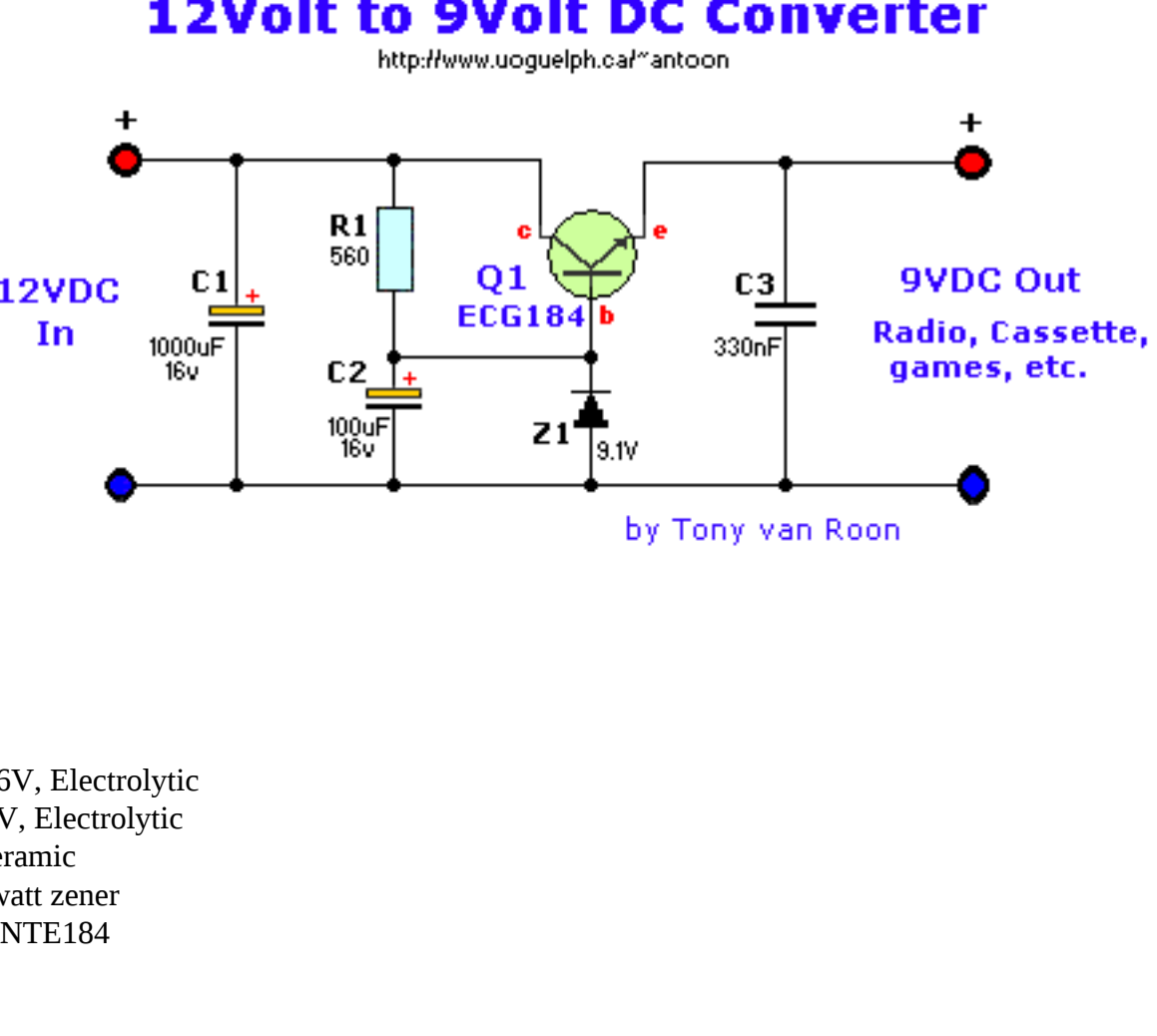
Car Backup Alarm

by **Tony van Rooy**
<http://www.uoguelph.ca/~antoon>



The brake lights of the automobile trigger this circuit on and off. This save the annoyance of the alarm when it is not needed. This is an older circuit which was published in Popular Electronics Magazine, but still a good circuit today.

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Parts List:

R1 = 560 ohm
C1 = 1000 μ F/16V, Electrolytic
C2 = 100 μ F/16V, Electrolytic
C3 = 330nF, Ceramic
Z1 = 9.1V, 0.4watt zener
Q1 = ECG184, NTE184

Notes:

To get a more precise output voltage, replace zener diode Z1 with 10V and R1 with a 1Kilo ohm potentiometer. A Coolrib for Q1 is optional. Simple circuit to power your 9 volt cassette recorder and other stuff.

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Christmas Lights Tester

© by Jan Hamer

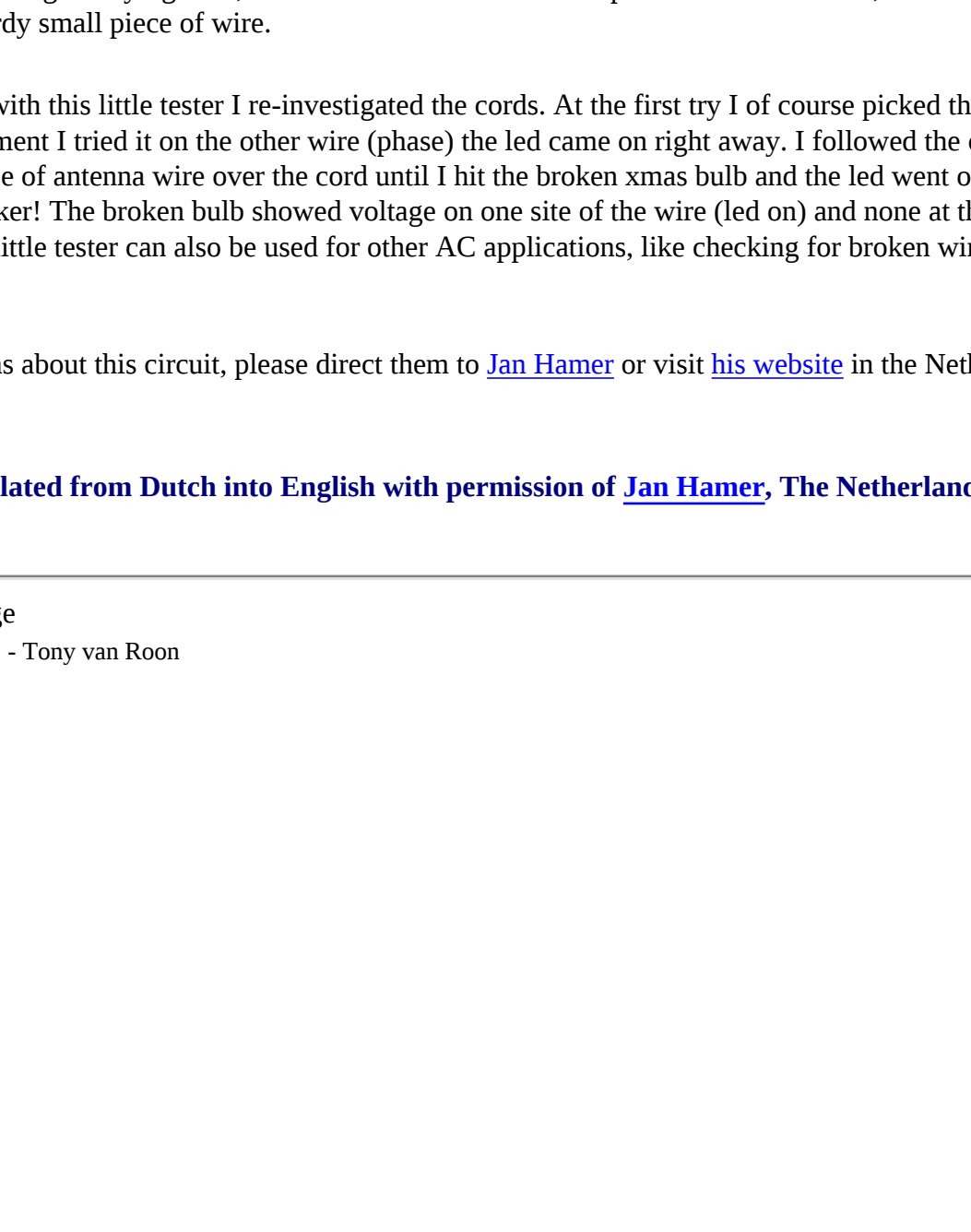
Like every year around the same time, I hurried to get my Christmas tree all set up and the first thing we do when the tree is 'standing' we like to hang the lights in the tree. Okay, better first test them before putting all 50 of them in the tree. Yep! Working beautifully. I started a carefully planned organization of the lights so they would be evenly divided over the branches. Now the second string of lights, tested, yep working. In the tree with them. Putting the plugs into the receptacle and... oh no-- one series of them are on in full glory, all the others are out. Annoyed I tried to 'fix them' by trying to push each bulb further into their sockets. Still no go.

It was a crime trying to pull all the bulbs out of their sockets to measure them for continuity. Funny enough, and against the law of nature, it was not even the last bulb in the string of 50 which was defective, but number 41. I put a new bulb in it, and yes here we go, they all light up beautifully. Alright! Happy again I again hung them in the tree. Finally the big moment arrived, as soon as I plugged them in they would shine in all their glory. Right? Oh no! The second I plugged in my lights only the first series of bulbs lighted up, same as before. All my work for nothing. Sigh...

In the mean time it was already way past midnight and so I decided for my next attempt to wait till next morning. Irritated and very annoyed I went to bed. However, I was so irritated that I couldn't sleep immediately and so was thinking of a smart way to get to the defective bulb the easy way. All over sudden I got it; if the bulb was not lit, there was no current draw either and up to the defective bulb I would measure the 115V AC (phase). Now I knew the solution, I almost fell asleep satisfied right away.

The next day I had to get some groceries in I noticed new xmas lights for a small price. \$5.95 for a string of 100 lights, and with a CSA and UL sticker. Wow, I thought for that kind of money I might as well forget the repair and buy a new set. So I did. Coming home I plugged the new lights into the receptacle and yes, all 100 were doing fine.

Happy again with the new lights I again hung them in to the Christmas tree, not suspecting that this could be another rotten day. After fiddling with the lights to get them all neatly organized in the tree the moment had arrived to plug them in and awe at the fascinating beauty of those little lights. Yes? NO! Not again. Isn't this to explode out of your skin! Angry I was looking for a solution, but there was none. I finally decided to put a circuit together on a piece of experimenters board from Radio Shack.



The heart of this little "CIRCUIT" is established by a hex inverter IC, the MC14069. By positive feedback to the input, the first inverter acts as an analogue amplifier, which amplification can be adjusted a bit via the 50K trim potentiometer.

To get the correct polarity on the basis of the transistor a second and third stage inverter have been added the same way. The others I put to the positive input voltage of the 9-volt battery.

When you touch a voltage carrying wire, with the antenna connected to pin 1 of the MC14069, the led will light up. The antenna is just a sturdy small piece of wire.

Armed to the teeth with this little tester I re-investigated the cords. At the first try I of course picked the wrong wire; the neutral (0). The moment I tried it on the other wire (phase) the led came on right away. I followed the cord from bulb to bulb sliding the piece of antenna wire over the cord until I hit the broken xmas bulb and the led went out. Aha! Finally got the bloody little sucker! The broken bulb showed voltage on one site of the wire (led on) and none at the other end of the bulb (led off). This little tester can also be used for other AC applications, like checking for broken wires behind the wall and stuff.

If you have questions about this circuit, please direct them to [Jan Hamer](#) or visit [his website](#) in the Netherlands (if you can read Dutch).

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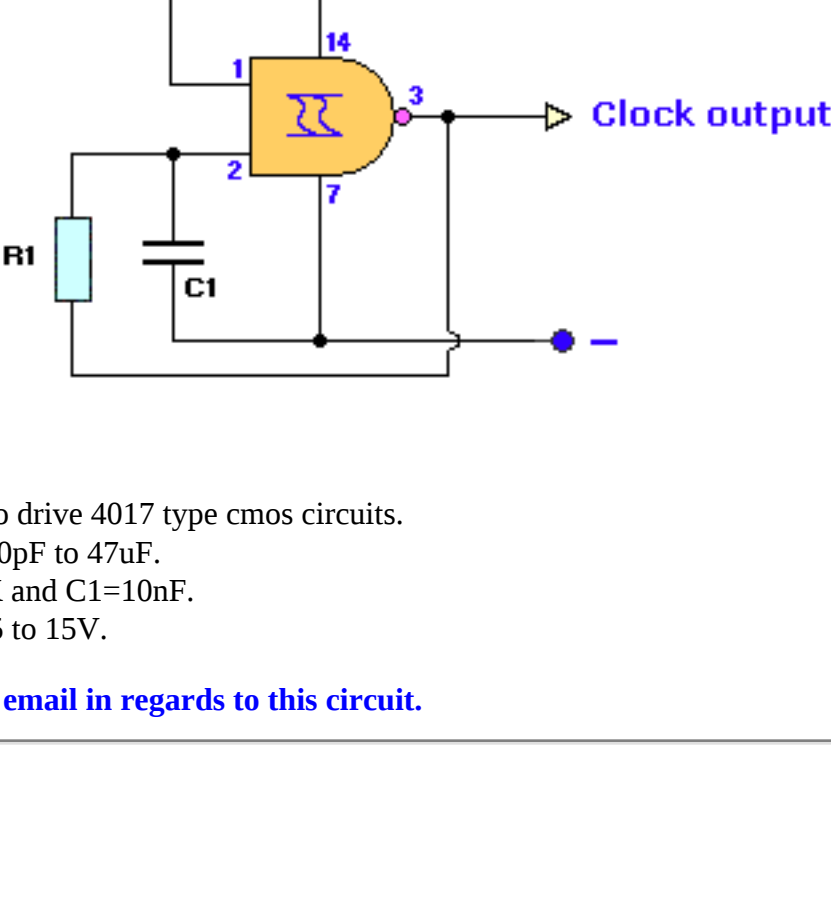
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Clock Generator

by Tony van Roon

<http://www.uoguelph.ca/~antoon>



- o - Excellent clock generator to drive 4017 type cmos circuits.
- o - R1 = 10K to 10M, C1 = 100pF to 47uF.
- o - Fo is $\pm 1\text{Kz}$ when R1=100K and C1=10nF.
- o - Input voltage can be from 5 to 15V.

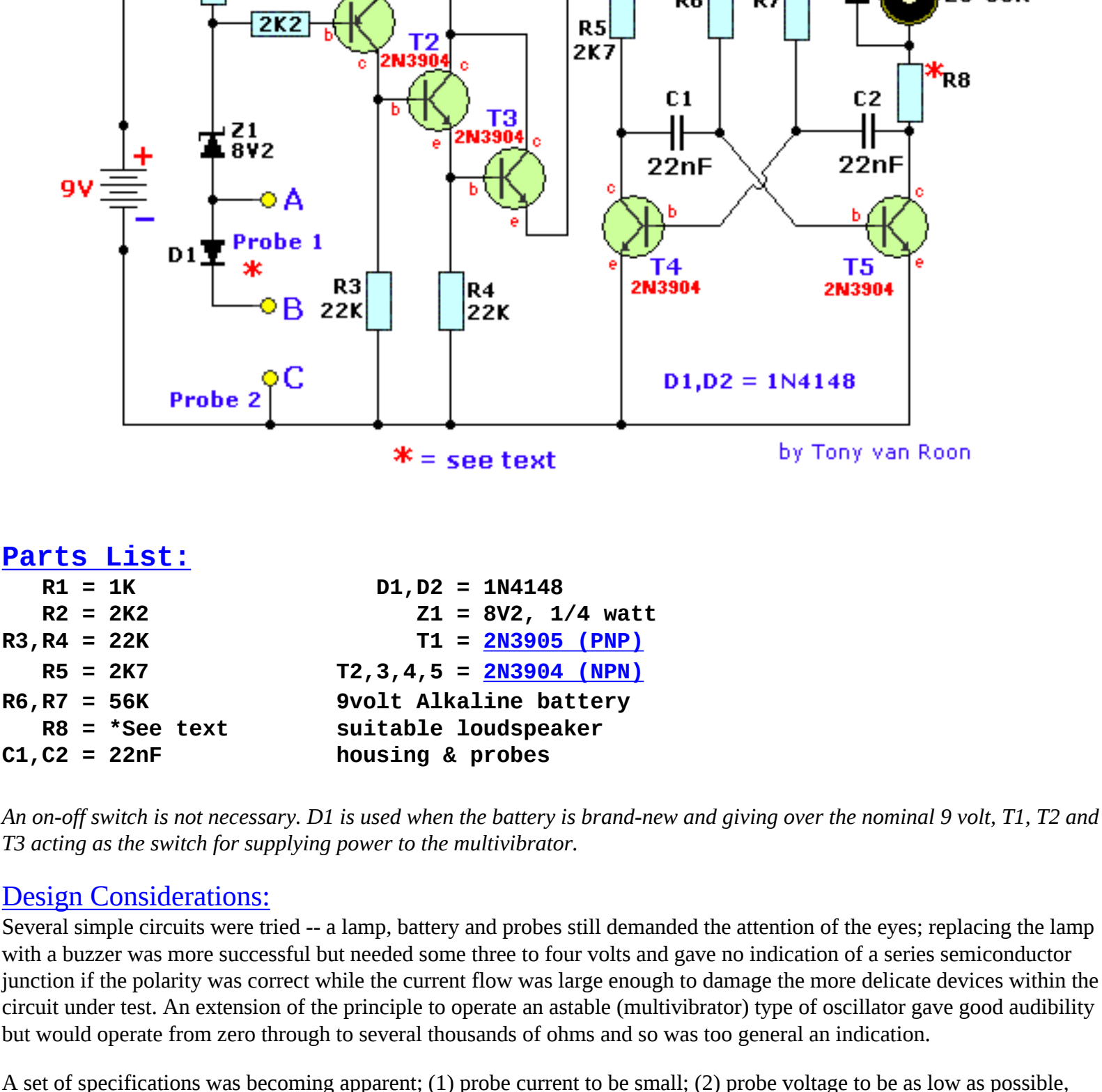
Please note: I will answer no email in regards to this circuit.

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Continuity Tester

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Parts List:

- R1 = 1K
- R2 = 2K2
- R3, R4 = 22K
- R5 = 2K7
- R6, R7 = 56K
- R8 = *See text
- C1, C2 = 22nF
- D1, D2 = 1N4148
- Z1 = 8V2, 1/4 watt
- T1 = 2N3905 (PNP)
- T2, 3, 4, 5 = 2N3904 (NPN)
- 9volt Alkaline battery
- suitable loudspeaker housing & probes

An on-off switch is not necessary. D1 is used when the battery is brand-new and giving over the nominal 9 volt, T1, T2 and T3 acting as the switch for supplying power to the multivibrator.

Design Considerations:

Several simple circuits were tried -- a lamp, battery and probes still demanded the attention of the eyes; replacing the lamp with a buzzer was more successful but needed some three to four volts and gave no indication of a series semiconductor junction if the polarity was correct while the current flow was large enough to damage the more delicate devices within the circuit under test. An extension of the principle to operate an astable (multivibrator) type of oscillator gave good audibility but would operate from zero through to several thousands of ohms and so was too general an indication.

A set of specifications was becoming apparent; (1) probe current to be small; (2) probe voltage to be as low as possible, preferable less than 0.3V to avoid seeing germanium or silicon junctions as a continuous circuit; (3) no on/off switch to be used.

The above circuit was the result and several have been designed and are earning their keep for both "heavy" electricians and electronic technicians.

How it works:

Starting with a 9 volt supply, when the probes are shortcircuited there is a 8.2 volt drop across the zener diode Z1 leaving a maximum of 0.8 volt across R1. Application of Ohms' Law shows that a maximum current of $0.8/1,000 = 0.8$ mA flows via the probes and this satisfies the first design requirement of low probe current.

T1 is a silicon type and the base-emitter voltage will need to be about 0.5 to 0.6 volt to forward-bias the junction and initiate collector current. With a maximum of 0.8 volt available across R1 it is seen that if a semiconductor junction or resistor is included in the outside circuit under test and drops only 0.3 volt then there will be 0.5 volt remaining across R1, barely enough to bias T1 into conduction.

Assuming that the probes are joined by nearly zero resistance, the pd across R1 is 0.7 - 0.8 volt and T1 turns on, its collector voltage rising positively to give nearly 9 volt across R3. T2 is an emitter follower and its emitter thus rises to about 8.3 volt and this base voltage on T3 (a series regulator circuit or another emitter-follower if you prefer it) results in some 7.7 volt being placed across the T4 - T5 oscillator circuit. All the transistors are silicon types and unless the probes are joined, the only leakage current flows from the battery thus avoiding the need for an On-Off switch. When not in use, the battery in the tester should have a life in excess of a year. My own unit lasted for more than 2 years with one standard Alkaline battery.

Descriptive Notes:

The output from the speaker is not loud but is more than adequate for the purpose. I used a small transistor radio loudspeaker with an impedance of 25 - 80 Ohms. The resistance should be brought up to 300 ohms by adding series resistor R8. Example, if your speaker is 58 ohms, then $R8 = 242$ ohms.

An experiment worth doing is to select the value of either C1 or C2 to produce a frequency oscillation that coincides with the mechanical resonant frequency of the particular loudspeaker in use. Having chosen the right value, which probably lies in the range of 10n - 100n, the tone will be louder and more earpiercing. A "freewheel" diode D2 is connected across the transducer since fast switching action of the oscillator circuit can produce a surprisingly high back e.m.f. across the coil and these high voltages might otherwise lead to transistor damage or breakdown.

Zener diodes do not provide an absolutely constant volt-drop regardless of current; at the 0.8 mA design current an 8.2 volt diode will quite possibly give only about 8.0 volt drop since test current for zener selection and marking is typically 5 mA or more. A further possible source of error is the battery; the one suggested, nominally provides 9V but a brandnew one may be as much as 9.2 - 9.6V until slightly run-down and this "surplus" voltage, combined with an "under-voltage" zener volt-drop will leave considerably more than the forecast voltage available at the probes. A silicon diode D1 is therefore connected in series with the zener to decrease the probe voltage by a further 0.6 volt or so.

During your final testing and before boxing your circuit, the most suitable connection, A or B, is selected for the positive probe wire. The aim is to have the circuit oscillating with short circuited probes but to stop oscillation with the least amount of resistance or the inclusion of a diode (try both ways) between the probes.

No sensitivity control is fitted because I don't think it is worthwhile nor necessary and would spoil the simplicity of the circuit.

There is no easy way to proof the unit against connection to the supply. Be **careful** if checking AC line wiring and switch off first. In a similar way, if checking electronic apparatus for unwanted bridging between tracks, for instance or a suspected crack in a PCB (Printed Circuit Board) track switch off power first also. **DISCHARGE ALL LARGE CAPACITORS**. Good luck!

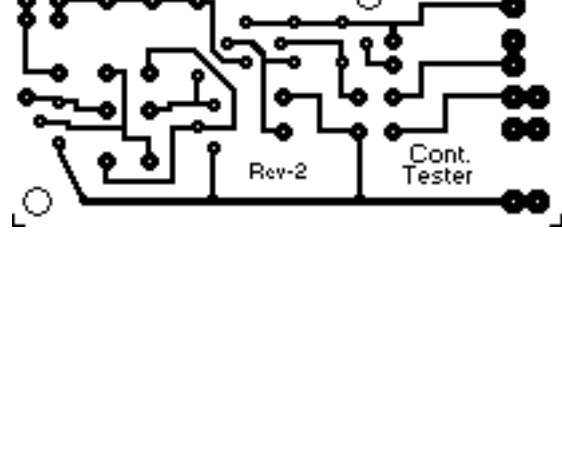


[Click here for the PCB.](#)

The pcb pattern above is shown full-size at 73mm x 33mm (2-7/8" x 1-1/4")

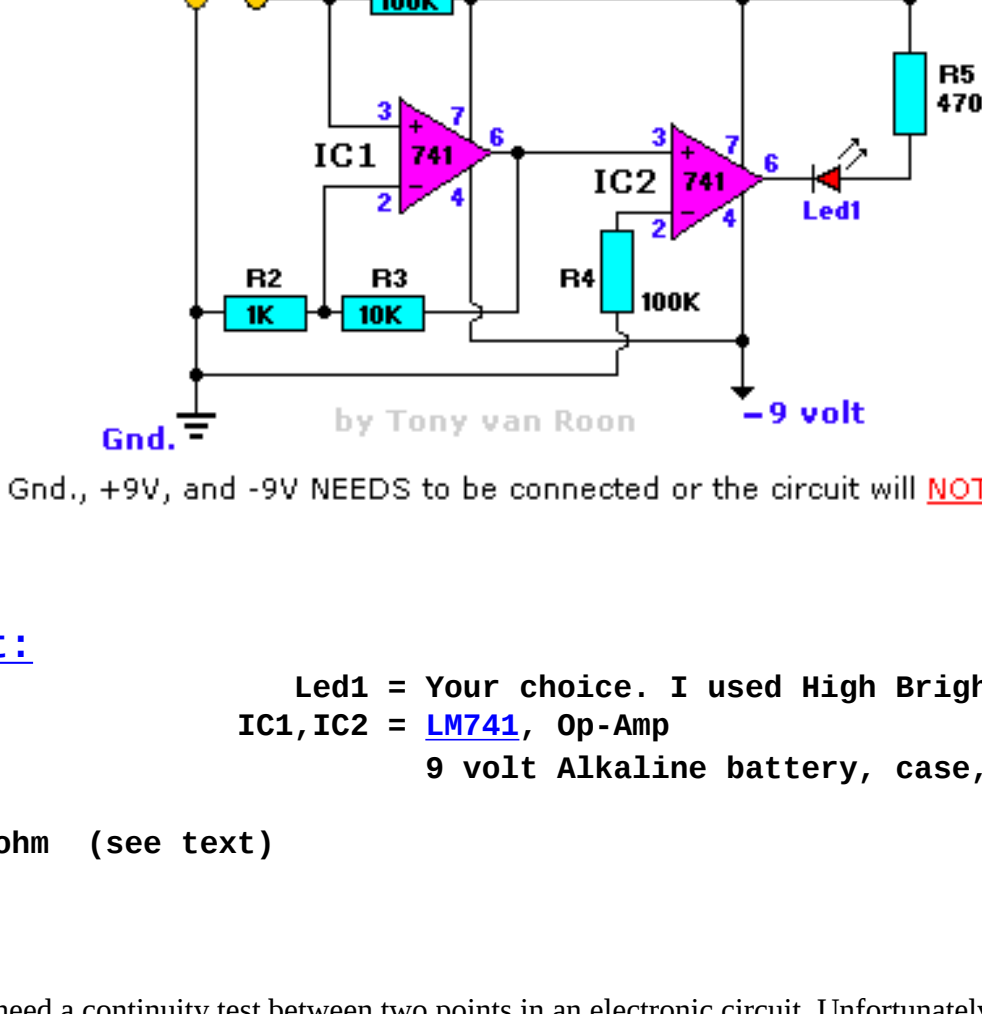
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Smart Continuity Tester

http://www.uoguelph.ca/~antoon



Gnd., +9V, and -9V NEEDS to be connected or the circuit will **NOT** work!

Parts List:

- R1 = 100K
- R2 = 10K
- R3 = 1K
- R4 = 100K
- *R5 = 470 ohm (see text)
- Led1 = Your choice. I used High Brightness LED, RED, 5mm
- IC1, IC2 = LM741, Op-Amp
- 9 volt Alkaline battery, case, probes

How it works:

Occasionally you need a continuity test between two points in an electronic circuit. Unfortunately, most continuity testers are prone to "lie". They don't do that deliberately, but if they see a small resistance, they *still* tell you that you have continuity. This unit is different. If you have continuity it will tell you so. And if you're reading even a low resistance through a component, the unit will tell you that as well.

The unit uses two LM741 op-amps. It offers a short-circuit test current of less than 200µA. It detects resistance values of less than approximately 3 ohms. Nicest of all, it will not break down a PN junction. Since then I have long ago upgraded to the 'Latching' tester since it suits the type of work I do better.

In building this circuit, use good electronic practice, mounting the 741's in suitable ic sockets on perf-board. While there's nothing critical here, keep the work neat, and leads nice and short. *If needed, reduce the value of R5 to 330 ohms if you are using an older type led. When you're done, mount the unit in a small plastic box. A small dab of silicon rubber adhesive keeps the 9-volt battery in place at the bottom of the case, and will last a long time.

At the bottom of the page I have included the diagram how to connect the dual 9v power.

Just in case you're just starting out in electronics, here is how to get the -9, +9, and Gnd(Ground) connections.

A small hole with a grommet keeps the leads (probes) together. Another hole with a grommet holds the LED in place on top of the box where it is plainly visible. This makes a nice one-evening project. Enjoy!

Caution:

There is no easy way to proof the unit against connection to the supply. Please, please be *careful* if checking AC line wiring and switch off first. In a similar way, if checking electronic apparatus for unwanted bridging between tracks, for instance or a suspected crack in a PCB (Printed Circuit Board) track switch off power first also. Always practice good safety and *think-before-you-do!*



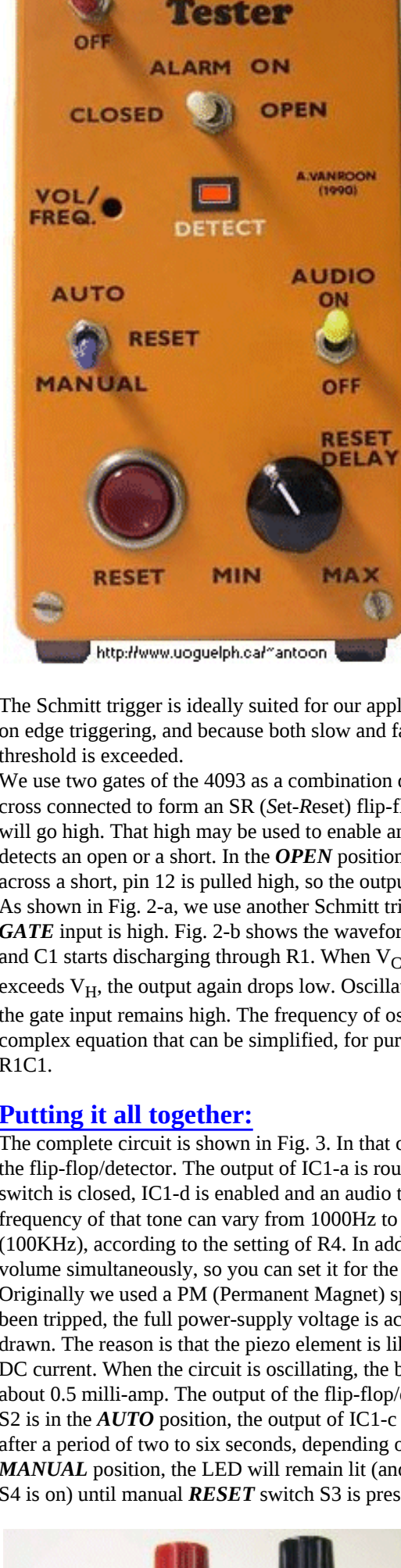
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Latching Continuity Tester

by Tony van Roon

This Latching Continuity Tester can help you locate those difficult-to-find intermittent short and opens that other testers always seem to miss. It has been part of my workbench for many years and performs superb. I have solved many intermittent problem with this highly flexible unit.



<http://www.uoguelph.ca/~antoon>

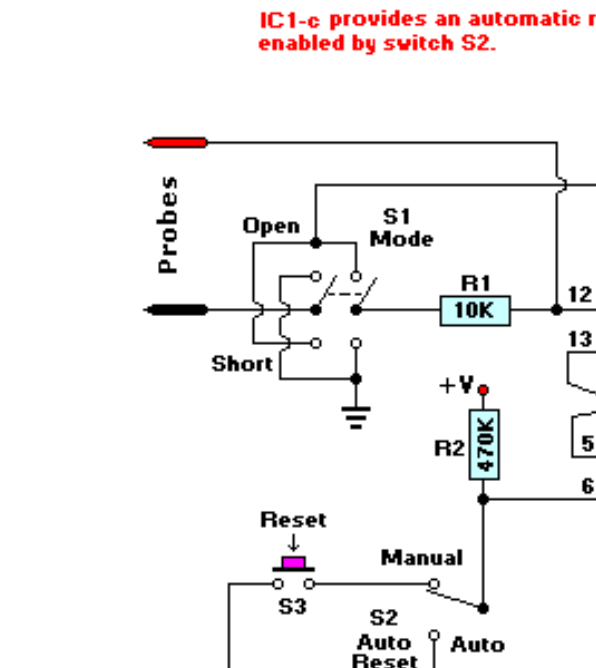
The Schmitt trigger is ideally suited for our application because it is not dependent on edge triggering, and because both slow and fast signals trigger it when either threshold is exceeded.

We use two gates of the 4093 as a combination detector and latch. The gates are cross connected to form an SR (Set-Reset) flip-flop. When pin 12 goes low, pin 11 will go high. That high may be used to enable an LED or other indicator. Switch S1 will go high, pin 12 is pulled high, so the output drops low. The circuit works in the converse manner when S1 is in the **CLOSED** position.

As shown in Fig. 2-a, we use another Schmitt trigger to build a gated astable oscillator. A gated astable oscillator produces output as long as the **GATE** input is high. Fig. 2-b shows the waveforms that are present at various points in the circuit. When the pin-8 input goes high, pin 10 goes low, and C1 starts discharging through R1. When V_C falls below V_{L1} , the output of the gate goes high, so C1 starts charging through R1. When V_C exceeds V_{H1} , the output again drops low. Oscillation continues in that way as long as the gate input remains high. The frequency of oscillation is given by a fairly complex equation that can be simplified, for purposes of approximation, as $F = 1 / R1C1$.

Putting it all together:

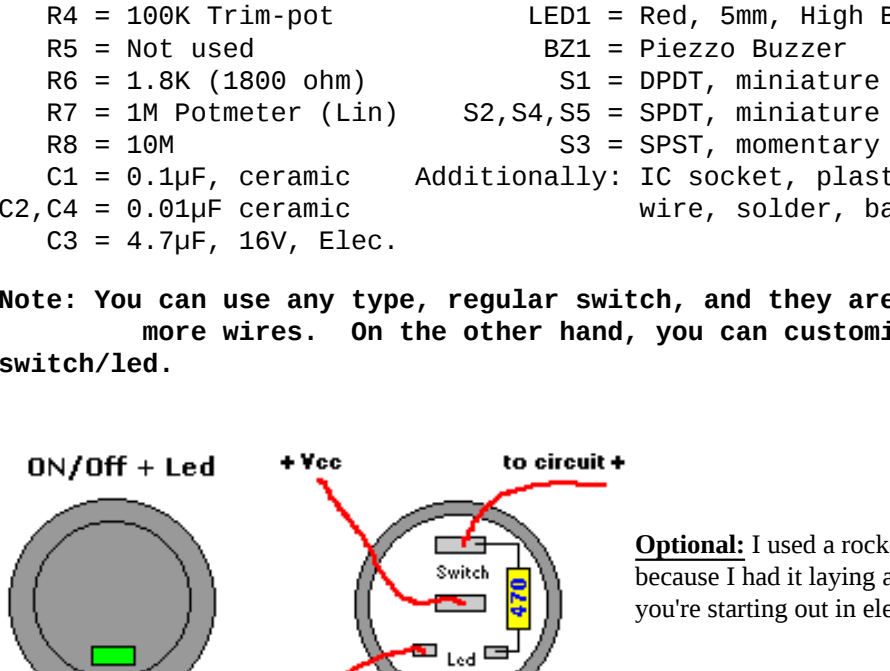
The complete circuit is shown in Fig. 3. In that circuit, IC1-a and IC1-b function as the flip-flop/detector. The output of IC1-a is routed through S4, **AUDIO**. When that switch is closed, IC1-d is enabled and an audio tone will be output by BZ1. The frequency of that tone can vary from 1000Hz to well above the audio range (100KHz), according to the setting of R4. In addition, R4 varies frequency and volume simultaneously, so you can set it for the combination that pleases you best. Originally we used a PM (Permanent Magnet) speaker. When the detector has not been tripped, the full power-supply voltage is across the buzzer, but no current is drawn. The reason is that the piezo element is like a capacitor and does not conduct DC current. When the circuit is oscillating, the buzzer consumes a current of only about 0.5 milli-amp. The output of the flip-flop/detector circuit also drives IC1-c. If S2 is in the **AUTO** position, the output of IC1-c will automatically reset the flip-flop after a period of two to six seconds, depending on the position of R7. If S2 is in the **MANUAL** position, the LED will remain lit (and the buzzer will continue buzzing, if S4 is on) until manual **RESET** switch S3 is pressed



<http://www.uoguelph.ca/~antoon>

eliminates a rat's nest. (see prototype picture below)

Referring to Fig. 4, mount and solder the components in this order: diodes, fixed resistors, IC-sockets, capacitors, variable resistors, and then the pcb mounted switches. The regular ones will work too it just means more wire. Mount the buzzer and the LED last as described below. Trimmer potentiometer R7 is manufactured by Piher (903 Feehanville Drive, Mount Prospect, IL 60056); it has a shaft that extends through the panel. If the Piher pot is unavailable, an alternate is available from Digi-Key (701 Brooks Ave, South, P.O. Box 677, Thief River Falls, MN 56701). The disadvantage of the alternate is that it has no shaft, so it must be adjusted using a miniature screwdriver.

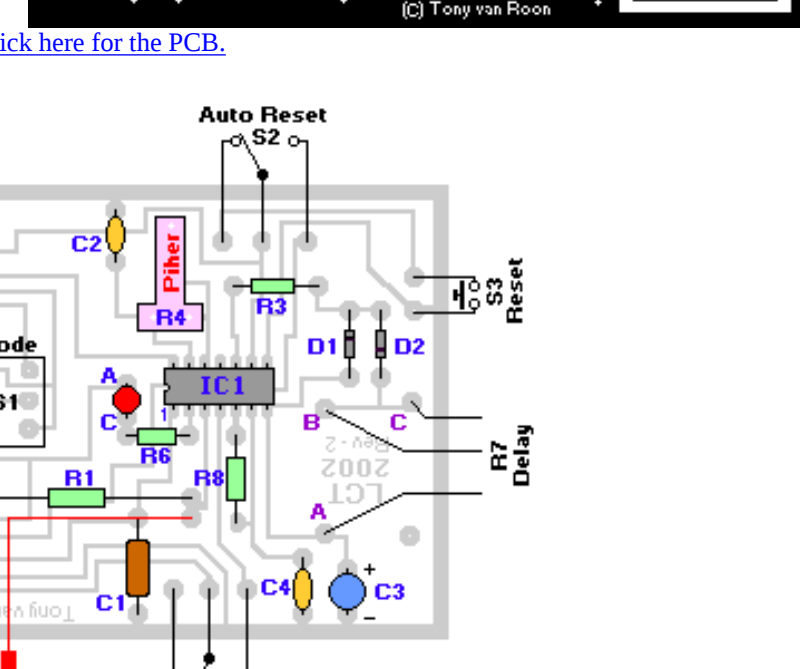


Note: You can use any type, regular switch, and they are fine (and cheaper) just more soldering and more wires. On the other hand, you can customize the look like I did with the rocker switch/Led.

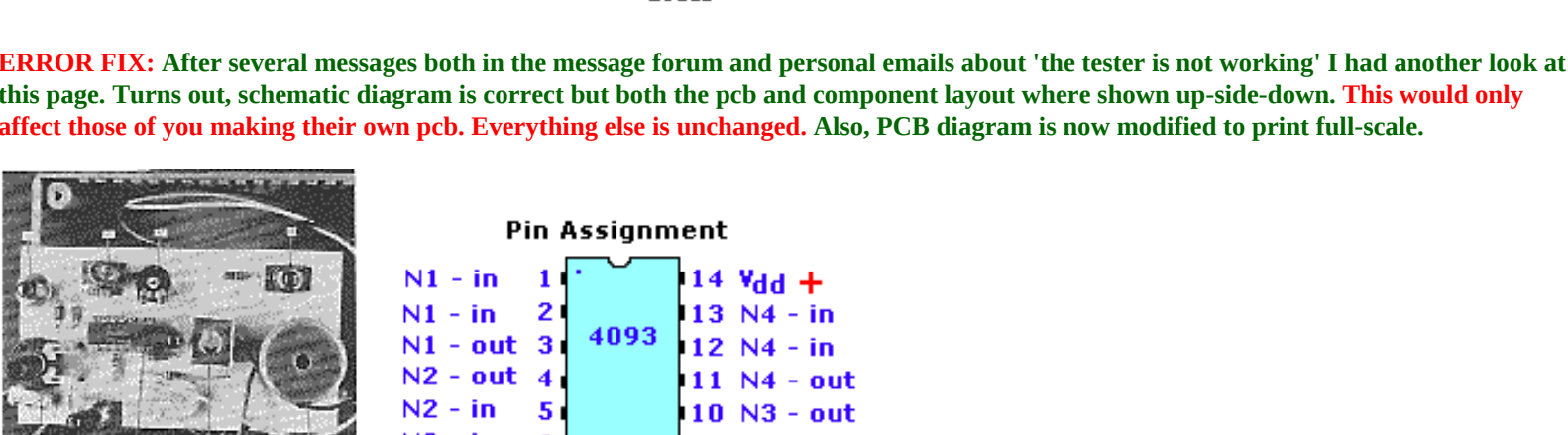


Tony van Roon

Optional: I used a rocker type on-off switch (in my second unit) which contains an led because I had it laying around. Drawing at the left shows how to hook it up just in case you're starting out in electronics.



[Click here for the PCB.](#)



ERROR FIX: After several messages both in the message forum and personal emails about 'the tester is not working' I had another look at this page. Turns out, schematic diagram is correct but both the pcb and component layout where shown up-side-down. **This would only affect those of you making their own pcb. Everything else is unchanged.** Also, PCB diagram is now modified to print full-scale.

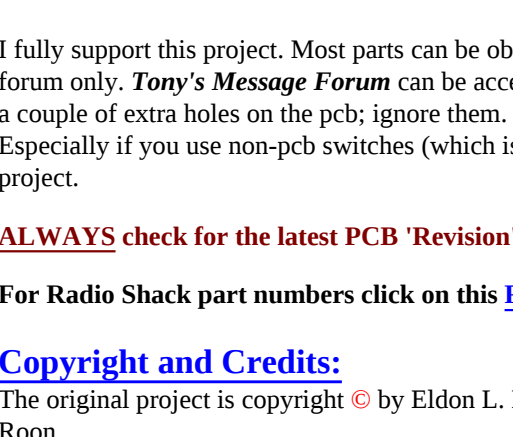


Fig. 5
The assembled pcbboard reveals the low parts-count and easy assembly of the continuity tester

Pin Assignment	
N1 - in	14
N1 - in	14
N1 - out	4
N2 - out	4
N2 - in	5
N2 - in	6
Gnd.	7
N14 Vdd	14
N13 N4 - in	13
N12 N4 - in	12
N11 N4 - out	11
N10 N3 - out	10
N9 N3 - in	9
N8 N3 - in	8

Tony van Roon

I fully support this project. Most parts can be obtained via your local Radio Shack or Tandy store. I will answer all questions but via the message forum only. **Tony's Message Forum** can be accessed via the main page, gadgets, or circuits page. I'm fine-tuning this project at this time. There are a couple of extra holes on the pcb; ignore them. When you're done soldering everything up check your wiring before connecting the battery. Especially if you use non-pcb switches (which is okay) it is very easy to make a wiring error. Good luck and have fun building this most versatile project.

ALWAYS check for the latest PCB 'Revision' number (currently 4-08-2003, Rev.4).

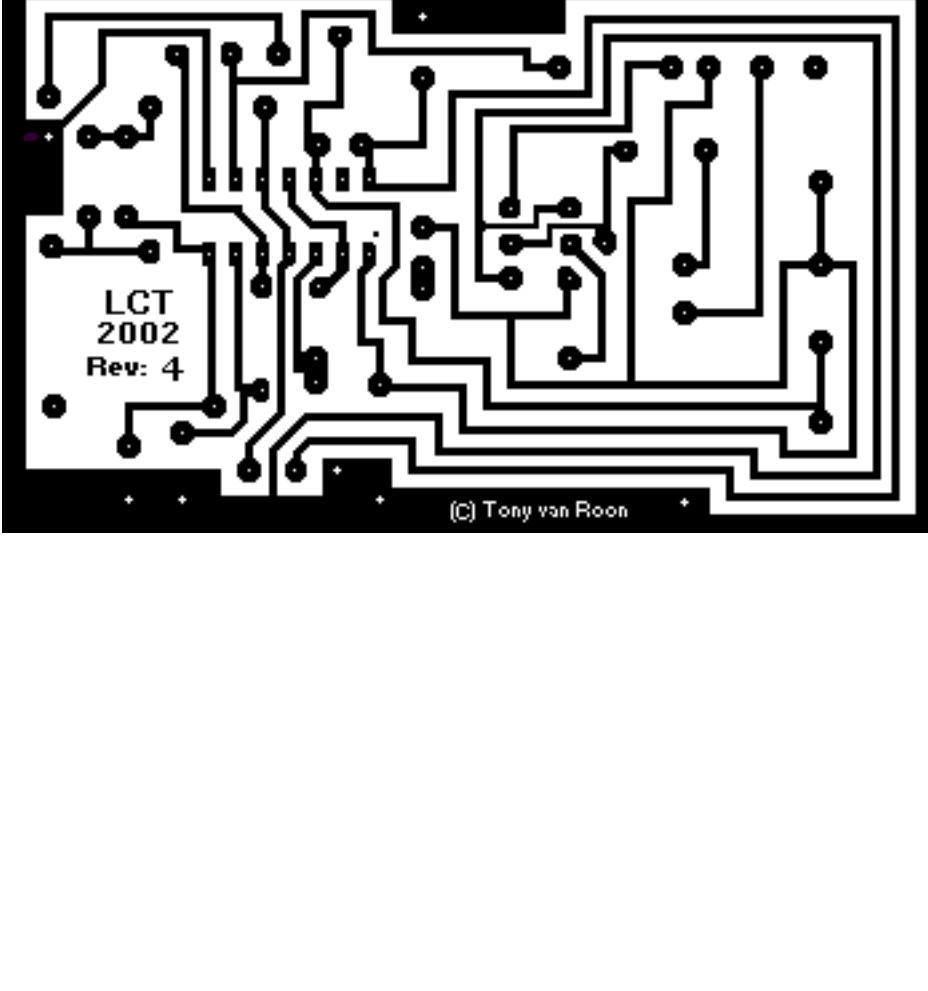
For Radio Shack part numbers click on this [RS data sheet](#).

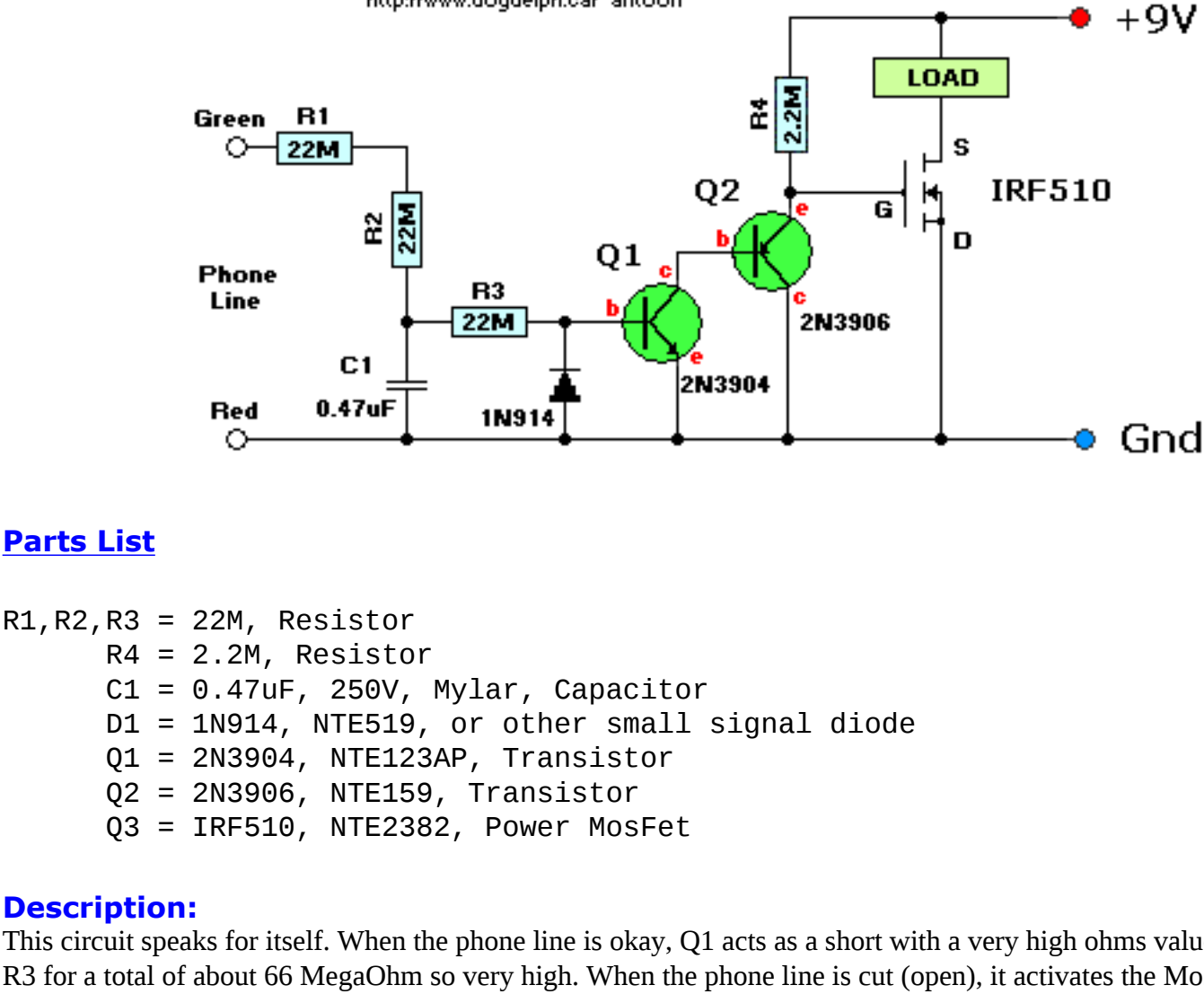
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The original project is copyright © by Eldon L. Knight (1986). Document updates & modifications, all diagrams, and PCB/Layout by Tony van Roon.
Photographs by Yves Savoret.

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Parts List

- R1, R2, R3 = 22M, Resistor
R4 = 2.2M, Resistor
C1 = 0.47uF, 250V, Mylar, Capacitor
D1 = 1N914, NTE519, or other small signal diode
Q1 = 2N3904, NTE123AP, Transistor
Q2 = 2N3906, NTE159, Transistor
Q3 = IRF510, NTE2382, Power MosFet

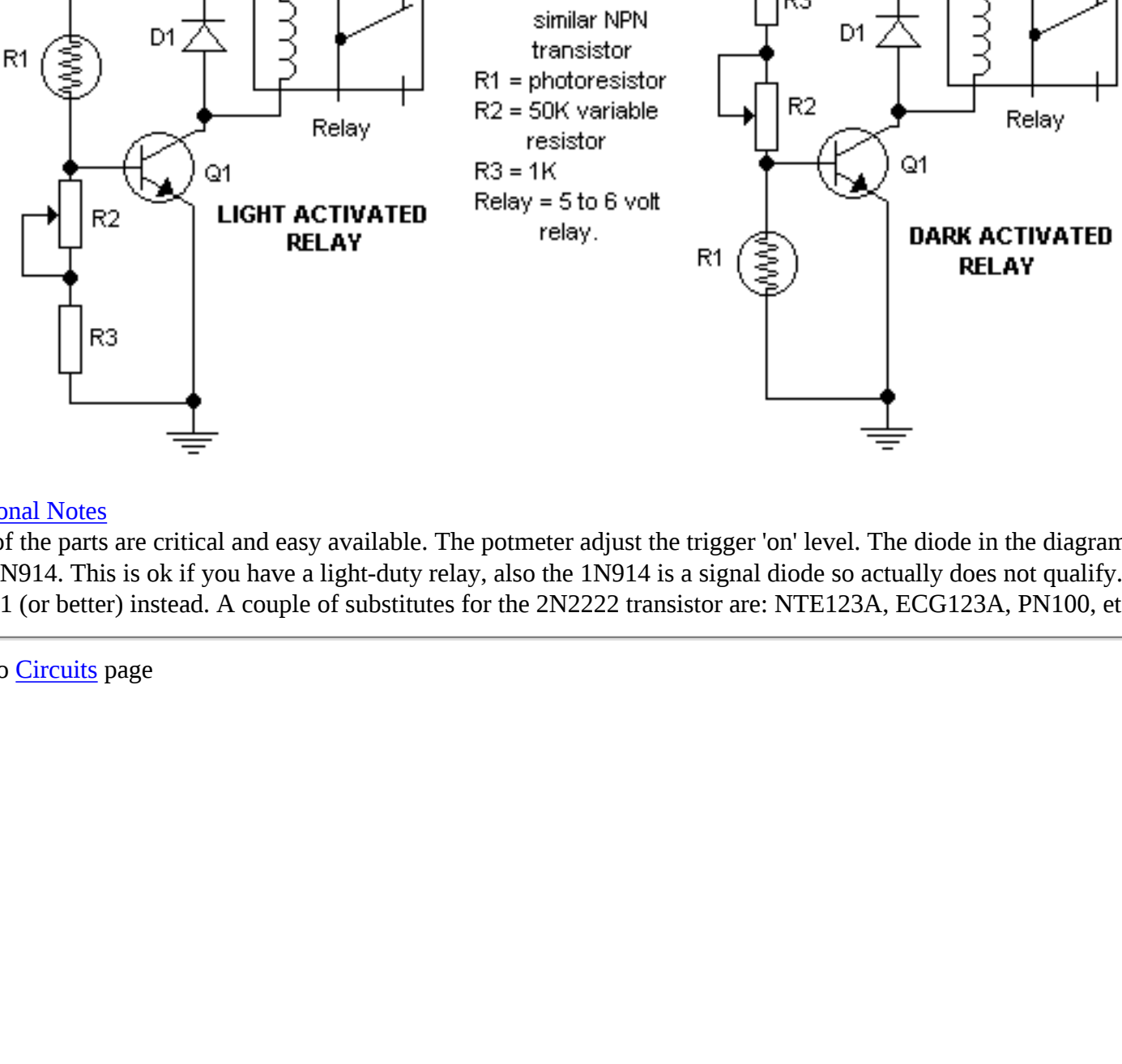
Description:

This circuit speaks for itself. When the phone line is okay, Q1 acts as a short with a very high ohms value via R1, R2, and R3 for a total of about 66 MegaOhm so very high. When the phone line is cut (open), it activates the MosFet (Q3) via transistor Q2 to drive the load. Substitutes are fine, none of the components are critical.
The 'Red' and 'Green' wires of the telephone wire are "NOT" the positive and negative. They are the TIP and RING wires. So, don't get confused why the red telephone wire is connected to Gnd.

The 'LOAD' can be anything you like. A relay, motor, lamp, tape-recorder, stereo, security system, or whatever.
Keep in mind that Phone companies don't like to have anything 'directly' connected to their wires for obvious reasons, so use this circuit at your own risk. If you like to play it save use an Opto-Isolator or something, which also will keeps your phone company happy. They don't like anything hooked up to their wires directly.

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Dark/Light Activated Relay



[Additional Notes](#)

None of the parts are critical and easy available. The potmeter adjust the trigger 'on' level. The diode in the diagram shows to be 1N914. This is ok if you have a light-duty relay, also the 1N914 is a signal diode so actually does not qualify. Use a 1N4001 (or better) instead. A couple of substitutes for the 2N2222 transistor are: NTE123A, ECG123A, PN100, etc.

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Electronic Dazer

http://www.uoguelph.ca/~anton

The oscillator does nothing more than send sharp current pulses through T1. The back EMF across the secondary winding is then pumped through the multiplier stages to produce the very-high output voltage across the electrodes, enough to pack quite a punch.

CAUTION!
Please exercise caution.
Being careless can be a shocking experience!

(C) 1987 by Rick Duker

Electroshock

Parts List

R1 = 3300 ohm, 1/4 watt, 5%
R2 = 1M, 1/4 watt, 5%
C2 = 0.1uF, monolithic capacitor
C2-C9 = 0.01uF 400 volt polyester capacitors
D1-D8 = 1N4007, 1000 Volt diodes
Neon = Type NE-2 neon bulb
Q1 = MJE521 NPN power transistor (40V/40W/4A)
Q2 = MJE371 PNP power transistor (40V/40W/4A)
T1 = 1200:8 ohm audio power transformer (Armco AT-49)
S1 = SPST momentary-contact, pushbutton switch

Additionally:

9-volt battery clip, 10 x 5 x 2.5cm plastic case, 7.5 x 4cm perfboard or pboard, two 8/32 x 1-1/4 bolts and nuts for electrodes, adhesive for mounting NE1, circuit board standoffs (optional), hookup wire, solder, etc.

Substitutes:

Q1 (MJE521), the NTE184 or 2N5190 will work, and for Q2 (MJE371) the NTE185 or 2N5193 will work. T1: Mode 60-282-0 (Audio) about \$2.00, Armco AT-49 (Audio) about \$5.00, Hammond 141P (Audio) about \$19.00. I have not experimented with the 1000:8 ohm type. Try it. No guarantees it will work. Why an audio power transformer? The windings are much finer and the overall size of this transformer is much smaller than the average power transformer. Compare it this way, holding a mini-cell phone versus a stone brick. Again, and just in case you don't know, the Audio Transformer mentioned for this project is measured in **OHMS** (impedance) and not turns or windings.

WARNING: THIS DEVICE IS NOT A TOY! We present it for EDUCATIONAL and EXPERIMENTAL purposes ONLY. The circuit develops about 2000 volts at a respectable amperage. It can cause you pain and even damage if you become careless and touch its output terminals. The unit can also damage property as well so use it wisely. You should NEVER use the device on another person! It may not be against the law to possess such a device in your area, but if you use it on someone you may be deemed liable a civil and/or criminal action suit. Don't just follow the golden rule after constructing the project, instead just don't do it unto anyone. Included in the article are a number of instructions on how to build, test, and operate the Dazer; all of them must be followed to the letter. **Do not deviate from the procedure.**

The *Electronic Dazer* is a modern, portable, non-lethal-personal-protection appliance. It generates high potential energy to ward off vicious animals or other attackers. It is an aid to help escape from a potentially dangerous situation. This device develops about 2000 volts. Higher voltages may be attained by adding additional multiplier stages, but it should be noted that those stage(s) will also increase the overall size of the unit.

The Dazer is very compact, being built into a small plastic case. It is powered by a single 9-volt Alkaline battery. The high voltage is applied to two electrodes which require only light contact to be effective. When touched with the Dazer, the victim or animal will receive a stunning, but non-lethal jolt of electricity that will usually discourage any further encounters. The electronic Dazer is a power supply which consists of a micro-size regenerative amplifier/oscillator coupled to an energy multiplier section. It should not be confused with cheap induction-type cattle prods. The Dazer is more versatile than other high-voltage stun devices currently being sold. Those devices are basically high-voltage, AC generators which jam the nervous system. However, the Dazer may be used for heating and burning applications, or anywhere a high voltage DC supply is required.

(Tony's Note: Don't confuse the Dazer with a Stun-Gun. The Dazer emits high voltage about 2000V DC, a Stun-Gun can generate VERY High Voltages varying from 15,000V to 650,000VAC (as claimed by some manufacturers), and can cause personal injury or even death. Stun-Guns are considered banned illegal fire-arms, you risk criminal prosecution if law enforcement finds one in your possession (Canada, not sure about USA).

How it Works:

Referring to the schematic diagram, the two power transistors Q1 and Q2, form a regenerative amplifier operating as a power oscillator. When Q1 turns on, Q2 turns on and that shorts the power supply across the primary of T1. That current pulse induces a high voltage in the secondary of T1. As C1 charges, Q1 turns on again and the cycle repeats itself. Therefore, a rapid series of DC pulses are generated and stepped up by T1 to approximately 300 volts at full battery charge. That voltage is rectified and increased by the voltage multiplier section which consists of C2 to C9, and D1 to D8. The final output is approximately 1500-2000 volts. The neon bulb 'Neon' is used as a charge indicator and indicates that the unit is charged and operating properly, but can be left out.

Check out fig. 1 at the right; these are standard voltage doublers found in many data books and others like the NTE, Newark, or Electro-Sonic catalogs. They can even be found on the internet. Just do a search on one of the major search engines like Yahoo or Google and search for 'voltage doubler' or 'HV'.

Fig. 1

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Construction:

As with all projects start out by laying out and identifying. If you do not wish to make a printed-circuit-board, then you may use perf board as long as you remember to keep the leads of all high-voltage components isolated. That is to prevent sparks from arcing across your board. A 4 x 7.5 cm of perfboard is suitable for that purpose.

The first components you should mount are the two transistors Q1, Q2, transformer T1, resistor R1, and neon bulb 'Neon'. Solder them in place (for PCB construction) being sure that the transformer and transistors are hooked up correctly. Apply a small amount of adhesive to the base of NE1 to hold it securely in place.

Mount D1 to D8 and C2 to C9 on the board and make all solder connections. Note proper polarity of the diodes. The off-board components are next. Solder in leads for S1, and the output electrodes. Also solder in the battery clip for B1.

Build the enclosure from some nonconductive material such as ABS plastic. Drill holes for S1, Neon, and output electrodes. Be sure that the output electrodes are about a cm or greater apart. Connect the output wires to the electrodes and insert them through holes from inside of the case. Thread on the retaining nuts and tighten them securely. Set the circuit board in the case and mount S1, securing with a nut. Coat the voltage doubler stages with clear nail polish or varnish. File down ALL sharp points and edges to prevent sparking at those points. That completes the construction.

Testing:

Before inserting the battery and closing the case, a few test measurements should be made to ensure correct operation. With the ground clip connected to the battery (do NOT test the complete clip to the battery **ONLY** the ground), connect a volt or multimeter between the positive clip and the positive terminal of the battery. Set the meter for current reading, and press S1. You should measure a current of approximately 300 to 500mA. The 'Neon' light should be glowing. With a high voltage multimeter or VOM, you should measure about 2000 volts on the output terminals. Those measurements indicate proper circuit operation. Let the unit run for about one minute (keep pressing S1). Transistors Q1 and Q2 should be warm, but not hot to the touch (**BE CAREFUL!**). Insert the battery in the holder and close the case. That wraps up the Electronic Dazer. (see pictures below)

Transformer and C1

Doubler Stages

The Probes

Battery clip to minus for testing clip

R1 (3K3)

Operation and Use:

CAUTION!

Activate the unit by pressing S1. The Neon-bulb will light indicating the dazer is fully charged and ready to use. Notice also that only one pole of the neon light will glow, indicating DC voltage present. **It is important to remember that the device holds a charge even after S1 is off.** To discharge, (do not press S1) touch the electrodes to a metal object and note the healthy spark discharge.

The Electronic Dazer was designed as a self-defense weapon for use against vicious dogs or other attacking animals. The device is most effective when the electrodes contact an area of low resistance such as skin or flesh. Those include the snout or mouth since the resistance of those areas are much lower than areas of hair or of fur. The electrodes could be pointed to penetrate these areas better. The dazer generates great stopping power. One contact will give a powerful jolt and should discourage any further attacks.

The device can burn and heat materials with low resistance. Those include flesh, moistened paper or wood, etc. That makes the unit potentially hazardous to humans. Remember, the dazer is *not* a toy but a quality electrical appliance and therefore must be treated accordingly. Use the utmost discretion with this device!

Another use for this device is as a high voltage DC power supply. It may be constructed as variable power supply if output taps are taken from various stages of the voltage multiplier section. Remember, always disconnect the battery and fully discharge the capacitors before working with the circuitry.

Note that if you decide to 'Turbo-charge' your unit, select diodes and capacitors which can handle the extra voltage. This unit can easily be damaged (and stops working) by incorrect parts choice, careless (sharp) soldering joints, and so on. So be careful and watch yourself. Again, being careless is gonna hurt!!!

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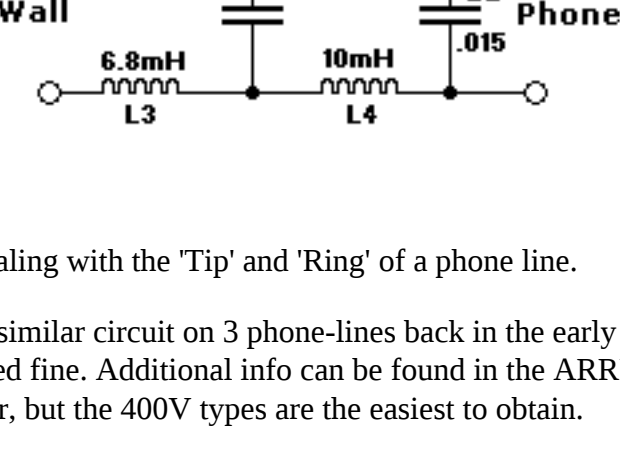
Again, this project is for educational and/or laboratory purposes only and even so, it is your responsibility to check with local, provincial, and federal law enforcement in regards to the legality for having in possession or the construction of this project. I take no responsibility, whatsoever, for the use, experimentation, or having possession of this high voltage device.

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http://www.uoguelph.ca/~anton/circ/dazer.htm [1/2/05 12:25:24 PM]

DSL Filter



Parts & Description

L1, L2 = 6.8mH, inductor
L3, L4 = 10mH, inductor
C1 = 0.022uF, 250-600V
C2 = 0.015uF, 250-600V

The above diagram is a standard low-pass telephone line filter (L1,C1,L3,C2). L2 and L4 are needed since

we're dealing with the 'Tip' and 'Ring' of a phone line.

I used a similar circuit on 3 phone-lines back in the early 80's when I was running Scottsdale BBS and the filters performed fine. Additional info can be found in the ARRL Handbook, etc. For the two capacitors, the higher the voltage the better, but the 400V types are the easiest to obtain.

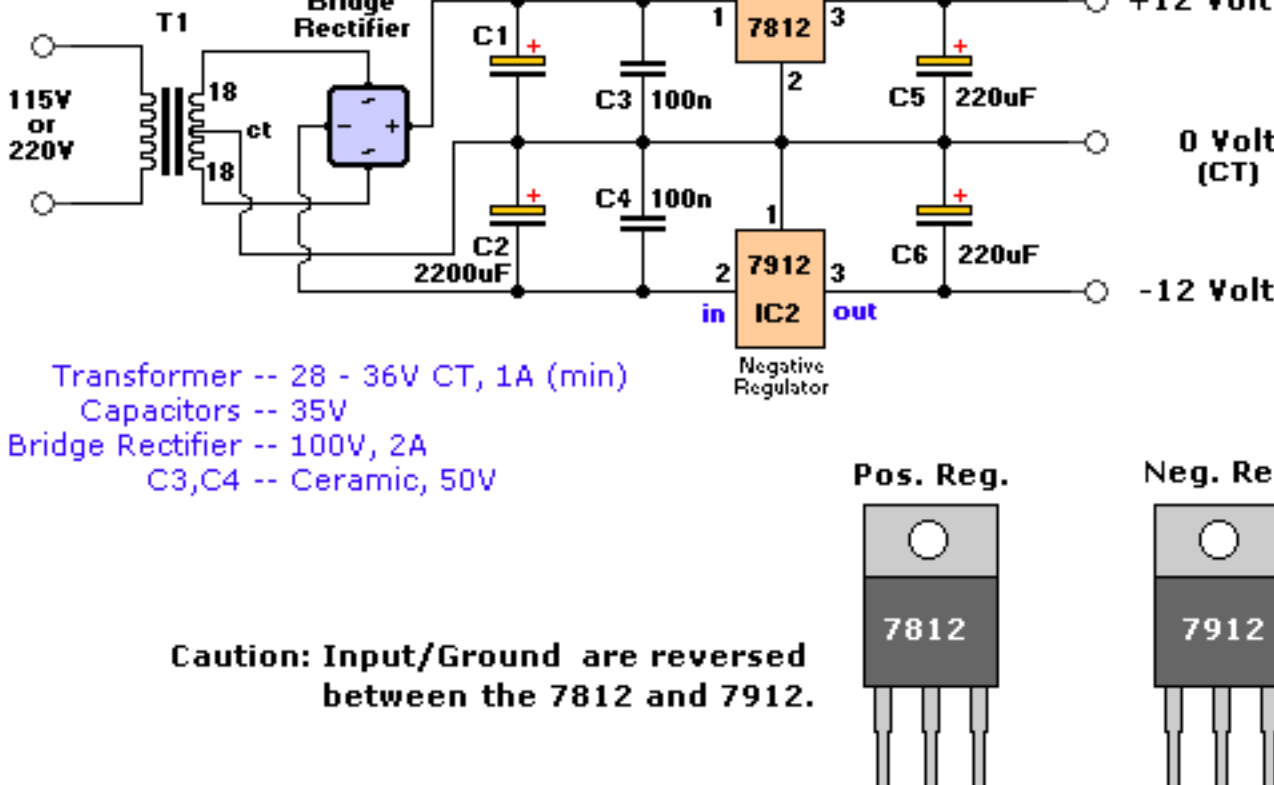
This above circuit is © BenJammin.Net

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Dual Voltage Power Supply

<http://www.uoguelph.ca/~antoon>



Transformer -- 28 - 36V CT, 1A (min)

Capacitors -- 35V

Bridge Rectifier -- 100V, 2A

C3,C4 -- Ceramic, 50V

**Caution: Input/Ground are reversed
between the 7812 and 7912.**

Pos. Reg.

7812

1 2 3

IN Out

Gnd

Neg. Reg.

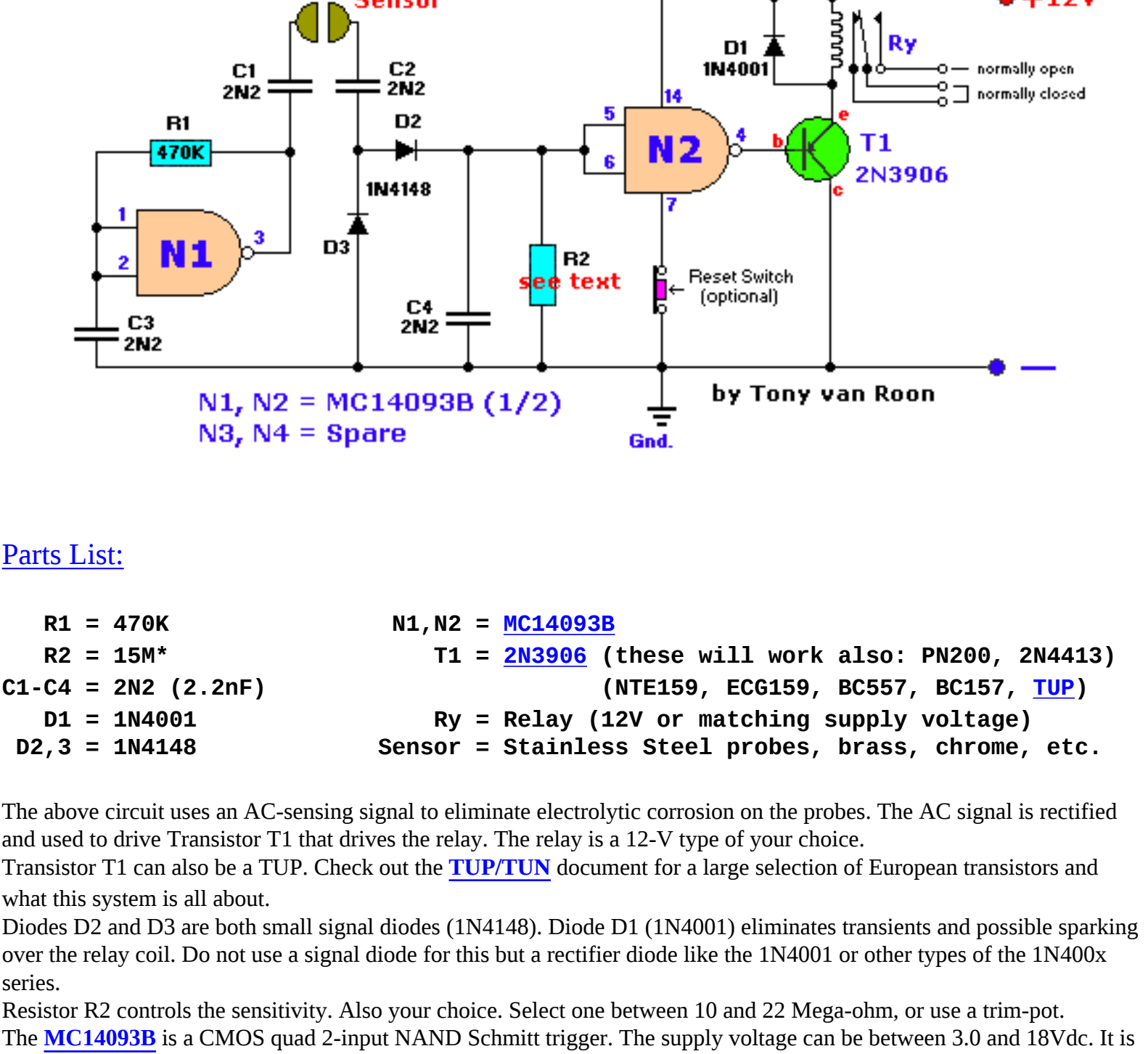
7912

1 2 3

Gnd Out

IN

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Wire Tracer (Fox & Hound)

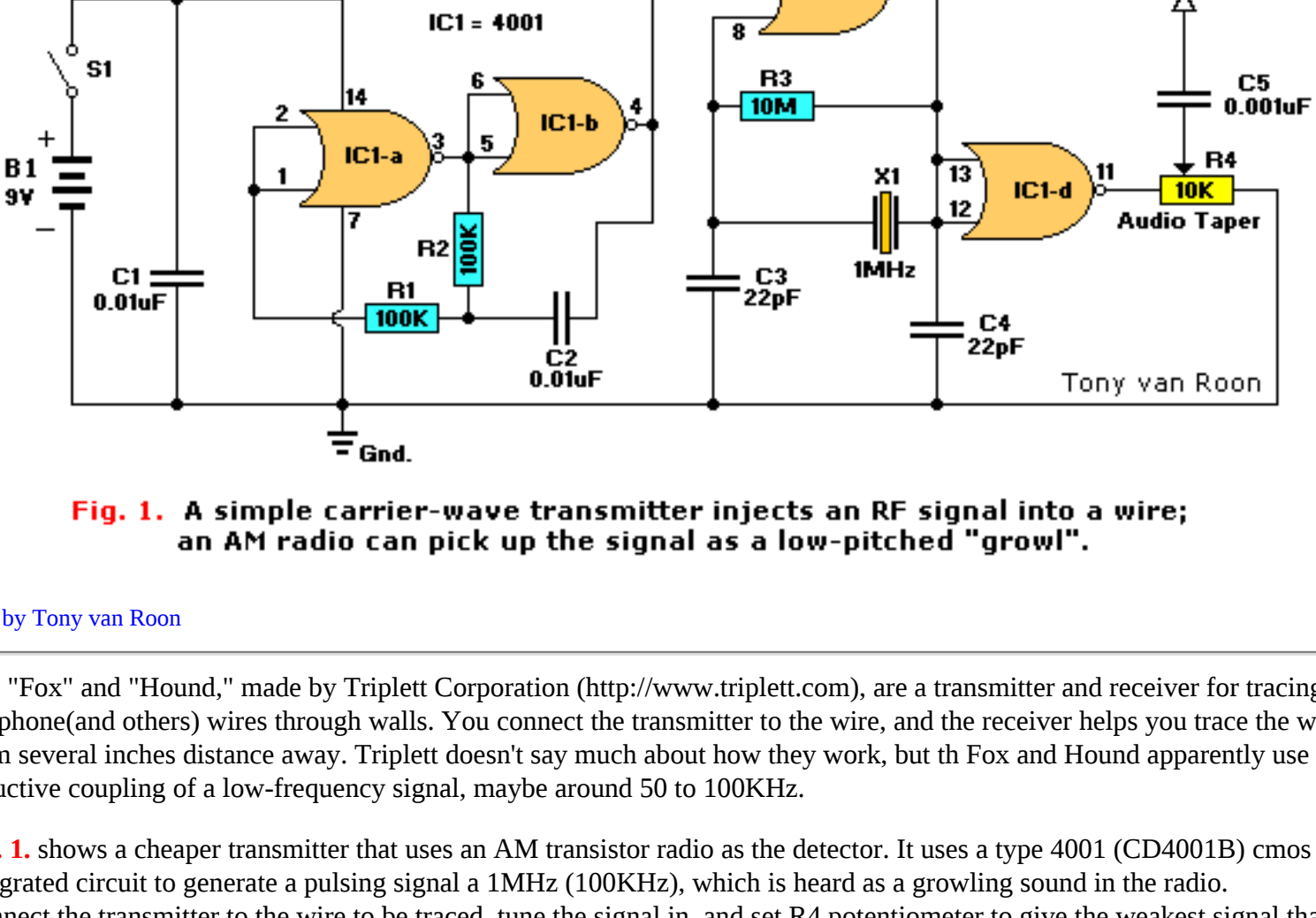


Fig. 1. A simple carrier-wave transmitter injects an RF signal into a wire; an AM radio can pick up the signal as a low-pitched "growl".

© by Tony van Roon

The "Fox" and "Hound," made by Triplett Corporation (<http://www.triplett.com>), are a transmitter and receiver for tracing telephone(and others) wires through walls. You connect the transmitter to the wire, and the receiver helps you trace the wire from several inches distance away. Triplett doesn't say much about how they work, but th Fox and Hound apparently use inductive coupling of a low-frequency signal, maybe around 50 to 100KHz.

Fig. 1. shows a cheaper transmitter that uses an AM transistor radio as the detector. It uses a type 4001 (CD4001B) cmos integrated circuit to generate a pulsing signal a 1MHz (100KHz), which is heard as a growling sound in the radio. Connect the transmitter to the wire to be traced, tune the signal in, and set R4 potentiometer to give the weakest signal that does the job. At maximum setting you can probably pick it up several feet away; lower settings will enable you to locate wires within an inch or two. Note that you are using the AM loop antenna inside the radio, not the FM whip, whip should be fully retracted, or if it is a screw-in type, unscrew it.



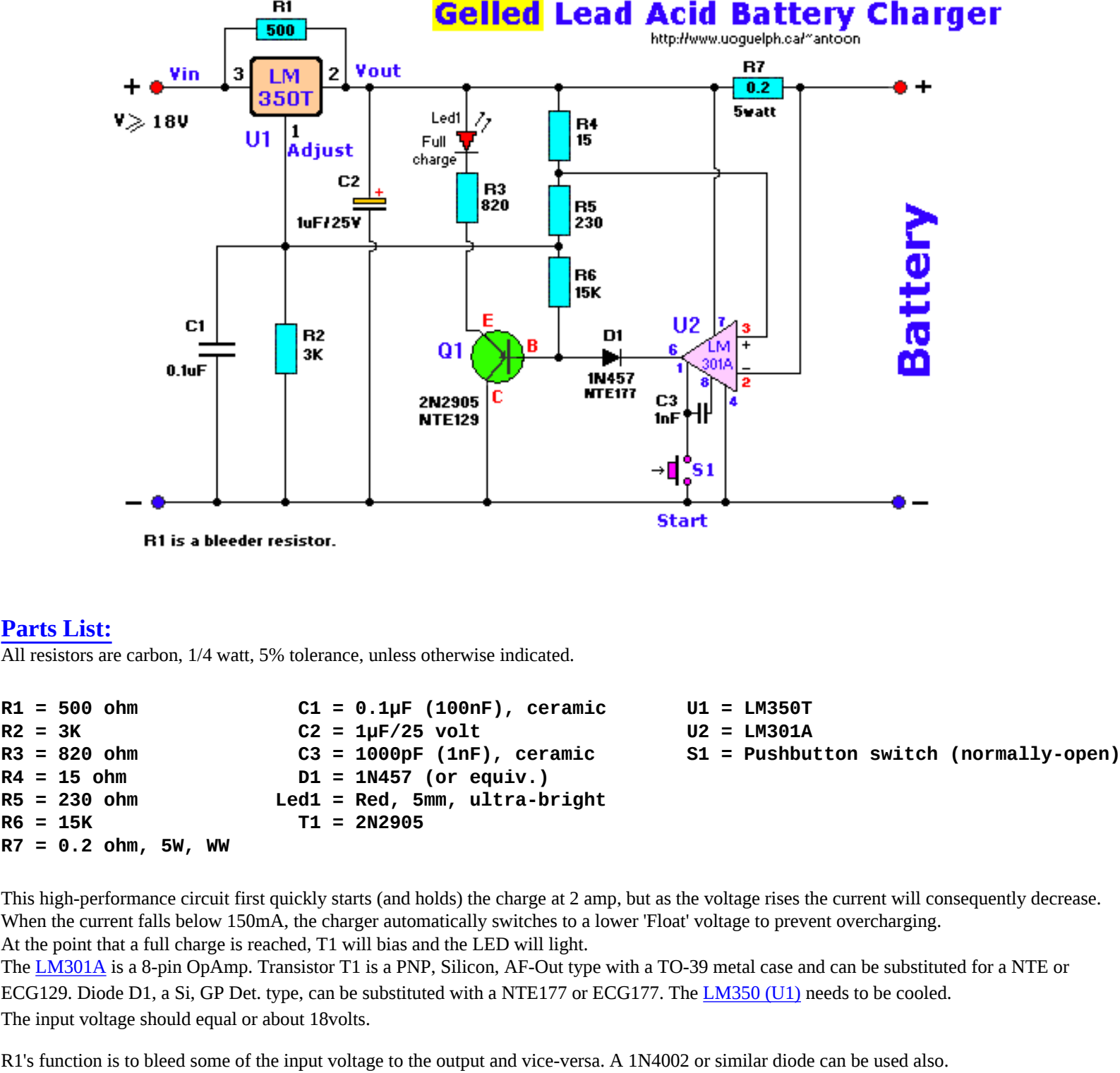
As shown, the circuit transmits on 1000KHz and is controlled by a 1-MHz microprocessor crystal. **Fig. 2.** shows how to use an LC oscillator to get other frequencies or to save having to order a crystal. Although build with a CMOS gate, this is simply a Colpitts oscillator. Note that the two capacitors are effectively in series, so only half of their capacitance is present in the tuned circuit.

Now for the bad news. As you may have discovered, this type of device probably will not detect a small break in a phone line. Radio waves that can go several inches through wood and plaster can also jump across a tiny gap in metal wire. Nonetheless, with care, you may be able to find the break by looking for a place where the signal strength drops dramatically.

Another approach would be to use a much lower-frequency signal, such as 5 KHz from an audio-signal generator, and pick it up inductively with a microphone-level audio amplifier. Try using a coil from a relay as the detector, in place of a microphone. Low-frequency signals are harder to pick up but also less able to jump across breaks in the wiring.

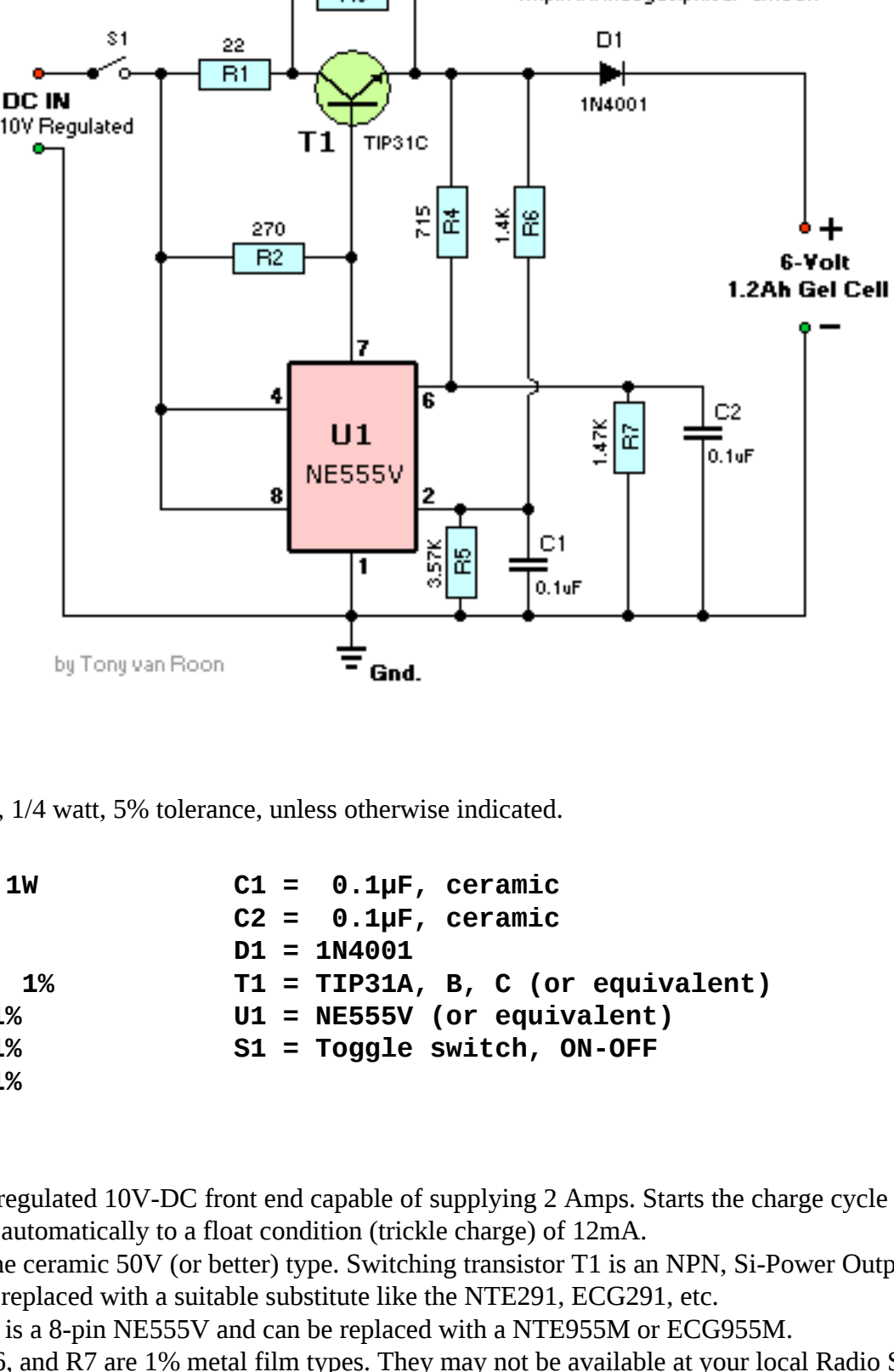
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6-Volt Gel Cell Charger

http://www.uoguelph.ca/~antoon



by Tony van Roon

Parts List:

Resistors are carbon, 1/4 watt, 5% tolerance, unless otherwise indicated.

R1 = 22 ohm, 1W	C1 = 0.1μF, ceramic
R2 = 270 ohm	C2 = 0.1μF, ceramic
R3 = 220 ohm	D1 = 1N4001
*R4 = 715 ohm, 1%	T1 = TIP31A, B, C (or equivalent)
*R5 = 3.57K, 1%	U1 = NE555V (or equivalent)
*R6 = 1.49K, 1%	S1 = Toggle switch, ON-OFF
*R7 = 1.47K, 1%	

Description:

This circuit needs a regulated 10V-DC front end capable of supplying 2 Amps. Starts the charge cycle at 240mA and at full charge switches automatically to a float condition (trickle charge) of 12mA. The capacitors are the ceramic 50V (or better) type. Switching transistor T1 is an NPN, Si-Power Output/SW, with a TO-220 case and can be replaced with a suitable substitute like the NTE291, ECG291, etc. Timer/Oscillator U1 is a 8-pin NE555V and can be replaced with a NTE955M or ECG955M. Resistors R4, R5, R6, and R7 are 1% metal film types. They may not be available at your local Radio Shack/Tandy store and have to be ordered in. Try Electro-Sonic or Newark Electronics supply stores.

NOTE: For **6-volt, 1.2Ah Gel Cell** type batteries only!

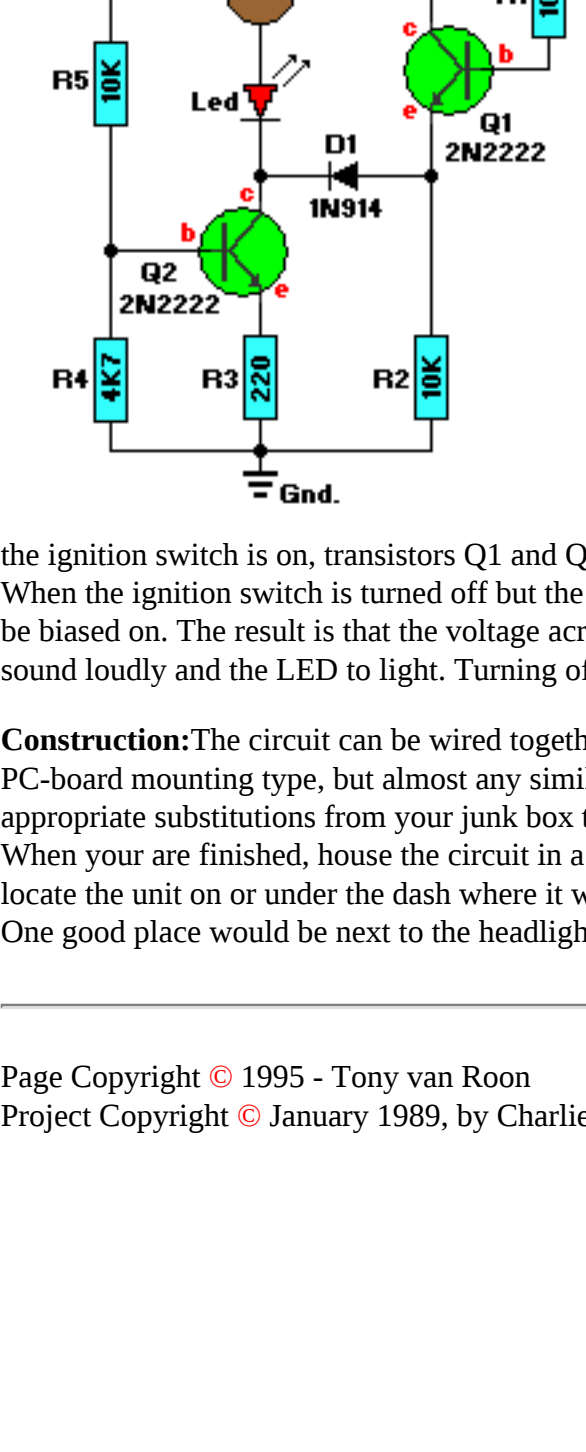
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Headlight Alarm

By Tony van Roon

"Never forget to turn off your head light ever again! Most newer cars already have this feature built-in but there are still lots of cars out there without it. This simple circuit is cheap and can be built for about \$5 bucks!"



It's 5:00pm and you've just finished a long day at the office. You climb into your car, turn the ignition switch on, and nothing happens. That's when you suddenly realize the problem; you left your headlights on this morning. Unfortunately, the realization has come about eight hours too late and now your battery is dead.

The preceding incident has probably happened to your at least once; in my case it has happened more often than I care to remember. Or at least it used to. Now, I have installed the simple circuit shown in Fig. 1 in my car. Of course, the circuit is a headlight alarm. It has saved me from embarrassment and aggravation on several occasions.

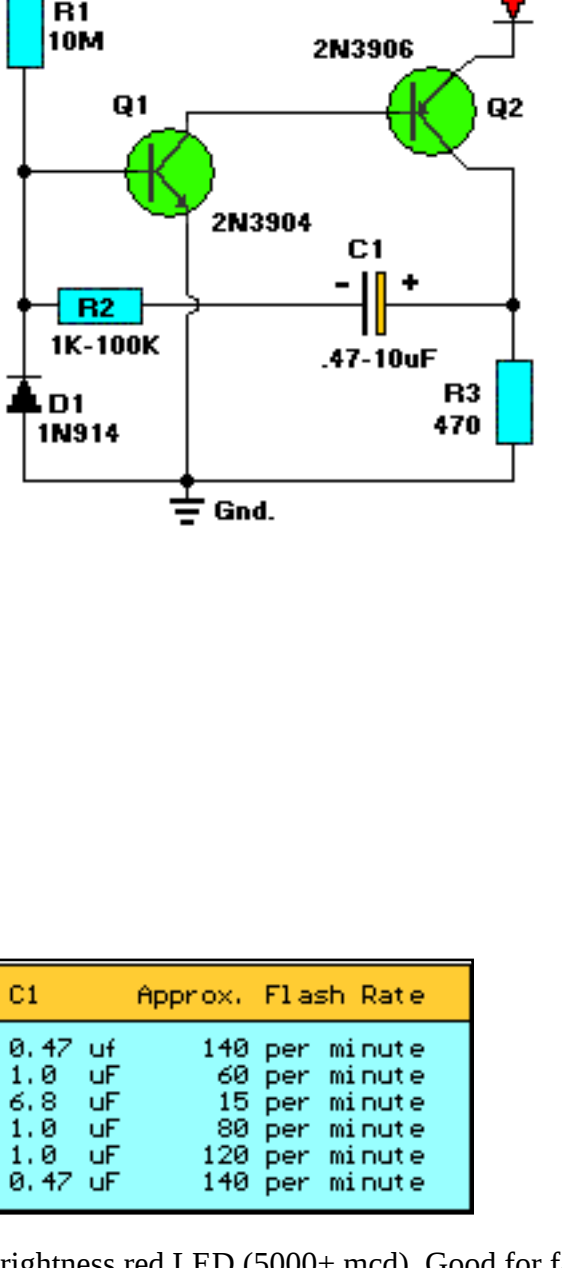
The Circuit: While many cars are equipped with a headlight alarm, many more, unfortunately are not. For those cars this little circuit offers a low-cost way to add that valuable feature. Let's see how it works.

The base of Q1 is connected to the car's ignition circuit; the easiest point to make that connection is at the ignition switch via the fuse panel. Also, one side of the piezoelectric buzzer is connected to the instrument-panel light fuse; remember that when the headlights or parking lights are on, the instrument panel is lit too. When the headlights are off, no current reaches the buzzer and therefore nothing happens. What happens when the headlights are on depends on the state of the ignition switch. When the ignition switch is on, transistors Q1 and Q2 are biased on, effectively removing the buzzer and the LED from circuit. When the ignition switch is turned off but the headlights are on, transistor Q1 is turned off, but transistor Q2 continues to be biased on. The result is that the voltage across the piezoelectric buzzer and the LED is sufficient to cause the buzzer to sound loudly and the LED to light. Turning off the headlight switch will end the commotion quickly.

Construction: The circuit can be wired together on a piece of perf-board. The buzzer I used was a Radio Shack 273-065 PC-board mounting type, but almost any similar buzzer will do. Circuit parameters are not critical, so feel free to make appropriate substitutions from your junk box to further reduce the cost.

When your are finished, house the circuit in a small, plastic experimenter's box (in my case a plastic film container) and locate the unit on or under the dash where it will be out of the way and mount only the LED where it can be seen easily. One good place would be next to the headlight switch on the dash; that will provide more of a custom look.

2-Transistor Led Flasher



Parts List

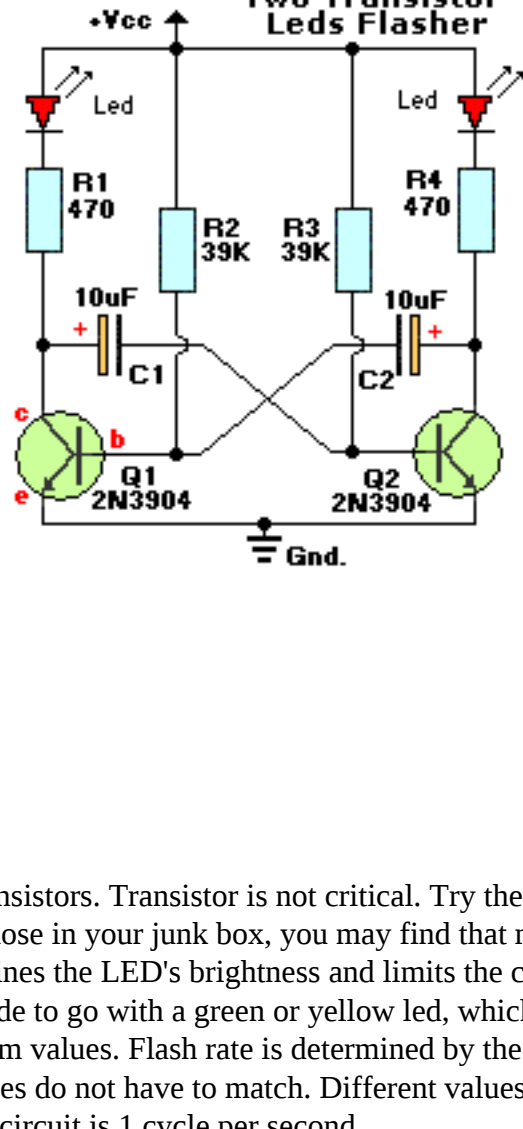
- R1 = 10M, 5%
- R2 = 1K - 100K, 5%
- R3 = 470, 5%
- C1 = 0.47µF - 10µF/25V
- D1 = 1N914
- Q1 = 2N3904
- Q2 = 2N3906
- Led = High Brightness Red LED

Volts	R1	R2	R3	C1	Approx.	Flash Rate
12	10 Meg	22 K	470	0.47 uf	140	per minute
12	10 Meg	10 K	470	1.0 uF	60	per minute
9	6.8 Meg	1 K	330	6.8 uF	15	per minute
6	3.3 Meg	10 K	220	1.0 uF	80	per minute
3	1.5 Meg	10 K	51	1.0 uF	120	per minute
3	3.3 Meg	47 K	51	0.47 uF	140	per minute

This circuit will flash a bright or high-brightness red LED (5000+ mcd). Good for fake car alarm or other attention getting device. Component values are not critical, try anything else first from your junkbox. Obviously, the 470 ohm resistor (R3) determines the LED's brightness and limits the current flow to about 20mA. 390 ohm can also be used as a save value. If you decide to go with a green or yellow led, which draw more current, you may want to replace the 470 ohm with an appropriate value. Flash rate is determined by R2 and C1 and is approximately three time constants (3*R2*C1). R1 provides bias to Q1 which should be low enough not to saturate Q2 with the capacitor disconnected. If the circuit does not oscillate, R1 may be too low or R2 too high. D1 allows for higher duty cycle operation and limits the feedback at the base of Q1 to -0.7 volts. D1 may be omitted for low supply power like 6 - 9V and low duy cycle operation.

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Parts List

- R1,R4 = 470, 5%
- R2,R3 = 39K, 5%
- C1,C2 = 10uF/16V
- Q1,Q2 = 2N3904
- Led's = High Brightness, Red

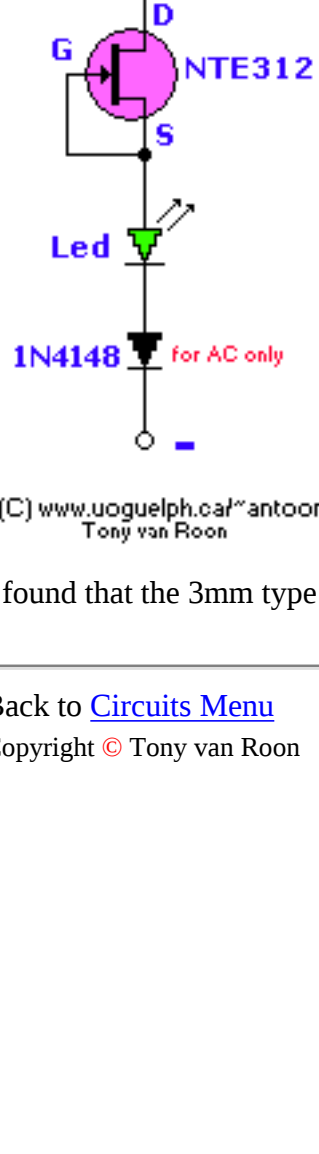
Classic astable multivibrator using 2 transistors. Transistor is not critical. Try these: 2N4401, 2N2222, NTE123A, NTE123AP, NTE159, TUP/TUN and those in your junk box, you may find that most of them will work. Obviously, the 470 ohm resistor determines the LED's brightness and limits the current flow to about 20mA. 390 ohm can also be used as a save value. If you decide to go with a green or yellow led, which draw more current, you may want to replace the 470 ohm with 270 or 330 ohm values. Flash rate is determined by the 39K resistors and the 10uF capacitors (determines the 'ON' time). The two sides do not have to match. Different values for each side can give a nice effect for unique duty-cycles. Flashrate for above circuit is 1 cycle per second.

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Led Pilot Light

by *Tony van Roon*



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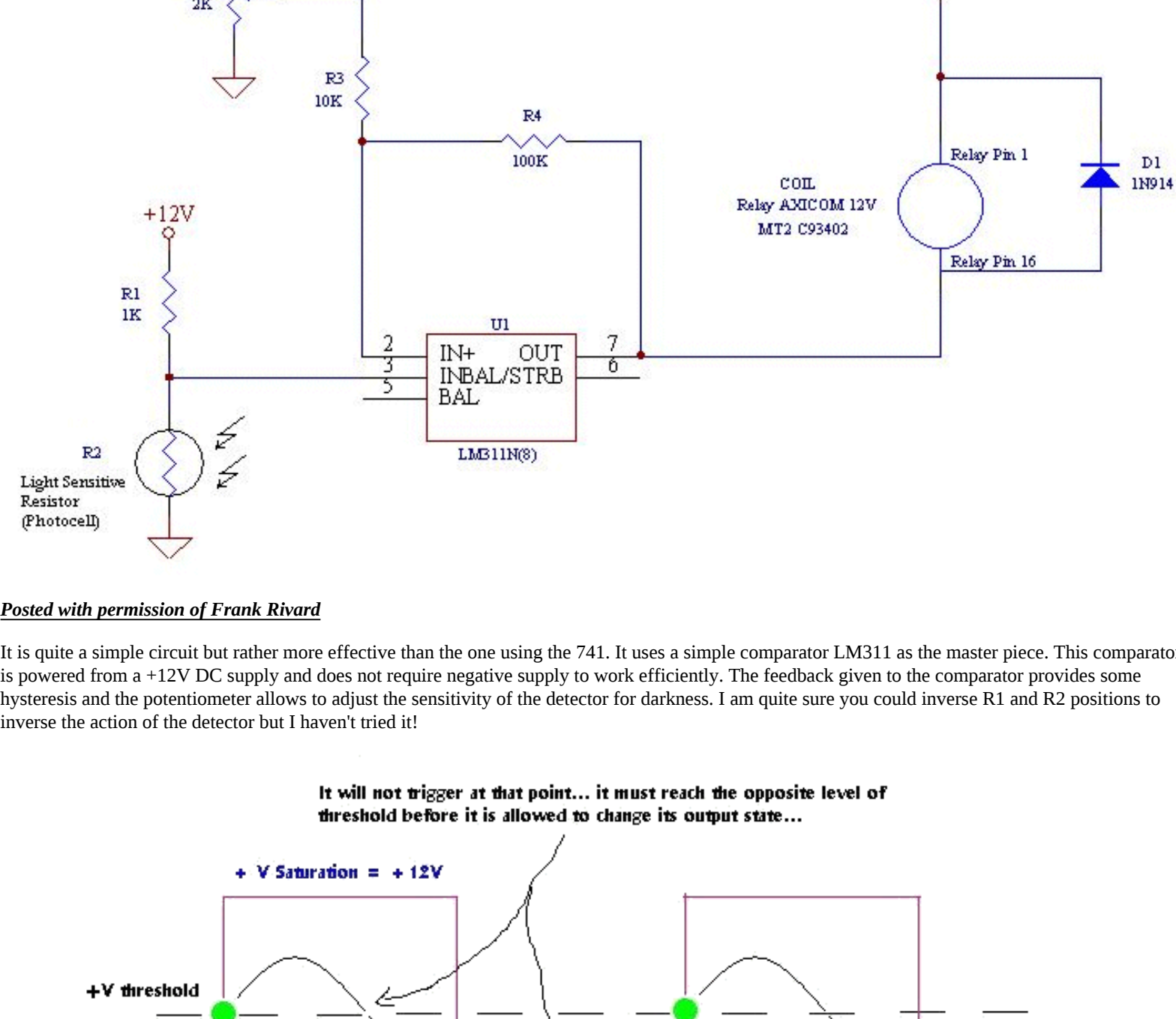
LED's are funny things. They only work at Vdc within specific tolerances, and normally connected with a current limiting resistor to the powersource. Instead of a resistor, you can use a FET (Field Effect Transistor) such as the ECG312, NTE312 which are good for up to 30Vdc max. The MPP102 will also work just fine, just the max voltage is 25V. Other types will also work, just watch the maximum rated voltage versus your input voltage. They easily blow if the you go above the maximum specifications. Keep in mind that, although the circuit works as shown, it is not protected against voltage spikes. You can add that feature yourself if needed. I actually strongly recommend it.

When the gate and the source are connected together, it behaves as a current regulator. In the circuit above the current is constant between 6 and 8 mA at 5 to 30Vdc. Because of the set current of around 6mA the older LED's will glow faintly at best. I'm talking about the led types from the 70's wich are still kicking around. And another tip, try to get the results you want with a variable powersupply and start with about 5volts or so. It may save a couple types of J-Fets from early retirement... :-)

If a diode is added such as a 1N4148 or similar, it can be connected to a AC source of 5 to 20 V-AC (NTE312).

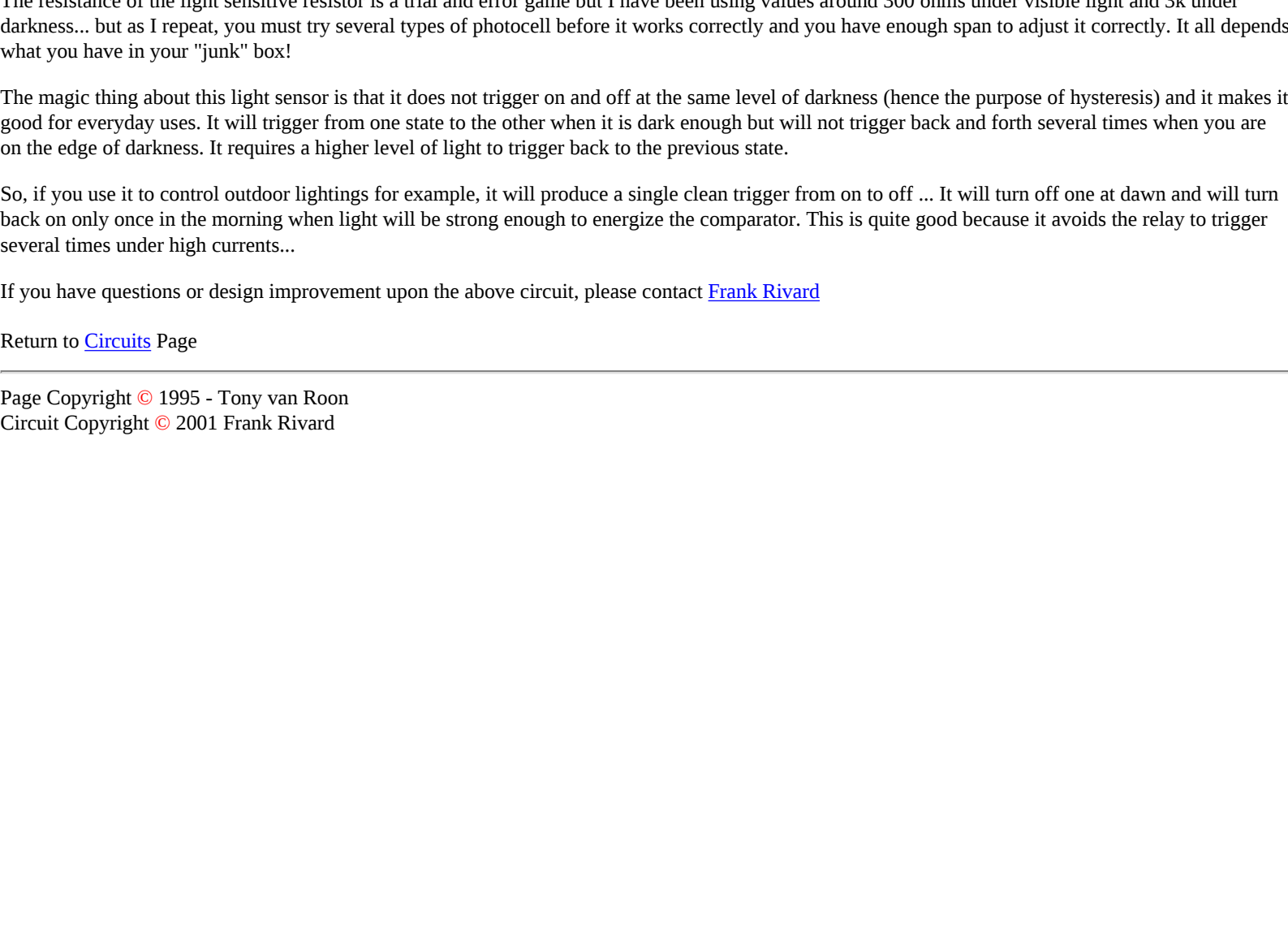
I found that the 3mm type led's work best and give the green leds preference.

Light Sensor with Hysteresis



Posted with permission of Frank Rivard

It is quite a simple circuit but rather more effective than the one using the 741. It uses a simple comparator LM311 as the master piece. This comparator is powered from a +12V DC supply and does not require negative supply to work efficiently. The feedback given to the comparator provides some hysteresis and the potentiometer allows to adjust the sensitivity of the detector for darkness. I am quite sure you could inverse R1 and R2 positions to inverse the action of the detector but I haven't tried it!



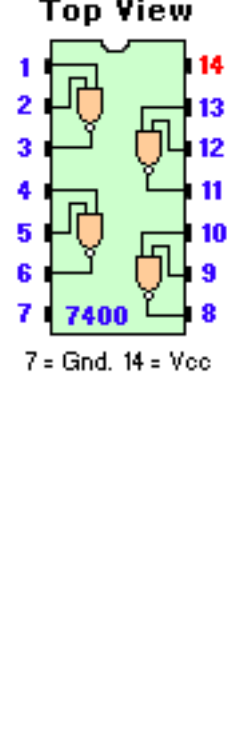
The resistance of the light sensitive resistor is a trial and error game but I have been using values around 300 ohms under visible light and 3k under darkness... but as I repeat, you must try several types of photocell before it works correctly and you have enough span to adjust it correctly. It all depends what you have in your "junk" box!

The magic thing about this light sensor is that it does not trigger on and off at the same level of darkness (hence the purpose of hysteresis) and it makes it good for everyday uses. It will trigger from one state to the other when it is dark enough but will not trigger back and forth several times when you are on the edge of darkness. It requires a higher level of light to trigger back to the previous state.

So, if you use it to control outdoor lightings for example, it will produce a single clean trigger from on to off ... It will turn off one at dawn and will turn back on only once in the morning when light will be strong enough to energize the comparator. This is quite good because it avoids the relay to trigger several times under high currents...

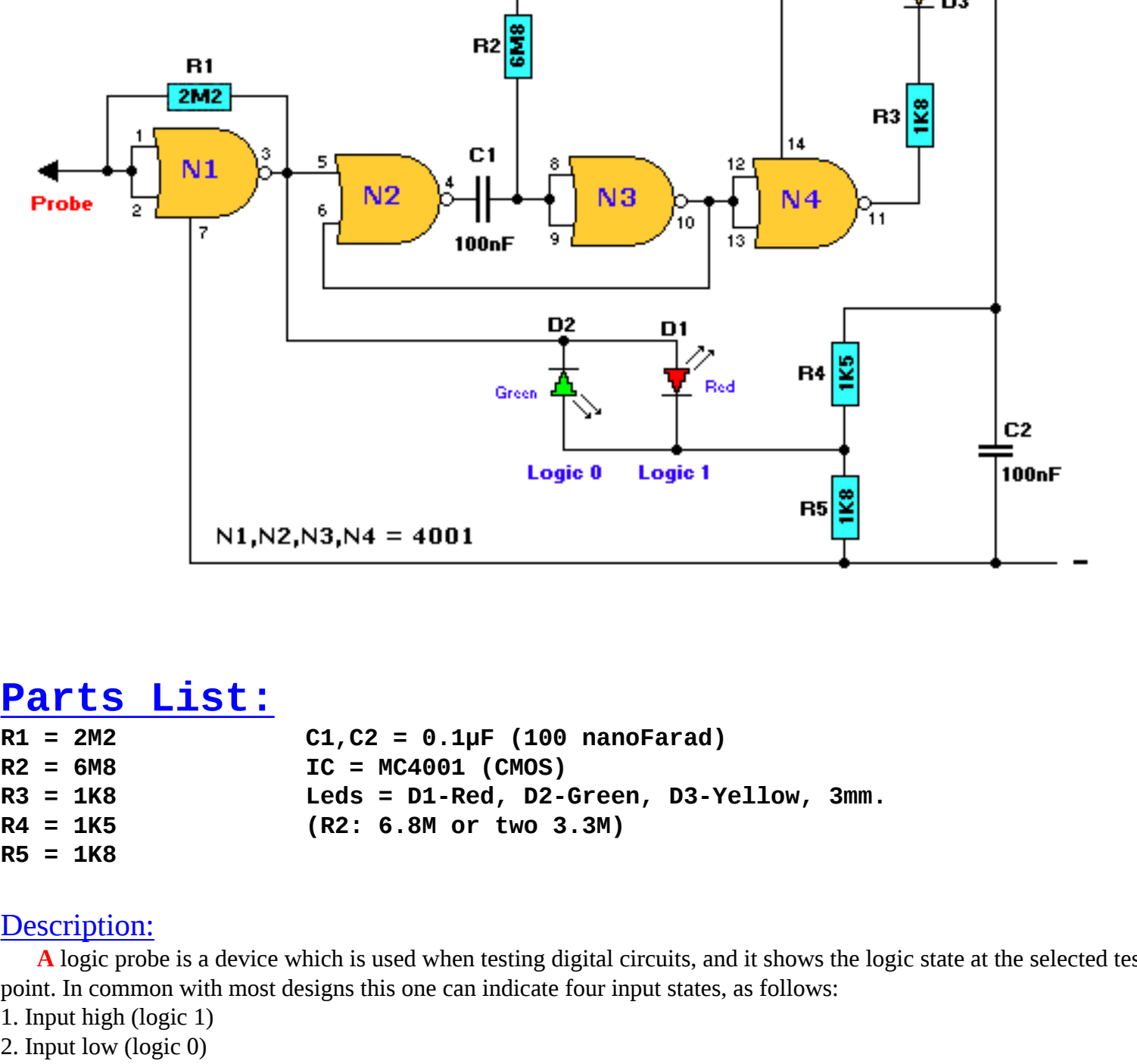
If you have questions or design improvement upon the above circuit, please contact [Frank Rivard](#)

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CMOS Logic Probe

http://www.uoguelph.ca/~antoon



Parts List:

R1 = 2M2
R2 = 6M8
R3 = 1K8
R4 = 1K5
R5 = 1K8
C1, C2 = 0.1µF (100 nanoFarad)
IC = MC4001 (CMOS)
Leds = D1-Red, D2-Green, D3-Yellow, 3mm.
(R2: 6.8M or two 3.3M)

Description:

A logic probe is a device which is used when testing digital circuits, and it shows the logic state at the selected test point. In common with most designs this one can indicate four input states, as follows:

1. Input high (logic 1)
2. Input low (logic 0)
3. Input pulsing (pulse)
4. Input floating

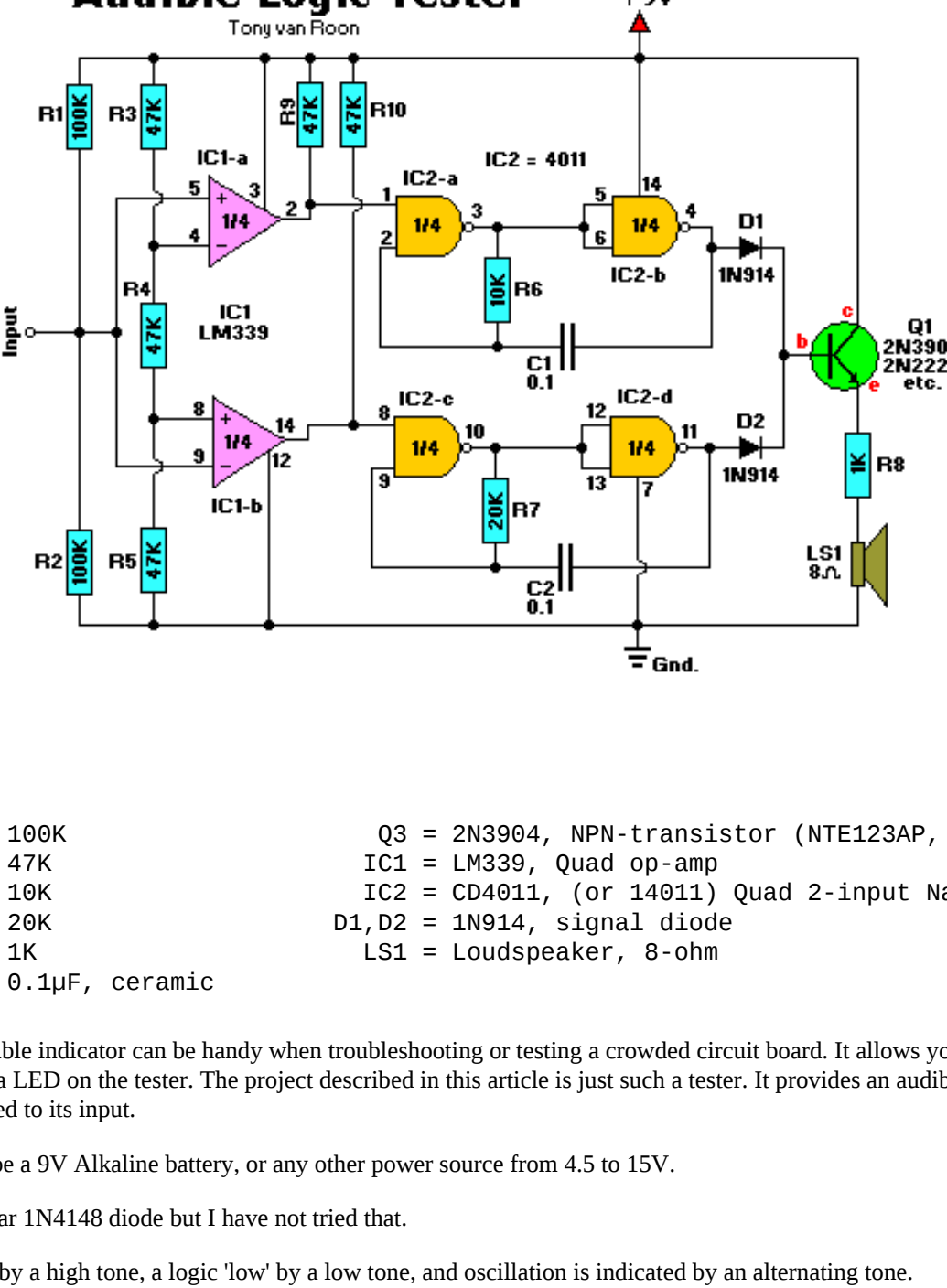
This circuit uses the four 2 input NOR gates contained within the 4001 CMOS IC, and is primarily intended for testing cmos circuits. The probe derives its power from the supply of the circuit being tested. The first gate, N1, has its inputs tied together so that it operates as an inverter, and it is biased by R1 so that roughly half the supply potential appears at its output. A similar voltage appears at the junction of R4 and R5, and so no significant voltage will be developed across D1 and D2 which are connected between this junction and gate 1's output pin 3. Thus under quiescent conditions, or if the probe is connected to a floating test point, neither D1 or D2 will light up. If the input is taken to a high logic point, gate 1's output will go low and switch on D1(red), giving a logic 'high' indication. If the input is taken to a low test point, gate 1's output pin 3 will go high and light D2(green) to indicate a logic 'low'.

A pulsed input will contains both logic states, causing both Led's D1 and D2 to switch on alternately. However, if the duty cycle of the input signal is very high this may result in one indicator lighting up very brightly while the other does not visibly glow at all. In order to give a more reliable indication of a pulsed input, gates N2 to N4 are connected as a buffered output monostable multivibrator. The purpose of this circuit is to produce an output pulse of predetermined length (about 1/2 a second in this case) whenever it receives a positive going input pulse. The length of the input pulse has no significant effect on the output pulse. Led D3 is connected at the output of the monostable, and is switched on for about 1/2 a second whenever the monostable is triggered, regardless of how brief the triggering input pulse happens to be. Therefore, a pulsing input will be clearly visible by the yellow Led D3 switching on. The various outputs will be: Floating input -- all Leds off. Logic 0 input -- D2 (green) switched on (D3 briefly flashes on). Logic 1 input -- D1 switched on. Pulsing input -- D3(yellow) switched on or pulsing in the case of a low frequency input signal (one or both of the other indicators will switch on, showing if one input state pre-dominates).

The finished project can easily be housed in a magic marker felt pen or something. The probe-tip is made of a piece of piano wire, but a bronze finishing nail is a good choice too. Solder the probe wire to the nail or pianowire and you are all set. Have fun building it and make it part of your trouble-shooting equipment.

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- Parts List:**
- | | |
|---------------------------|---|
| R1, R2 = 100K | Q3 = 2N3904, NPN-transistor (NTE123AP, 2N2222(A), etc.) |
| R3, R4, R5, R9, R10 = 47K | IC1 = LM339, Quad op-amp |
| R6 = 10K | IC2 = CD4011, (or 14011) Quad 2-input Nand |
| R7 = 20K | D1, D2 = 1N914, signal diode |
| R8 = 1K | LS1 = Loudspeaker, 8-ohm |
| C1, C2 = 0.1µF, ceramic | |

A logic tester with an audible indicator can be handy when troubleshooting or testing a crowded circuit board. It allows you to keep your eyes on the circuit, rather than on a LED on the tester. The project described in this article is just such a tester. It provides an audible indication of the logic level of the signal presented to its input.

Power for the circuit can be a 9V Alkaline battery, or any other power source from 4.5 to 15V.

D1/D2 can be also a regular 1N4148 diode but I have not tried that.

A logic 'high' is indicated by a high tone, a logic 'low' by a low tone, and oscillation is indicated by an alternating tone.

The input is high impedance, so it will not load down the circuit under test. It can be used to troubleshoot both TTL or CMOS logic.

The choice for Q1 is not critical. It is a NPN, general purpose type. Almost anything will do: 2N4401, 2N2222, BC548, TUN, ECG123AP, etc. Originally the circuit called for 50K resistors for R3, R4, and R5, but 47K or 51K will do fine. It is just a voltage divider and either value will work.

For R7 use two 10K resistors in series if you can't find the 20K value.

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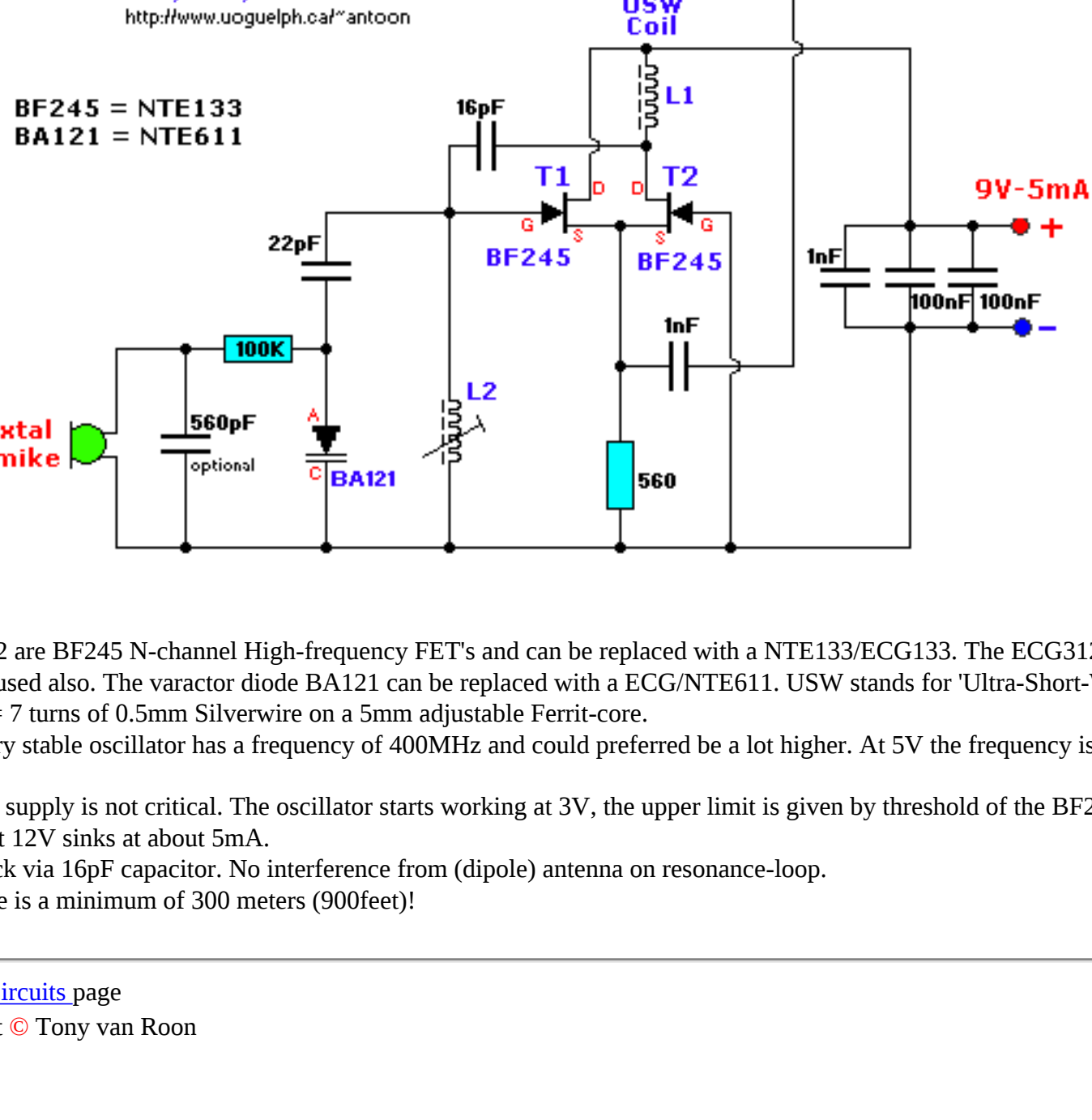
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Micro-Spy with FETs

by Tony van Rooy

<http://www.uoguelph.ca/~antoon>

BF245 = NTE133
BA121 = NTE611



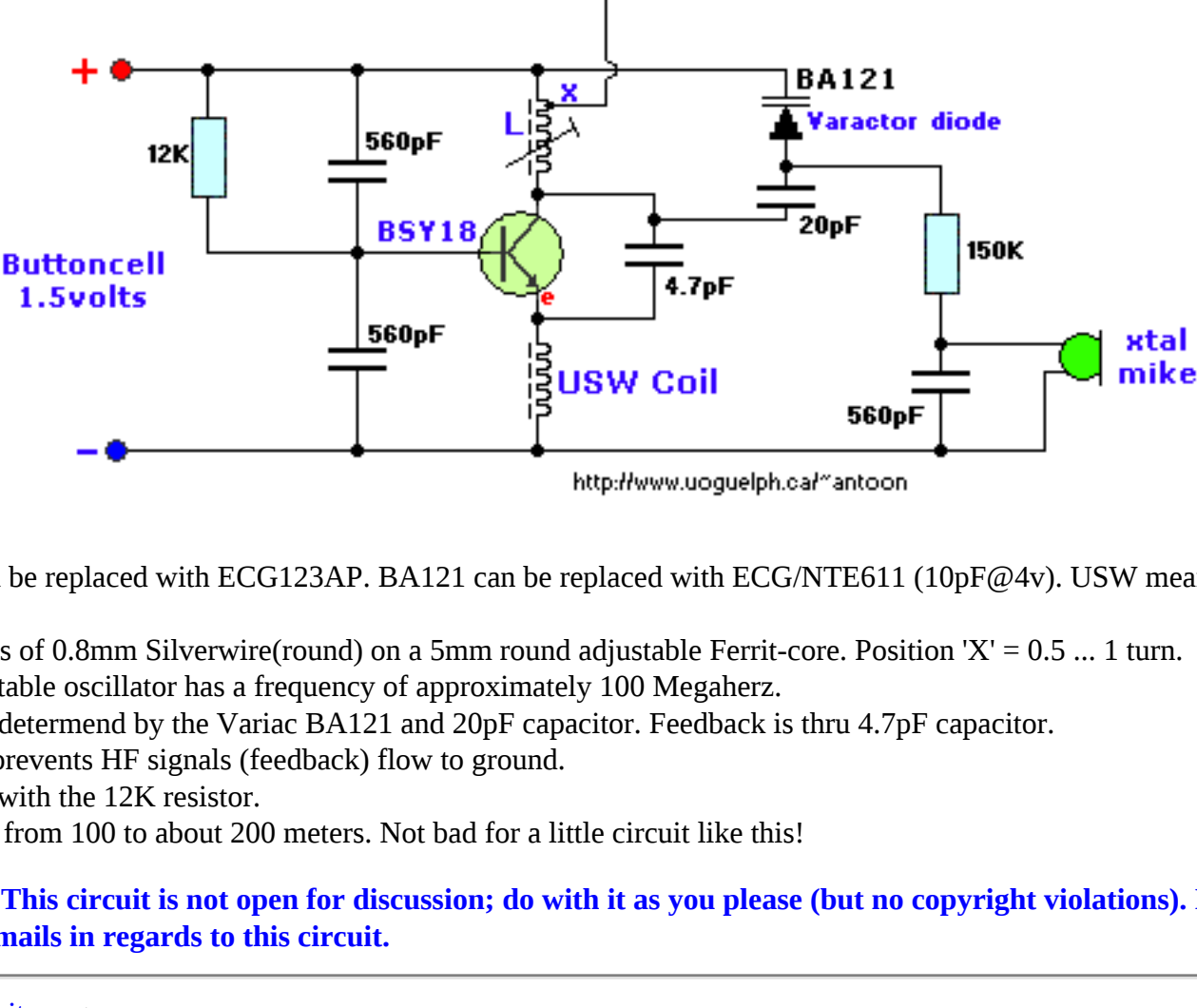
- o T1 & T2 are BF245 N-channel High-frequency FET's and can be replaced with a NTE133/ECG133. The ECG312 could likely be used also. The varactor diode BA121 can be replaced with a ECG/NTE611. USW stands for "Ultra-Short-Wave".
- o L1/L2 = 7 turns of 0.5mm Silverwire on a 5mm adjustable Ferrit-core.
- o This very stable oscillator has a frequency of 400MHz and could preferred be a lot higher. At 5V the frequency is around 137MHz.
- o Voltage supply is not critical. The oscillator starts working at 3V, the upper limit is given by threshold of the BF245 and is 30V. At 12V sinks at about 5mA.
- o Feedback via 16pF capacitor. No interference from (dipole) antenna on resonance-loop.
- o Distance is a minimum of 300 meters (900feet)!

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Shortwave Bug

by Tony van Roon



- o BSY18 can be replaced with ECG123AP. BA121 can be replaced with ECG/NTE611 (10pF@4v). USW means 'Ultra-Short-Wave'.
- o L1 = 7 turns of 0.8mm Silverwire(round) on a 5mm round adjustable Ferrii-core. Position 'X' = 0.5 ... 1 turn.
- o This very stable oscillator has a frequency of approximately 100 Megaherz.
- o Frequency determend by the Variac BA121 and 20pF capacitor. Feedback is thru 4.7pF capacitor.
- o USW coil prevents HF signals (feedback) flow to ground.
- o DC biased with the 12K resistor.
- o Distance is from 100 to about 200 meters. Not bad for a little circuit like this!

Please note: This circuit is not open for discussion; do with it as you please (but no copyright violations). I will answer no emails in regards to this circuit.

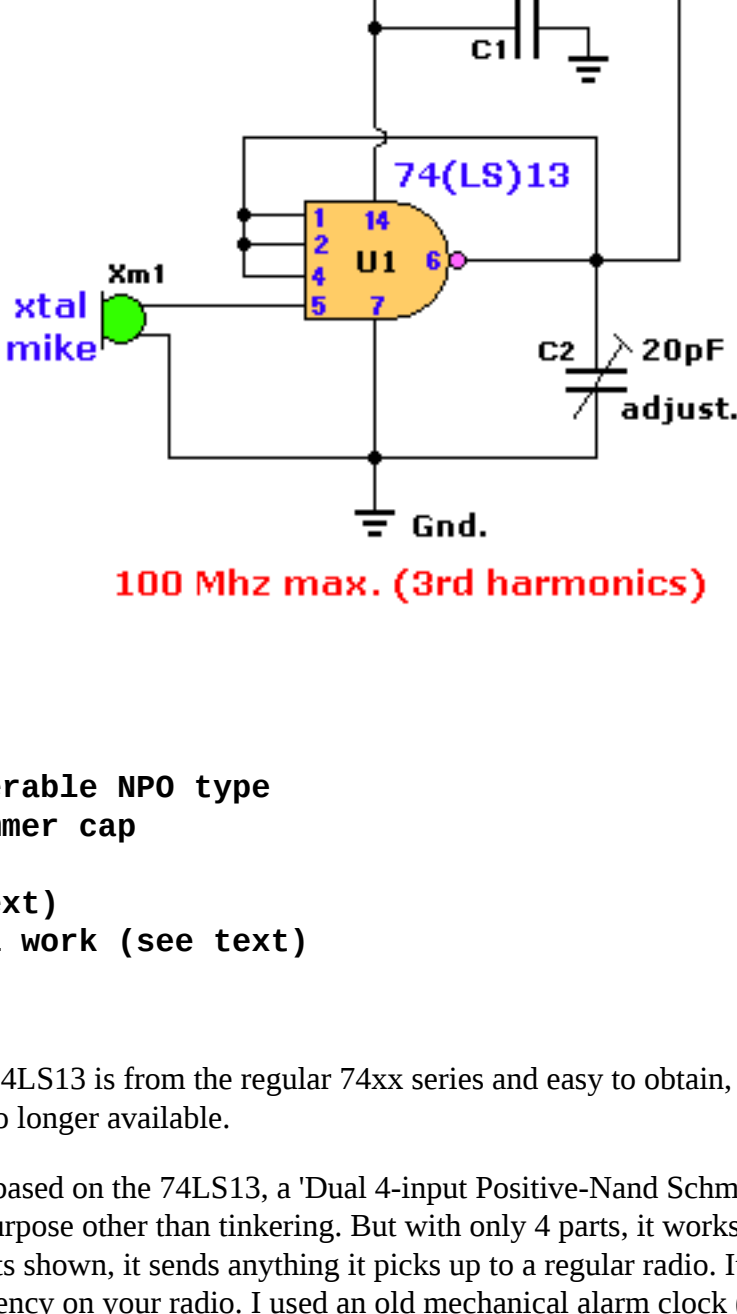
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TTL Micro-Spy

by Tony van Roon

<http://www.uoguelph.ca/~antoon/>



Parts List:

C1 = 10nF, ceramic. Preferable NPO type

C2 = 20pF adjustable trimmer cap

IC1 = 74LS13

Xm = Crystal Mike (see text)

Ant = Almost anything will work (see text)

Couple Notes:

This circuit is old (70's) but since the 74LS13 is from the regular 74xx series and easy to obtain, I decided to keep the circuit in place until components are no longer available.

Not much to tell here. Performance is based on the 74LS13, a 'Dual 4-input Positive-Nand Schmitt Trigger'. This circuit was experimental and so has no real purpose other than tinkering. But with only 4 parts, it works. Working on the 3rd harmonics (100MHz) and with the parts shown, it sends anything it picks up to a regular radio. It may take a bit of experimentation to find the right frequency on your radio. I used an old mechanical alarm clock (with those large bells) and put the microphone close to it. That allowed me to find the "tick-tack" signal on my radio at my leisure. The adjustable trimmer cap (C2) will fine-tune performance and sensitivity a bit by balancing the output signal to ground. Sound is picked up by the mike and fed to pin 5 which acts as a pre-amp stage. The other 3 inputs are configured to send out the amplified signal.

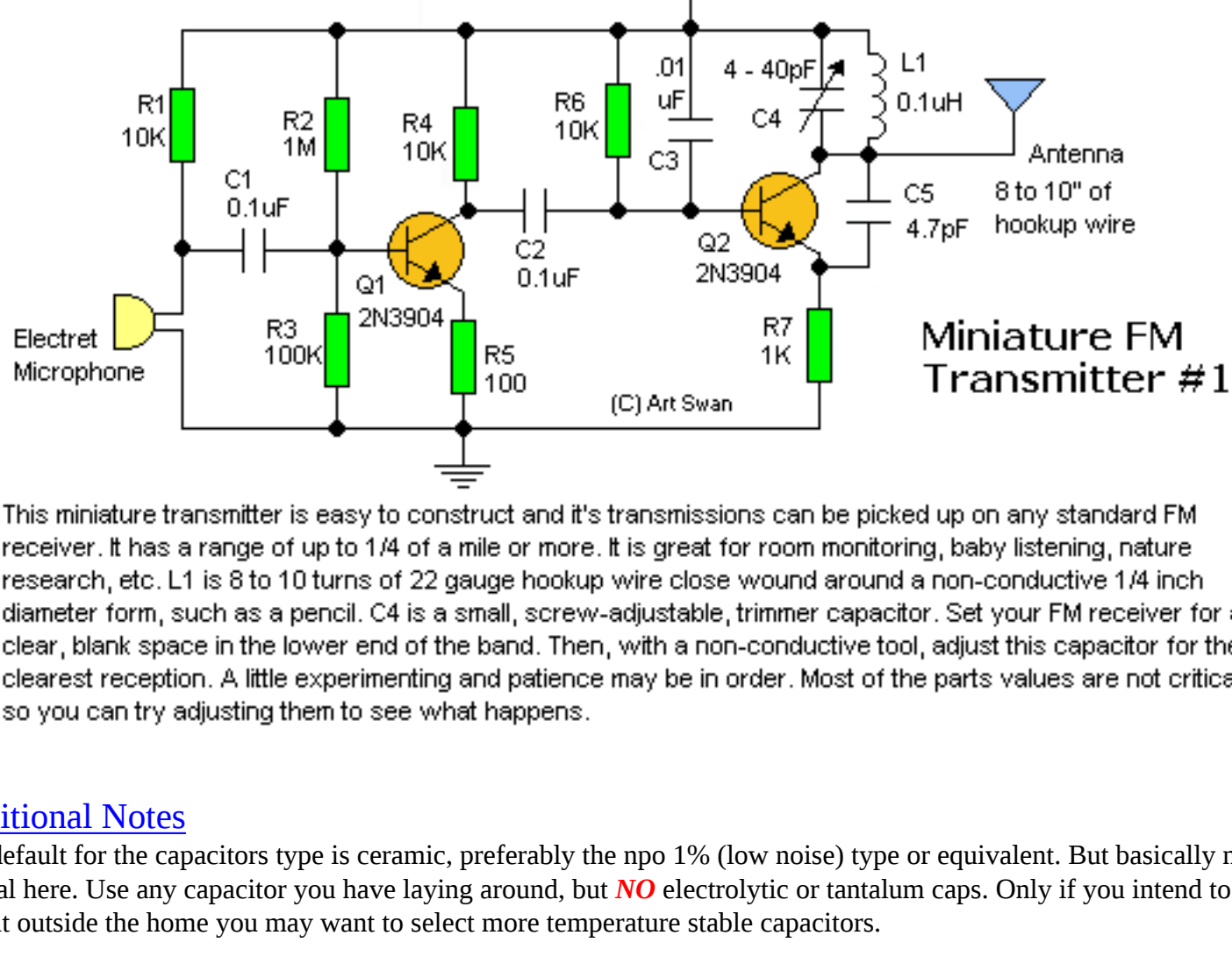
The crystal mike is actually one of those 'oldie' large clumsy pink ear pieces which where popular in the 70's. They are still available at Tandy/RadioShack or your local electronics parts shop. To use as a microphone, unscrew the plastic earpiece.

As you probably already noticed the power, and consequently the transmitting distance, is small. I believe if I remember well at the most 10 to 30 feet or so but depends on the antenna and input voltage. I used a piece of thin, 12" piano wire. But use whatever performs best. Regular wire can also be used.

Voltage to the circuit must *not* exceed 7 volts for the 'LS' type. However, for the regular 7413 model that is only 5.5 volts. C1 is decoupling any possible little spikes on the power rail.

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Miniature FM Transmitter #1

This miniature transmitter is easy to construct and it's transmissions can be picked up on any standard FM receiver. It has a range of up to 1/4 of a mile or more. It is great for room monitoring, baby listening, nature research, etc. L1 is 8 to 10 turns of 22 gauge hookup wire close wound around a non-conductive 1/4 inch diameter form, such as a pencil. C4 is a small, screw-adjustable, trimmer capacitor. Set your FM receiver for a clear, blank space in the lower end of the band. Then, with a non-conductive tool, adjust this capacitor for the clearest reception. A little experimenting and patience may be in order. Most of the parts values are not critical, so you can try adjusting them to see what happens.

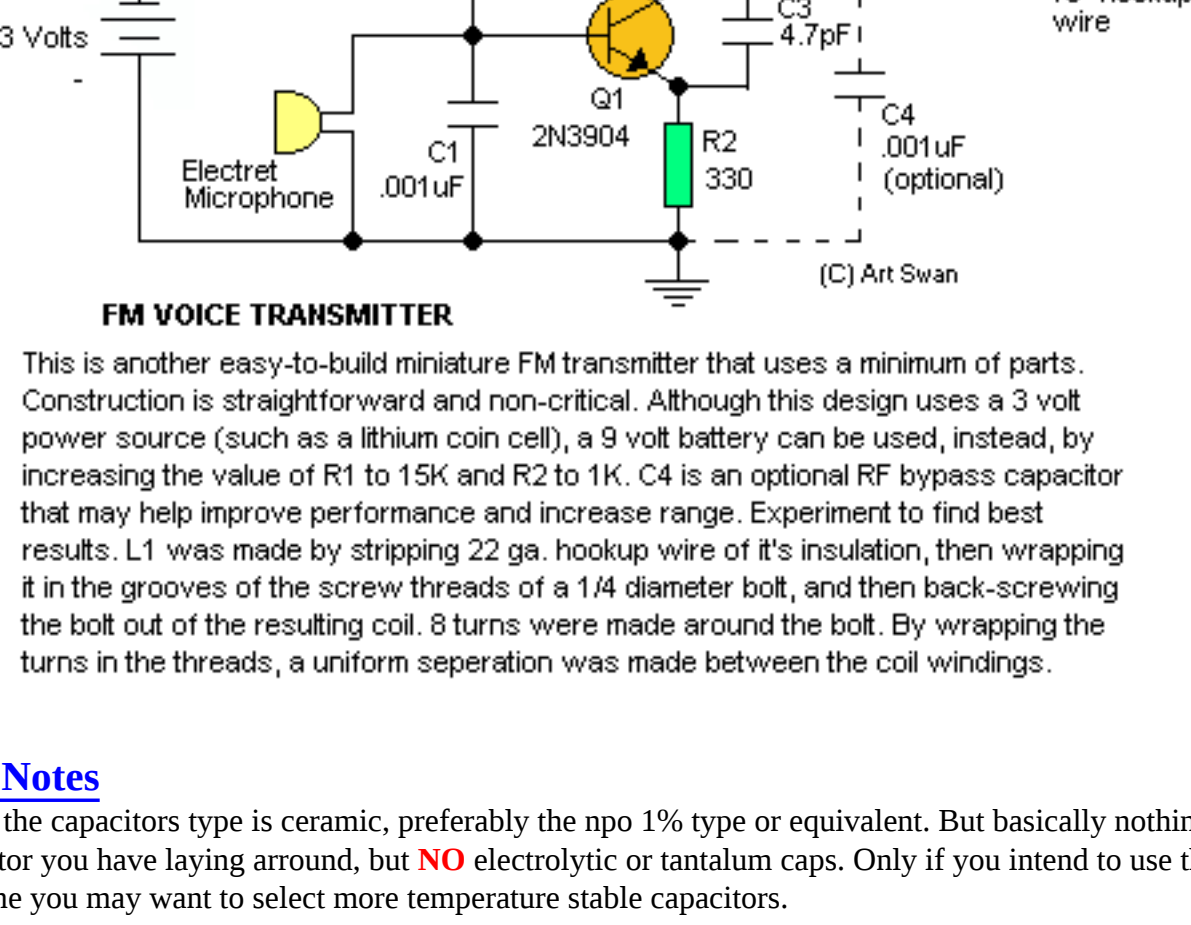
Additional Notes

The default for the capacitors type is ceramic, preferably the npo 1% (low noise) type or equivalent. But basically nothing critical here. Use any capacitor you have laying around, but **NO** electrolytic or tantalum caps. Only if you intend to use this circuit outside the home you may want to select more temperature stable capacitors.

To find the signal on your receiver, make sure there is a signal coming into the microphone, otherwise the circuit won't work. I use an old mechanical alarm clock (you know, with those two large bells on it). I put this clock by the microphone which picks up the loud tick-tock. I'm sure you get the idea... Or you can just lightly tap the microphone while searching for the location of the signal on your receiver.

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Miniature FM Transmitter #2



FM VOICE TRANSMITTER

This is another easy-to-build miniature FM transmitter that uses a minimum of parts. Construction is straightforward and non-critical. Although this design uses a 3 volt power source (such as a lithium coin cell), a 9 volt battery can be used, instead, by increasing the value of R1 to 15K and R2 to 1K. C4 is an optional RF bypass capacitor that may help improve performance and increase range. Experiment to find best results. L1 was made by stripping 22 ga. hookup wire of it's insulation, then wrapping it in the grooves of the screw threads of a 1/4 diameter bolt, and then back-screwing the bolt out of the resulting coil. 8 turns were made around the bolt. By wrapping the turns in the threads, a uniform seperation was made between the coil windings.

Additional Notes

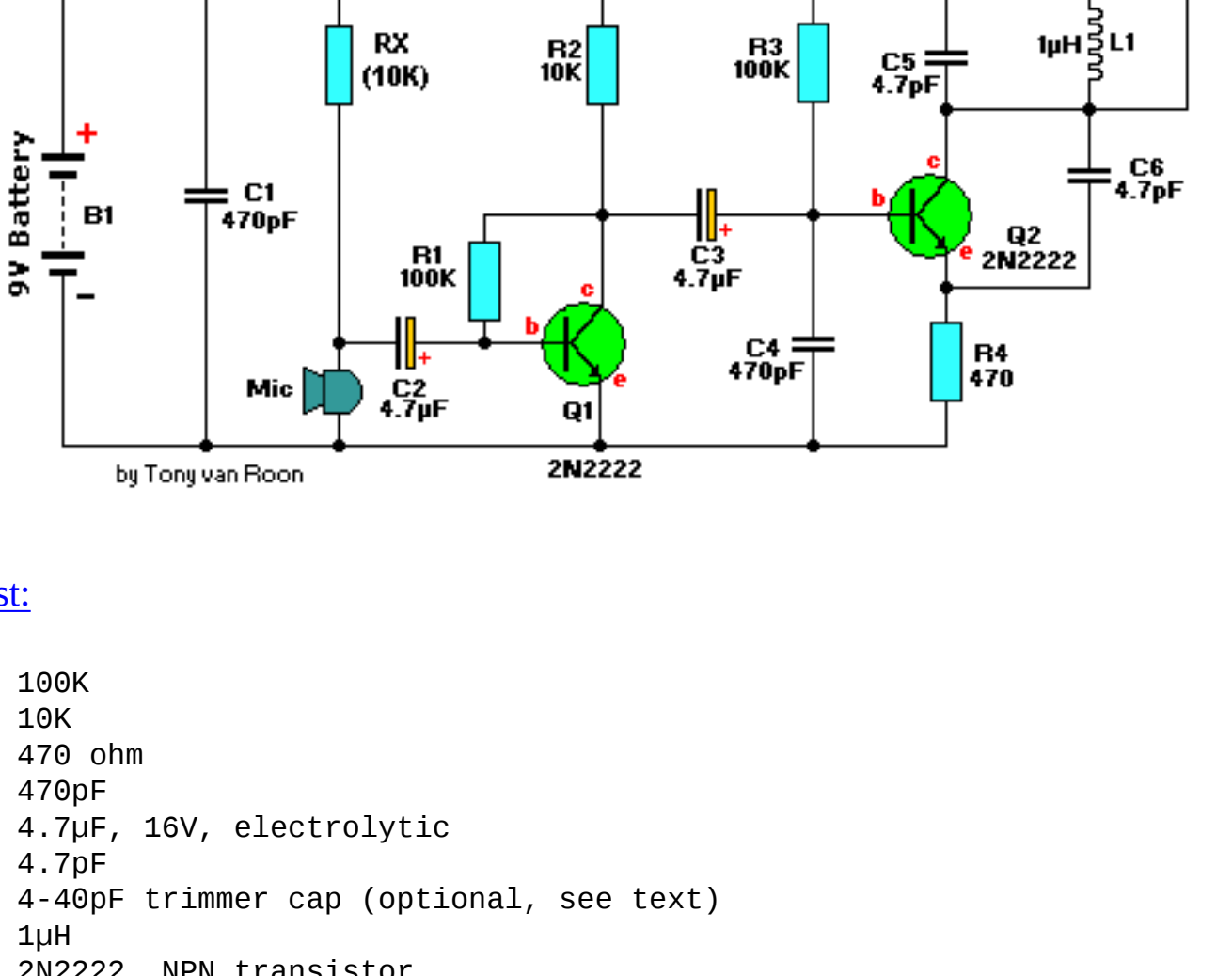
The default for the capacitors type is ceramic, preferably the npo 1% type or equivalent. But basically nothing critical here. Use any capacitor you have laying around, but **NO** electrolytic or tantalum caps. Only if you intend to use this circuit outside the home you may want to select more temperature stable capacitors.

To find the signal on your receiver, make sure there is a signal coming into the microphone, otherwise the circuit won't work. I use an old mechanical alarm clock (you know, with those two large bells on it). I put this clock by the microphone which picks up the loud tick-tock. I'm sure you get the idea... Or you can just lightly tap the microphone while searching for the location of the signal on your receiver.

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FM-Transmitter
<http://www.uoguelph.ca/~antoon>

FMT-4



Notes:
Nothing critic

The antenna is not

To find the sign

work. I use an old me-

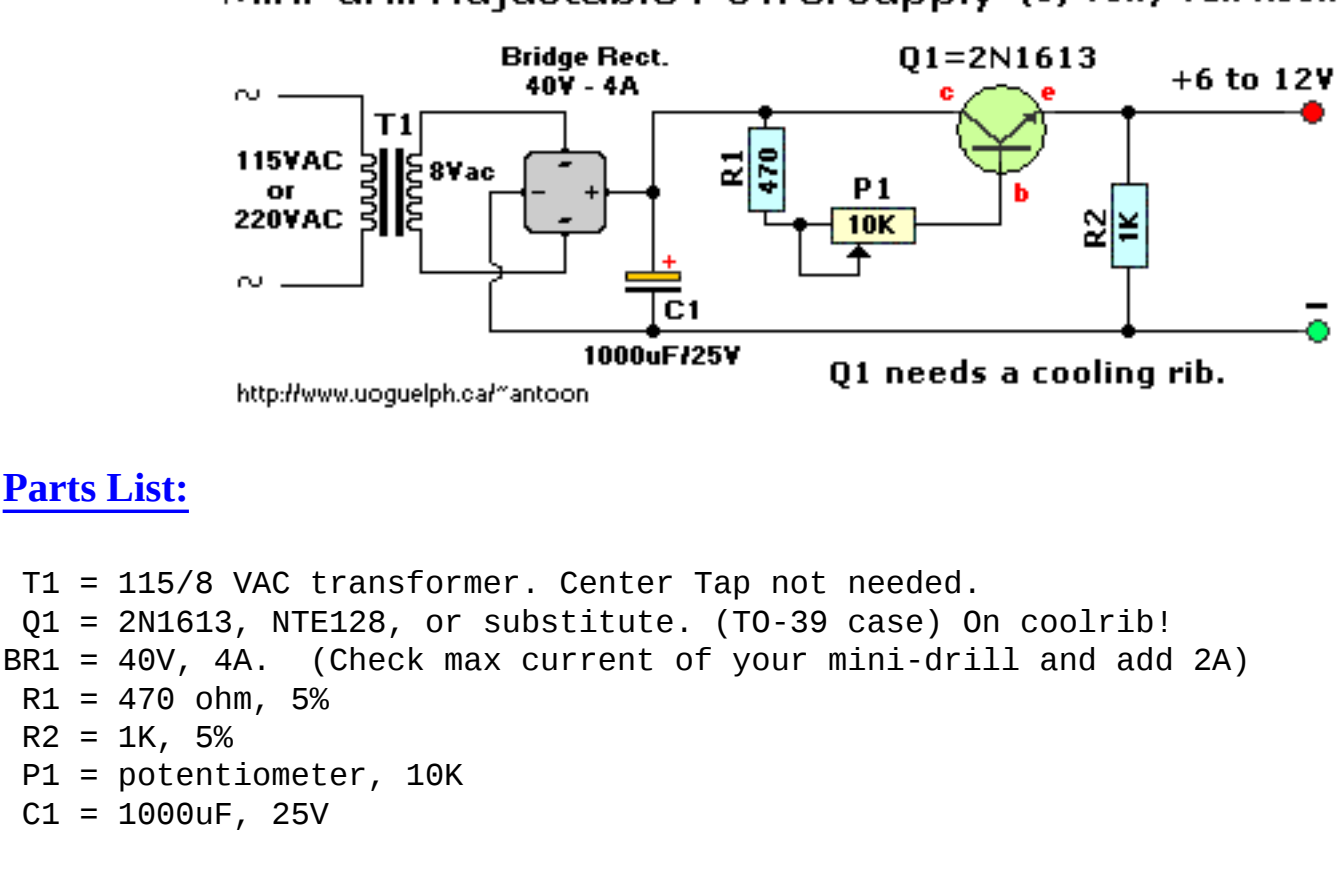
which picks up the $\mathbf{I}$ for the location of the

for the location of the signal on your receiver.

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Parts List:

- T1 = 115/8 VAC transformer. Center Tap not needed.
Q1 = 2N1613, NTE128, or substitute. (TO-39 case) On coolrib!
BR1 = 40V, 4A. (Check max current of your mini-drill and add 2A)
R1 = 470 ohm, 5%
R2 = 1K, 5%
P1 = potentiometer, 10K
C1 = 1000uF, 25V

Notes:

C1 filters the noise and spikes off the ac. If you find the circuit output too noisy add another electrolytic capacitor over the output terminals. Value can be between 10 and 100uF/25V. The output voltage is variable with the 10K-potentiometer.

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Basic Missing Pulse Detector

by Tony van Roon -- <http://www.uoguelph.ca/~antoon>

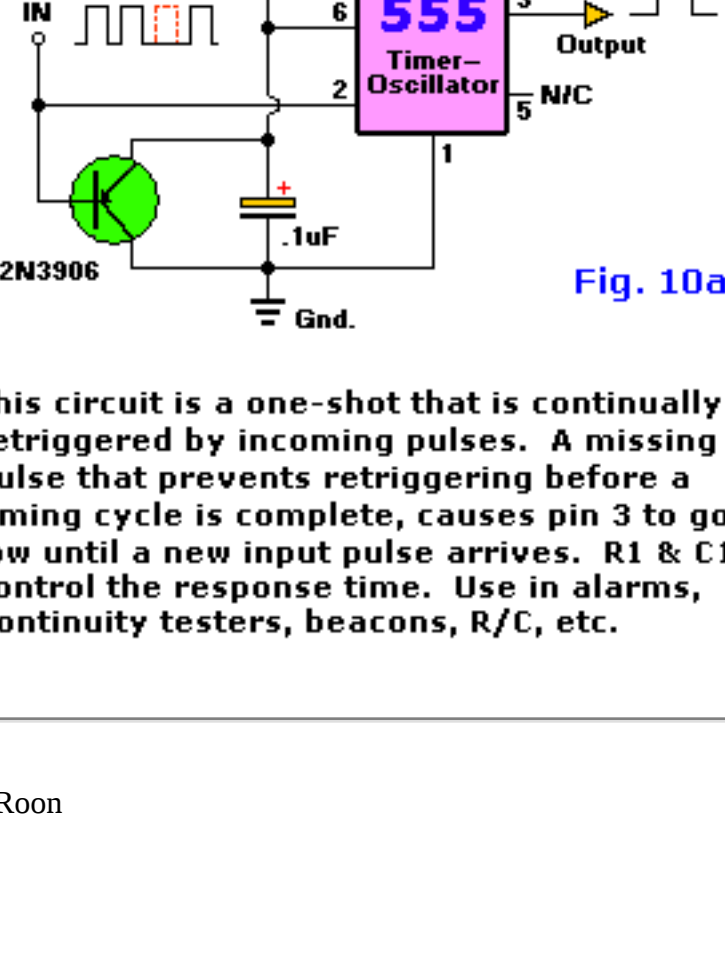


Fig. 10a

This circuit is a one-shot that is continually retriggered by incoming pulses. A missing pulse that prevents retriggering before a timing cycle is complete, causes pin 3 to go low until a new input pulse arrives. R1 & C1 control the response time. Use in alarms, continuity testers, beacons, R/C, etc.

Morse Code Practice Oscillator

by Tony van Roon

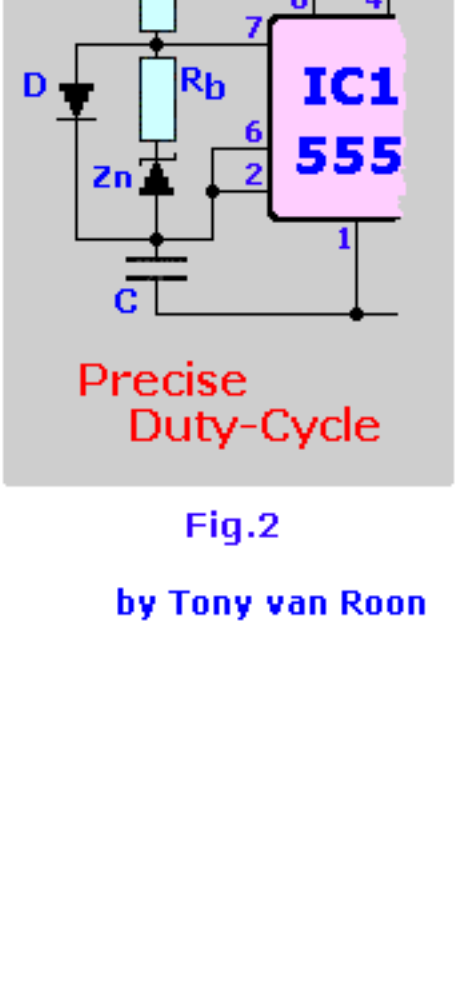
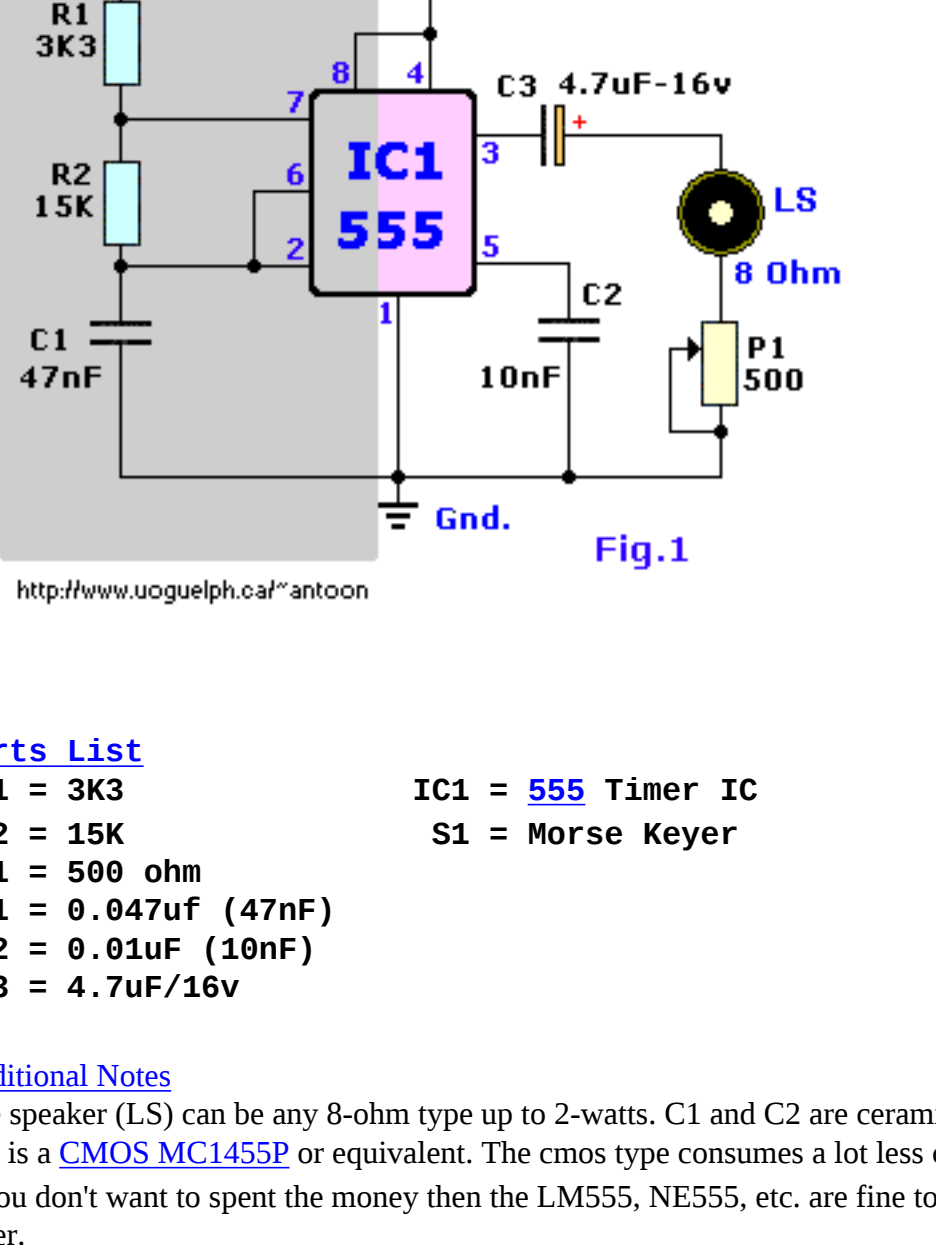


Fig.2

by Tony van Roon

Parts List

- | | |
|---------------------|--------------------|
| R1 = 3K3 | IC1 = 555 Timer IC |
| R2 = 15K | S1 = Morse Keyer |
| P1 = 500 ohm | |
| C1 = 0.047uF (47nF) | |
| C2 = 0.01uF (10nF) | |
| C3 = 4.7uF/16v | |

Additional Notes

The speaker (LS) can be any 8-ohm type up to 2-watts. C1 and C2 are ceramic capacitors. C3 is an electrolytic type. IC1 is a [CMOS MC1455P](#) or equivalent. The cmos type consumes a lot less current when used with the 9-volt battery, but if you don't want to spent the money then the LM555, NE555, etc. are fine too and are pin-for-pin compatible with each other.

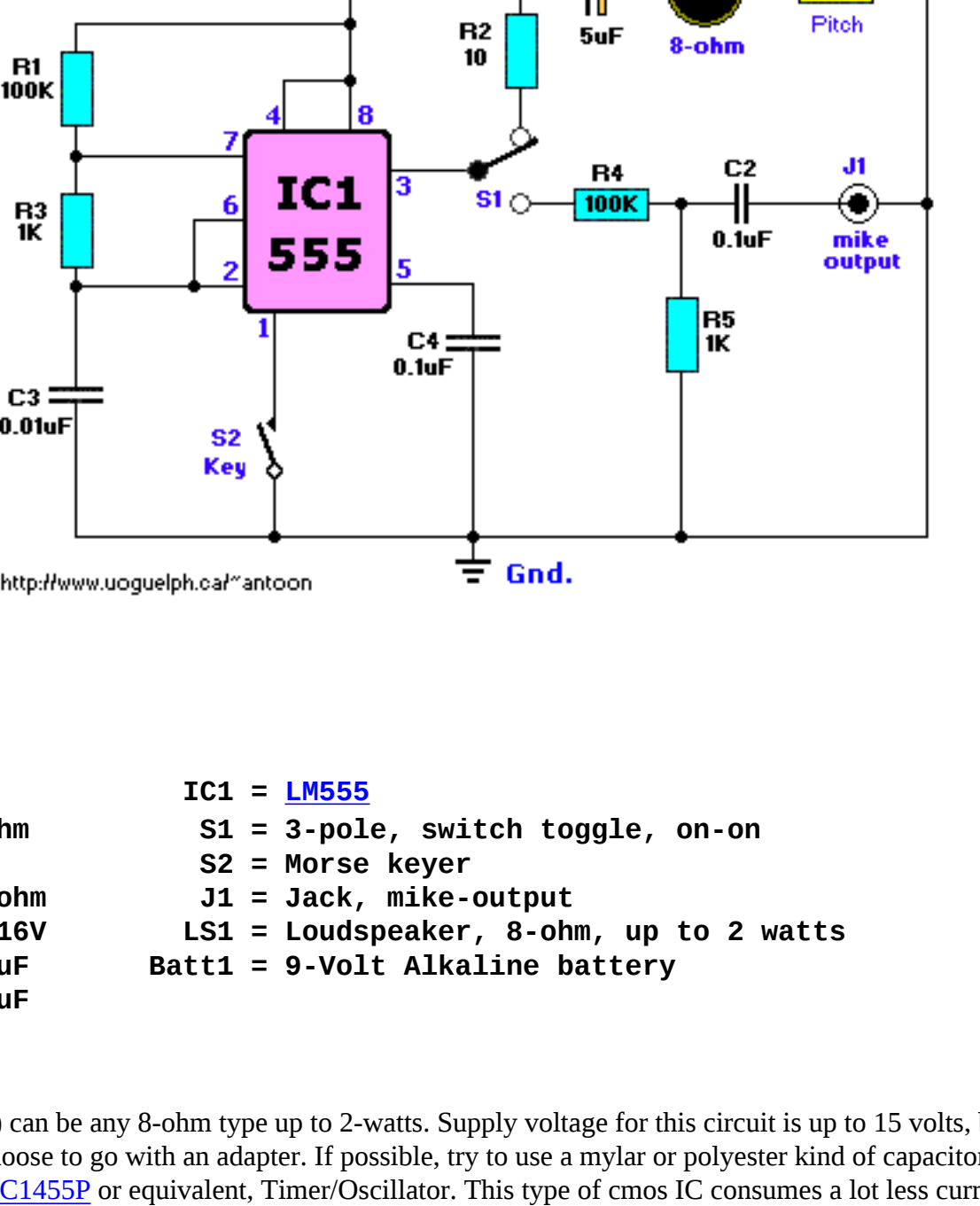
And obviously, S1 is your Morse-keyer. To get a more precise duty-cycle replace the components within the shaded gray area from Fig. 1 with the ones in Fig. 2. The diode can be 1N4148 or equivalent. The zenerdiode is between 5.2 and 5.8 volt. Ra and Rb are experimental to suit your personal taste. C is about the same.

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Morse Code Keyer (2)

by Tony van Roon



<http://www.uoguelph.ca/~antoon>

Parts List:

- | | |
|------------------------|--|
| R1, R4 = 100K | IC1 = LM555 |
| R2 = 10 ohm | S1 = 3-pole, switch toggle, on-on |
| R3, R5 = 1K | S2 = Morse keyer |
| P1 = 500 ohm | J1 = Jack, mike-output |
| C1 = 5uF/16V | LS1 = Loudspeaker, 8-ohm, up to 2 watts |
| C2, C4 = 0.1 uF | Batt1 = 9-Volt Alkaline battery |
| C3 = 0.01uF | |

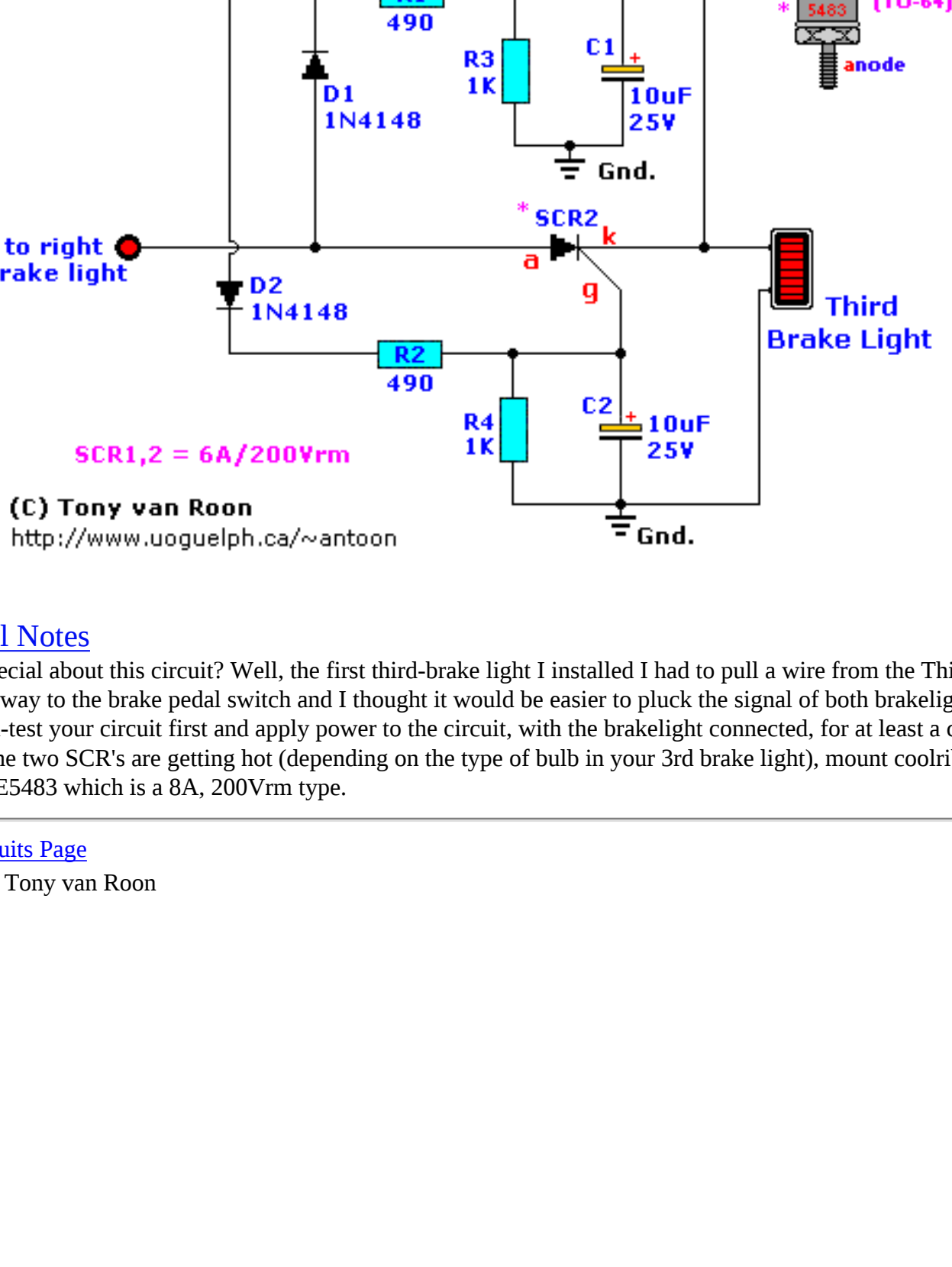
Description:

The speaker (LS1) can be any 8-ohm type up to 2-watts. Supply voltage for this circuit is up to 15 volts, but 12V is more desirable if you choose to go with an adapter. If possible, try to use a mylar or polyester kind of capacitor for C2. IC1 is a CMOS [MC1455P](#) or equivalent, Timer/Oscillator. This type of cmos IC consumes a lot less current when used with the 9-volt battery, but if you don't want to spent the money then the [LM555](#), [NE555](#), etc. are fine too and are pin-for-pin compatible with each other. The timing circuit is formed by R1, R3, and C3. Resistors R4 & R5 are a voltage divider to reduce the microphone output to a safe level. Potentiometer P1 can be used to control the 'Pitch'. Capacitor C5 is used as a bypass capacitor to clean up unwanted noise. C1 is specified as a 5uF electrolytic but a standard 4.7uF will work fine too. S2 is your Morse-key or Paddle. S1 switches between your speaker and the microphone output jack (J1), which you can hookup to your stereo, amplifier, or cassette player. Match J1 with the jack you hook it up to.

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Third Brake Light



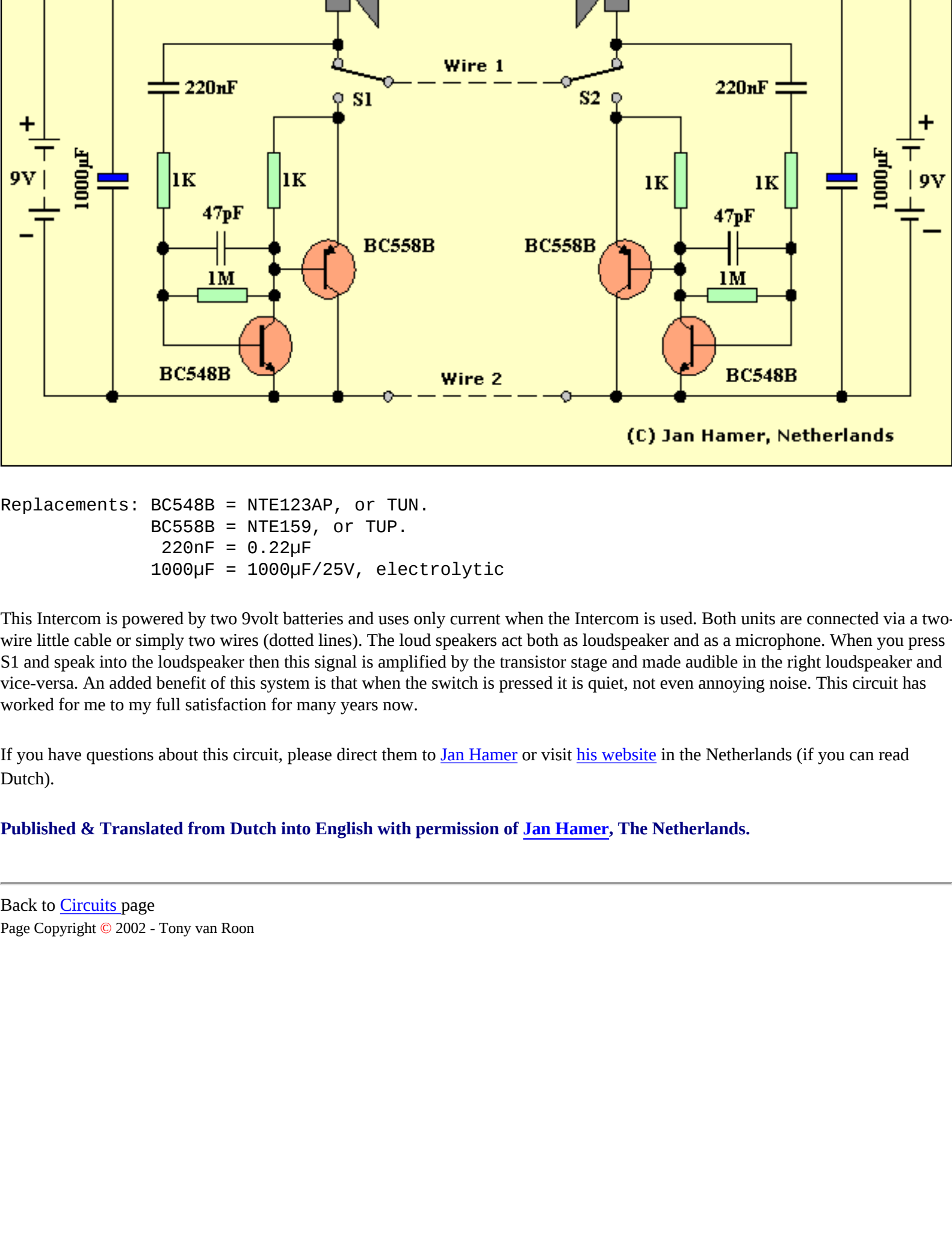
Additional Notes

What's so special about this circuit? Well, the first third-brake light I installed I had to pull a wire from the Third Brake Light all the way to the brake pedal switch and I thought it would be easier to pluck the signal of both brakelights via the trunk. Bench-test your circuit first and apply power to the circuit, with the brakelight connected, for at least a couple of minutes. If the two SCR's are getting hot (depending on the type of bulb in your 3rd brake light), mount coolirbs on them. I used the NTE5483 which is a 8A, 200Vrm type.

Practical Intercom

© by Jan Hamer

"Baby-monitors, baby-phones, or simply intercoms are for sale everywhere in a variety of models and colors. Some work on AC, others wireless or just via a little wire. We all have our preferences. Just in case you're looking for a VERY reliable Intercom, the circuit below will suit your needs."



Replacements: BC548B = NTE123AP, or TUN.
BC558B = NTE159, or TUP.
220nF = 0.22µF
1000µF = 1000µF/25V, electrolytic

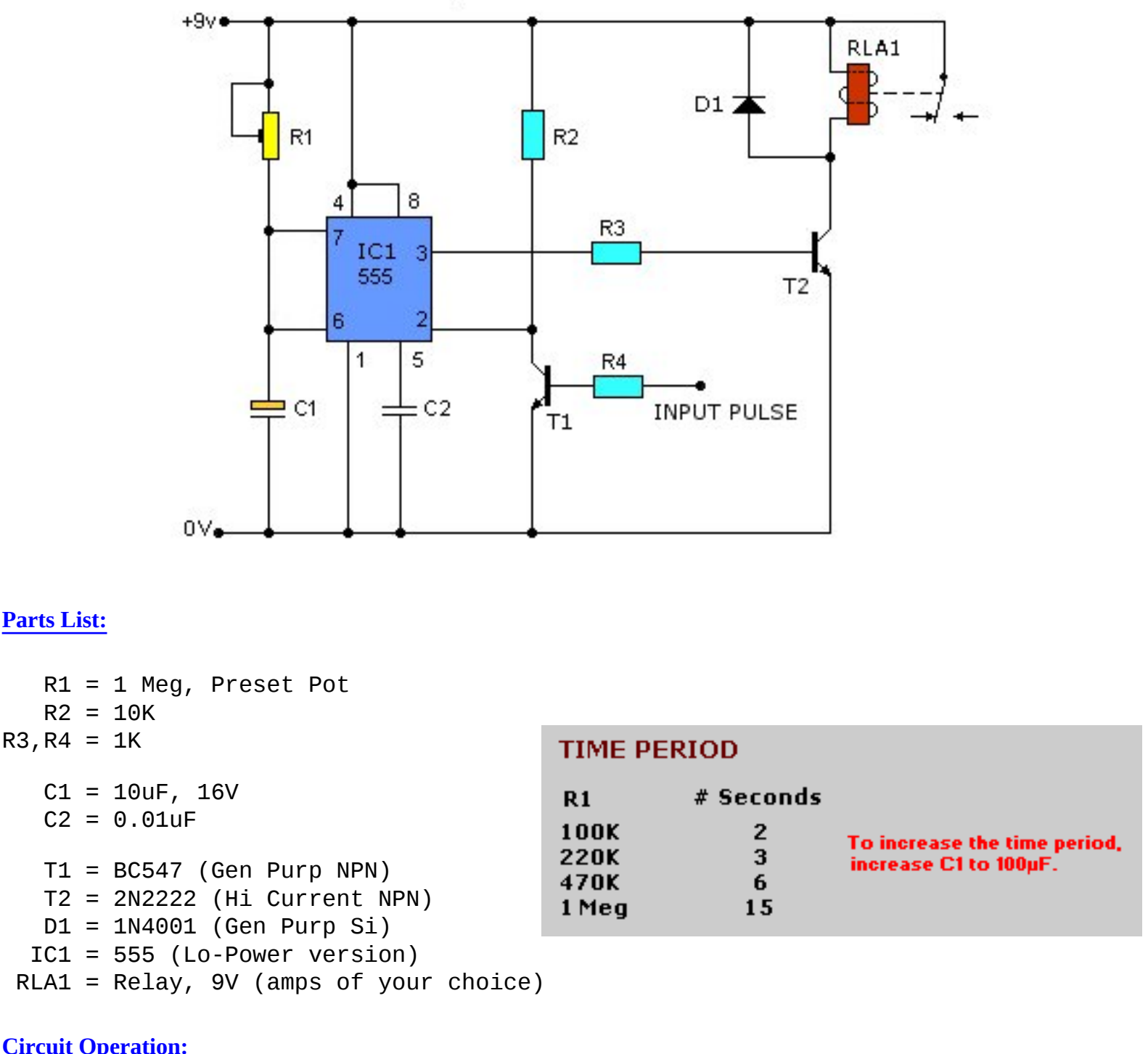
This Intercom is powered by two 9volt batteries and uses only current when the Intercom is used. Both units are connected via a two-wire little cable or simply two wires (dotted lines). The loud speakers act both as loudspeaker and as a microphone. When you press S1 and speak into the loudspeaker then this signal is amplified by the transistor stage and made audible in the right loudspeaker and vice-versa. An added benefit of this system is that when the switch is pressed it is quiet, not even annoying noise. This circuit has worked for me to my full satisfaction for many years now.

If you have questions about this circuit, please direct them to [Jan Hamer](#) or visit [his website](#) in the Netherlands (if you can read Dutch).

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Parts List:

- R1 = 1 Meg, Preset Pot
R2 = 10K
R3, R4 = 1K
C1 = 10uF, 16V
C2 = 0.01uF
T1 = BC547 (Gen Purp NPN)
T2 = 2N2222 (Hi Current NPN)
D1 = 1N4001 (Gen Purp Si)
IC1 = 555 (Lo-Power version)
RLA1 = Relay, 9V (amps of your choice)

TIME PERIOD

R1	# Seconds	
100K	2	
220K	3	
470K	6	
1 Meg	15	

To increase the time period, increase C1 to 100uF.

Circuit Operation:

IC1 is wired as a monostable multivibrator. Input pulses are applied to the base of transistor T1. This causes T1 to conduct, taking pin 2 of IC1 'low'. IC1 then enters a timing cycle, the duration of which is set by R1/C1, causing pin 3 of IC1 to go 'high'. This causes T2 to conduct. At the end of the timing cycle T2 switches off, and the circuit waits for the next pulse to T1.

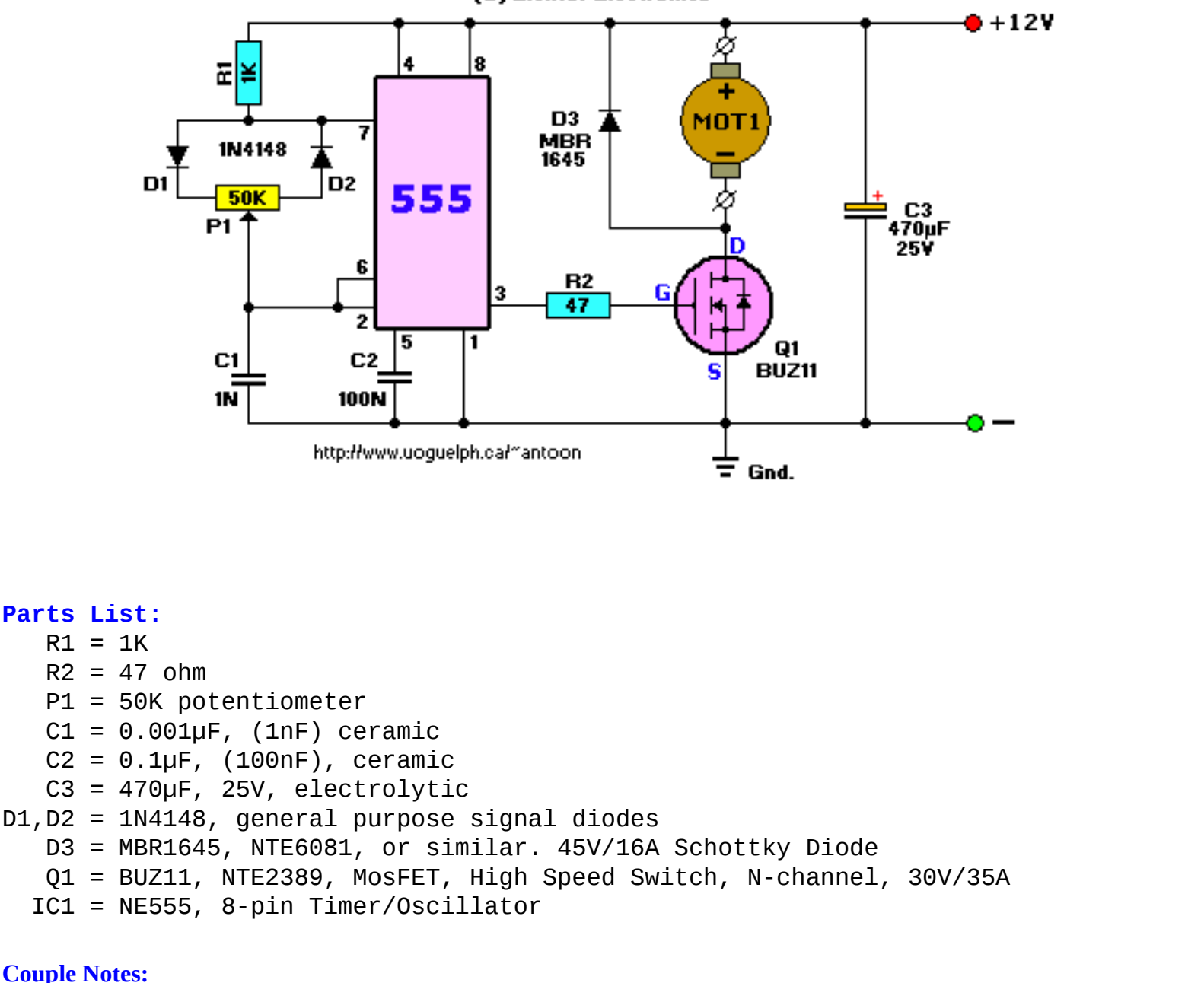
T1 replacements: ECG123AP or NTE123AP (Rotate device 180° to conform with original lead configuration).
T2 replacements: ECG123A or NTE123A.

Paul's Note:

A question I see cropping up quite often on the forum is "how do I switch on a relay for 'x' seconds with a 'y' volts pulse". You can use this circuit as a building block.

If you have any questions or are in need of other additional information in regards to the above circuit, please contact [Paul Hancock](#) here.

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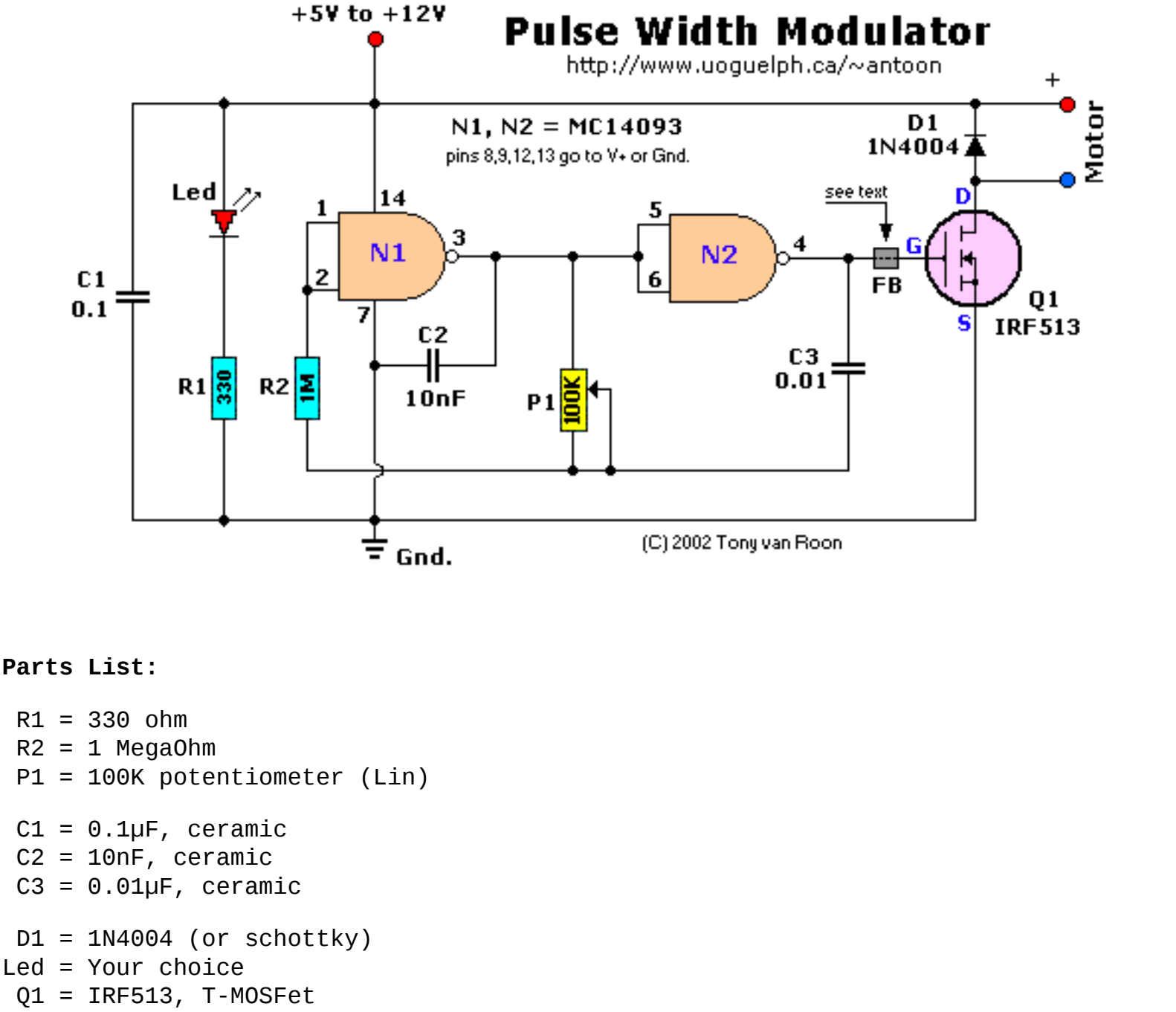


Parts List:

- R1 = 1K
- R2 = 47 ohm
- P1 = 50K potentiometer
- C1 = 0.001μF, (1nF) ceramic
- C2 = 0.1μF, (100nF), ceramic
- C3 = 470μF, 25V, electrolytic
- D1, D2 = 1N4148, general purpose signal diodes
- D3 = MBR1645, NTE6081, or similar. 45V/16A Schottky Diode
- Q1 = BUZ11, NTE2389, MosFET, High Speed Switch, N-channel, 30V/35A
- IC1 = NE555, 8-pin Timer/Oscillator

Couple Notes:

This circuit is capable of regulating 12V motors and DC light bulbs. No coolrib required for Q1 or D3 if the current does not exceed 2A. If it does, a sufficient coolrib for both the Schottky Diode (D3) and MosFET Q1 is required. The regulation is obtained via PWM or Pulse Width Modulation. The output pin 3 of the 555 provides square-wave with an adjustable duty-cycle. What that basically means is that the pulse width changes the speed of the motor. The output from the 555 feeds the mosfet via current limiting resistor R2 of 47 ohms. Because the MosFET Q3 only "switches" and is not behaving like a pot, its energy-waste level is negliable, and also provides the motor more coupling at low rpm. The maximum current Q1 can provide (safely) is about 10A. The replacement type mentioned in the parts list (NTE2389 can provide up to 35A at 60V. I use a cpu-cooler-fan for additional cooling at high rpm.



Parts List:

- R1 = 330 ohm
- R2 = 1 Megaohm
- P1 = 100K potentiometer (Lin)
- C1 = 0.1μF, ceramic
- C2 = 10nF, ceramic
- C3 = 0.01μF, ceramic
- D1 = 1N4004 (or schottky)
- Led = Your choice
- Q1 = IRF513, T-MOSFet
- FB = Ferrite Bead (see text)
- IC1 = MC14093, Quad 2-input NAND Schmitt Trigger

Couple Notes:

The IC used is a CMOS type MC14093, a quad 2-input NAND Schmitt trigger. If you wish, it can be directly interchanged with the CMOS MC14011 but this type is noisy.
The speed is adjustable from 0-max. Max rpm is 2/3 the supply voltage.
Supply voltage can be from 3 - 18volt, but I think around 12v works best for this application.
Input pins 8, 9, 12, and 13, need to be connected to Gnd. or 'V+'. Output pins 10 & 11 are left floating.
Maximum current draw, with the components shown, is approximately 220 mA max using a small type motor. Standby current at idle is about 88mA.

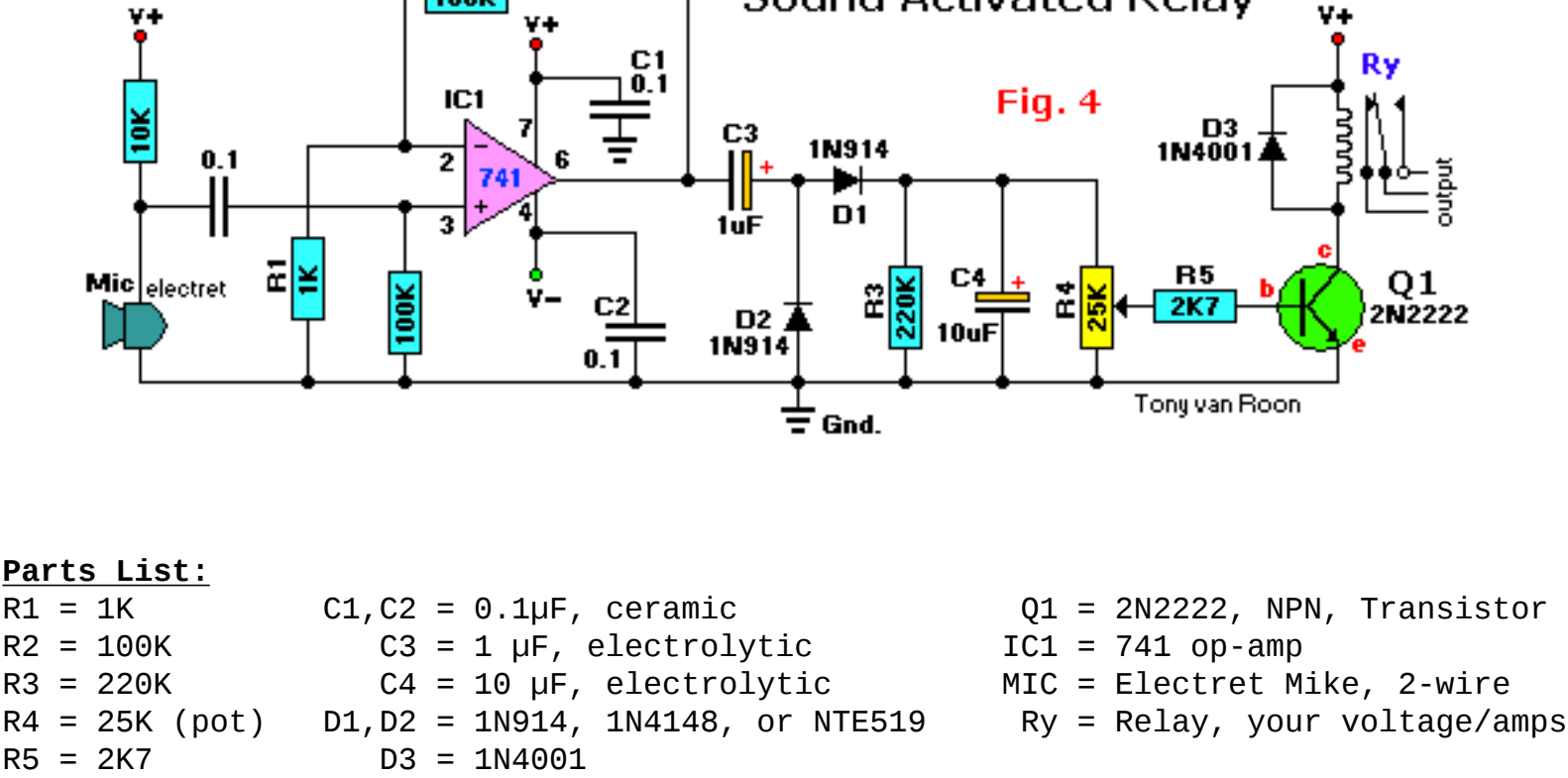
The way pulse modulation works is that it controls the motor by very short pulses. The longer the duration of the pulses the faster the motor turns. This method eliminates the excess heat associated with more conventional setups.
Depending on the motor, Q1 may need a coolib, and C2 modified to eliminate the 'jerk' at the end of P1's adjustment.
P1, the 100K potentiometer can be a multi-turn type if your needs are towards specific rpm's.
For Q1, the IRF513, I experimented with several other types such as the IRFZ42, IRF511, IRF513, and IRF620. They all seem to do the job, although I prefer the IRFZ42 type for its very low R_{ds}on

To minimize RFI (Radio Frequency Interference), put a **Ferrite Bead** on the gate of Q1, or if you can't obtain one, wind some 5 turns of thick magnet wire on a 10-ohm resistor (diameter approx. 1/4")
A schottky diode of proper specs may be required for some motors which require faster switching.

Here is some information in regards to the motor I used. Remember those full-height, black floppy drives from those old IBM pc's? That is exactly the motor I used. For those of you who remember that type, it was a belt drive model. The belt drove a little aluminum spindle. This motor is of excellent quality and made by the Buehler company in Kingston, USA. A nice added feature is that those motors have a speed-sensor build-in and reads the rpm in AC volts. The yellow & green wires are the speed sensor and the red & blue wires are the positive/negative. It also has an extra aluminum shield around the motor-housing to keep rf interference to a minimum. Who wouldn't like a motor like that? If you can get your hands on them, take it!

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- Parts List:**
- | | | |
|----------------|----------------------------------|-------------------------------|
| R1 = 1K | C1,C2 = 0.1µF, ceramic | Q1 = 2N2222, NPN, Transistor |
| R2 = 100K | C3 = 1 µF, electrolytic | IC1 = 741 op-amp |
| R3 = 220K | C4 = 10 µF, electrolytic | MIC = Electret Mike, 2-wire |
| R4 = 25K (pot) | D1,D2 = 1N914, 1N4148, or NTE519 | Ry = Relay, your voltage/amps |
| R5 = 2K7 | D3 = 1N4001 | |

This relay remains dormant until the op-amp activates upon sound via the electret-microphone. I only tested the 2-wire type. The input stage is a regular off-the-shelf 741 operational amplifier and connected as a non-inverting follower audio amplifier.

Gain is approximately 100 which you can raise by increasing the value of R2.

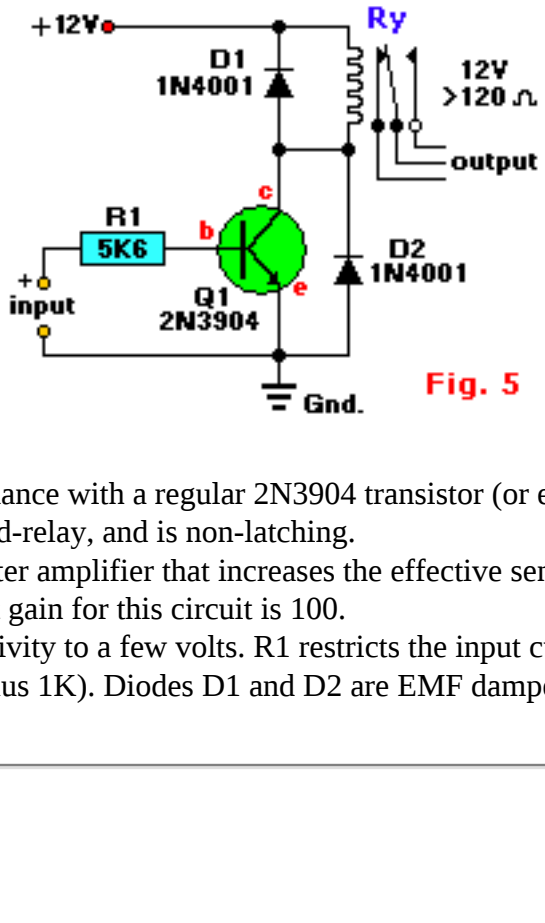
The amplified signal is rectified and filtered via C3, D1/D2, and R3 to an acceptable DC level. D1 and D2 can be any signal diode like 1N914, 1N4148, or the NTE519.

Q1, the 2N2222, is a general purpost NPN transistor and is not critical. The NTE123A will work too.

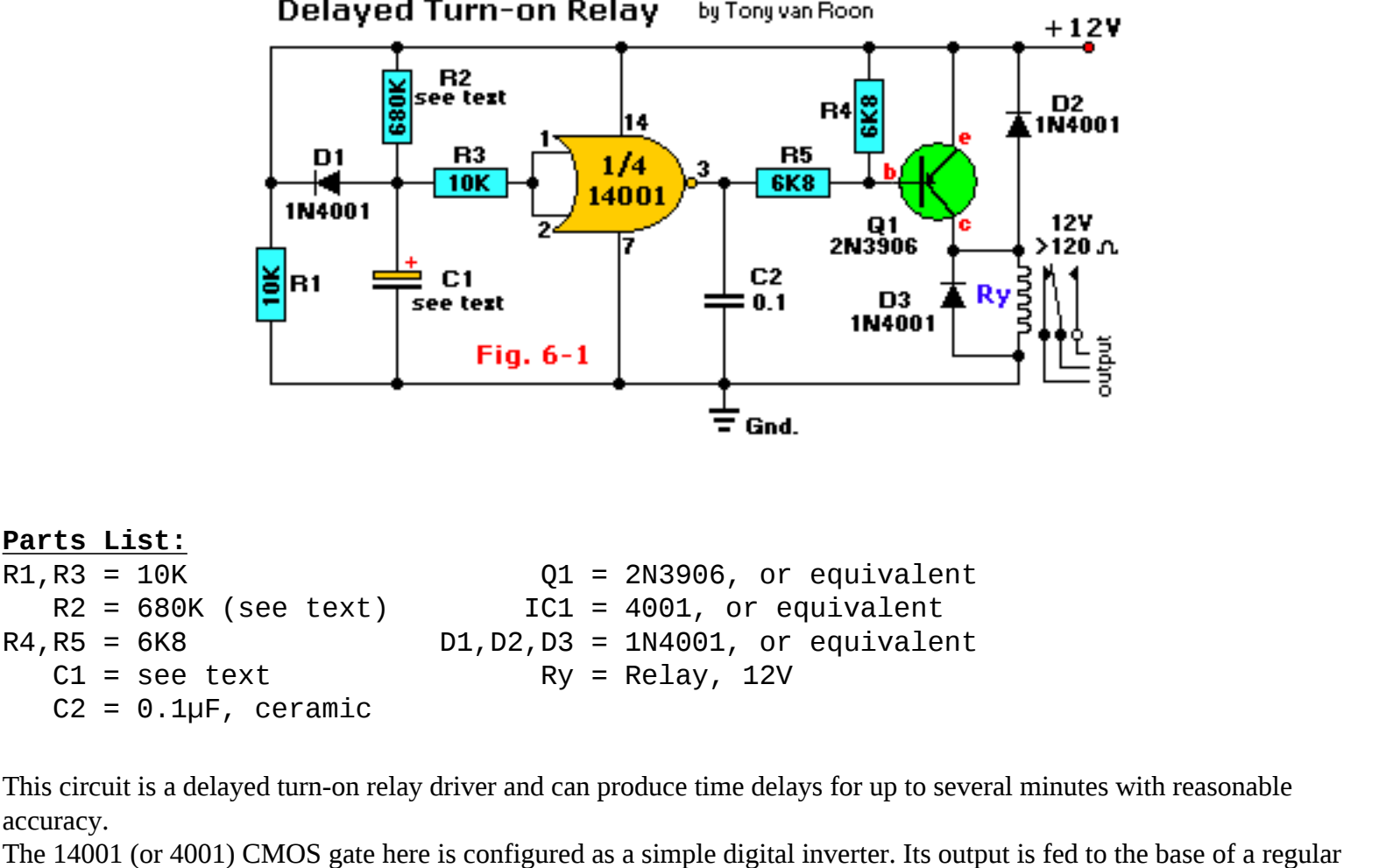
Potentiometer R4 is used to set the audio level to a desired sensitivity value to activate the relay via transistor Q1.

Diode D3 is mounted over the relay coil to absorb sparks when the relay opens. Cathode goes to '+'.
The op-amp configuration in this particular drawing needs a dual voltage powersupply which can be made from two 9 volt alkaline batteries.





This relay driver **boosts** the input impedance with a regular 2N3904 transistor (or equivalent). Very common driver. It can drive a variety of relays, including a reed-relay, and is non-latching. Transistor Q1 is a simple common-emitter amplifier that increases the effective sensitivity of the 12 volt relay coil about a 100 times, or in other words, the current gain for this circuit is 100. Using this setup reduces the relay sensitivity to a few volts. R1 restricts the input current to Q1 to a safe limit (the impedance is equal to the value of R1 plus 1K). Diodes D1 and D2 are EMF dampers and filter off any sparking when the relay de-energizes.



Parts List:

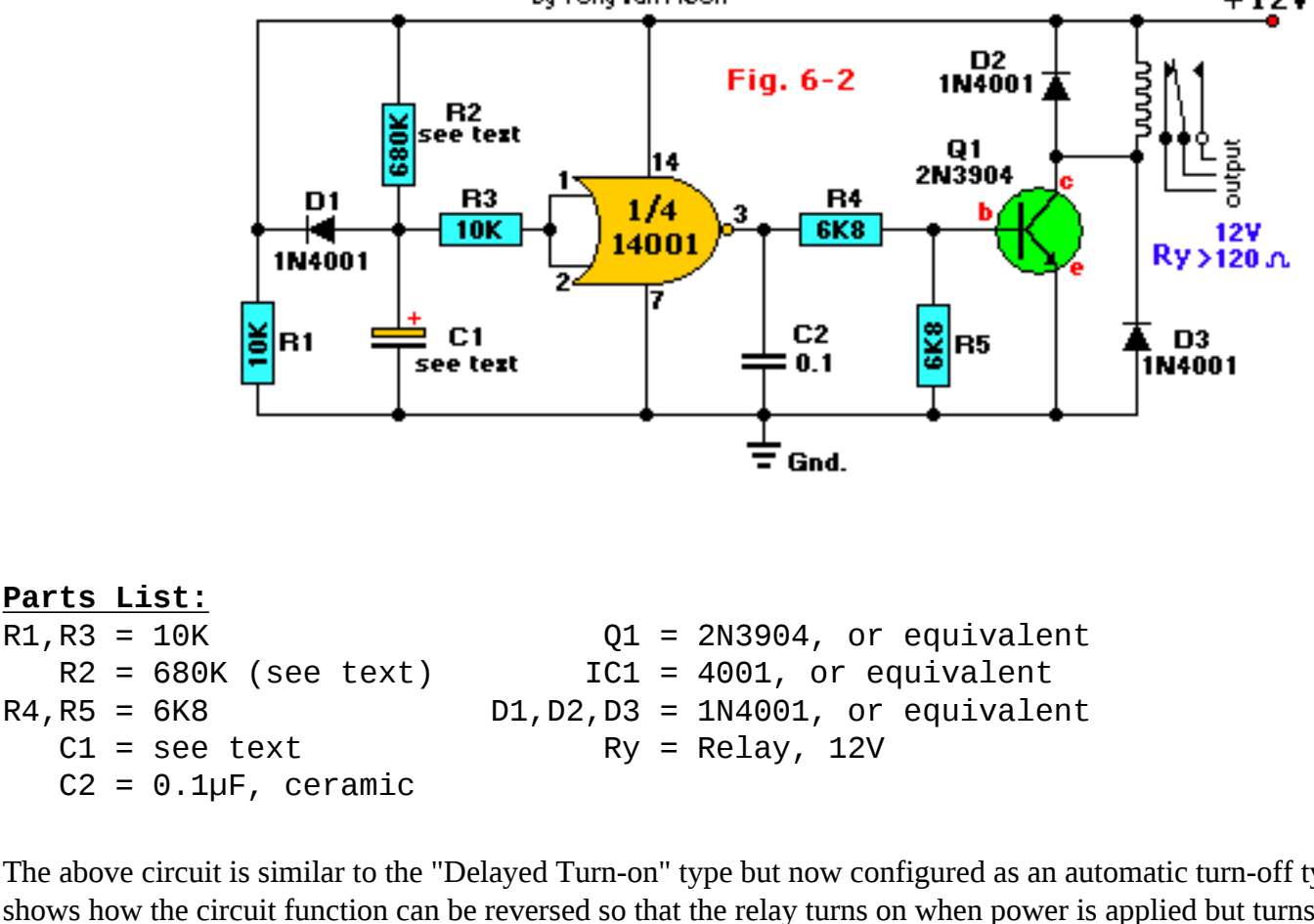
- | | |
|----------------------|------------------------------------|
| R1, R3 = 10K | Q1 = 2N3906, or equivalent |
| R2 = 680K (see text) | IC1 = 4001, or equivalent |
| R4, R5 = 6K8 | D1, D2, D3 = 1N4001, or equivalent |
| C1 = see text | Ry = Relay, 12V |
| C2 = 0.1μF, ceramic | |

This circuit is a delayed turn-on relay driver and can produce time delays for up to several minutes with reasonable accuracy.

The 14001 (or 4001) CMOS gate here is configured as a simple digital inverter. Its output is fed to the base of a regular 2N3906 (PNP) transistor, Q1, at the junction of resistor R5 and capacitor C2. The input to IC1 is taken from the junction of the time-controlled potential divider formed by R2 and C1. Before power is applied to the circuit, C1 is fully discharged. Therefore, the inverter input is grounded, and its output equals the positive supply rail; Q1 and RY1 are both off under this circuit condition. When power is applied to the circuit, C1 charges through R2, and the exponentially rising voltage is applied to the input of the CMOS inverter gate.

After a time delay determined by the RC time constant values of C1 and R2, this voltage rises to the threshold value of the CMOS inverter gate. The gate's output then falls toward zero volts and drives Q1 and relay RY 'ON'. The relay then remains on until power is removed from the circuit. When that occurs, capacitor C1 discharges rapidly through diode D1 and R1, completing the sequence.

The time delay can be controlled by different values for C1 and R2. The delay is approximately 0.5 seconds for every μF as value for C1. The delay can further be made variable by replacing R2 with a fixed and a variable resistor equal to that of the value of R2. Taken the value for R2 of 680K, it would be a combination of 180K for the fixed resistor in series with a 500K variable trim pot. The fixed resistor is necessary.



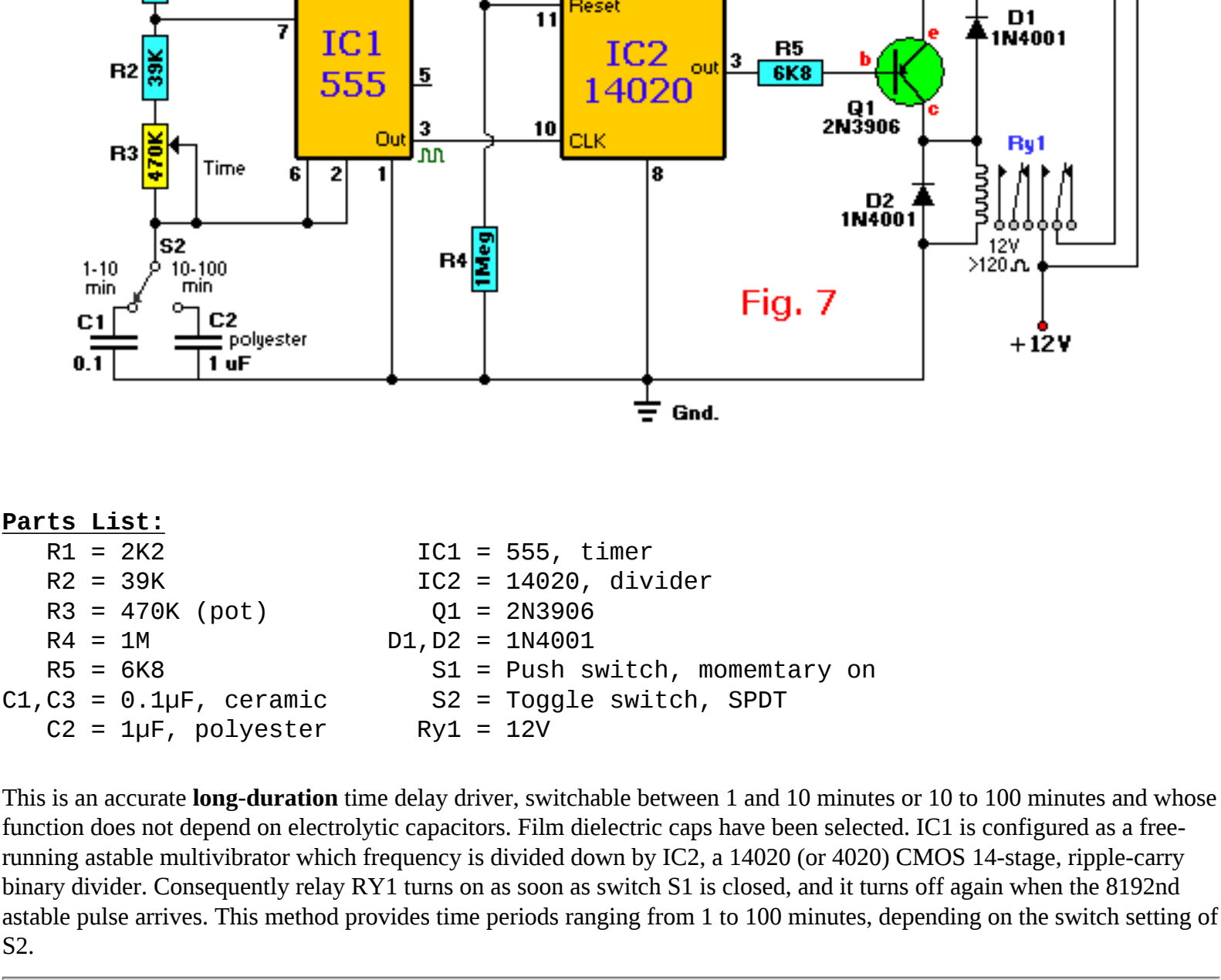
Parts List:

- | | |
|----------------------|------------------------------------|
| R1, R3 = 10K | Q1 = 2N3904, or equivalent |
| R2 = 680K (see text) | IC1 = 4001, or equivalent |
| R4, R5 = 6K8 | D1, D2, D3 = 1N4001, or equivalent |
| C1 = see text | Ry = Relay, 12V |
| C2 = 0.1μF, ceramic | |

The above circuit is similar to the "Delayed Turn-on" type but now configured as an automatic turn-off type. The diagram shows how the circuit function can be reversed so that the relay turns on when power is applied but turns off again automatically after a preset delay. This response is obtained by modifying the relay-driving stage for an NPN transistor like the 2N3904.

It is worth noting again that the diagram provides a time delay of about 0.5 seconds for every microfarad in the value of capacitor C1. This permits delays of up to several minutes. If desired, the delay periods can be made variable by replacing resistor R2 with a fixed *and* variable resistor in series whose nominal values are approximately equal of the total value of R2 (680K).

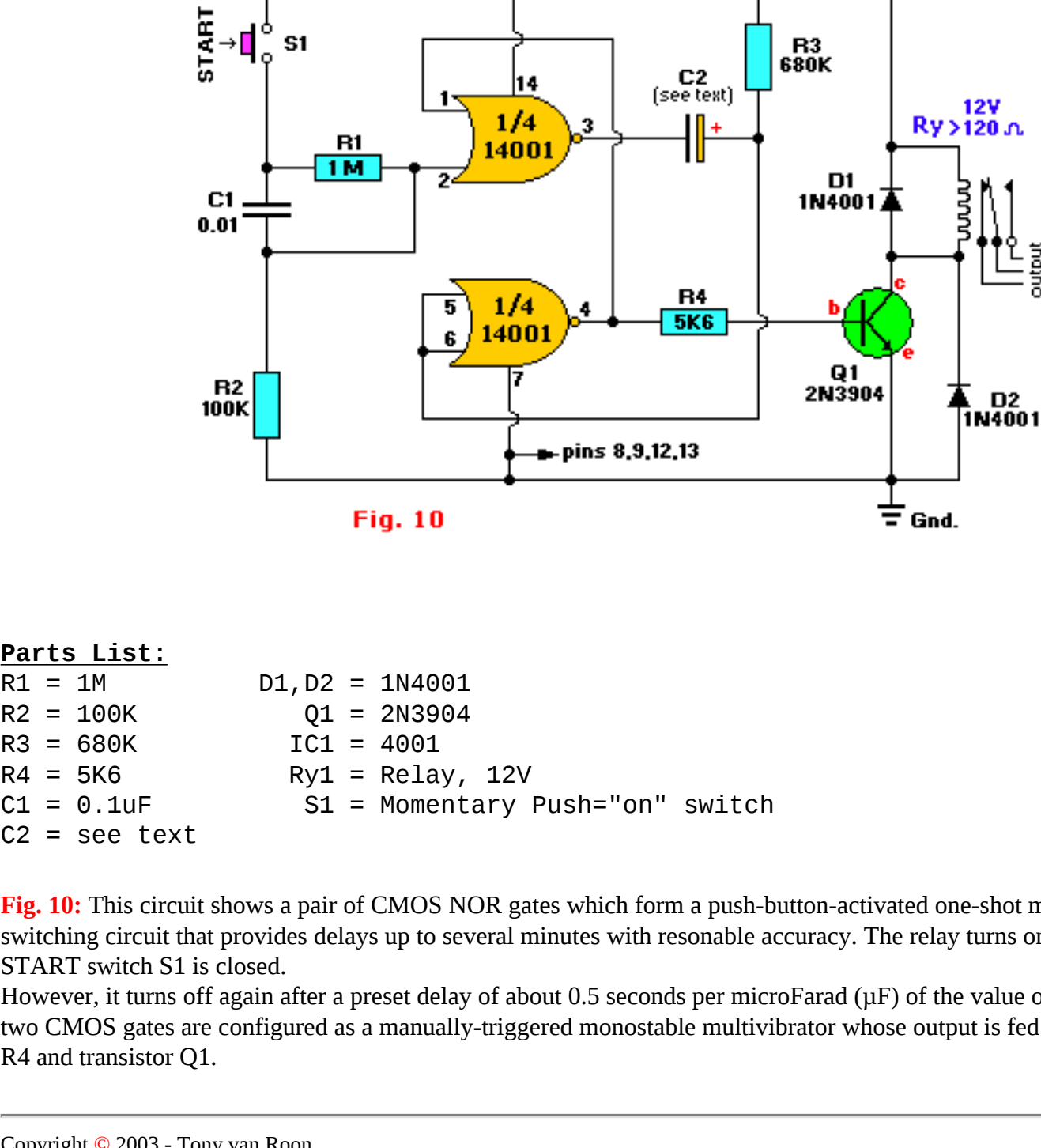
1 to 100 Minute Timer Relay



Parts List:

- | | |
|-------------------------|--------------------------------|
| R1 = 2K2 | IC1 = 555, timer |
| R2 = 39K | IC2 = 14020, divider |
| R3 = 470K (pot) | Q1 = 2N3906 |
| R4 = 1M | D1, D2 = 1N4001 |
| R5 = 6K8 | S1 = Push switch, momentary on |
| C1, C3 = 0.1uF, ceramic | S2 = Toggle switch, SPDT |
| C2 = 1uF, polyester | Ry1 = 12V |

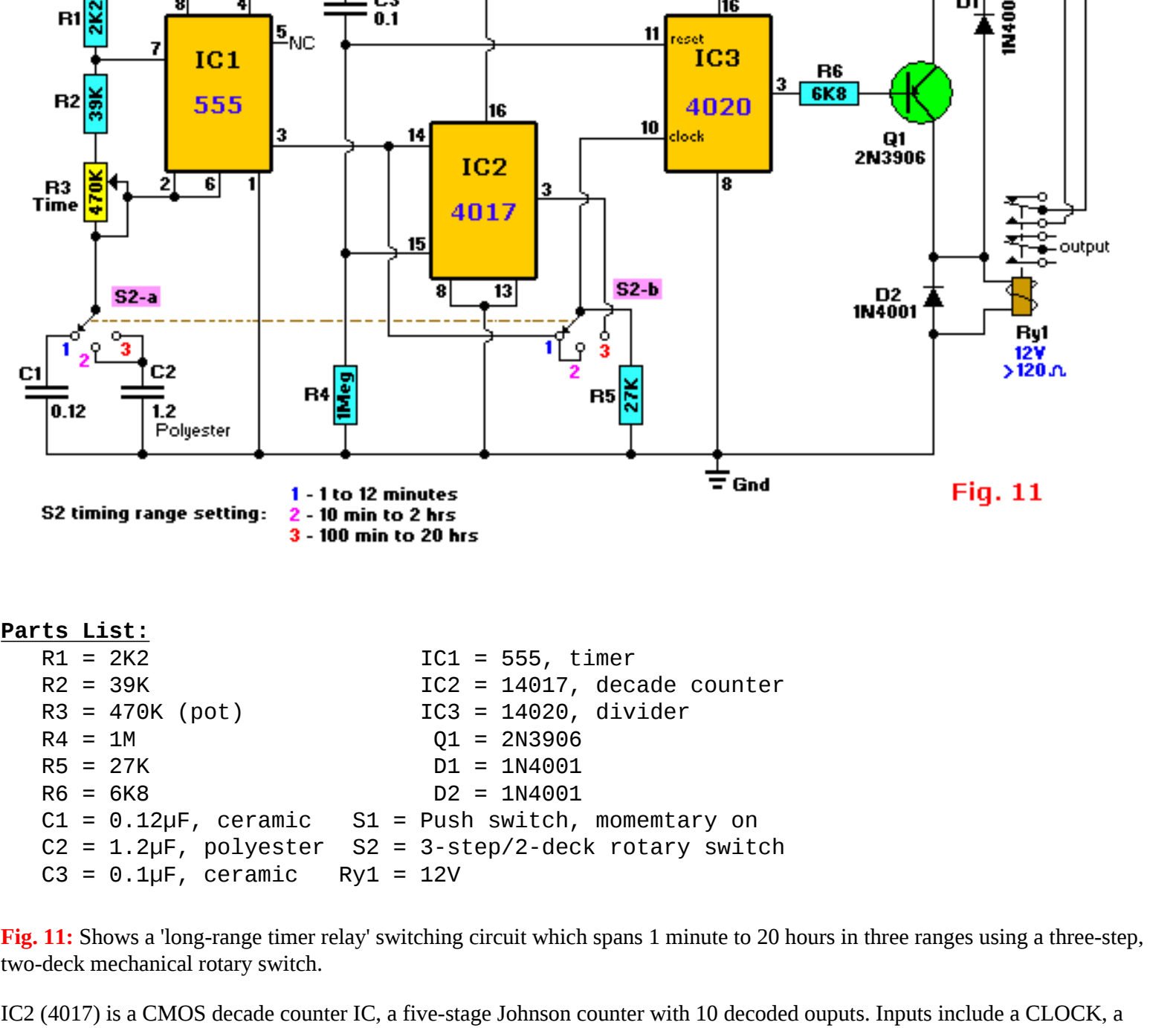
This is an accurate **long-duration** time delay driver, switchable between 1 and 10 minutes or 10 to 100 minutes and whose function does not depend on electrolytic capacitors. Film dielectric caps have been selected. IC1 is configured as a free-running astable multivibrator which frequency is divided down by IC2, a 14020 (or 4020) CMOS 14-stage, ripple-carry binary divider. Consequently relay RY1 turns on as soon as switch S1 is closed, and it turns off again when the 8192nd astable pulse arrives. This method provides time periods ranging from 1 to 100 minutes, depending on the switch setting of S2.



Parts List:

R1 = 1M	D1, D2 = 1N4001
R2 = 100K	Q1 = 2N3904
R3 = 680K	IC1 = 4001
R4 = 5K6	Ry1 = Relay, 12V
C1 = 0.1uF	S1 = Momentary Push="on" switch
C2 = see text	

Fig. 10: This circuit shows a pair of CMOS NOR gates which form a push-button-activated one-shot multivibrator relay-switching circuit that provides delays up to several minutes with reasonable accuracy. The relay turns on as soon as the START switch S1 is closed.
However, it turns off again after a preset delay of about 0.5 seconds per microFarad (μF) of the value of capacitor C2. The two CMOS gates are configured as a manually-triggered monostable multivibrator whose output is fed to the relay through R4 and transistor Q1.



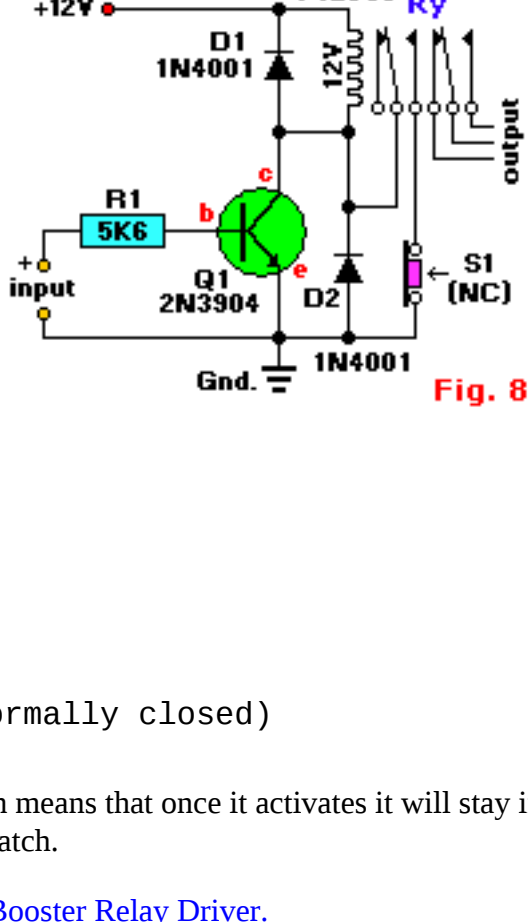
Parts List:

- | | |
|-----------------------|----------------------------------|
| R1 = 2K2 | IC1 = 555, timer |
| R2 = 39K | IC2 = 14017, decade counter |
| R3 = 470K (pot) | IC3 = 14020, divider |
| R4 = 1M | Q1 = 2N3906 |
| R5 = 27K | D1 = 1N4001 |
| R6 = 6K8 | D2 = 1N4001 |
| C1 = 0.12µF, ceramic | S1 = Push switch, momentary on |
| C2 = 1.2µF, polyester | S2 = 3-step/2-deck rotary switch |
| C3 = 0.1µF, ceramic | Ry1 = 12V |

Fig. 11: Shows a 'long-range timer relay' switching circuit which spans 1 minute to 20 hours in three ranges using a three-step, two-deck mechanical rotary switch.

IC2 (4017) is a CMOS decade counter IC, a five-stage Johnson counter with 10 decoded outputs. Inputs include a CLOCK, a RESET, and a CLOCK INHIBIT signal. This IC, together with IC3 and the 3-step rotary switch, can provide a maximum division ratio of 81,920 making it possible to time for periods up to 20 hours or so. Circuits like this are used in battery chargers and area security lighting systems with time-controlled turn-off.

IC3 (4020) is a CMOS 14-stage, ripple-carry binary divider. Normally a 'high' would occur as soon as switch S1 is closed and a 'low' when the 8192nd astable pulse arrives. All counter stages of IC3, the 4020, are master-slave flip-flops. The state of a counter advances one count on the negative going transition of each input pulse, and a high level on the RESET line resets the counter to its all zeros state. All inputs and outputs are buffered.

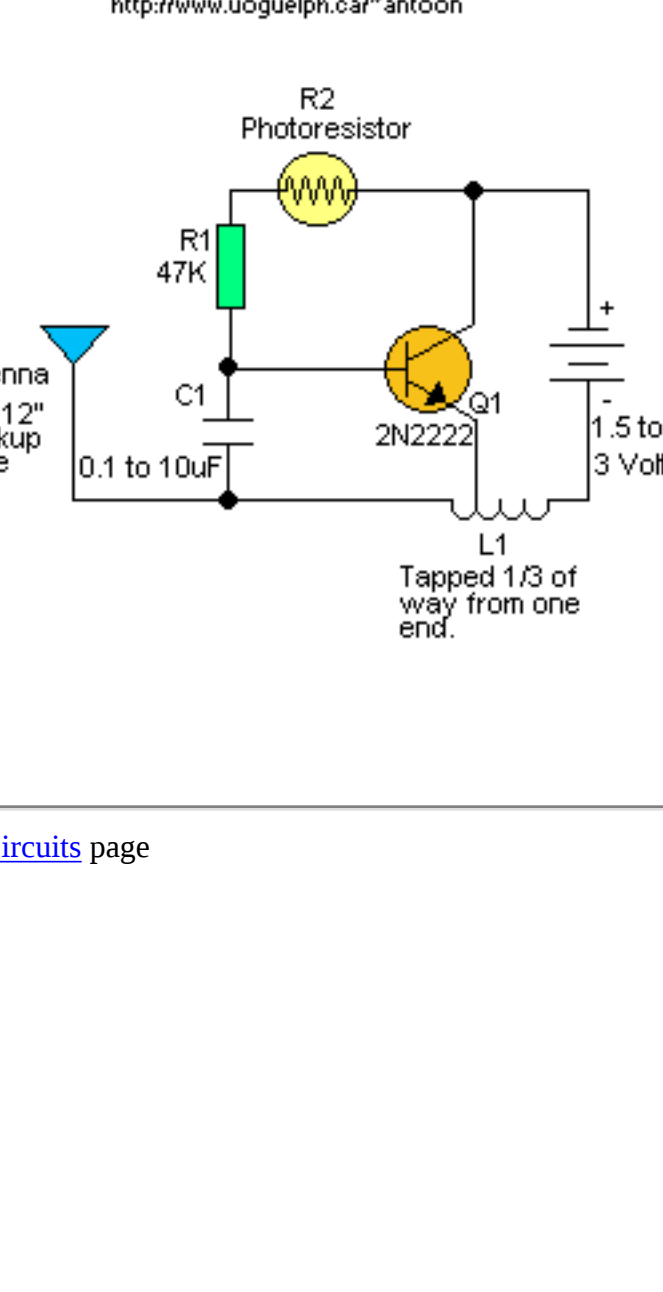


Parts List:

- R1 = 5K6
- D1, D2 = 1N4001
- Q1 = 2N3904
- Ry = Relay, 12V
- S1 = Momentary break (normally closed)

This relay driver is **Self-Latching** which means that once it activates it will stay in remain in that state until S1 is pressed and momentarily disrupts power to the latch.

The rest of the circuit is the same as in [Booster Relay Driver](#).



This transmitter is very similar to the Simplest RF Transmitter. The only difference being the photoresistor placed in series with R1. This could also be a thermistor or other variable resistance sensor. The frequency of the tone or "clicks" that is transmitted varies with the amount of light falling on the photoresistor.

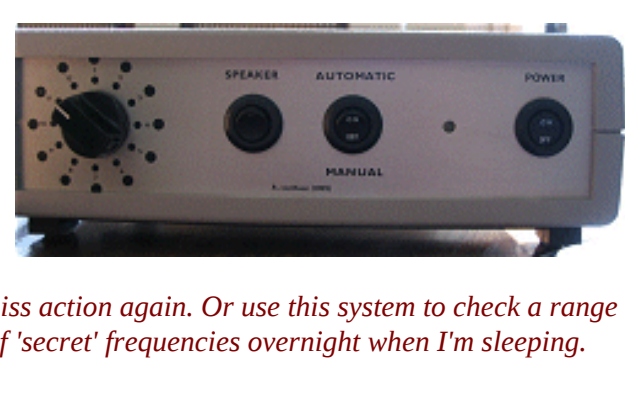
L1 is 20 to 30 turns of 24 to 32 ga. magnet wire close wound around a 1/8 to 1/4" diameter non-conductive form and tapped 1/3 of the way from one end. The tap is connected to the emitter of Q1.

The user should be able to pick up the signal from this transmitter on any regular FM or VHF receiver. By increasing the number of turns on L1, the RF frequency can be dropped down all the way into the AM broadcast band.



ScanMate

by Tony van Roon



"Add this easy project to your regular scanner or DX'ing apparatus and never miss action again. Or use this system to check a range of frequencies for band activity when you're not there. I use it to check a range of 'secret' frequencies overnight when I'm sleeping. Works for me."

Introduction:

What exactly is 'ScanMate'? Read on. It never seems to fail. You wake up in the morning, turn on the radio news, and there it is: A major fire across town, a drug bust in the local park, police chases, or an airliner forced to make an emergency landing along the highway. Such events always seem to happen just after you have turned off your scanner and gone to bed, or left the house. Some of the hottest action to come over the air waves for months, and you missed it....that is, until *ScanMate!* With ScanMate connected between your scanner and a tape recorder (via the recorder's microphone or auxiliary input and its remote start jack), you will never have to worry about missing any of the action again.

ScanMate is similar to several of the available commercial units, but offers greater flexibility. The ScanMate unit has a 'level' control that allows it to be used successfully with any type of scanner--portable or base unit--regardless of its output-amplifier configuration. It also provides control over the length of time the recorder continues to run after the transmission ceases. Also included in the circuit is a switch that allows you to select either automatic or manual operation.

When ScanMate is set to the auto-mode, the recorder's motor operates only during transmissions. In the manual-mode, the motor is activated whenever any of the recorder's functions (play, rewind, etc.) is selected. That allows all the interconnection cables to remain in place when you decide to rewind and listen to the tape. A speaker in/out switch is provided to allow monitoring (via the circuit's built-in speaker) while recording. In addition, ScanMate provides both microphone and line-level outputs, so that even the least-sophisticated recorders can be used.

How It Works:

Figure 1 is the schematic diagram of the ScanMate circuit. Audio coming from the scanner's earphone or speaker jack is fed to the circuit via J1. Jack J2, which is wired parallel with Jack J1, provides a line-level output for input to the recorder via its auxiliary input jack. The signal is also fed through a voltage divider, consisting of resistors R1 and R2, which attenuate the signal for the mic-out jack J3.

Switch S1 is used to switch speaker LS1 in and out of the circuit. In the 'out' position, a 10-ohm resistor, R3, is switched into the circuit in place of the speaker's 8-ohm impedance, providing a fairly constant load for the scanner's output. Capacitor C1 blocks any DC voltage that might be present. The signal is then fed to the inverting input of U1a (1/2 of a LM1458 dual op-amp), the gain of which is set to about 150 by the R4/R5 combination. The output of U1a at pin 1 is rectified by diode D1. The peak voltage is fed across C2 to the non-inverting input of U1b, which is configured as a voltage comparator. When the voltage at pin 5 is higher than that set by P1 (the level/sensitivity control) at pin 6, the output of U1b swings to near the positive supply rail, lighting the green half of LED1, a bi-color Light Emitting Diode.

Resistor R7 limits the current to LED1. The relay at U1b's output (pin 7) also turns on T1 which, in turn, activates a reed relay, Ry1, causing its contacts to close. The contacts of the relay act as the tape-recorder's motor on/off switch. When the voltage at pin 5 of U1b is lower than that at pin 6, its output swings close to the negative supply rail, illuminating the red half of LED1, and at the same time turning off T1 and Ry1, as well as the tape recorder's motor.

The discharge rate of C2, combined with the setting of P1, determines the time the recorder runs after the last transmission. With an LM1458 Op-Amp, and its relatively low input impedance, a C2 value of 0.1uF provides an ideal discharge rate. However, if a high input impedance op-amp is used, such as one with JFET inputs, C2's value should be increased to around 5uF (4.7uF is ok) and the value of P2 should be adjusted to near 10-megohms. Some experimentation with the setting of P2 -- which value should be between 5 and 30 megohms -- may be necessary to achieve optimum performance. I only used the adjustable potmeter (P2) to find the optimum setting and then measured that resistance and replaced the pot with an appropriate value of a resistor (Rx). Works.

Diode D3 and capacitor C3 are used to shunt any harmful spikes produced by the relay's coil away from T1. Switch S2 is the 'Manual/Auto' select switch. When S2 is closed, it acts like the closed contacts of the relay, turning on the tape-recorder motor. The circuit is powered from a dual 8-volt power supply, (see Fig. 2) consisting of a handful inexpensive components. The AC line voltage is fed through S3 (the on/off switch) and a Fuse of 0.25 Amp (250mA) to power transformer TR1, which reduces the 117V line to 6.3 volts. That voltage is then full-wave rectified by D4 and D5, and filtered by electrolytic capacitors C4 and C5, to provide a suitable power source for the circuit.

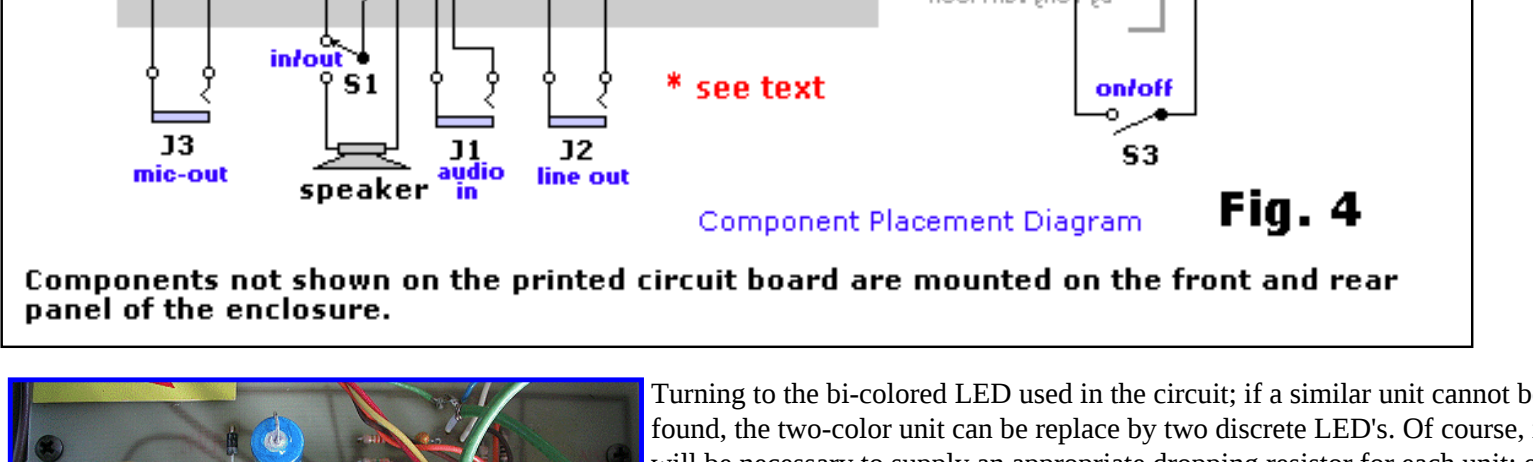
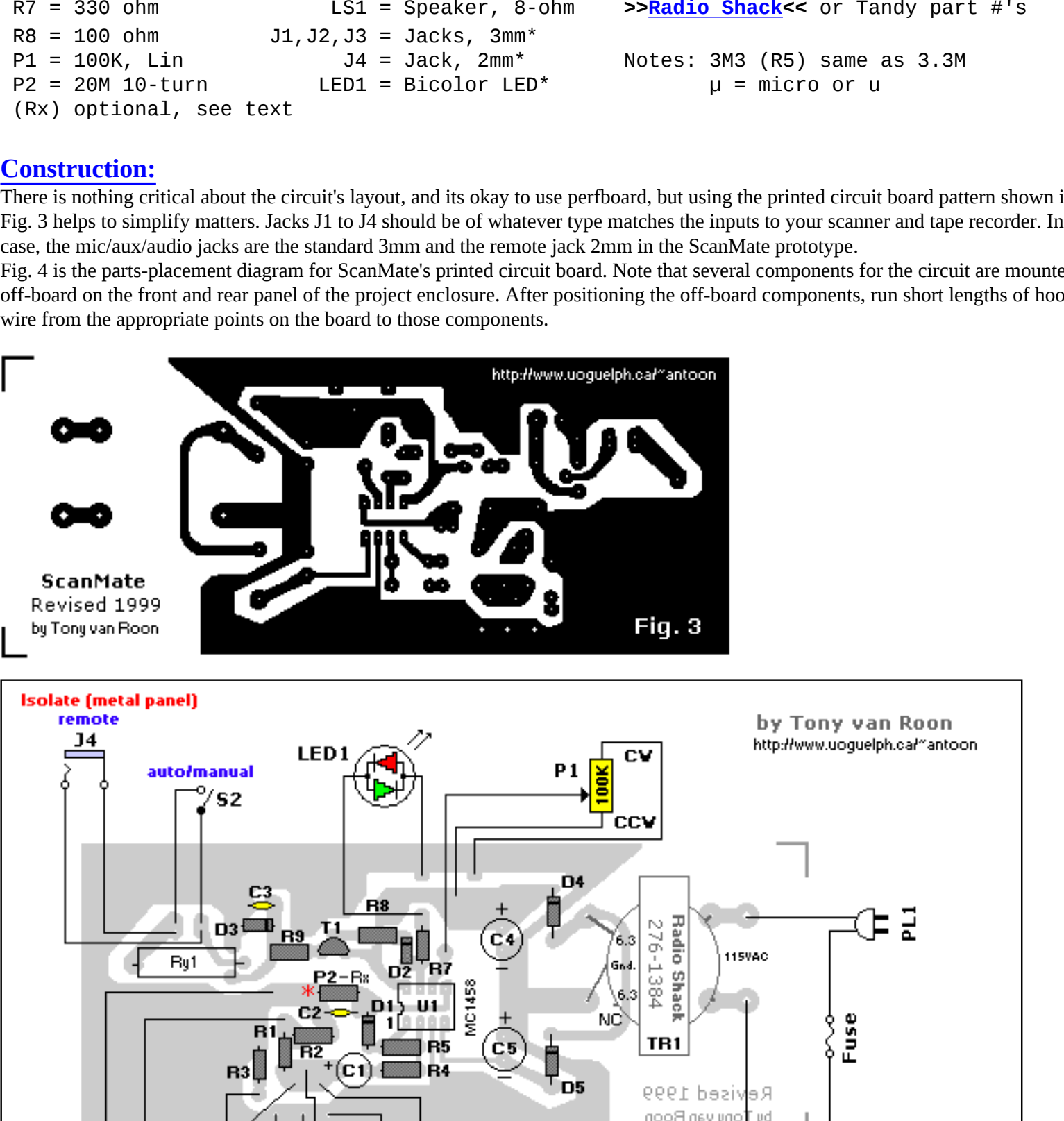


Fig. 1
Fig. 2

by Tony van Roon
<http://www.uoguelph.ca/~antoon>

Parts List:

- | | | |
|-------------------------|------------------------------|---------------------------------------|
| R1 = 47K | C1 = 1uF/16V | S1 = on-on, SPDT Switch |
| R2 = 470 ohm | C2, C3, C4 = 0.1uF (ceramic) | S2 = on-off, SPST Switch |
| R3 = 10 ohm | C5, C6 = 1000uF/25V | S3 = on-off, SPST Switch (115VAC) |
| R4 = 22K | D1, D2, D3, D4 = 1N4001 | Ry1 = Reed Relay, 5V-1A |
| R5 = 3M3 | T1 = 2N2222 | TR1 = Transformer, 12.6V CT, PC-Mount |
| R6 = 100 ohm | U1 = LM1458 | Socket for U1 (8-pin) |
| R7 = 330 ohm | LS1 = Speaker, 8-ohm | >>Radio Shack<< or Tandy part #'s |
| R8 = 100K, Lin | J1, J2, J3 = Jacks, 3mm" | Notes: 3M3 (R5) same as 3.3M |
| P2 = 20M 10-turn | J4 = Jack, 2mm" | μ = micro or u |
| (Rx) optional, see text | LED1 = Bicolor LED* | |

Construction:

There is nothing critical about the circuit's layout, and its okay to use perfboard, but using the printed circuit board pattern shown in Fig. 3 helps to simplify matters. Jacks J1 to J4 should be of whatever type matches the inputs to your scanner and tape recorder. In my case, the mic/aux/audio jacks are the standard 3mm and the remote jack 2mm in the ScanMate prototype.

Fig. 4 is the parts-placement diagram for ScanMate's printed circuit board. Note that several components for the circuit are mounted off-board on the front and rear panel of the project enclosure. After positioning the off-board components, run short lengths of hookup wire from the appropriate points on the board to those components.

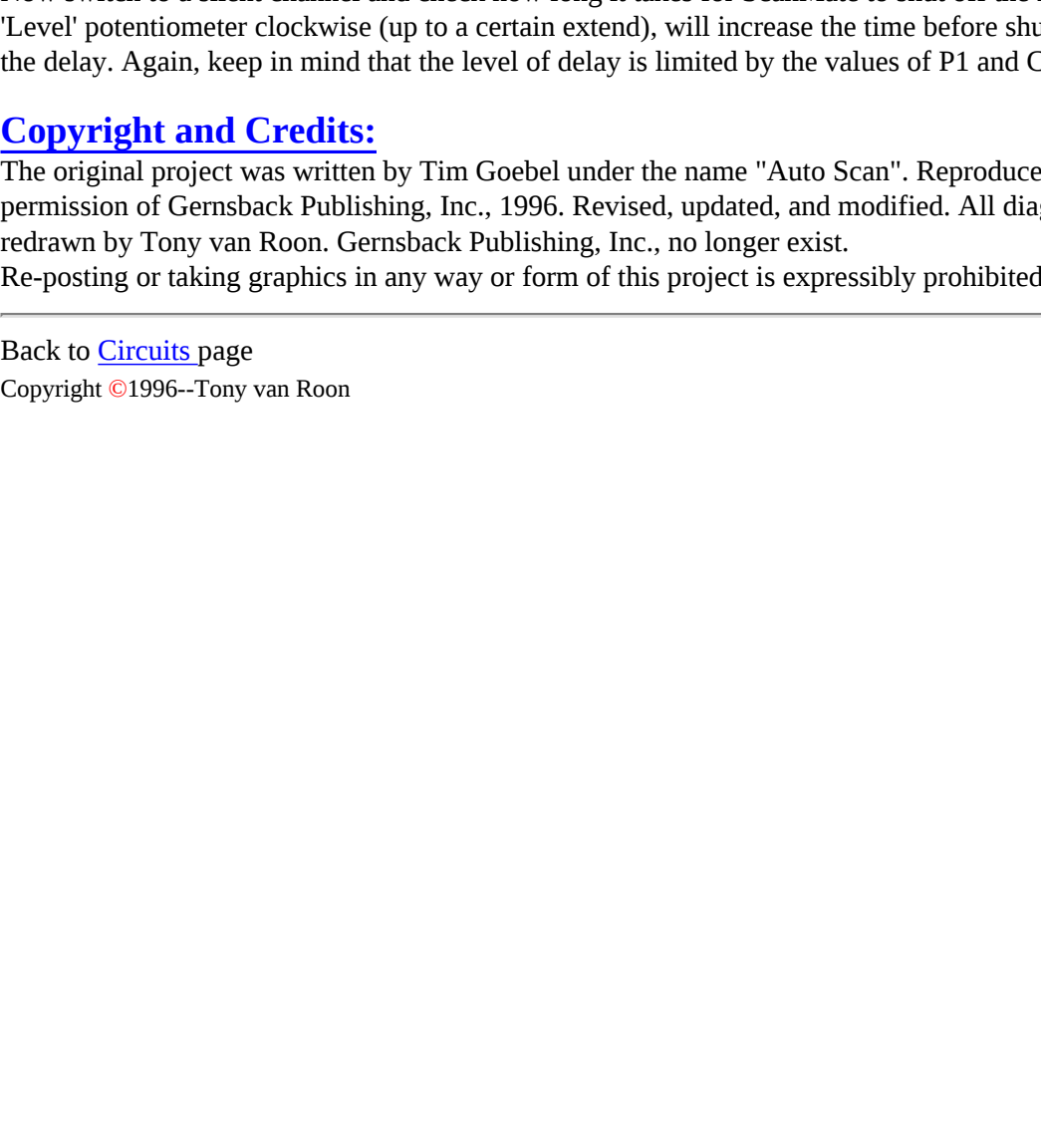


Fig. 3
Fig. 4

Components not shown on the printed circuit board are mounted on the front and rear panel of the enclosure.



Turning to the bi-colored LED used in the circuit; if a similar unit cannot be found, the two-color unit can be replaced by two discrete LEDs. Of course, it will be necessary to supply an appropriate dropping resistor for each unit; or if you decide to hook them up back-to-back (duplicating the unit's schematic symbol), you may have to play with the value of the dropping resistor. I used a Radio Shack 12.6 volt, center-tapped (ct) transformer in the power-supply of his prototype. I was unable to obtain the 300mA version so saddled for the 500mA type which meant modifying the PCB a bit since the transformer is larger in size. The output of the transformer is taken from its center tap, thereby providing 6.3 volts AC for the rectifier circuit. If you have difficulty in locating a similar unit, you might consider using a 12-volt transformer (with sufficient current rating), along with a 7808 and a 7908 (positive and negative, respectively), 8-volt, three terminal regulators. If you choose to go that route, be sure not to overlook the filter capacitors. I have not experimented with an DC-type adapter but don't see why that should not work. If you have a 8 or 9 volt DC adapter of at least 300mA or better, try it. Saves the cost of the power supply parts + powercord in Fig. 2.

As for the enclosure itself, there are a couple of things to watch for should you decide to use a metal cabinet to house the project (as in my case). A lot of tape recorders with positive grounds or other unusual circuitry react violently to having either side of their remote start switches grounded. To prevent that problem, the remote start jack (J4) should be covered with heat shrink, or whatever, to keep the contacts completely isolated from ScanMate's other circuitry. You will most likely hear tremendous 'hum' if the remote jack is improperly isolated from the metal panel. (If, of course, you use a case with metal front and rear panels). You may have noticed that, unlike the other jacks, the remote jack is not connected directly to ground.

TR1 is a pc-mountable 12.6volt/300mA Center Tapped transformer. I purchased mine at Radio Shack: #276-1385. Some modifications were required to the PCB-layout to make the transformer fit nicely. Just in case you don't have a lot of experience with electronics and you're wondering why the schematic shows 6.3V and the parts list 12.6V. The transformer is a so-called 'center-tapped' model which means 12.6V - 0 - 6.3V. Either side of the '0' provides 6.3V. The '0' is the center-tap (Gnd.), or CT for short. We only use one side of the transformer with the center tap. CAUTION: Because of the +8 and -8 volts, the above circuit ONLY uses the ground coming from the center-tap of TR1!

In addition, because the circuit derives power from a 117-volt AC outlet, make certain that the board is mounted in its enclosure on standoffs to prevent the board from coming in contact with the cabinet.

Making a neat cutout for speakers is always a problem, if you're not handy with mechanical equipment, but can be easily solved by putting the opening at the bottom of the cabinet, where imperfections won't be noticed. I solved the problem by drilling 3 millimeter holes in a half star pattern. Looks really good. Anyone can drill a couple of holes right?

Check my [Radio Shack](#) data sheet for partnumbers; makes things easier when you visit the Radio Shack/Tandy store.

Just in case you have any problems finding some of the parts: You can replace the 2N2222 for a NTE123A (not AP), a 2N2219, BC107, or a TUN type as specified in Elektor (Elektor), or try something else (if it works it works right?). By the way, a 2N2222 is the same as the MPS2222A type from Radio Shack. If you can't find the LM or MC1458, use the NTE778A, or the 276-038 model from Tandy/Radio Shack; they are all pin-for-pin compatible as far as I know. The 1N4001 diodes can be substituted with a NTE116 or the #276-1101 model from Radio Shack. A 1N4002 or 1N4003 model will work just fine also, they just have a higher PIV. Transformer TR1 is available from Radio Shack at the #273-1384 6.3v/300mA. Use what's available in your area.



Using The ScanMate:

After connecting ScanMate, a scanner, and a tape recorder together, flip the speaker switch (S1) to the 'on' position and turn the 'level/sensitivity' potentiometer (P1) fully counter-clockwise. Next, find a busy channel on the scanner and put the tape unit into the record mode. LED1 should be red, meaning the tape is stopped. Slowly turn the P1 potentiometer clockwise until the bi-colored led turns green. At that point, your tape recorder should be running, recording everything coming over the scanner. Turn back a little but until the red led comes on again and the tape recorder stops. Monitor the whole thing for a bit and re-adjust if necessary.

Now switch to a silent channel and check how long it takes for ScanMate to shut off the recorder. If the delay isn't right, turning the 'Level' potentiometer clockwise (up to a certain extend), will increase the time before shut-off, turning it counterclockwise shortens the delay. Again, keep in mind that the level of delay is limited by the values of P1 and C2.

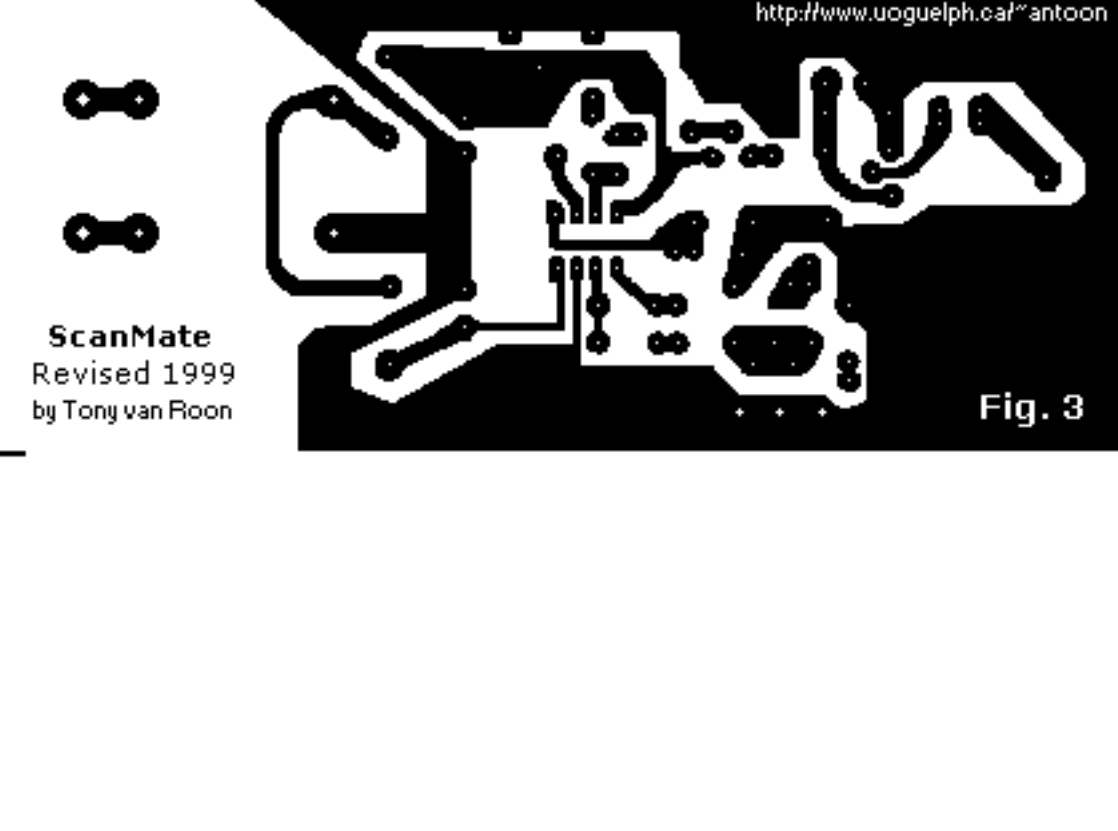
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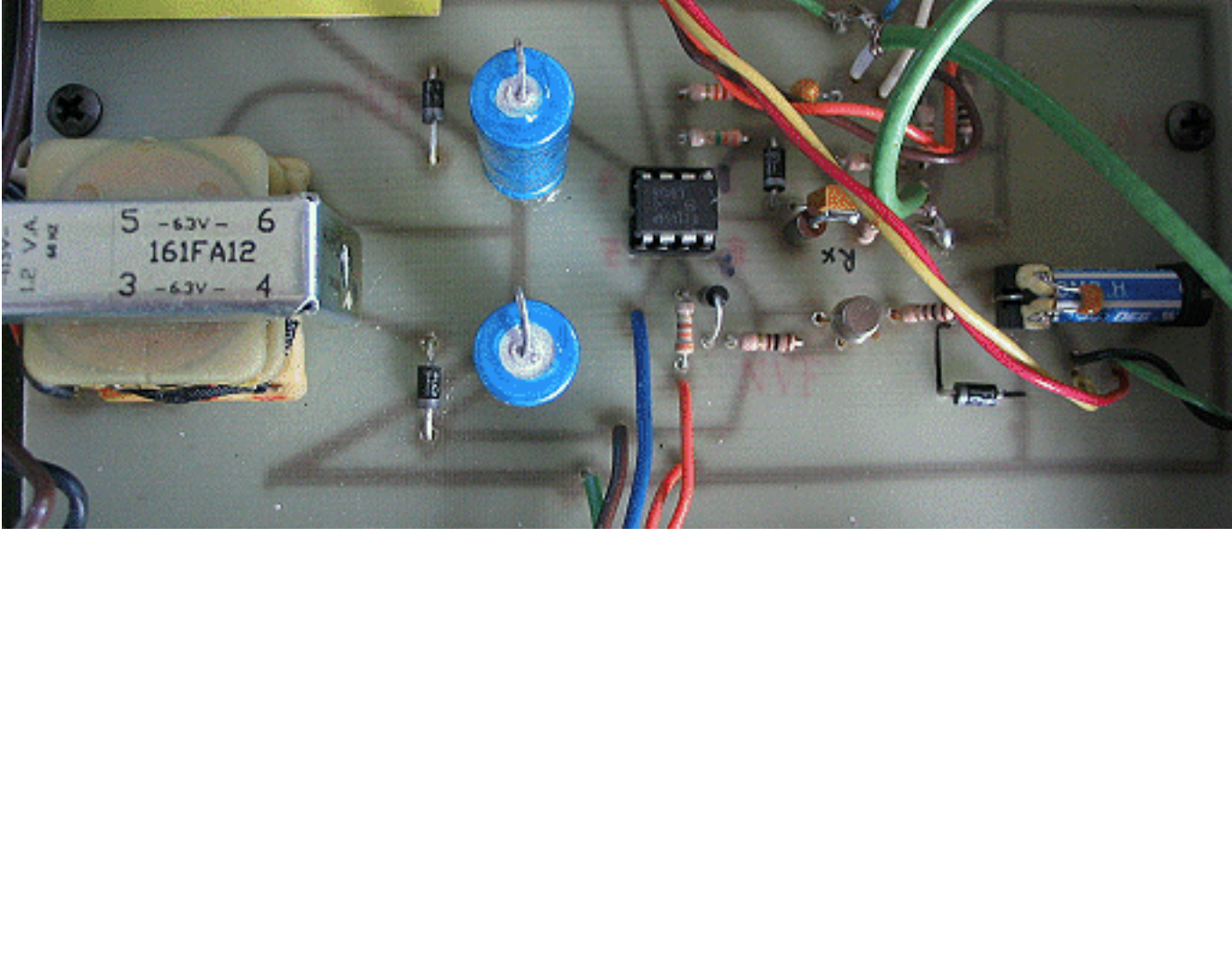
The original project was written by Tim Goebel under the name "Auto Scan". Reproduced from Popular Electronics, August 1989, by permission of Gernsback Publishing, Inc., 1996. Revised, updated, and modified. All diagrams, Printed-Circuit Board and Layout redrawn by Tony van Roon. Gernsback Publishing, Inc., no longer exist.

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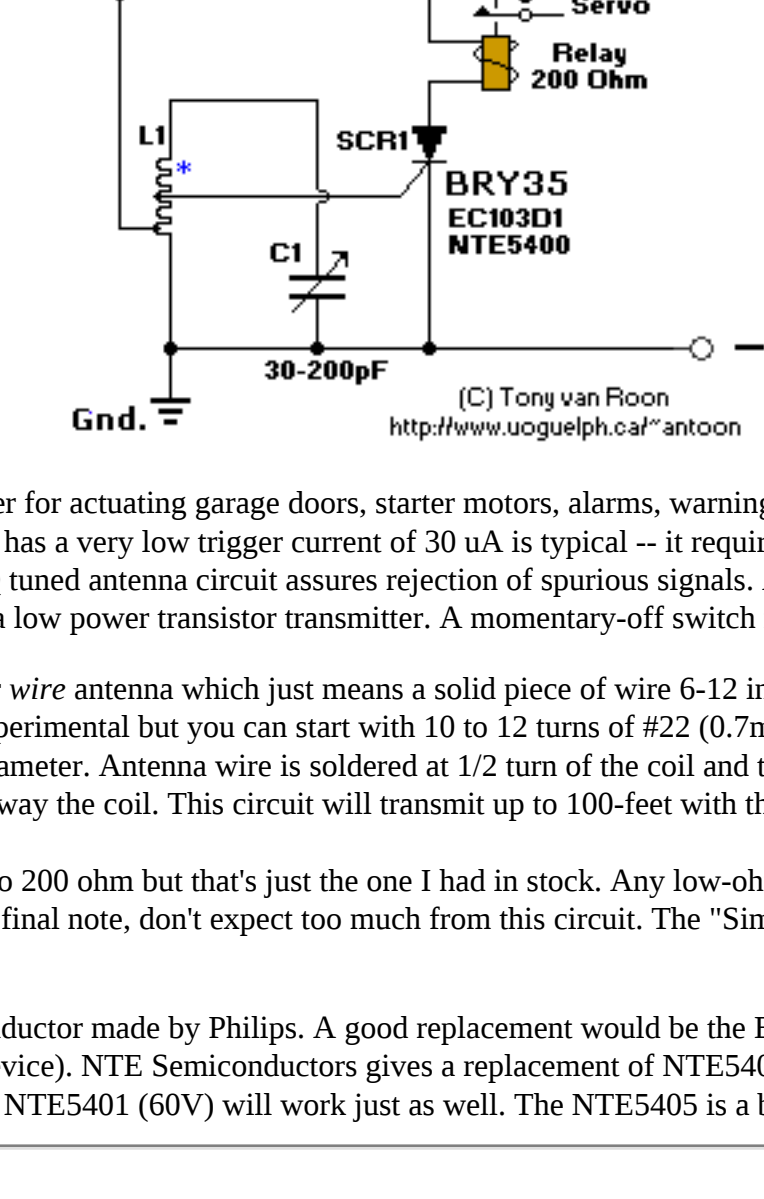
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Simplest R/C Circuit

by Tony van Roon



A simple and effective receiver for actuating garage doors, starter motors, alarms, warning systems and numerous other possibilities. The SCR, which has a very low trigger current of 30 uA is typical -- it requires an input power of only 30 uW to activate the relay. A high Q tuned antenna circuit assures rejection of spurious signals. A whip or wire antenna is adequate up to 100 feet from a low power transistor transmitter. A momentary-off switch resets the circuit.

The circuit specifies a *whip* or *wire* antenna which just means a solid piece of wire 6-12 inches long (15-30cm). The antenna coil is experimental but you can start with 10 to 12 turns of #22 (0.7mm) magnet wire, and 5/16" (8mm) coil diameter. Antenna wire is soldered at 1/2 turn of the coil and the gate of the BRY35 is soldered about halfway the coil. This circuit will transmit up to 100-feet with the above specifications @ 30uA.

The relay coil is specify's up to 200 ohm but that's just the one I had in stock. Any low-ohm relay, even at 9V or so, should work. And a final note, don't expect too much from this circuit. The "Simplest R/C Circuit" is just that; SIMPLE!

The BRY35 is an old semiconductor made by Philips. A good replacement would be the EC103D1, also made by Philips (see pin-out picture for this device). NTE Semiconductors gives a replacement of NTE5405, but I have not tried it. In my opinion, a NTE5400 (30V) or NTE5401 (60V) will work just as well. The NTE5405 is a bit overkill at 400V.

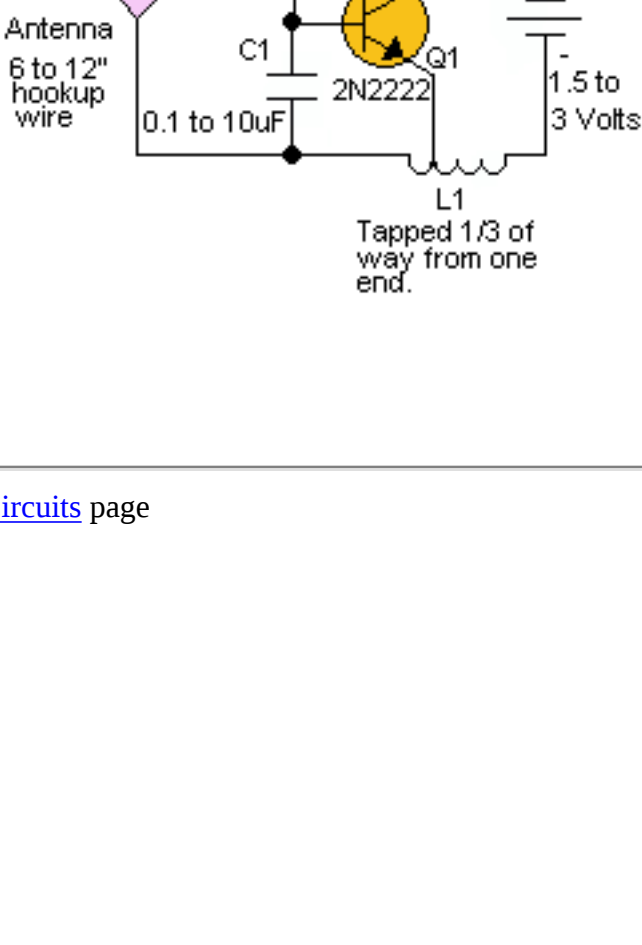


Bottom View

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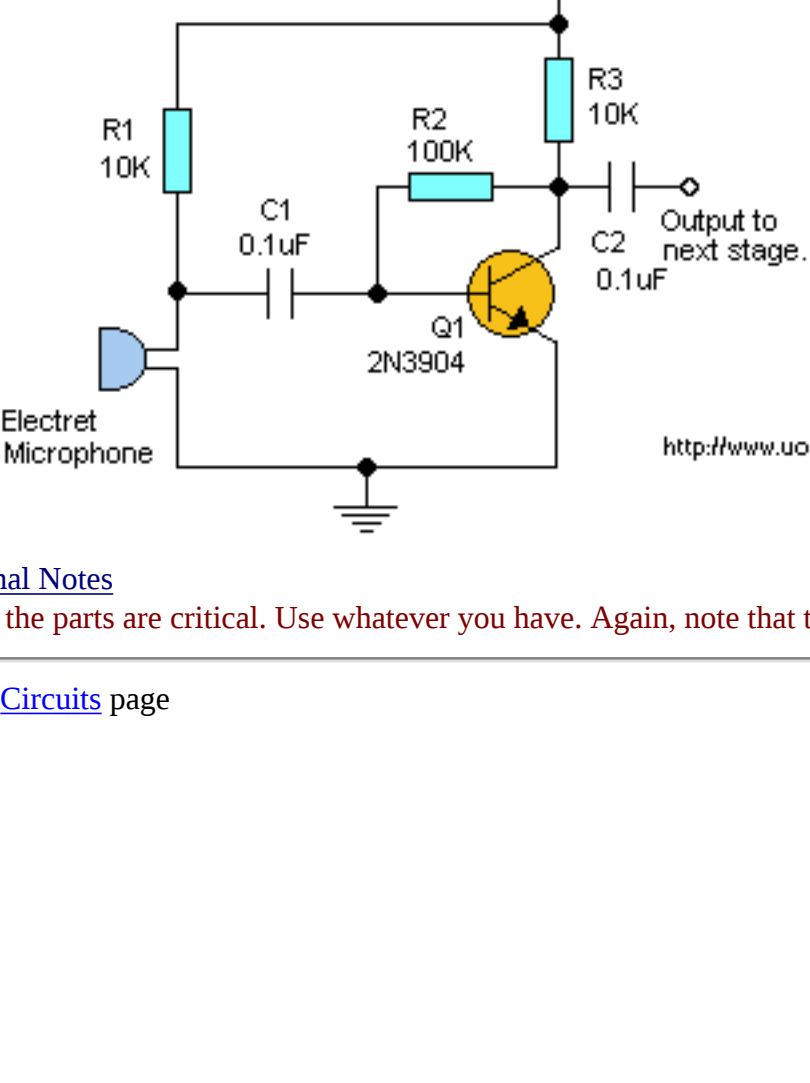
Simplest RF Transmitter

[http://www.uoguelph.ca/~antoon](http://www.uoguelph.ca/~antoon/circ/rt1.htm)



This is probably the simplest radio transmitter that you will find anywhere. It has a total of five parts and can be constructed into a very small space. It is great for science fair projects or other science related projects where short range transmission is useful. It runs on 1.5 to 3 volts, with small hearing aid batteries or lithium "coin" cells being ideal. A thermistor or photoresistor can be inserted in series with R1 to have a varying output frequency dependent on the input. The frequency can also be changed by changing the value of C1. A 2N2222 transistor is recommended, but you can try other types also. Performance tends to vary from type to type as well as from transistor to transistor. L1 is 20 to 30 turns of thin magnet wire (24 to 32 ga.) close wound around a 1/8 to 1/4" diameter non-conductive form. The coil is tapped 1/3 of the way from one end and the tap connected to the emitter of Q1. Experiment with all of the values in this circuit. Nothing is critical, but performance can be varied considerably.

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SIMPLE AUDIO PREAMP

This easy circuit provides good gain to weak audio signals. Use it in front of an RF oscillator to make an RF transmitter that is very sensitive to sound.

<http://www.uoguelph.ca/~antoon>

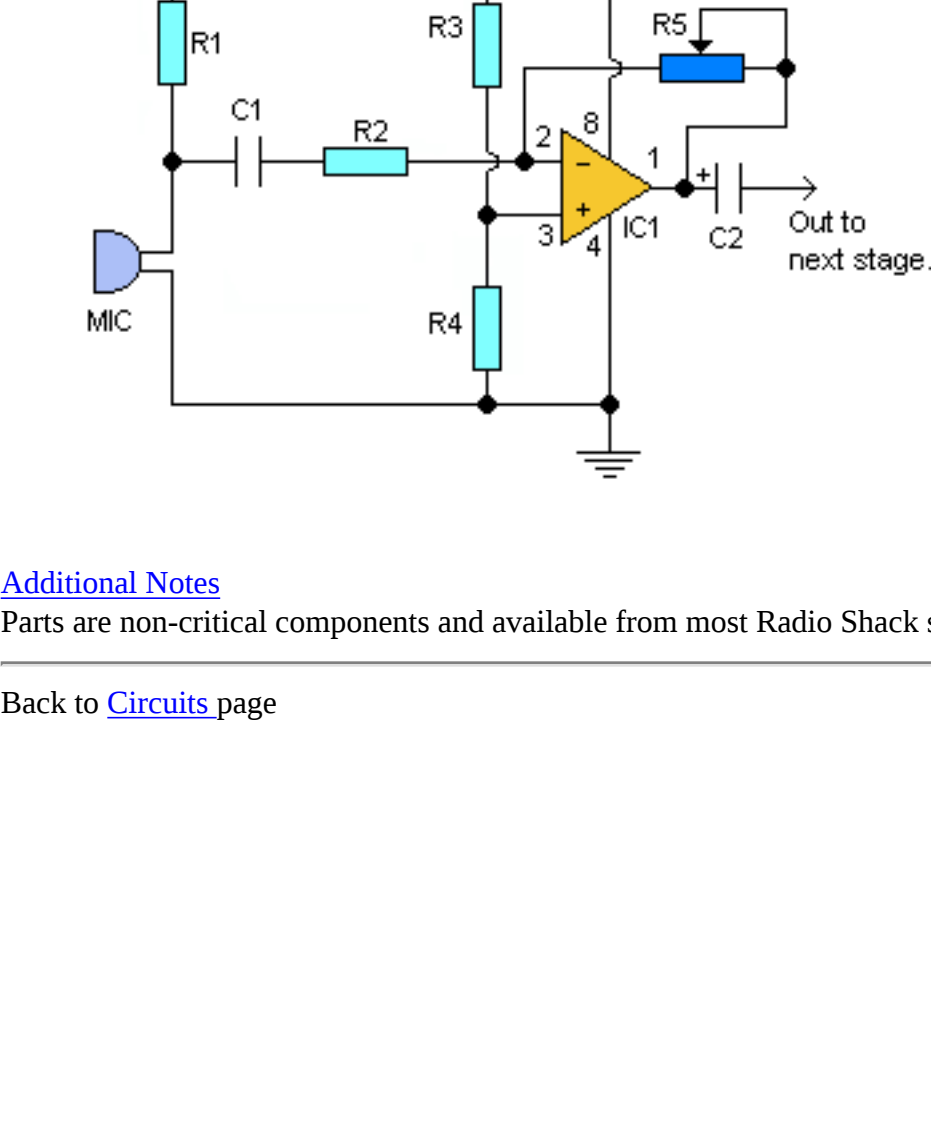
[Additional Notes](#)

None of the parts are critical. Use whatever you have. Again, note that the microphone is a "electret" type.

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Single IC Audio Preamplifier

by Tony van Roon



Single IC Audio PreAmplifier

<http://www.uoguelph.ca/~antoon>

PARTS LIST

- C1 = 0.1uF disc capacitor
- C2 = 4.7uF electrolytic capacitor
- IC1 = LM358 single-supply dual op-amp
- MIC = electret microphone
- R1, R3, R4 = 10K
- R2 = 1K
- R5 = 100K to 1M potentiometer

Additional Notes

Parts are non-critical components and available from most Radio Shack stores.

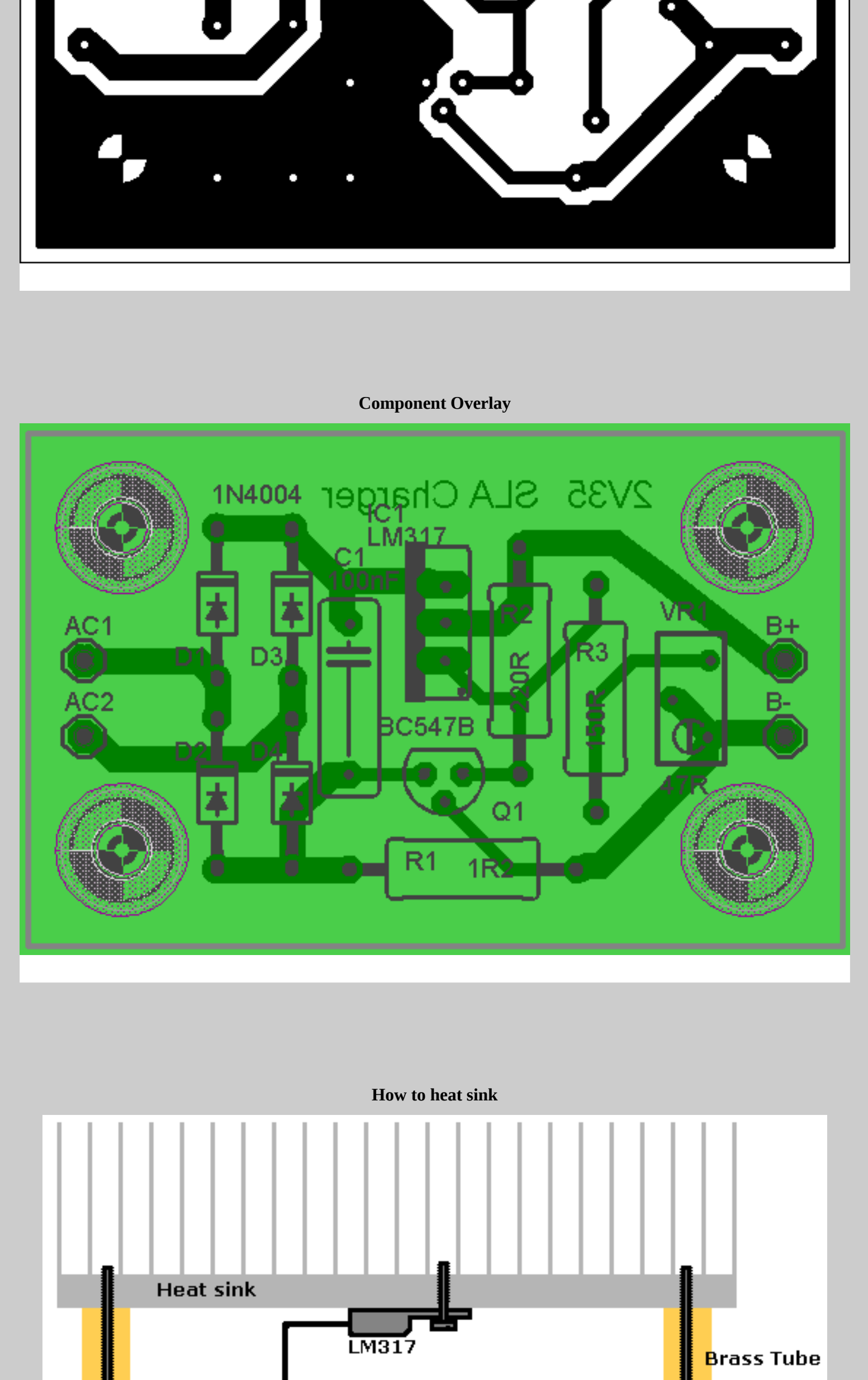
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Single Cell SLA Charger

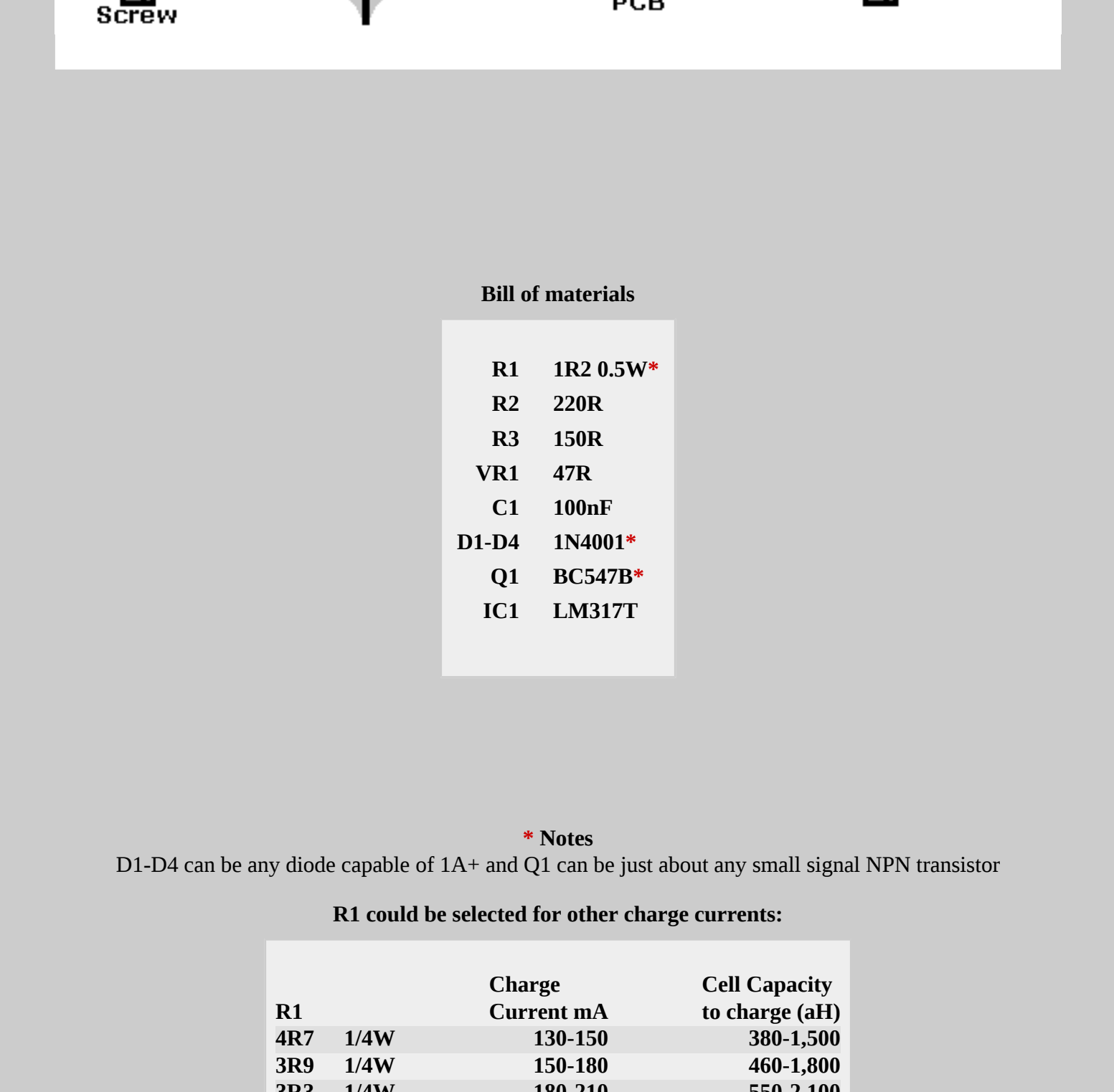


SLA = Sealed Lead Acid

Schematic of the charger



Component Overlay



Bill of materials

R1	1R2 0.5W*
R2	220R
R3	150R
VR1	47R
C1	100nF
D1-D4	1N4001*
Q1	BC547B*
IC1	LM317T

* Notes

D1-D4 can be any diode capable of 1A+ and Q1 can be just about any small signal NPN transistor

R1 could be selected for other charge currents:

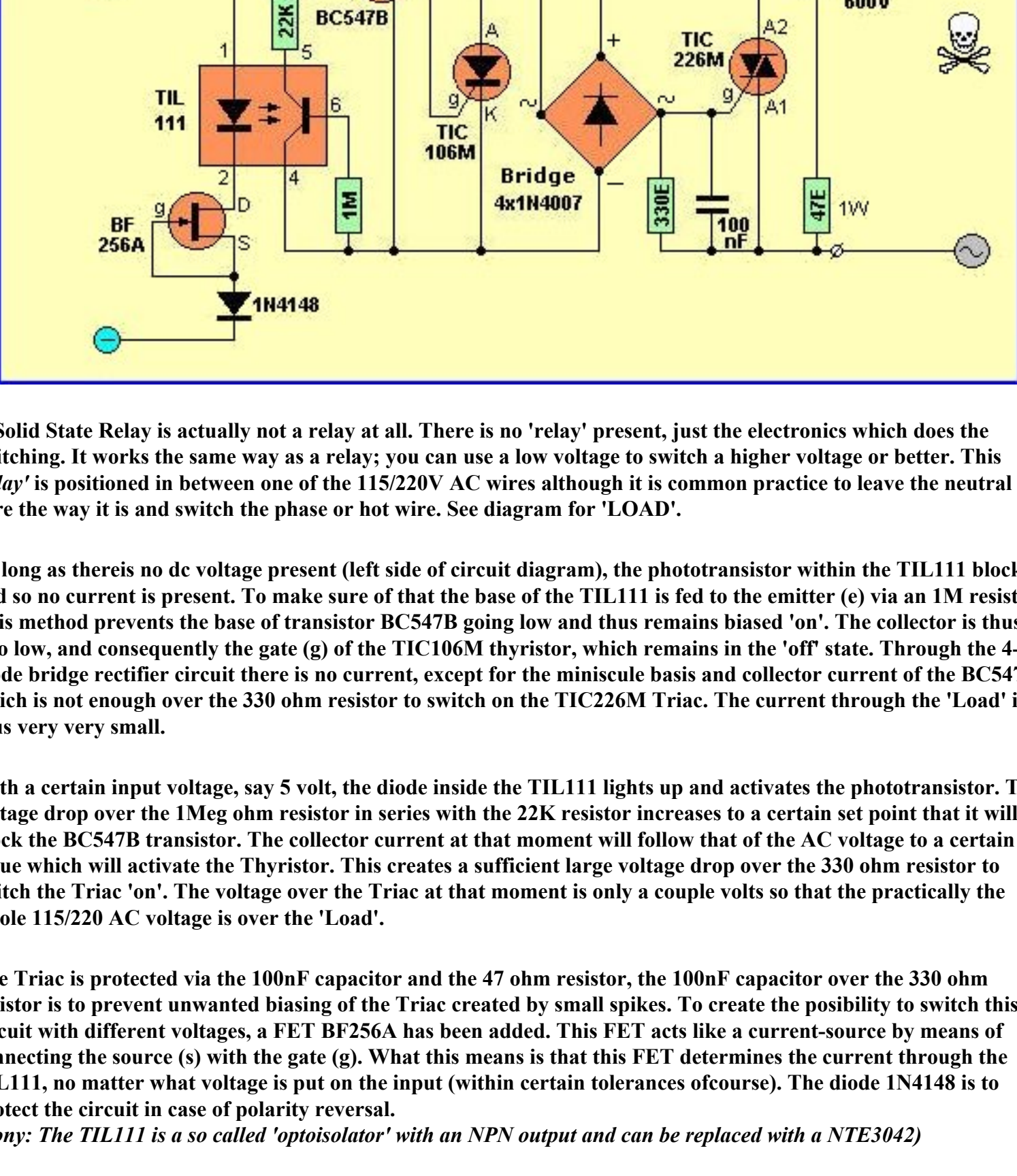
R1	Charge Current mA	Cell Capacity to charge (aH)
4R7 1/4W	130-150	380-1,500
3R9 1/4W	150-180	460-1,800
3R3 1/4W	180-210	550-2,100
2R7 1/4W	220-260	670-2,600
2R2 1/4W	270-320	820-3,200
1R8 1/3W	330-390	1,000-3,900
1R5 1/3W	400-470	1,200-4,700
1R2 1/2W	500-580	1,500-5,800
1R0 1/2W	600-700	1,800-7,000
0R82 1W	700-900	2,200-8,500
0R68 1W	900-1,000	2,600-10,300

2004-10-27, by Søren.

Solid State Relais

by Jan Hamer

Solid State Relays are available almost everywhere these days, however they remain very expensive. Therefore, your efforts to build one yourself pays off. Especially since it only needs a handful components and the circuitry is simple and straightforward.



A Solid State Relay is actually not a relay at all. There is no 'relay' present, just the electronics which does the switching. It works the same way as a relay; you can use a low voltage to switch a higher voltage or better. This 'relay' is positioned in between one of the 115/220V AC wires although it is common practice to leave the neutral wire the way it is and switch the phase or hot wire. See diagram for 'LOAD'.

As long as there is no dc voltage present (left side of circuit diagram), the phototransistor within the TIL111 blocks and so no current is present. To make sure of that the base of the TIL111 is fed to the emitter (e) via an 1M resistor. This method prevents the base of transistor BC547B going low and thus remains biased 'on'. The collector is thus also low, and consequently the gate (g) of the TIC106M thyristor, which remains in the 'off' state. Through the 4-diode bridge rectifier circuit there is no current, except for the miniscule basis and collector current of the BC547B which is not enough over the 330 ohm resistor to switch on the TIC226M Triac. The current through the 'Load' is thus very very small.

With a certain input voltage, say 5 volt, the diode inside the TIL111 lights up and activates the phototransistor. The voltage drop over the 1Meg ohm resistor in series with the 22K resistor increases to a certain set point that it will block the BC547B transistor. The collector current at that moment will follow that of the AC voltage to a certain value which will activate the Thyristor. This creates a sufficient large voltage drop over the 330 ohm resistor to switch the Triac 'on'. The voltage over the Triac at that moment is only a couple volts so that the practically the whole 115/220 AC voltage is over the 'Load'.

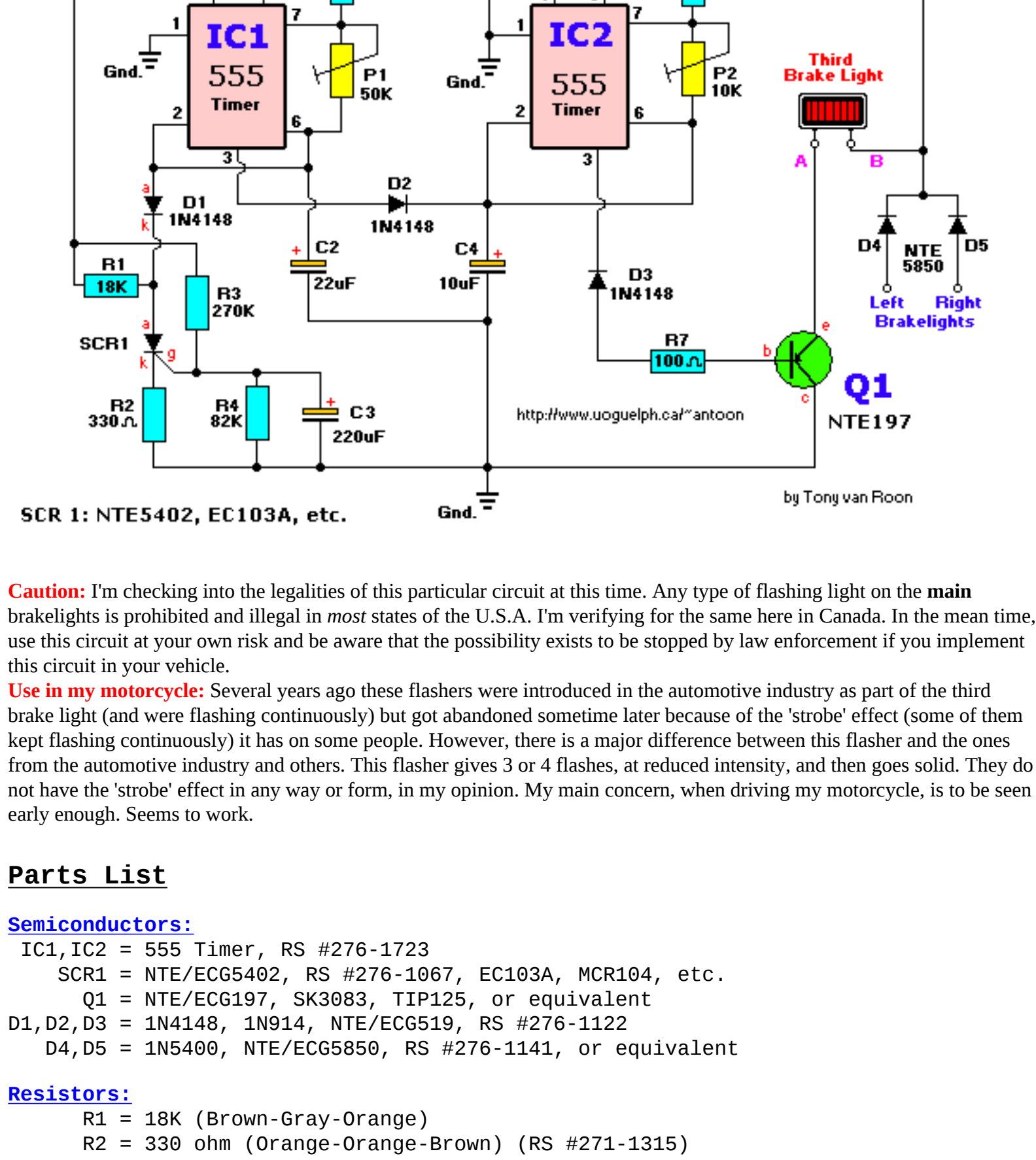
The Triac is protected via the 100nF capacitor and the 47 ohm resistor, the 100nF capacitor over the 330 ohm resistor is to prevent unwanted biasing of the Triac created by small spikes. To create the possibility to switch this circuit with different voltages, a FET BF256A has been added. This FET acts like a current-source by means of connecting the source (s) with the gate (g). What this means is that this FET determines the current through the TIL111, no matter what voltage is put on the input (within certain tolerances of course). The diode 1N4148 is to protect the circuit in case of polarity reversal.
(Tony: The TIL111 is a so called 'optoisolator' with an NPN output and can be replaced with a NTE3042)

A good point of a circuit like this is the separation of the DC and AC voltages, so this circuit could be used in a variety of applications, up to approximately 1.5 KiloWatt, if you mount the Triac on a large cooling-rib. The 'M' indicator noted on the Triac means it is a 600volt type, a 'D' stands for 400volt. So make sure you go for the M type.
(Tony: The NTE replacements for this circuit are 600volt types which is more than sufficient for our 110/115VAC.) Also, if you decide to make a pcb for this circuit, to create sufficient space between the AC lines and don't make these AC tracks too narrow.

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R4 = 82K (Gray-Red-Orange)
R5, R6 = 1K2 (Brown-Red-Red) (1200 ohm)
R7 = 100 ohm (Brown-Black-Brown) (RS# 271-1311)
P1 = 50K, 10-turn
P2 = 10K, 10-turn

Capacitors:

C1 = 100µF/16V (RS# 272-1016)
C2 = 22µF/16V (RS# 272-1014)
C3 = 220µF/16V (RS# 272-1017)
C4 = 10µF/16V (RS# 272-1013)

Q1 is a PNP Silicon Audio Power Out/Medium Power Switch Transistor, 7A, with a TO-220 case. As long as you have a transistor which is close it will work fine. The SCR is a 100vrm, 0.8A, sensitive gate with a TO-92 case. Diodes D1, D2 and D3 are standard small signal diodes. Power diodes D4 and D5 are the 6A, 50vprv types, cathode case. The 60vrm type will work as well. I used for IC1 & IC2 the LM555 type. P1 controls the 'on' and pulse-duration, P2 controls the pulse-timing.

Applying the Brakes: When I first press the brakes, this circuit will turn on your 3rd brake light via the main brake lights. After about a second a series of short pulses occur. The number of pulses can range from approximately 1 to 10, depending on the setting of P1/P2 and when the brake pedal was applied last. After the pulses have been applied the third brake light assumes normal operation. The prototype was set for five flashes which seemed more than enough. Two days later I re-adjusted the trimmer potentiometers for 4 flashes. Looks pretty cool!

Circuit Description: The schematic consists of two 555 timer/oscillators in a dual timer configuration both setup in astable mode. When power is applied via the brake pedal, the brake light driver Q1 is switched on via the low-output pin 3 of IC2, and timer IC1 begins its timing cycle. With the output on pin 3 going high, inhibiting IC2's pin 2 (trigger) via D2, charge current begins to move through R3, R4 and C2.

When IC1's output goes low, the inhibiting bias on pin 2 of IC2 is removed and IC2 begins to oscillate, pulsing the third

conduct turning on
time will reset the 9
immediately and w

maximum available light
losses are not noticeable

Building Tips: You can easily build this circuit on perfboard or on one of RS/Tandy's use the associated printed circuit board listed here.

Keep in mind that Q1 will draw most likely 2 or 3 amps and mounting this device on a 1

Verify that the scr is the 'sensitive gate' type. In incandescent bulbs, there is a time lag b

and peak brightness. The lag is quite noticeable in an automotive bulb, so the duration o

should be set long enough to permit full illumination. For that reason, and because lamp

adjustment via P1 and P2 is necessary to provide the most effective pulse timing for t

The reason that the third light is connected to both brake lights is to eliminate the possib

when you see a rear signal with the brake applied.

Point A goes to metal ones also

European third brake lights.

Don't forget the three jumpers on the pcb; two jumpers underneath IC1/IC2 between the two ICs and one jumper between the two ICs and the two LEDs.

If you use a metal case, don't forget to insulate the D4/D5 diodes. (For motorcycle applications).

Some 90's cars, like my 1992 Mercury Sable, have two bulbs inside the third brake light to the left and right brake light for reasons only Ford knows. [Click here](#) for a possible explanation.

I modified mine to get it working; and that was easier than I expected. Current drawn is 1.85Amps (1850mA). Even with double the current none of the circuit components got too hot. I was worried about the bench testing was done with one bulb.

<http://www.uoguelph.ca/~antoon/>



The image shows a custom electronic circuit board for a third brake light. The board is populated with two integrated circuits (IC1 and IC2), several resistors, and a diode (D4). It is connected to a red LED strip light and a D4 diode, which is labeled 'left brake light'. The board is mounted on a metal surface, and there are some handwritten labels like 'b c e' and '1Q'.

50

metal case (as a coolrib) and use heavy duty wiring between the Q1 and the PCB. [Click HERE](#) for the PCB shown at the left.

Bench Testing: I tested different semiconductors like the 1N5401/1N5404, NTE153, and 4A type power diodes for DA/D5. All worked very well. As expected,

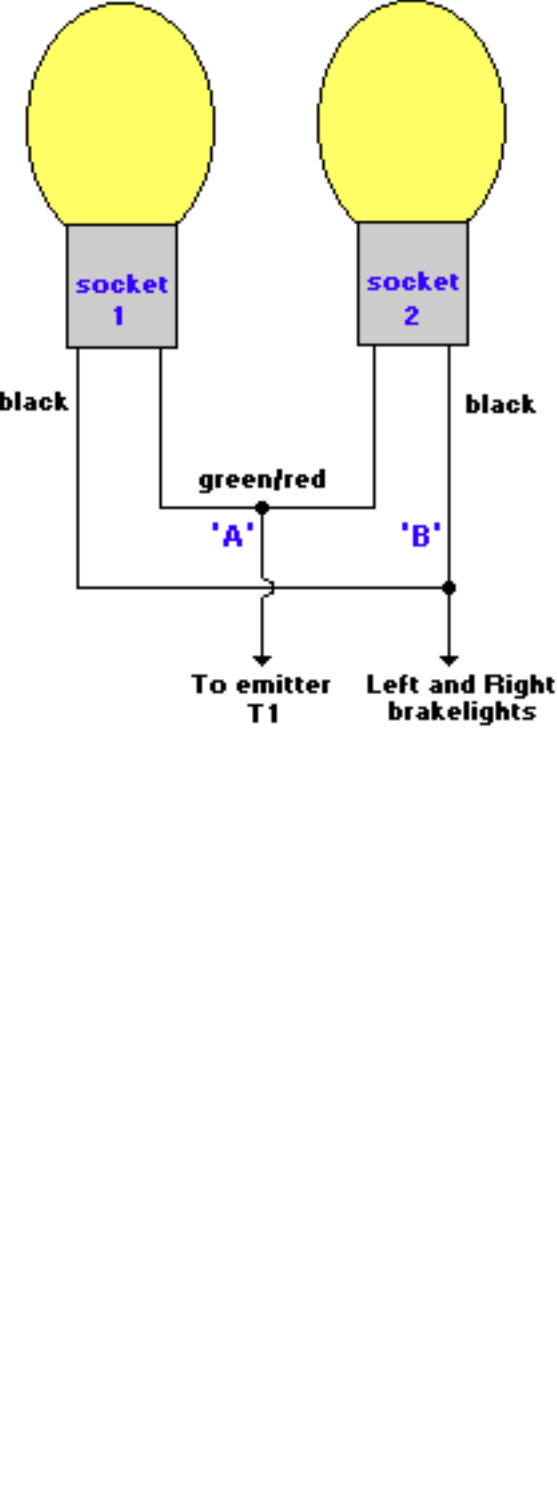
Q1 is getting very hot. Current draw was measured between 680 - 735mA with a regular automotive 'headlight' bulb, extra heavy duty to make sure the circuit was safe. I tested several other power transistors including some darlington like the

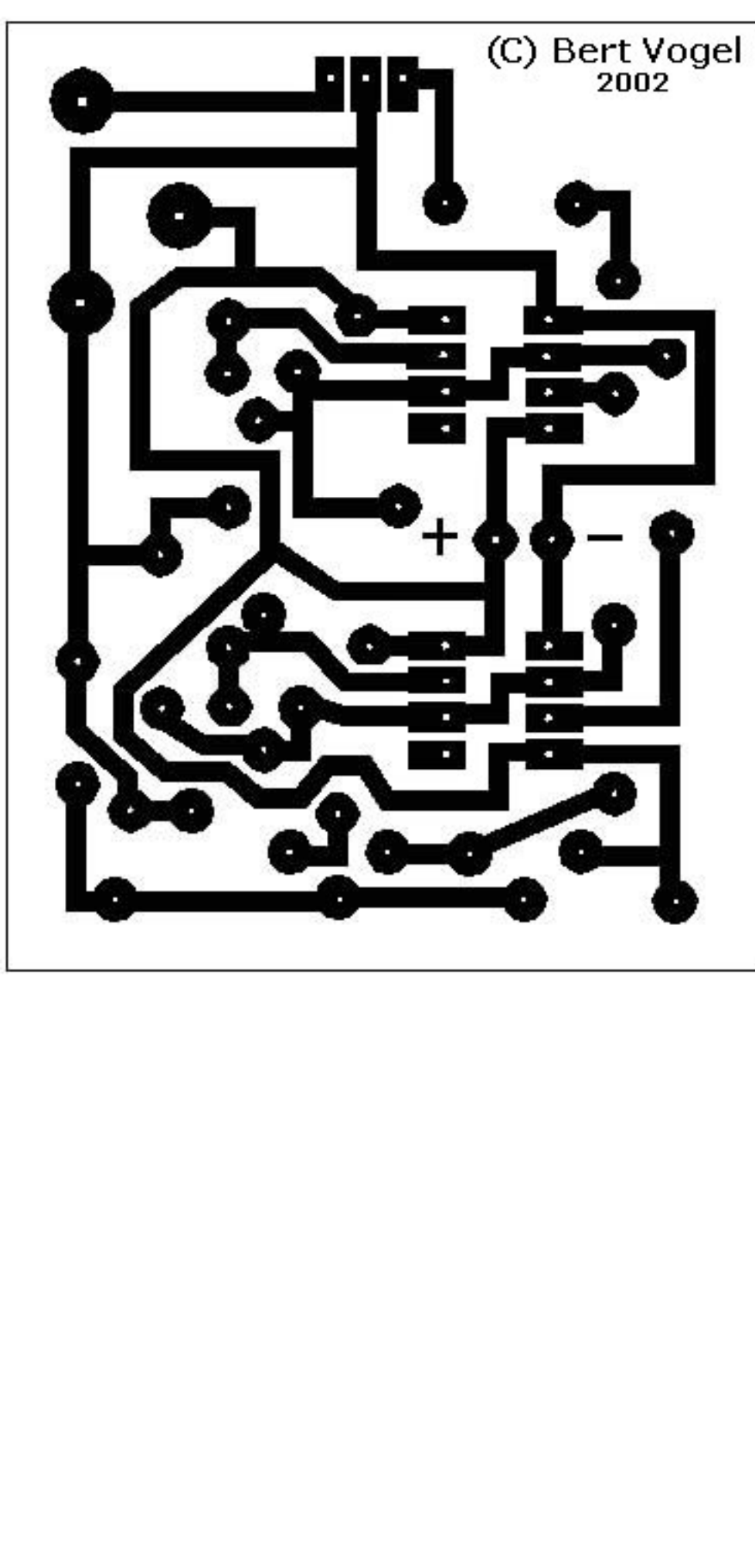
The actual third brake bulb is a lot smaller. Adjusting the trim pots ($P1/P2$) may take a bit of patience but really fine-tunes the circuit well.

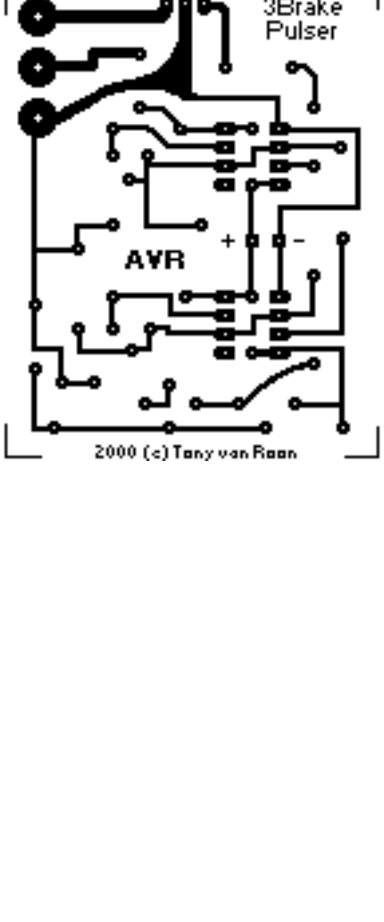
The circuit I have installed on the brakelight of my motorcycle works fine for more than 2 years. There are NO delays for the light to come on or delay between flashes and solid on. When the break pedal is pressed, the light should start to flash immediately.

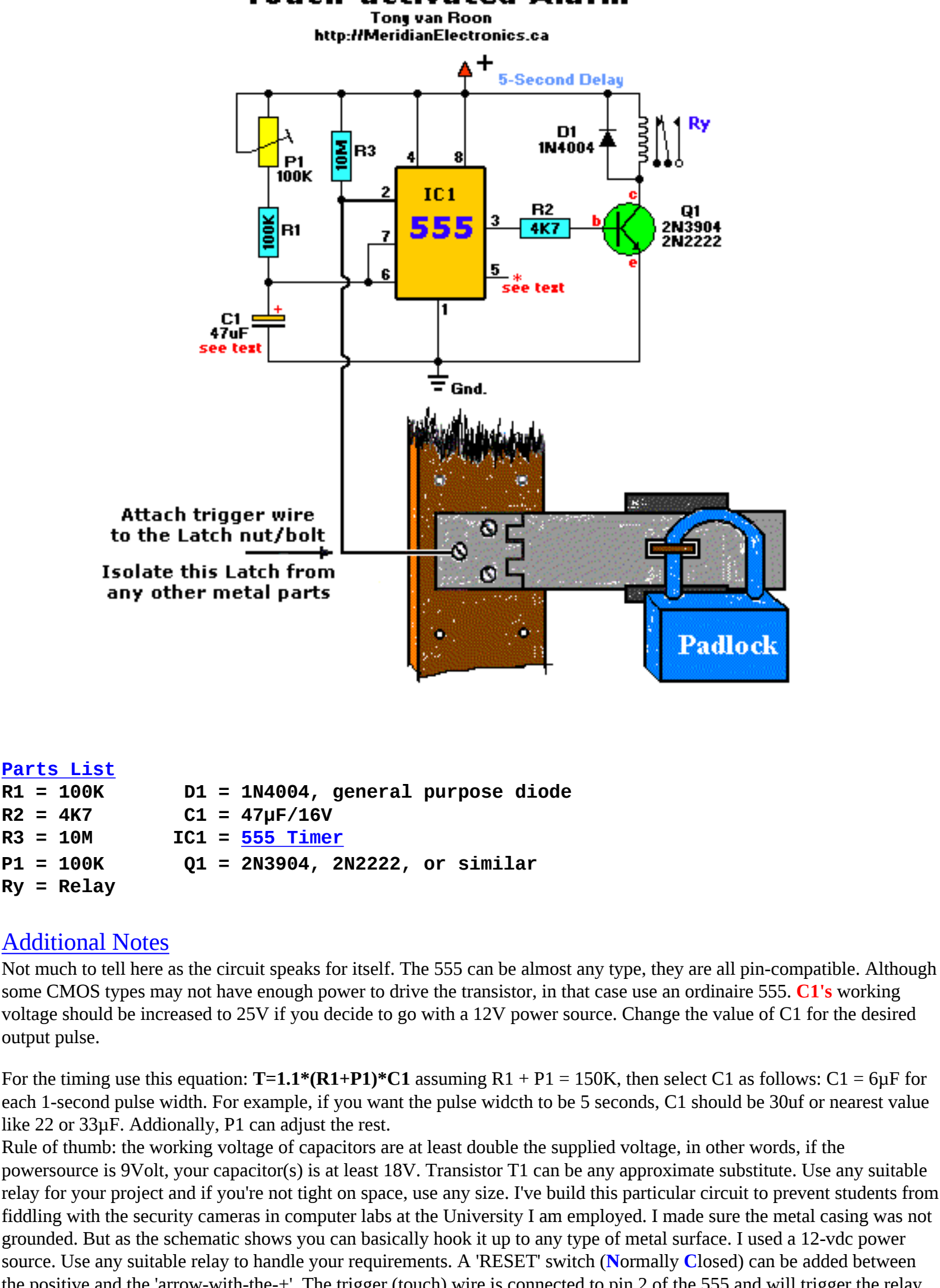
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Parts List

R1 = 100K
R2 = 4K7
R3 = 10K
P1 = 100K
D1 = 1N4004, general purpose diode
C1 = 47µF/16V
IC1 = 555 Timer
Q1 = 2N3904, 2N2222, or similar
Ry = Relay

Additional Notes

Not much to tell here as the circuit speaks for itself. The 555 can be almost any type, they are all pin-compatible. Although some CMOS types may not have enough power to drive the transistor, in that case use an ordinaire 555. **C1's** working voltage should be increased to 25V if you decide to go with a 12V power source. Change the value of C1 for the desired output pulse.

For the timing use this equation: $T=1.1*(R1+P1)*C1$ assuming $R1 + P1 = 150K$, then select C1 as follows: $C1 = 6\mu F$ for each 1-second pulse width. For example, if you want the pulse width to be 5 seconds, C1 should be 30uf or nearest value like 22 or 33µF. Additionally, P1 can adjust the rest.

Rule of thumb: the working voltage of capacitors are at least double the supplied voltage, in other words, if the powersource is 9Volt, your capacitor(s) is at least 18V. Transistor T1 can be any approximate substitute. Use any suitable relay for your project and if you're not tight on space, use any size. I've build this particular circuit to prevent students from fiddling with the security cameras in computer labs at the University I am employed. I made sure the metal casing was not grounded. But as the schematic shows you can basically hook it up to any type of metal surface. I used a 12-vdc power source. Use any suitable relay to handle your requirements. A 'RESET' switch (Normally Closed) can be added between the positive and the 'arrow-with-the-+'. The trigger (touch) wire is connected to pin 2 of the 555 and will trigger the relay, using your body resistance, when touched. It is obvious that the 'touching' part has to be clean and makes good contact with the trigger wire. This particular circuit may not be suitable for all applications. Just in case you wonder why pin 5 is not listed in the schematic diagram; it is not really needed. In certain noisy conditions a small 0.01µF ceramic capacitor is placed between pin 5 and ground. It does no harm to add one or leave it out.

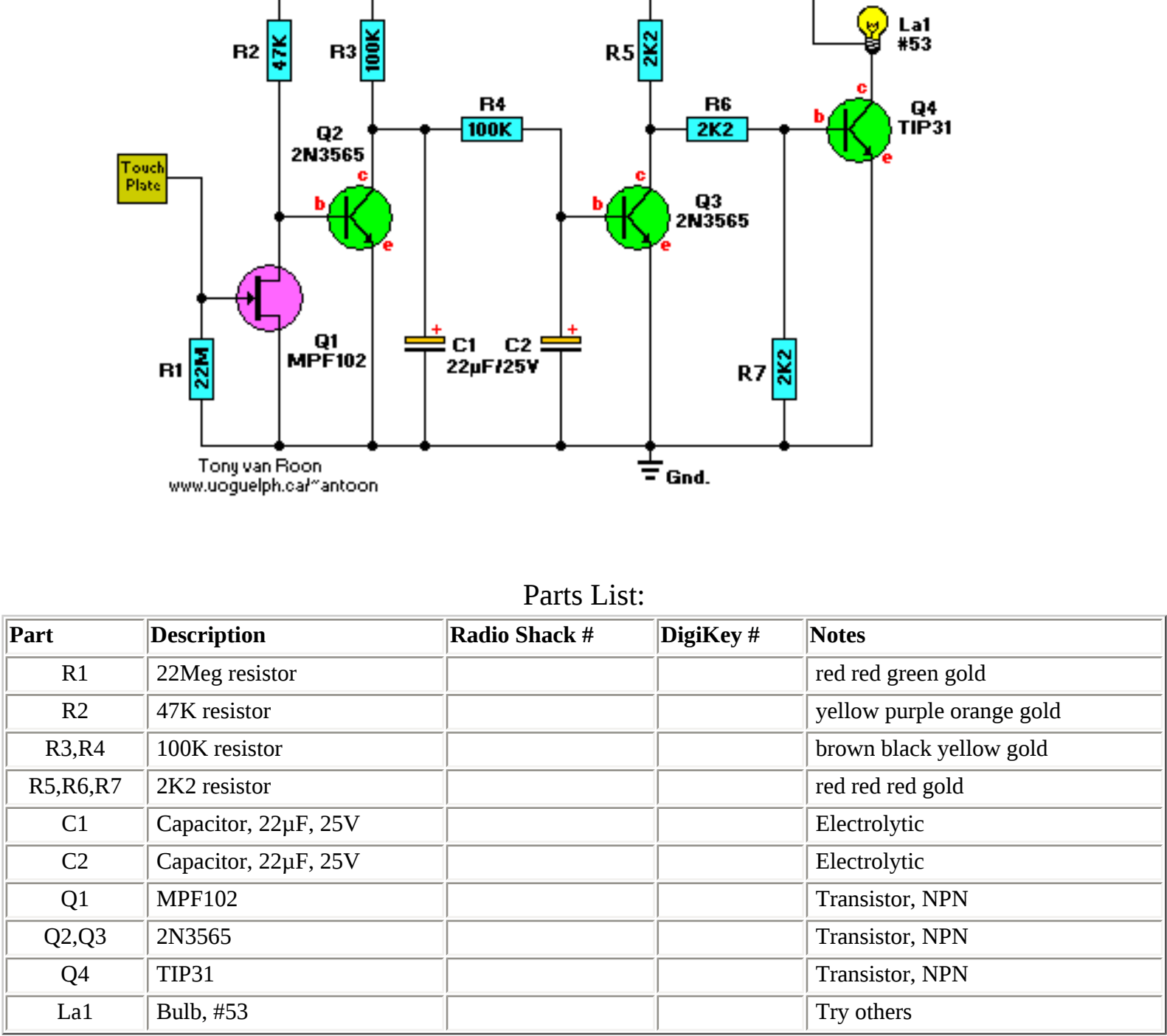
NOTE: For those of you who did not notice, there is an approximate 5-second delay build-in before activation of the relay to avoid false triggering, or a 'would-be' thief, etc.

AGAIN, make sure the latch is not touching anything 'ground' or the circuit just keeps resetting itself and so will not work. My shed has wooden doors so works fine. If you can't get yours to work, check the trigger input, verify there is some sort of signal coming from output pin 3, play with the value of R3/C1, etc. If you are interested in a short tutorial about the 555 Timer/Oscillator IC or find yourself having some problems understanding some of the pin functions, please check here: [555 Tutorial](#)

Thank you Ron Harrison for the modifications.

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Parts List:

Part	Description	Radio Shack #	DigiKey #	Notes
R1	22Meg resistor			red red green gold
R2	47K resistor			yellow purple orange gold
R3,R4	100K resistor			brown black yellow gold
R5,R6,R7	2K2 resistor			red red red gold
C1	Capacitor, 22μF, 25V			Electrolytic
C2	Capacitor, 22μF, 25V			Electrolytic
Q1	MPPF102			Transistor, NPN
Q2,Q3	2N3565			Transistor, NPN
Q4	TIP31			Transistor, NPN
La1	Bulb, #53			Try others

Couple Notes:

The MPPF102 (Q1) can be replaced with a NTE451 or ECG451, but still widely available. JFET-N-CHAN, UHF/VHF AMP

The 2N3565 (Q1/Q2) can be replace with a 2N2222(A), BC107, BC108, BC109(A/B/C), NTE123A, or ECG123A.

The TIP31 (Q3) can be replaced with a NTE196 or ECG196, but is a common type and widely available. NO suffix.

The 'Touch Plate' can be anything non corrosive. I use a silver quarter.

You can also use a small relay instead of the #53 bulb.

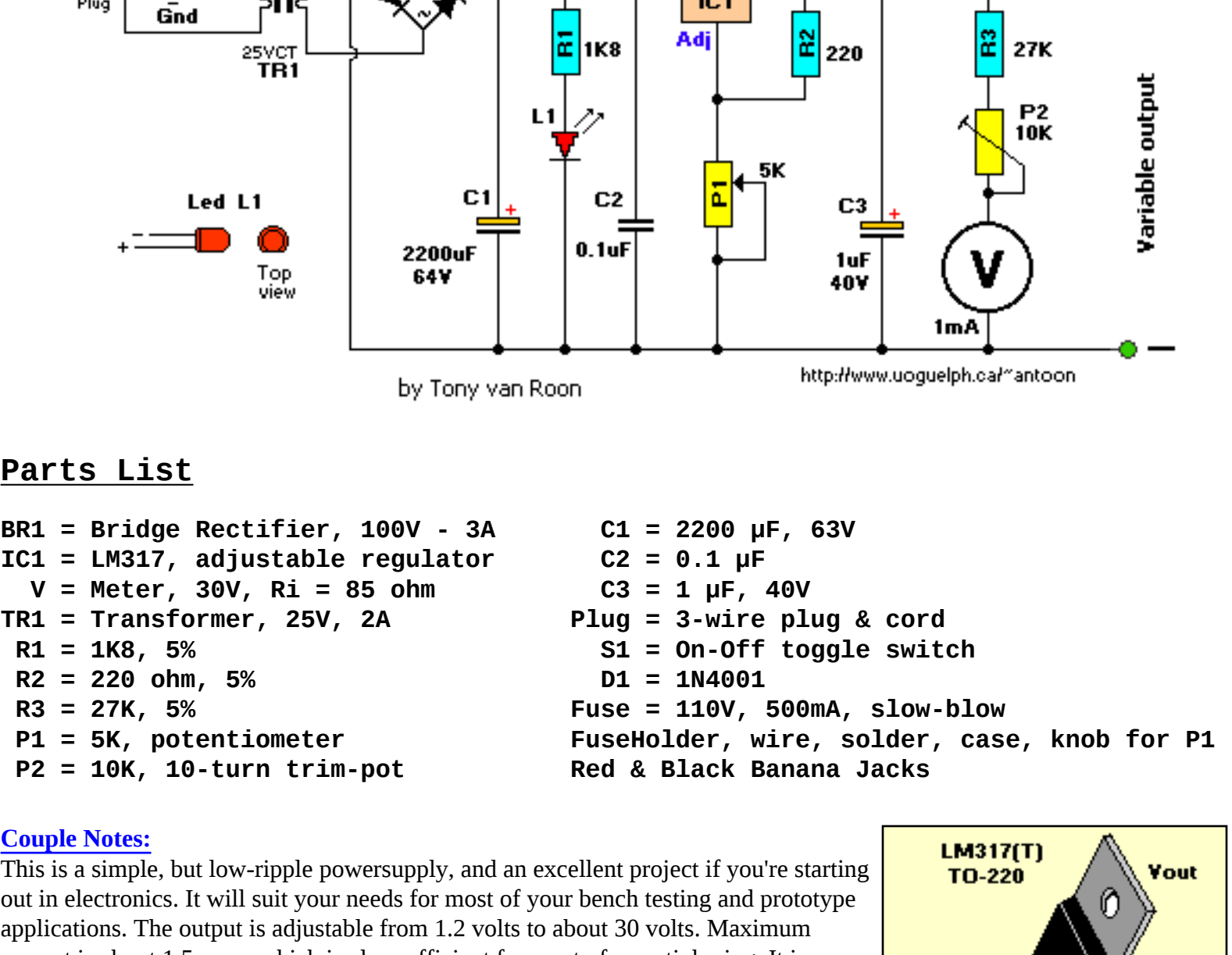
The phone number for [DigiKey](#) is 1-800-Digi-Key.

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Variable Regulated Power Supply

1.2 to 30Volts @ 1.5 Amps.



by Tony van Roon

http://www.uoguelph.ca/~antoon

Parts List

- | | |
|---|---|
| BR1 = Bridge Rectifier, 100V - 3A | C1 = 2200 μ F, 63V |
| IC1 = LM317, adjustable regulator | C2 = 0.1 μ F, 40V |
| V = Meter, 30V, R _i = 85 ohm | C3 = 1 μ F, 40V |
| TR1 = Transformer, 25V, 2A | Plug = 3-wire plug & cord |
| R1 = 1K8, 5% | S1 = On-Off toggle switch |
| R2 = 220 ohm, 5% | D1 = 1N4001 |
| R3 = 27K, 5% | Fuse = 110V, 500mA, slow-blow |
| P1 = 5K, potentiometer | FuseHolder, wire, solder, case, knob for P1 |
| P2 = 10K, 10-turn trim-pot | Red & Black Banana Jacks |

Couple Notes:

This is a simple, but low-ripple powersupply, and an excellent project if you're starting out in electronics. It will suit your needs for most of your bench testing and prototype applications. The output is adjustable from 1.2 volts to about 30 volts. Maximum current is about 1.5 amps which is also sufficient for most of your tinkering. It is relatively easy to build and can be pretty cheap if you have some or all the required parts. A printed circuit board is not included and I'm not planning on adding one since the whole thing can easily be build on perforated or vero board. Or buy one of Radio Shack/Tandy's experimenters boards (#276-150). Suit yourself. The meter and the transformer are the money suckers, but if you can scrounge them up from somewhere it will reduce the cost significantly. BR1 is a full-wave bridge rectifier. The two '-' denotes 'AC' and are connected to the 25vac output coming from the transformer. IC1 is a 3-pin, TO-220 model. Be sure to put a cooling rib on IC1, at it's max 1.5 A current it quickly becomes very hot... Most of the parts can be obtained from your local Radio Shack or Tandy store. The physical size of the power supply case depends largely on the size of the meter &: transformer. But almost anything will do, even wood. Go wild.

Circuit Description:

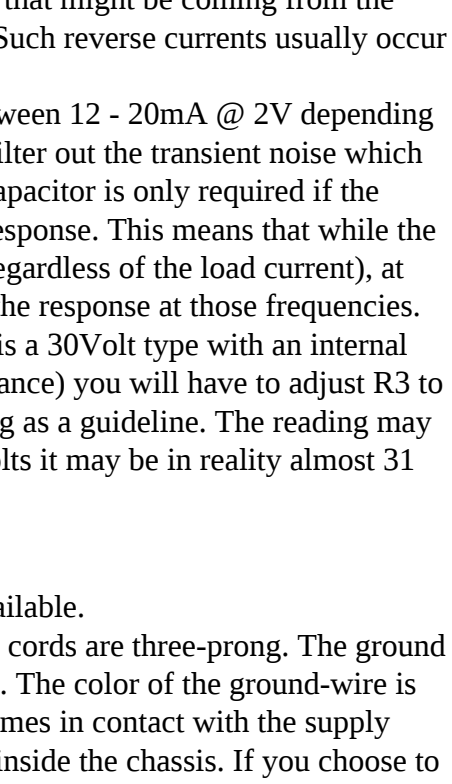
The 110V-AC coming from the powercord is fed to the transformer TR1 via the on-off switch and the 500mA fuse. The 30vac output (approximately) from the transformer is presented to the BR1, the bridge-rectifier, and here rectified from AC (Alternating Current) to DC (Direct Current). If you don't want to spend the money for a Bridge Rectifier, you can easily use four general purpose 1N4004 diodes. The pulsating DC output is filtered via the 2200 μ F capacitor (to make it more manageable for the regulator) and fed to 'IN'-put of the adjustable LM317 regulator (IC1). The output of this regulator is your adjustable voltage of 1.2 to 30'volts varied via the 'Adj' pin and the 5K potmeter P1. The large value of C1 makes for a good, low ripple output voltage. Why exactly 1.2V and not 0-volt? Very basic, the job of the regulator is two-fold; first, it compares the output voltage to an internal reference and controls the output voltage so that it remains constant, and second, it provides a method for adjusting the output voltage to the level you want by using a potentiometers. Internally the regulator uses a zener diode to provide a fixed reference voltage of 1.2 volt across the external resistor R2. (This resistor is usually around 240 ohms, but 220 ohms will work fine without any problems). Because of this the voltage at the output can never decrease below 1.2 volts, but as the potentiometer (P1) increases in resistance the voltage across it, due to current from the regulator plus current from R2, its voltage increases. This increases the output voltage. D1 is a general purpose 1N4001 diode, used as a feedback blocker. It steers any current that might be coming from the device under power around the regulator to prevent the regulator from being damaged. Such reverse currents usually occur when devices are powered down. The 'ON' Led will be lit via the 18K resistor R1. The current through the led will be between 12 - 20mA @ 2V depending on the type and color Led you are using. C2 is a 0.1 μ F (100nF) decoupler capacitor to filter out the transient noise which can be induced into the supply by stray magnetic fields. Under normal conditions this capacitor is only required if the regulator is far away from the filter cap, but I added it anyway. C3 improves transient response. This means that while the regulator may perform perfectly at DC and at low frequencies, (regulating the voltage regardless of the load current), at higher frequencies it may be less effective. Adding this 1 μ F capacitor should improve the response at those frequencies. R3 and the trimmer pot (P2) allows you to 'zero' your meter to a set voltage. The meter is a 30Volt type with an internal resistance of 85 ohms. I you have or obtained a meter with a different R_i (internal resistance) you will have to adjust R3 to keep the current of meter to 1mA. Just another note in regards this meter, use the reading as a guideline. The reading may or may not be off by about 0.75volts at full scale, meaning if your meter indicates 30 volts it may be in reality almost 31 volts or 29 volts. If you need a more precise voltage, then use your multimeter.

Construction:

Because of the few components you can use a small case but use whatever you have available. I used a power cord from a computer and cut the computer end off. All computer power cords are three-prong. The ground wire, which is connected to the middle pin of the power plug is connected to the chassis. The color of the ground-wire is either green or green/yellow. It is there for your protection if the 110vac accidentally comes in contact with the supply housing (case). BE CAREFUL always to disconnect the powerplug when you working inside the chassis. If you choose to use an in-line, or clip-type fuseholder be sure to isolate it with heat shrink or something to minimize accidental touching. I use perf-board (or Vero board) as a circuit board. This stuff is widely available and comes relatively cheap. It is either made of some sort of fiber material or Phenolic or Bakelite pcb. They all work great. Some Phenolic boards come with copper tracks already on them which will make soldering the project together easier. I mounted the LM317(T) regulator on a heatsink. If you use a metal/aluminum case you can mount it right to the metal case, insulated with the mica insulator and the nylon washer around the mounting screw. Note that the metal tab of the LM317 is connected internally to the 'Output' pin. So it has to be insulated when mounting directly to the case. Use heat sink compound (comes in transparent or white color) on the metal tab and mica insulator to maximize proper heat transfer between LM317 and case/ or heatsink. Drill the holes for the banana jacks, on/off switch, and LED and make the cut-out for the meter. It is best to mount everything in such a way that you are able to trouble-shoot your circuit board with ease if needed. One more note about the on-off switch S1, this switch has 110VAC power to it. After soldering, insulate the bare spots with a bit of silicon gel. Works great and prevents electrical shock through accidental touching. If all is well, and you are finished assembling and soldering everything, check all connections. Check capacitors C1 & C3 for proper polarity (especially for C1, polarity reversal may cause explosion). Hookup a multimeter to the power supply output jacks. Set the meter for DC volts. Switch on S1 (led will light, no smoke or sparks?) and watch the meter movement. Adjust the potentiometer until it reads on your multimeter 15Volts. Adjust trimpot P2 until the meter also reads 15volts. When done, note any discrepancies between your multimeter and the power supply meter at full scale (max output). Maybe there is none, maybe there is a little, but you will be aware of it. Good luck and have fun building!

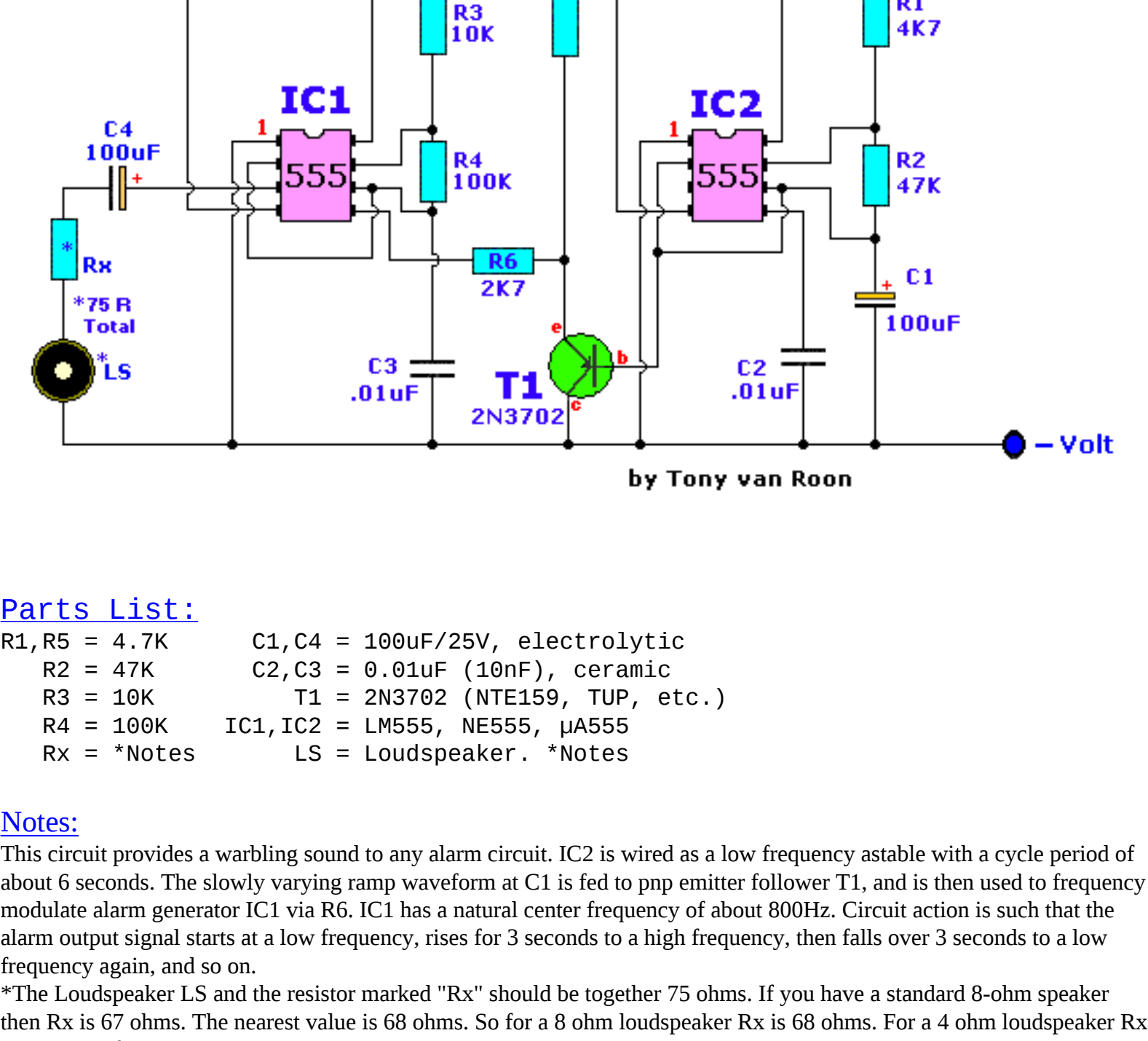
Final Note:

You can add two silicon diodes (in series) to the output of the LM317 to drop the final 1.2V, giving the full 0-30V range. I built a similar supply using the LM317, to supply a wafer coating spinner motor. The 1.2V kept the motor spinning at over 100rpm, which was unacceptable to the researcher, who needed to ramp the motor speed from 0-8krpm. This solution was provided to me by a technician from the National High Magnetic Field Laboratory. (3-04-2004, Gary Poplin)



Wailing Alarm Siren

by Tony van Roon



Parts List:

R1, R5 = 4.7K C1, C4 = 100uF/25V, electrolytic
R2 = 47K C2, C3 = 0.01uF (10nF), ceramic
R3 = 10K T1 = 2N3702 (NTE159, TUP, etc.)
R4 = 100K IC1, IC2 = LM555, NE555, uA555
Rx = *Notes LS = Loudspeaker. *Notes

Notes:

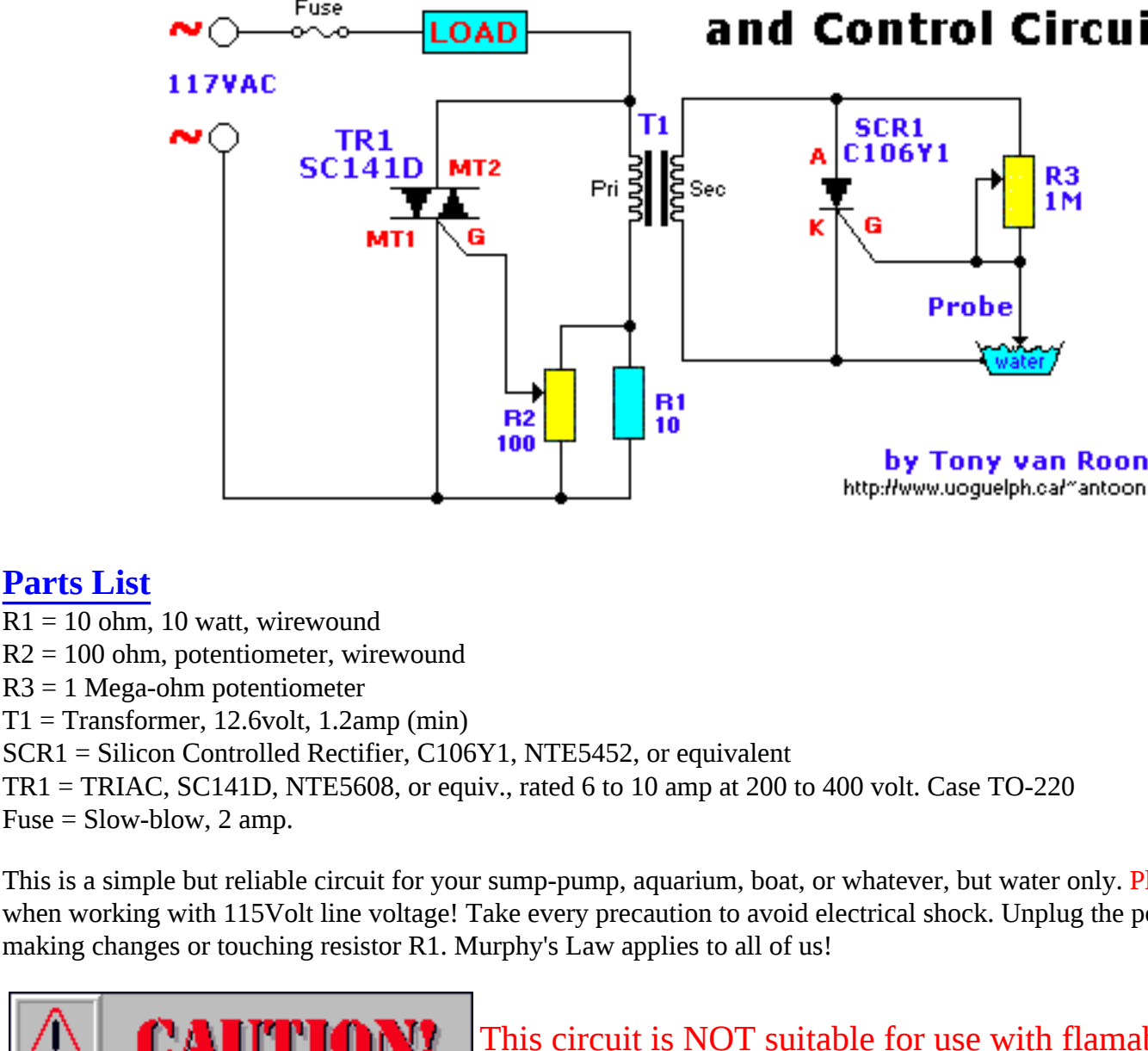
This circuit provides a warbling sound to any alarm circuit. IC2 is wired as a low frequency astable with a cycle period of about 6 seconds. The slowly varying ramp waveform at C1 is fed to pnp emitter follower T1, and is then used to frequency modulate alarm generator IC1 via R6. IC1 has a natural center frequency of about 800Hz. Circuit action is such that the alarm output signal starts at a low frequency, rises for 3 seconds to a high frequency, then falls over 3 seconds to a low frequency again, and so on.

*The Loudspeaker LS and the resistor marked "Rx" should be together 75 ohms. If you have a standard 8-ohm speaker then Rx is 67 ohms. The nearest value is 68 ohms. So for a 8 ohm loudspeaker Rx is 68 ohms. For a 4 ohm loudspeaker Rx is 71 ohms, for a 25 ohm loudspeaker Rx is 50 ohms, etc, etc.

BUT, the Rx value is not very critical. It is just there as some sort of volume control. Experiment with it. C2 and C3 are 0.01uF (10nF) and a simple ceramic type will do the job. I tested the circuit at 9, 12, and 15 volt. My choice would be 9volt alkaline for battery operation or 12volt for use with a small powersupply. Output pin 3 of IC2 is NOT connected; just in case you are wondering... :-) In my prototype I used LM555 timers.

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Parts List

R1 = 10 ohm, 10 watt, wirewound

R2 = 100 ohm, potentiometer, wirewound

R3 = 1 Mega-ohm potentiometer

T1 = Transformer, 12.6volt, 1.2amp (min)

SCR1 = Silicon Controlled Rectifier, C106Y1, NTE5452, or equivalent

TR1 = TRIAC, SC141D, NTE5608, or equiv., rated 6 to 10 amp at 200 to 400 volt. Case TO-220

Fuse = Slow-blow, 2 amp.

This is a simple but reliable circuit for your sump-pump, aquarium, boat, or whatever, but water only. **Please be careful** when working with 115Volt line voltage! Take every precaution to avoid electrical shock. Unplug the power before making changes or touching resistor R1. Murphy's Law applies to all of us!



This circuit is NOT suitable for use with flammable liquids!!

A Couple Notes

Triac TR1 energizes a load which might control a valve, indicator light, audible alarm, relays, etc. The SC141D can be substituted with NTE5608, NTE5635, or Radio Shack 276-1001 model.

When the water-level is "low", the probe is out of the water and SCR1 is triggered "on". It conducts and imposes a heavy load on Transformer T1's secondary winding. That load is reflected back into the primary, gating TR1 on which energizes the load. The C106Y1 can be substituted with a NTE5452 or Radio Shack (or Tandy) 276-1352

T1 is 12.6V not 12V. Applications of the circuit are limited only by one's imagination.

The load may vary from a watervalue, a relay controlling a pump, etc. Lots of possibilities. Value of the (slow-blow) fuse may vary depending on your load. Select your probe carefully, keeping in mind the hardness and/or pH level of the water. In either case, on occasion it will be necessary to clean your probe from contaminants.

If your country's electrical supply is 220VAC change TR1 to a 400 - 600 volt type, potentiometer R2 to 220 - 500 ohms. If you find that 500 ohms is too coarse go with 220 ohm.

Experiment with the value for wire-wound resistor R1. It can be anywhere from 5 to 47 ohms. Start with 15 ohms or so and take it from there. Feel if it gets real hot (unplug the power first!). If so, increase the value.

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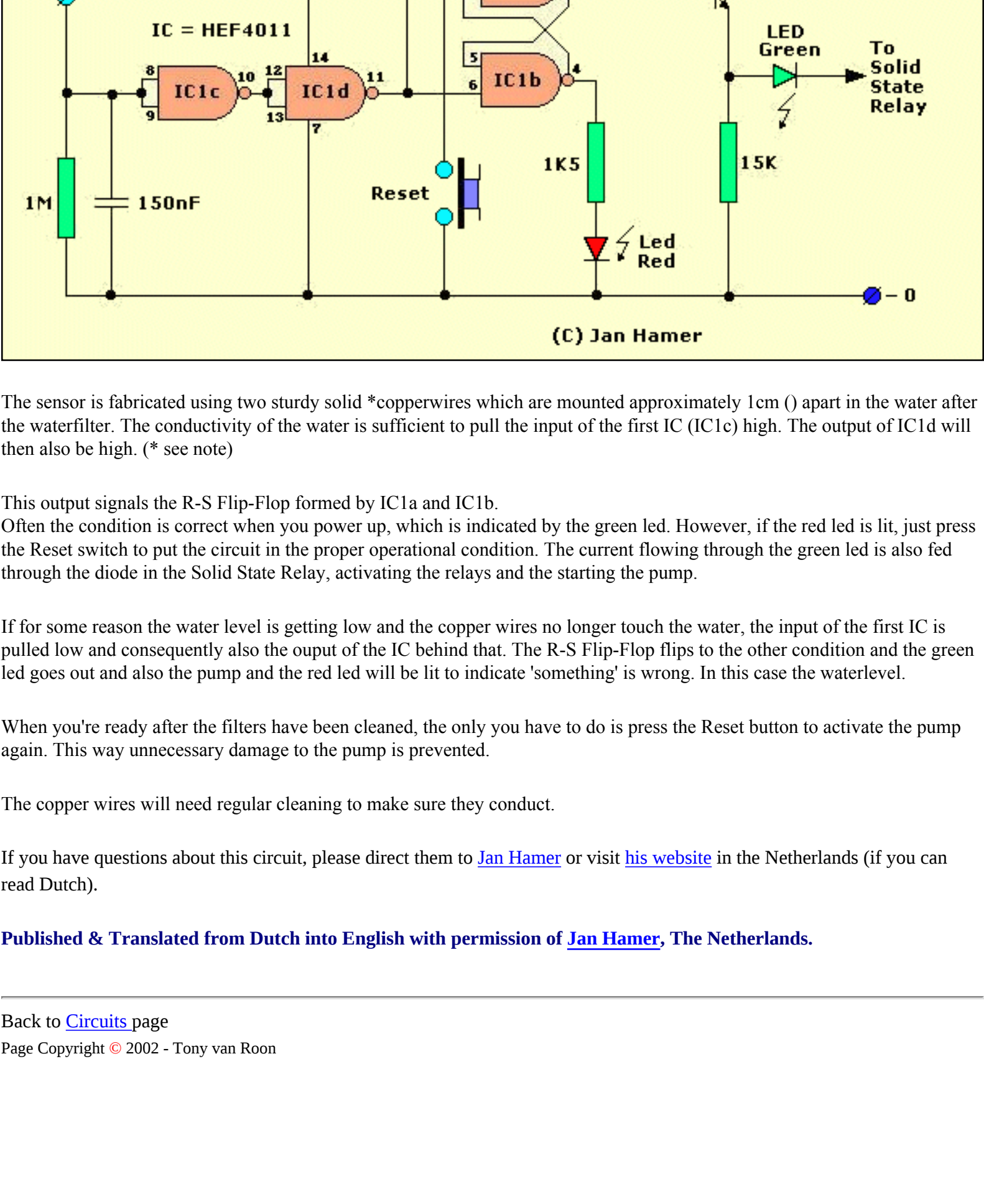
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Waterpump Safety Guard for Fish-pond

© by Jan Hamer

The circuit below was developed to guard the fish pond. In this case to prevent that the pump sucks just air when the waterlevel get below the pump. When the waterfilters get saturated and dirty, the water level behind the filter gets to an unacceptable level. You can see this when the pump also produces airbubbles in the water.

Because you are not all day peeking if this is the case, I connected the pump via a [Solid State Relais](#), which acts as a power switch mounted in one of the AC wires and is controlled by the circuitry below.



The sensor is fabricated using two sturdy solid *copperwires which are mounted approximately 1cm () apart in the water after the waterfilter. The conductivity of the water is sufficient to pull the input of the first IC (IC1c) high. The output of IC1d will then also be high. (* see note)

This output signals the R-S Flip-Flop formed by IC1a and IC1b. Often the condition is correct when you power up, which is indicated by the green led. However, if the red led is lit, just press the Reset switch to put the circuit in the proper operational condition. The current flowing through the green led is also fed through the diode in the Solid State Relay, activating the relays and the starting the pump.

If for some reason the water level is getting low and the copper wires no longer touch the water, the input of the first IC is pulled low and consequently also the output of the IC behind that. The R-S Flip-Flop flips to the other condition and the green led goes out and also the pump and the red led will be lit to indicate 'something' is wrong. In this case the waterlevel.

When you're ready after the filters have been cleaned, the only you have to do is press the Reset button to activate the pump again. This way unnecessary damage to the pump is prevented.

The copper wires will need regular cleaning to make sure they conduct.

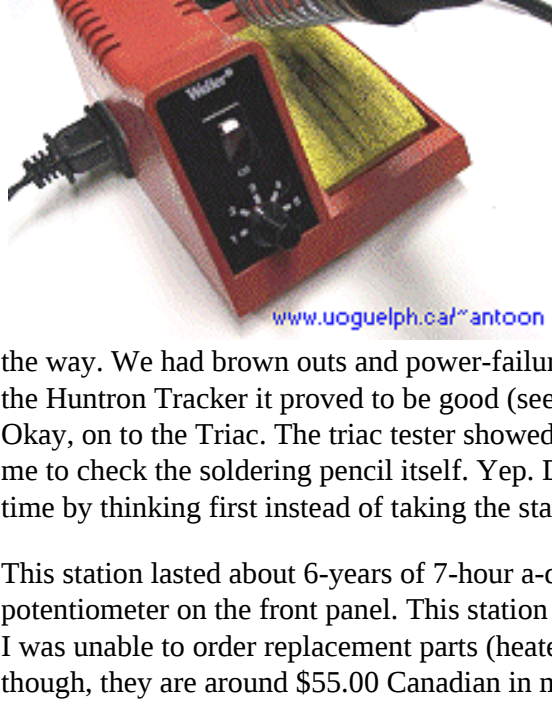
If you have questions about this circuit, please direct them to [Jan Hamer](#) or visit [his website](#) in the Netherlands (if you can read Dutch).

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Weller WLC100 Electronic Soldering Station



the way. We had brown outs and power-failures that afternoon so my first thought was a defective diac but after a quick test with

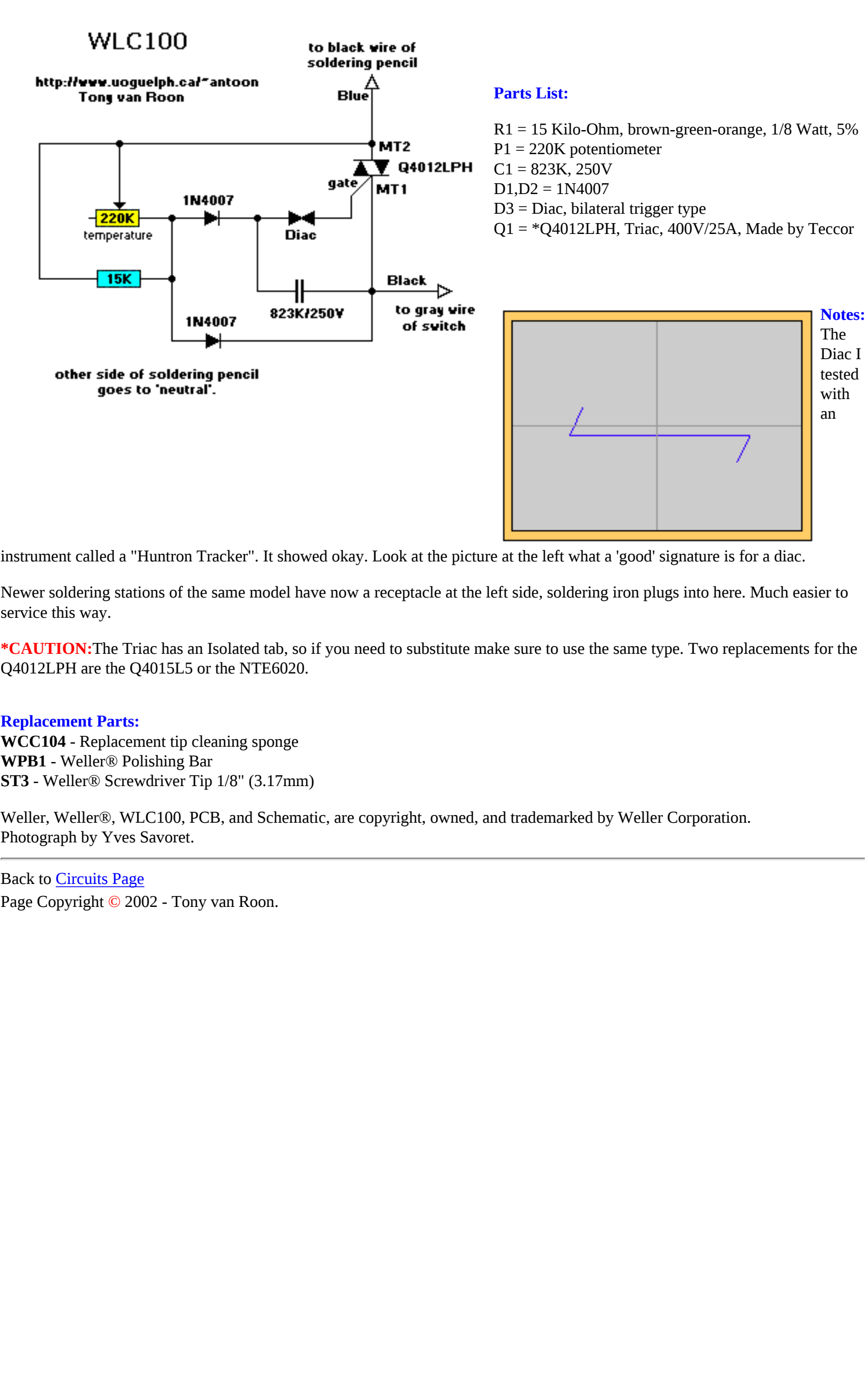
Okay, on to the Triac. The triac tester showed the triac capable of switching and holding its state. Also good. Finally it occurred to

me to check the soldering pencil itself. Yep. Damn thing was open. Murphy's Law at work again. Could have saved myself a lot of

time by thinking first instead of taking the station apart impulsively. Oh well, one lesson learned.

This station lasted about 6-years of 7-hour a-day use, so really fantastic. Power output is adjustable from 5 to 40 Watts via a potentiometer on the front panel. This station is supplied with a ST3 1/8" screwdriver tip. Seems to be suitable for almost all jobs. I was unable to order replacement parts (heater) for my older model I was forced to purchase a new station, not really expensive though, they are around \$55.00 Canadian in my area so a good buy.

The WLC100 is a cheap and well build, temperature controlled, soldering station and works really well for most applications. Below I have drawn out the lay-out and pcb, and included a circuit diagram and parts list. The pcb measures about 1-7/8 by 1-inch. This document my help you in repairing your own station if the time comes.



instrument called a "Huntron Tracker". It showed okay. Look at the picture at the left what a 'good' signature is for a diac.

Newer soldering stations of the same model have now a receptacle at the left side, soldering iron plugs into here. Much easier to service this way.

***CAUTION:**The Triac has an Isolated tab, so if you need to substitute make sure to use the same type. Two replacements for the Q4012LPH are the Q4015L5 or the NTE6020.

Replacement Parts:

WCC104 - Replacement tip cleaning sponge

WPB1 - Weller® Polishing Bar

ST3 - Weller® Screwdriver Tip 1/8" (3.17mm)

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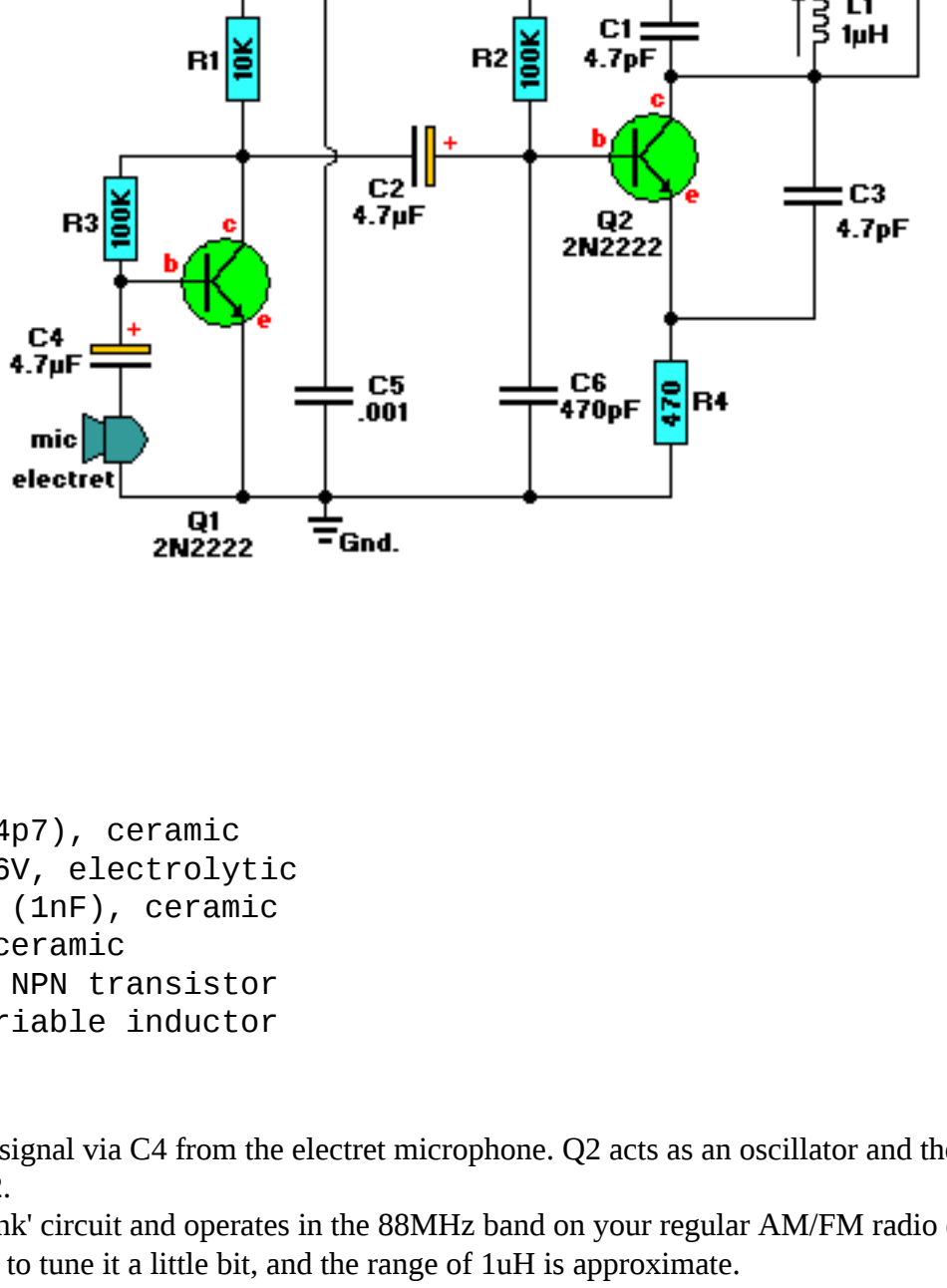
Photograph by Yves Savoret.

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Wireless Microphone

www.uoguelph.ca/~antoon



Parts List:

- R1 = 10K
- R2, R3 = 100K
- R4 = 470 ohm
- C1, C3 = 4.7pF (4p7), ceramic
- C2, C4 = 4.7uF-16V, electrolytic
- C5 = 0.001uF (1nF), ceramic
- C6 = 470pF, ceramic
- Q1, Q2 = 2N2222, NPN transistor
- L1 = 1uH, variable inductor

Couple Notes:

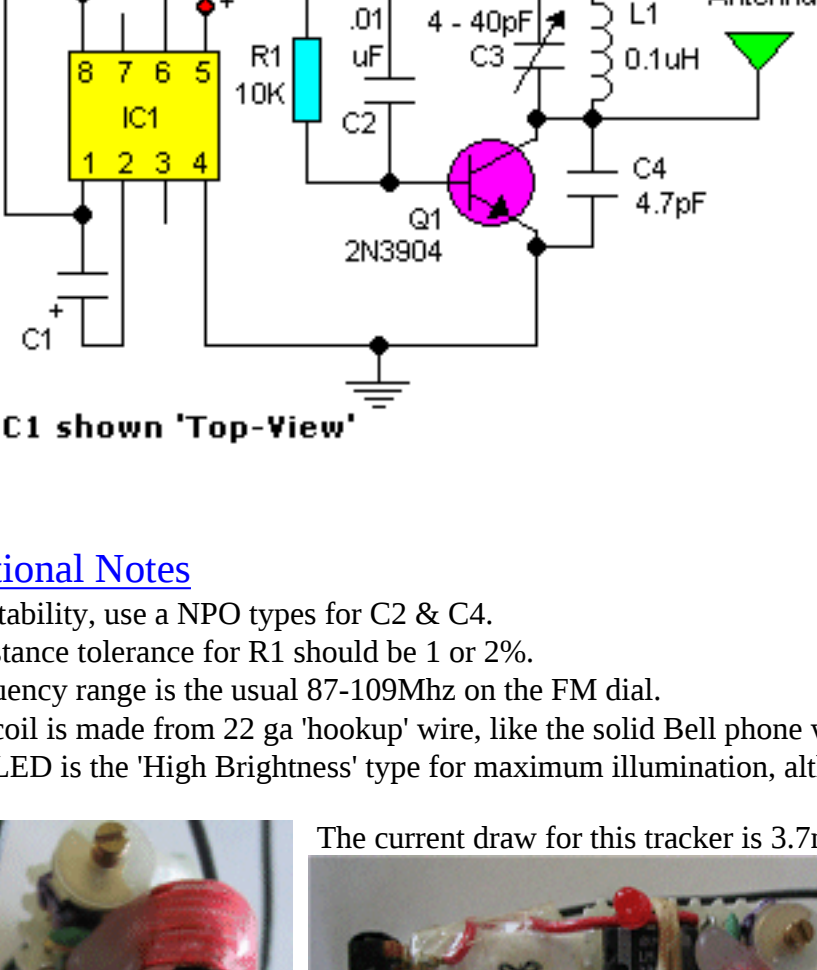
Q1 amplifies the input signal via C4 from the electret microphone. Q2 acts as an oscillator and the signal coming off C2 is fed onto the base of Q2.
L1/C1 is a so called 'tank' circuit and operates in the 88MHz band on your regular AM/FM radio dial. L1 is a 1uH variable inductor coil to be able to tune it a little bit, and the range of 1uH is approximate.
The antenna can be as simple as a 8" (21cm) piece of wire of any kind.

1.5 Volt Tracking Transmitter

http://www.uoguelph.ca/~antoon

Parts List

- C1 = 100 uF electrolytic capacitor
- C2 = .01uF disc capacitor
- C3 = 4 to 40 pF trimmer capacitor
- C4 = 4.7 pF disc capacitor
- L1 = 0.1 uH, 6 to 8 turns of 22 gauge hookup wire close wound around a 1/4" diameter non-conductive core, such as a pencil
- IC1 = LM3909 LED flasher
- LED1 = red LED
- Q1 = 2N3904 NPN silicon transistor
- R1 = 10K
- Antenna = 10 to 12 inches of hookup wire.



IC1 shown 'Top-View'

Additional Notes

- o For stability, use a NPO types for C2 & C4.
- o Resistance tolerance for R1 should be 1 or 2%.
- o Frequency range is the usual 87-109Mhz on the FM dial.
- o The coil is made from 22 ga 'hookup' wire, like the solid Bell phone wire. Leave the insulation on.
- o The LED is the 'High Brightness' type for maximum illumination, although this type will draw more current.



The current draw for this tracker is 3.7mA, so the 1.5V button cell will last awhile. My experimental version was tuned to 87.6MHz and worked as expected on only 1.5 volts. The photo shows I just glued the whole thing on a 1.5V AA battery. The led glows at the same oscillation as the beat-frequency

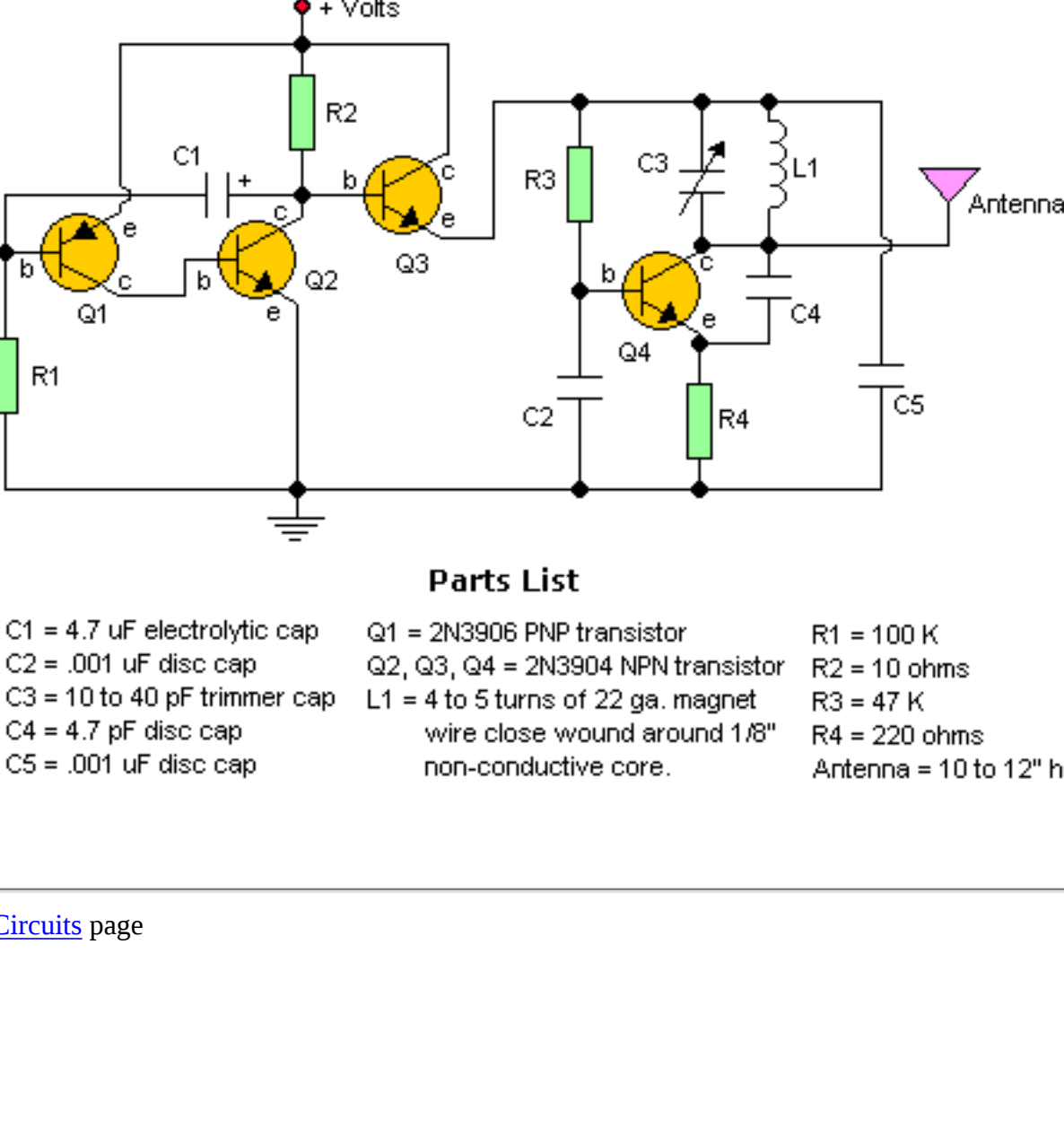
What the heck am I suppose to hear you ask? When your circuit is working you should see the LED flash quite fast. Take your FM radio and search for the low-beat 'thumpe-thumpe-thumpe-etc' equal to the flash of the LED (probably around the 100Mhz). Found it? If that position is interfering with a radio station you can fine-tune it with the variable capacitor. If you like to have the tracker around the 88Mhz (or lower) you can do that by spreading the windings from the home-made coil just a bit (1/2 a millimeter or so). Anyways, play with it and learn. It may take alot of patience to find the signal but once you know where it is it becomes simple. It is a nice learning project.

The 12-inch antenna can be anything, it is not really that critical. I used a piece of 22 gauge flexible wire. The range at 1.5V is around 30feet or so. At 3V it will be significantly different. Have fun with it. -Tony

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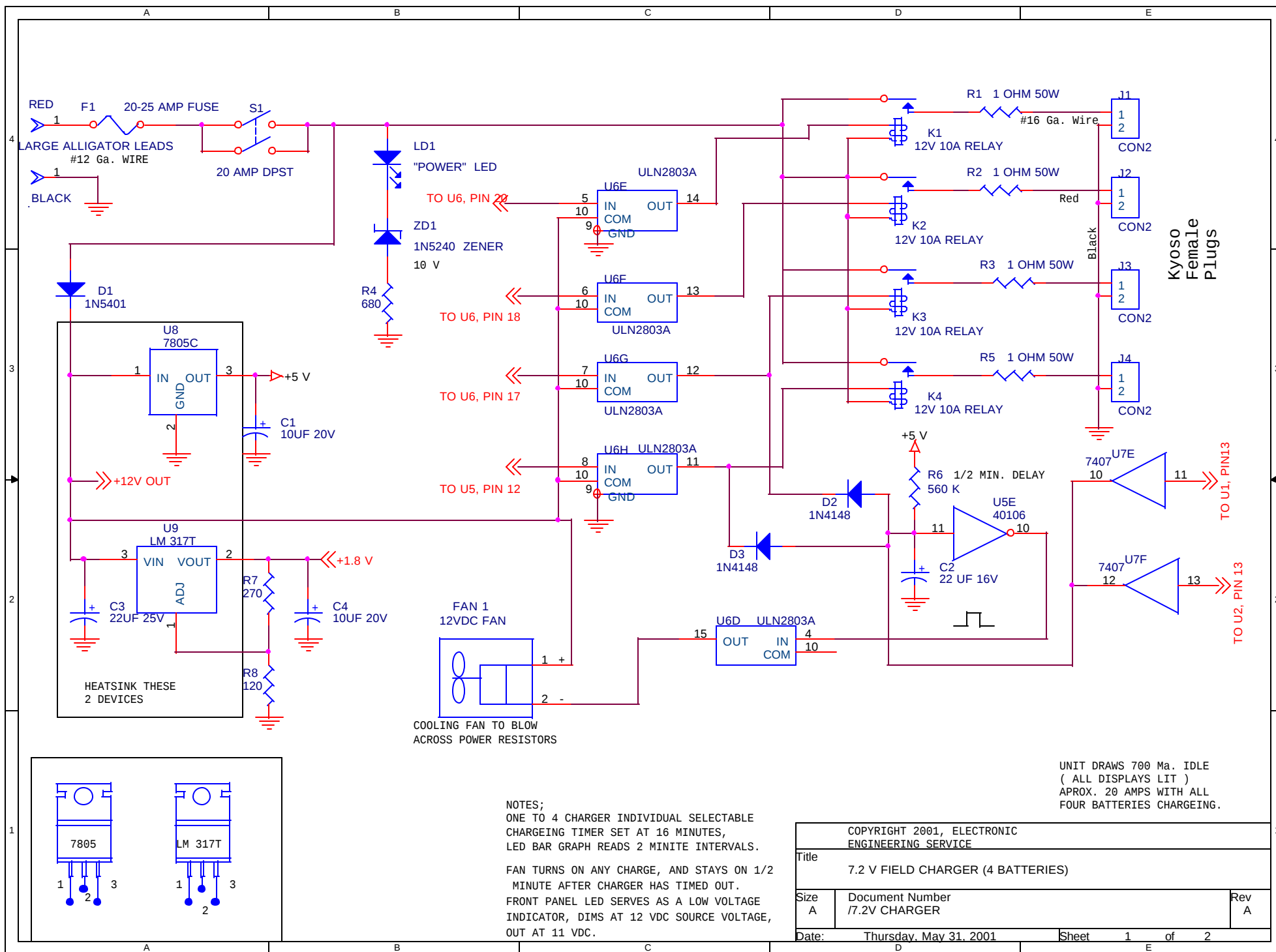
4-Transistor Tracking Transmitter

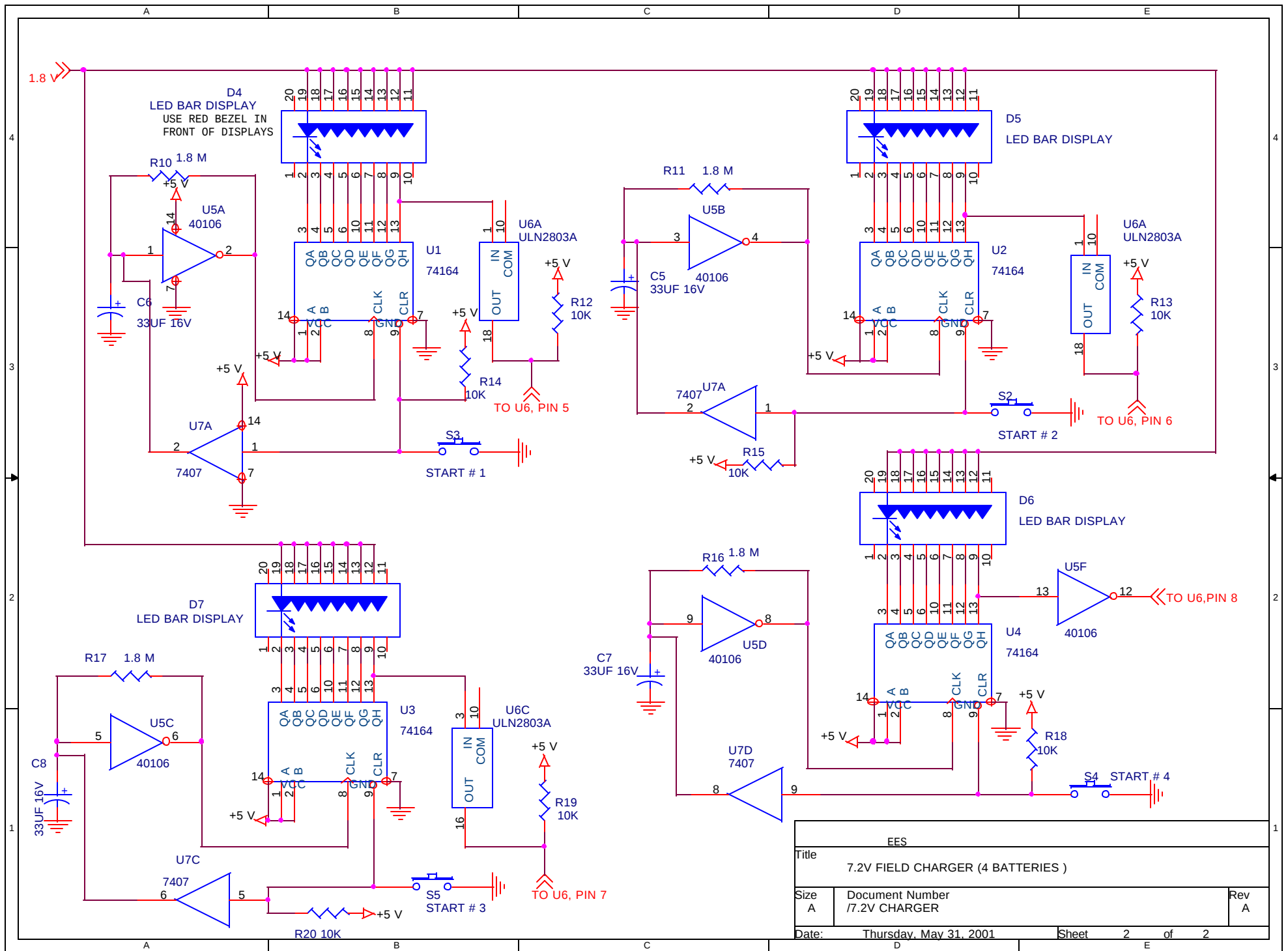
http://www.uoguelph.ca/~antoon



Parts List

- | | | |
|------------------------------|--|----------------------------------|
| C1 = 4.7 uF electrolytic cap | Q1 = 2N3906 PNP transistor | R1 = 100 K |
| C2 = .001 uF disc cap | Q2, Q3, Q4 = 2N3904 NPN transistor | R2 = 10 ohms |
| C3 = 10 to 40 pF trimmer cap | L1 = 4 to 5 turns of 22 ga. magnet wire close wound around 1/8" non-conductive core. | R3 = 47 K |
| C4 = 4.7 pF disc cap | | R4 = 220 ohms |
| C5 = .001 uF disc cap | | Antenna = 10 to 12" hookup wire. |





EES		
Title		
7.2V FIELD CHARGER (4 BATTERIES)		
Size	Document Number	Rev
A	/7.2V CHARGER	A
Date:	Thursday, May 31, 2001	Sheet 2 of 2

7.2 V FIELD CHARGER (4 BATTERIES) Revised: Thursday, May 31, 2001
/7.2V CHARGER Revision: A

Bill Of Materials May 31,2001 9:53:53 Page1
Item Quantity Reference Part

1	1	RED BEZEL PLASTIC (FOR LED 4 DISPLAYS)	
2	2	C4,C1 10UF 20V	
3	1	C2 22 UF 16V	
4	1	C3 22UF 25V	
5	4	C5,C6,C7,C8 33UF 16V	
6	1	D1 1N5401 3A DIODE	
7	2	D2,D3 1N4148 DIODE	
8	4	D4,D5,D6,D7 LED BAR DISPLAY	
9	1	FAN 1 SMALL 12VDC FAN	
10	1	F1 20-25 AMP FUSE	
11	4	J1,J2,J3,J4 KYOSHO CONN.	
12	4	K1,K2,K3,K4 12V 10A RELAY	
13	1	LD1 "POWER" .2" LED	
14	1	RED LARGE ALLIGATOR LEAD	
15	4	R1,R2,R3,R5 1 OHM 50W	
16	1	R4 680 OHM	
17	1	R6 560 K	
18	1	R7 270 OHM	
19	1	R8 120 OHM	
20	4	R10,R11,R16,R17 1.8 M	
21	7	R12,R13,R14,R15,R18,R19, 10K	
		R20	
22	1	S1 20 AMP DPST	
23	1	S2 S2 S3 S4 MOMENTARY CONTACT SWITCH	
24	1	PANEL MOUNT LED HOLDER	
25	1	FAN FINGER GUARD	
26	1	FRONT PANEL FUSE HOLDER	
27	4	U1,U2,U3,U4 74164 I.C.	
28	1	U5 40106 I.C.	
29	1	U6 ULN2803A I.C.	
30	1	U7 7407 I.C.	
31	1	U8 7805C REG.	
32	1	U9 LM 317T REG.	
33	1	ZD1 1N5240 ZENER	
34	1	3/8" GROMMET	
35	4	1/4" GROMMET	

This charger was designed by me in 1975 to fill a need that I had. This was I had two R.C. model boats that needed 6 batteries each and I needed to charge them simultaneously, from my car battery. I could not find a commercial unit to do this, so I came up with a neat project to fill the bill. Layout was done on a 2 proto-boards, one lays flat, and the other vertical for the bar graph displays. The displays have a red filter in front of them.

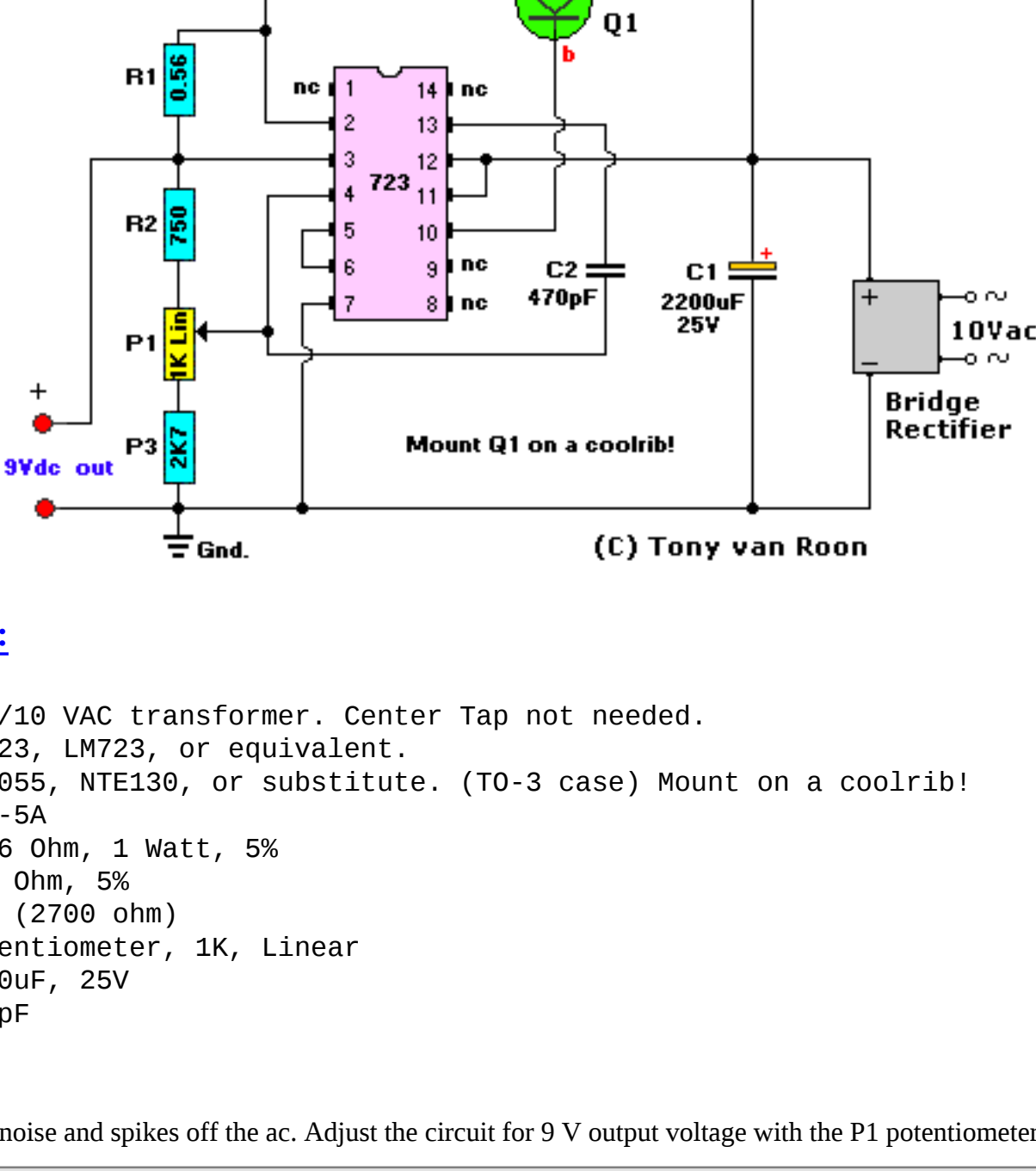
The unit is novel as its display graph shows you the time the battery has been charging in 1 minute intervals up to 10 minutes when finished.

The power led indicates source voltage as it dims, and goes out at 11 vdc, this is needed because the unit draws 10 amps fully charging 6 batteries as you will need to run your engine or you will walk home. The d.c. fan needs to be situated as to force air across the power resistors, the fan has a circuit to turn off 1 minute after the unit quits charging. Heat sink the two regulators (7805 and 7806) to the metal case also. All of the parts are easy to get, most available at radio shack, allied, or digi-key.

Good luck and happy charging,
Dave

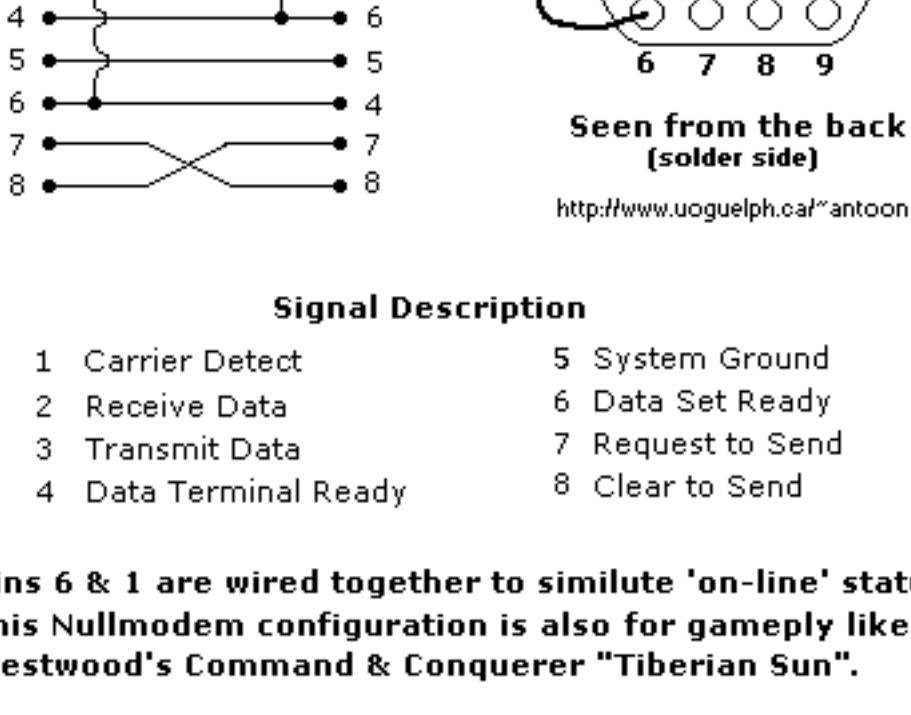
Stabilized 9-V Power Supply

10



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Nullmodem (9-9) Cable 9-pin to 9-pin female

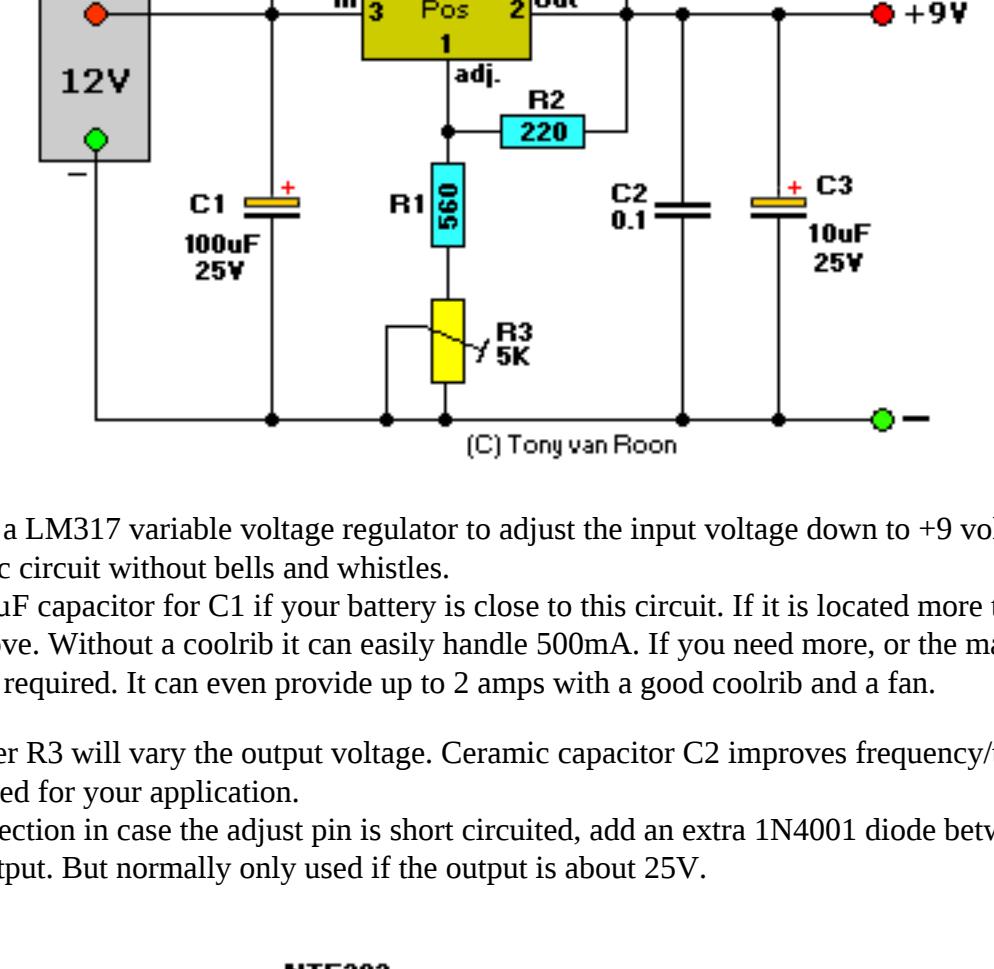


Signal Description

- | | |
|-----------------------|-------------------|
| 1 Carrier Detect | 5 System Ground |
| 2 Receive Data | 6 Data Set Ready |
| 3 Transmit Data | 7 Request to Send |
| 4 Data Terminal Ready | 8 Clear to Send |

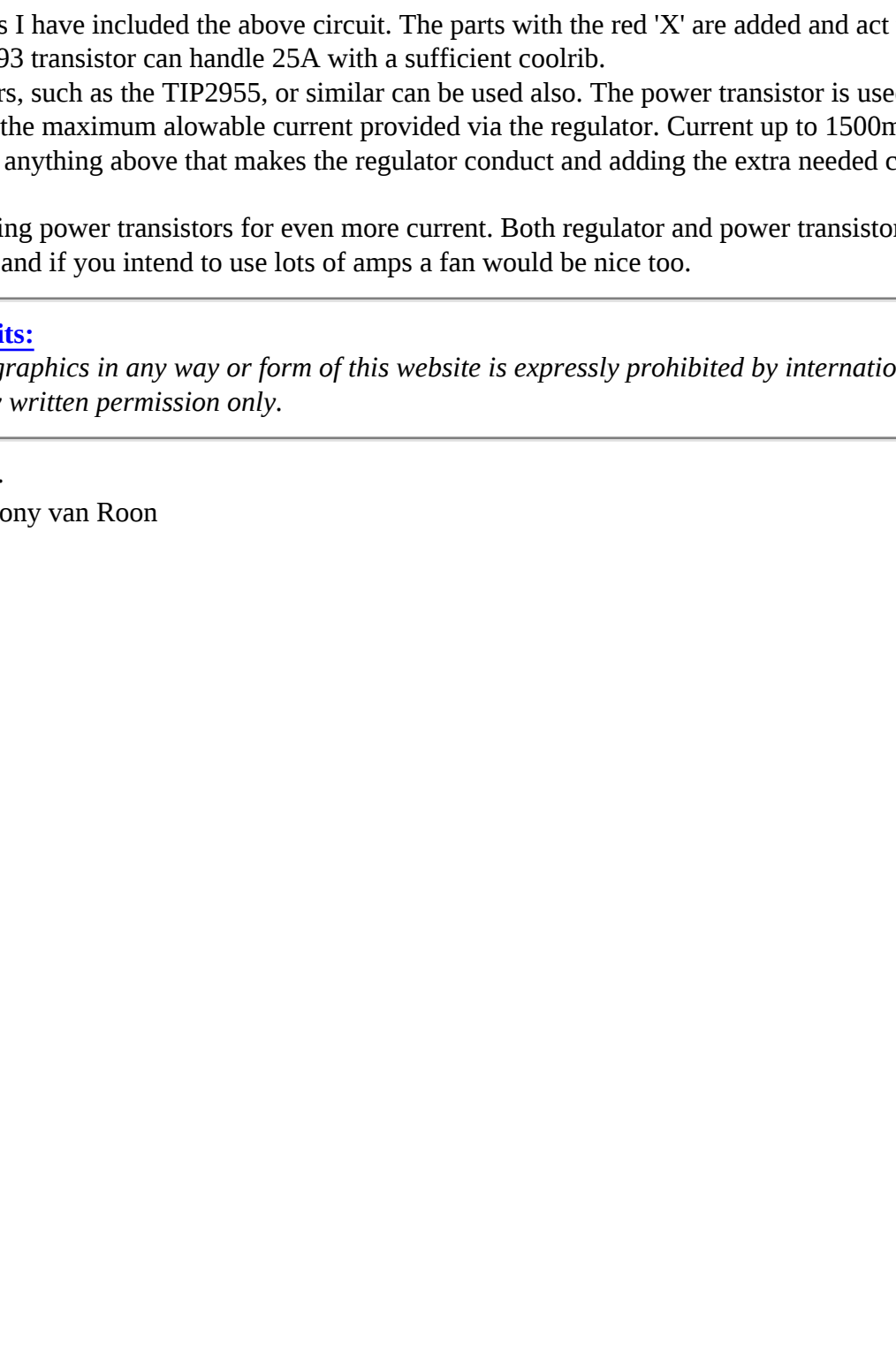
Pins 6 & 1 are wired together to similitude 'on-line' status.
This Nullmodem configuration is also for gameply like
Westwood's Command & Conquerer "Tiberian Sun".

+ 12V to +9V converter



This little circuit uses a LM317 variable voltage regulator to adjust the input voltage down to +9 volt, or whatever else you need. Just a solid basic circuit without bells and whistles. You can do with a 10µF capacitor for C1 if your battery is close to this circuit. If it is located more than 3 feet increase the value to 100µF or above. Without a coolrib it can easily handle 500mA. If you need more, or the maximum current (1.5A), then a good coolrib is required. It can even provide up to 2 amps with a good coolrib and a fan.

Trimmer potentiometer R3 will vary the output voltage. Ceramic capacitor C2 improves frequency/transient response. Can be omitted if not needed for your application. If you want extra protection in case the adjust pin is short circuited, add an extra 1N4001 diode between pin 1 and the output. Cathode to output. But normally only used if the output is about 25V.



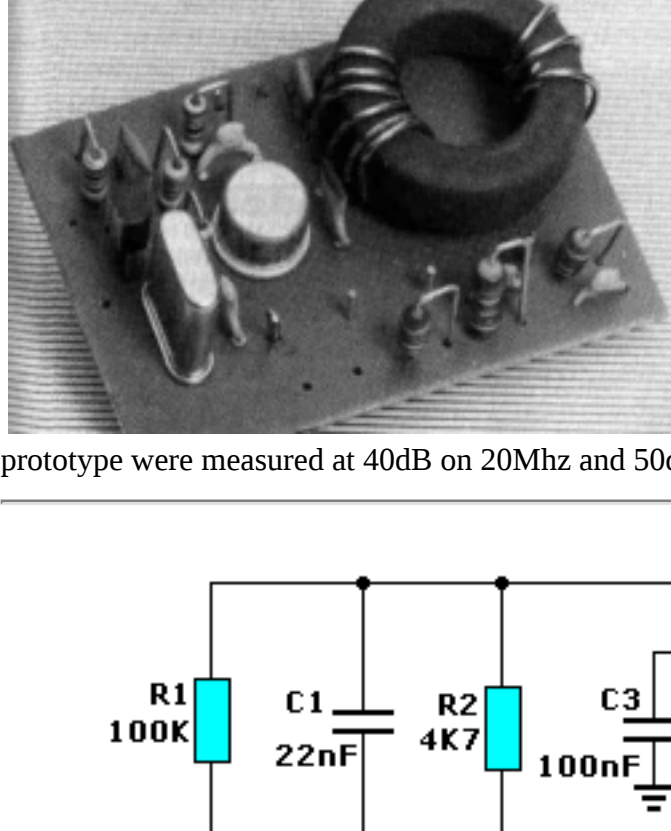
After dozens of emails I have included the above circuit. The parts with the red 'X' are added and act to boost the amperage. The NTE393 transistor can handle 25A with a sufficient coolrib. Other power transistors, such as the TIP2955, or similar can be used also. The power transistor is used to boost the extra needed current above the maximum allowable current provided via the regulator. Current up to 1500mA(1.5A) will flow through the regulator, anything above that makes the regulator conduct and adding the extra needed current to the output load.

It is no problem stacking power transistors for even more current. Both regulator and power transistor **must** be mounted on an adequate heatsink, and if you intend to use lots of amps a fan would be nice too.

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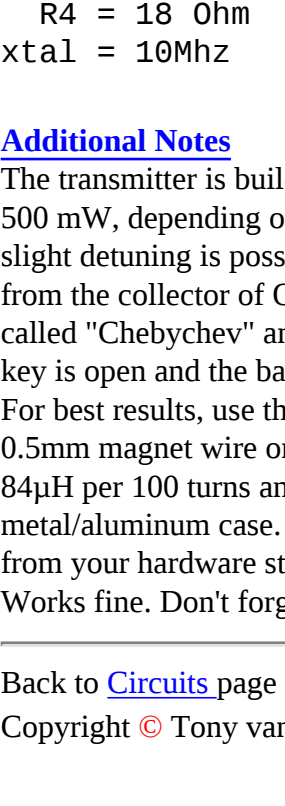
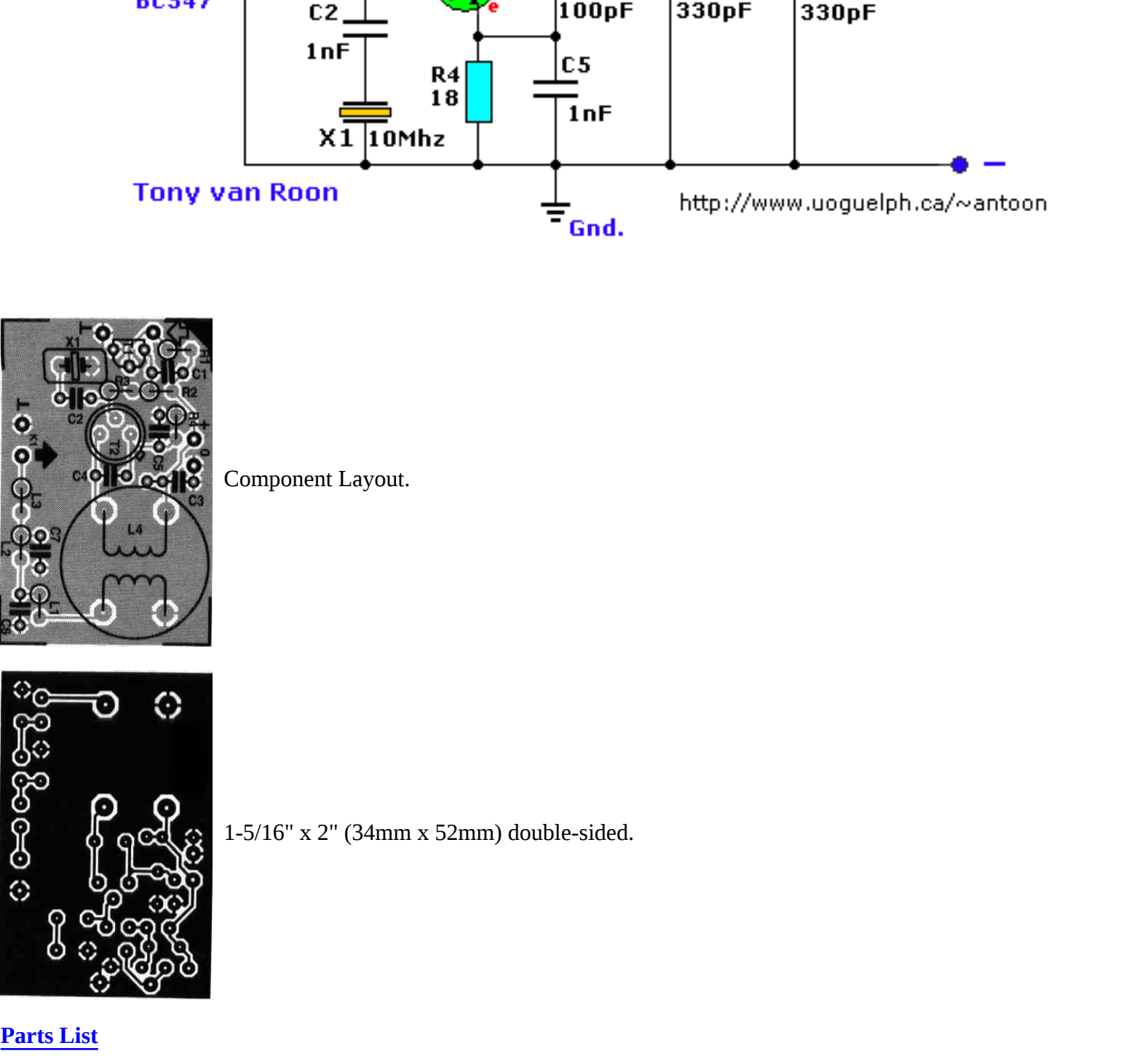
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30-Meter QRP (CW)

by P. Wyns, ON7WP (Belgium)

This transmitters' intended purpose is for morse-code only in the 30 meter band (10Mhz). It is a low-power QRP type and needs to be connected to your existing transceiver. The harmonic rejections on the prototype were measured at 40dB on 20Mhz and 50dB on 30Mhz.



Component Layout.



1-5/16" x 2" (34mm x 52mm) double-sided.

Parts List

R1 = 100K	C1 = 22nF	L1, L3 = 820nH	BNC connector
R2 = 4K7	C2, C5 = 1nF	L2 = 1.8uH	Coolrib for Q2
R3 = 12K	C3 = 100nF	L4 = T-94-2 (Amidon)	Morse-key, single pole
R4 = 18 Ohm	C4 = 100pF	Q1 = BC547	All-metal case
xtal = 10Mhz	C6, C7 = 330pF	Q2 = 2N2219(A)	

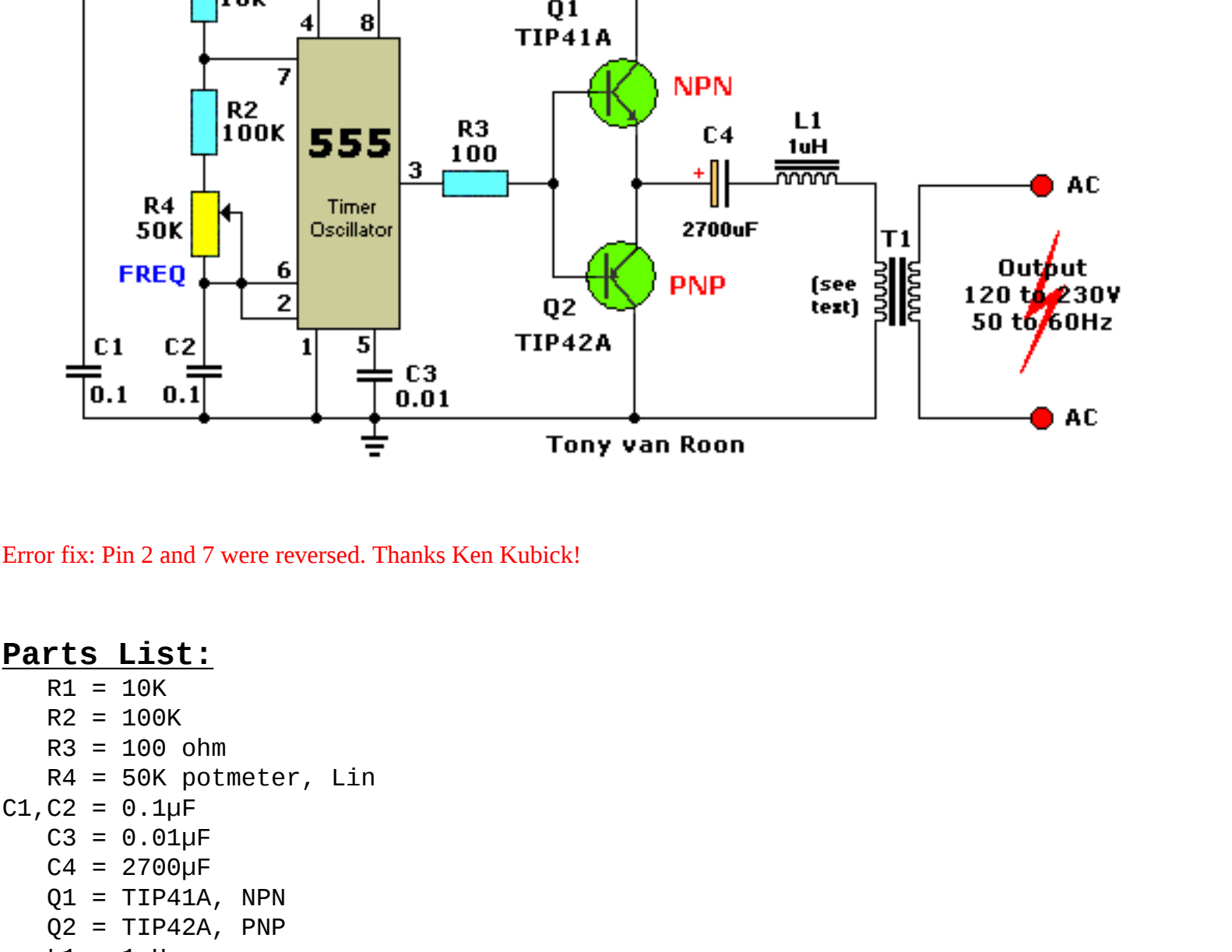
Additional Notes

The transmitter is build as a Colpitts Oscillator with a strong 2N2219(A) transistor. HF-output of the oscillator is 100 to 500 mW, depending on the supply voltage of 5 to 20 Volts. The transmit frequency is stabilized with the 10Mhz crystal. A slight detuning is possible by putting a 150pF trimmer capacitor between C2 and the xtal. The oscillator signal is taken from the collector of Q2 by induction and via a low-feedthrough filter and guided to the output. This particular filter is called "Chebychev" and uses standard E12 type values. The oscillator is keyed by Q1, which biases as long as the morse-key is open and the base of Q1 is at ground level. By keying the morse-key Q1 is blocked and allows Q2 to freely oscillate. For best results, use the double sided pcb as shown above. Coil L4 exists of Primary 6 turns and secondary 3 turns of 0.5mm magnet wire on a Amidon T-94-2 donut. Outside diameter is 24 mm and inside diameter is 14mm; the A(l) value is 84uH per 100 turns and permeability of 10. Q2 needs a coolrib! The whole circuit needs to be mounted in an all-metal/aluminum case. If you're unable to obtain an all-metal case, then use a roll of self-sticking aluminum tape (available from your hardware store), just make sure that all individual pieces of aluminum-tape are conducting with each other. Works fine. Don't forget the coolrib on T2.

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DC to AC Inverter with the 555



Error fix: Pin 2 and 7 were reversed. Thanks Ken Kubick!

Parts List:

- R1 = 10K
- R2 = 100K
- R3 = 100 ohm
- R4 = 50K potmeter, Lin
- C1, C2 = 0.1µF
- C3 = 0.01µF
- C4 = 2700µF
- Q1 = TIP41A, NPN
- Q2 = TIP42A, PNP
- L1 = 1µH
- T1 = Filament transformer, your choice

This DC-to-AC inverter schematic produces an AC output at line frequency and voltage. The 555 is configured as a low-frequency oscillator, tunable over the frequency range of 50 to 60 Hz by Frequency potentiometer R4. The 555 feeds its output (amplified by Q1 and Q2) to the input of transformer T1, a reverse-connected filament transformer with the necessary step-up turns ratio. Capacitor C4 and coil L1 filter the input to T1, assuring that it is effectively a sine wave. Adjust the value of T1 to your voltage.

The output (in watts) is up to you by selecting different components. Input voltage is anywhere from +5V to +15Volt DC, adjust the 2700µF cap's working voltage accordingly. Replacement types for Q1 are: TIP41B, TIP41C, NTE196, ECG196, etc. Replacement types for Q2 are: TIP42B, TIP42C, NTE197, ECG197, etc. Don't be afraid to use another type of *similar specs*, it's only a transistor... ;-)

If the whole thing is working, good. If not, relax and don't get frustrated. Do the following checks:

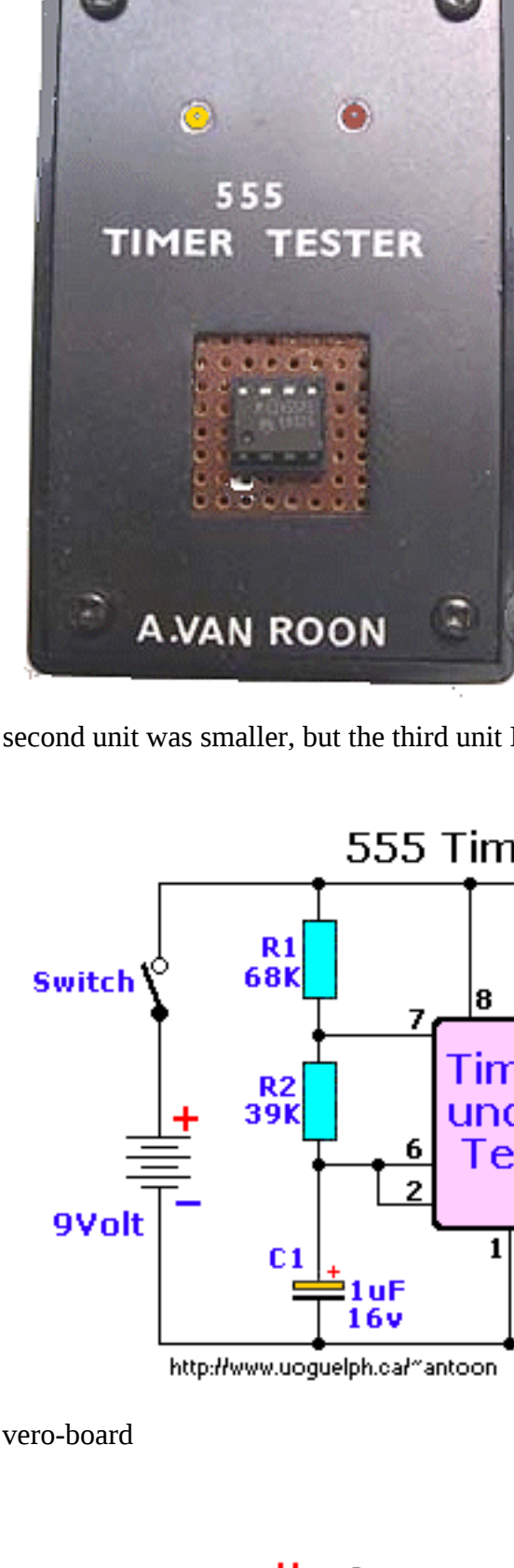
- 1) **You have connected the filament transformer in REVERSE** yes?
- 2) If not, **disconnect the power and reverse. If you have, disconnect the transformer and measure the voltage after L1 and ground.**
- 3) Just in case, **GROUND** for this circuit is same as negative (-).
- 4) Q1/Q2 are opposites, e.i. npn/pnp.
- 5) Is your 555 perhaps defective? Disconnect R3 from pin 3 and check **pin 3** for a pulse.
- 6) Check your transistors to make sure they are not defective.

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555 Timer/Oscillator Tester

by Tony van Roon



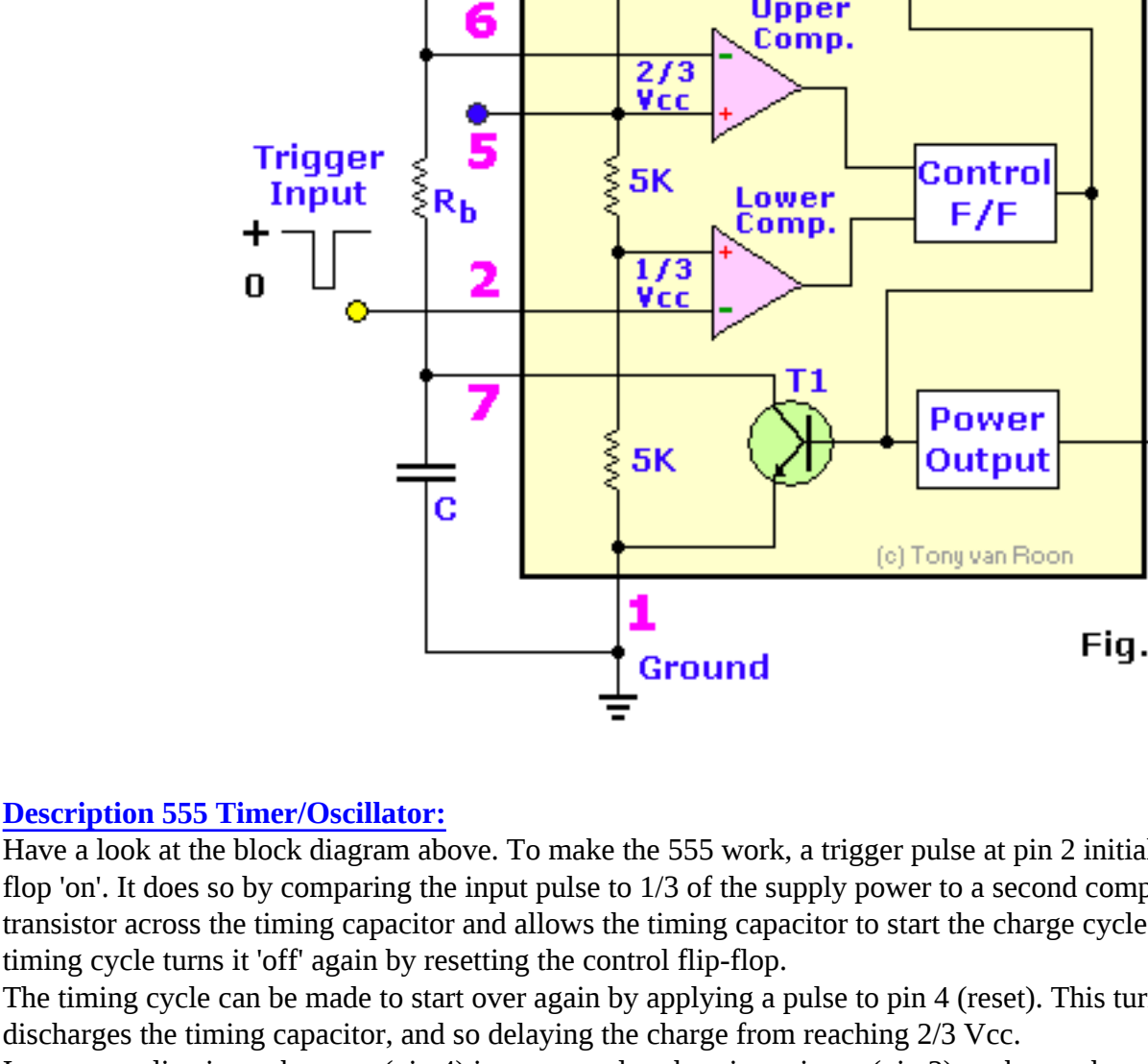
Description 555 Tester:

The 555-tester above is basically a led flasher circuit but with the 555 removed. Imagen the output being a square-wave pulse with a high and low pulse, and is so indicated by the two leds, one 'Hi' and the other one 'Lo'. When you have a good 555 under test, the hi and lo leds are flashing steadily. If you have a defective 555 you may get both leds off, one or both on steady, or one or both on faintly. In all these case the 555 is defective. Oh yeah, just in case you are just starting out in electronics; do NOT insert a 555 (or take it out) with the power on. The flash-rate can be changed with different values for C1 and R2. Try it, its fun. At pin 5 there is a small ceramic 10nF capacitor. It is just there to filter out any noise and is optional. Experiment with leaving C2 out. C2 can be a value of 0.001 to 0.01µF, but the latter is the most common value. The datasheet for the 555 documentation specifies to use a general purpose ceramic 0.01µF capacitor.

Read the [555 Timer/Oscillator Tutorial](#) for more information of the pin functions.

In regards to R3 and R4; depending on your Led type; start with 220 ohm and go up or down from 100 to 330 ohms, again, depending on your Led (e.i. regular, high, ultra bright, 2mm, 3mm, 5mm, etc.). The prototype was constructed with as few parts in mind as possible. In that regards you could save money by replacing the two leds with a bi-color (3 legs) one if you have a unit in your junkbox somewhere; it will then flash green/red. The

second unit was smaller, but the third unit I build was so small it was about 2 x 1 x 1/2 inch and fitted nicely in my pocket.



Parts List:

- R1 = 68K, 5%
- R2 = 39K, 5%
- R3 = 100 to 330 ohm depending on LED
- R4 = Same as R3
- C1 = 1µF, 16V
- C2 = 0.01µF ceramic (see text)
- Two led's, red or green.
- 8-pin dip socket
- On-off switch or momentary 'push-on' switch
- Solderless breadboard: Radio Shack #276-175, or



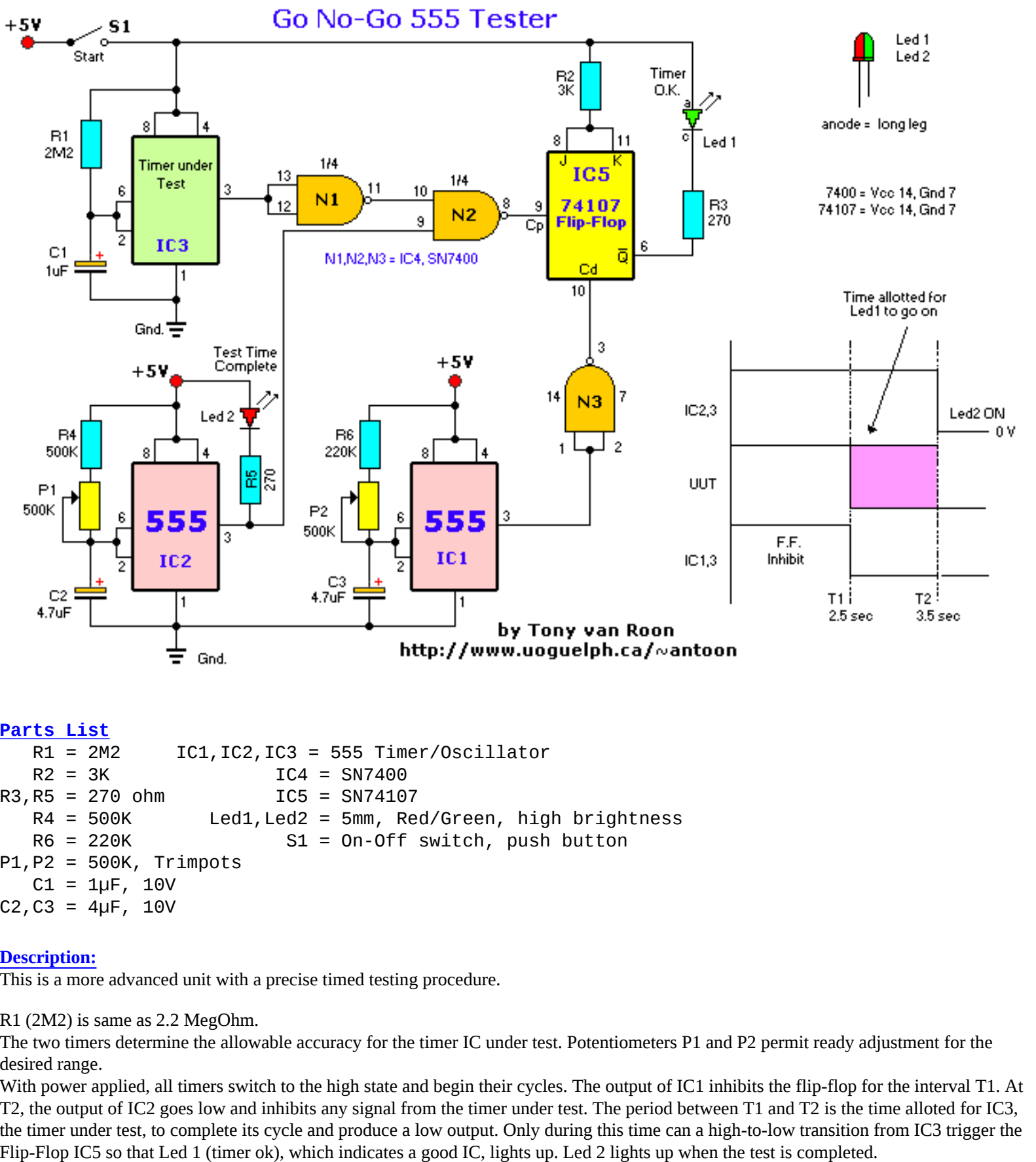
When the threshold at pin 2 drops, at the end of a timing cycle, that voltage drop can be used to start a new timing cycle right away by connecting pin 6 (threshold) to pin 2, the trigger input. This type of system is called an "astable, free running, oscillator" and is the most common one. If you look at a variety of diagrams where a 555 is used you notice that in most cases pins 2 and 6 are connected.

The 555's output circuit includes two high current transistors, each capable of handling at least 200mA. One transistor is connected between the output pin 3 and Vcc, and the other between pin 3 and ground. This way you can use the output pin 3 to either supply Vcc to your load (source) or provide a ground for your load (sink). If you have heard mentioning about 'sink' or 'source' this is exactly what it means. This tester will flash the led's alternately with good 555 under test, because both led's are driven from the single output pin 3 because of the way the 555 is designed. What an awesome chip!

If you wish to learn more about the 555 Timer/Oscillator, I invite you to read the [555 Timer/Oscillator](#) tutorial.

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My Electronic Icons Template for Paint Shop Pro

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Over the past 10 years or so I have created all sorts of symbols and icons and keep them in a template from which I copy-and-paste whatever I need to create a circuit diagram. I decided to share this template with anyone interested in creating beautiful and easy to read schematic diagrams, just to keep our declining hobby alive. For ease of use, and you may have noticed, **all my circuits are in .gif format and 256-colors palet**. It is important to keep reading...

Right near 'ICI' (right lower corner) you will see this 'block-of-colors':  Click on it to see an enlarged picture. You probably wonder why it is there, and what it does. Well, it is a trick I use to maintain a full palet of colors after the circuit diagram is saved in gif format to ensure that, whenever I have/want to change something in the diagram I still have a full palet of colors. Without this color-block the .gif file only saves whatever colors are used in a new palet. Try it, you will see it works. You can add your own colors to the color-bar, one pixel will be enough, just make sure they come from the 256-color palet.

All my schematics are drawn in 256-color format and so the color-block. More colors are not needed and keeps a lid on the size of gif files you draw. Keep this in mind. Trying to use my template with anything more than 256 colors will result in distorted colors when you zoom in and have a close look at the symbols. When you open a 'new' file in Paint Shop Pro or any other drawing program, set the parameters to 256-colors (8-bit) and you be fine. Then one of the first symbols to copy-and-paste is the color-block (or color-bar). Save the new file and when you're all done with the new drawing save it, cut the color bar and save again. The palet colors will now always be there for future enhancements. **If you have questions about a symbol or icon you can reach me in the Message Forum of the main page.**

One more thing, color cartridges for printers are expensive. Try to remember that when you create your schematics. I'm not referring to the colored electronic icons but rather too much color used in text or background. It is best to keep the background of your drawings white. I have made the same mistakes and learned my lessons. Now, whenever I have to update a diagram I try to scale back the color usage. Every bit helps. Since I created the symbols (except the bulbs) and know how to use all of them, I never bothered to put a name with it. I found it would just clutter up my "**parts.gif**" template (as I call it).

Well, that's it I guess. Click here: [\[Parts Template\]](#) to save a copy of my template to your harddrive and start using it. If I have a new icon to add I will let everyone know. Vice-versa, If you created a nice looking icon and wish to share, let me know and I will add it to the template. The "parts.gif" file is a bit wider then the screen and so it looks like it is squeezed a bit. Don't worry about it, it'll be fine. When you see the pic, richt-click on it to save a copy.

One more thing--you are NOT allowed to feature my template on your website, it is for your personal use only. I have a good lawyer and all copyright violations will be pursued.

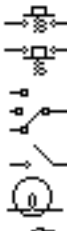
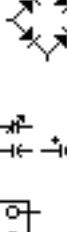
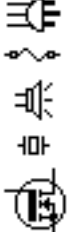
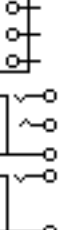
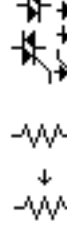
Have fun creating beautiful and eye pleasing schematics, and again, share your icons. Cheers! --Tony van Roon

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Last updated October 25, 2004



	Transistors		Relay		Op Amp
	Phototransistor		Piezo speaker		Switches
	Transformer		Logic gates		Lamp
	Bridge		Diodes		120 VAC Power Outlet
	Capacitors		Diodes		Fuse
	RJ-11 Phone Jacks		Diodes		Speaker
	Connectors		Resistors		Crystal
	120V plug		Photoresistor		MosFet
			Buzzer	Misc Parts 	

[Additional Notes](#)
(N/A)

Archived, older circuits

Some are working, others are not. That's why they are here, either non-working or obsolete. But they may still be of use either as example circuits or perhaps you can use snippets of the diagrams. Whatever. Use at your own risk. There is NO SUPPORT for any of these circuits.

- [Basic IC MonoStable Multivibrator](#)
- [Basic RF Oscillator #1](#)
- [Birdie Doorbell Ringer](#) - Audio transformer sometimes difficult to obtain
- [Bug Detector with Beep](#)
- [Gel Cell Charger, I](#) - No time to figure out the problems...
- [Inverter](#) - 12V-DC to 115V-AC, **Updated** 1-15-2004
- [Micro-Spy with FETs](#) - 70's
- [Micro-Spy with USW](#) - 70's
- [Micro-Spy with TTL](#) - 70's
- [Miniature FM Transmitter #1](#)
- [Miniature FM Transmitter #2](#)
- [Miniature FM Transmitter #3](#)
- [Servo Tester #1](#) - Working. Not bad; I will revamp this one.
- [Servo Tester #4](#) - Working, but not to my satisfaction
- [Servo Tester #5](#) - Working, but not to my satisfaction
- [Simplest R/C Circuit](#)
- [Simplest RF Transmitter](#)

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Basic IC MonoStable Multivibrator

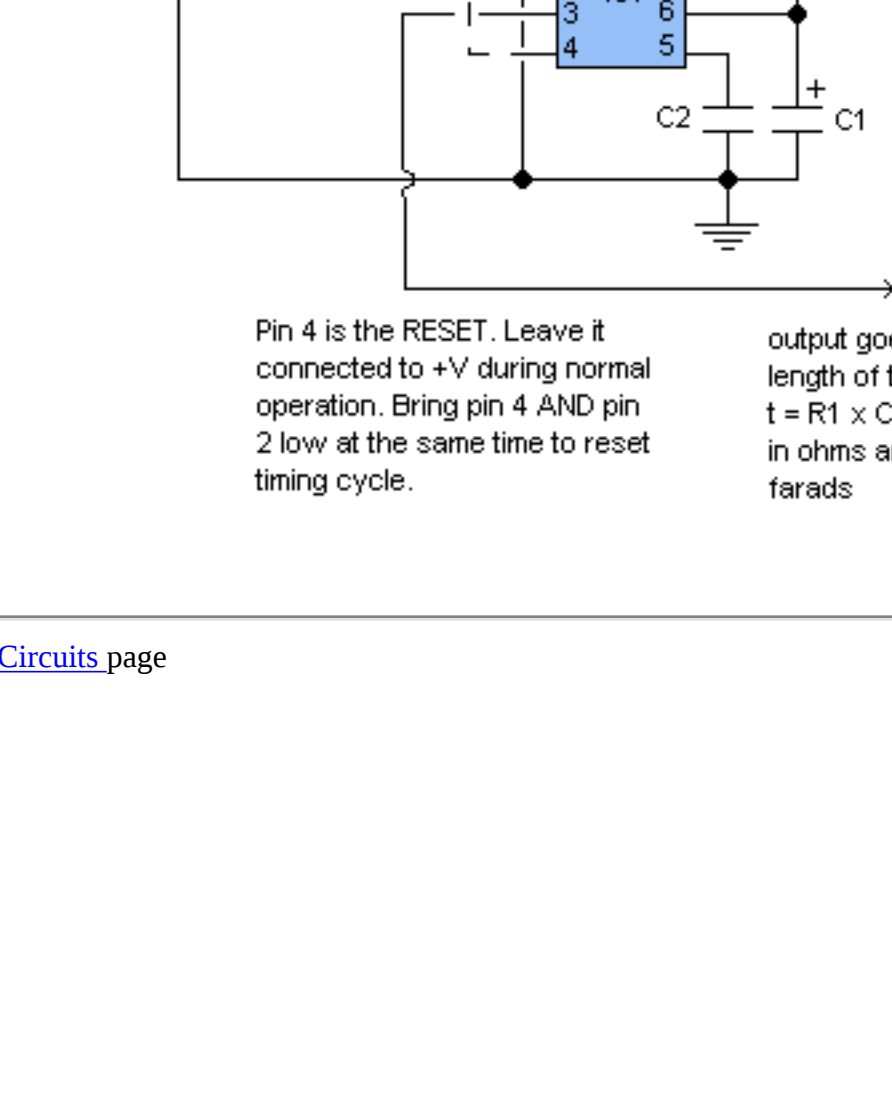
by Tony van Roon

<http://www.uoguelph.ca/~antoon>

BASIC LM555 MONOSTABLE CIRCUIT

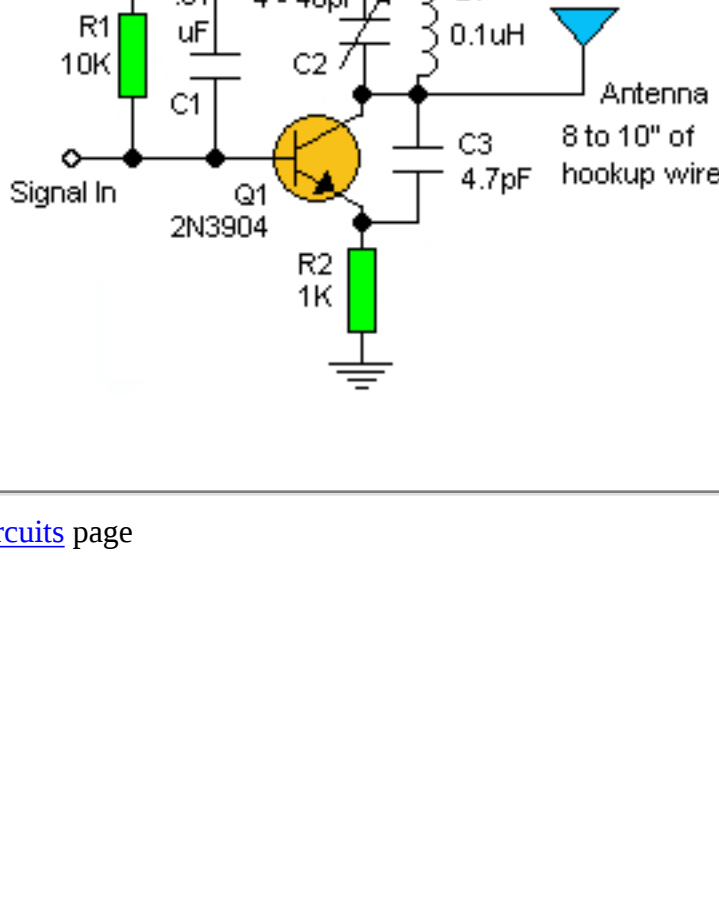
Parts List

C2 = .01uF
IC1 = LM555 Timer
SW1 = n.o. momentary switch
R1 and C1 determine length of output pulse where $t = R1 \times C1$ and R1 is in ohms and C1 is in farads.

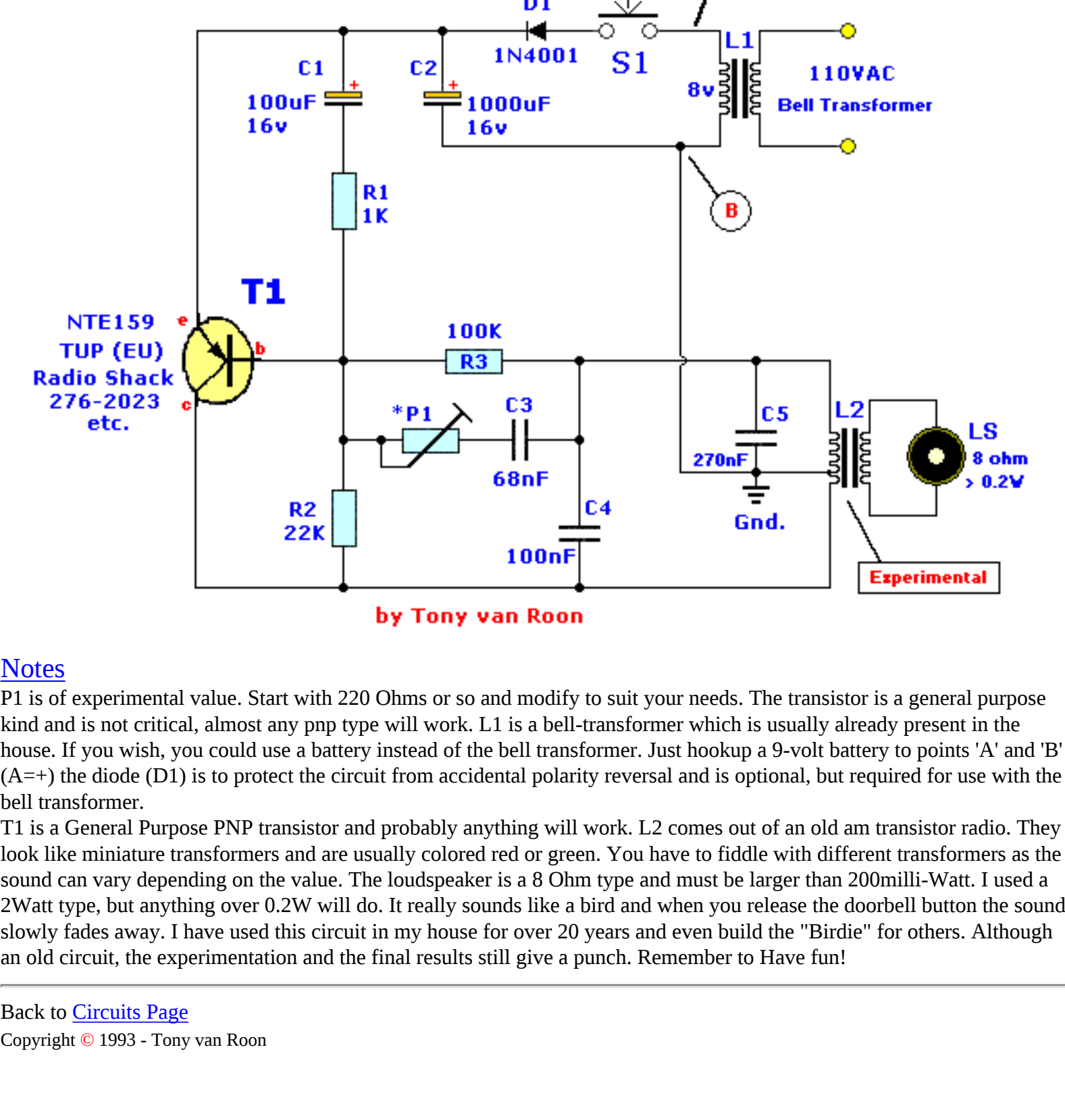


Basic RF Oscillator

<http://www.uoguelph.ca/~antoon>



This basic circuit is easy to build and the components are not critical. Most of them can be found in your junk parts box. The L1 antenna coil can be made by close winding 8 to 10 turns of 22 gauge insulated hookup wire around a 1/4 inch form such as a pencil. You can experiment with the size of the coil and the number of turns to see how it affects the frequency and signal output of the oscillator. You should be able to pick up its signal with a standard FM radio receiver. The "Signal in" should be coupled by a disc capacitor of about 0.1uF to the stage in front of it.



Notes

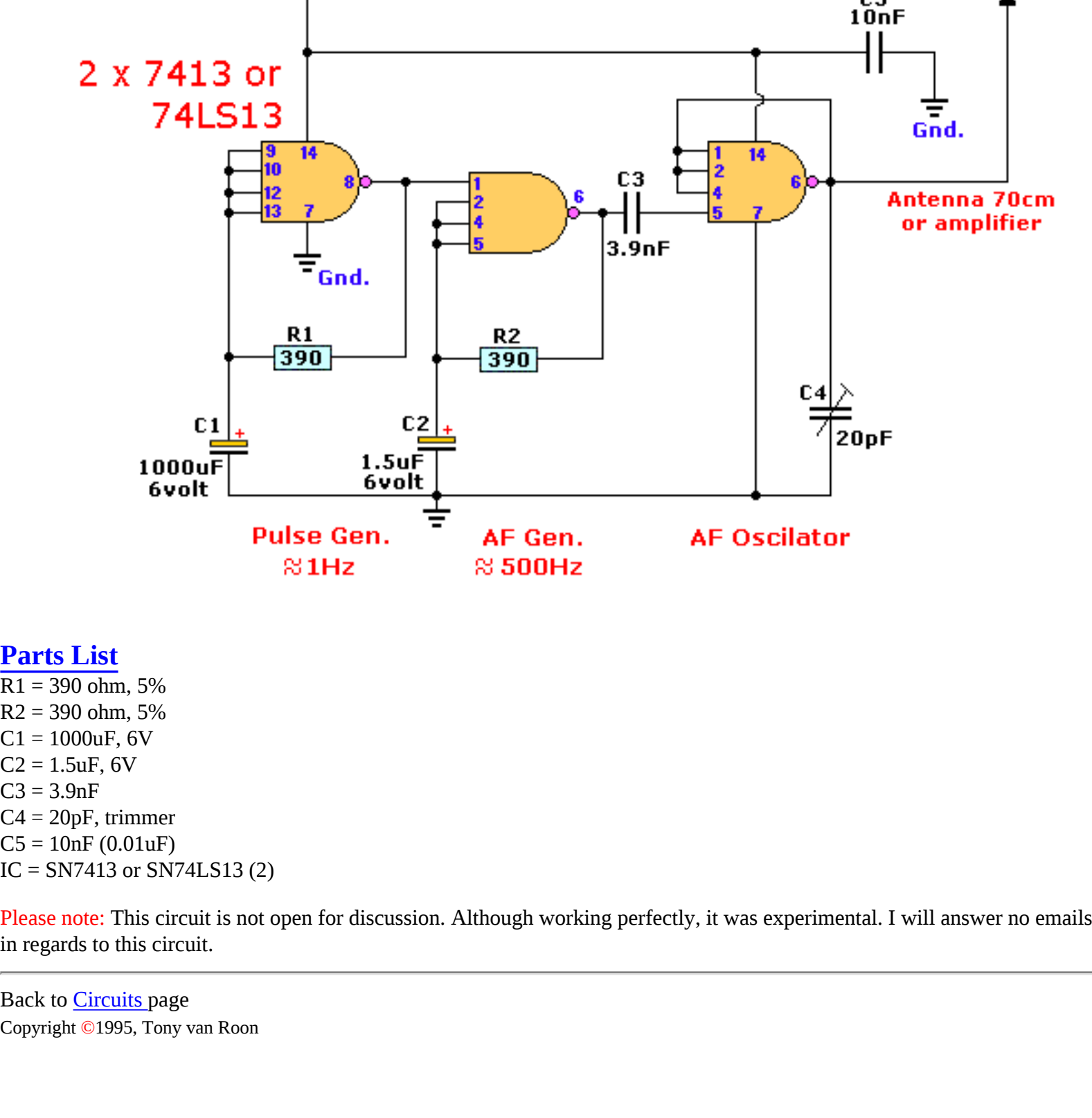
P1 is of experimental value. Start with 220 Ohms or so and modify to suit your needs. The transistor is a general purpose kind and is not critical, almost any pnp type will work. L1 is a bell-transformer which is usually already present in the house. If you wish, you could use a battery instead of the bell transformer. Just hookup a 9-volt battery to points 'A' and 'B' (A=+) the diode (D1) is to protect the circuit from accidental polarity reversal and is optional, but required for use with the bell transformer.

T1 is a General Purpose PNP transistor and probably anything will work. L2 comes out of an old am transistor radio. They look like miniature transformers and are usually colored red or green. You have to fiddle with different transformers as the sound can vary depending on the value. The loudspeaker is a 8 Ohm type and must be larger than 200milli-Watt. I used a 2Watt type, but anything over 0.2W will do. It really sounds like a bird and when you release the doorbell button the sound slowly fades away. I have used this circuit in my house for over 20 years and even build the "Birdie" for others. Although an old circuit, the experimentation and the final results still give a punch. Remember to Have fun!

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Bug Detector with Beep by Tony van Roon



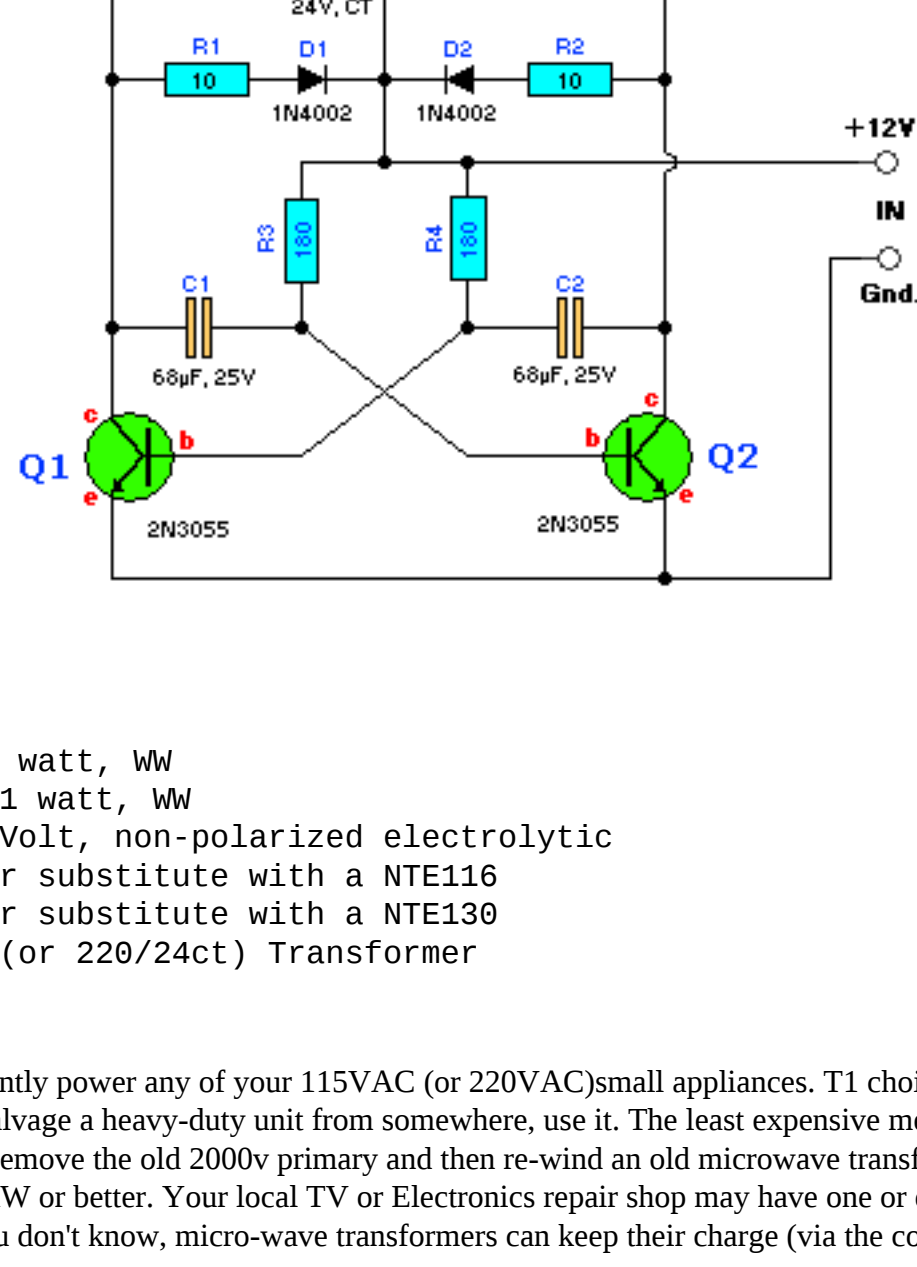
Parts List

- R1 = 390 ohm, 5%
- R2 = 390 ohm, 5%
- C1 = 1000uF, 6V
- C2 = 1.5uF, 6V
- C3 = 3.9nF
- C4 = 20pF, trimmer
- C5 = 10nF (0.01uF)
- IC = SN7413 or SN74LS13 (2)

Please note: This circuit is not open for discussion. Although working perfectly, it was experimental. I will answer no emails in regards to this circuit.

Inverter

www.meridianelectronics.ca



Parts List

R1, R2 = 10 ohm, 5 watt, WW
R3, R4 = 180 ohm, 1 watt, WW
C1, C2 = 68uF, 50 Volt, non-polarized electrolytic
D1, D2 = 1N4002, or substitute with a NTE116
Q1, Q2 = 2N3055, or substitute with a NTE130
*T1 = 120/24ct (or 220/24ct) Transformer

Description:

This inverter will sufficiently power any of your 115VAC (or 220VAC) small appliances. T1 choice of amperage is yours to make, but if you can salvage a heavy-duty unit from somewhere, use it. The least expensive method to get a larger transformer would be to remove the old 2000v primary and then re-wind an old microwave transformer. Most of these transformers are rated 1KW or better. Your local TV or Electronics repair shop may have one or dig one up from the dumpster. Just in case you don't know, micro-wave transformers can keep their charge (via the connected electronics) for a long time, so be careful!

R1 and R2 are 10 ohm, wire-wound, and at least 5 watts. Wattage/cooling should be increased accordingly if you decide to beef up the output. For D1 and D2 you can use any power diode like the 1N4002 to 1N4005.

If you live in Europe, Australia, or any other country with a 220VAC system, the only different is the transformer. This particular circuit can be constructed to handle up to 1 KiloWatt (1000 watt). If there is enough interest, I can modify this circuit to include a crow-bar circuit, battery backup, or more output in watts, or everything.

The power output is determined by transformer T1, and power transistors Q1 & Q2. Assume a transformer of about 15A and the chosen transistors of 2N3055 (15A) type, the inverter can supply about **300 watts** with the parts shown. If you are good with electronics all you have to do is replace the 2N3055's and T1 accordingly for more output. It is imperative to **mount Q1 and Q2 on large coolrrips**. If you intend to beef everything up with a couple kilowatts a standard (5") cooling fan will also be required. If this is the case, the 2N3771 power transistor is a good choice at 30Amps. NTE's replacement, NTE181, is an improved version of the 2N3771 and carries 90volts instead of the 40 volts and can dissipate 200W instead of 2N3771's 150W.

It is **mandatory** to include at least one suitable fuse and enclose this project in the correct casing. To be really safe you may want to include a primary and secondary fuse for your own protection. You are dealing with 120VAC or 220VAC at respectable amperage so be careful. The powercord also needs to be secured to prevent accidents.

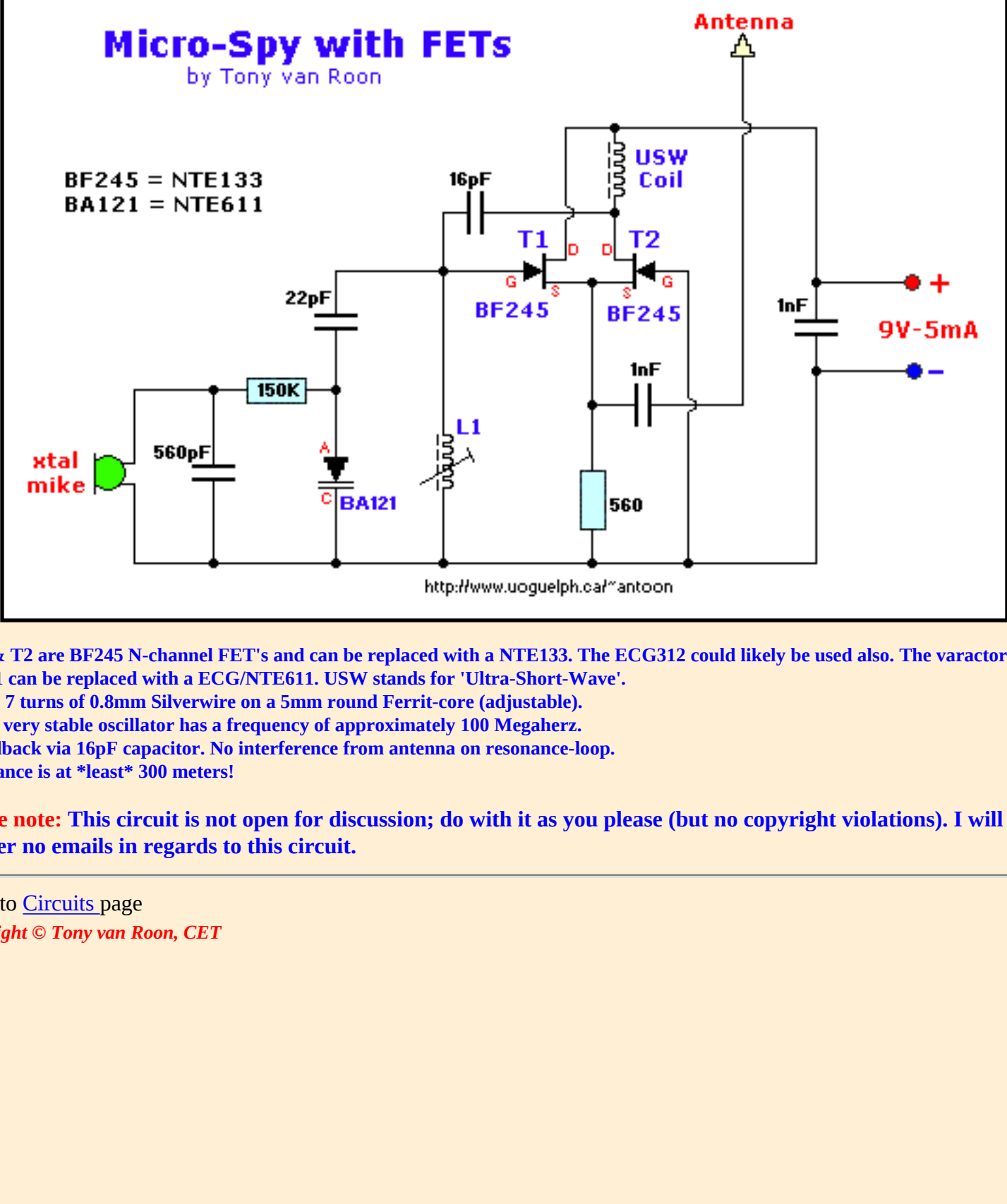
The 68uF capacitors are non-polarized electrolytic types (thanks Gary)! This is an update from the previous types, which specified tantalums. The tantalums however get very hot and explode.

Somesort of cooling fan inside the project case may be a good choice, I myself use a ball-bearing cpu-fan from an old computer. New they don't cost that much either, about 3 bucks or so.

Since T1, and Q1/Q2 are NOT part of the PCB, these few parts can easily be used on a piece of Vero or experimenters board. Radio Shack and Tandy have these boards also available at a very reasonable price (in Canada \$3.50). The receptacle(s) on T1's output will be part of the case (obviously). I just a small note about the 12 Volt battery, this circuit and others similar can draw huge amounts of current and will drain your battery in hurry so don't let your battery go dead! That's why a wind/solar power combination would be an excellent future addition. For those interested in a PCB, I have included one below with a layout. As soon as I get my digital camera I will include pictures of the finished project.

If you wish to check for pin-outs or other references, visit their website: [NTE Electronics](http://www.meridianelectronics.ca)





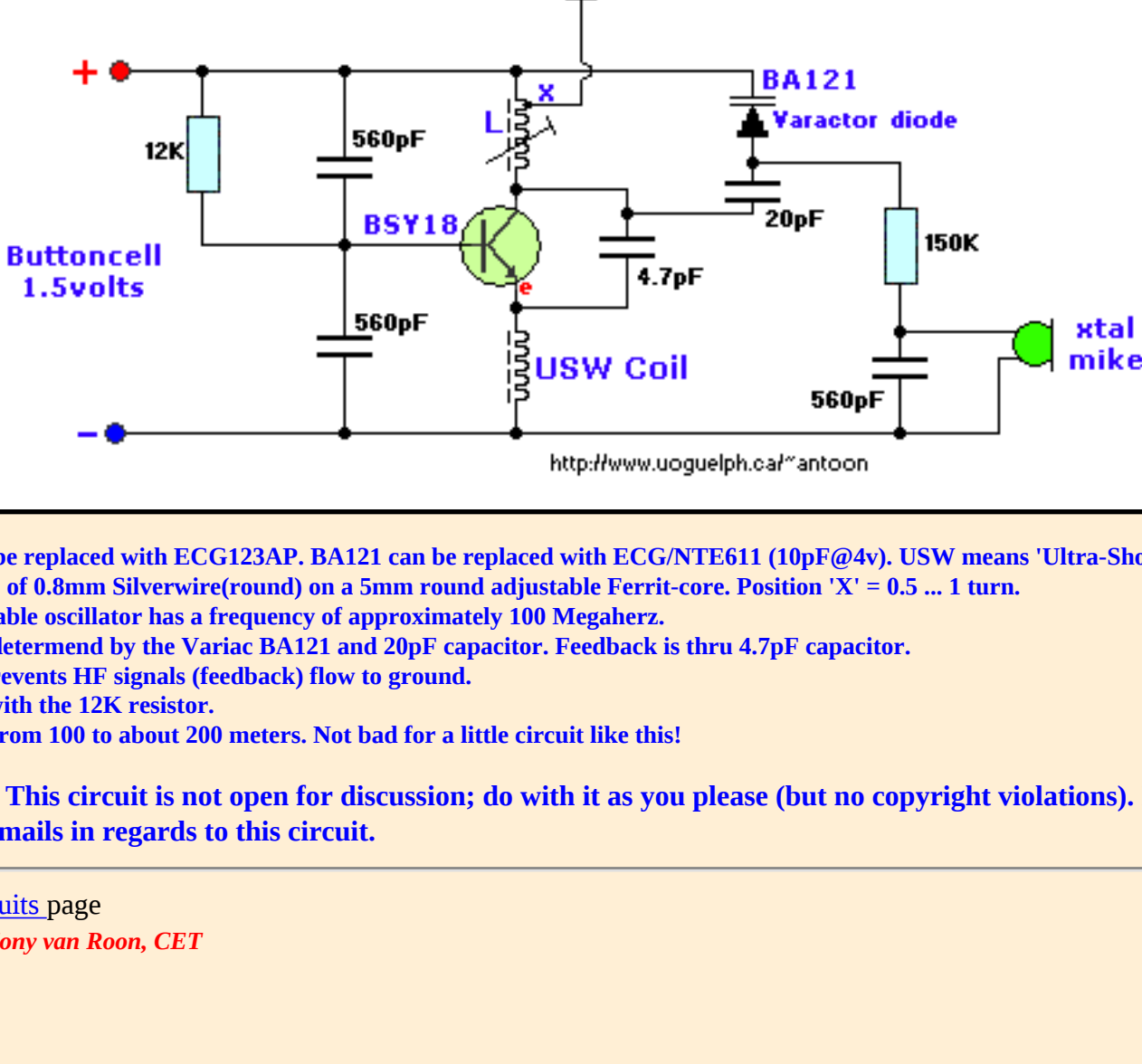
- o T1 & T2 are BF245 N-channel FET's and can be replaced with a NTE133. The ECG312 could likely be used also. The varactor diode BA121 can be replaced with a ECG/NTE611. USW stands for 'Ultra-Short-Wave'.
- o L1 = 7 turns of 0.8mm Silversilver on a 5mm round Ferrit-core (adjustable).
- o This very stable oscillator has a frequency of approximately 100 Megahertz.
- o Feedback via 16pF capacitor. No interference from antenna on resonance-loop.
- o Distance is at *least* 300 meters!

Please note: This circuit is not open for discussion; do with it as you please (but no copyright violations). I will answer no emails in regards to this circuit.

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Shortwave Bug

by Tony van Roon

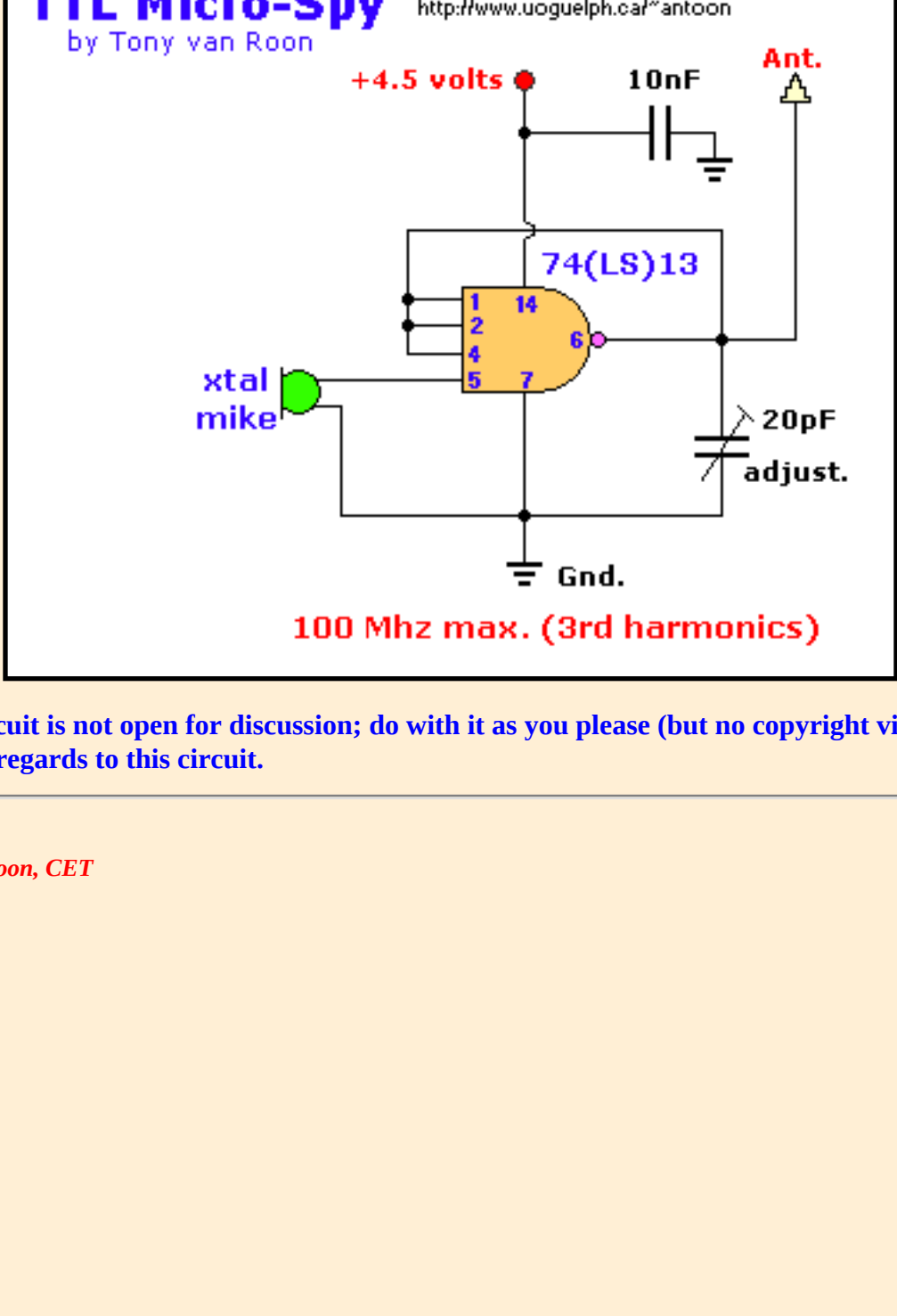


- o BSY18 can be replaced with ECG123AP. BA121 can be replaced with ECG/NTE611 (10pF@4v). USW means 'Ultra-Short-Wave'.
- o L1 = 7 turns of 0.8mm Silverwire(round) on a 5mm round adjustable Ferrit-core. Position 'X' = 0.5 ... 1 turn.
- o This very stable oscillator has a frequency of approximately 100 Megahertz.
- o Frequency determined by the Varic BA121 and 20pF capacitor. Feedback is thru 4.7pF capacitor.
- o USW coil prevents HF signals (feedback) flow to ground.
- o DC biased with the 12K resistor.
- o Distance is from 100 to about 200 meters. Not bad for a little circuit like this!

Please note: This circuit is not open for discussion; do with it as you please (but no copyright violations). I will answer **no** emails in regards to this circuit.

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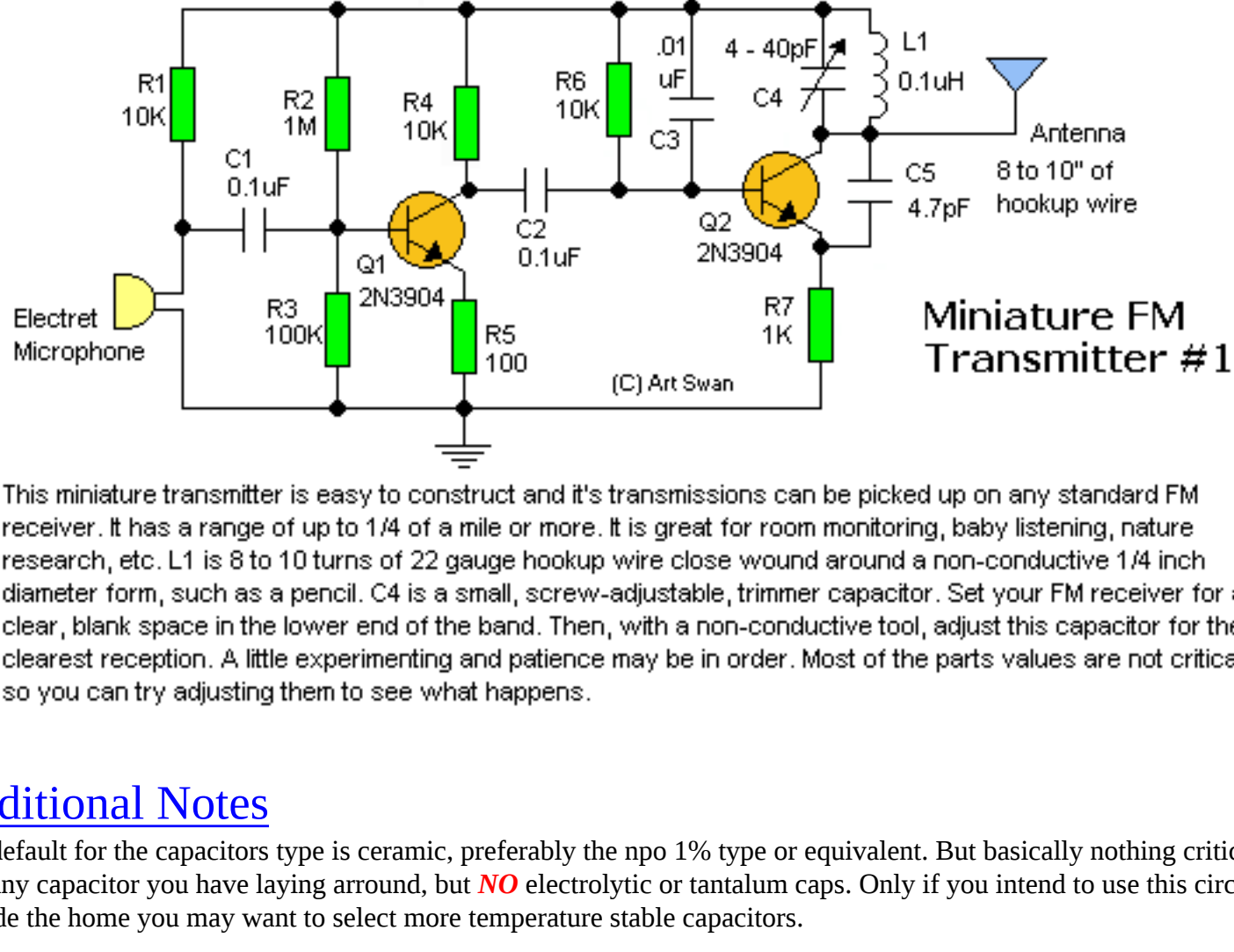
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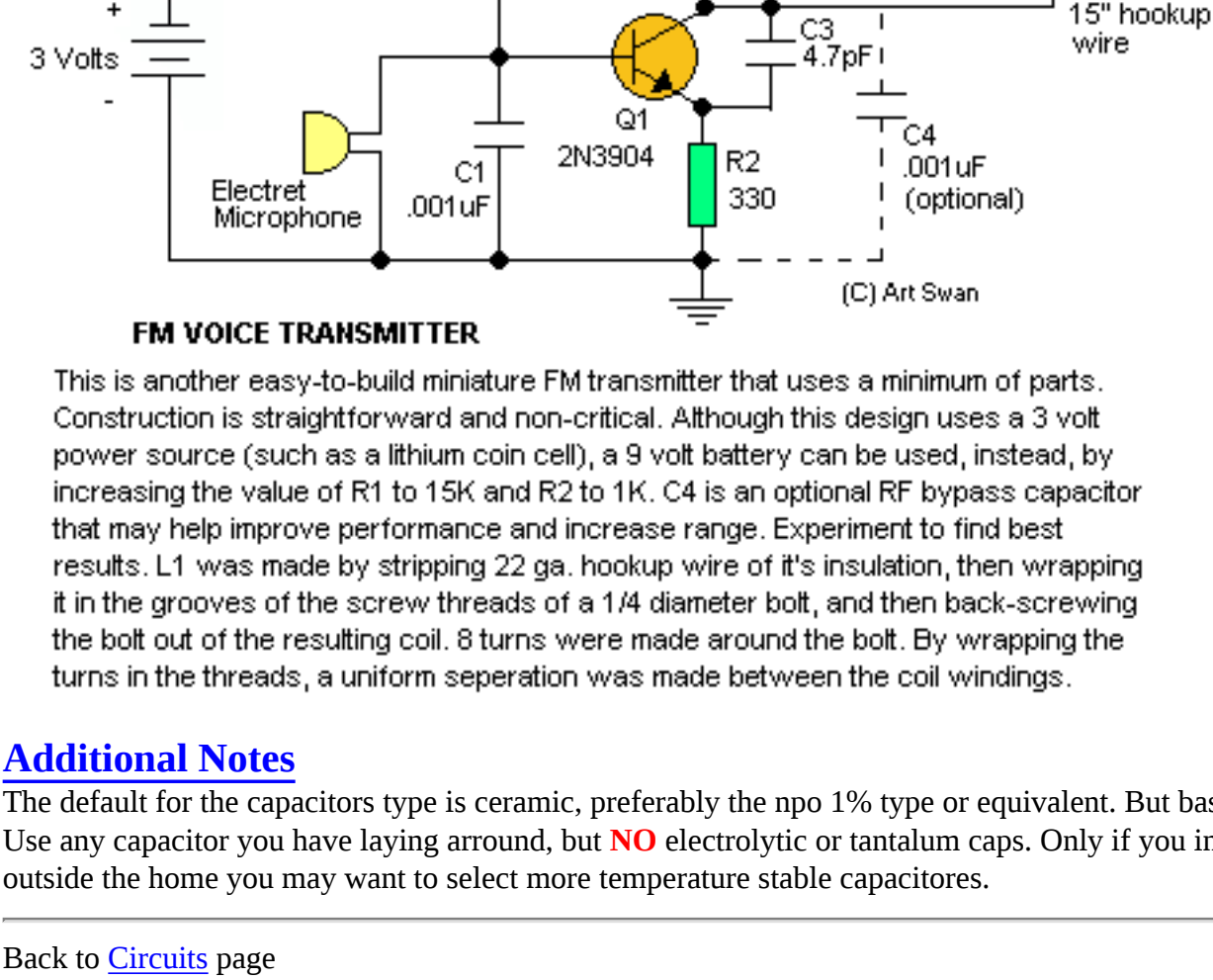
This miniature transmitter is easy to construct and it's transmissions can be picked up on any standard FM receiver. It has a range of up to 1/4 of a mile or more. It is great for room monitoring, baby listening, nature research, etc. L1 is 8 to 10 turns of 22 gauge hookup wire close wound around a non-conductive 1/4 inch diameter form, such as a pencil. C4 is a small, screw-adjustable, trimmer capacitor. Set your FM receiver for a clear, blank space in the lower end of the band. Then, with a non-conductive tool, adjust this capacitor for the clearest reception. A little experimenting and patience may be in order. Most of the parts values are not critical, so you can try adjusting them to see what happens.

Additional Notes

The default for the capacitors type is ceramic, preferably the npo 1% type or equivalent. But basically nothing critical here. Use any capacitor you have laying around, but **NO** electrolytic or tantalum caps. Only if you intend to use this circuit outside the home you may want to select more temperature stable capacitors.

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Miniature FM Transmitter #2



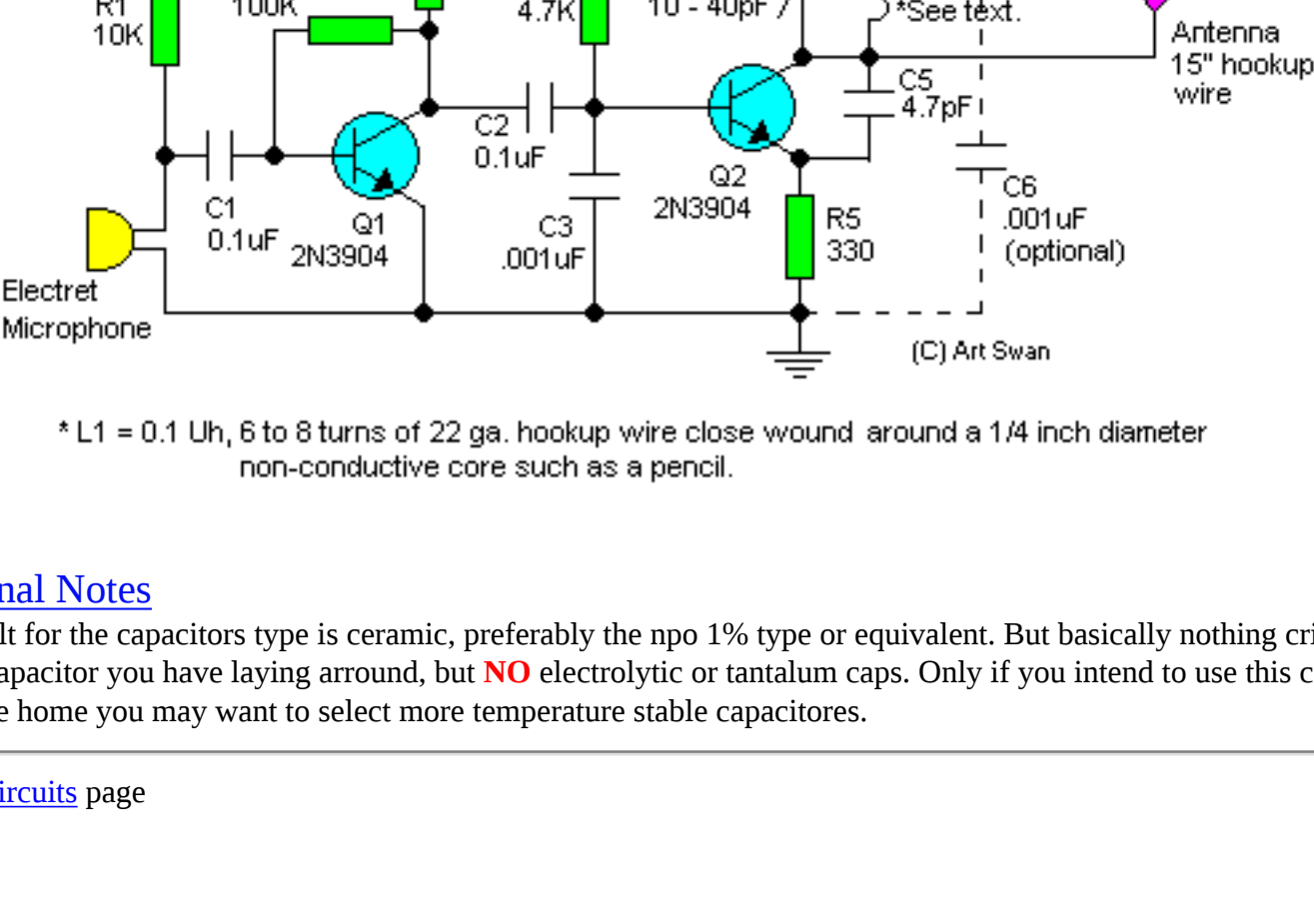
This is another easy-to-build miniature FM transmitter that uses a minimum of parts. Construction is straightforward and non-critical. Although this design uses a 3 volt power source (such as a lithium coin cell), a 9 volt battery can be used, instead, by increasing the value of R1 to 15K and R2 to 1K. C4 is an optional RF bypass capacitor that may help improve performance and increase range. Experiment to find best results. L1 was made by stripping 22 ga. hookup wire of it's insulation, then wrapping it in the grooves of the screw threads of a 1/4 diameter bolt, and then back-screwing the bolt out of the resulting coil. 8 turns were made around the bolt. By wrapping the turns in the threads, a uniform separation was made between the coil windings.

Additional Notes

The default for the capacitors type is ceramic, preferably the npo 1% type or equivalent. But basically nothing critical here. Use any capacitor you have laying around, but **NO** electrolytic or tantalum caps. Only if you intend to use this circuit outside the home you may want to select more temperature stable capacitors.

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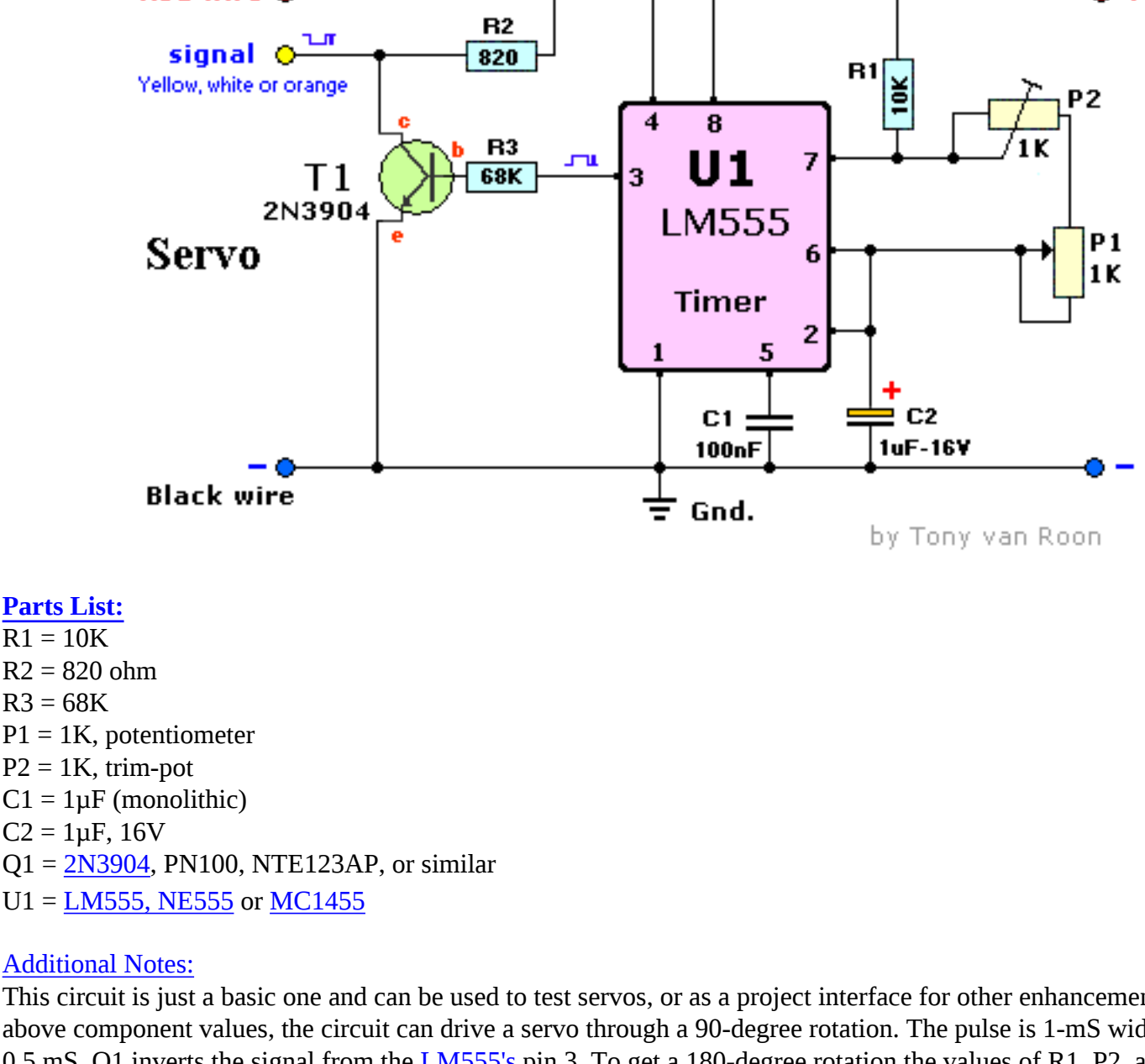
Sensitive FM Transmitter



Additional Notes

The default for the capacitors type is ceramic, preferably the npo 1% type or equivalent. But basically nothing critical here. Use any capacitor you have laying around, but **no** electrolytic or tantalum caps. Only if you intend to use this circuit outside the home you may want to select more temperature stable capacitors.

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Parts List:

- R1 = 10K
- R2 = 10K ohm
- R3 = 68K
- P1 = 1K, potentiometer
- P2 = 1K, trim-pot
- C1 = 1uF (monolithic)
- C2 = 1uF, 16V
- Q1 = 2N3904, PN100, NTE123AP, or similar
- U1 = LM555, NE555 or MC1455

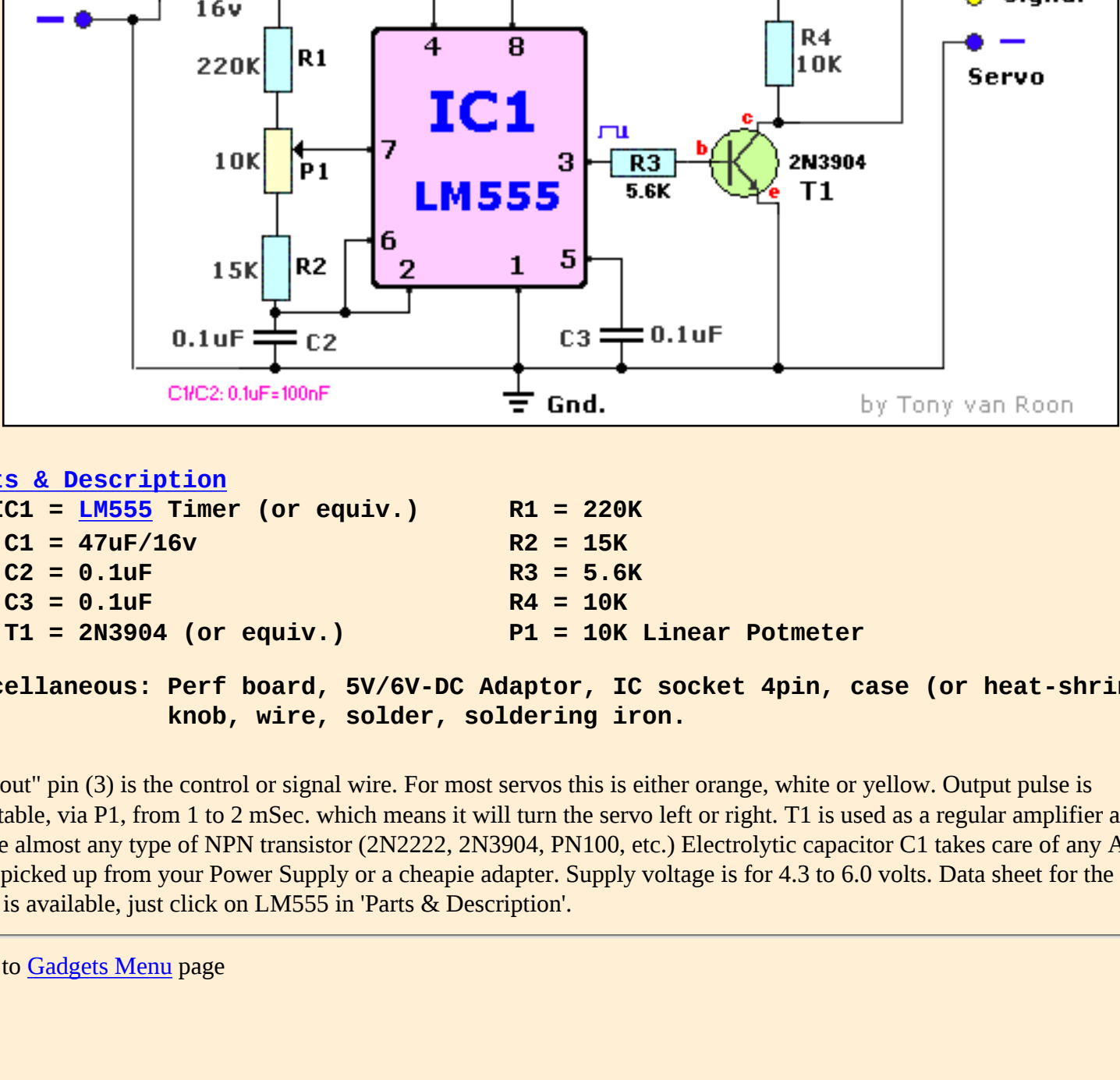
Additional Notes:

This circuit is just a basic one and can be used to test servos, or as a project interface for other enhancements. With the above component values, the circuit can drive a servo through a 90-degree rotation. The pulse is 1-mS wide, plus or minus 0.5 mS. Q1 inverts the signal from the LM555's pin 3. To get a 180-degree rotation the values of R1, P2, and C1 should be changed to 5K6, 560Ohm and 2uF respectively. R3 accounts for shift variations in the different variety of servo motors.

- Pin 1 = Ground (-)
- Pin 2 = Trigger
- Pin 3 = Output
- Pin 4 = Reset
- Pin 5 = Control Voltage
- Pin 6 = Threshold
- Pin 7 = Discharge
- Pin 8 = Vcc (+)

Servo Driver, 4

by Tony van Roon



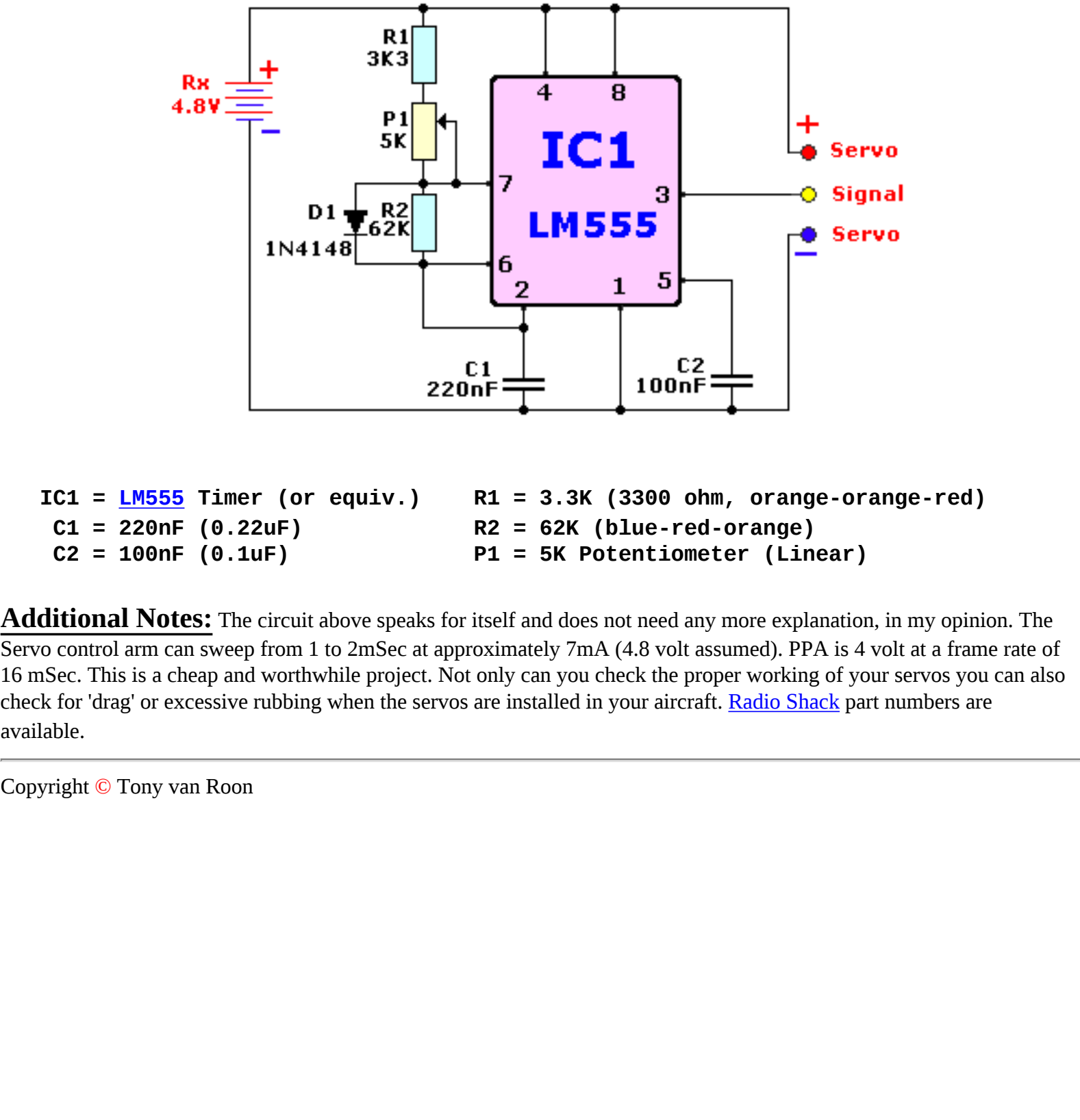
Parts & Description

IC1 = LM555 Timer (or equiv.)	R1 = 220K
C1 = 47uF/16v	R2 = 15K
C2 = 0.1uF	R3 = 5.6K
C3 = 0.1uF	R4 = 10K
T1 = 2N3904 (or equiv.)	P1 = 10K Linear Potmeter

Miscellaneous: Perf board, 5V/6V-DC Adaptor, IC socket 4pin, case (or heat-shrink), knob, wire, solder, soldering iron.

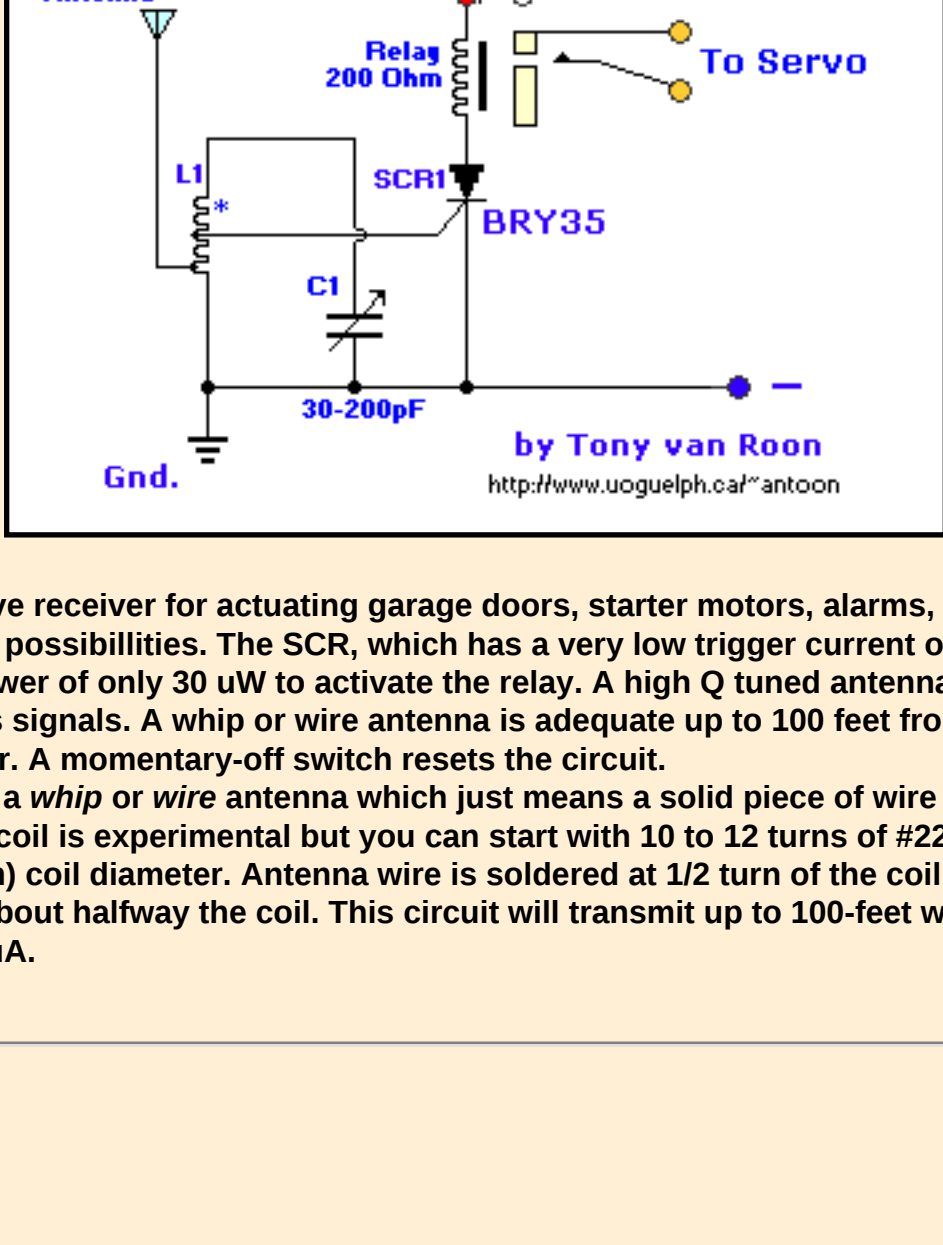
The "out" pin (3) is the control or signal wire. For most servos this is either orange, white or yellow. Output pulse is adjustable, via P1, from 1 to 2 mSec. which means it will turn the servo left or right. T1 is used as a regular amplifier and can be almost any type of NPN transistor (2N2222, 2N3904, PN100, etc.) Electrolytic capacitor C1 takes care of any AC-Hum picked up from your Power Supply or a cheapie adapter. Supply voltage is for 4.3 to 6.0 volts. Data sheet for the 555 timer is available, just click on LM555 in 'Parts & Description'.

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Simplest R/C Circuit

by Tony van Roon

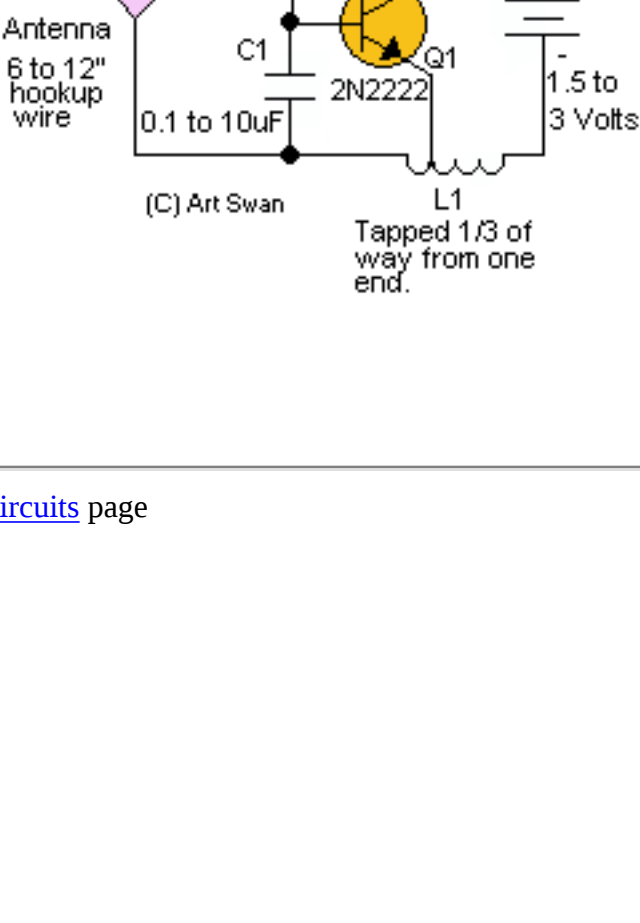


A simple and effective receiver for actuating garage doors, starter motors, alarms, warning systems and numerous other possibilities. The SCR, which has a very low trigger current of 30 uA is typical -- it requires an input power of only 30 uW to activate the relay. A high Q tuned antenna circuit assures rejection of spurious signals. A whip or wire antenna is adequate up to 100 feet from a low power transistor transmitter. A momentary-off switch resets the circuit. The circuit specifies a *whip* or *wire* antenna which just means a solid piece of wire 6-12 inches long (15-30cm). The antenna coil is experimental but you can start with 10 to 12 turns of #22 (0.7mm) magnet wire, and 5/16" (8mm) coil diameter. Antenna wire is soldered at 1/2 turn of the coil and the gate of the BRY35 is soldered about halfway the coil. This circuit will transmit up to 100-feet with the above specifications @ 30uA.

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Simplest RF Transmitter

<http://www.uoguelph.ca/~antoon>



This is probably the simplest radio transmitter that you will find anywhere. It has a total of five parts and can be constructed into a very small space. It is great for science fair projects or other science related projects where short range transmission is useful. It runs on 1.5 to 3 volts, with small hearing aid batteries or lithium "coin" cells being ideal. A thermistor or photoresistor can be inserted in series with R1 to have a varying output frequency dependent on the input. The frequency can also be changed by changing the value of C1. A 2N2222 transistor is recommended, but you can try other types also. Performance tends to vary from type to type as well as from transistor to transistor. L1 is 20 to 30 turns of thin magnet wire (24 to 32 ga.) close wound around a 1/8 to 1/4" diameter non-conductive form. The coil is tapped 1/3 of the way from one end and the tap connected to the emitter of Q1. Experiment with all of the values in this circuit. Nothing is critical, but performance can be varied considerably.

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by Tony van Roon

Toroids & RF-chokes, come in different shapes and sizes, like in donut, tube, and stick models, and are used on a large scale in a variety of electronic equipment. Toroids can be of different materials, like Ferrite or Iron. The most common applications today are filtering, and transformers. If you check your cable at the back of your computer monitor you will find one, or even two, on the cable going to your computer. They are also used in Power Supplies, Radio, Ham Radio, Scanners, Transmitters, Transformers, and Electro-Magnet applications.

Here is an excellent link to provide more 'Amidon' information: [Bytemark Inc.](#)

Below I have made up 4 tables with the most common-size toroids. I hope they can be of some assistance to you. The μ stands for the permeability factor of the core. All measurements are given in 'inches'. I don't have or know the info in mm (metric) so don't ask.

Red E Cores: 500Khz - 30Mhz ($\mu=10$)

Core	OD	ID	H (in inches)
T12-2	0.125	0.062	0.050
T16-2	0.160	0.078	0.060
T20-2	0.200	0.088	0.070
T25-2	0.255	0.120	0.096
T30-2	0.307	0.151	0.128
T37-2	0.375	0.205	0.128
T44-2	0.440	0.229	0.159
T50-2	0.500	0.303	0.190
T68-2	0.690	0.370	0.190
T80-2	0.795	0.495	0.250
T94-2	0.942	0.560	0.312
T106-2	1.060	0.780	0.437
T130-2	1.300	0.950	0.437
T157-2	1.570	0.950	0.570
T184-2	1.840	1.250	0.710
T200-2	2.000	1.250	0.550
T200A-2	2.000	1.405	1.000
T225-2	2.250	1.485	0.550
T225A-2	2.250	1.250	1.000
T300-2	3.058	1.925	0.500
T300A-2	3.048	1.925	1.000
T400-2	4.000	2.250	0.650
T400A-2	4.000	2.250	1.300
T520-2	5.200	3.080	0.800

(c) Tony van Roon

Black W Cores: 30Mhz - 100Mhz ($\mu=6$)

Core	OD	ID	H (in inches)
T12-10	0.125	0.062	0.050
T16-10	0.160	0.078	0.060
T20-10	0.200	0.088	0.070
T25-10	0.255	0.120	0.096
T30-10	0.307	0.151	0.128
T37-10	0.375	0.205	0.128
T44-10	0.440	0.229	0.159
T50-10	0.500	0.303	0.190
T68-10	0.690	0.370	0.190
T80-10	0.795	0.495	0.250
T94-10	0.942	0.560	0.312
T106-10	1.060	0.780	0.437
T130-10	1.300	0.950	0.437
T157-10	1.570	0.950	0.570
T184-10	1.840	0.950	0.710
T200-10	2.000	1.250	0.550
T200A-6	2.000	1.250	1.000
T224-6	2.250	1.405	0.550

(c) Tony van Roon

Yellow SF Cores: 10Mhz - 50Mhz ($\mu=8$)

Core	OD	ID	H (in inches)
T12-6	0.125	0.062	0.050
T16-6	0.160	0.078	0.060
T20-6	0.200	0.088	0.070
T25-6	0.255	0.120	0.096
T30-6	0.307	0.151	0.128
T37-6	0.375	0.205	0.128
T44-6	0.440	0.229	0.159
T50-6	0.500	0.303	0.190
T68-6	0.690	0.370	0.190
T80-6	0.795	0.495	0.250
T94-6	0.942	0.560	0.312
T106-6	1.060	0.780	0.437
T130-6	1.300	0.780	0.437
T157-6	1.570	0.950	0.570
T184-6	1.840	0.950	0.710
T200-6	2.000	1.250	0.550
T200A-6	2.000	1.250	1.000
T224-6	2.250	1.405	0.550

(c) Tony van Roon

Ferrite Toroids (Amidon)

Core	OD	ID	H (in inches)
FT-23	0.230	0.120	0.060
FT-37	0.375	0.187	0.125
FT-50	0.500	0.281	0.188
FT-82	0.825	0.520	0.250
FT-87	0.870	0.540	0.250
FT-87A	0.870	0.540	0.500
FT-114	1.142	0.750	0.295
FT-114A	1.142	0.750	0.545
FT-140	1.400	0.900	0.500
FT-140A	1.400	0.900	0.590
FT-150	1.500	0.750	0.250
FT-150A	1.500	0.750	0.500
FT-193	1.932	1.250	0.625
FT-193A	1.932	1.250	0.750
FT-240	2.400	1.400	0.500

(c) Tony van Roon

Iron Powder Properties:

Material	Basic-powder	Permeability (μ)	Freq.Range (MHz)	Color-Code
0	Phenolic	1	100 - 300	Tan
1	Carbonyl C	20	0.5 - 5.0	Blue
2	Carbonyl E	10	2.0 - 30.0	Red
3	Carbonyl HP	35	0.05 - 0.5	Gray
6	Carbonyl SF	8	10 - 50	Yellow
7	Carbonyl TH	9	5.0 - 35.0	White
10	Carbonyl W	6	30 - 100	Black
12	Synthetic Oxide	4	50 - 200	Green/White
15	Carbonyl GS6	25	0.10 - 2.0	Red/White
17	Carbonyl	4	50 - 200	Blue/Yellow
26	Special	75	LF Filters, Chokes	Yellow/White

*Non Linear: Material #17 was developed as a temperature stable (50) alternative to the #12 (170). Frequency ranges shown are for best 'Q'/Useful over broader frequency ranges with lower 'Q'.



The photograph at left shows a Toroid Red 'E' Iron core and is used in a QRP CW-transmitter (morse-code) application in the 30-meter band.

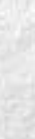
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Other Electronics Links:

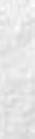
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-  [Website on LEDs](#)
-  [Zapping NiCads/Lithium-Ion batteries](#)

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Last Updated: November 5, 2004

NOTE

If you found this page with a search engine and there is no directory to the right of this page, click HERE to properly load the page.

Overview:

This site will help you to understand basic electronics and some electronic devices. It will, of course, also touch on car audio acoustics and car audio equipment. To make the lessons as painless as possible, you'll find hundreds of diagrams and pictures, .wav files and more than 50 javascript calculators on the 125+ individual web pages. If you make even a modest effort, you'll learn more about car audio electronics than you ever thought possible.

NEWBIES:

If you're new to this site, please read everything on this page before venturing into the rest of the site.

Flash Demos and Javascript Calculators for YOUR Site:

If you want original calculators or Flash animations/demos for your site, Email me. The price will depend on complexity. It doesn't have to be related to electronics. All Flash material will be submitted for your approval before you pay anything. The only exception would be for very complex projects where I would require some sort of deposit.

Email:

If you email me for more specific information, Please do the following:

- Do a search to see if the question is answered on the site.
- Use proper grammar and punctuation (question marks). If you expect me to take time to answer your questions, the least you can do is make an effort to make the questions clear. Of course, if you're not from the 'states' and are not from a native english speaking country, just do your best. It's a shame that the email I get from outside the US has better grammar and sentence structure than the email I get from inside the US. :-4
- Leave a blank line between the end of one question and the beginning of the next question. It makes it easier to read. It also makes sure that I see all of the questions.
- If you email me multiple times and have a question about your system, list the equipment every time. I get a lot of email and can't always remember what you have.

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Sending Links:

If you want to send someone a link to one of the pages in the directory, right click on the desired link and left click on 'copy link location' or 'copy shortcut' in the drop down menu. This will copy the link to the windows clipboard. You can use the 'paste' command or 'ctrl V' to paste the link into your outgoing message. This will provide a direct link to the appropriate page.

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Printing Pages of the Site:

To print pages of this site with Internet Explorer go to the toolbar (at the top of the page) and select... TOOLS, INTERNET OPTIONS, ADVANCED TAB, PRINTING and deselect the print backgrounds option. Then click inside the window with the content that you want to print to make the browser focus on the proper frame. The page should print with dark gray text and no background color. If you're using Netscape... Good luck. I use Netscape for browsing, but for some reason, I can't make it print right so I use IE for printing.

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Flash graphics have a few additional options when compared to static graphics. If you right click on any part of the graphic (not the transparent background), you will see a special menu. If you uncheck the 'play' command, the motion will stop. If you select 'zoom', you can zoom in on the image. When zoomed in, the standard cursor will change to a hand cursor when over the graphic. The hand allows you move the graphic around in the window.

Don't Cheat Yourself:

If you don't fully understand something, reread it. I don't believe that anyone (especially those who are new to car audio) will be able to fully understand everything here without having to reread more than a few pages. This information is based on my experience and should NOT be your only source of information. As a matter of fact, you should read everything that you can find on as many different sites as you can. We all have slightly different perspectives and will explain things in different ways.

DISCLAIMER:

After reading this, it does NOT qualify you to install any audio or electronic equipment. This is only a VERY basic introduction into car audio electronics. I make every effort to insure that the information contained herein is accurate but I cannot be held responsible for any errors in text, calculators or graphics. Use the information provided at your own risk.

Try to follow the tutorial in order from top to bottom, I have tried to put everything in the most efficient order possible.

Guestbook

Use the guestbook for comments.
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If you want a topic added or have a question, E-mail me.
You can also contact me at: ICQ# 926828

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	Page contains a search engine
	Page contains test questions
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	CD ROM version contains additional test questions on this page.
	Page contains electronics schematics
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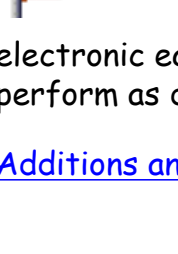
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Capacitor & Speaker
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Tri-Mode Speaker Connection
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Quantifying AC Voltage
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Speaker Ratings
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Speaker Impedance vs Power Output
.
Series/Parallel Impedance
.
Total Harmonic Distortion
Head Unit Bridged?
RCA Cable
Vehicle Chassis Ground
.
Gain Controls
.
Amplifier Heat Sink
Cooling Fans
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Decibel
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Octave
Bass & Treble
Loudness Contour
Oscilloscope
Printed Circuits
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Cassette Tape Head
Bipolar Transistor
Transistor Example
Field Effect Transistor (MOSFET)
Soldering Technique
Servo Loops
Operational Amplifiers
Transformer Ratio
Electronic XO vs Passive XO
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PWM Power Supply

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	Integrated Circuits
	Making Prototype Circuit Boards
  	Rectification & Filtering Additional Information Available On CD ROM
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  	Passive Crossover Slope II ..
  	Trigonometry and Right Triangles
  	Impedance Calculations (advanced)
	Tri-mode Power
	Basic Audio Troubleshooting ..
	Mechanical Noise
	Output Transistor Failure .
	Output Impedance
 	Damping Factor
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 	Regulated vs Unregulated Power Supplies
	Measuring Amplifier Output Power
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Bowden's Hobby Circuits



A small collection of electronic circuits for the hobbyist or student. Site includes over 100 circuit diagrams, links to related sites, commercial kits and projects, newsgroups and educational areas. Most of the circuits can be built with common components available from Radio Shack or salvaged from scrap electronic equipment. Most all of the circuits have been built and tested and believed to perform as described, however possible mistakes may be found.

[Additions and Corrections \(12/04/03\)](#)

Digital/Computer • 16 Bit PC Serial Port Receiver (CMOS) • 24 bit ISA card Installs into your computer. Parts, plans, schematics and programming available. Also may be purchased as a kit. • 32 Bit Serial Receiver (57.6 K Baud TTL & CMOS) • Parallel Port Relay Interface Circuit • Reading Data From The Parallel Port • 1 Second Time Base From Crystal Osc. • 32.768 KHz Oscillator Using A Common Watch Crystal • Digital Electronic Lock Telephone Circuits • Use Old Telephones as Intercom • Telephone In-Use LED Indicator • Telephone In-Use Relay Circuit • Telephone Ring Generator Using 60Hz Power Transformer • Telephone Ring Generator Using Switching Power Supply • Telephone Audio Interface LED Circuits • 40 LED Bicycle Light (555 Timer - 6 volt) • 28 LED Clock • 72 LED Clock • Binary Based Decimal (BCD) Clock • Digital LED Clock and Timer • Astable Multivibrator • Expandable 16 Stage LED Sequencer • 16 Stage Bi-Directional LED Sequencer • 10 Stage LED Sequencer • 9 Second LED Relay Timer • 9 Second Digital Readout Timer • Two Transistor LED Flasher • 1.5 Volt LED Flashers • LED Photo Sensor Circuit • Fading Red Eyes • 12 Volt Lamp Fader (LEDs or incandescents) • LED Battery Condition Indicator • 8 Stage LED VU Meter • Battery Equal Charge Indicator • IR Remote Control Tester • AC Line Powered LEDs • LED Traffic Lights Analog / RF Circuits • LED Decibel Meter • Whistle On - Whistle Off • Long Loopstick AM Radio Antenna • Micro Power AM Broadcast Transmitter • FM Beacon Transmitter (88-108 MHz) • Op-Amp Basics - The text information for the basic Op-Amp operation, 2nd order filters and bandpass filters was obtained in part from the paper back book "Design of Active Filters, With Experiments" by Howard M. Berlin, 1977. The book is out of print but possibly can be found at used book stores, or through Amazon.com • Active 2nd Order Filters • Bandpass Filter (Single Op-Amp) • Low Power Op-Amp - Audio Amp (Intercom) • Crystal Radio Circuits • Simple Op-Amp Radio • Low Frequency Sinewave Generator • 3 Transistor Audio Amp (50 milliwatt) • RC Notch Filter (Twin T) • Analog Milliamp Meter Used as Voltmeter	Power Circuits • Simple Variable Voltage Source • LM317 Variable Voltage Regulator • LM317 Regulator With Pass Transistor • Variable 3 - 24 Volt / 3 Amp Power Supply • Variable Voltage and Current Power Supply • 2 watt switching power supply • Low Power DC to DC Converter • Constant Current Battery Charger • 120VAC Lamp Chaser Using Solid State Relays • 120 VAC Lamp Dimmer (full wave SCR) • Varying Brightness AC Lamp • 12 Volt Lamp Fader (Automatic) • 1.5 Hour Lamp Fader (Sunset Lamp) • 12 Volt Lamp Dimmer (using a pot) • Interfacing 5 volt CMOS to 12 volt loads • Low Voltage , High Current Time Delay Circuit • High Current Regulated Power Supply • Thermostat for 1KW Space Heater (SCR controlled) Miscellaneous • Triangle and Squarewave Generator • Transistor Schmitt Trigger Oscillator • Discrete Set/Reset Flip Flop • Discrete Bistable Flip Flop • Toggle Switch Debounced Pushbutton • High Current MOSFET Flip Flop With Debounced Pushbutton • Monostable Flip Flops (one shot) • Ignition Coil High Voltage Circuit • Ignition Coil Buzz Box • Capacitor Discharge Ignition Circuit • Generating Long Time Delays • Flashing Neons (NE-51 / NE-2) • Sequencing Neons (NE-51 / NE-2) • 555 Tone Generator (8 Ohm Speaker) • Generating Negative 5 Volts from 9 Volt Battery • Touch Activated Lamp • Game Show Who's First Indicator Lights • Salt Water Battery • Transistor, Diode, IC outlines Circuits Controlling Relays • Push Button Relay Toggle Circuit With One Transistor • CMOS Toggle Flip Flop Using Push Button (CD4013) • CMOS Toggle Flip Flop Using Laser Pointer • 555 Timer Monostable Circuit Using Pushbutton • Generating a Delayed Pulse With a dual 555 Timer • Light Activated Relay (toggle) • Photo Electric Street Light • Power-On Time Delay Relay Circuit • Power-Off Time Delay Relay Circuit • Electronic Thermostat Relay Circuit • AC Line Current Detector • Pinewood Derby Finish Line Lights • Pinewood Derby Finish Line Using a Computer - Scores times and places. • Controlling relays with logic voltages •
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Semiconductor Data Sheets

[TI Semiconductors \(search\)](#) [National Semiconductors \(search\)](#) [Motorola](#) [NTE](#)

Software (Moved to separate page)

Java Script Calculators

[Resistor Color Code Calculator](#) - Graphical resistor color code calculator by Danny Goodman. Uses pulldown menus and a realistic picture of a resistor.

[Another Resistor Color Code Calculator](#) - This one uses check boxes instead of pulldown menus and also calculates the equivalent value of two resistors in parallel. My own creation.

[Ohm's Law Calculator](#) - Java Script to solve Ohm's Law for Voltage, Current, Resistance and Power. Enter any two unknowns and solve for the other two.

[Voltage Divider Calculator](#) - Solves voltage, current, and power dissipation problems for two element resistive voltage dividers.

[L or C Reactance Calculator](#) - Java Script to calculate capacitive or inductive reactance and resonant frequency. For ideal devices only, resistance not included.

[Allen Newman's Impedance Calculator](#) - Solves passive series RLC networks, for reactance, impedance and phase angle.

[RC Time Calculator](#) - Java Script to solve R and C values for given values of time or instantaneous voltages.

[RL Time Calculator](#) - Java Script to solve R and L values for given values of time or instantaneous current.

[555 Timer - Frequency and Time Interval Calculator](#) - Calculates positive and negative time intervals for the 555 timer based on R and C values. Also contains descriptions and operation of each input and output of the timer and schematics for the two basic modes of operation (monostable or "one-shot" and astable or "rectangular wave oscillator"). Also contains a pictorial diagram of the timer connected as a LED flasher and a table of connections for the 556 timer (dual 555 timer).

[LED Series Resistor Calculator](#) - Finds the series resistance needed for various series LED combinations and supply voltages.

[The Electronics Calculator Website](#) - Several calculators for Ohm's law, capacitor or inductor impedance, tuned circuits and RC time constants.

[Several JavaScript Calculators by John Owen](#) - Audio op-amp filter, Op-amp circuit, Decibels, Zener Diodes and more...

[Gregorian Calendar](#) - Displays any month from Oct 1582 forward.

Links to Other Hobby Electronics Sites and Useful Information

[Don Klipstein's LED Website](#) - Lots of useful LED information, FAQs, and sources for the brightest and most efficient LEDs.

[Circuit Archive](#) - University of Washington Circuit Archive, lots of good circuits and links.

[EDUCYPEDIA](#) - The educational encyclopedia (Electronics section)

[Tomi Engdahl's Electronic Info](#) - Links to a wide variety of analog and digital circuits.

[Imagingering On-Line Magazine, The Design Corner, over 100 circuits in pdf format.](#)

[Tom Loredto's Electronics Bookmarks](#) - Many resources for electronics hardware and software.

[Harry's Homebrew Homepage](#) - For building amateur radio equipment. Antennas, Receivers, Transmitters and other useful circuits.

[Links for FM Transmitter Kits, Circuits, Electronics ...](#)

[Electronics Links and Resources](#) -Links to circuits, components, educational sites and more..

[Tony's Website](#) - R/C Gadgets and electronic circuits for the hobbyist.

[Steve Walz's FTP Site](#) - FTP Resource Site, 1000 Files in 50 Directories.

[Wenzel & Associates \(Circuits\)](#) - Technical Library, Hobby Circuits.

[Samuel M. Goldwasser Homepage](#) - Silicon Sam's Technology Resource - FAQs, Links, Troubleshooting & Repair, Laser info, Circuits.

[Diana's Electronics info page](#)

[Beyond Logic](#) - Information on the PC Parallel, Serial and USB ports.

[How Stuff Works](#) - Interesting site on how things work, but you will have to clear your screen of many pop up ads.

[Deep Cycle Battery Frequently Asked Questions](#)

[Energinzer Battery Data](#) - Capacity, Weight, Size, etc.

[www.saroff.com](#) Has some useful search engines for locating parts and data sheets.

Commercial Electronic Kits and Projects • TheLEDLight.com Luxeon LEDs, LED bulbs, fixtures, flashlights, lanterns, clusters, arrays, and more... • Isdiodes.com Basic collection of bright LEDs in several colors at low prices. Brightness ranges from 4000 mcd to 12,000 mcd for the white LEDs. • JDR Microcontrollers Books, Kits, Test Equipment and more. • Alltronics Electronic Kits • KitZ Electronic Kits • Electronics USA - LED Digital and Binary Clocks, LED Timers (Up and down counting), LED flashlights, and a few other items, as kits or assembled. • Centerpoint Electronics Store • Hobbytron - The largest selection of fun electronics and toys! • Almost All Digital Electronic Kits • DTE Microsystems • Hallbar Electronic Kits and Projects • Kits-R-Us Electronic Kits • Microchip Technology Inc. (PIC) Controllers • Circuits For Sale -Subscribe and receive schematics for 1000 circuits, plus FREE software - SuperCAD Lite, SuperPCB Lite, to draw circuit diagrams and build printed circuit boards. • Mental Automation's products ECAD tools: schematic capture, printed circuit board design/layout, autorouting, circuit simulation, SPICE, and CD ROM Encyclopedia of Electronic Circuits, all running under Windows. • Express Printed Circuit Boards Download PCB software to layout your project, E-mail the resulting file and receive delivery of finished circuit boards via Federal Express in 3 working days. • PCB Express 1-Day Delivery, Economical, Easy to order and track, Lot charge as low as \$80, E-Mail Help • Used Electronic Equipment For Sale at E-Bay Online auction community, buy, sell, trade. • C. Crane Company LED Flashlights, windup radios, and other specialty items. • Cyber Circuits Software and Demos • SpamCop - Locate the source of unsolicited mail (Spam) and file a report with the postmaster or abuse department of the originating site. All spam received at my e-mail address will be forwarded to the abuse department of this web page host. •	Electronics Educational Sites • PIC Microcontroller Tutorial A very good introduction to PIC micros that includes 13 tutorial pages to get you started programming PICs. You will also need a programmer to load the finished program (.HEX file) into the PIC. The DOS programmer software and schematic for the programmer can be downloaded from David Tai's PIC archiveThe file you need is PIC84V05.ZIP. The file contains DOS software and programmer schematic that will work with the PIC16C84, PIC16F84 or the newer PIC16F628 which can be purchased on e-bay for about \$2.68 or obtained from www.glicthbuster.com • Lessons In Electric Circuits - A free series of textbooks on the subjects of electricity and electronics. • Play Hooky Basic ideas about op-amps, analog circuits, optics, computers and digital logic. • Alex's Electronic Resource Library An online guide to useful electrical and electronic information. • Electronics Tutorials A good comprehensive site with detailed examples and book recommendations. • Basic Electronics Tutorial (Iguana Labs) • The Art of Electronics (Purchase the book) 1125 large format pages, 80 component-selection tables,1500 figures, extensive practical advice, back-of-the-envelope techniques, exhaustive 4000-entry index. • CircuitMaker Student Version (3.4M) Get ahead in class with the FREE CircuitMaker Student Version. You will be able to build and simulate circuits in a fraction of the time it takes in the lab. • DC Circuits Department of Physics, University of Guelph. • Elements of AC Electricity • John Adams Beginners Electronics • Electronics For Beginners Newsgroups • sci.electronics.basics • sci.electronics.components • sci.electronics.design • sci.electronics.respair • sci.electronics.misc • sci.electronics.cad • sci.electronics.components • sci.electronics.equipment • alt.engineering.electrical • Search Newsgroup Discussions Electronic Component Suppliers • Mouser Electronics • DIGI-KEY Corporation • Allied Electronics • Surplus Traders (Solar panels) • Jameco • Hosfelt Electronics • Radio Shack • Electronix Express - Components and test equipment for schools, colleges and industry. Very nice site. • Dan's Small Parts and Kits -Good selection of small components at low cost. • Bill's Surplus Parts For Sale- Resistors, capacitors, semiconductors and a few other items. I don't have a large inventory, just more than I need.
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Having trouble building a circuit similar to something on this site?

Try posting a message with circuit details to one of the electronic newsgroups, either [sci.electronics.basics](#) or [sci.electronics.design](#) Many readers of those groups will offer ideas and a few specifics at no charge. If you need more detailed help and follow up advice, maybe I can help.

Send a detailed description of your circuit and objective. If it is within my expertise and relates to the projects on this site, I will work with you via email to help solve the problem. I can also test and refine the circuit on a vector board for a nominal fee.

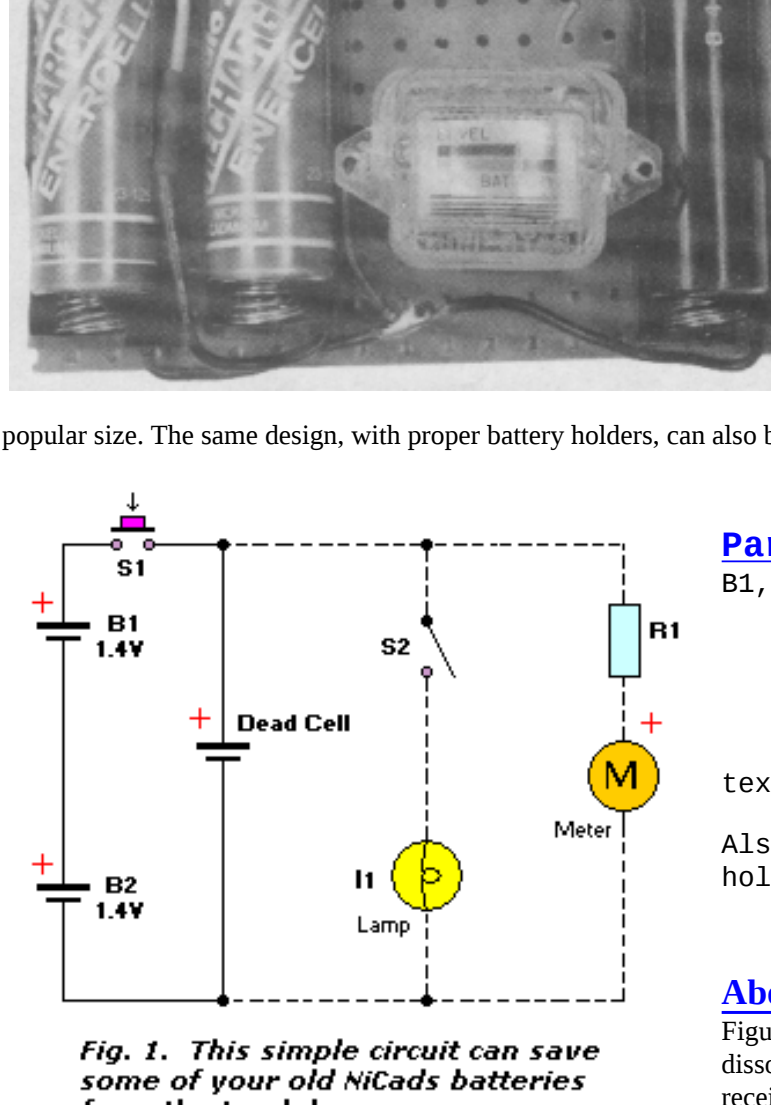
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The ZAP-Adaptor, rejuvenates DEAD NiCads

By Tony van Roon

"Don't throw away those seemingly un-chargeable, rechargeable batteries; they could very well be brought back to life with the aid of this simple circuit."



It is a well known fact that rechargeable batteries have a tendency to "play possum", appearing to be dead, while merely napping instead. It is also a known fact that such batteries can be awakened from their siesta by giving them the proper "wake-up call". The *Zap-Adaptor* described in this article is designed to arouse most of those batteries from their seemingly endless slumber.

Nickel-Cadmium batteries have a tendency to grow internal "whiskers"--fine weblike shorting paths between the internal battery elements--when not used for prolonged periods of time. Those whiskers eventually discharge the cell completely, when attempting to charge such a battery, the internal whiskers short out the relatively small charging current (which is usually only about 1/10th of the cell's ampere rating), preventing the battery from being recharged. Awakening a nickel-cadmium cell (assuming that it can be aroused) requires that a high-current be applied to the battery for a couple seconds to blast away the whiskers. Once the whiskers are gone, you can charge the battery in the normal manner.

The Zap-Adapter that we'll describe is intended for use with AA rechargeable nickel-cadmium batteries, which seem to be the most popular size. The same design, with proper battery holders, can also be used for AAA, C, or D cells, all of which are single cell types.

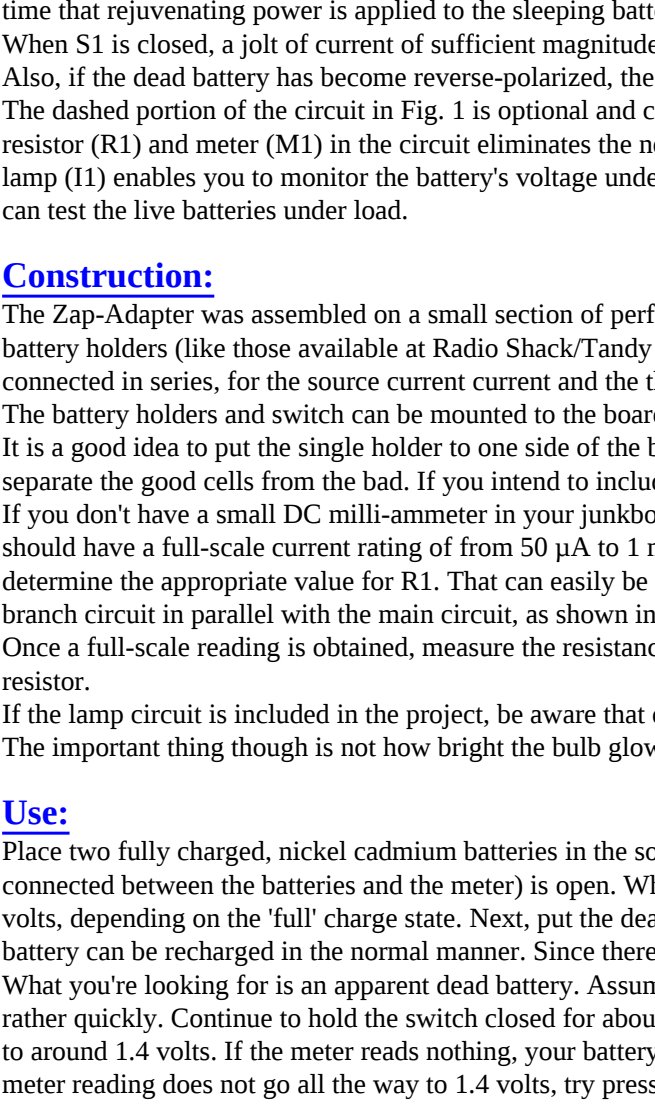


Fig. 1. This simple circuit can save some of your old NiCads batteries from the trash heap.

Nickel cadmium batteries were used for the source because they can deliver lots of current. For example, AA-size cells can deliver a continuous current of 0.5 amperes. Switch S1 allows you to control the amount of time that rejuvenating power is applied to the sleeping battery.

When S1 is closed, a jolt of current of sufficient magnitude is sent through the battery so as to cause the tiny whiskers (shorts) within to open. Also, if the dead battery has become reverse-polarized, the polarity is also corrected by the harsh treatment.

The dashed portion of the circuit in Fig. 1 is optional and can be included to allow you to monitor/test the circuit's operation. Including the resistor (R1) and meter (M1) in the circuit eliminates the need for an external meter. Adding a second switch (S2 in Fig. 1) and a flashlight lamp (I1) enables you to monitor the battery's voltage under load. By removing the dead battery and closing S1 and S2 at the same time, you can test the live batteries under load.

Construction:

The Zap-Adapter was assembled on a small section of perfboard, just large enough to hold the circuit components. Three inexpensive AA battery holders (like those available at Radio Shack/Tandy or other electronic distributors) were mounted to the board; two battery holders, connected in series, for the source current current and the third for the battery that is to be awakened. A push button switch was used for S1. The battery holders and switch can be mounted to the board using double-side tape.

It is a good idea to put the single holder to one side of the board and the double holder (or two holder combination) to the other side to separate the good cells from the bad. If you intend to include the meter and/or lamp circuit in your project, be sure to leave room for them. If you don't have a small DC milli-ammeter in your junkbox, look for one at swap meets, surplus outlets, or small order catalogs. The meter should have a full-scale current rating of from 50 μ A to 1 mA. If you intend to include a meter in your circuit, it will be necessary to determine the appropriate value for R1. That can easily be done by placing a 50K potentiometer in series with the meter, and connecting that branch circuit in parallel with the main circuit, as shown in Fig. 1. Press S1, and adjust the potentiometer for a full-scale meter deflection. Once a full-scale reading is obtained, measure the resistance of the potentiometer, and replace the potentiometer with an equal-value fixed resistor.

If the lamp circuit is included in the project, be aware that different lamps draw different currents, and some may not light with only 1.3 volts. The important thing though is not how bright the bulb glows (if at all), but how the meter reacts.

Use:

Place two fully charged, nickel cadmium batteries in the source battery holders. The meter should give a 0-volt reading since S1 (which is connected between the batteries and the meter) is open. When the switch is closed, the meter reading should jump to between 2.5 and 3.0 volts, depending on the 'full' charge state. Next, put the dead cell in the holder provided. If the meter reading is between 1.3 and 1.4 volts, the battery can be recharged in the normal manner. Since there is no load on the dead battery, even a weak battery must show a normal reading. What you're looking for is an apparent dead battery. Assuming the meter shows the battery to be dead, press S1; the meter reading should rise rather quickly. Continue to hold the switch closed for about three seconds; the meter should go to around 1.4 volts. If the meter reads nothing, your battery has too far gone to revive. If the meter reading does not go all the way to 1.4 volts, try pressing S1 again to see if you can get it up to 1.4 volts. A couple deep-discharge/full-recharge cycles should rejuvenate the battery.

I fully support this project. Most parts can be obtained via your local Radio Shack or Tandy store. I will answer all questions but via the message forum only. ***Tony's Message Forum*** can be accessed via the main page, gadgets, or circuits page.

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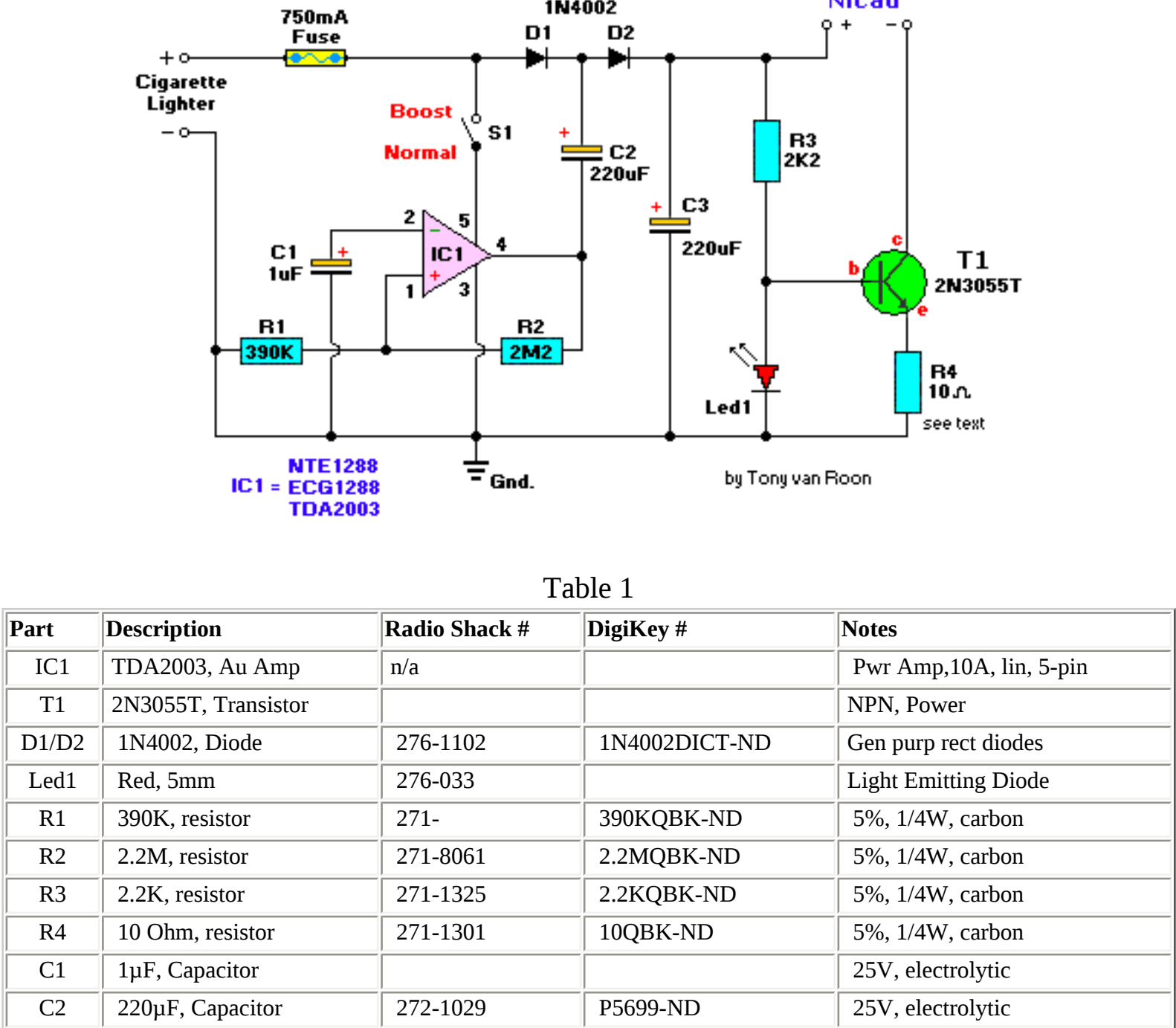


Table 1				
Part	Description	Radio Shack #	DigiKey #	Notes
IC1	TDA2003, Au Amp	n/a		Pwr Amp,10A, lin, 5-pin
T1	2N3055T, Transistor			NPN, Power
D1/D2	1N4002, Diode	276-1102	1N4002DICT-ND	Gen purp rect diodes
Led1	Red, 5mm	276-033		Light Emitting Diode
R1	390K, resistor	271-	390KQBK-ND	5%, 1/4W, carbon
R2	2.2M, resistor	271-8061	2.2MQBK-ND	5%, 1/4W, carbon
R3	2.2K, resistor	271-1325	2.2KQBK-ND	5%, 1/4W, carbon
R4	10 Ohm, resistor	271-1301	10QBK-ND	5%, 1/4W, carbon
C1	1µF, Capacitor			25V, electrolytic
C2	220µF, Capacitor	272-1029	P5699-ND	25V, electrolytic
S1	Switch, on-off			SPST, sub-miniature
Fuse	750mA			Slow Blow

This circuit provides up to 20V output from a regular 13.2V automotive battery, to enable constant current charging of nicad battery packs up to 15 cells @ 1.2V (18V total).
IC1 is a Linear, Audio Power Amp (10W) and was originally designed for car radios by Toshiba. Several replacement types can be used, like the ECG1288, NTE1288 and other substitutes will work fine.
In this circuit, with S1 set in the 'boost' position, IC1 is used to form a squarewave oscillator, and by coupling this square wave to the 13.2V battery supply via D1 and D2 to obtain over 20 vdc. If this is not needed, S1 is left open (normal).
T1 acts as a current regulator to determine the charge rate of the battery pack. T1 should be mounted on a sufficient coolrib.
R4 is selected from the table below, or it can be adapted and switched with a rotary selector switch (watch current rating!).
R4 can easily be adjusted for any value to suit your needs other than listed here.

Cell Size	Amp/hr Rate	R4 Value
N	150mA	120 ohms/0.25 W
AA	500mA	47 ohms/0.5W
C	1500mA	12 ohms/0.5W
D	1500mA	12 ohms/0.5W
D	4000mA	3.3 ohms/2W
(High Capacity)		R4 value at 14hr rate



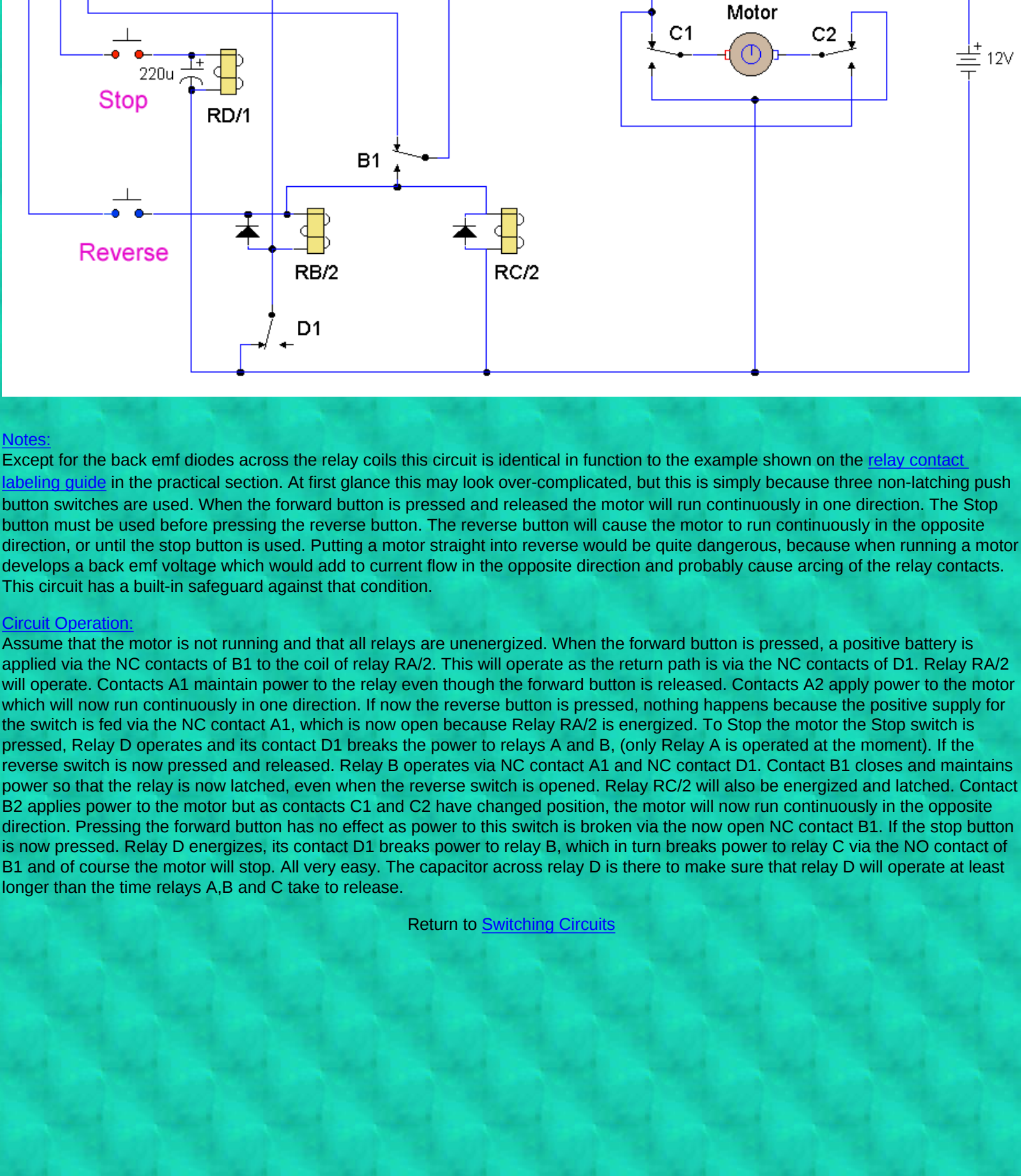
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DC Motor Reversing Circuit

Circuit: Andy Collinson
Email: anc@mitedu.freemove.co.uk

Description:
A DC motor reversing circuit using non latching push button switches. Relays control forward, stop and reverse action, and the motor cannot be switched from forward to reverse unless the stop switch is pressed first.



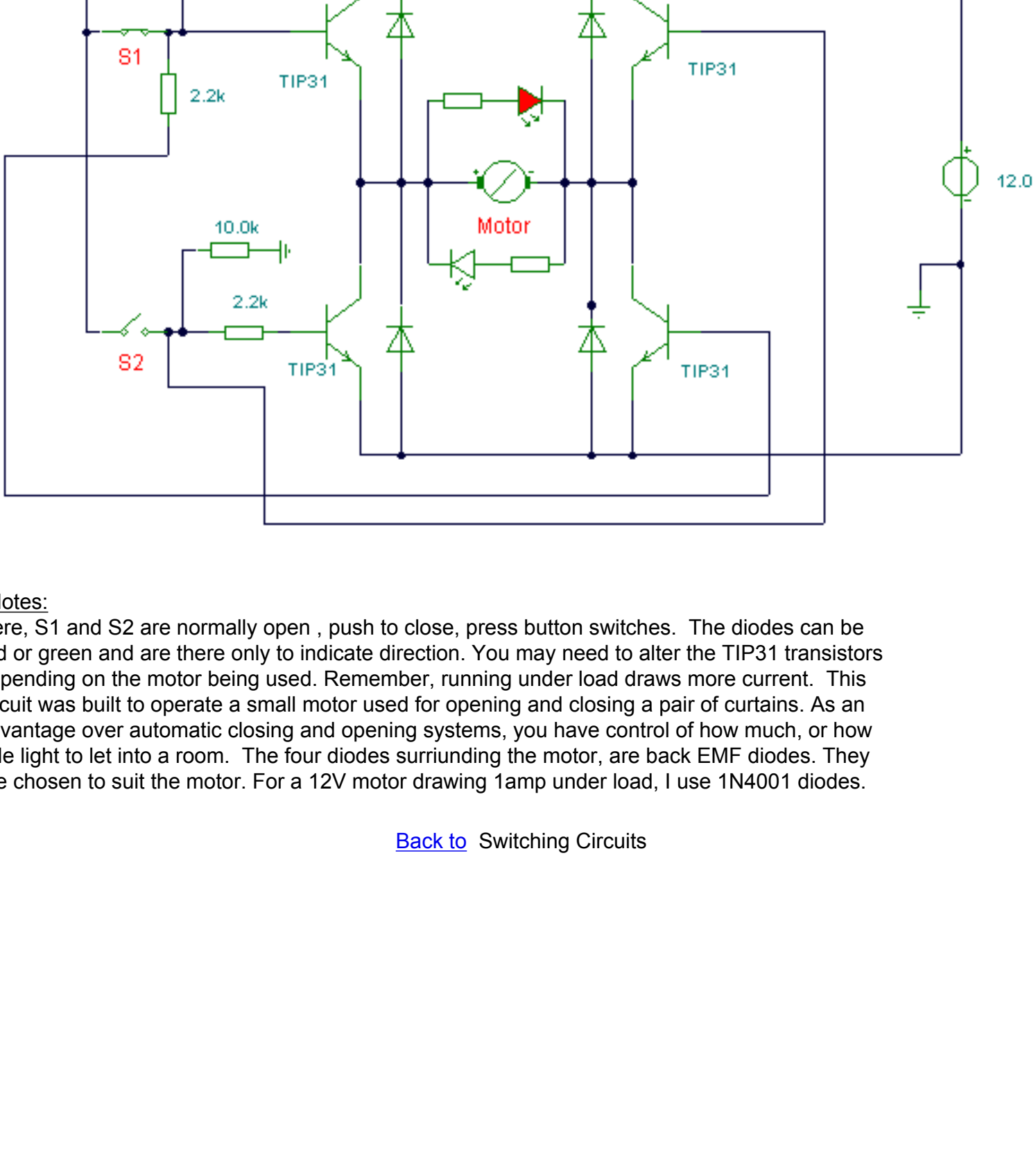
Notes:
Except for the back emf diodes across the relay coils this circuit is identical in function to the example shown on the [relay contact labelling guide](#) in the practical section. At first glance this may look over-complicated, but this is simply because three non-latching push button switches are used. When the forward button is pressed and released the motor will run continuously in one direction. The Stop button must be used before pressing the reverse button. The reverse button will cause the motor to run continuously in the opposite direction, or until the stop button is used. Putting a motor straight into reverse would be quite dangerous, because when running a motor develops a back emf voltage which would add to current flow in the opposite direction and probably cause arcing of the relay contacts. This circuit has a built-in safeguard against that condition.

Circuit Operation:
Assume that the motor is not running and that all relays are unenergized. When the forward button is pressed, a positive battery is applied via the NC contacts of B1 to the coil of relay RA/2. This will operate as the return path is via the NC contacts of D1. Relay RA/2 will operate. Contacts A1 maintain power to the relay even though the forward button is released. Contacts A2 apply power to the motor which will now run continuously in one direction. If now the reverse button is pressed, nothing happens because the positive supply for the switch is fed via the NC contact A1, which is now open because Relay RA/2 is energized. To Stop the motor the Stop button is pressed. Relay D operates and its contact D1 breaks the power to relays A and B, (only Relay A is operated at the moment). If the reverse switch is now pressed and released, Relay B operates via NC contact A1 and NC contact D1. Contact B1 closes and maintains power so that the relay is now latched, even when the reverse switch is opened. Relay RC/2 will also be energized and latched. Contact B2 applies power to the motor but as contacts C1 and C2 have changed position, the motor will now run continuously in the opposite direction. Pressing the forward button has no effect as power to this switch is broken via the now open NC contact B1. If the stop button is now pressed, Relay D energizes, its contact D1 breaks power to relay B, which in turn breaks power to relay C via the NO contact of B1 and of course the motor will stop. All very easy. The capacitor across relay D is there to make sure that relay D will operate at least longer than the time relays A,B and C take to release.

[Return to Switching Circuits](#)

DC Motor Control Circuit

Motor Control Circuit



Notes:
Here, S1 and S2 are normally open , push to close, press button switches. The diodes can be red or green and are there only to indicate direction. You may need to alter the TIP31 transistors depending on the motor being used. Remember, running under load draws more current. This circuit was built to operate a small motor used for opening and closing a pair of curtains. As an advantage over automatic closing and opening systems, you have control of how much, or how little light to let into a room. The four diodes surrounding the motor, are back EMF diodes. They are chosen to suit the motor. For a 12V motor drawing 1amp under load, I use 1N4001 diodes.

[Back to](#) Switching Circuits

Electronics Projects for R/C

by VA3AVR

[Tony's Message Forum](#) Ask your questions here. Someone may answer them.

Tutorials

- 555 Timer/Oscillator
- 741 Op-Amp
- Capacitors updated Added Fig.3b, 10-27-2004
- MosFet Test
- Piezo Education/Tutorial
- Phase Locked Loop
- Resistor Color Code
- SCR Test
- Triac Test
- UJT Test
- Coils
- Integrated Circuits
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- Relays, Relay Drivers, Solid-State

Circuits

- 555 Timer Tester - Test those 555's in your junkbox
- 555 Go-No/Go Tester - 555 tester, more advanced.
- 7.2Volt Cycler - 7.2V NiCad packs
- 7.2V Field Charger (.pdf file)
- Airtronics AM/FM - Trainer Cord
- Automatic Device Locator - Beacon
- Auto Pilot for R/C
- 9-V Nicad Charger - From the Netherlands!
- Battery Backup (1) - For Large Aircraft
- Battery Backup (2) - Small system
- Battery Cycler - For Rx/Tx NiCads
- Car NiCad Charger - Using car battery)
- Charger - Constant Current Charger
- Circuits - for the Hobbyist Page
- Crashed Plane Locator - Beacon
- Discharger - NiCad discharger
- Elevon Mixer - by Malcolm Aldred
- Flasher - 'KIT' Back and Forth Flasher
- Futaba-AM - Trainer Cord
- Futaba-FM - Trainer Cord

- Futaba to JR - Trainer Cord
- Futaba (AM) to Futaba (FM) - Trainer Cord
- FlyWire (Deans Ant.) - For Helicopter
- Glowplug Driver - Project for your Flightbox (1)
- Glowplug Panel - Project for your Flightbox (2)
- Hotchk - Brent's website
- Hot Wire Foam Cutter, 1 - by Tom Weedom New
- Hot Wire Foam Cutter, 2 - by Charles Wenzel New
- Hot Wire Foam Cutter, 3 - by Steven Mohr New
- Hot Wire Foam Cutter, 4 - by JoeBoy New
- Hot Wire Foam Cutter, 5 - by The Hermit
- MachineShop New
- Hot Wire Foam Cutter, 6 - by Al Schoepp New
- Hot Wire Foam Cutter, 7 - by Rocket Team
- Vatsaas New
- Hot Wire Foam Cutter, 8 - by Daniel Hartman New
- IRF-511 FET - TMOS FET Data Sheet
- JR-FM - JR Trainer Cord
- Lead Acid Charger, 1 - For Gel-Cell Batteries
- Lead-Acid Charger, 2 - Battery Charger
- Lead-Acid Charger, 3 - Charger with 'Float'
- Mini-Drill P.S. - Variable speed for your mini-drill
- Modifying a Servo - Modifying for indefinite

- rotation New
- Model Rocket Launcher - Time delayed
 - Model Rocket Strobe - Xenon Flash Tube
 - Model Rocket Parachute - Delayed
 - NiCad Sensor - NiCad Voltage Monitor for Rx
 - Night Blades - Helicopter night-blades
 - Noise Trap - For long servo leads Error-Fix! 5-04-2004
 - PCM/PPM Locator & Voltage Watch - by M.J.
- Pawlowsky New
- Power Panel - Combine it with the Glowplug Driver
 - R/C Switch2 - For driving accessories
 - R/C Switch3 - Similar, but with 4001
 - R/C Timer Switch - Adjustable, 20-80 seconds
 - Receiver Regulator - Rx Down-converter to 5V.
 - RX-Volt - Dot/Bar Rx Voltmeter.
 - Simple Charger - With 'Peak-Detect'
 - Simple Constant Current Source - by John Nooyen
 - Sequencial Led Flasher - 10 led's
 - Servo Tester (2) - Servo Pulse Generator
 - Servo Tester (3) - Servo Pulse Tester
 - Solar Charging - NiCad Charger
 - Two-Tone Train Horn - Dual Tone
 - Tail Nav Light - For Heli or Aircraft
 - Variable Power Supply - 1 to 30V/1.5A
 - Wingtip Nav Lights - Like the real thing
 - ZAP Adapter - Rejuvenate 'dead' NiCads.
 - Electronic Symbols Template - Windows Paint/Paint Shop Pro

  "Green" means on-line, "Red" means off-line

Bookmark this valuable page with 'Ctrl-D'.

Just in case you're gonna ask: **All drawings are created with Paint Shop Pro**

Info/Data

- Circuits Archive - Older circuits. Most are working, some are not. Could be still useful.
- My Circuits Page - More interesting circuits can be found here.
- Radio Shack Partnumbers - For the most common parts
- Resistor Value Calculator - By Danny Goodman, AE9F REMOVED
- Data Sheet - Pin-outs for a variety of other components
- TUP/TUN/DUS/DUG - Elektor/Elektuur's Substitute system
- Toroids, RF/EMI Cores - Variety of commonly used toroids, colors, etc.
- Zapping NiCads/Lithium-Ion batteries - Getting the most from your batteries REMOVED
- LM301A - High Performance OP-AMP
- LM334 - Three Terminal Adjustable Current Source
- LM3914 - Dot/Bar Display Driver Data Sheet
- MC1455 Timer IC - CMOS Timer/Oscillator (CMOS) Data Sheet
- MC14001 - Quad 2-input NOR Data Sheet
- MC14013B - Dual Type D Flip-Flop Data Sheet
- MC3456/MC3556 Timer IC - CMOS Dual Timer/Oscillator Data Sheet
- MC14093B Schmitt Trigger - Quad 2-input NAND Schmitt Trigger Data Sheet
- NE555 Timer IC - Timer/Oscillator Data Sheet
- NE555 Timer IC - Dual Timer/Oscillator Data Sheet
- PN100/200 - Data Sheets for the PN100 and PN200
- LF13741 JFet OpAmp - Monolithic JFET Input OpAmp Data Sheet
- Brent's R/C Electronic Page - Optoglow, Reverser, Go-slow, HotChek.
- Derzsi' Website in Hungary - Good homemade r/c electronics.
- John Nooyen's Site - **Site is down. Anyone has his new url?**
- Johann Aichinger R/C Electronics Page - Excellent site, damn all those bloody pop-ups.
- Model Railroad Electronics from Ruger - Flasher, crossing, etc.
- Stefan's Electric R/C Website - Miniature Speed Controllers, and more!
- Sirius Datasheets - for jumpering the charging diode in transmitters

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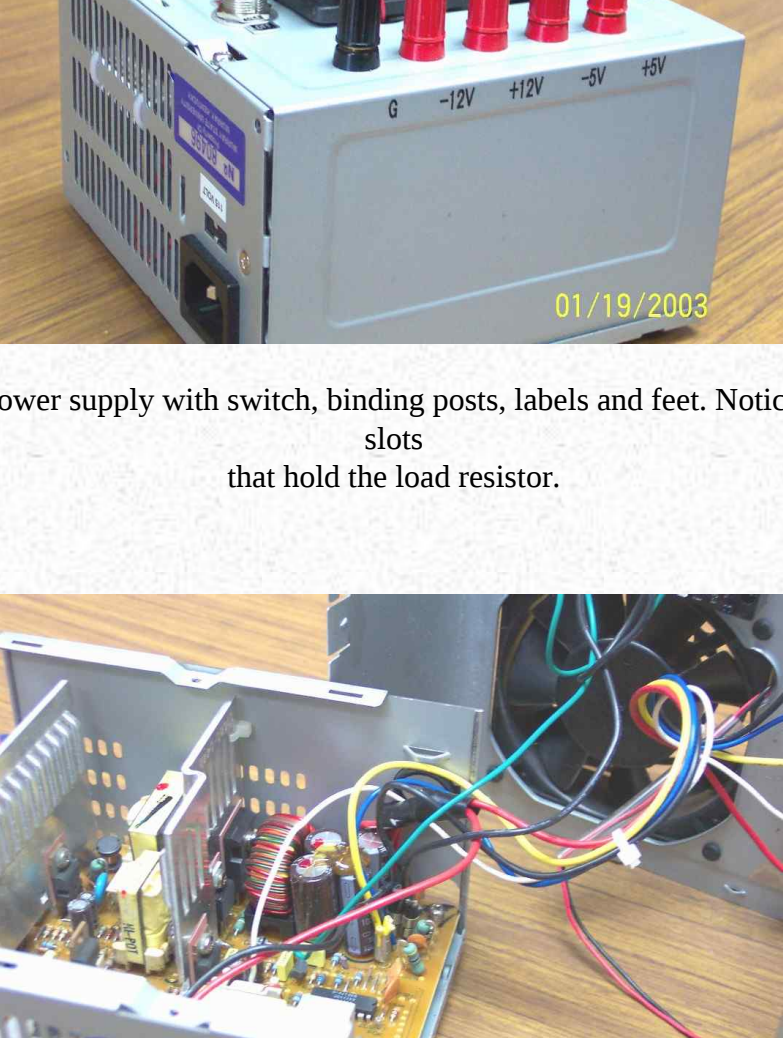


DISCLAIMER: Although tested with my own JR gear, I take no responsibility whatsoever for the use and/or implementation thereof, or the misuse leading to damage of your R/C equipment by using any of the above circuits.

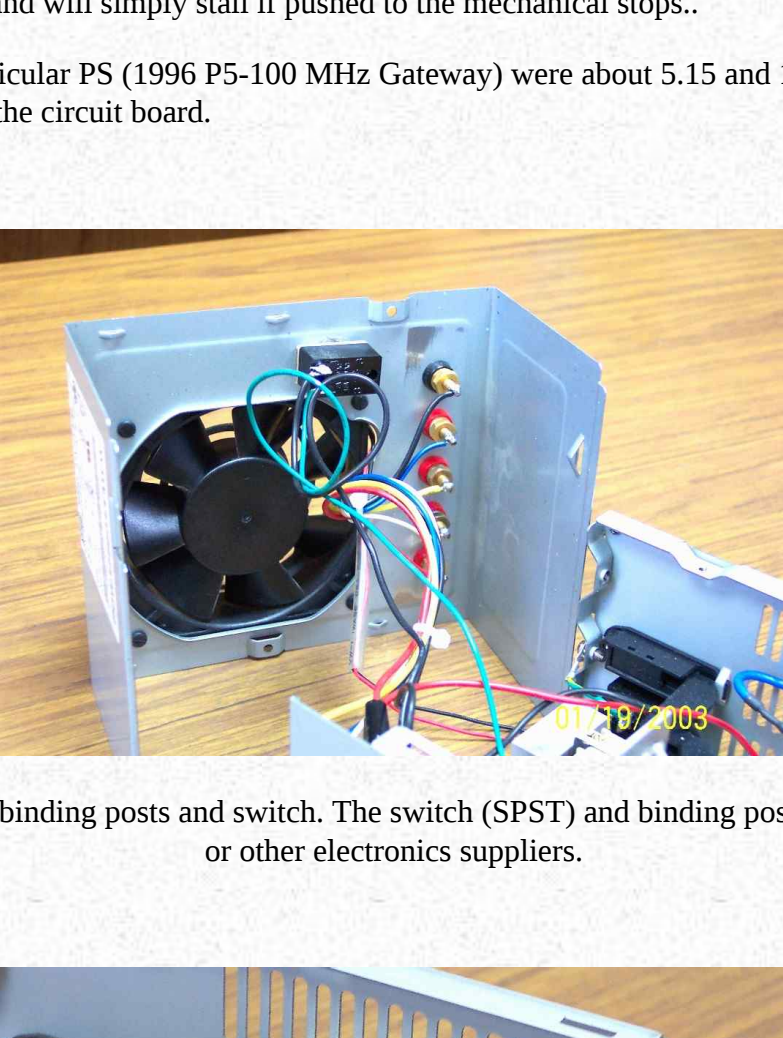
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Desktop Power Supply from a PC

(See the narrative and disclaimer at the bottom of the page)

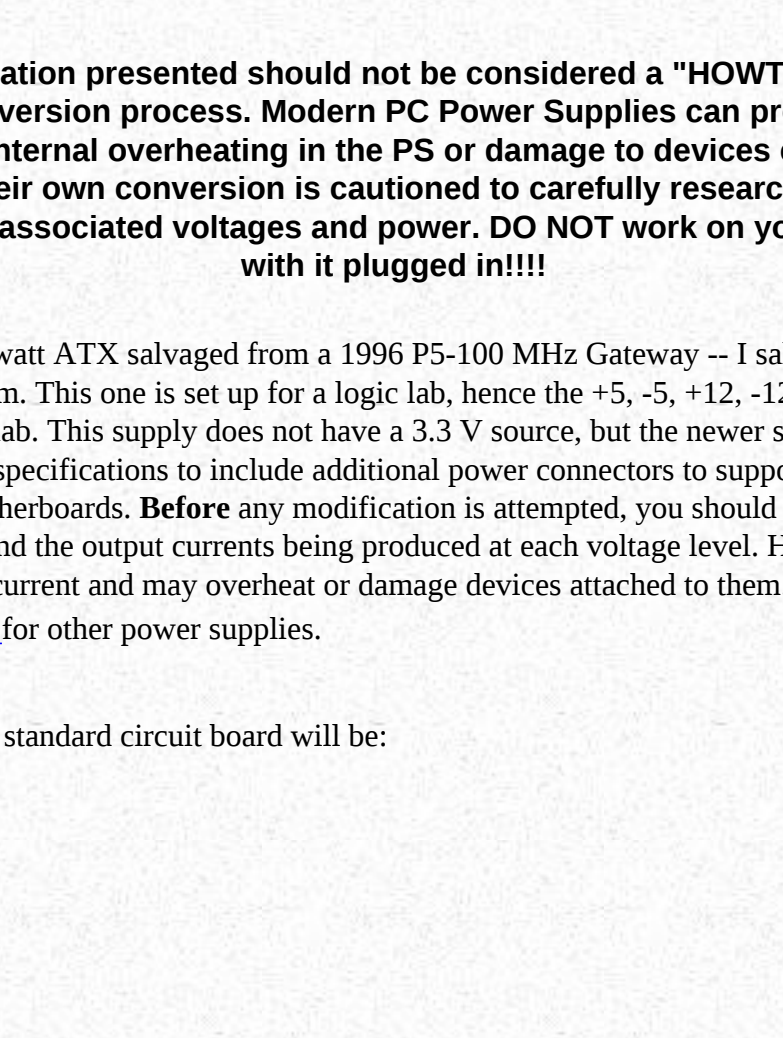


A completed 145 watt ATX power supply with switch, binding posts, labels and feet. Notice the zip ties in the ventilation slots that hold the load resistor.

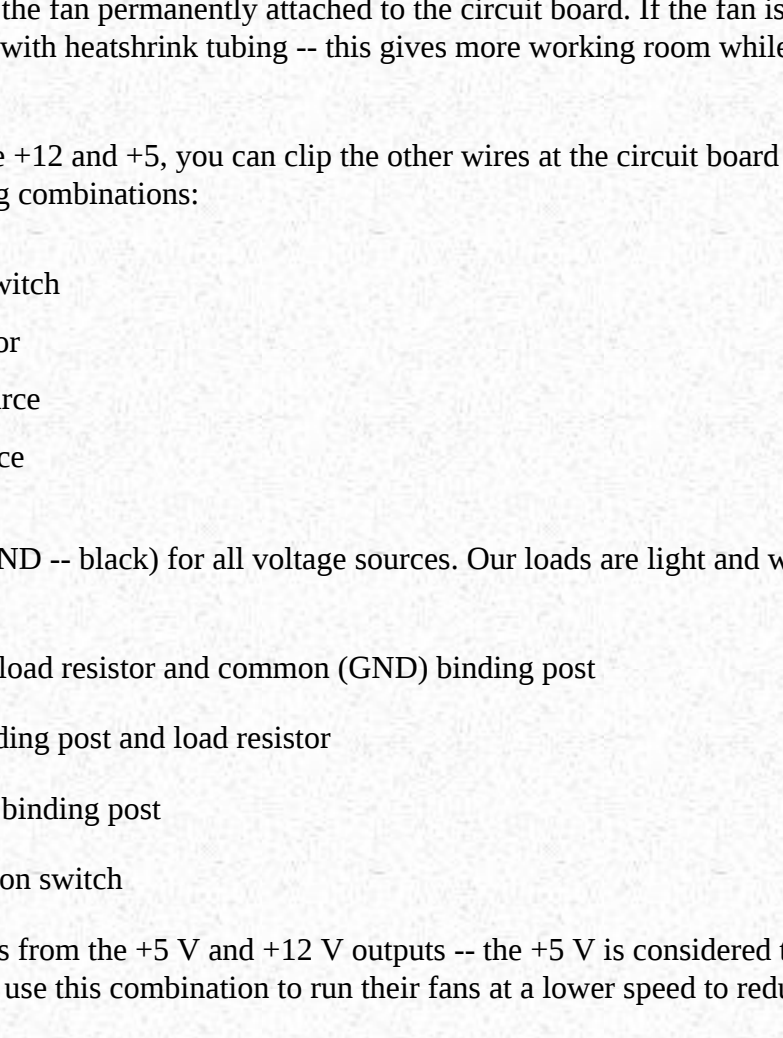


This ATX PS board has leads for +5 (RED), -5 (WHITE), +12 (YELLOW), -12 (BLUE) volts, Ground (BLACK) and switch (GREEN). Dell power supplies manufactured between 1996 and 2000 do not follow the industry standard pinout and color codes. The fan has also been unplugged for better viewing. Since this PS was converted for use in the logic and robotics labs, the selected voltages were tapped. Other users may want combinations of +3.3 V (ORANGE), +5 V and/or +12 V if they are converting one of the newer supplies. For R/C applications, the 5 volt output can also serve as a desktop source to drive receivers and servos. If used as a power source for the micro and sub-micro servos, you must be careful not to drive the servo to either endpoint to avoid stripping the smaller gears in these units. Most standard servos have sufficiently robust gear trains and will simply stall if pushed to the mechanical stops..

Measured voltages on this particular PS (1996 P5-100 MHz Gateway) were about 5.15 and 11.75 volts. The remaining leads have been clipped off at the circuit board.



View of the case top with fan, binding posts and switch. The switch (SPST) and binding posts are available at Radio Shack or other electronics suppliers.



Power supplies in today's computers are known as SWITCHMODE or Switching Mode power supplies and require a load to continue to operate after being switched on (the term switching mode actually applies to the technique of A/C to D/C conversion and not to the power up action). This load is provided by a 10 watt, 10 ohm wire wound load resistor (sandbar - about \$0.80 at Radio Shack) across the +5 volt supply. Some inexpensive power supplies may fail if forced on without a load. The sandbar has been zip tied to the case with a small amount of heat sink compound applied. Without cooling, the resistor will get very hot and may fail prematurely. With this arrangement, the resistor will remain barely warm to the touch. If you are using a high wattage supply, it may be necessary to double up on your load resistors to avoid overheating.

Additional comments

Disclaimer: The information presented should not be considered a "HOWTO" article, but merely a documentation of my conversion process. Modern PC Power Supplies can produce high output current levels that may cause internal overheating in the PS or damage to devices connected to them. Any individual attempting their own conversion is cautioned to carefully research their PS specifications and to be mindful of the associated voltages and power. DO NOT work on your opened power supply with it plugged in!!!!

The PS in the picture is a 145 watt ATX salvaged from a 1996 P5-100 MHz Gateway -- I salvage all usable parts from the older PC's before dumping them. This one is set up for a logic lab, hence the +5, -5, +12, -12 volt taps. We also use the +5 to drive servos in the robotics lab. This supply does not have a 3.3 V source, but the newer supplies do. INTEL has continued to modify the ATX specifications to include additional power connectors to support the increased power requirements of the newer motherboards. **Before** any modification is attempted, you should be sure of the type of power supply you are working with and the output currents being produced at each voltage level. Higher wattage supplies can generate fairly hefty levels of current and may overheat or damage devices attached to them. See the [Table of Representative Current Levels](#) for other power supplies.

Wiring coming off an industry standard circuit board will be:

ORANGE	+3.3 V
YELLOW	+12 V
BLUE	-12 V
RED	+5 V
WHITE	-5 V
BLACK	GND
GREEN	POWER-ON
GRAY	POWER-OK What is this??
PURPLE	+5 V STANDBY



*** Note that the 1996-2000 Dell's did not completely follow this color coding -- check your voltage levels with a meter before wiring ***

The yellow, red and black wires will likely be grouped together with a clip. Some of the PS's will have a detachable plug for the fan and some will have the fan permanently attached to the circuit board. If the fan is attached, I usually clip the wires then re-solder and cover with heatshrink tubing -- this gives more working room while modifying the PS and allows me to lube the fan.

If you are going to use only the +12 and +5, you can clip the other wires at the circuit board level. For the +5 / +12 volt PS, you will need the following combinations:

GREEN /	Power on Switch
BLACK	
RED / BLACK	Load Resistor
YELLOW /	+12 volt source
BLACK	
RED / BLACK	+5 volt source

I use a single common post (GND -- black) for all voltage sources. Our loads are light and we don't require separate grounds for each.

Leave 3 black wires -- switch, load resistor and common (GND) binding post

Leave 2 red wires -- 5 volt binding post and load resistor

Leave 1 yellow wire -- 12 volt binding post

Leave the green wire -- power on switch

As an aside, you can get 7 volts from the +5 V and +12 V outputs -- the +5 V is considered the negative (GND) and +12 the positive -- some geeks will use this combination to run their fans at a lower speed to reduce noise.



I've followed all the instructions, but the output voltage on the +12 V side is still low -- what can I do?? Many of the R/C folks are converting power supplies for the purpose of driving field chargers and are finding that voltage levels below 12 volts are sometimes insufficient to power their chargers. Here are some [tips](#) that may help increase this voltage level, a little theory and connector pinouts found on most PC supplies.

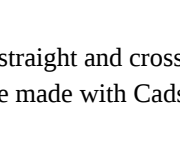
Cut everything else off even with the board. I usually cut the power harnesses so I can keep as much together as possible. The wires remaining in the power supply should be left long and cut to length as needed. If you leave them too long, they will get in the way when boxing it up, especially if the fan is internal rather than external. Be sure that they stay out of the way of the fan blades. Also be sure to reattach the fan -- some supplies will not function without the fan attached - in any event, you need the cooling. This PS in the pictures has the fan mounted on rubber shock mounts and is extremely quiet. I will also disassemble the fan and lube the bearings while I have the PS open. Since these are salvaged, the fans have been in use for some time and normally the bearings are dry -- I use a high grade sewing machine oil from SINGER. Any light oil will work, just don't use WD40 --

These power supplies are called SWITCHMODE or SWITCHING MODE power supplies and must have a load to function -- hence the 10 ohm 10 watt load resistor on the 5 volt line. These resistors are known as wire wound or sandbar resistors and can be purchased from Radio Shack for about \$0.80 each. This resistor will get hot and should have some sort of heat sink. The technique I use keeps them amazingly cool and is easy to do -- just pick the flattest side of the resistor, apply some heatsink compound and attach to the case. I will usually hit the inside of the case with a file to remove any stamping flash on the ventilation slots. The switch (single pole, single throw) and binding posts can also be found at Radio Shack or other electronics supply houses.

I usually deal with on-line suppliers such as Jameco, Digikey, Mouser, etc. because we are buying in larger quantities and Radio Shack is too expensive for large numbers of items. However, you should be able to convert your PC supply for \$5.00 or \$6.00 dollars -- less if you have a junk box of parts. I suppose you could add a LED indicator with dropping resistor to show the PS is turned on, but the fan is a pretty good hint. We have had supplies running 24/7 for months without problems -- just electricity consumption.

The PS has some fairly hefty electrolytic capacitors and can still give a bit of a shock immediately after being unplugged -- let it sit a couple of minutes before poking around inside. Obviously, you can get whacked if you are inside the case with it still plugged in -- probably won't kill you, but you WILL turn it loose (never mind how I discovered this bit of information).

If you have any questions, comments or corrections, feel free to [mail](#) me.

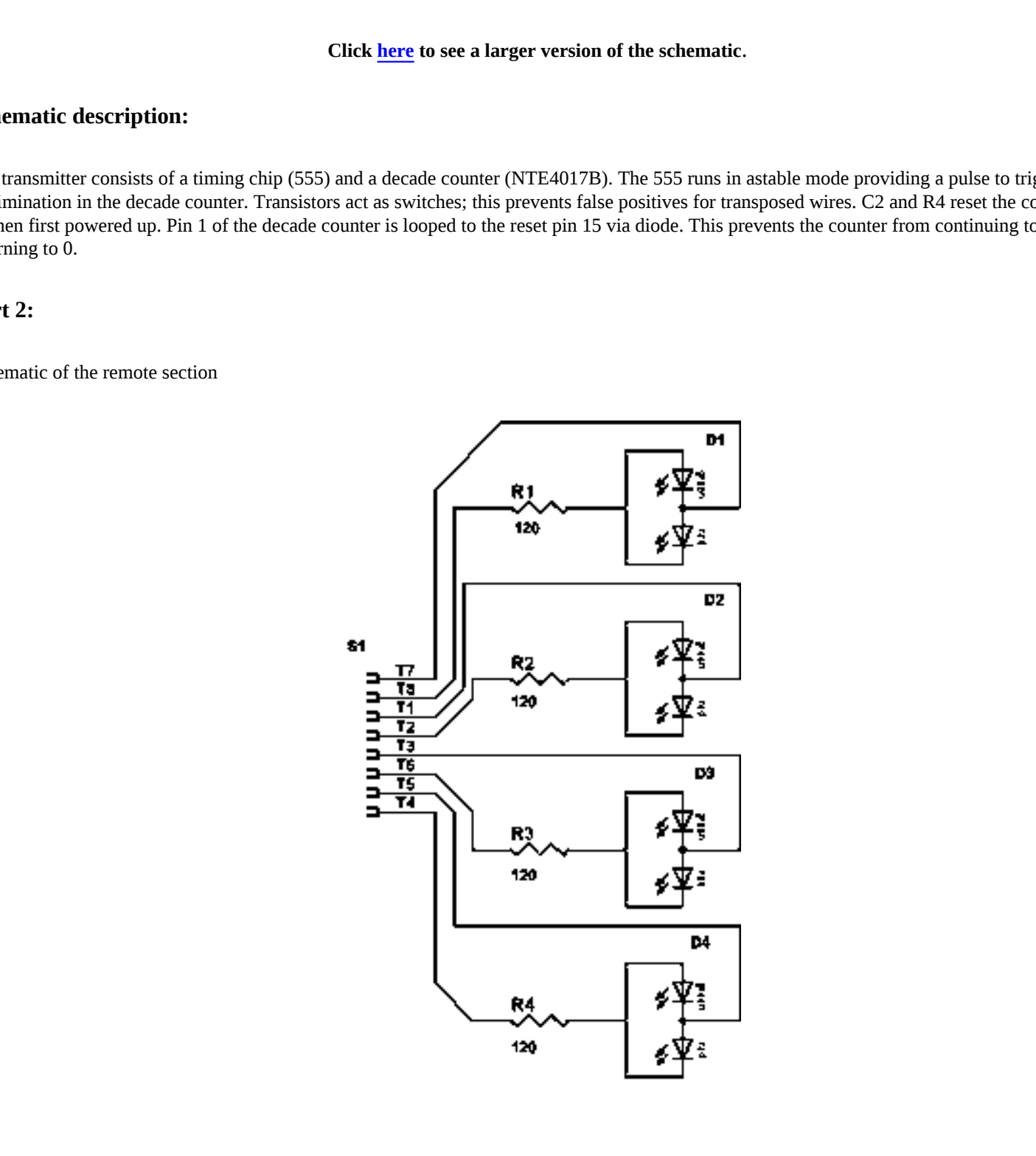


Vea en [Español](#), [Portuguese](#)

This analog tester will verify straight and crossover cables for continuity, polarity and pair sequence. It consists of a transmitter and a remote. The schematics and PCB were made with Cadsoft Eagle layout editor available at <http://www.cadsoft.de>.

Part 1:

Schematic of the transmitter.



Click [here](#) to see a larger version of the schematic.

Schematic description:

The transmitter consists of a timing chip (555) and a decade counter (NTE4017B). The 555 runs in astable mode providing a pulse to trigger incrimination in the decade counter. Transistors act as switches; this prevents false positives for transposed wires. C2 and R4 reset the counter to 0 when first powered up. Pin 1 of the decade counter is looped to the reset pin 15 via diode. This prevents the counter from continuing to 9 before returning to 0.

Part 2:

Schematic of the remote section



Click [here](#) to see a larger version of the schematic.

Schematic description:

Use 5V dual color LED's with two terminals if you use my PCB. The purpose of the dual color LED's is to test the polarity of each pair of wires in the cable under test. Single color LED's may be used but you will not be able to detect polarity errors.

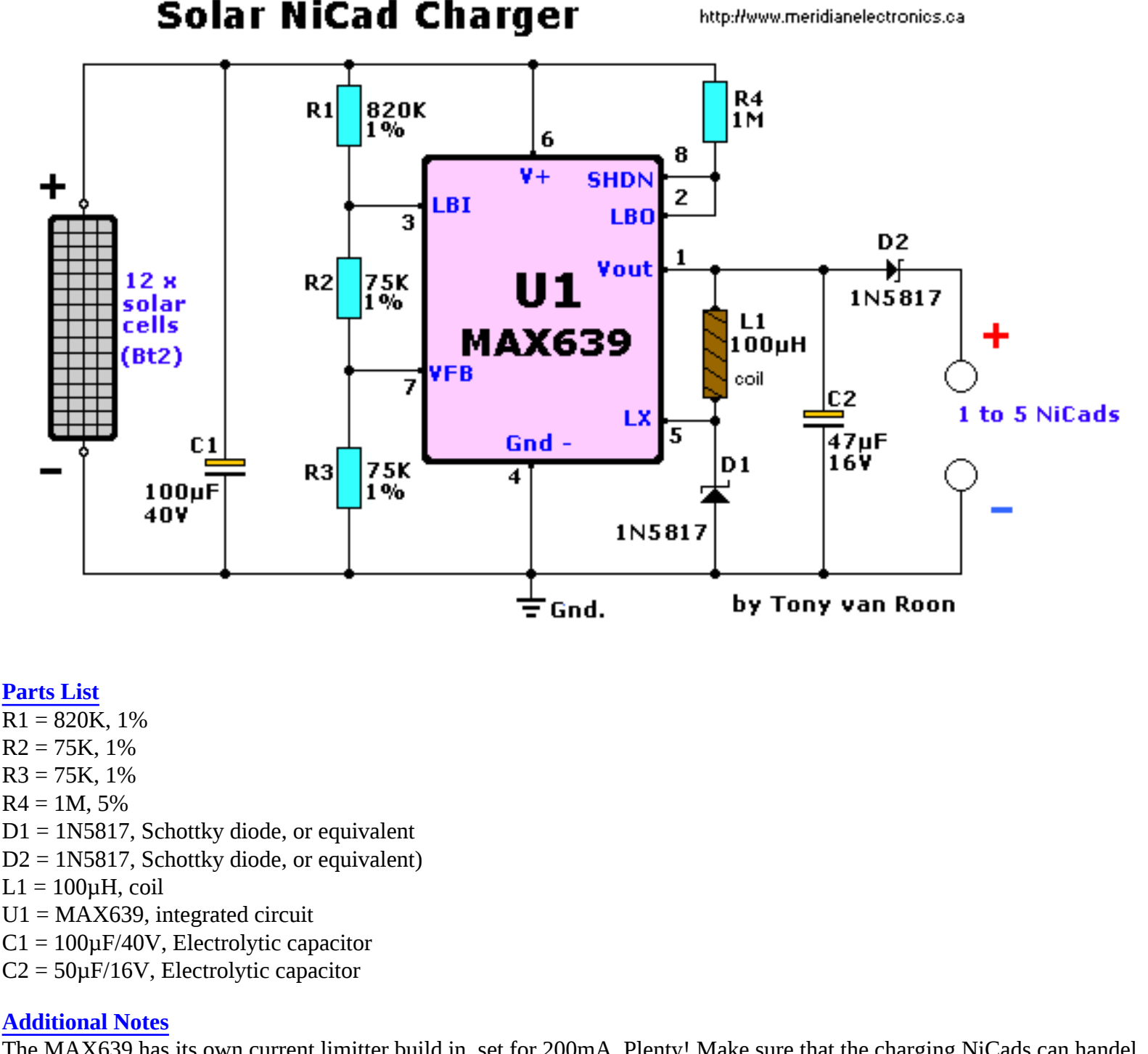
PNG's of [PCB](#) and [component](#) side of transceiver unit.

PNG's of [PCB](#) and [component](#) side of the remote unit.

[Pictures](#) of my completed tester. I've named this version "Jack" because of Sabrina, a good friend of mine. When she saw it, she asked, "Who's Jack?"

Last updated December 26, 2004

© Bruce Marcus



Parts List

- R1 = 820K, 1%
- R2 = 75K, 1%
- R3 = 75K, 1%
- R4 = 1M, 5%
- D1 = 1N5817, Schottky diode, or equivalent
- D2 = 1N5817, Schottky diode, or equivalent)
- L1 = 100µH, coil
- U1 = MAX639, integrated circuit
- C1 = 100µF/40V, Electrolytic capacitor
- C2 = 50µF/16V, Electrolytic capacitor

Additional Notes

The MAX639 has its own current limiter build in, set for 200mA. Plenty! Make sure that the charging NiCads can handle the continuous current of 200mA, for example, NiCad battery packs of 1700+ mA used for R/C (Radio Control) cars and electric aircraft.

Back to [Gadgets](#) or [Circuits](#)page.

A Basic Stun Gun Concept

Updated "Jan 9 2004"

The low powered version is probably still around 50,000 volts on a slower pulse rate. (If its Built right.)

The main power limitation to this device is T1. It is actually a minature audio transformer connected in reverse to step up the 12 volts to around 400 volts, with no load. But this is not an ideal part for this purpose as it doesn't have the ability to produce the high currents that would result in a more sustained spark on the output.

This Medium powered version has a center tapped primary with dual transistors, resulting in a more efficient circuit. For Simplicity and "Off the Shelf", this was the best I could do.

If your an adventurist, you could wind a small transformer for any of these units below. This would allow for higher efficiency and more current draw.

On the "Low Power" Stun-gun, Current draw is about 80 Ma at 9 volts.

On the "More Power" Stun-gun, Current draw is about 225 Ma at 9 volts. With dual batteries, Better yet, 6 to 8 "AA" cells

On the "Super Power" Stun-gun, Current draw is "take a guess" at 9 volts.
Should I Dare to actually post this considerably Lethal Circuit

My hope is this info is a Help to some of you who like to play.

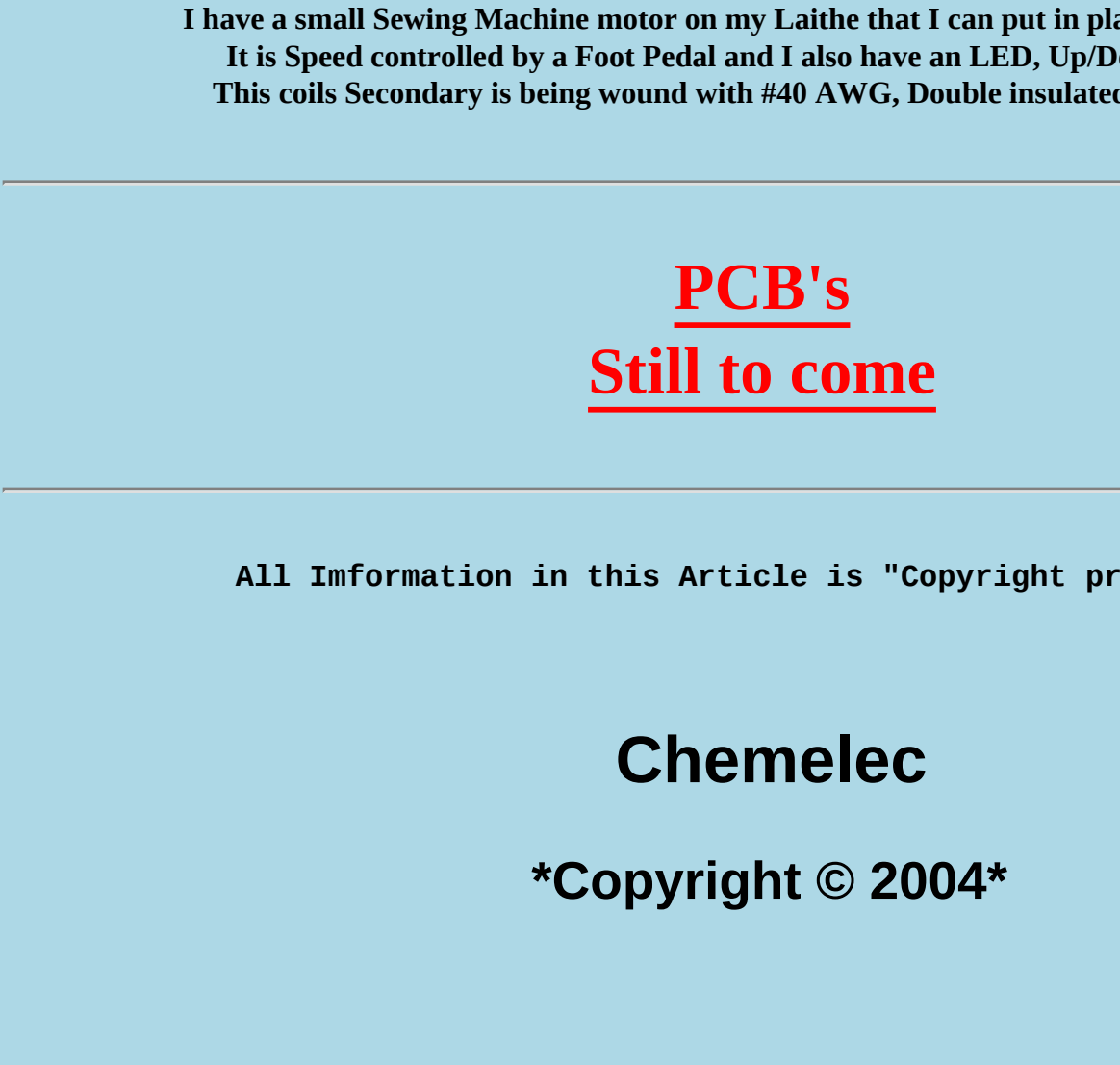
In No Way Do I Recommend Building these Stun-Guns or the actual use of them for any purpose what so-ever.

I Assume NO LIALIBTY for any resulting actions of those persons who build or use any of these devices!

A Real Misconception about Stun-Guns, Is the Voltages.
It Sound Good in the Ads, But it is Current that does the damage and any spark capable of pentrating through the clothing and skin is totally sufficant to do the job.

A blue spark looks pretty, but a yellow spark is much higher current and really dangerous.

Points to Ponder, Also Interesting, Here is a picture of a 10 inch Diameter Porcelain Insulator! This is the type used on the High Tension Power lines that run through the country side. On a 750,000 volt line, they will use about 35 of these insulators hooked together in a series string.



The "Flash-over Voltage" of this Insulator is 80,000 Volts and that is over a "surface distance" of about 11 inches.

When have you ever seen a 100 KV Stun Gun with even a 10 inch Spark Gap?
In Reality, the spark gap determines the "Actual Voltage Available at the probes".
With a spark gap of 1 to 2 inches or so, it is No-where near the 100,000 to 750,000 volts that these manufacturers make claims of.

NOTE: It is "Illegal" to "Make", and/or "Possess", and/or "Use" this device in most countries throughout the world.

SO CHECK OUT YOUR LAWS AND PLAY CAREFULLY

"Back to My HOME Page"

Simple "Low Power" Stun-gun Schematic

"More Power" Stun-gun Schematic

"Super Power" Stun-gun, Schematic Still to come, MAYBE.

"An Assortment of Coil Winding Pictures for T2".

I have a small Sewing Machine motor on my Lathe that I can put in place when needed.
It is Speed controlled by a Foot Pedal and I also have an LED, Up/Down Counter.
This coils Secondary is being wound with #40 AWG, Double insulated Magnet wire.

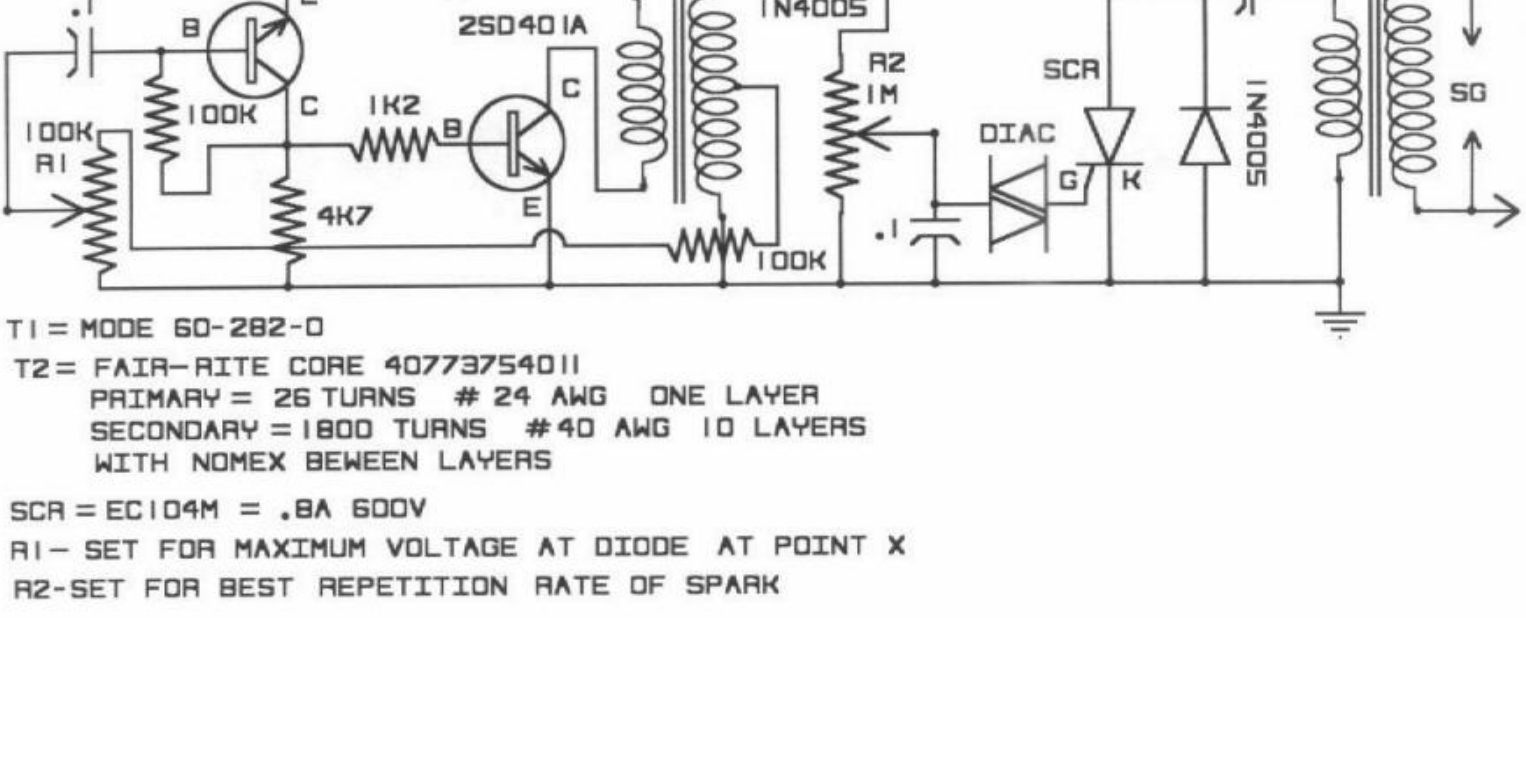
PCB's
Still to come

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Chemelec

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SIMPLE STUN GUN



T1 = MOORE 60-282-0

T2 = FAIR-RITE CORE 40773754011

PRIMARY = 26 TURNS # 24 AWG ONE LAYER

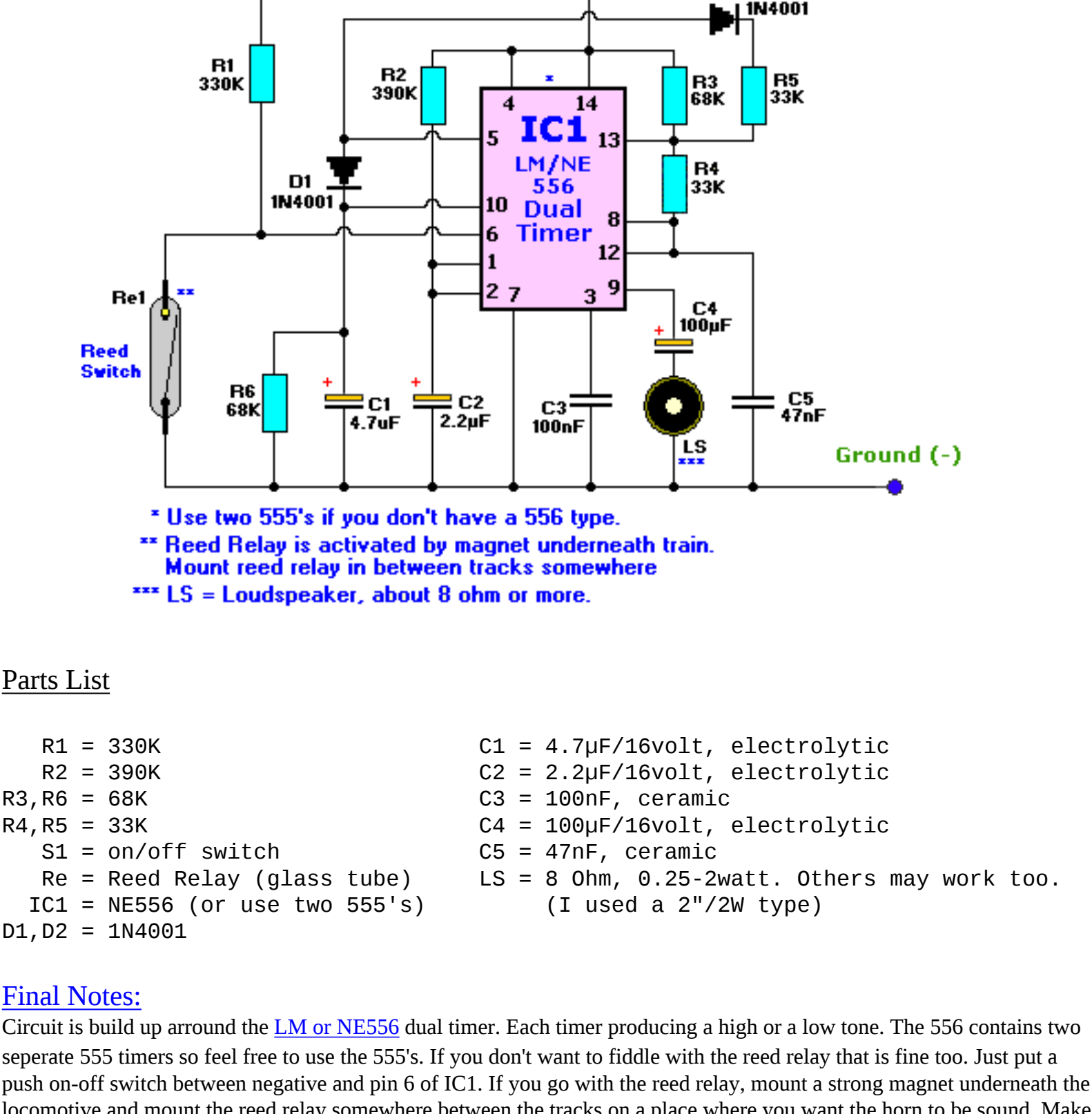
SECONDARY = 1800 TURNS # 40 AWG 10 LAYERS

WITH NOEX BETWEEN LAYERS

SCR = EC104M = .8A 600V

R1 - SET FOR MAXIMUM VOLTAGE AT DIODE AT POINT X

R2 - SET FOR BEST REPETITION RATE OF SPARK



Parts List

R1 = 330K	C1 = 4.7μF/16volt, electrolytic
R2 = 390K	C2 = 2.2μF/16volt, electrolytic
R3, R6 = 68K	C3 = 100nF, ceramic
R4, R5 = 33K	C4 = 100μF/16volt, electrolytic
S1 = on/off switch	C5 = 47nF, ceramic
Re = Reed Relay (glass tube)	LS = 8 Ohm, 0.25-2watt. Others may work too.
IC1 = NE556 (or use two 555's)	(I used a 2"/2W type)
D1, D2 = 1N4001	

Final Notes:

Circuit is build up around the [LM](#) or [NE556](#) dual timer. Each timer producing a high or a low tone. The 556 contains two seperate 555 timers so feel free to use the 555's. If you don't want to fiddle with the reed relay that is fine too. Just put a push on-off switch between negative and pin 6 of IC1. If you go with the reed relay, mount a strong magnet underneath the locomotive and mount the reed relay somewhere between the tracks on a place where you want the horn to be sound. Make sure the reed relay is positioned in such a way that the magnet is able to close the contacts. Make sure reed relay contacts are facing upwards. The sound is very realistic.

C1 & C2 determine the duration (length) of the tones, C1 & C3 determine the frequencies. My original circuit was used and modified for use with a R/C boat, I modified the caps in such a way it gave very low tones with a small 2" speaker. Have fun!

555 Timer/Oscillator Tutorial

the pulse is positive-going, both the '0' and 'pulse' led's will be on. If the pulse is negative-going, the '1' and 'pulse' led's will be on.

Error Fix: Switch position was modified. Please read document for details.

INPUTS			OUTPUTS	
Pin 4 (LOW)	Pin 6 (HIGH)	Pin 2 (LOW)	National LM555H	Signetics NE555V
	0	1	Resets 	Resets 
	1	1	0	0
	0	0		
	1	0	0	
1		1	Resets	Resets
1		0		1
0		1	0	0
0		0	0	0
1	0		sets 	sets 
1	1		0	
0	0		0	0
0	1		0	0

Pin 2 = Trigger, Pin 4 = Reset, Pin 6 = Threshold
Pin 2, 4, and 6 are 'active'

Table 2.

Check the listing in Table 2. It shows some variations in the 555 manufacturing process by two different manufacturers, National Semiconductor and Signetics Corporation. Since there are other manufacturers then these two I suggest when you build a circuit to stick with the particular 555 model they specify in the schematic.
Unless you know what you're doing of course... [grin].

The absolute maximum ratings (in free air) for NE/SA/SE types are:

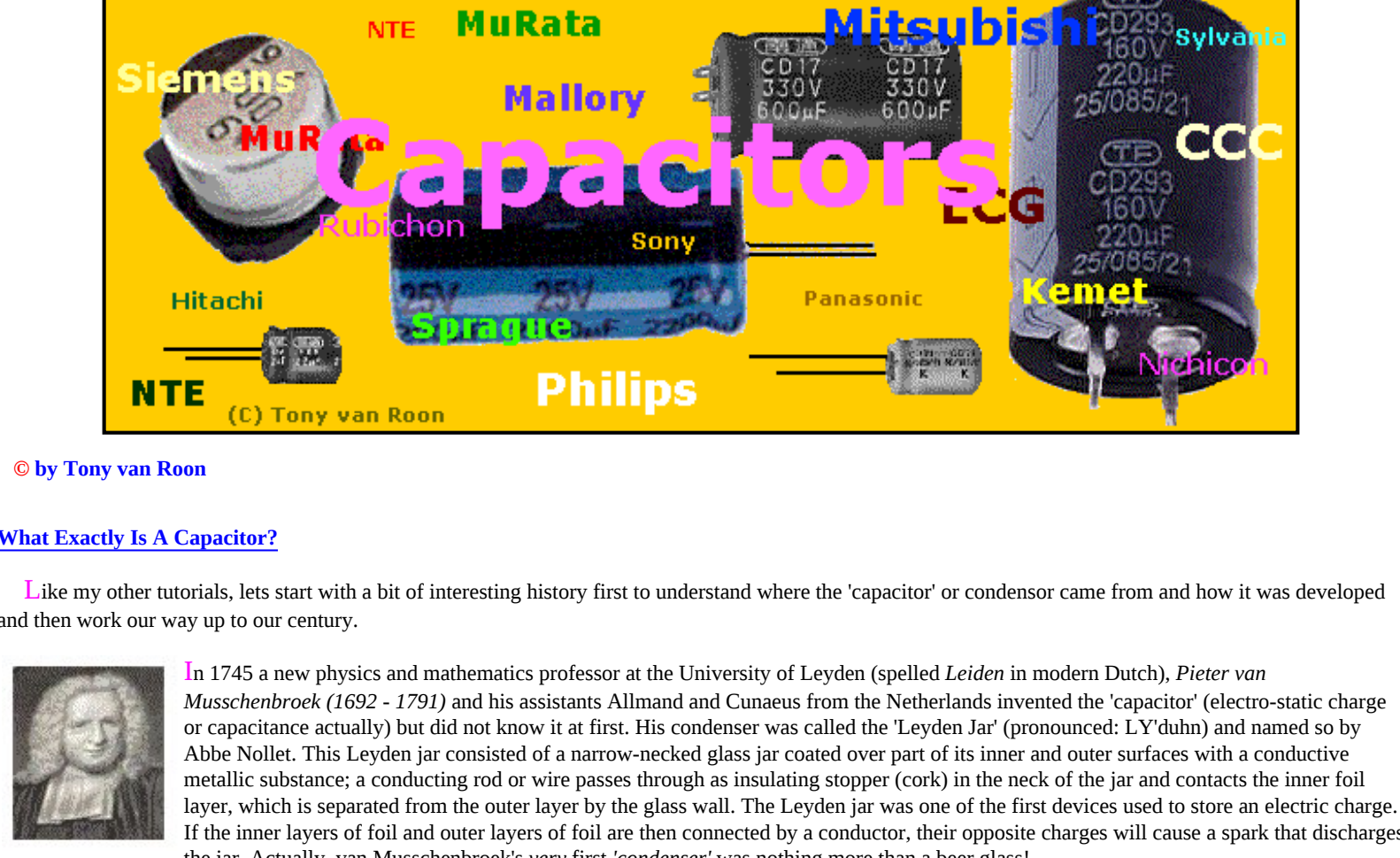
Vcc, supply voltage: 18V
Input voltage (CONT, RESET, THRES, TRIG): Vcc
Output current: 225mA
(approx)

Operating free-air temp. range:

NE555..... 0°C - 70°C
SA555..... -40°C - 85°C
SE555, SE555C... -55°C - 125°C

Storage temperature range: -65°C - 150°C
Case temperature for 68sec. (PK package): 260°C

- Suggested Reading:**
1. 555 Timer IC Circuits. Forrest M. Mims III, Engineer's Mini Notebook, Radio Shack Cat. No. 62-5010.
"Create & experiment with pulse generators, oscillators, and time delays."
 2. IC Timer Cookbook, Walter G. Jung. Published by Howard W. Sams & Co., Inc. ISBN: 0-672-21932-8.
"A reference 'must' for hobby, technicians, and engineers."
 3. The 555 Timer Applications Sourcebook, Howard M. Berlin. Published by Sams Inc. ISBN: 0-672-21538-1.
"Learn how to connect the 555, perform 17 simple experiments."
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Last updated: July 29, 2004.



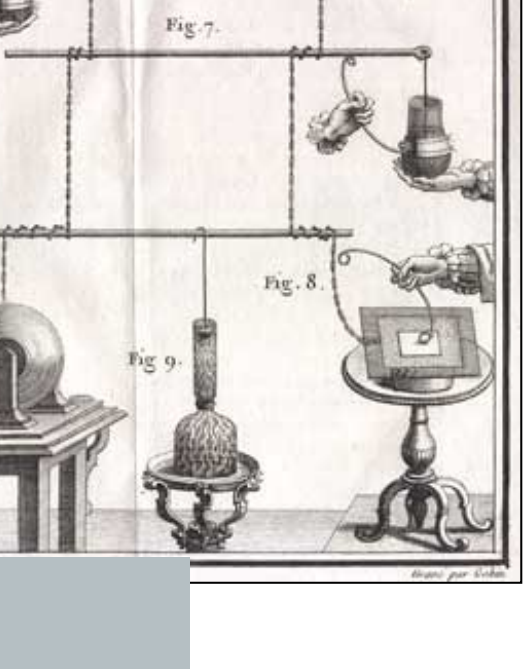
© by Tony van Roon

What Exactly Is A Capacitor?

Like my other tutorials, lets start with a bit of interesting history first to understand where the 'capacitor' or condensor came from and how it was developed and then work our way up to our century.

In 1745 a new physics and mathematics professor at the University of Leyden (spelled *Leiden* in modern Dutch), *Pieter van Musschenbroek* (1692 - 1791) and his assistants Allmand and Cuneaus from the Netherlands invented the 'capacitor' (electro-static charge or capacitance actually) but did not know it as first. His condenser was called the 'Leyden Jar' (pronounced: LY 'duhn) and named so by Abbe Nollet. This Leyden jar consisted of a narrow-necked glass jar coated over part of its inner and outer surfaces with a conductive metallic substance; a conducting rod or wire passes through insulating support (cork) in the neck of the jar and connects the inner foil layer, which is separated from the outer layer by the glass wall. The Leyden jar was one of the first devices used to store an electric charge. If the inner layers of foil and outer layers of foil are then connected by a conductor, their opposite charges will cause a spark that discharges the jar. Actually, van Musschenbroek's very first 'condenser' was nothing more than a beer glass!

By modern standards, the Leyden jar is cumbersome and inefficient. It is rarely used except in exciting laboratory demonstrations of capacitance, and exiting they are! Benjamin Franklin was acquainted with the Leyden Jar experiments also so he decided to test his ideas that 'charge' could also be caused by thunder and lightning. Franklin tested his theories, in Philadelphia in June 1752, via his now famous 'Electrical Fluid Theory' to prove that lightning was an electrical phenomenon. What he did was fly a kite which had a metal tip. The kite was tied with wet conducting thin hemp cord and at the end he attached a metal key to the cord. A non-conducting silk string was attached which he held in his hand; when he held his knuckles near the key he could draw sparks from it. Although his experiment was completed successfully and the results as he had calculated before, the next couple people after him who tried the hazardous experiment were killed by lightning strikes. I guess Franklin was extremely lucky with his hazardous experiments. I myself believe in some sort of "time-line" in which inventions are invented "too matter what".



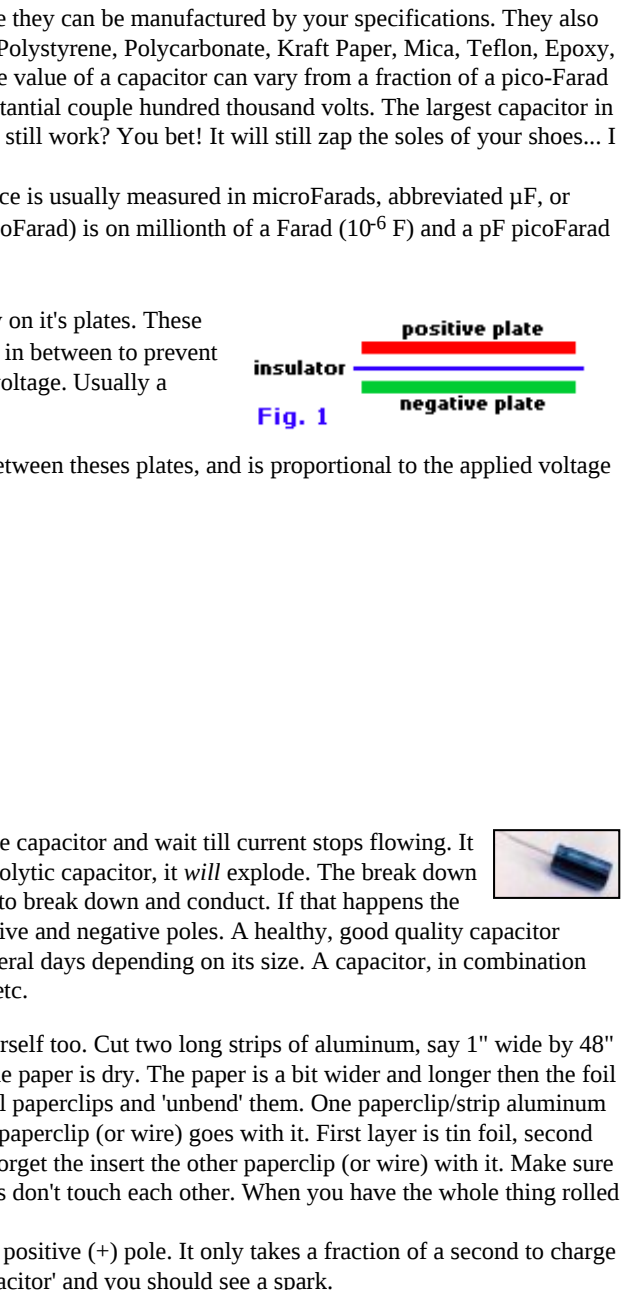
A similar device was invented independently by *Ewald Georg von Kleist*, *Dean of the Kamin Cathedral in Pomerania*, at about the same time (October 1745), but these facts were not published immediately at that particular time. As a matter of fact, van Musschenbroek announced his discovery in January, 1746. However, a letter dated February 4, 1745 appearing in *Philosophical Transactions* suggests that the jar existed in van Musschenbroek's laboratory almost a year before that date. There is still some residual controversy about this but the generally held opinion is: 'Trembley, the editor, or the composer of the letter in *PT* either misdated the letter, or failed to translate properly into the new style (NS). Until 1752 the English began their legal year on March 25 so that, roughly speaking, their dates were a year behind continental ones for the first quarter of every continental year. This makes sense because there would be no reason for van Musschenbroek and also for him to delay announcing for 11 months, the working of the potential claim to priority discovered by Von Kleist.

Look at the picture at the right; the worlds first illustration of the special of a Leyden Jar, by Abbe Jean-Antoine Nollet!

Trembley's letter is fascinating as it is one of the earliest first-hand accounts of this new discovery. He happened to be in Holland about the time of the discovery and his letter was the first word to England of the marvelous new jar.

Georg von Kleist tried using an electrostatic generator to place a charge on an iron nail inside a small glass bottle. Again later in 1745, a lawyer by the name of *Amreus Cuneaus* who frequently visited one the laboratories at the University of Leyden, was trying to electricity water. He used a chain hanging into a flask of water, and brought the end of the chain into contact with an electrostatic generator. In both cases, after disconnecting the generator, the experimenter touched the metal nail or chain inside the flask with one hand while the other hand still surrounded the outside of the container, and got zapped with an electric shock as a result.

But van Musschenbroek and von Kleist were certainly not the only ones playing with static discharge or electromagnetism. The Greeks, by means of Greek philosopher Thales of Miletus, had already determined that friction made a substance become electrically charged. The first scientific study of electrical and magnetic phenomena, however, did not appear until AD 1600, when the researches of the English physician William Gilbert were published. Gilbert was the first to apply the term electric (Greek *elektron*, 'amber') to the force that such substances exert after rubbing. He also distinguished between magnetic and electric action.



Leyden Jars

Capacitors (also called condensers) are funny things, creating enormous problems when troubleshooting for a fault and yet are absolutely necessary for almost every electronic circuit. They come in a variety of sizes, shapes, models, or if you so desire they can be manufactured by your specifications. They also come in a variety of materials, to name a few: Aluminum foil, Polypropylene, Polyester (Mylar), Polystyrene, Polycarbonate, Kraft Paper, Mica, Teflon, Epoxy, Oil-filled, Electrolytic, Tantalum, and the list goes on. Latest product (in research) is Niobium. The value of a capacitor can vary from a fraction of a pico-Farad to more than a million µF and (10¹² F).

The basic unit of capacitance is the Farad. Clumsy and not very practical to work with, capacitance is usually measured in microFarads, abbreviated µF, or picoFarads (pF). The unit Farad is used in converting formulas and other calculations. A µF (microFarad) is on millionth of a Farad (10⁻⁶ F) and a pF/picoFarad is one-millionth of a microFarad (10⁻¹² F).

What exactly is a 'Capacitor'? A capacitor is a device that stores an electrical charge or energy on it's plates. These plates (see Fig. 1), a positive and a negative plate, are placed very close together with an insulator in between to prevent the plates from touching each other. A capacitor can carry a voltage equal to the battery or input voltage. Usually a capacitor has more than two plates depending on the capacitance or dielectric type.

The 'Charge' is called the amount of stored electricity on the plates, or actually the electric field between these plates, and is proportional to the applied voltage and capacitor's 'capacitance'. The formula to calculate the amount of capacitance is **Q = C * V** where:

- Q = Charge in Coulombs
- C = Capacitance in Farads
- V = Voltage in Volts

There is also something else involved when there is 'charge', something stored called 'Energy'. The formula to calculate the amount of energy is: **W = V * Q / 2** where:

- W = Energy in Joules
- V = Voltage in Volts
- C = Capacitance in Farads

Is it difficult or complicated to 'charge' a capacitor? Not at all. Put proper voltage on the legs of the capacitor and wait till current stops flowing. It goes very fast. Do NOT exceed the capacitor's working breakdown voltage or, in case of an electrolytic capacitor, it will explode. The break down voltage is the voltage that when exceeded will cause the dielectric (insulator) inside the capacitor to break down and conduct. If that happens the results can be catastrophic. And in case of a polarized capacitor, watch the orientation of the positive and negative poles. A healthy, good quality capacitor (disconnected) can hold a charge for a long time. From seconds to several hours and some for several days depending on its size. A capacitor, in combination with other components, can be used as a filter that blocks DC or AC, being it current, frequency, or more.

An interesting experiment for a classroom. Try to build another capacitor than the Leyden Jar yourself too. Cut two long strips of aluminum, say 1" wide by 48 inch (25mm x 120mm). Cut a strip of paper which is 1.5" by 50" (38mm x 125mm). Make sure the paper is dry. The paper is a bit wider and longer than the foil to prevent the strips of foil from touching each other when you roll them up. Take two small metal paperclips and 'unbend' them. The paperclip (or wire) goes with it. First layer is tin foil, second one is paper (the insulator), and third layer is tin foil again. When you're almost at the end, don't forget the insert the other paperclip (or wire) with it. Make sure the paper is dry or it won't work. Don't forget the paperclips (or wire) and make sure the two strips don't touch each other. When you have the whole thing rolled up *lightly* as possible secure it with tape or an elastic band or whatever. Take a 9-volt battery and connect the negative (-) to one pole of the capacitor, and the other to your positive (+) pole. It only takes a fraction of a second to charge it up. You can check the charge by hooking up a voltmeter or if that is not available shoot the 'capacitor' and you should see a spark.

Capacitor Codes

I guess you really like to know how to read all those different codes. Not to worry, it is not as difficult as it appears to be. Except for the electrolytic and large types of capacitors, which usually have the value printed on them like 470µF 25V or something, most of the smaller caps have two or three numbers printed on them, some with one or two letters added to that value. Check out the little table below.

3rd Digit	Multiplier	Letter	Tolerance
0	1	D	0.5 pF
1	10	F	1 %
2	100	G	2 %
3	1,000	H	3 %
4	10,000	J	5 %
5	100,000	K	10 %
6	Not Used	M	20 %
7	.01	P	+100%, -0 %
8	.1	Z	+80%, -20 %

Have a look at Fig. 2 and Fig. 3. As you can see it all looks very simple. If a capacitor is marked like this 105, it just means 10+5zeros = 10 + 00000 = 1,000,000pF = 1000 nF = 1 µF. And that's exactly the way you write it too. Value is in pF (PicoFarads). The letters added to the value is the tolerance and in some cases a second letter is the temperature coefficient mostly only used in military applications, so basically industrial stuff.

So, for example, if you have a ceramic capacitor with 474J printed on it it means: 47+4zeros = 470000 = 470,000pF, J=5% tolerance. (470,000pF = 470nF = 0.47µF) Pretty simple, huh? The only major thing to get used to is to recognize if the code is µF nF, or pF.

Other capacitors may just have 0.1 or 0.01 printed on them. If so, this means a value in µF. Thus 0.1 means just 0.1 µF. If you want this value in nanoFarads just move the comma three places to the right which makes it 100nF. Easy huh?

"NPO" is standard for temperature stability and 'low-noise', it does "NOT" mean non-polarized even though you might think so because the abbreviation looks similar. Polarized ceramic capacitors do not exist. The abbreviation "NPO" stands for "Negative-Positive-Zero" (what is read as an 'O' is actually zero), and means that the negative and positive temperature coefficients of the device are zero—that is the capacitance does not vary with temperature. ONLY the black top indicates NPO qualification and the value are in the range from 1.8pF to 120pF, unless manufactured with different values for Military and/or industrial purposes on special request. The feature 2% tolerance which comes down to about 0.25pF results can be catastrophic. And in case of a polarized capacitor, watch the orientation of the positive and negative poles. A healthy, good quality capacitor (disconnected) can hold a charge for a long time. From seconds to several hours and some for several days depending on its size. A capacitor, in combination with other components, can be used as a filter that blocks DC or AC, being it current, frequency, or more.

But the average hobbyist uses only a couple types like the common electrolytic and general purpose ceramic capacitors and depending on the application, a more temperature stable type like metal-film or polypropylene.

X=value	F	10 pF	2%
NPO	H	12 pF	--
	G	15 pF	--
	S	22 pF	--
	L	27 pF	--
N750	P	47 pF	--
	Q	56 pF	--
	K	100 pF	--
	S	150 pF	--
N150	J	180 pF	--
	L	270 pF	--
	M	330 pF	--
	A	470 pF	--
N400	F	1k pF	10% (1.0nF)
	N	1N5	10% (1.5nF)

EIA CLASS II CAPACITOR CODE Fig. 3b					
Letter Symbol	Low Temp. Requirement	Number Symbol	High Temp. Requirement	Letter Symbol	Max. Capacitance Change Over Tmp. rating
Z	+10°C	2	+45°C	A	±1.0%
				B	±1.5%
		4	+65°C	C	±2.2%
				D	±3.3%
Y	-30°C	5	+85°C	E	±4.7%
				F	±7.5%
		6	+105°C	P	±10.0%
				R	±15.0%
X	-55°C	7	+125°C	S	±22.0%
				T	±22% - 33%
				U	±22% - 56%
				V	±22% - 82%

Dielectric Constant of Materials			
Air	1.00	Paper	3.00
Aluminum 196	5.70	Polyethylene	2.30
Bakelite	4.90	Polyethylene	2.80
Cellulose	3.70	Polystyrene	2.60
Fiber	2.2	Pyrex	5.7
Formica	4.75	Quartz	3.80
Glass	7.75	Steatite	5.80
Mica	5.40	Teflon	2.10
Mycalex	7.40		

The larger the plate area and the smaller the area between the plates, the larger the capacitance. Which also depends on the type of insulating material between the plates which is the smallest with air. (You see this type of capacitor sometimes in high-voltage circuits and are called 'spark-caps') Replacing the air space with an insulator will increase the capacitance many times over. The capacitance ratio using an insulator material is called *Dielectric Constant* while the insulator material itself is called just *Dielectric*. Using the table in Fig. 4, if a Polystyrene dielectric is used instead of air, the capacitance will be increased 2.60 times.

Look below for a more detailed explanation for the most commonly used caps.

Electrolytic - Made of electrolyte, basically conductive salt in solvent. Aluminum electrolytes are used by using a thin oxidation membrane. Most common type, polarized capacitor. Applications: Ripple filters, timing circuits. Cheap, readily available, good for storage of charge (energy). Not very accurate, marginal electrical properties, leakage, drifting, not suitable for use in hf circuits, available in very small or very large values in µF.

They WILL explode if the rated working voltage is exceeded or polarity is reversed, so be careful. When you use this type capacitor in one of your projects, the rule-of-thumb is to choose the supply voltage. Example, if your supply power is 12 volt you would choose a 24volt (25V) type. This type has come a long way and characteristics have constantly improved over the years. It is and always will be an all-time favorite; unless something better comes along to replace it. But I don't think so for this decade; polarized capacitors are heavily used in almost every kind of equipment and consumer electronics.

Tantalum - Made of Tantalum Pentoxide. They are electrolytic capacitors but used with a material called tantalum for the electrodes. Superior to electrolytic capacitors, excellent temperature and frequency characteristics. When tantalum powder is baked in order to solidify it, a crack forms inside. An electric charge can be stored on this crack. Like electrolytics, tantalums are polarized so watch the '+' and '-' indicators. Mostly used in analog signal systems because of the lack of current-spike-noise. Small size fits anywhere, reliable, most common values readily available. Expensive, easily damaged by spikes, large values exists but may be hard to obtain. Largest in my own collection is 220µF/35V beige color.

Super Capacitors - The Electric Double Layer capacitor is a real miracle piece of work. Capacitance is 0.47 Farad (470,000 µF). Despite the large capacitance value, its physical dimensions are relatively small. It has a diameter of 21 mm (almost an inch) and a height of 11 mm (1/2 inch). Like other electrolytics the super capacitor is also polarized so exercise caution in regards to the break-down voltage. Care must be taken when using this capacitor. It has a large capacitance value, but it is not suitable for high frequency applications, without precautions, it would destroy part of a powersupply such as the bridge rectifier, volt regulator, or whatever because of the huge inrush current at charge. For a brief moment, this capacitor acts like a short circuit when the capacitor is charged. Protection circuitry is a must for this type.

Polyester Film - This capacitor uses a thin polyester film as a dielectric. Not as high a tolerance as polypropylene, but cheap, temperature stable, readily available, widely used. Tolerance is approx 5% to 10%. Can be quite large depending on capacity or rated voltage and so may not be suitable for all applications.

Polypropylene - Mainly used when a higher tolerance is needed then polyester caps can offer. This polypropylene film is the dielectric. Very little change in capacitance when these capacitors are used in applications within frequency range 100KHz. Tolerance is about 1%. Very small values are available.

Polystyrene - Is used as a dielectric. Constructed like a coil inside is not suitable for high frequency applications. Well used in filter circuits or timing applications using a couple hundred KHz or less. Electrodes may be reddish of color because of copper leaf used or silver when aluminum foil is used for electrodes.

Metalized Polyester Film - Dielectric made of Polyester or DuPont trade name "Mylar". Good quality, low drift, temperature stable. Because the electrodes are thin they can be made very true name. Good all-round capacitor.

Epoxy - Manufactured using an epoxy dipped polymers as a protective coating. Widely available, stable, cheap. Can be quite large depending on capacity or rated voltage and so may not be suitable for all applications.

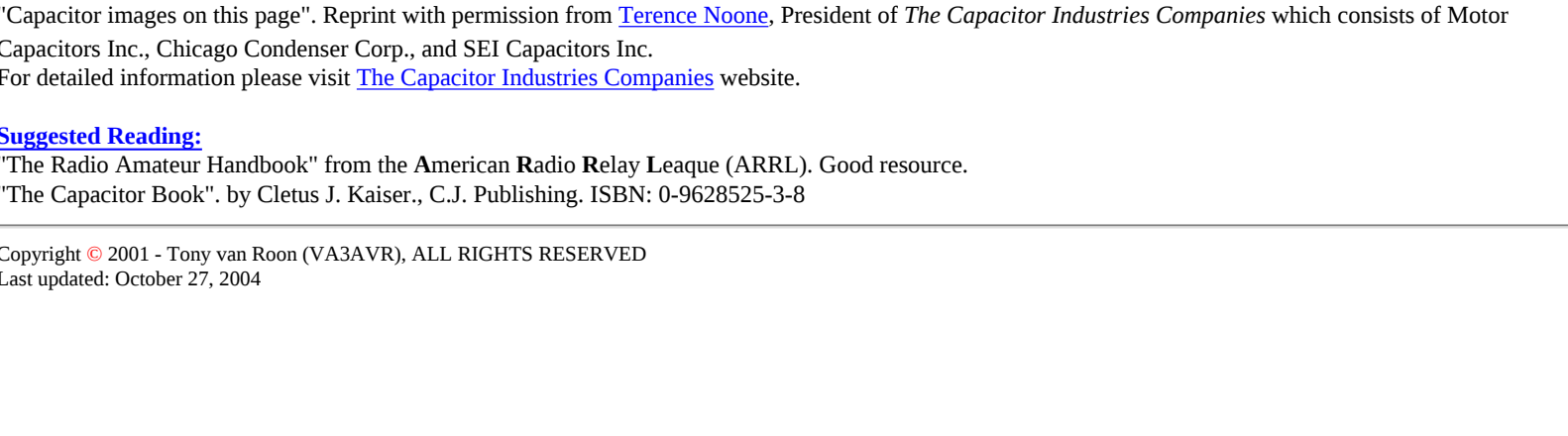
Ceramic - Constructed with materials such as titanium acid barium for dielectric. Internally these capacitors are not constructed as a coil, so they are well suited for use in high frequency applications. They are used to by-pass high frequency signals to ground. They don't have a disk, available in very small capacitance values and very small sizes. Together with the electrolytics the most widely available and most variation, and all are '100V' types. You may sometimes find NPO-type caps marked with the EIA (Electronic Industrial Association) code "C0G". The EIA has the temperature stable types. They are identified by a black stripe on top.

Multilayer Ceramic - Dielectric is made up of many layers. Small in size, very good temperature stability, excellent frequency stable characteristics. Used in applications to filter or bypass the high frequency to ground. They don't have a polarity. *Multilayer caps suffer from high-Q internal (parallel) resonances - generally in the VHF range. The CK05 style 0.1µF/50V caps for example resonate around 30MHz. The effect of this resonance is effectively no apparent capacitance near the resonance frequency. As with all ceramic capacitors, be careful bending the legs or spreading them apart to close to the disc body or they may get damaged.

Silver-Mica - Mica is used as a dielectric. Used in resonance circuits, frequency filters, and military RF applications. Highly stable, good temperature coefficient, excellent for endurance because of their frequency characteristics, no large values, high voltage types available, can be expensive but worth the extra dime.

Adjustable Capacitors - Also called trimmer capacitors or variable capacitors. It uses ceramic or plastic as a dielectric. Most of them are color coded to easily recognize their tunable size. The ceramic type has the value printed on them. Colors are: yellow (5pF), blue (7pF), white (10pF), green (30pF), brown (60pF). There are a couple more colors like red, beige, and purple which are not listed here. Anyways, you get the idea...

Tuning or 'air-core' capacitors. They use the surrounding air as a dielectric. I have seen these capacitors of incredible dimensions, especially the older ones. Amazing it all worked. Mostly used in radio and radar equipment. This type usually have more (air) capacitors combined (ganged) and so when the adjustment axle is turned, the capacitance of all of them changes simultaneously. The one on the right has a polyester film as a dielectric constant and combines two independent capacitors plus included is a trimmer cap, one for each side.



(C) The Capacitor Industries Companies

Combining Capacitors & Formula's:

Is it possible to combine capacitors to get to a certain value like we do with resistors? Certainly! Check below how go about it.

Capacitors in Parallel



Capacitors connected in parallel, which is the most desirable, have their capacitance added together, which is just the opposite of parallel resistors. It is an excellent way of increasing the total storage capacity of an electric charge. **C_{total} = C₁ + C₂ + C₃**

Keep in mind that only the total capacitance changes, not the supplied voltage. Every single capacitor will see the same voltage, no matter what. Be careful not to exceed the specified voltage on the capacitors when combining them all with different voltage ratings, or they may explode. Example: say you have three capacitors with voltages of 16V, 25V, and 50V. The voltage must not exceed the lowest voltage in this case the 16V one. In a rule-of-thumb, always choose a capacitor which is twice the supplied input voltage. Example: If the input voltage is 12V you would select a 24V type (in real-life 25V).

Capacitors in Series



Again, just the opposite way of calculating resistors. Multiple capacitors connected in series with each other will have the total capacitance lower than the lowest single value capacitor in that circuit. Not the preferred method but acceptable.

For a regular two capacitor series combo use this simple formula: **C_{total} = C₁ C₂ / (C₁ + C₂)**

If you have two identical capacitors in series the formula is simplicity itself: **C_{total} = 1/2 C**

microFarads (µF)	nanoFarads (nF)	picoFarads (pF)
0.000001µF	= 0.001nF	= 1pF
0.000001µF	= 0.01nF	= 10pF
0.0001µF	= 0.1nF	= 100pF
0.001µF	= 1nF	= 1000pF
0.01µF	= 10nF	= 10,000pF
0.1µF	= 100nF	= 100,000pF
1µF	= 1,000nF	= 1,000,000pF
10µF	= 10,000nF	= 10,000,000pF
100µF	= 100,000nF	= 100,000,000pF

Table 1. Capacitance Conversion

Things Capacitors Don't Like:

Capacitors are very fickle devices. There are any number of conditions they don't like. Many type, for instance, lose a significant amount of their capacitance at high frequencies, making them unsuitable for RF applications. You also have to watch out for the inductance some may introduce in places where you don't want it. For that reason, some types of capacitors are indicated specifically as "non-inductive".

Temperature extremes are another thing to which capacitors, particularly electrolytics, are sensitive. Electrolytic capacitors, at elevated and at depressed temperatures, lose much of their capacitance. If you are going to operate electrolytics at extremes of temperature, make sure their tolerances extend to that temperature range.

Most capacitors do not care for alternating current either. It makes them overheat and—before they self-destruct—operate inefficiently. Polarized capacitors, as they already been pointed out, cannot tolerate reverse voltages. Not only does that make them heat up, it can cause them—especially tantalum types—to heat up so rapidly that a sudden and violent explosion can result (most polarized capacitors are encase in tightly sealed containers). Explosions can also result from polarized capacitors being installed "backwards" in a circuit. The cathode (negative) side of a polarized capacitor should always connect to ground.

Uncommon Capacitors:

Capacitors vary in size from microscopic to enormous. At the small end of the scale, there are the capacitors that are deposited on a substrate during the manufacture of integrated circuits. Hybrid integrated circuits such as those containing tunnel circuits may require very precise capacitor values—with tolerances that are impossible to achieve using any economically feasible straight manufacturing process.

The precise capacitances required are obtained by intentionally making the capacitors oversize, and then trimming them with a laser until the circuit of which they are apart resonates at exactly the right frequency.

At the other end of the scale, the enormous energy requirements of the acceleration dev ideas used in subatomic-particle research are also met by capacitors—lots full of them! One of the largest such devices, a particle accelerator located outside of Chicago, is said to be able to store enough energy to meet the electrical demand of the entire world! Of course, that's only for an instant during the discharge cycle, but the figure involve is still big enough to boggle the mind.

The Capacitor Future:

The future for capacitors looks good. A constant search is going on by companies like Murata, Kemet, etc. Kemet in particular is researching a new type of a dielectric substance called Niobium. Niobium Pentoxide (Nb2O5) offers a higher dielectric constant of 41 in comparison to Tantalum Pentoxide (Ta2O5) at 26. It implies that approximately 1.5 more CV (Capacitance x Voltage rating) can be obtained from the same amount of material, everything else being equal. What does this mean in plain english? Much smaller capacitors with larger capacity, especially important in surface mount technology. Recently, a new type capacitor with very high capacitance has been developed with capacitance designed in Farads! Yes, you read it well, Farads. This type of Electric Double Layer capacitor is known as a "Super Capacitor". I am sure we haven't heard the last of it about this type.



Copyright & Portrait:

"Leyden jars" and portrait of "van Musschenbroek". Reprint with permission from John D. Jenkins. More antique equipment and apparatus can be viewed at John's website called *The Spark Museum*. This website contains a treasure of information and pictures, from vacuum tubes to radio transmitters. If it is antique, John probably has it. I spend literally several weeks browsing and reading through his website. Amazing piece of work!

"Capacitor images on this page". Reprint with permission from Terence Noone, President of *The Capacitor Industries Companies* which consists of Motor Capacitors Inc., Chicago Condenser Corp., and SEI Capacitors Inc. For detailed information please visit *The Capacitor Industries Companies* website.

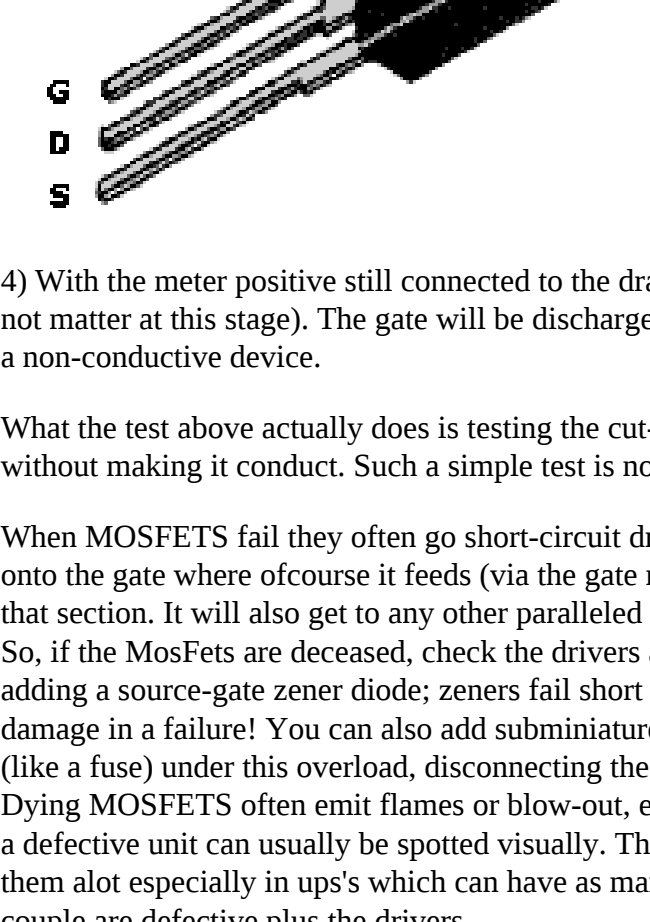
Suggested Reading:

"The Radio Amateur Handbook" from the American Radio Relay League (ARRL). Good resource.
"The Capacitor Book" by Cletus J. Kaiser, C.J. Publishing. ISBN: 0-9628523-3-8

Testing a MOSFET

Metal Oxide Semiconductor Field Effect Transistor

This testing procedure is for use with a digital multimeter in the diode test-range with a minimum of 3.3 volt over d.u.t. (diode-under-test). If your multi-meter is less than that it will not do the test. Check your meter manual for the specs.



Connect the 'Source' of the MosFet to the meter's negative (-) lead.

- 1) Hold the MosFet by the case or the tab but don't touch the metal parts of the test probes with any of the other MosFet's terminals until needed. Do NOT allow a MOSFET to come in contact with your clothes, plastic or plastic products, etc. because of the high static voltages it can generate.
- 2) First, touch the meter positive lead onto the MosFet's 'Gate'.
- 3) Now move the positive probe to the 'Drain'. You should get a 'low' reading. The MosFet's internal capacitance on the gate has now been charged up by the meter and the device is 'turned-on'.

4) With the meter positive still connected to the drain, touch a finger between source and gate (and drain if you like, it does not matter at this stage). The gate will be discharged through your finger and the meter reading should go high, indicating a non-conductive device.

What the test above actually does is testing the cut-off voltage, which is basically the highest voltage put on the gate without making it conduct. Such a simple test is not 100% -- but is useful and usually adequate.

When MOSFETS fail they often go short-circuit drain-to-gate. This can put the drain voltage back onto the gate where ofcourse it feeds (via the gate resistors) into the drive circuitry, possibly blowing that section. It will also get to any other paralleled MosFet gates, blowing them also. So, if the MosFets are deceased, check the drivers as well! This fact is probably the best reason for adding a source-gate zener diode; zeners fail short circuit and a properly connected zener can limit the damage in a failure! You can also add subminiature gate resistors -- which tend to fail open-circuit (like a fuse) under this overload, disconnecting the dud MosFet's gate. Dying MOSFETS often emit flames or blow-out, even more so in hobby built electronics projects. What that means is that a defective unit can usually be spotted visually. They show a burned hole or 'something black' somewhere. I have seen them alot especially in ups's which can have as many as 8 or more mosfets in parallel. I always replace all of them if a couple are defective plus the drivers.

NEVER use one of those hand held solder-suckers (you know, the ones with a plunger) to desolder a HEX MOSFET. They create enough Electro Static Discharge to destroy a mosfet. Best method is using solder-wick or a professional 'ESD' safe desoldering station.

Below are a couple HexFET applications using an IRF511.

Fig. 1 is configured as a simple **Class-A Audio Amplifier**. With zero gate bias applied, Q1 is like switch in the off state, so no current flows through the load resistor R2. Ideally speaking, the voltage across Q1 and the load resistor should be equal for class-A operation. A 100K potentiometer (R3) and a 1-MegaOhm fixed resistor (R1) make up a simple adjustable gate-bias circuit. Place a voltmeter between the Drain (D) of Q1 and the circuit ground, and adjust R3 for a meter reading of half the power supply voltage. Almost any resistor value can be used for R2 as long as the maximum current and power ratings of the FET are not exceeded. A resistor value between 22 and 100 ohms is a good choice for experimenting. At high currents, a suitable heat sink should be used.

Fig. 2 has the power FET setup as a **Relay-Controller**. With zero-gate bias applied, Q1 acts like an open switch, but when a DC voltage greater than 5 volts is applied to the input of the circuit, Q1 turns on, completing the relay circuits and thereby activating the relay coil. The input bias current required to turn on Q1 and operate the relay is less than 10 μ A (microAmps), which is about 1/1,000,000 of the current required to bias the popular 2N3055 power transistor to operate the same relay.

Fig. 3 is shown as a regular **Incandescent Lamp Flasher** using two IRF511 HexFets which are configured as a simple astable multivibrator to alternately switch the two lamps, La1 and La2, on and off. The R & C values given set the flash rate to about 1/3 Hz. By varying either the resistor or capacitor values almost any flash rate can be obtained. Increase either C1 and C2, or R1 and R2, and the flash rate slows. Decrease them and the rate increases. Unlike most semiconductor devices, the power MosFet can be paralleled, without special current-sharing components, to control larger load currents. That can be an important feature when the device is used to turn on incandescent lamps, because the lamp's cold resistance is much lower than the normal operating resistance. A typical #1815 12 to 14-volt lamp measures 6 ohms cold. When 120 volts is applied, the initial current drawn is 2 amps. The same lamp, when operating at 12 volts, requires only about 200mA. The hot resistance figures out to be ten times its cold resistance, or 60 ohms. That tidbit should be considered when picking any semiconductor device to control an incandescent lamp.

ERROR FIX: Q1's source (Fig.3) was shown connected to C2. Source should be connected to Ground (Gnd.) Corrected.

Fig. 4 is a **Proximity Switch**. This design takes advantage of the ultra-high input impedance and power-handling capabilities of the IRF511 to make a simple, but sensitive, proximity sensor and alarm driver circuit. A 3x3-inch piece of circuit board (or similar size metal object), which functions as the pick-up sensor, is connected to the gate of Q1. A 100 MegaOhm resistor, R2, isolates Q1's gate from R1, allowing the input impedance to remain very high. If a 100-MegaOhm resistor cannot be located, just tie 5 22-MegaOhm resistors in series and use that combination for R2. In fact, R2 can be made even higher in value for added sensitivity. Potentiometer R1 is adjusted to a point where the piezo buzzer just begins to sound off and then carefully backed off to the point where the sound ceases. Experimenting with the setting of R1 will help in obtaining the best sensitivity adjustment for the circuit. Potentiometer R1 may be set to a point where the pick-up must be contacted to set of the alarm sounder. A relay or other current-hungry component can take the place of the piezo sounder to control almost any external circuit.



Back to [Circuits](#) or [Gadgets](#) page.



[Practical Answers](#)

Information for working with piezo elements and building prototypes

[Introduction to Piezo Transducers](#)

A mix of practical and technical information explaining the capabilities of and applications for piezo transducers

[Application Data](#)

Extensive technical information, including the relationship among variables for functional applications

[Recommended Reading](#)

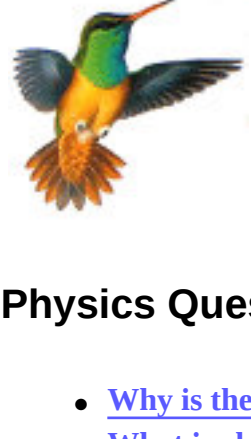
A list of publications that provide further information.

[Glossary](#)

Includes alternate terms for piezo components & devices, as well as definitions for the symbols used on our site.

[History of Piezoelectricity](#)

The background basics from discovery to current applications.



Frequently Asked Questions

Physics Questions

- [Why is there piezoelectricity?](#)
- [What is electric field?](#)
- [What is strain?](#)
- [What is elastic modulus \(or Young's Modulus\)?](#)
- [What is tensile strength?](#)
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Piezo Technology

- [Where in everyday life do I find piezo devices?](#)
- [How are piezoceramics used in vibration cancellation?](#)
- [Will piezo technology replace magnetic technology?](#)

Physics Questions	
Q. Why is there piezoelectricity?	A. Because some atomic lattice structures have as an essential unit (or "cell") a cubic or rhomboid cage made of atoms, and this cage holds a single semi-mobile ion which has several stable quantum position states inside the cell. The ion's post ion state can be caused to shift by either deforming the cage (applied strain) or by applying an electric field. The coupling between the central ion and the cage provides the basis for transformation of mechanical strain to internal electric field shifts and vice versa.
Q. What is electric field?	A. An electric field is always associated with the presence of electric charges. It fills the space around the charge and is the mechanism of interaction between charges. A test particle with small known charge (Q) placed near a charge concentration will experience an accelerating force (F) due to the field. The value of the electric field (E) at that location is the ratio F/Q (a vector).
Q. What is strain?	A. When a solid object like a rod of length (L) is stretched to a new length (L + delta L), the strain in the rod is defined as the ratio (delta L)/L. This is a dimensionless measure of stretching or compression often stated as "inches per inch", "millimeters per meter", or "microns per meter (microstrain)" for convenience of visualization.
Q. What is elastic modulus (or Young's modulus) ?	A. A material property of all elastic solids, Young's modulus (Y) is used to describe "stiffness" of materials. When rod or plate of cross section (A) and length (L) is pulled with force (F) resulting in an elongation (Δ L), the Young's modulus can be computed as follows: $Y = (L/A)*(F/\Delta L)$ In piezo applications Y is frequently used to estimate the equivalent spring constant of a rod or a plate of material that is in contact with a piezo actuator (F/ ΔF).
Q. What is tensile strength?	A. Tensile strength is the stress (measured in Newtons/m*2 or psi) at which a sample of solid material will break from tension.
Q. What is poling/depoling in piezoceramic materials?	A. The piezoelectric property of ceramics does not arise simply from its chemical composition. In addition to having the proper formulation the piezoceramics must be subjected to a high electric field for a short period of time to force the randomly oriented micro-dipoles into alignment. This alignment by application of high voltage is called "poling". At a later time, if an electric field is applied in the opposite direction it exerts a "dislodging stress" on the micro-dipoles. Low level applied fields result in no permanent change in the polarization (it bounces back upon removal). Medium fields result in partial degradation of the polarization (with partial loss of properties). High applied fields result in repolarization in the opposite direction.
Q. What is damping?	A. 'Damping' is the term used for the general tendency of vibrating materials or structures to lose some elastic energy to internal heating or external friction.
Q. Can piezoceramic actuators be used at cryogenic temperatures?	A. Yes. All piezo actuators continue to function right on down to zero degrees Kelvin. This may seem counter-intuitive at first; however, you must remember that the basis for the piezoelectric effect is inter-atomic electric fields, and electric fields are not affected by temperature at all. Quantitatively, the piezo coupling of most common piezoceramics does decrease as temperature drops. At liquid helium temperatures, the motion of most materials drops to about one-seventh of that measured at room temperature.
Q. What is the pyroelectric effect?	A. The tendency of some materials to exhibit a change in internal electrical polarization state in response to a change in temperature. If the materials are equipped with electrodes on two surfaces, a voltage will arise between the electrodes in response to temperature shifts.

Handling & Preparation Questions	
Q. How do I cut up a sheet of piezoceramic into the size I want?	A. Ceramic is best cut using a special diamond saw. Small prototype parts can be cut from piezoceramic sheet stock by using a razor blade and a straight edge to score the piezo surface and then making a controlled break. Even with practice this method does not yield straight-sided parts or repeatable cuts. Use at your own risk.
Q. How do I bond/attach piezoceramic sheet to a structure like an aluminum beam?	A. Cyanoacrylates and two part epoxies have proven useful in many applications. We suggest that you contact a manufacturer of these materials and explain your specific bonding requirements, including: 1. The metal surfaces to be joined 2. Temperature of operation 3. Any unusual shear stress requirements Note: University of Missouri at Rolla has a very helpful section on this.
Q. Can I just use 'superglue'?	A. Good quality temporary bonds may be made with cyanoacrylate (e.g. "super glue"). An added benefit of cyanoacrylate bonds is that the bond easily achieves electrical contact. The length of time the bond will last will be application dependent, from seconds to years. For a short time the performance of the part is very close to that achieved using the best bonds, which makes it useful for exploratory work.
Q. Are piezoceramic sheets fragile and easy to break?	A. Yes, they are very fragile! Single sheet piezoceramic should always be handled with great care. Dropping them almost always results in a shattered part. When two piezo sheets are bonded together with a metal shim between them, as most standard bending elements are, they become rugged enough to be dropped without being damaged.
Q. How do I make electrical contact to the side of the piezoceramic that is bonded down?	A. The most common method is to make a conductive bond between a metal substrate and the piezo part. Then one electrical lead is attached to the substrate, and one to the outward face of the piezoceramic sheet. In cases where a conductive bond is not possible (i.e. when the substrate is glass or plastic), a wire must be soldered to the "down" side of the ceramic at some location and a corresponding "ish", "cutout", or "overhang" must be used to allow room for the wire when bonding the piezo sheet to the substrate.
Q. How do I attach wire leads to the piezoceramic?	A. All of the PSI piezoceramic parts come with a thin (~3000 Angstrom units) metallic electrode already on the ceramic. Wire leads can be soldered (use ordinary 60/40 resin core solder) anywhere on the electrode to suit the application/experiment. Most PSI ceramics have thin nickel electrodes and require the use of an additional liquid flux for uniform results. Our Solder/Flux Kit was designed to make this task much easier.
Q. How can I access the center shim?	A. Support the bender underneath; using a milling machine, take .001 - .002" passes to remove ceramic and expose center shim. Water can be used to lubricate the cutting.
Q. How do I hook up a bender element so it works?	A. This depends on how the two piezoceramic plates are polarized. If 5A-type, .0075" thick plates are poled for series operation (i.e. poling arrows pointing in opposite directions) then a wire is attached to each of the outer electrodes of the bender. ±180 volts is then applied between the wires. If the plates are poled for parallel operation (i.e. poling arrows pointing in the same direction) then the two outer electrodes are shorted together forming one lead, and a wire is attached to the center metal shim forming the second lead. ±90 volts may be applied between these leads. (See Tutorial)
Q. How can I remove the electrode?	A. You can chemically etch, sandblast, sandpaper, or laser ablate the electrode.
Q. How far can I stretch a sheet before it breaks?	A. A sheet can be stretched to a strain of approximately 500 microstrain (micrometers per meter) in regular use. Higher surface strains can be achieved, but the statistics of survival get worse. Proceed with caution.
Q. How far can I bend a bimorph before it breaks?	A. If a T220-type bender (.020" thick) is cantilevered to a distance of one inch, the tip can be pushed a distance of 0.055 inch before the bender is heard to "snap".
Q. If a sheet loses some properties, can it be repoled?	A. Yes. For 5H material, an electric field of 40 - 60 volts/ml will restore nearly all lost polarization. For 5A, use 50 - 100 volts/ml.

Application Questions	
Q. What is the frequency limit of piezoceramic sheet?	A. There is no inherent frequency limit for a piezoceramic sheet. In practice the frequency limits of applications are usually determined by resonances associated with the shape and/or size of the transducer design. A typical 2.85" square, .0075" thick sheet of PSI-5A material has a thickness mode vibration in the neighborhood of 13 MHz and a planar dilatation mode at around 14 KHz. At ultrasonic frequencies large surface area parts draw considerable current and resistive heating of the electrodes becomes the limiting factor.
Q. What is the highest voltage that I can drive a piezoceramic sheet to?	A. For low frequency operation (0 to 5 KHz) a conservative recommendation for applied bi-polar voltage for a .0075" thick single sheet of PSI-5A ceramic is ±90 volts. Voltage applied in the poling direction only can be raised up to ~300 volts. Use caution!
Q. How much mechanical power can I get out of one sheet?	A. In theory, one standard PSI-5A sheet (1.5" x 2.5" x .0075") used as an "extender" can do .00035 joules of work on the outside world in a quasistatic cycle (i.e. a slowly executed sinusoidal cycle). When operated just under its first longitudinal resonance of 15 KHz, and that we collect 100% of the stored electrical energy at its height twice per cycle we would get approximately 9 watts of electrical power from the sheet. The mechanical energy input under these assumptions would be in excess of 100 watts. Resonant designs can be considerably more efficient. However, the mechanical apparatus for achieving the above mentioned 15 KHz high strain excitation is not available, and there is no known electronic method for extracting 100% of the available energy.
Q. How much electrical power can be extracted from a typical piezo bender element in practice?	A. A "Double Quick Mount" bending element bolted to a rigid surface provides a convenient demonstration of a cantilever mount generator. Applying 80 gram force to its tip at a frequency of 60 Hz produces an open circuit voltage of 15V peak between its two electrical leads. When the leads are connected to a 8 Kohm resistive load, the output to the load is 5.3 Vrms, representing a power output of 3.6 mW.
Q. Can piezo transducers be used for force sensors?	A. Piezo transducers are not suitable for static force measurements because of charge leakage. They can be used effectively for transient force measurements lasting less than 0.1 second.
Q. What is the expected fatigue life of piezoelectric material?	A. The "fatigue life" is pretty difficult to estimate; although we've had a piezo fan running constantly here since 1982, no conclusive tests have been done. It would depend on mounting, voltages, etc.
Q. Is a "spice model" available for piezo sensors?	A. We do not have any spice models. As you probably have guessed, for each new thing the piezo is glued to, a new "AC source" characteristic arises. With so many various applications for piezo, we do not have the resources to comment on application-specific questions.
Q. Can piezoceramic sheet be used to pick up vibrations in machinery?	A. Yes. Almost any size or shape of piezoceramic element will give off a measurable signal when fastened somewhere on machinery. See 'strain gages'.
Q. Can piezoceramic sheet be used as a strain gage?	A. Yes. Piezoceramic is one of the most sensitive strain gage technologies existing, and it is the only one which is self-powered.
Q. How repeatable are the voltage outputs from a piezo strain gage?	A. Outputs from piezoceramics which are 'following' surface vibrations are generally very repeatable and stable. If the sensor is initially calibrated it can be trusted for years of accurate service.
Q. How repeatable is the motion of a piezo actuator?	A. A piezoceramic actuator which is cyclically driven at a constant cycle time between the same two points will perfectly repeat its path every time. However, if the cycle time or either endpoint is changed, hysteresis and creep effects cause non-repeatable motions.
Q. What are the effects of temperature on piezoceramic transducers?	A. Temperature changes cause a voltage to appear across the electrodes of any piezo transducer. This is due to the pyroelectric properties of piezoceramic. Temperature also affects every property of piezoceramics (elastic, dielectric and piezoelectric coupling). There is no general trend. Each dependence must be looked up or better yet measured in the context of your experiment.
Q. What is the resonant frequency of a piezoceramic sheet?	A. There is no one 'resonance'. There are many resonances. The number of them and their location in the frequency spectrum depend on the shape and thickness of the part. For a flat sheet as shipped, three obvious resonances are the ones associated with the length, width, and thickness of the sheet.
Q. Can I drive a piezo transducer with a 'square wave'?	A. The answer is application dependent. If the square wave voltage is low (i.e., less than 30 V), then the answer is usually yes. If the square wave voltage is higher, there is a good chance for shockwave, damage, cracking, reduced life, or other failures. Careful control of the square wave rise time/fall time is the solution.

Piezo Technology Questions	
Q. Where in everyday life do I find piezo devices??	A. All 'watch beepers' are piezoceramic audio transducers, most bulky operated smt detector alarms, fish finders, some cigarette lighters, many gas grill igniters.
Q. How are piezoceramics used in vibration cancellation??	A. Two piezoceramic sheets can be bonded directly to the surface of a structure (such as a strut, or beam) close to one another at a site where unwanted bending occurs. One is used to sense surface strain. The output from the strain sensor is fed into a "smart box" (which can be anything from a simple op-amp to an elaborate Digital Signal Processing computer) which in turn controls a power amplifier that drives the other piezoceramic sheet. Ideally the resulting mechanical contractions of the second piezo sheet inject a vibration into the structure which is equal and opposite of the initially detected one so that the net vibration is canceled.
Q. Will piezo technology replace magnetic technology??	A. No. Fundamentally, magnetic technology is based on a force which arises 'at a distance', without physical contact. Piezo technology is based on physical contact and elastic coupling. On an application by application basis one is usually better than the other. Take solenoid actuators as an example. Piezo actuators can be designed to replace almost any solenoid but they always come out bulkier and often heavier so it is unlikely that full scale replacement will ever occur. On the other hand, they always take much less power to operate; so in any application where power consumption is an issue, piezo actuators are preferred.

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Introduction to Piezo Transducers

Piezo Motors (Actuators)

- Single Layer Motors
- 2-Layer Motors
- Multi-Layer Motors
- Motor Performance

Piezo Generators (Sensors)

- Single Layer Generators
- 2-Layer Generators
- Multi-Layer Generators
- Generator Performance
- Static & Dynamic Operation
- Series & Parallel Operation
- X & Y Poling Configurations

Transducers convert one form of energy to another. **Piezo motors (actuators)** convert electrical energy to mechanical energy, and **piezo generators (sensors)** convert mechanical energy into electrical energy. In most cases, the same element can be used to perform either task.

Single sheets can be energized to produce motion in the thickness, length, and width directions. They may be stretched or compressed to generate electrical output. Thin **2-layer elements** are the most versatile configuration of all. They may be used like single sheets (made up of 2 layers), they can be used to bend, or they can be used to extend. "Benders" achieve large deflections relative to other piezo transducers.

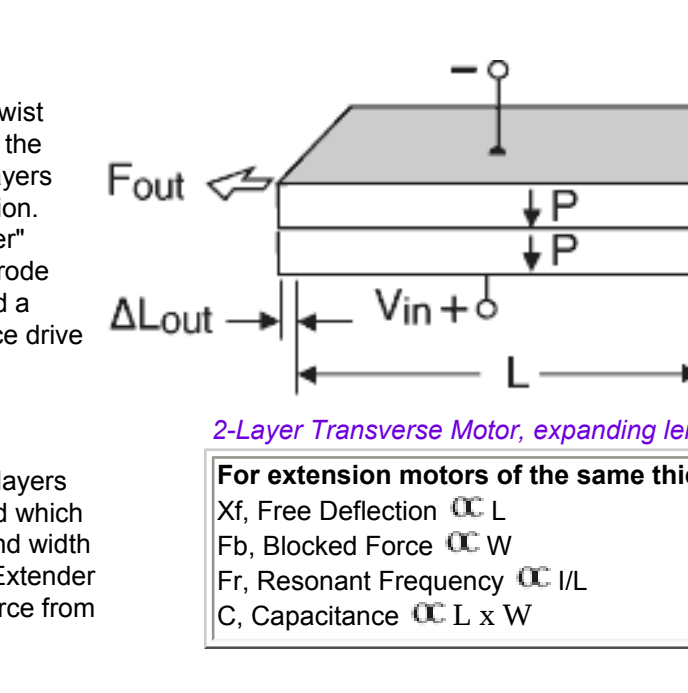
Multilayered piezo **stacks** can deliver and support high force loads with minimal compliance, but they deliver small motions.

PIEZO MOTORS (ACTUATORS)
Piezo motors convert voltage and charge to force and motion.

Single Layer Motors

Longitudinal and Transverse Motors:

When an electrical field having the same polarity and orientation as the original polarization field is placed across the thickness of a single sheet of piezoceramic, the piece expands in the thickness or "longitudinal" direction (i.e., along the axis of polarization) and contracts in the transverse direction (perpendicular to the axis of polarization). When the field is reversed, the motions are reversed. Sheets and plates utilize this effect. However, the motion of a sheet in the thickness direction is extremely small (on the order of tens of nanometers). On the other hand, the transverse motion along the length is generally larger (on the order of microns to tens of microns) since the length dimension is often substantially greater than the thickness. The transverse motion of a sheet laminated to the surface of a structure can induce it to stretch or bend, a feature often exploited in structural control systems.



2-Layer Motors

Two -layer elements can be made to elongate, bend, or twist depending on the polarization and wiring configuration of the layers. A center shim laminated between the two piezo layers adds mechanical strength and stiffness, but reduces motion. "2-layer" refers to the number of piezo layers. The "2-layer" element actually has nine layers, consisting of: four electrode layers, two piezoceramic layers, two adhesive layers, and a center shim. The two layers offer the opportunity to reduce drive voltage by half when configured for parallel operation.

2-Layer Transverse Motor, expanding lengthwise

For extension motors of the same thickness:
Xf, Free Deflection $\propto L^2$
Fb, Blocked Force $\propto WL$
Fr, Resonant Frequency $\propto 1/L^2$
C, Capacitance $\propto L \times W$

Extension Motors:

A 2-layer element behaves like a single layer when both layers expand (or contract) together. If an electric field is applied which makes the element thinner, extension along the length and width results. Typically, only motion along one axis is utilized. Extender motion on the order of microns to thousands of microns, and tender force from tens to hundreds of Newtons is typical.

Bending Motors:

A 2-layer element produces curvature when one layer expands while the other layer contracts. These transducers are often referred to as benders, bimorphs, or flexural elements. Bender motion on the order of hundreds to thousands of microns, and tender force from tens to hundreds of grams, is typical.

Bending Motor, cantilever mount

For cantilevered benders of the same thickness:
Xf = 1/4 X cantilever motion
Fb = Blocked Force $\propto WL$
Fr = 3X cantilever frequency
C = same as cantilever capacitance
Characteristics: End takes on an angle. Simple to mount.

Bending Motor, "S" configuration, cantilever mount

To convert cantilever to "S" beam performance:
Xf = 1/2 x cantilever motion
Fb = 1/2 x cantilever force
Fr = same as cantilever frequency
C = same as cantilever capacitance
Characteristics: end moves up and down in a parallel plane

Bending Motor, simple beam mount

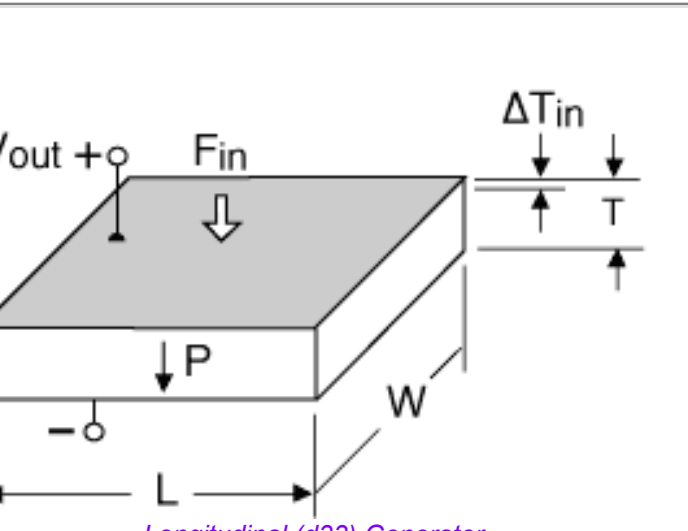
To convert cantilever to simple beam performance:
Xf = 1/4 X cantilever motion
Fb = 4X cantilever force
Fr = 3X cantilever frequency
C = same as cantilever capacitance
Characteristics: center moves up and down in a parallel plane.

Multi-Layer Motors

Any number of piezo layers may be stacked on top of one another. Increasing the volume of piezoceramic increases the energy that may be delivered to a load. As the number of layers grows, so does the difficulty of accessing and wiring all the layers. Typically, more than 4 layers becomes impractical.

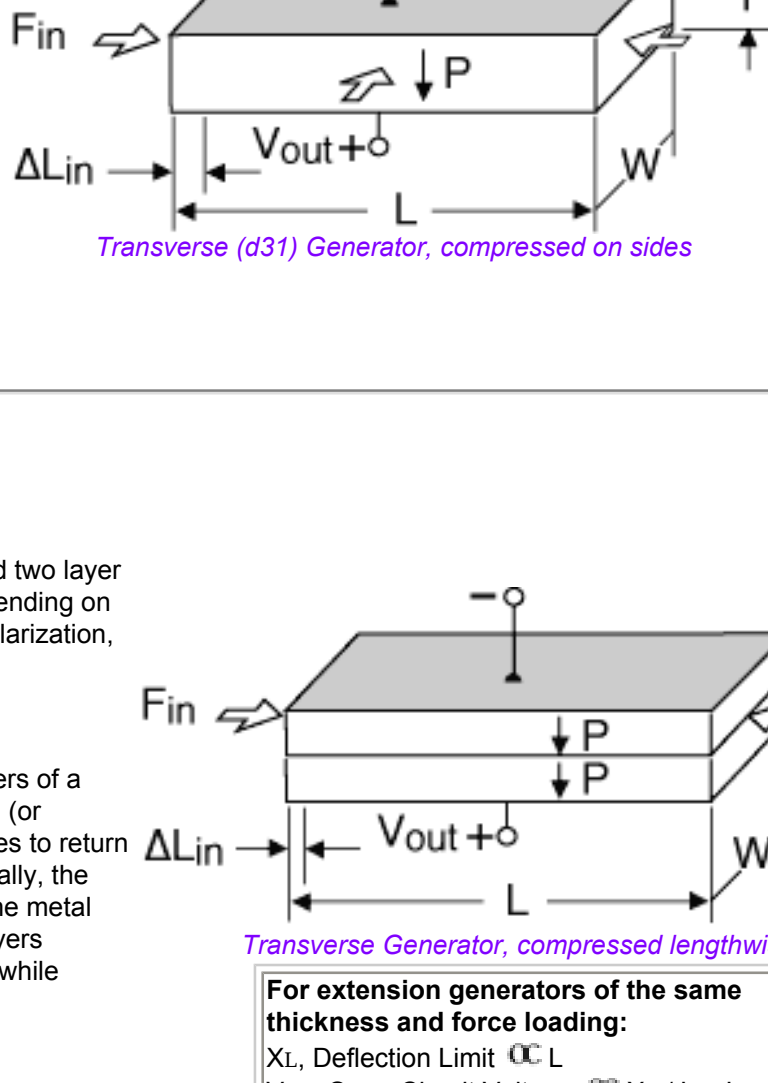
Stack Motors:

The co-fired stack seen below is a practical way to assemble and wire a large number of piezo layers into one monolithic structure. The tiny motions of each layer contribute to the overall displacement. Stack motion on the order of microns to tens of microns, and force from hundreds to thousands of Newtons is typical.



Motor Performance

Piezoelectric actuators are usually specified in terms of their free deflection and blocked force. Free deflection (X_f) refers to displacement attained at the maximum recommended voltage level when the actuator is completely free to move and is not asked to exert any force. Blocked force (F_b) refers to the force exerted at the maximum recommended voltage level when the actuator is totally blocked and not allowed to move. Deflection is at a maximum when the force is zero, and force is at a maximum when the deflection is zero. All other values of simultaneous displacement and force are determined by a line drawn between these two points on a force versus deflection line, as shown here.



Generally, a piezo motor must move a specified amount and exert a specified force, which determines its operating point on the force vs. deflection line. An actuator is considered optimized for a particular application if it delivers the required force at one half its free deflection. All other actuators satisfying the design criteria will be larger, heavier, and consume more power.

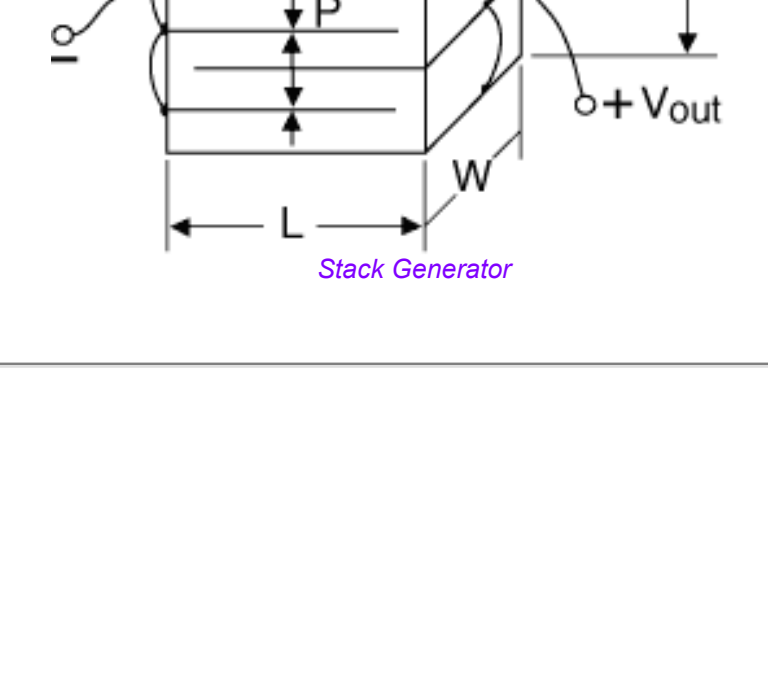
PIEZO GENERATORS (SENSORS)
Piezo generators convert force and motion to voltage and charge.

Single Layer Generators

Longitudinal and transverse generators:

When a mechanical stress is applied to a single sheet of piezoceramic in the longitudinal direction (parallel to polarization), a voltage is generated which tries to return the piece to its original thickness.

Similarly, when a stress is applied to a sheet in a transverse direction (perpendicular to polarization), a voltage is generated which tries to return the piece to its original length and width. A sheet bonded to a structural member which is stretched or flexed will induce electrical generation.



2-Layer Generators

Applying a mechanical stress to a laminated two layer element results in electrical generation depending on the direction of the force, the direction of polarization, and the wiring of the individual layers.

Transverse Generator, compressed lengthwise

For extension generators of the same thickness and force loading:
Xi, Deflection Limit $\propto L^2$
Voc, Open Circuit Voltage $\propto Xi / L = 1$
Icc, Closed Circuit Current $\propto L \times W$

Bending Generators:

When a mechanical force causes a suitable polarized 2-layer element to bend, one layer is compressed and the other is stretched. Charge develops across each layer in an effort to counteract the imposed strains. This charge may be collected as observed here.

Bending Generator, cantilever mount

For Bending Generators of the same thickness and force loading:
Xi, Deflection Limit $\propto L^2$
Voc, Open Circuit Voltage $\propto Xi / L^2 = 1$
Icc, Closed Circuit Current $\propto L \times W$

Bending Generator, simple beam mount

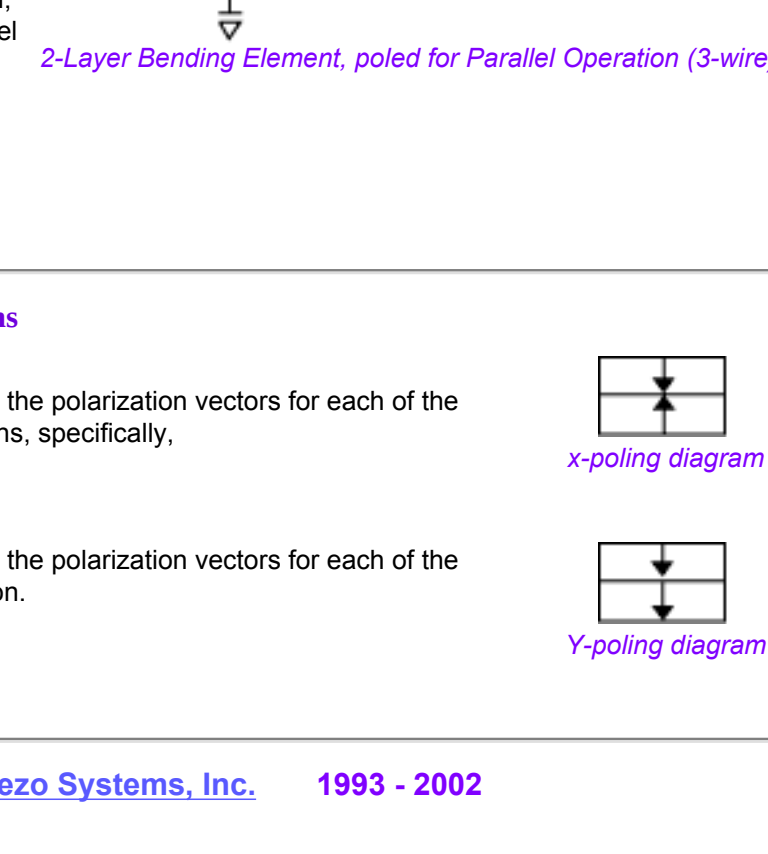
To convert cantilever to simple beam generator performance (for the same thickness and force load):
Voc = 1/4X cantilever voltage
Icc = 1/4X cantilever current
To convert cantilever to simple beam generator performance (for the same thickness and deflection):
Voc = 4X cantilever voltage
Icc = 4X cantilever current

Stack Generator

The stack, which comprises a large number of piezo layers, is a very stiff structure with a high capacitance. It is suitable for handling high force and collecting a large volume of charge.

Generator Performance

Piezoelectric generators are usually specified in terms of their closed-circuit current (or charge) and open-circuit voltage. Closed-circuit current, I_{cc} , refers to the total current developed, at the maximum recommended strain level and operating frequency, when the charge is completely free to travel from one electrode to the other, and not asked to build up voltage. Open-circuit voltage, V_{oc} , refers to the voltage developed at the maximum recommended strain level, when charge is prohibited from traveling from one electrode to the other. Current is at a maximum when the voltage is zero, and voltage is at a maximum when the charge transfer is zero. All other values of simultaneous current and voltage levels are determined by a line drawn between these points on a voltage versus current line, as shown here.



Generally, a piezo generator must deliver a specified current and voltage, which determines its operating point on the voltage vs. current line. Maximum power extraction for a particular application occurs when the generator delivers the required voltage at one half its closed circuit current. All other generators satisfying the design criteria will be larger, heavier, and require more power input.

Static & Dynamic Operation

As a sensor or force gauge, piezo elements are excellent for detecting dynamic and transient inputs, but poor at measuring static inputs. This is due to charge leakage between electrodes and monitoring circuits. Piezoceramic may be used as a strain gauge for easy and rapid determination of dynamic strains in structures. They exhibit extremely high signal/noise ratios, on the order of 50 times that of wire strain gauges, and are small enough that on most structures they will not materially affect the vibrational characteristics of the structure.

Series & Parallel Operation

Series Operation refers to the case where supply voltage is applied across all piezo layers at once. The voltage on any individual layer is the supply voltage divided by the total number of layers. A 2-layer device wired for series operation uses only two wires, one attached to each outside electrode.



Parallel Operation refers to the case where the supply voltage is applied to each layer individually. This means accessing and attaching wires to each layer. A 2-layer bending element wired for parallel operation requires three wires; one attached to each outside electrode and one attached to the center shim. For the same motion, a 2-layer element poled for parallel operation needs only half the voltage required for series operation.



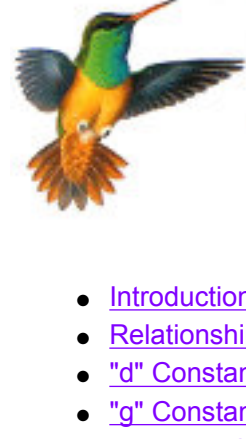
X and Y Poling Configurations

X-Poled refers to the case where the polarization vectors for each of the 2 layers point in opposite directions, specifically, towards each other.



Y-Poled refers to the case where the polarization vectors for each of the 2 layers point in the same direction.





- [Introduction](#)
- [Relationships](#)
- ["d" Constant](#)
- ["g" Constant](#)
- [Dielectric Constants](#)
- [Capacitance](#)
- [Coupling Coefficients](#)
- [Young's Modulus](#)
- [Density](#)
- [Dissipation Factor](#)
- [Mechanical \(Qm\)](#)
- [Curie Temperature](#)
- [Aging Rate](#)
- [Pyroelectricity](#)
- [Performance](#)
- [Linear Mathematical Relations \(Motors & Generators\)](#)
- [Temperature Dependence of Piezoelectric Properties](#)

INTRODUCTION

When a piezoceramic element is stressed electrically by a voltage, its dimensions change. When it is stressed mechanically by a force, it generates an electric charge. If the electrodes are not short-circuited, a voltage associated with the charge appears.

A piezoceramic is therefore capable of acting as either a sensing or transmitting element, or both. Since piezoceramic elements are capable of generating very high voltages, they are compatible with today's generation of solid-state devices - rugged, compact, reliable, and efficient.

The following text describes the terminology of piezoceramics and the relationship among variables for functional applications.

RELATIONSHIPS

Relationships between applied forces and the resultant responses depend upon: the piezoelectric properties of the ceramic; the size and shape of the piece; and the direction of the electrical and mechanical excitation.

To identify directions in a piezoceramic element, three axes are used. These axes, termed 1, 2, and 3, are analogous to X, Y, and Z of the classical three dimensional orthogonal set of axes.

The polar, or 3 axis, is taken parallel to the direction of polarization within the ceramic. This direction is established during manufacturing by a high DC voltage that is applied between a pair of electrode faces to activate the material. In shear operations, these poling electrodes are later removed and replaced by electrodes deposited on a second pair of faces. In this event, the 3 axis is not altered, but is then parallel to the electrode faces found on the finished element. When the mechanical stress or strain is shear, the subscript 5 is used in the second place.

Piezoelectric coefficients with double subscripts link electrical and mechanical quantities. The first subscript gives the direction of the electrical field associated with the voltage applied, or the charge produced. The second subscript gives the direction of the mechanical stress or strain. d_{33} applies when the force is in the 3 direction (along the polarization axis) and is impressed on the same surface on which the charge is collected. d_{31} applies when the charge is collected on the same surface as before, but the force is applied at right angles to the polarization axis.

The units for d_{15} indicate that the charge is collected on electrodes which are at right angles to the original poling electrodes and that the applied mechanical stress is shear.

The units for the d_5 coefficients are commonly expressed as coulombs/square meter per newton/square meter.

$$d = \frac{\text{short circuit charge density}}{\text{applied electric field}}$$

It is useful to remember that large d_5 constants relate to large mechanical displacements which are usually sought in motion transducer devices. Conversely, the coefficient may be viewed as relating the charge collected on the electrodes, to the applied mechanical stress. d_{33} applies when the force is in the 3 direction (along the polarization axis) and is impressed on the same surface on which the charge is collected. d_{31} applies when the charge is collected on the same surface as before, but the force is applied at right angles to the polarization axis.

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The units for the d_5 coefficients are commonly expressed as coulombs/square meter per newton/square meter.

$$d = \frac{\text{short circuit charge density}}{\text{applied mechanical stress}}$$

When the force that is applied is distributed over an area which is fully covered by electrodes (even if that is only a portion of the total electrode) the units of the area cancel from the equation and the coefficient may be expressed in terms of change per unit force, coulombs per newton. To view the d_5 coefficients in this manner is useful when charge generators are contemplated, e.g., accelerometers.

"g" CONSTANT

The piezoelectric constants relating the electric field produced by a mechanical stress are termed the voltage constants, or the "g" coefficients. The units may then be expressed as volts/meter per newtons/square meter.

$$g = \frac{\text{open circuit electric field}}{\text{applied mechanical stress}}$$

Output voltage is obtained by multiplying the calculated electric field by the thickness of ceramic between electrodes. A "33" subscript indicates that the electric field and the mechanical stress are both along the polarization axis. A "31" subscript signifies that the pressure is applied at right angles to the polarization axis, but the voltage appears on the same electrodes as in the "33" case.

A "15" subscript implies that the applied stress is shear and that the resulting electric field is perpendicular to the polarization axis. High g_{15} constants favor large voltage output, and are sought after for sensors. Although the g coefficient are called voltage coefficients, it is also correct to say the g_{15} is the ratio of strain developed over the applied charge density with units of meters per meter over coulombs per square meter.

$$g = \frac{\text{strain developed}}{\text{applied charge density}}$$

DIELECTRIC CONSTANTS

The relative dielectric constant is the ratio of the permittivity of the material, ϵ_r , to the permittivity of free space, ϵ_0 , in the unconstrained condition, i.e., well below the mechanical resonance of the part.

$$K = \frac{\text{permittivity of material}}{\text{permittivity of free space}} = \frac{\epsilon_r}{\epsilon_0}$$

CAPACITANCE

Whereas the relative dielectric constant is strictly a material property, the capacitance is a quantity dependent on the type of material and its dimensions. Capacitance is calculated by multiplying the relative dielectric constant by the permittivity of free space ($\epsilon_0 = 8.9 \times 10^{-12}$ farads/meter) and electrode surface area, then dividing by the thickness separating the electrodes. Units are expressed in farads.

$$C = \frac{K \epsilon_0 A}{t}$$

K_3 is related to the capacitance between the original poling electrodes. K_1 is related to the capacitance between the second pair of electrodes applied after removal of the poling electrodes for the purposes of shear excitation.

At frequencies far below resonance, piezoelectric ceramic transducers are fundamentally capacitors. Consequently, the voltage coefficients g_5 are related to the charge coefficients d_5 by the dielectric constant K_5 as, in a capacitor, the voltage V is related to the charge Q by the capacitance C.

The equations are:

$$Q = CV$$
$$d_{33} = K_{33}^T \epsilon_{03} g_{33}$$
$$d_{31} = K_{31}^T \epsilon_{03} g_{31}$$
$$d_{15} = K_{11}^T \epsilon_{01} g_{15}$$

At resonance, the dielectric constant will be reduced by the factor (1-k²) where k is the coupling coefficient of the mode in question.

COUPLING COEFFICIENTS

Electromechanical coupling k_{33} , k_{31} , k_{15} , and k_{12} describe the conversion of energy by the ceramic element from electrical to mechanical form or vice versa. The ratio of the stored converted energy of one kind (mechanical or electrical) to the input energy of the second kind (electrical or mechanical) is defined as the square of the coupling coefficient.

$$k = \sqrt{\frac{\text{mechanical energy stored}}{\text{electrical energy applied}}}$$

or

$$k = \sqrt{\frac{\text{electrical energy stored}}{\text{mechanical energy applied}}}$$

Subscripts denote the relative directions of electrical and mechanical quantities and the kind of motion involved. They can be associated with vibratory modes of certain simple transducer shapes; k_{33} is appropriate for a long thin bar, electrode on the ends, and polarized along the length, and vibrating in a simple length expansion and contraction. k_{31} relates to a long thin bar, electrode on a pair of long faces, polarized in thickness, and vibrating in simple length expansion and contraction. k_{15} signifies the coupling of electrical and mechanical energy in a thin round disc, polarized in thickness and vibrating in radial expansion and contraction. k_{12} describes the energy conversion in a thickness shear vibration. Since these coefficients are energy ratios, they are dimensionless.

YOUNG'S MODULUS

As with all solids, piezoelectric ceramics have mechanical stiffness properties described as Young's Modulus. Young's Modulus is the ratio of stress (force per unit area) to strain (change in length per unit length).

$$Y = \frac{\text{stress}}{\text{strain}}$$

Because mechanical stressing of the ceramic produces an electrical response which opposes the resultant strain, the effective Young's Modulus with electrodes short circuited is lower than with the electrodes open circuited. In addition, the stiffness is different in the 3 direction from that in the 1 or 2 direction. Therefore, in expressing such quantities both direction and electrical conditions must be specified. Y_{33}^E is the ratio of stress to strain in the 3 direction at constant field E (electrodes shorted). Y_{33}^0 is the equivalent with the electrodes open circuited. Y_{11}^E and Y_{11}^0 are the moduli in the 1 or 2 direction. Y_{15}^E and Y_{15}^0 are the ratios of shear stress to shear strain. Units are usually newtons/square meter.

It should be clearly understood that the piezoceramic properties described above are defined for ideal shapes measured under ideal mechanical and electrical boundary conditions. When put to use under practical device operating conditions, the predicted performance is approached but seldom realized. Non-ideal shapes and non-ideal boundary conditions contribute to transduction losses due to such things as standing waves, interfering vibrational modes, pseudo-clamping, stray electric and dielectric resistances. Since the possibilities are infinite, the designer must evaluate each component under the use conditions for which it is intended.

DENSITY

The ratio of the mass to volume in the material, expresses in kg/m³

$$\rho = \frac{\text{mass}}{\text{volume}}$$

DISSIPATION FACTOR

A measure of the dielectric losses in the material-defined as the tangent of the loss angle or the ratio of parallel resistance to the parallel reactance, expressed in percent.

MECHANICAL (Qm)

The ratio of reactance to resistance in the equivalent series circuit representing the mechanical vibrating resonant systems. The shape of the part affects the value.

CURIE TEMPERATURE

The temperature at which the crystal structure changes from a non-symmetrical (piezoelectric) to a symmetrical (non-piezoelectric) form, expresses in degrees Celsius.

AGING RATE

Aging is the attempt of the ceramic to change back to its original state prior to polarization. Aging of piezoelectric ceramics is a logarithmic function with time. The aging rate defines change in the material parameters per decade of time, i.e., 1-10 days, 5-50 days, etc.

PYROELECTRICITY

Piezoelectric materials are also pyroelectric. They produce electric charge as they undergo a temperature change. When their temperature is increased, a voltage develops having the same orientation as the polarization voltage. When their temperature is decreased, a voltage develops having an orientation opposite to the polarization voltage, creating a depolarizing field with the potential to degrade the state of polarization of the part.

The maximum electric field which arises due to a temperature shift is:

$$E(\text{pyro}) = \frac{\alpha (\Delta T)}{K_3 \epsilon_0}$$

where E (pyro) is the induced electric field in volts/meter, α is the pyroelectric coefficient in Coulomb/C meter², ΔT is the temperature difference in °C, K_3 is the dielectric constant, and ϵ_0 is the dielectric permittivity of free space. For PZT piezoceramic, α is typically ~ 400x10⁻⁶ coulomb/C meter².

PERFORMANCE

Deflection and Force: Piezoelectric actuators are usually specified in terms of their free deflection and blocked force. Free deflection, X(f), refers to displacement at a given voltage level without the actuator working against any external load. Blocked force, F(b), refers to the force exerted at a given voltage level when the actuator is not allowed to move. Since the force at maximum deflection is zero, all other values of simultaneous displacement and force (for a given voltage level) are determined by a line drawn between these points on a force versus deflection. In practice, a bending motor must move a specified amount and exert a specified force, which determines its operating point on the force versus deflection diagram. Work is maximized when the deflection permitted permits one half the blocked force to be developed. This occurs when the deflection equals one half the free deflection.

For cantilevered bending motors, X(f) and F(b) are approximated by observing the tip deflection after energizing, and by holding a force gauge against the tip during energization.

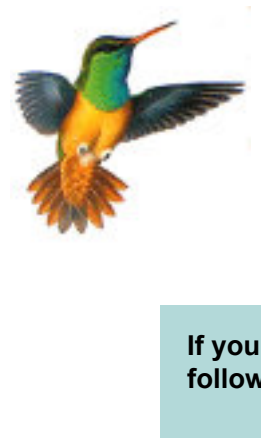
LINEAR MATHEMATICAL RELATIONS

The expressions listed in the diagrams represent the linear relations measured at low voltages.

- [Motor Transducer Relationships](#)
- [Generator Transducer Relationships](#)

TYPICAL THERMAL PROPERTIES

- [Temperature Dependence of Piezoelectric Properties](#)



If you haven't found enough information about piezoelectricity online, we suggest the following publications to further your knowledge.

Since many of these publications are out of print or hard to find, we have included links where we have found specific books in the past.

Advanced Fibers and Composites
Francis S. Galasso



Applications of Acoustical Phenomena
Warren Perry Mason

[The Journal of Acoustical Society of America](#),
Vol. 68, No. 1

Ceramic Materials for Electronics
Reiva C. Buchanan



Developments in Fabrication of Piezoelectric Devices
Kiyoshi Okazaki

Ferroelectrics Journal, Vol. 41

Electromagnetoelasticity: Piezoelectrics and Electrically Conductive Solids
V.Z. Parton, B.A. Kudryavstev



Ferroelectric Transducers and Sensors
J.M. Herbert



Fifty Years of Ferroelectricity
Warren Perry Mason

[The Journal of Acoustical Society of America](#),
Vol. 50, No. 5

Fundamentals of Piezoelectricity
Takuro Ikeda

[Oxford University Press](#)

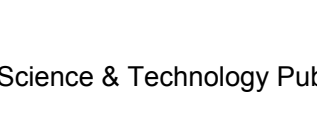
An Introduction to the Mechanics of Solids: Second Edition with SI Units
Crandall, Dahl and Lardner



Introduction to Ultrasonic Motors *T. Sashida, T. Kenjo*



Lattice Dynamical Foundations of Continuum Theories: Elasticity, Piezoelectricity
(Series in Theoretical and Applied Mechanics, Vol. 2)
Attila Askar



Linear Piezoelectric Plate Vibrations - Elements of the Linear Theory of Piezoelectricity and the Vibrations of Piezoelectric Plates
H.F. Tiersten

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Warren Perry Mason

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Physical Properties of Crystals
J.F. Nye



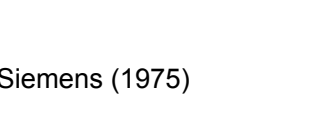
Physics of Crystalline Dielectrics Vol 2, Electrical Properties
I.S. Zheludev

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Piezoelectric Accelerometer and Vibration Preamplifier Handbook
Mark Serridge and Torben R. Licht

[Brüel & Kjær](#)

Piezoelectric Actuators and Ultrasonic Motors
Kenji Uchino



Piezoelectric Ceramics
Jaffe, Cook & Jaffe



Piezoelectric Ceramics
J. van Randerlaet and R.E. Settrington

Eindhoven, The Netherlands, 1968

Piezoelectric Crystals and Their Application to Ultrasonics
Warren Perry Mason

[Van Nostrand-Reinhold](#)

Piezoelectric Devices in Japan
Tetsuro Tanaka

Ferroelectrics Journal, Vol. 40

Piezoelectric Physics
Weilie Zhong

Science & Technology Publishing House

Piezoelectricity
J.J. Gagnepain and T.R. Meeker

1982

Piezoelectricity (Ferroelectricity and Related Phenomena, Vol. 4)
George Taylor



Piezoelectricity (Key Papers in Physics)
Carol Zwick Rosen, et al



Piezoelectricity: An Introduction to the Theory and Applications of Electromechanical Phenomena in Crystals
Walter Guyton Cady

Dover Press (1964)

Piezoelectricity, Its History and Applications
Warren Perry Mason

[Journal of Acoustical Society of America](#), Vol. 70, No. 6

Proceedings of the First International Symposium on Piezoelectricity in Biomaterials and Biomedical Devices (Numbers 1,2,3, &4)
Pierre Galletti



Solid State Magnetic and Dielectric Devices
H.W. Katz

[John Wiley](#)

Some Design Considerations in the Use of Bimorphs as Motor Transducers
C. Germano

[TP 237, Vernitron Piezoelectric Division](#)

Structure, Properties and Preparation of Perovskite Type Compounds
F.S. Galasso

Permagon Press

The Theory of Piezoelectric Shells and Plates
Nellya N. Rogacheva



Transformation of Energy in Piezoelectric Drive Systems
I. Lucas

Siemens (1975)

Ultrasonic Motors, Theory and Applications
S. Ueha (1993)

[Oxford University Press](#)

Ultrasonic Transducer Materials
D. Berlincourt (1971)

[Plenum Press](#)

Vibrations of Elastic Plates: Linear and Nonlinear Dynamical Modeling of Sandwiches, Laminated composites, and Piezoelectric layers
Yi-yuan Yu



Glossary of Piezo Terms; List of Symbols

Bimorph	A common alternate term for "bender" or 2-layer element. Two layers of piezoceramic with or without a center shim.
Capacitance (free)	Referring to capacitance measurement on piezoelectric sample, the capacitance value obtained with sample being totally free of mechanical constraint during measurement process.
Capacitance (clamped)	Referring to capacitance measurement on a piezoelectric sample, the capacitance value obtained with sample being totally constrained from motion (i.e., "clamped") during measurement.
Coercive Field	Relating to a uniform ferroelectric material, the electric field required to oppose and bring to zero the internal polarization.
Charge Constant (d)	see "d" Constant
Compliance (s)	see "s" Constant
Coupling Coefficient (k)	A dimensionless number related to the effectiveness of electrical to mechanical energy conversion in nonresonant piezoelectric devices.
Curie Temperature:	Temperature at which the crystal structure undergoes a phase change from non-symmetrical lattice (such as tetragonal) to symmetrical lattice (such as cubic). Drastic dielectric and piezoelectric coefficient changes accompany this phase change.
"d" Constant	The piezoelectric constant relating applied electric field to resultant strain (units of meters per volt).
Density	In reference to piezoceramics, the mass per unit volume of a fired ceramic body. High density is an important measure of the quality and uniformity of ceramic material because it indicates the absence of microscopic pores which weaken the ceramic and cause poling difficulties.
Dielectric Constant	see "K" Constant (capital "K")
Electrostrictive Materials	An important class of solid state motor materials which exhibit strains proportional to the square of the applied electric field strength. (By contrast piezoelectric materials exhibit strains directly proportional to the applied field strength.
Ferroelectric Materials	Class of crystalline materials which possess an internal polarization which can be reversed by an externally applied field, i.e., a crystalline material which can be poled. All of the commonly used piezoceramics are ferroelectric.
Flaw Detection	An early practical application of piezoelectrics, taking advantage of the fact that ultrasonic sound waves travel freely in a solid object (such as a steel girder) until they hit an air bubble or a structural flaw, at which point they reflect backwards and are detectable.
Frequency Constant	see "N" Frequency Constant.
"g" Constant	Piezoelectric coefficient relating the stress applied to a crystal to the resultant electric field in the crystal (units of volt meters per Newton).
"K" Constant (Dielectric Constant)	For a piezoceramic material, the ratio of its dielectric permittivity to the dielectric permittivity of free space (8.85 E -12 Farads per Meter).
Mechanical Q	Referring to both piezoelectric materials and non-piezoelectric materials - the INVERSE of the percentage of mechanical input energy which is converted to heat (the balance being stored as recoverable elastic energy). A material with Q = 100, when subjected to 1.00 Joules of work, will lose .01 Joules to internal heating.
"N" Frequency Constant	Referring to resonating piezoelectric bodies of various geometries - the product of the resonant frequency and the length of the body along the axis of motion for the designated vibrational mode.
Piezo Electricity	An observed phenomenon in some crystals - the generation of surface charges in response to applied stresses.
Pyroelectricity	An observed phenomenon in some crystals - the generation of surface charges in response to the application of uniform temperature changes.
"s" Constant (compliance)	In an elastic body, the ratio of uniaxial strain to uniaxial stress. Saw Device: Piezoelectric acoustic device employing surface acoustic waves.
Sonar	Name given to piezoelectric application consisting of measuring distances to submerged objects by broadcasting a sound "pulse" and timing the reflected signal.
Strain	The ratio of change-in-length to length. Used in describing the effects of applied stresses or applied electric fields.
Stress	In a mechanical sample, the ratio of applied force to cross-sectional area which bears that force.
Ultrasonic	Refers to the frequency of operation of an electric or acoustic device - a general term for "higher than 20 kilohertz".
Voltage Constant (g)	see "g" constant.
Young's Modulus	Elastic modulus of a solid sample, i.e., the ratio of stress in a sample to applied strain. For practical purposes, Young's modulus is equal to the inverse of the appropriate "s" constant.

List of Symbols

Symbol	Name	Unit
A	Area	m ²
C	Capacitance	F
D	Diameter	m
D _i *	Dielectric displacement	C / m ²
d _{ij} *	Piezoelectric charge constants	C / N
E _i *	Electric field components	V / m
E _c	Coercive field	V / m
F _r	Resonant frequency	Hz
F	Force	N
F _b	Blocking force	N
g _{ij} *	Piezoelectric voltage constants	V m / N
G	Shear modulus	N / m ²
k	Electromechanical coupling coefficient	
k ₃₃	Longitudinal coupling coefficient	
k ₃₁	Transverse coupling coefficient	
k ₁₅	Shear coupling coefficient	
k _p	Planar coupling coefficient	
k _t	Thickness coupling coefficient	
k _{eff}	Effective coupling coefficient	
K _i S *	Relative dielectric constant at constant strain	
K _i T *	Relative dielectric constant at constant stress	
L	Length	m
p	Pressure	N / m ²
p	Pyroelectric coefficient	C / m ² K
P _i	Polarization components	C / m ²
P	Power	W
Q	Mechanical quality factor	
Q	Electric charge	C
Q _s	Short circuit charge	C
R	Electrical resistance	Ω
s _{ij} *	Elastic compliance at constant E	m ² / N
S _i	Strain components	
S _{max}	Maximum recommended strain	
t	Time	s
t	Thickness	m
t _r	Response time	s
T	Thickness	m
T _i *	Stress components	N / m ²
V	Volume	m ³
V	Electrical voltage	V
V _o	Open circuit voltage	V
v _s	Velocity of sound	m / s
x	Deflection	m
x _o	Free deflection	m
α	Thermal expansion coefficient	1 / K
ε _o	Dielectric constant of free space	F / m
ρ	Density	kg / m ³
ρ	Electrical bulk resistivity	Ω m
* i = 1 to 3 * j = 1 to 6		



- [Discovery And Insights 1880 - 1882](#)
- [A Laboratory Curiosity - A Mathematical Challenge 1882 - 1917](#)
- [First Generation Applications With Natural Crystals 1920 - 1940](#)
- [Second Generation Applications With Piezoelectric Crystals 1940 - 1965](#)
- [Japanese Developments 1965 - 1980](#)
- [Search for High Volume Markets 1980 - present](#)

DISCOVERY AND INSIGHTS

1880 - 1882

The first experimental demonstration of a connection between macroscopic piezoelectric phenomena and crystallographic structure was published in 1880 by Pierre and Jacques Curie. Their experiment consisted of a conclusive measurement of surface charges appearing on specially prepared crystals (tourmaline, quartz, topaz, cane sugar and Rochelle salt among them) which were subjected to mechanical stress. These results were a credit to the Curies' imagination and perseverance, considering that they were obtained with nothing more than tinfoil, glue, wire, magnets and a jeweler's saw.

In the scientific circles of the day, this effect was considered quite a "discovery," and was quickly dubbed as "piezoelectricity" in order to distinguish it from other areas of scientific phenomenological experience such as "contact electricity" (friction generated static electricity) and "pyroelectricity" (electricity generated from crystals by heating).

The Curie brothers asserted, however, that there was a one-to-one correspondence between the electrical effects of temperature change and mechanical stress in a given crystal, and that they had used this correspondence not only to pick the crystals for the experiment, but also to determine the cuts of those crystals. To them, their demonstration was a confirmation of predictions which followed naturally from their understanding of the microscopic crystallographic origins of pyroelectricity (i.e., from certain crystal asymmetries).

The Curie brothers did not, however, predict that crystals exhibiting the direct piezoelectric effect (electricity from applied stress) would also exhibit the converse piezoelectric effect (stress in response to applied electric field). This property was mathematically deduced from fundamental thermodynamic principles by Lippmann in 1881. The Curies immediately confirmed the existence of the "converse effect," and continued on to obtain quantitative proof of the complete reversibility of electro-elasto-mechanical deformations in piezoelectric crystals.

A LABORATORY CURIOSITY - A MATHEMATICAL CHALLENGE

1882 - 1917

At this point in time, after only two years of interactive work within the European scientific community, the core of piezoelectric applications science was established: the identification of piezoelectric crystals on the basis of asymmetric crystal structure, the reversible exchange of electrical and mechanical energy, and the usefulness of thermodynamics in quantifying complex relationships among mechanical, thermal and electrical variables.

In the following 25 years (leading up to 1910), much more work was done to make this core grow into a versatile and complete framework which defined completely the 20 natural crystal classes in which piezoelectric effects occur, and defined all 18 possible macroscopic piezoelectric coefficients accompanying a rigorous thermodynamic treatment of crystal solids using appropriate tensorial analysis. In 1910 Voigt's "Lehrbuch der Kristallphysik" was published, and it became the standard reference work embodying the understanding which had been reached.

During the 25 years that it took to reach Voigt's benchmark, however, the world was not holding its breath for piezoelectricity. A science of such subtlety as to require tensorial analysis just to define relevant measurable quantities paled by comparison to electro-magnetism, which at the time was maturing from a science to a technology, producing highly visible and amazing machines. Piezoelectricity was obscure even among crystallographers; the mathematics required to understand it was complicated; and no publicly visible applications had been found for any of the piezoelectric crystals.

The first serious applications work on piezoelectric devices took place during World War I. In 1917, P. Langevin and French co-workers began to perfect an ultrasonic submarine detector. Their transducer was a mosaic of thin quartz crystals glued between two steel plates (the composite having a resonant frequency of about 50 KHz), mounted in a housing suitable for submersion. Working on past the end of the war, they did achieve their goal of emitting a high frequency "chirp" underwater and measuring depth by timing the return echo. The strategic importance of their achievement was not overlooked by any industrial nation, however, and since that time the development of sonar transducers, circuits, systems, and materials has never ceased.

FIRST GENERATION APPLICATIONS WITH NATURAL CRYSTALS

1920 - 1940

The success of sonar stimulated intense development activity on all kinds of piezoelectric devices, both resonating and non-resonating. Some examples of this activity include:

- Megacycle quartz resonators were developed as frequency stabilizers for vacuum-tube oscillators, resulting in a ten-fold increase in stability.
- A new class of materials testing methods was developed based on the propagation of ultrasonic waves. For the first time, elastic and viscous properties of liquids and gases could be determined with comparative ease, and previously invisible flaws in solid metal structural members could be detected. Even acoustic holographic techniques were successfully demonstrated.
- Also, new ranges of transient pressure measurement were opened up permitting the study of explosives and internal combustion engines, along with a host of other previously unmeasurable vibrations, accelerations, and impacts.

In fact, during this revival following World War I, most of the classic piezoelectric applications with which we are now familiar (microphones, accelerometers, ultrasonic transducers, bender element actuators, phonograph pick-ups, signal filters, etc.) were conceived and reduced to practice. It is important to remember, however, that the materials available at the time often limited device performance and certainly limited commercial exploitation.

SECOND GENERATION APPLICATIONS WITH PIEZOELECTRIC CERAMICS

1940 - 1965

During World War II, in the U.S., Japan and the Soviet Union, isolated research groups working on improved capacitor materials discovered that certain ceramic materials (prepared by sintering metallic oxide powders) exhibited dielectric constants up to 100 times higher than common cut crystals. Furthermore, the same class of materials (called ferroelectrics) were made to exhibit similar improvements in piezoelectric properties. The discovery of easily manufactured piezoelectric ceramics with astonishing performance characteristics naturally touched off a revival of intense research and development into piezoelectric devices.

The advances in materials science that were made during this phase fall into three categories:

1. Development of the barium titanate family of piezoceramics and later the lead zirconate titanate family
2. The development of an understanding of the correspondence of the perovskite crystal structure to electro-mechanical activity
3. The development of a rationale for doping both of these families with metallic impurities in order to achieve desired properties such as dielectric constant, stiffness, piezoelectric coupling coefficients, ease of poling, etc.

All of these advances contributed to establishing an entirely new method of piezoelectric device development - namely, **tailoring a material to a specific application**. Historically speaking, it had always been the other way around. This "lock-step" material and device development proceeded the world over, but was dominated by industrial groups in the U.S. who secured an early lead with strong patents. The number of applications worked on was staggering, including the following highlights and curiosities:

- Powerful sonar - based on new transducer geometries (such as spheres and cylinders) and sizes achieved with ceramic casting.
- Ceramic photo cartridge - cheap, high signal elements simplified circuit design
- Piezo ignition systems - single cylinder engine ignition systems which generated spark voltages by compressing a ceramic "pill"
- Sonobouy - sensitive hydrophone listening/radio transmitting bouys for monitoring ocean vessel movement
- Small, sensitive microphones - became the rule rather than the exception
- Ceramic audio tone transducer - small, low power, low voltage, audio tone transducer consisting of a disc of ceramic laminated to a disc of sheet metal
- Relays - snap action relays were constructed and studied, at least one piezo relay was manufactured

It is worth noting that during this revival, especially in the U.S., device development was conducted along with piezo material development within individual companies. As a matter of policy, these companies did not communicate. The reasons for this were threefold: first, the improved materials were developed under wartime research conditions, so the experienced workers were accustomed to working in a "classified" atmosphere; second, post war entrepreneurs saw the promise of high profits secured by both strong patents and secret processes; and third, the fact that by nature piezoceramic materials are extraordinarily difficult to develop, yet easy to replicate once the process is known.

From a business perspective, the market development for piezoelectric devices lagged behind the technical development by a considerable margin. Even though all the materials in common use today were developed by 1970, at that same point in time only a few high volume commercial applications had evolved (phono cartridges and filter elements, for instance). Considering this fact with hindsight, it is obvious that while new material and device developments thrived in an atmosphere of secrecy, new market development did not - and the growth of this industry was severely hampered.

JAPANESE DEVELOPMENTS

1965 - 1980

In contrast to the "secrecy policy" practiced among U.S. piezoceramic manufacturers at the outset of the industry, several Japanese companies and universities formed a "competitively cooperative" association established as the Barium Titanate Application Research Committee, in 1951. This association set an organizational precedent for successfully surmounting not only technical challenges and manufacturing hurdles, but also for defining new market areas.

Beginning in 1965 Japanese commercial enterprises began to reap the benefits of steady applications and materials development work which began with a successful fish-finder test in 1951. From an international business perspective they were "carrying the ball," i.e., developing new knowledge, new applications, new processes, and new commercial market areas in a coherent and profitable way.

Persistent efforts in materials research had created new piezoceramic families which were competitive with Verrillon's PZT, but free of patent restrictions. With these materials available, Japanese manufacturers quickly developed several types of piezoceramic signal filters, which addressed needs arising in television, radio, and communications equipment markets; and piezoceramic igniters for natural gas/butane appliances.

As time progressed, the markets for these products continued to grow, and other similarly valuable ones were found. Most notable were audio buzzers (smoke alarms, TTL compatible tone generators), air ultrasonic transducers (television remote controls and intrusion alarms) and SAW filter devices (devices employing Surface Acoustic Wave effects to achieve high frequency signal filtering).

By comparison to the commercial activity in Japan, the rest of the world was slow, even declining. Globally, however, there was still much pioneering research work taking place as well as device invention and patenting.

SEARCH FOR HIGH VOLUME MARKETS

1980 - Present

The commercial success of the Japanese efforts has attracted the attention of industry in many other nations and spurred a new effort to develop successful piezoceramic products. If you have any doubts about this, just track the number of piezo patents granted by the U.S. Patent Office every year - there has been a phenomenal rise. Another measure of activity is the rate and origin of article publication in the piezo materials/applications area - there has been a large increase in publication rate in Russia, China and India.

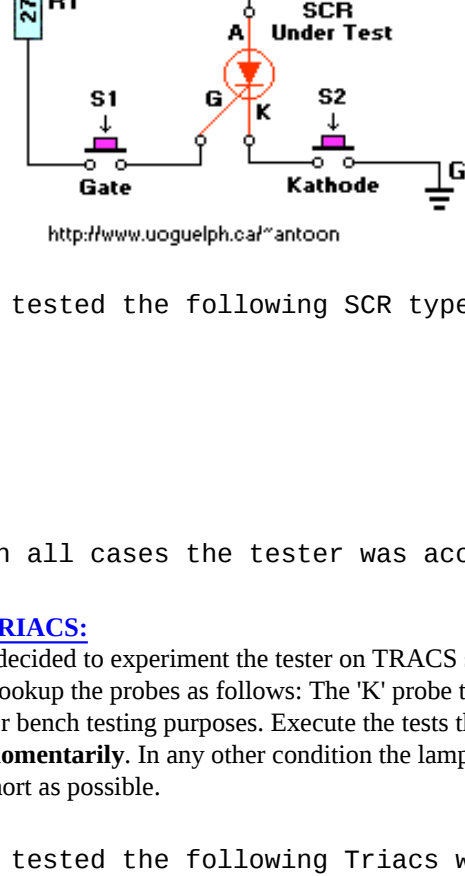
Solid state motion is presently the single most important frontier. The technical goals of the frontier are to obtain useful and reasonably priced actuators which are low in power and consumption and high in reliability and environmental ruggedness; or, more simply stated, "solenoid replacements," or "electrostatic muscles."

The search for perfect piezo product opportunities is now in progress. Judging from the increase in worldwide activity, and from the successes encountered in the last quarter of the 20th century, important economic and technical developments seem certain.

Testing a SCR

Silicon Control Rectifier

"This simple SCR tester can be made with only a couple components. It will provide a visual 'go' or 'no-go' indication--it is simply a voltage source, a lamp, and a resistor through which gate current is supplied."



This handy tester will provide a visual "on" or "off" switching and latching indication. When finished, you can test all those possible 'duds' in your junkbox and dump some of those in the garbage. If the scr is latching and can hold the latch it is most likely okay.

Look at the circuit diagram, it shows a 3-amp, 50-volt SCR (under test) and a test circuit. Points "Gate" and "Kathode" are temporary connections, so that they can easily be opened. I used toggle switches for each, but use whatever you feel comfortable with, a simple jumper wire would do the trick. I use this gadget in my shop and so have it mounted in a small case. This circuit can even be bread-boarded for your purpose.

When "Kathode" is closed, the lamp doesn't light. When "Gate" is **also** closed, the lamp lights to its full intensity. The lamp remains lit even if "Gate" is opened again. But when "Kathode" is opened, even momentarily, the lamp does not close again when "Kathode" is closed. That illustrates the "ON" and "OFF" operation of the SCR.

I tested the following SCR types:

C106D1 (400V/4A)	T106Y1 (30V/4A)
C106F (500V/4A)	C106F1 (50V/4A)
C106B (200V/4A)	CSM2B2 (100V/4A)
T106D1 (400V/4A)	NTE5402 (100V/0.8A)
T1C106M (600V/8A)	NTE5457 (400V/4A)
T1C126M (600V/25A)	CR6AM-B (400V/10A)
MCR106-3 (100V/4A)	NTE5455 (200V/4A)

In all cases the tester was accurate in telling 'good' from the 'bad'.

TRIACS:
I decided to experiment the tester on TRACS since they operate on the same principle. The pin-out of a Triac is usually MT1, MT2, and Gate. Hookup the probes as follows: The 'K' probe to 'MT1'; the 'A' probe to 'MT2' and the 'G' probe to 'Gate'. I used a 9Volt and a 12Volt power-supply for bench testing purposes. Execute the tests the same way as a SCR. The lamp should only be on when the K switch is on and G switches on **momentarily**. In any other condition the lamp should remain off. If not, the Triac will almost certainly be defective. Keep the tests on any Triac as short as possible.

I tested the following Triacs with good results:

Q4006L4 (400V/8A)	- Tested Good (was new)
Q6006LT (600V/10A)	- Tested Defective (was defective)
Q6010L5 (600V/10A)	- Tested Good (was new)
L4004F31 (400V/4A)	- Tested Defective (was defective)
MAC15A (400V/15A)	- Tested Good (was new)
NTE5610 (800V/8A)	- Tested Good (was new)

Again, in all cases the tester was correct. I compared the results of the two defective Triacs with the results of a very expensive commercial SCR/Triac tester. On the commercial tester you can set the actual VRM (volt) of a Triac and check for leakage and what not but I found the end result the same; "is it good or bad" and is it "switching or not".



I am planning to modify this circuit to include all scr's and triac's, including sensitive gate units. See picture at the left. It is in the prototype stage, so far so good.

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Testing a Triac

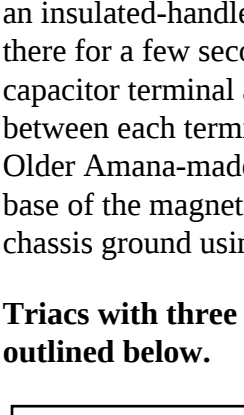
by Tony van Roon

These two testing procedures are for use with a digital multimeter in the Ohm's test-range. Testing procedure was actually designed for testing inside micro-waves (magnetrons), but should be no difference in any other circuit. Test in- or out circuit.

A Triac is an electronic switch or relay. Triacs come in many shapes, sizes, and colors. Check the standard terminal designations in the picture below which shows most of the types of triacs that are commonly used in microwave ovens, along with their standard terminal designations.

Located either externally or fixed within an appliance or equipment, the triac operates when it receives an electronics "gate" signal from the control circuitry. It then switches to its closed or "on" state, thus providing for example, a voltage path to the primary winding of the H.V. transformer in a microwave oven and so activating the cooking controls. Or used in a laboratory water-bath which needs to be kept on a specific temperature. The probe-sensor, which is immersed in the water, keeps track of the temperature and sends a gate signal to the triac to either switch on the heating or cooling elements. Most of these probe sensors only contain one or more diodes of the general 1N4148 or 1N914 types.

Important Safety Information



Working on a microwave oven is a VERY dangerous task. Therefore, BEFORE performing any tests, troubleshooting, or repairs, for your personal safety, I strongly urge you to carefully read, fully understand and be prepared to follow the very important safety precautions.

If you are uneasy or unsure about any of these safety procedures or warnings; or if you feel uncertain as to their importance or your ability to manage them, it would be in your best interest to leave the repair to a qualified professional.

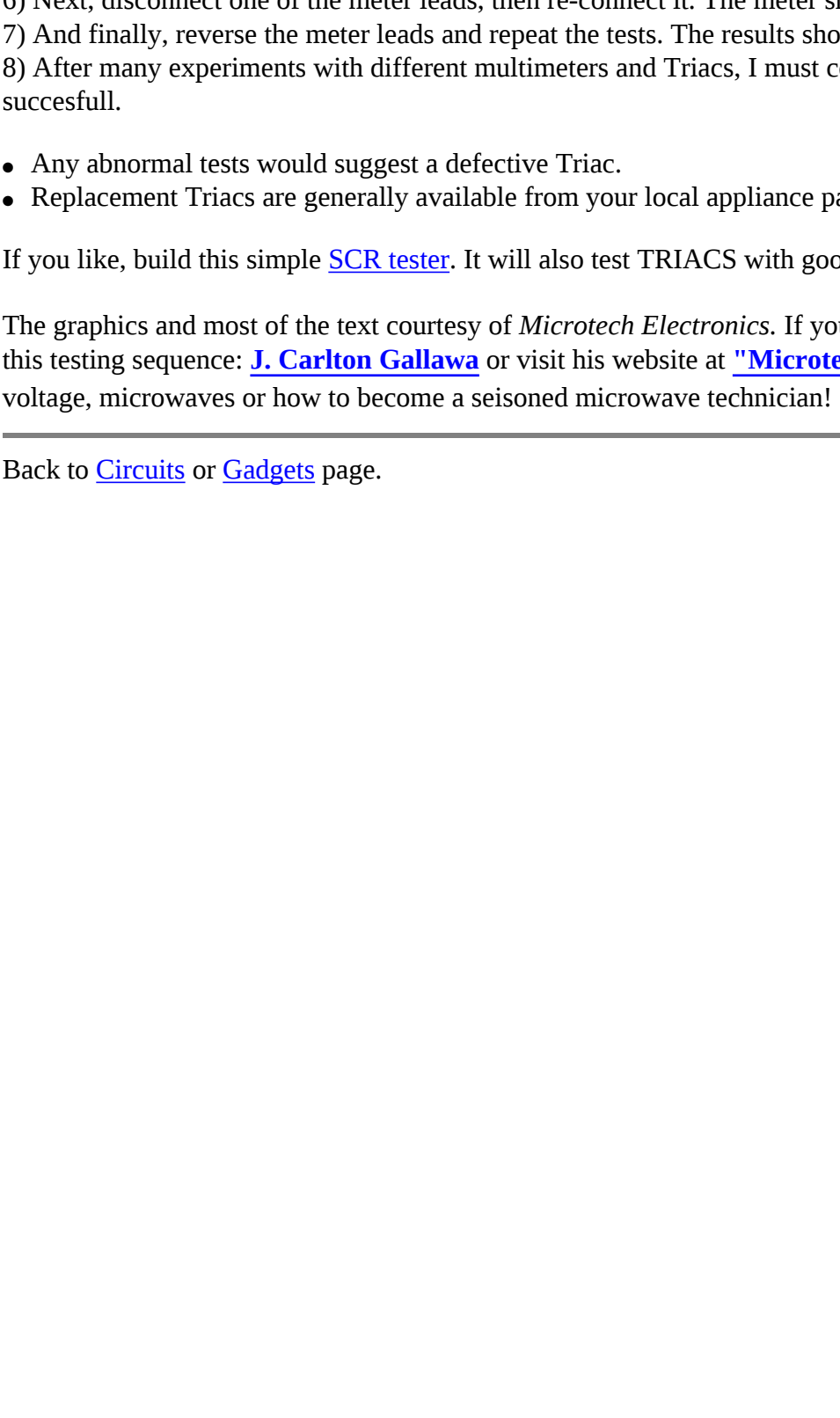
FIRST and ALWAYS, before attempting any repairs, make certain that the unit is not plugged in. Before touching any components or wiring, **ALWAYS DISCHARGE THE HIGH VOLTAGE CAPACITOR!** The high voltage capacitor will quite normally maintain a painfully high-voltage charge even after the oven is unplugged. Some capacitors employ a bleeder resistor (either externally or internally) that allows the charge to slowly bleed (or drain) off after the oven is unplugged. Do not trust a bleeder resistor—it may be open.

If you forget to discharge the capacitor, your fingers may ultimately provide the discharge path. You only make this mistake a few times, because, while the electric shock is painful, the real punishment comes when you reflexively yank your hand out leaving behind layers of skin on razor-like edges that are there as a reminder to never again forget to discharge the high voltage capacitor.

How To Discharge The High Voltage Capacitor: The capacitor is discharged by creating a short circuit (direct connection) the two capacitor terminals and from each terminal, to chassis ground bare metal surface. Do this by touching the blade of an insulated-handled screw driver to one terminal, then slide it toward the other terminal until it makes contact and hold it there for a few seconds. (This can result in a rather startling "pop!") Repeat the procedure to create a short between each capacitor terminal and chassis ground. If the capacitor has three terminals, use the same procedure to create a short circuit between each terminal and then from each terminal to ground.

Older Amana-made models (generally those manufactured before 1977) have red, round filter capacitors mounted in the base of the magnetron tube which can also hold a charge. Ground each magnetron terminal by creating a short circuit to chassis ground using the blade of a screwdriver as explained above.

Triacs with three terminals, such as most shown below, can be tested by making a series of resistance checks as outlined below.



In-Circuit: Discharge any capacitors, or high-voltage capacitors by shorting them out with a piece of wire or insulated screwdriver. **BEFORE** you do that however, make sure it is **UNPLUGGED!** Just in case it is a HV capacitor, be warned that it may give quite a crack! Repeat the procedure a couple times to make sure they are completely discharged.

Here is the complete testing procedure for **TEST-1:**

- 1) Unplug the appliance, equipment, or whatever you're working on.
- 2) **DISCHARGE THE HIGH VOLTAGE CAPACITOR**
- 3) First identify the terminals. The three terminals are generally designated as G (gate), T1 and T2 (a rule of thumb: smallest terminal is the gate; medium sized is T1; largest is T2).
- 4) Carefully remove all harness leads. A soldered-in varactor or snubber may remain

attached providing it is in good condition.

- 5) Set and zero the ohmmeter to a scale capable of reading about 40 Ohms.
- 6) Measure from the *gate* to *T1*, note the reading, then reverse the leads.
- 7) In each measurement, a normal reading would be in the range of 10 to 200 ohms, depending on the Triac model.
- 8) Next, set the meter to its highest resistance scale. Each of the following reading should produce a normal reading of *infinity*:
 - a. From T1 to T2.
 - b. From T1 to the gate.
 - c. From each terminal to chassis ground.

These reading are approximate and may vary with manufacturer, but generally speaking, any results that are significantly different would point to a defective Triac.

CAUTION! Test 2

A second way to test the Triac is to evaluate its gate-firing capability:

- 1) **Unplug the oven.**
- 2) **DISCHARGE THE HIGH VOLTAGE CAPACITOR.**
- 3) Remove all the harness leads. Set the meter to a scale capable of reading about 50 Ohms.
- 4) Attach the **negative** meter lead to **T1** and the **positive** lead to **T2**.
- 5) Now, using a screwdriver blade, create a momentary short between **T2** and the **gate**. This brief contact should turn the triac "on", thus producing a meter reading of about 15 to 50 Ohms.
- 6) Next, disconnect one of the meter leads, then re-connect it. The meter should return a reading of **infinity**.
- 7) And finally, reverse the meter leads and repeat the tests. The results should be the same.
- 8) After many experiments with different multimeters and Triacs, I must conclude that this method is not always successful.

- Any abnormal tests would suggest a defective Triac.
- Replacement Triacs are generally available from your local appliance parts distributor(like Sears) or electronics store.

If you like, build this simple [SCR tester](#). It will also test TRIACS with good results. A simple "good/bad".

The graphics and most of the text courtesy of *Microtech Electronics*. If you have any question(s), please ask the author of this testing sequence: [J. Carlton Gallawa](#) or visit his website at "[Microtech Electronics](#)" to learn more about high voltage, microwaves or how to become a seasoned microwave technician!

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Testing a UJT

Uni Junction Transistor

This testing procedure is for use with a digital multimeter in the OHM's test-range. The UJT is a solid-state 3-terminal (TO-18 case) semiconductor. UJT's are used in pulse/timing, oscillator, sensing, and thyristor triggering circuits. The most common one being probably the 2N2646 from Motorola.

UJT testing is pretty easy once you know how to do it.

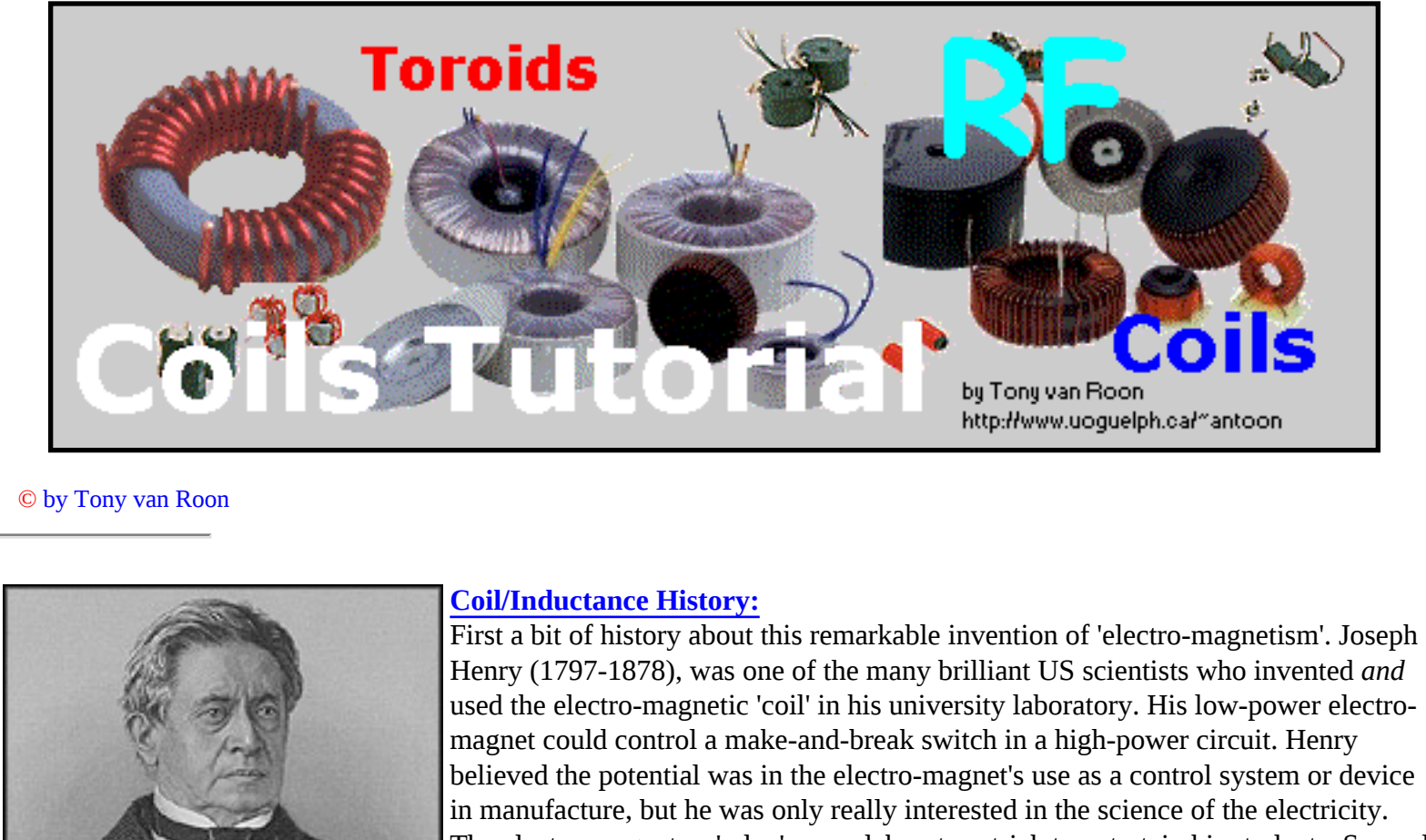
1) With a Digital Multimeter, set in the Ohms position, read the resistance between the Base 1 and Base 2; then reverse the meter-leads and take another reading. Regardless of the meter-lead polarity the measured resistance should approximately be equal (high resistance).

2) Now connect the negative (-) lead of the ohmmeter to the emitter of the UJT. With the positive (+) lead, measure the resistance from the emitter to Base 1 and then from the emitter to base 2. Both readings should indicate high resistance and about equal to each other.

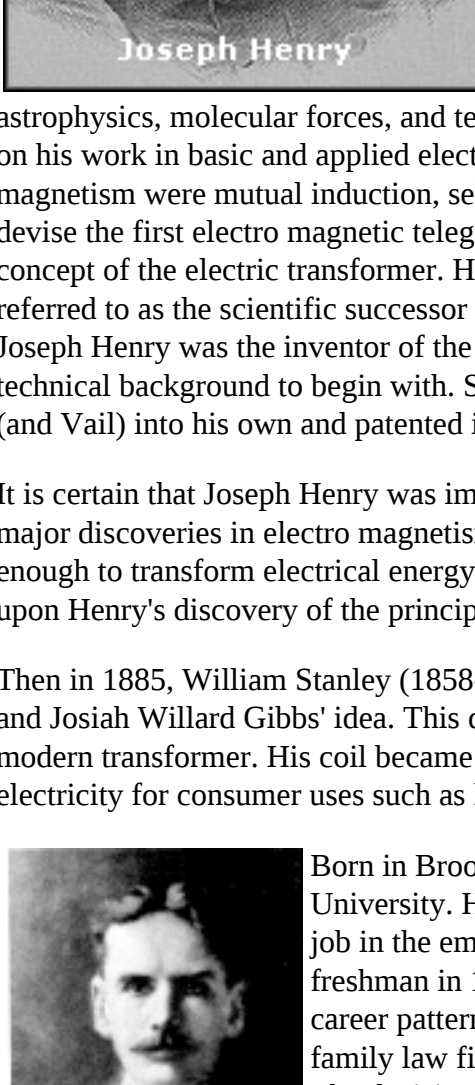
3) Exchange the negative lead to the emitter with the positive lead. Measure with the negative lead the resistance between emitter and Base 1 and from Base 2 to emitter. Both readings should show low resistance and about equal to each other.

'Bottom' view

I bench tested the following UJT models: 2N2646, NTE6401, ECG6401, 2N2647, NTE6409. Tested with the above testing procedures. Testing method was accurate. I also tested faulty UJT's of the same make and models. Testing method was also accurate.



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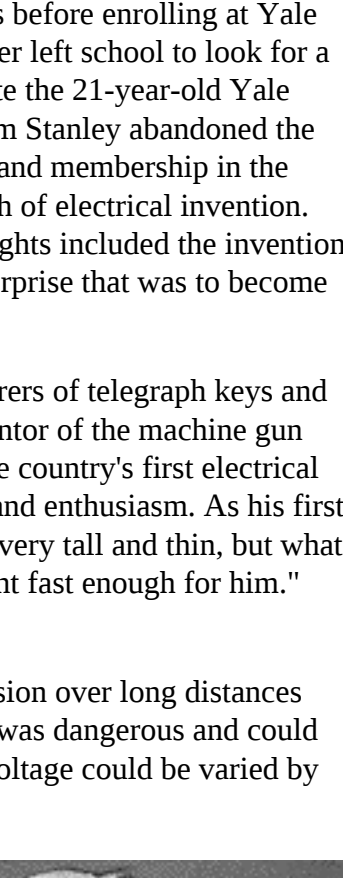
Joseph Henry

astrophysics, molecular forces, and terrestrial magnetism, but his reputation was built primarily on his work in basic and applied electro magnetism. Among his discoveries in electro magnetism were mutual induction, self-induction, the electro magnetic relay--enabling him to devise the first electro magnetic telegraph that could be used over long distances--and the concept of the electric transformer. He also invented the first electric motor. Henry was often referred to as the scientific successor to Benjamin Franklin. Today, it is the general opinion that Joseph Henry was the inventor of the telegraph and not Samuel Morse, who did not have a technical background to begin with. Samuel Morse adapted the ideas and inventions of Henry (and Vail) into his own and patented it, making him the owner.

Coil/Inductance History:

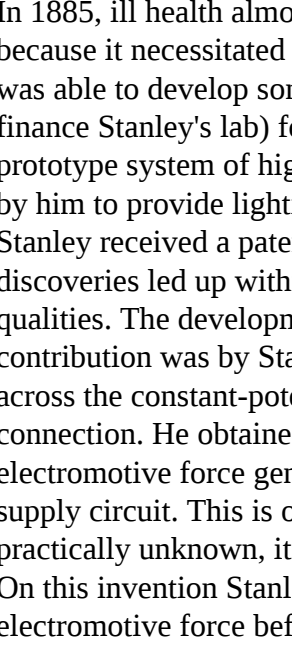
First a bit of history about this remarkable invention of 'electro-magnetism'. Joseph Henry (1797-1878), was one of the many brilliant US scientists who invented *and* used the electro-magnetic 'coil' in his university laboratory. His low-power electro-magnet could control a make-and-break switch in a high-power circuit. Henry believed the potential was in the electro-magnet's use as a control system or device in manufacture, but he was only really interested in the science of the electricity. The electro-magnet or 'relay' was a laboratory trick to entertain his students. Samuel Morse later adapted Henry's electro-magnetic-relay device after re-designing it (and claiming it as his own by patent) using thinner wire, to carry morse-code signals over long kilometers of wire.

In 1846, Joseph Henry was professor of natural philosophy (physics) at the College of New Jersey (now known as Princeton University). He had published scientific articles on a wide variety of subjects, including electro magnetism, optics, acoustics, astrophysics, molecular forces, and terrestrial magnetism, but his reputation was built primarily on his work in basic and applied electro magnetism. Among his discoveries in electro magnetism were mutual induction, self-induction, the electro magnetic relay--enabling him to devise the first electro magnetic telegraph that could be used over long distances--and the concept of the electric transformer. He also invented the first electric motor. Henry was often referred to as the scientific successor to Benjamin Franklin. Today, it is the general opinion that Joseph Henry was the inventor of the telegraph and not Samuel Morse, who did not have a technical background to begin with. Samuel Morse adapted the ideas and inventions of Henry (and Vail) into his own and patented it, making him the owner.



It is certain that Joseph Henry was important to the history of the telegraph in two ways. First, he was responsible for major discoveries in electro magnetism, most significantly the means of constructing electromagnets that were powerful enough to transform electrical energy into useful mechanical work at a distance. Much of Morse's telegraph did indeed rest upon Henry's discovery of the principles underlying the operation of such electromagnets.

Then in 1885, William Stanley (1858-1916), Jr. built the first practical alternating current device based on Lucien Gaulard and Josiah Willard Gibbs' idea. This device was called an induction coil and was very primitive. It was the precursor of the modern transformer. His coil became the prototype for all future transformers and made practical the transmitting of electricity for consumer uses such as lighting.



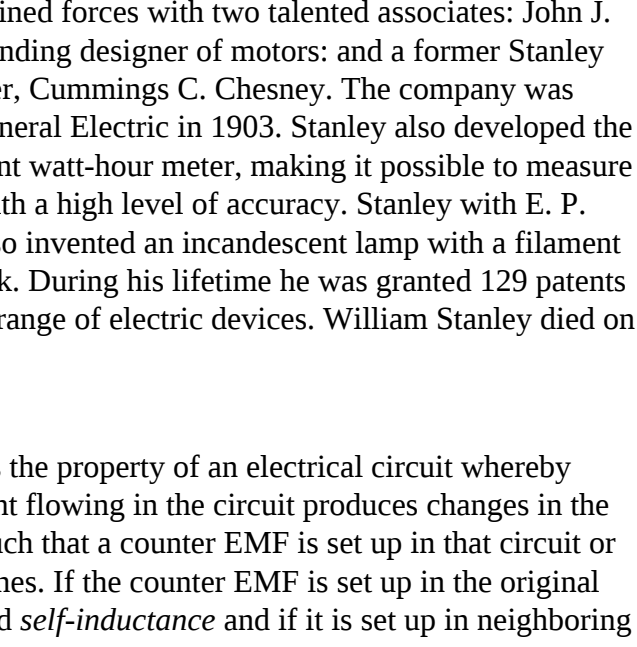
William Stanley, Jr.

Born in Brooklyn, New York, William Stanley attended private schools before enrolling at Yale University. He began to study law at age 21 but less than a semester later left school to look for a job in the emerging field of electricity. "Have had enough of this," wrote the 21-year-old Yale freshman in 1879. "Am going to New York." With these words, William Stanley abandoned the career pattern that his father had laid out for him - college, law school, and membership in the family law firm - and set out instead on the more risky and exciting path of electrical invention. The decision marked the beginning of a productive career whose highlights included the invention of the modern type of transformer, and the creation of the business enterprise that was to become General Electric's Pittsfield Works.

Stanley's first job was as an electrician with one of the early manufacturers of telegraph keys and fire alarms. He then worked in a metal-plating establishment before joining Hiram Maxim, inventor of the machine gun and already a pioneer in the electrical industry. As Maxim's assistant, Stanley directed one of the country's first electrical installations, in a store on New York's Fifth Avenue. Stanley gave early evidence of his ability and enthusiasm. As his first employer, inventor Hiram S. Maxim described him: "Mr. Stanley was very young. He was also very tall and thin, but what he lacked in bulk, he made up for in activity. He was boiling over with enthusiasm. Nothing went fast enough for him." This dynamism helped him gain an outstanding reputation in the early electrical industry.

In the 1880s every system for distributing electricity used direct current (DC). But DC transmission over long distances was impractical. Transmitting at low voltage required thick wires. Transmitting at high voltage was dangerous and could not be reduced for consumer uses such as lighting. It was known that alternating current (AC) voltage could be varied by use of induction coils, but no practical coil system had been invented.

Inventor and industrialist George Westinghouse learned of Stanley's accomplishments and hired him as his chief engineer at his Pittsburgh factory. It was during this time that Stanley began work on the transformer. Actually the first practical AC transformer was developed by Frenchman Lucien Gaulard and Englishman John Gibbs; improvements were made at the Ganz company in Budapest. Westinghouse instructed Stanley and his assistants, Schmid and Shallenberger, to make tests to determine the commercial value of the Gaulard and Gibbs system. He also arranged to have a number of the transformers and a Siemens alternating-current generator forwarded from England to Pittsburgh. Stanley, working under the direction of Westinghouse, devised a further improvement, which consisted in securing the enclosure of the coils by making the core of E-shaped plates, the central projections of each successive plate being alternately inserted through prewound coils from opposite sides, thus permitting separate winding and consequently the better insulation of the coils. This form was further improved by Albert Schmid, who extended the ends of the arms of the E to meet the central projection. When inserting these plates the extensions were temporarily bent upward, and upon being released each plate formed a closed magnetic circuit about the sides of the coils.

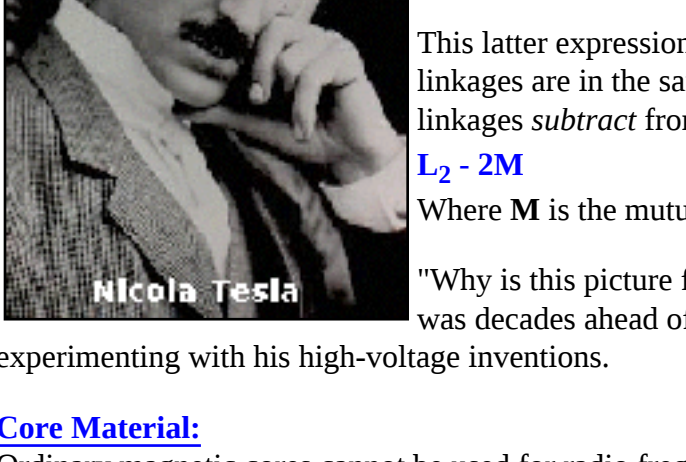


Stanley Transformer

In 1885, ill health almost cut short his career--some say he worked himself too hard. But it proved a disguised blessing, because it necessitated a move to his family home, Great Barrington, Massachusetts. In those peaceful surroundings, he was able to develop some ideas he had suggested two years earlier to his employer, George Westinghouse (who helped finance Stanley's lab) for a new type of transformer. This work resulted, on March 20, 1886, in the demonstration of a prototype system of high voltage transmission employing Stanley's parallel connected transformer. This system was used by him to provide lighting for offices and stores on the town's Main Street.

Stanley received a patent on his transformer: "Induction-Coil", Patent No. 349,611. These various inventions and discoveries led up within a year to commercial production of transformers of high efficiency and excellent regulating qualities. The development was a fine engineering performance in speed and in quality. The most important single contribution was by Stanley. He brought out the parallel connection in which the transformers are connected in parallel, across the constant-potential alternating-current system, instead of being arranged in series, as in the Gaulard and Gibbs connection. He obtained patents on the method, involving the construction of transformers in which the counter electromotive force generated in the primary coil of the transformer was practically equal to the electromotive force of the supply circuit. This is obvious now, but in 1886, when the principles and characteristics of the alternating current were practically unknown, it was a wonderful invention, and revolutionary in character.

On this invention Stanley's fame largely rests. Of course Stanley did not discover or invent a theory of counter electromotive force before any one else had thought of it. Such fundamental things seldom happen in invention. His claim to great and original merit rests on the discovery of a theory which was new to him and the use of it in making a structure of immense importance in the affairs of men. Briefly, all transformers now made are built upon practically the same principles as those that were developed in these early products of the Westinghouse Company.



Assisted by William Stanley, George Westinghouse worked to refine the transformer design and build a practical AC power network. In 1886, Westinghouse and Stanley installed the first multiple-voltage AC power system in Great Barrington, Massachusetts. The network was driven by a hydro power generator that produced 500 volts AC. The voltage was stepped up to 3,000 volts for transmission, and then stepped back down to 100 volts to power electric lights. In 1890 Stanley established the Stanley Electric Manufacturing Company in Pittsfield, Massachusetts, to make transformers and auxiliary electrical equipment as well as electrical appliances. To organize it, he joined forces with two talented associates: John J. Kelley, an outstanding designer of motors; and a former Stanley laboratory worker, Cummings C. Chesney. The company was purchased by General Electric in 1903. Stanley also developed the alternating-current watt-hour meter, making it possible to measure electricity use with a high level of accuracy. Stanley with E. P. Thomson had also invented an incandescent lamp with a filament of carbonized silk. During his lifetime he was granted 129 patents covering a wide range of electric devices. William Stanley died on May 14, 1916.

Inductance:

Inductance (L) is the property of an electrical circuit whereby changes in current flowing in the circuit produces changes in the magnetic field such that a counter EMF is set up in that circuit or in neighboring ones. If the counter EMF is set up in the original circuit, it is called *self-inductance* and if it is set up in neighboring circuit it is called *mutual inductance*.

The unit of inductance is the *Henry (H)* and is defined as that value of inductance in which an induced EMF of one volt is produced when the inducing current is varied at the rate of one ampere per second. The Henry is commonly sub-divided into several smaller units, the *milliHenry (10⁻³ Henry)* abbreviated *mH*, the *microHenry (10⁻⁶ Henry)* abbreviated *μH*, and the *nanoHenry (10⁻¹² Henry)* abbreviated *nH*.

The storage of energy in a magnetic field is expressed in *joules* and is equal to $L^2/2$ and the dimensions are in *watt-seconds*.

Mutual Inductance:

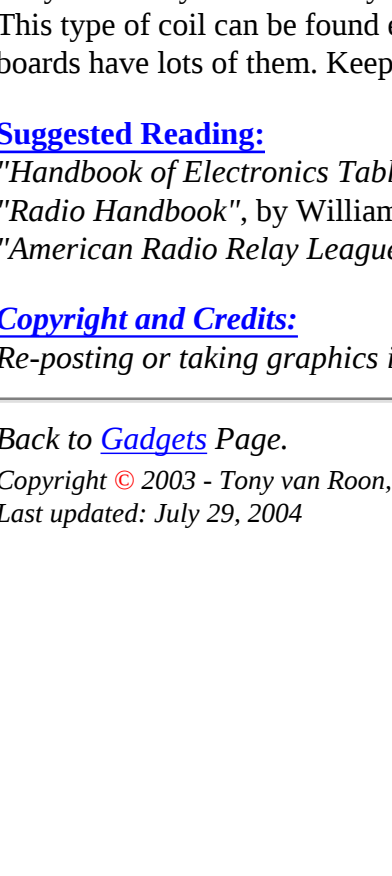
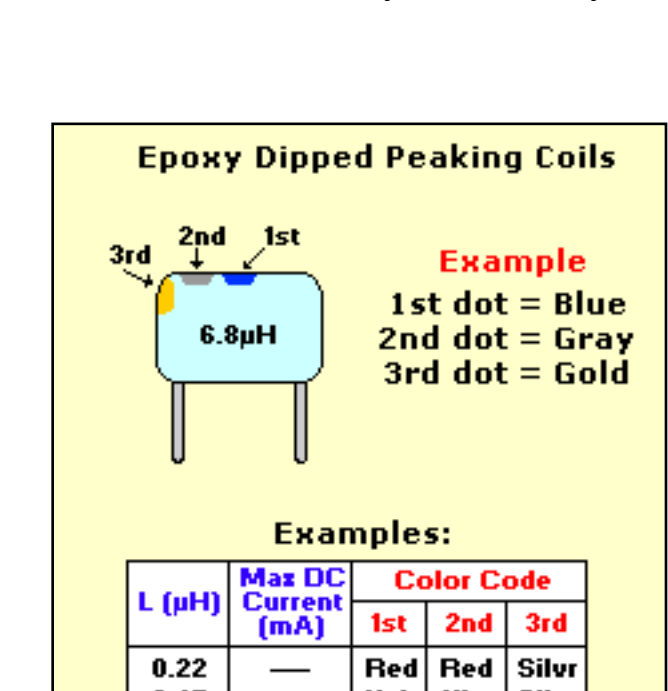
When one coil is near another, a varying current in one will produce a varying magnetic field which cuts the turns of the other coil, inducing a current in it. This induced current is also varying, and will therefore induce another current in the first coil. This reaction between two couple circuits is called *mutual inductance*, and can be calculated and expressed in henrys.

The symbol for mutual inductance is *M*. Two circuits thus joined are said to be *inductively coupled*.

Size magnitude of the mutual inductance depends on the shape and size of the two circuits, their positions and distances apart, and the permeability of the medium. The extent to which two inductors coupled is expressed by a relation known as *coefficient of coupling (k)*. This is the ratio of the mutual inductance actually present at the maximum possible value.

Thus, when *k* is 1, the coils have the maximum degree of mutual induction.

The mutual inductance of two coils can be formulated in terms of the individual inductances and the coefficient of coupling with the formula: $M = k \sqrt{L_1 L_2}$



Nikola Tesla

Inductors in Series:

Inductors in series are, just like resistors, additive. Provided that no mutual inductance exists.

In this case, the total inductance **L** is: $L = L_1 + L_2 + ...$ etc.

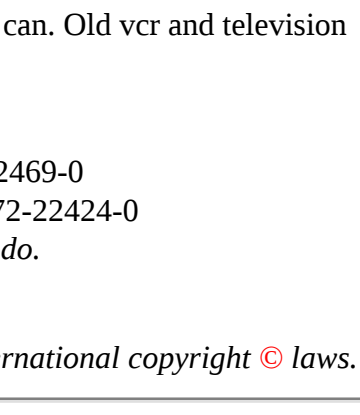
Where mutual inductance does exist: $L = L_1 + L_2 + 2M$

Where **M** is the mutual inductance.

This latter expression assumes that the coils are connected in such a way that all flux linkages are in the same direction, i.e. additive. If this is not the case and the mutual linkages *subtract* from the self-linkages, the following formula should be used: $L = L_1 + L_2 - 2M$

Where **M** is the mutual inductance.

"Why is this picture from Nikola Tesla here" you may ask. Well, like Joseph Henry, Tesla was decades ahead of time. Tesla had his own variety of "transformer" look-alike while experimenting with his high-voltage inventions.



Core Material:

Ordinary magnetic cores cannot be used for radio frequencies because the "eddy current and hysteresis losses" in the core material become enormous as the frequency is increased. The principal use for conventional magnetic cores is in the audio frequency range below approximately 15,000 hertz, whereas at very low frequencies (50 or 60Hz) their use is mandatory if an appreciable value of inductance is desired.

Copper Wire Table:

Below is part of an example of a so called "Copper Wire Table" with the most popular gauge #'s and associated diameter in milli-meters. I did not specify the Mills' or Capacity specs. A 'Mil' is 1/1000 (one thousandth) of an inch. But this information can be found in the ARRL Handbook for Radio Amateurs which is available at your local library.

Gauge (ga)	Ohms per 1000 feet	Diameter in mm
18	6.510	1.024
19	8.210	.9146
20	10.35	.8128
21	13.05	.7230
22	16.46	.6438
23	20.76	.5733
24	26.17	.5106
25	33.00	.4547
26	41.62	.4049
27	52.48	.3606
28	66.17	.3211
29	83.44	.2859
30	105.2	.2546
31	132.7	.2268
32	167.3	.2019
33	211.0	.1798
34	266.0	.1601
35	335.0	.1426
36	423.0	.1270
37	533.4	.1131
38	672.6	.1007
39	848.1	.0897

Coils Color Code:

Very seldom a small coil or rf-choke will have the value stamped on them. Even the larger coils don't show anything but a code. They get a 'color-code' painted on them much like resistors have but usually only 3 bands or 3 dots, unless they are made by 'Mil Spec' (Military Specification). I opted for a couple of the most commonly used types as an example. The body itself may have a variety of colors depending on the dipped substance used.

This type of coil can be found everywhere these days and I'll take them from whatever board I can. Old vcr and television boards have lots of them. Keep a couple around, just in case.

Suggested Reading:

"Handbook of Electronics Tables and Formulas", by Howard W. Sams & Co., ISBN: 0-672-22469-0
"Radio Handbook", by William I. Orr, W6SAI, Howard W. Sams & Co.,(#22424), ISBN: 0-672-22424-0
"American Radio Relay League", or 'ARRL' book. Any handbook of the ARRL of any year will do.

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Last updated: July 29, 2004

Make Your Own Shunts

By Dean F. Poeth, II

"While they might not be as accurate as the commercial units, these easy-to-make shunts are more than sufficient for many uses, and cost far less."

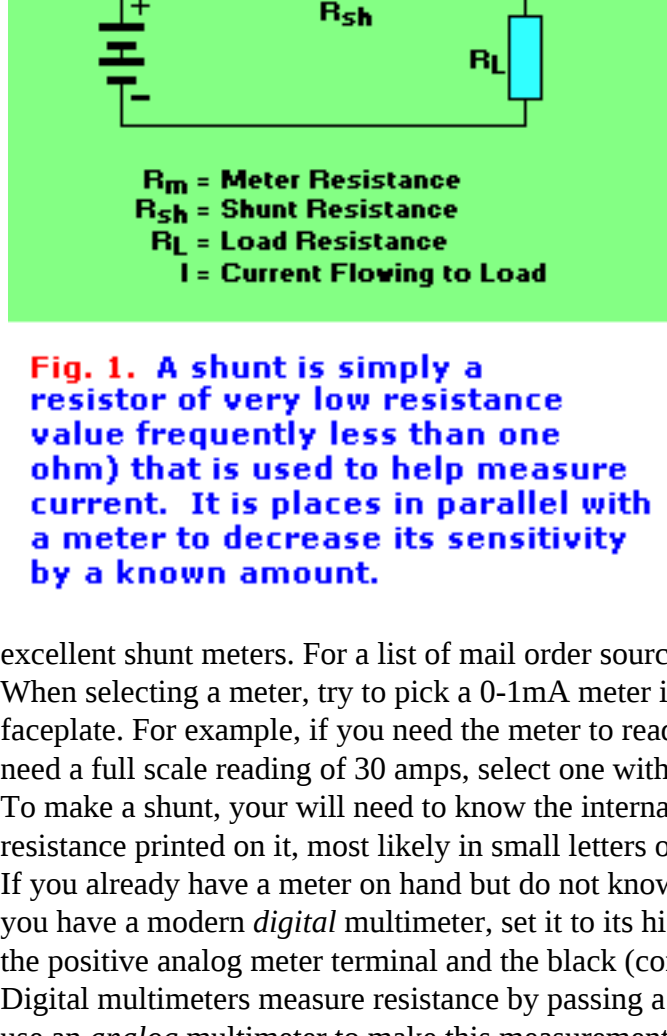


Fig. 1. A shunt is simply a resistor of very low resistance value frequently less than one ohm) that is used to help measure current. It is places in parallel with a meter to decrease its sensitivity by a known amount.

excellent shunt meters. For a list of mail order sources of surplus analog meters, as well as new ones, see the sidebar. When selecting a meter, try to pick a 0-1mA meter in good physical condition and one with a convenient scale on the faceplate. For example, if you need the meter to read 100-amps full scale, then select a meter graduated from 0-1. If you need a full scale reading of 30 amps, select one with a 0-3 graduation. This way the job is easy! To make a shunt, your will need to know the internal resistance of your meter. Therefore, select a unit that has its internal resistance printed on it, most likely in small letters on the meter face or on the back near the terminals. If you already have a meter on hand but do not know its internal resistance, there is a simple way it can be determined. If you have a modern *digital* multimeter, set it to its highest resistance range. Connect the multimeter's red (positive) lead to the positive analog meter terminal and the black (common) lead to the analog meter's negative terminal. Digital multimeters measure resistance by passing a small amount current through the device under test. Do not attempt to use an *analog* multimeter to make this measurement. These older multimeters use much more current to test resistance, enough to potentially destroy some mA meters. Watching your analog meter, work your way down the DMM's resistance ranges (remember you began at the highest range) until the analog meter's needle moves to a full-scale reading. Note the reading on your DMM, and write it on the back of the meter using a permanent marker. Be careful and take your time. If you go too fast and accidentally pin the meter, it could easily be damaged. (Tony's Note: I checked a dozen or so meters of different variety and found that this method of measuring the internal resistance of a particular meter is flawed and does not always work. Best is to obtain a meter with this resistance (Ri) written somewhere on the meter.)

Making the Shunt: The shunt is made from a short length of copper wire. All wire has resistance, so we can use that property to make a shunt resistor. To make a shunt, you first need to determine how much current will flow through it. For example, if your meter is going to measure 20 amps full scale, then the shunt wire must be safely able to carry that amount of current.

Let's say you are going to make a 20-amp shunt using a surplus analog 0-1 milliammeter (mA) whose face plate is graduated from 0-1. Go to a copper-wire table (there is one in every *ARRL HANDBOOK for Radio Amateurs*; if you don't have a copy, it is available at almost any public library) and select an appropriate gauge wire. Remember that the smaller the wire gauge, the more current it can safely carry. For most hobby applications, 250 circular mils per amp is more than adequate.

To find the circular mils per amp for the shunt wire, divide the circular mils for the selected wire (found in the copper wire table) by the current you intend to pass through the wire:

Circular Mils per amp = (circular mils for wire) / (current through the wire) (Eq. 1)

By using the copper wire table, you will find that 12-gauge wire has a cross-sectional area of 6530 circular mils. By dividing that by 20 amps, we get 326 circular mils/amp, which should work fine. 12 gauge wire is very common, and can be purchased in most hardware stores. To find the resistance of the shunt, use this equation:

Rsh=Rm / (n-1) (Eq. 2)

Where Rsh is the resistance of the shunt, Rm is the resistance of the surplus meter, and n is the shunt's multiplication factor. In our example, since we are using a 0-1mA meter and 1 mA=0.001amps, n=20amps / 0.001amps, or 20,000. Next, let's suppose that the resistance of your meter was 81 ohms. Plugging that resistance and n=20,000 into equation 2 (Eq.2) yields:

Rsh = 81 / 20,000 - 1) = 0.00405 Ohms.

That's not very much resistance, is it! A shunt having that resistance will pass 19.999 amps through it, and 0.001A (1 mA) will pass through the meter for a full scale reading. Next, we need to calculate the lenth of our copper wire shunt. Note that as stated in the copper-wire table, 12 gauge wire has a resistance of 1.619 ohms/1000ft. Therefore, the length of the shunt wire (Ls) can therefore be determined using:

Ls=Rsh / (XV/1000ft.) = 0.00405 / (1.619/1000ft.) = 2.5 ft.

So the 12-gauge wire shunt should be 2 feet 6 inches long when using a 0-1mA meter having an internal resistance of 81 ohms to measure 20 amps full-scale. If we made this shunt too long, however, we might have trouble with contact resistance. That is because even a good solder joint has a lot of resistance when compared to a 0.00405-ohm shunt. To make sure that the circuit's contact resistance is not part of the shunt resistance, two sense wires may be used. These sense wires are spaced Ls apart on the shunt wire as shown in **Fig. 2**. Any type of wire may used for the sense wires; they are noncritical. This simple feature will greatly increase the accuracy of your shunt.

Now we are ready to make our shunt. Cut a length of 12-gauge solid copper wire (also called Magnet Wire) about 3-feet long. Remove the insulating coating from the wire with a hobby knife or sand paper, being careful not to nick it. Now solder about 2 inches from one end and solder one sense wire there. Carefully measure 2 ft 6 inches from that sense wire and solder the second sense wire in position. Connect the shunt to its meter as shown in **Fig. 2**, and you're ready to measure current! If you want to make the shunt a little more compact, you can wind it over an insulated screwdriver handle, or something similar, such as a non-conductive wood dowel.

Calibrating the Shunt: Shunts made using this method can be very accurate. However, improved accuracy can be achieved by calibrating the shunt to a known standard, i.e. a calibrated meter. To do this, build the circuit shown in **Fig. 3**. Make sure that the load resistance, RL, can safely handle the power. I have found that car tail light lamps make a convenient load for the circuit.

To calibrate the shunt, solder one sense wire into position as described above. Power up the circuit and slide the second sense wire up and down the shunt wire until you find the spot where the shunt meter reads the same current as the calibrated meter. Remove power from the circuit and solder the second sense wire at that spot.

AWG	Diam. Mills	Circular Mills	Ohms / 1000ft at 25 °C	mm	Closest British SWG
18	40.3	1624.09	6.3860	1.024	20
20	32.0	1024.00	10.1280	0.813	22
21	28.5	812.25	12.7700	0.724	23
22	25.3	640.09	16.2000	0.643	24
24	20.1	404.01	25.6700	0.511	26
26	15.9	252.81	41.0200	0.404	29
28	12.6	158.76	65.3100	0.320	31
30	10.0	100.00	103.7100	0.254	34
32	8.0	64.00	162.0000	0.203	37
34	6.3	39.69	261.3000	0.142	38-39
36	5.0	25.00	414.8000	0.127	41
38	4.0	16.00	648.2000	0.102	43

Fig. 4

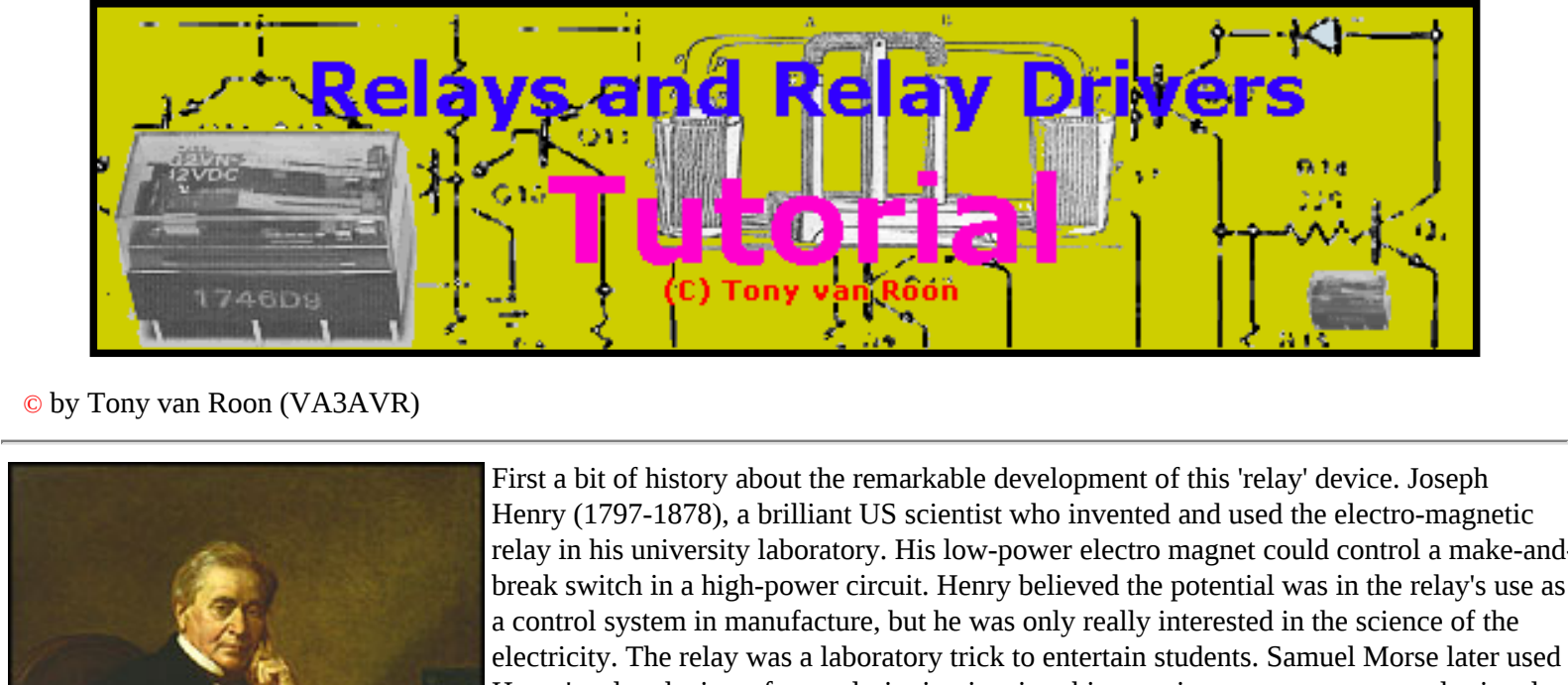
The table above **Fig. 4**, shows the most common wire types I use myself. If you need other AWG or wire information I suggest to purchase the ARRL Radio Amateur Handbook. It contains a HUGE treasure of all kinds of information. I will answer no emails in regards to the Copper Wire Specifications. Buy the ARRL Handbook, you will be impressed!

Conclusion: Using these methods you can make shunts for almost any range of DC currents. What's more, with a little care you should be able to make shunts accurate to within 5-10% if you keep them near room temperature. Of course, these shunts are not nearly as precise or temperature-stable as the commercial versions. Still, if you need one for a non-demanding application(like a variable power supply), or just want to have some fun, grab a few cents worth of wire and make your own shunt!

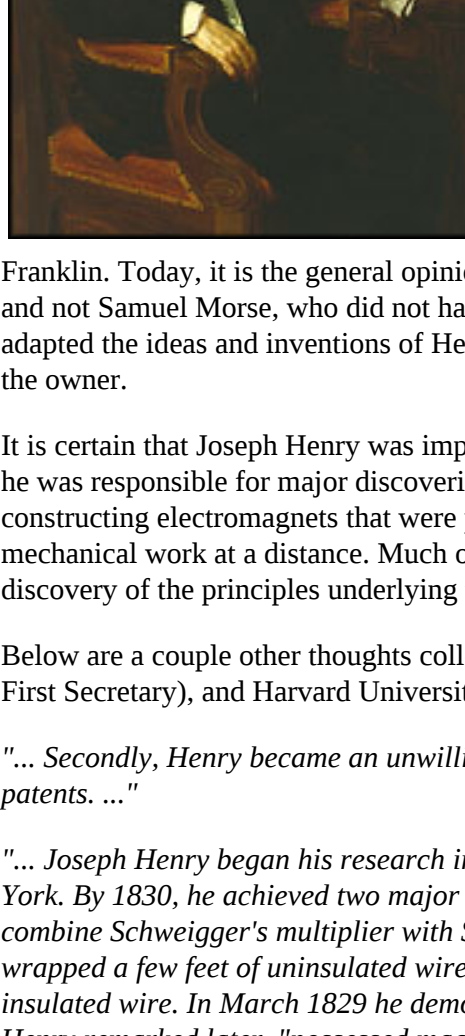
I fully support this project, since my unit has been in operation for quite a few years now and still using the same battery. Most parts can be obtained via your local electronics store. I will answer all questions but via the message forum only. **Tony's Message Forum** can be accessed via the main page, gadgets, or circuits page.

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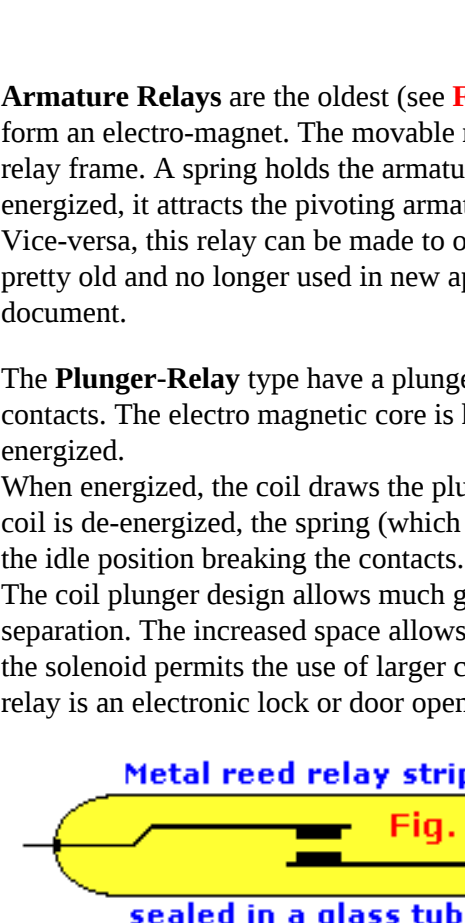
Franklin. Today, it is the general opinion that Joseph Henry was the inventor of the telegraph and not Samuel Morse, who did not have a technical background to begin with. Samuel Morse adapted the ideas and inventions of Henry (and Vail) into his own and patented it, making him the owner.

It is certain that Joseph Henry was important to the history of the telegraph in this way. First, he was responsible for major discoveries in electro magnetism, most significantly in the means of constructing electromagnets that were powerful enough to transform electrical energy into useful mechanical work at a distance. Much of Morse's telegraph did indeed rest upon Henry's discovery of the principles underlying the operation of such electromagnets.

Below are a couple other thoughts collected from the Smithsonian Institute (of which Henry was First Secretary), and Harvard University:

"... Secondly, Henry became an unwilling participant in the protracted litigation over the scope and validity of Samuel Morse's patents. ..."

"... Joseph Henry began his research into electro magnetism in 1827, while he was an instructor at the Albany Academy in New York. By 1830, he achieved two major breakthroughs ... His first crucial innovation, which he demonstrated in June 1828, was to combine Schweigger's multiplier with Sturgeon's electro magnet to obtain an extremely powerful magnet. While Sturgeon loosely wrapped a few feet of uninsulated wire around a horseshoe magnet, Henry tightly wound his horseshoe with several layers of insulated wire. In March 1829 he demonstrated an electro magnet with 400 turns, or about 35 feet, of insulated wire. This magnet, Henry remarked later, "possessed magnetic power superior to that of any before known."



Henry, was a scientist and physicist by trade and a true teacher to his students. As a reward, they (not his students) stole his ideas and scientific experiments. For that reason I'm convinced that Morse was a fraud, preying on the ideas and inventions (like the telegraph) of others and putting his patent on it (obtained on October 3, 1837). I do credit Samuel Morse, however, for the morse-code, which is still used to this date and no person without a 5-wpm morse-code qualification exam can call him/herself a Advanced Radio Amateur! (see Fig. a).

First a bit of history about the remarkable development of this 'relay' device. Joseph Henry (1797-1878), a brilliant US scientist who invented and used the electro-magnetic relay in his university laboratory. His low-power electro magnet could control a make-and-break switch in a high-power circuit. Henry believed the potential was in the relay's use as a control system in manufacture, but he was only really interested in the science of the electricity. The relay was a laboratory trick to entertain students. Samuel Morse later used Henry's relay device, after re-designing it using thinner wire, to carry morse-code signals over long kilometers of wire.

In 1846, Joseph Henry was professor of natural philosophy (physics) at the College of New Jersey (now known as Princeton University). He had published scientific articles on a wide variety of subjects, including electro magnetism, optics, acoustics, astrophysics, molecular forces, and terrestrial magnetism, but his reputation was built primarily on his work in basic and applied electro magnetism. Among his discoveries in electro magnetism were mutual induction, self-induction, the electro magnetic relay--enabling him to devise the first electro magnetic relay that could be used over long distances--and the concept of the electric transformer. He also invented the first electric motor. Henry was often referred to as the scientific successor to Benjamin Franklin.



Click Here

Henry did set out to demonstrate the practicality of an electro magnetic telegraph immediately after his paper appeared. His prototype consisted of a small battery and an "intensity" magnet connected through a mile of copper bell-wire strung through a lecture hall. In between the poles of this horseshoe electro magnetic he placed a permanent magnet. When the electro magnetic was energized, the permanent magnet was repelled from one pole and attracted to the other; upon reversing battery polarity, the permanent magnet returned to its original position. ... Henry caused the permanent magnet to tap a small office bell. He consistently demonstrated this arrangement to his classes at Albany during 1831 and 1832."

In short, this man, Joseph Henry, was a scientist and physicist by trade and a true teacher to his students. As a reward, they (not his students) stole his ideas and scientific experiments. For that reason I'm convinced that Morse was a fraud, preying on the ideas and inventions (like the telegraph) of others and putting his patent on it (obtained on October 3, 1837). I do credit Samuel Morse, however, for the morse-code, which is still used to this date and no person without a 5-wpm morse-code qualification exam can call him/herself a Advanced Radio Amateur! (see Fig. a).

International Alphabet:
Alfa Bravo Charlie Delta Echo Foxtrot Golf Hotel India Juliet Lima Mike November Oscar Papa Quebec Romeo Sierra Tango Uniform Victor X-ray Yankee Zulu
Fig. a

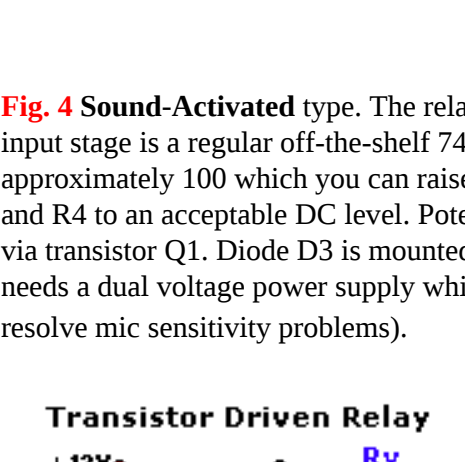


Fig. 1

Since this important day in 1836, when Joseph Henry transmitted a small electrical current down a wire to energize a remote coil and the completed circuit ringing a bell some 150 years ago, the relay has undergone steady evolution and today's relays are far removed from the crude and clumsy relays of Henry's day. In our millennium, solid-state has replaced the actual relay in many circuits, especially in AC applications. To sum it all up, the relay (and solenoids) have survived the tube, transistor, and integrated circuit (IC) eras.

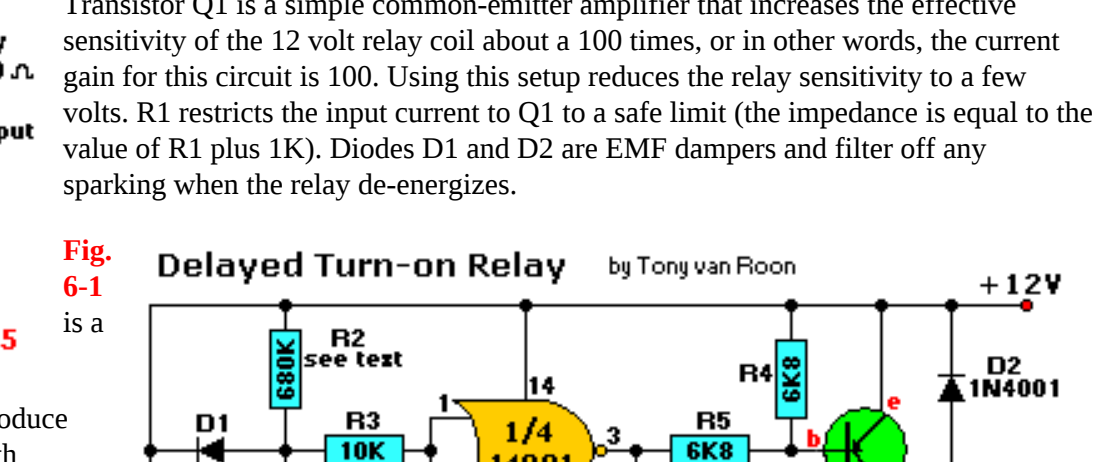


Fig. 2

Basically, a relay is an electrically operated switch, and actually the predecessor of the transistor. Solenoids are relays also but the very large types which carry huge amounts of current. Relays are the smaller types. Relays come in three types: electro mechanical, solid-state, and so-called hybrids which are a combination of the first two. There are also some specialized types that fall into neither category but I will deal with them later in this tutorial. Lets take electro-mechanical types first, they are available in three main models; armature, plunger, and reed. The

Armature Relays are the oldest (see Fig. 1) but elegant. Plenty tons of very fine magnet-wire are wound around an iron core to form an electro-magnet. The movable metal armature has an electrical contact that is positioned over a fixed contact attached to the relay frame. A spring holds the armature up so that the movable and fixed contacts are normally separated (open). When the coil is de-energized, the spring (which is mounted over a section of the plunger) retracts the plunger and positions the assembly in the idle position breaking the contacts. The coil plunger design allows much greater contact travel than the pivoting armature design, thus allowing wide contact separation. The increased space allows plunger systems to be used with higher voltages than armatures. The higher closing force of the solenoid permits the use of larger contacts and provides greater current handling capability. One application of a plunger-type relay is an electronic lock or door opener.

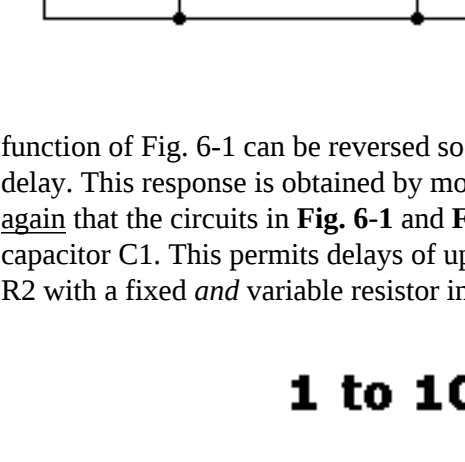
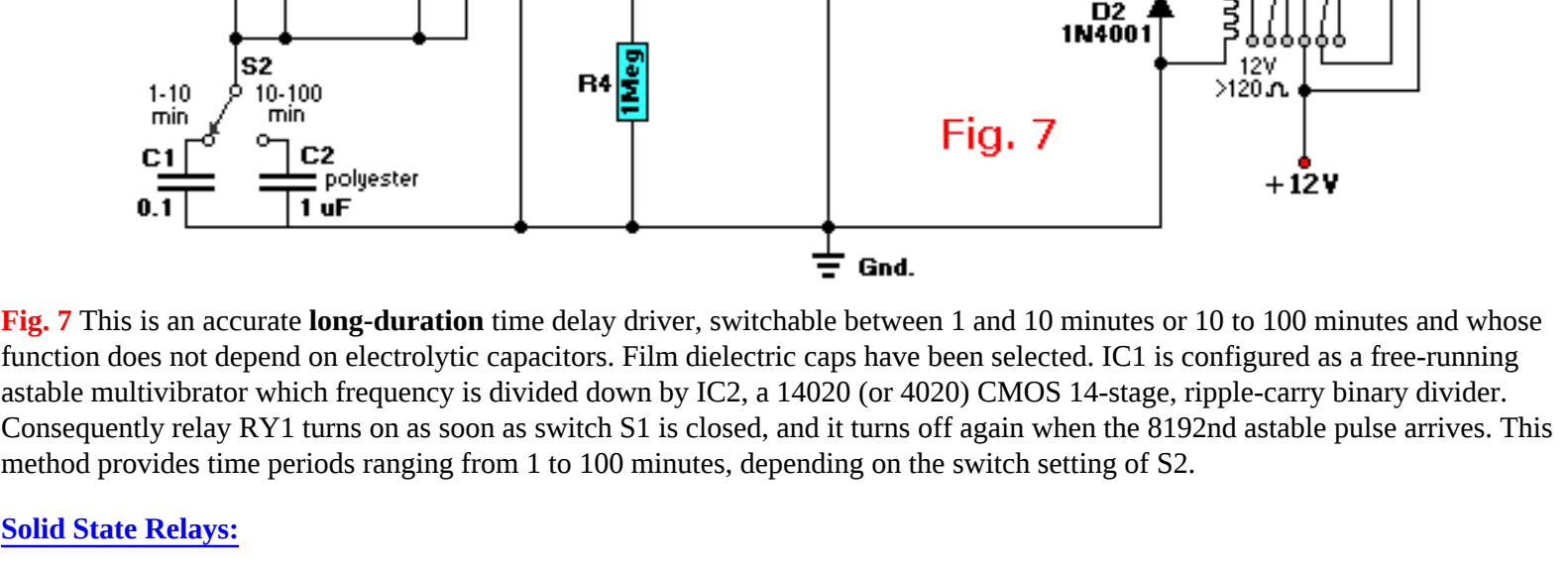


Fig. 3

Since their inception, electro-magnetic relays have improved in sensitivity, switching complexity, current handling, response time, and reliability. It allowed for miniaturization in radios, cassette recorders, Radio Control (R/C), NASA, and other home electronics applications. Being relatively small, **Reed Relays** fill the demand for all sorts of 'small' stuff. The use of flexible reeds and self-attraction distinguishes the reed relay. See Fig. 3, from other electro magnetic relays. Note that the drawing shows the reed-relay without the actuator coil. The contacts are mounted on thin metal strips (reeds) and hermetically sealed in a glass tube. The coil is surrounded by a magnetic coil which, when activated, magnetizes the reeds and causing them to attract each other which closes the contacts. When the coil is de-energized, the spring tension in the reeds causes them to separate again. This type of design has the advantages of high speed operation, long life, and very low price. One of the great advantages reed relays share with other electro magnetic relays is the relative ease with which they can be fitted with multiple contacts. As in the armature and plunger designs, the contact mechanisms can be stacked to provide multiple circuit-close or open designs, or even a combination of both, all activated by a single coil. In reed relays, multiple contact pairs, and in individual tubes, can be stacked and used with a single coil in a very small space. This is not a feature of solid-state relays.

Some Relay-driver Examples using regular components:



Data Sheet for various components

by Tony van Roon

(c) Tonyvan/Poon

LM350K
TO3

LM350T

Plastic Case

Pin 1: Adjust
2: Vin
3: Vout

Bottom view

Metal Case

Bottom view

LM350T

T-Suffix Plastic Package Case 221A-04

TO220

Pin 1: Adjust
2: Vin
3: Vout

Heatsink surface connected to Pin 3.

Pin out for LM134/LM234/LM334

3-Terminal Adjustable Current Sources

TO-46 Metal Can Package

Bottom view

TO-92 Plastic Package

Bottom view

LM301A - OpAmp

Balance/Compensation 1
Input 2
Input 3
V₋ 4
8 Compensation
7 V₊
6 Output
5 Balance

BD140

3 Collector

1 Pin 1: Emitter
2 Base
3: Collector

BC546, A, B BC547, A, B, C BC548, A, B, C

3 Collector

1 Emitter
2 Base
3 Collector

Amplifier Transistors NPN Silicon

(C) Tony van Raan

BC556, A, B BC557, A, B, C BC558, A, B, C

3 Collector

1 Emitter
2 Base
3 Collector

Amplifier Transistors PNP Silicon

(C) Tony van Raan

TO-92

1 Front View

2N3904, 2N3905 2N3906

Case 29-04, Style 1
TO-92 (TO226AA)

3 Collector

1 Emitter
2 Base
3 Collector

Amplifier Transistors NPN Silicon

(C) Tony van Raan

TIP42

3 Collector

1 Emitter
2 Base
3 Collector

Amplifier Transistors PNP Silicon

(C) Tony van Raan

Plastic Case

1 Front View

Bottom View
(C) Tony van Raan

Case 29-04, Style 1 TO-92 (TO226AA)

3 Collector

1 Emitter
2 Base
3 Collector

Amplifier Transistors NPN Silicon

(C) Tony van Raan

Pin 2 (Collector) is connected to metal tab. Insulated feedback wire connects to metal tab.

Top View

1 14 J
2 13 K
3 12 K
4 11 Gnd
5 10 K2
6 9 R
7 8 J

Top View

1 14 J
2 13 K
3 12 K
4 11 Gnd
5 10 K2
6 9 R
7 8 J

Top View

1 14 J
2 13 K
3 12 K
4 11 Gnd
5 10 K2
6 9 R
7 8 J

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Radio Shack Part Numbers

All listed resistors are for Carbon, 1/4 Watt, 5% tolerance, unless indicated by 'WW' which stands for 'Wire-Wound' and have 10% tolerance, except for the N.I. (Non Inductive) types which are 5%. Potentiometers of the 'Audio' type are indicated with 'Au' and similar for the linear type with 'lin'. Precision Metal Film resistors are sold in bags of 50 with 12 popular values. For capacitors, the (A) stands for 'Axial', (R) stands for 'Radial' (e.i. horizontal or vertical mounting), (C) means 'Ceramic', (NP) means 'Non-Polarized'. Over time, some parts may become obsolete and others added. I will try to list the types which are used in all my projects, if available at Radio Shack.

Component	Value	Part Number	Component	Value	Part Number
Resistor	10 ohm	271-1301	Resistor	100 ohm	271-1311
Resistor	150 ohm	271-1312	Resistor	220 ohm	271-1314
Resistor	270 ohm	271-1314	Resistor	330 ohm	271-1315
Resistor	470 ohm	271-1317	Resistor	1K	271-1321
Resistor	2K2	271-1325	Resistor	3K3	271-1328
Resistor	4K7	271-1330	Resistor	10K	271-1335
Resistor	22K	271-1339	Resistor	33K	271-1341
Resistor	47K	271-1342	Resistor	100K	271-1347
Resistor	220K	271-1350	Resistor	315K	271-1337
Resistor	470K	271-1354	Resistor	1Meg	271-1356
Resistor	15K	271-1337	Resistor	10Meg	271-1365
Resistor	560	271-8020	Resistor	2.2Meg	271-8061
Resistor ww/5w	0.47 ohm	271-1301	Resistor ww/10w	1.0 ohm	271-1311
Resistor ww/10w	10	271-132	Resistor ww/20w	50	271-1331
Resistor ww/10w	100	271-135	Resistor ww/20w	8 (N.I)	271-120
Potentiometer (Au)	5K	271-1720	Potentiometer (Au)	10K	271-1721
Potentiometer (Au)	100K	271-1722	Potentiometer (Au)	---	---
Potentiometer (lin)	4K7	271-1714	Potentiometer (lin)	10K	271-1715
Potentiometer (lin)	50K	271-1716	Potentiometer (lin)	100K	271-092
Capacitor (C)	0.1µF	272-1069	Capacitor (C)	0.22µF	272-1070
Capacitor (A)	0.22µF	272-1070	Capacitor (A)	4.7µF/35V	272-1012
Capacitor (A)	10µF/35V	272-1070	Capacitor (A)	47µF/35V	272-1015
Capacitor (A)	100µF/35V	272-1016	Capacitor (A)	470µF/35V	272-1018
Capacitor (A)	1000µF/35V	272-1019	Capacitor (A)	4700µF/35V	272-1022
Capacitor (A)	1000µF/50V	272-1047	Capacitor (A)	2200µF/50V	272-1048
Capacitor (R)	1000µF/16V	272-985	Capacitor (R)	4.7µF/35V	272-1024
Capacitor (R)	10µF/35V	272-1025	Capacitor (R)	22µF/35V	272-1026
Capacitor (R)	47µF/35V	272-1027	Capacitor (R)	100µF/35V	272-1028
Capacitor (R)	220µF/35V	272-1029	Capacitor (R)	470µF/35V	272-1030
Capacitor (R)	100µF/50V	272-1044	Cap. Trimmer	6 - 50pF	272-1340

Component	Value	Part Number	Component	Value	Part Number
Cap. Trimmer	95 - 420pF	272-1336	Metal Oxide Var.	Standard	276-570
Mini Buzzer	1.5 - 3V	273-053	Thermistor	10K @ 25°	271-110
Mini Buzzer	6V	273-054	Relay 12V, Mini	SPDT 1A	275-248
Mini Buzzer	12V	273-055	Relay 5V, DIP	SPDT 2A	275-249
Buzzer 12V	Extra Loud	273-051	Relay 12V, Micro	SPDT 1A	275-243
P. Transducer	1500-3000Hz	273-073	Relay 5V, Micro	SPDT 1A	275-240
Piezo Buzzer	4-28Vdc	273-060	Relay 12V, Micro	SPDT 1A	275-241
Diode	1N4148/1N914	276-1122	Relay 5V, Reed	SPDT 1A	275-232
Diode	1N4001	276-1101	Relay 12V, Reed	SPDT 1A	275-233
Diode	1N4003	276-1102	Relay 7-9V, Mini	SPDT 2A	275-005
Diode	1N4004	276-1103	Relay 12V + socket	DPDT 3A	275-8206
Diode	1N4005	276-1104	Relay 12V, Plug-in	4PDT 3A	275-8214
Diode	1N34A (Ge)	276-1123	Heat Sink	TO-220	276-1363
Zener 5V1	1N4733	276-565	LED	Blinking	276-036
Zener 6V2	1N4735	276-561	LED, Jumbo	2-in-1	276-065
Zener 9V1	1N4739	276-562	LED, clear	Brilliant	276-087
Zener 12V	1N4742	276-563	LED, Red	TLR-107	276-033
Zener 15V	1N4744	276-564	LED, Dual	2-color	276-012
Bridge Rect.	50 PIV	276-1146	IC Socket	8-pin	276-1995
Bridge Rect.	100 PIV	276-1171	IC Socket	14-pin	276-1999
Bridge Rect.	400 PIV	276-1173	IC Socket	16-pin	276-1998
IR Detector	5V	276-137	7-Segment	Red, CC	276-075
IC	555 Timer	276-1723	IC	74LS555	276-1718
IC	556 Dual	276-1728	IC	LM386	276-1731
IC	741 Op-Amp	276-007	IC	1458 Dual	276-038
IC	LM324 Quad	276-1711	IC	TL082 BiFet	276-1715
IC	LM3909	276-1705	IC	4001 4-NOR	276-1715
IC	4013 F-F	276-2413	IC	7400	276-1801
IC	7404	276-1802	IC	7490	276-1808
IC Regulator	LM317T	276-1778	Wire Terminals	PC, two position	276-1388
IC Regulator	LM7805	276-1770	OptoCoupler	MOC3010	276-134
IC Regulator	LM7812	276-1771	Phototransistor	TIL414, IR	276-145
SCR	6A-200V	276-1067	Transistor	MPS2907	276-2023
SCR	6A-400V	276-1020	Transistor	MPS2222A	276-2009
Crystal	Colorburst	272-1310	Transistor	MPS3904	276-2016
Switch, SPST	Push On/Off	275-8079	Transistor	TIP3055	276-2020
Switch, SPST	Momentary	275-8077	Transistor	MJE34	276-2027
Switch, SPST	Push On/Off	275-8051	Transistor	2N3053	276-2030
Switch, SPST	Momentary 'ON'	275-1547	Transistor	2N3055	276-2041
Switch, SPST	Momentary 'OFF'	275-1548	Panel Meter	0 - 15 Vdc	270-1754
Switch, DPDT	Mini toggle	275-663	Micro Electret	Needs 1 - 10V	270-085
Switch, SPST	Submini toggle	275-8068	Multi. PCB	solder vero-board	276-150
Transformer	6.3V/300mA	273-1384	Transformer	12.6V/300mA	273-1385
Transformer CT	12.6V/1.2A	273-1505	Transformer CT	12.6V/3A	273-1511
Transformer CT	18V/2A	273-1515	Transformer CT	25.2V/2A	273-1512
Breadboard	270 pin	276-175	Breadboard	550 pin	276-174

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Calculate [Resistor](#) Values from Color Codes

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Tolerance code updated: 2004 Tony van Roon (VA3AVR).

Small-signal Transistors

Marking codes

TYPE NUMBER TO MARKING CODE

TYPE NUMBER	MARKING CODE	PACKAGE
2PA1576Q	FtQ	SC-70
2PA1576R	FtR	SC-70
2PA1576S	FtS	SC-70
2PA1774Q	YQ	SC-75
2PA1774R	YR	SC-75
2PA1774S	YS	SC-75
2PB1219AQ	DtQ	SC-70
2PB1219AR	DtR	SC-70
2PB1219AS	DtS	SC-70
2PB709AQ	BQ	SC-59
2PB709AR	BR	SC-59
2PB709AS	BS	SC-59
2PB710AQ	DQ	SC-59
2PB710AR	DR	SC-59
2PB710AS	DS	SC-59
2PC4081Q	ZtQ	SC-70
2PC4081R	ZtR	SC-70
2PC4081S	ZtS	SC-70
2PC4617Q	ZQ	SC-75
2PC4617R	ZR	SC-75
2PC4617S	ZS	SC-75
2PD1820AQ	AtQ	SC-70
2PD1820AR	AtR	SC-70
2PD1820AS	AtS	SC-70
2PD601AQ	ZQ	SC-59
2PD601AR	ZR	SC-59
2PD601AS	ZS	SC-59
2PD602AQ	XQ	SC-59
2PD602AR	XR	SC-59
2PD602AS	XS	SC-59
BC807	5Dp	SOT23
BC807W	5Dt	SOT323
BC807-16	5Ap	SOT23
BC807-16W	5At	SOT323
BC807-25	5Bp	SOT23
BC807-25W	5Bt	SOT323
BC807-40	5Cp	SOT23
BC807-40W	5Ct	SOT323
BC808	5Hp	SOT23

TYPE NUMBER	MARKING CODE	PACKAGE
BC808W	5Ht	SOT323
BC808-16	5Ep	SOT23
BC808-16W	5Et	SOT323
BC808-25	5Fp	SOT23
BC808-25W	5Ft	SOT323
BC808-40	5Gp	SOT23
BC808-40W	5Gt	SOT323
BC817	6Dp	SOT23
BC817W	6Dt	SOT323
BC817-16	6Ap	SOT23
BC817-16W	6At	SOT323
BC817-25	6Bp	SOT23
BC817-25W	6Bt	SOT323
BC817-40	6Cp	SOT23
BC817-40W	6Ct	SOT323
BC818	6Hp	SOT23
BC818W	6Ht	SOT323
BC818-16	6Ep	SOT23
BC818-16W	6Et	SOT323
BC818-25	6Fp	SOT23
BC818-25W	6Ft	SOT323
BC818-40	6Gp	SOT23
BC818-40W	6Gt	SOT323
BC846	1Dp	SOT23
BC846A	1Ap	SOT23
BC846AT	1A	SC-75
BC846AW	1At	SOT323
BC846B	1Bp	SOT23
BC846BT	1B	SC-75
BC846BW	1Bt	SOT323
BC846W	1Dt	SOT323
BC847	1Hp	SOT23
BC847A	1Ep	SOT23
BC847AT	1E	SC-75
BC847AW	1Et	SOT323
BC847B	1Fp	SOT23
BC847BPN	13t	SC-88
BC847BS	1Ft	SC-88
BC847BT	1F	SC-75

Small-signal Transistors

Marking codes

TYPE NUMBER	MARKING CODE	PACKAGE
BC847BW	1Ft	SOT323
BC847C	1Gp	SOT23
BC847CT	1G	SC-75
BC847CW	1Gt	SOT323
BC847W	1Ht	SOT323
BC848	1Mp	SOT23
BC848A	1Jp	SOT23
BC848AT	1J	SC-75
BC848AW	1Jt	SOT323
BC848B	1Kp	SOT23
BC848BT	1K	SC-75
BC848BW	1Kt	SOT323
BC848C	1Lp	SOT23
BC848CT	1L	SC-75
BC848CW	1Lt	SOT323
BC848W	1Mt	SOT323
BC849	2Dp	SOT23
BC849B	2Bp	SOT23
BC849BW	2Bt	SOT323
BC849C	2Cp	SOT23
BC849CW	2Ct	SOT323
BC849W	2Dt	SOT323
BC850	2Hp	SOT23
BC850B	2Fp	SOT23
BC850BW	2Ft	SOT323
BC850C	2Gp	SOT23
BC850CW	2Gt	SOT323
BC850W	2Ht	SOT323
BC856	3Dp	SOT23
BC856A	3Ap	SOT23
BC856AT	3A	SC-75
BC856AW	3At	SOT323
BC856B	3Bp	SOT23
BC856BT	3B	SC-75
BC856BW	3Bt	SOT323
BC856W	3Dt	SOT323
BC857	3Hp	SOT23
BC857A	3Ep	SOT23
BC857AT	3E	SC-75
BC857AW	3Et	SOT323

TYPE NUMBER	MARKING CODE	PACKAGE
BC857B	3Fp	SOT23
BC857BS	3Ft	SC-88
BC857BT	3F	SC-75
BC857BW	3Ft	SOT323
BC857C	3Gp	SOT23
BC857CT	3G	SC-75
BC857CW	3Gt	SOT323
BC857W	3Ht	SOT323
BC858	3Mp	SOT23
BC858A	3Jp	SOT23
BC858AT	3J	SC-75
BC858AW	3Jt	SOT323
BC858B	3Kp	SOT23
BC858BT	3K	SC-75
BC858BW	3Kt	SOT323
BC858C	3Lp	SOT23
BC858CT	3L	SC-75
BC858CW	3Lt	SOT323
BC858W	3Mt	SOT323
BC859	4Dp	SOT23
BC859A	4Ap	SOT23
BC859AW	4At	SOT323
BC859B	4Bp	SOT23
BC859BW	4Bt	SOT323
BC859C	4Cp	SOT23
BC859CW	4Ct	SOT323
BC859W	4Dt	SOT323
BC860	4Hp	SOT23
BC860A	4Ep	SOT23
BC860AW	4Et	SOT323
BC860B	4Fp	SOT23
BC860BW	4Ft	SOT323
BC860C	4Gp	SOT23
BC860CW	4Gt	SOT323
BC860W	4Ht	SOT323
BC868	CAC	SOT89
BC868-10	CBC	SOT89
BC868-16	CCC	SOT89
BC868-25	CDC	SOT89
BC869	CEC	SOT89

Small-signal Transistors

Marking codes

TYPE NUMBER	MARKING CODE	PACKAGE
BC869-16	CGC	SOT89
BC869-25	CHC	SOT89
BCF29	C7p	SOT23
BCF30	C8p	SOT23
BCF32	D7p	SOT23
BCF33	D8p	SOT23
BCF81	K9p	SOT23
BCP51	BCP51	SOT223
BCP51-10	BCP51/10	SOT223
BCP51-16	BCP51/16	SOT223
BCP52	BCP52	SOT223
BCP52-10	BCP52/10	SOT223
BCP52-16	BCP52/16	SOT223
BCP53	BCP53	SOT223
BCP53-10	BCP53/10	SOT223
BCP53-16	BCP53/16	SOT223
BCP54	BCP54	SOT223
BCP54-10	BCP54/10	SOT223
BCP54-16	BCP54/16	SOT223
BCP55	BCP55	SOT223
BCP55-10	BCP55/10	SOT223
BCP55-16	BCP55/16	SOT223
BCP56	BCP56	SOT223
BCP56-10	BCP56/10	SOT223
BCP56-16	BCP56/16	SOT223
BCP68	BCP68	SOT223
BCP68-10	BCP68/10	SOT223
BCP68-16	BCP68/16	SOT223
BCP68-25	BCP68/25	SOT223
BCP69	BCP69	SOT223
BCP69-10	BCP/10	SOT223
BCP69-16	BCP/16	SOT223
BCP69-25	BCP/25	SOT223
BCV26	FDp	SOT23
BCV27	FFp	SOT23
BCV28	ED	SOT89
BCV29	EF	SOT89
BCV46	FEp	SOT23
BCV47	FGp	SOT23
BCV48	EE	SOT89

TYPE NUMBER	MARKING CODE	PACKAGE
BCV49	EG	SOT89
BCV61	1Mp	SOT143B
BCV61A	1Jp	SOT143B
BCV61B	1Kp	SOT143B
BCV61C	1Lp	SOT143B
BCV62	3Mp	SOT143B
BCV62A	3Jp	SOT143B
BCV62B	3Kp	SOT143B
BCV62C	3Lp	SOT143B
BCV63	D95	SOT143B
BCV63B	D96	SOT143B
BCV64B	C96	SOT143B
BCV65	97p	SOT143B
BCV65B	98p	SOT143B
BCV71	K7p	SOT23
BCV72	K8p	SOT23
BCW29	C1p	SOT23
BCW30	C2p	SOT23
BCW31	D1p	SOT23
BCW32	D2p	SOT23
BCW33	D3p	SOT23
BCW60A	AAp	SOT23
BCW60B	ABp	SOT23
BCW60C	ACp	SOT23
BCW60D	ADp	SOT23
BCW61A	BAp	SOT23
BCW61B	BBp	SOT23
BCW61C	BCp	SOT23
BCW61D	BDp	SOT23
BCW69	H1p	SOT23
BCW70	H2p	SOT23
BCW71	K1p	SOT23
BCW72	K2p	SOT23
BCW81	K3p	SOT23
BCW89	H3p	SOT23
BCX17	T1p	SOT23
BCX18	T2p	SOT23
BCX19	U1p	SOT23
BCX20	U2p	SOT23
BCX51	AA	SOT89

Small-signal Transistors

Marking codes

TYPE NUMBER	MARKING CODE	PACKAGE
BCX51-10	AC	SOT89
BCX51-16	AD	SOT89
BCX52	AE	SOT89
BCX52-10	AG	SOT89
BCX52-16	AM	SOT89
BCX53	AH	SOT89
BCX53-10	AK	SOT89
BCX53-16	AL	SOT89
BCX54	BA	SOT89
BCX54-10	BC	SOT89
BCX54-16	BD	SOT89
BCX55	BE	SOT89
BCX55-10	BG	SOT89
BCX55-16	BM	SOT89
BCX56	BH	SOT89
BCX56-10	BK	SOT89
BCX56-16	BL	SOT89
BCX70G	AGp	SOT23
BCX70H	AHp	SOT23
BCX70J	AJp	SOT23
BCX70K	AKp	SOT23
BCX71G	BGp	SOT23
BCX71H	BHp	SOT23
BCX71J	BJp	SOT23
BCX71K	BKp	SOT23
BDL31	BDL31	SOT223
BDL32	BDL32	SOT223
BDP31	BDP31	SOT223
BDP32	BDP32	SOT223
BF550	LAp	SOT23
BF570	B26	SOT23
BF620	DC	SOT89
BF621	DF	SOT89
BF622	DA	SOT89
BF623	DB	SOT89
BF720	BF720	SOT223
BF721	BF721	SOT223
BF722	BF722	SOT223
BF723	BF723	SOT223
BF820	1Vp	SOT23

TYPE NUMBER	MARKING CODE	PACKAGE
BF820W	1Vt	SOT323
BF821	1Wp	SOT23
BF822	1Xp	SOT23
BF822W	1Wt	SOT323
BF823	1Yp	SOT23
BF824	F8p	SOT23
BF824W	F8t	SOT323
BF840	NCp	SOT23
BF841	NDp	SOT23
BFS19	F2p	SOT23
BFS20	G1p	SOT23
BRY61	A5p	SOT23
BRY62	A51	SOT143B
BSP15	BSP15	SOT223
BSP16	BSP16	SOT223
BSP19	BSP19	SOT223
BSP20	BSP20	SOT223
BSP30	BSP30	SOT223
BSP31	BSP31	SOT223
BSP32	BSP32	SOT223
BSP33	BSP33	SOT223
BSP40	BSP40	SOT223
BSP41	BSP41	SOT223
BSP42	BSP42	SOT223
BSP43	BSP43	SOT223
BSP50	BSP50	SOT223
BSP51	BSP51	SOT223
BSP52	BSP52	SOT223
BSP60	BSP60	SOT223
BSP61	BSP61	SOT223
BSP62	BSP62	SOT223
BSR13	U7p	SOT23
BSR14	U8p	SOT23
BSR15	T7p	SOT23
BSR16	T8p	SOT23
BSR17A	U92	SOT23
BSR18A	T92	SOT23
BSR19	U35	SOT23
BSR19A	U36	SOT23
BSR20	T35	SOT23

Small-signal Transistors

Marking codes

TYPE NUMBER	MARKING CODE	PACKAGE
BSR20A	T36	SOT23
BSR30	BR1	SOT89
BSR31	BR2	SOT89
BSR32	BR3	SOT89
BSR33	BR4	SOT89
BSR40	AR1	SOT89
BSR41	AR2	SOT89
BSR42	AR3	SOT89
BSR43	AR4	SOT89
BSS63	BMp	SOT23
BSS64	AMp	SOT23
BST15	BT1	SOT89
BST16	BT2	SOT89
BST39	AT1	SOT89
BST40	AT2	SOT89
BST50	AS1	SOT89
BST51	AS2	SOT89
BST52	AS3	SOT89
BST60	BS1	SOT89
BST61	BS2	SOT89
BST62	BS3	SOT89
BSV52	B2p	SOT23
PDTA114EE	03	SC-75
PDTA114EK	03	SC-59
PDTA114ET	p03	SOT23
PDTA114EU	t03	SC-70
PDTA114TE	11	SC-75
PDTA114TK	23	SC-59
PDTA114TT	p11	SOT23
PDTA114TU	t23	SC-70
PDTA124EE	05	SC-75
PDTA124EK	05	SC-59
PDTA124ET	p05	SOT23
PDTA124EU	t05	SC-70
PDTA143EE	01	SC-75
PDTA143EK	01	SC-59
PDTA143ET	p01	SOT23
PDTA143EU	01t	SC-70
PDTA144EE	07	SC-75
PDTA144EK	07	SC-59

TYPE NUMBER	MARKING CODE	PACKAGE
PDTA144ET	p07	SOT23
PDTA144EU	t07	SC-70
PDTB114ET	p09	SOT23
PDTC114EE	09	SC-75
PDTC114EK	04	SC-59
PDTC114ET	p16	SOT23
PDTC114EU	t09	SC-70
PDTC114TE	24	SC-75
PDTC114TK	24	SC-59
PDTC114TT	p12	SOT23
PDTC114TU	t24	SC-70
PDTC124EE	06	SC-75
PDTC124EK	06	SC-59
PDTC124ET	p17	SOT23
PDTC124EU	t06	SC-70
PDTC143EE	02	SC-75
PDTC143EK	02	SC-59
PDTC143ET	p02	SOT23
PDTC143EU	t02	SC-70
PDTC144EE	08	SC-75
PDTC144EK	08	SC-59
PDTC144ET	p08	SOT23
PDTC144EU	t08	SC-70
PDTD114ET	p10	SOT23
PMBS3904	pO4	SOT23
PMBS3906	pO6	SOT23
PMBT2222	p1B	SOT23
PMBT2222A	p1P	SOT23
PMBT2369	p1J	SOT23
PMBT2907	p2B	SOT23
PMBT2907A	p2F	SOT23
PMBT3904	p1A	SOT23
PMBT3906	p2A	SOT23
PMBT4401	p2X	SOT23
PMBT4403	p2T	SOT23
PMBT5088	p1Q	SOT23
PMBT5401	p2L	SOT23
PMBT5550	p1F	SOT23
PMBT5551	pG1	SOT23
PMBT6428	p1K	SOT23

Small-signal Transistors

Marking codes

TYPE NUMBER	MARKING CODE	PACKAGE
PMBT6429	p1L	SOT23
PMBTA06	p1G	SOT23
PMBTA13	p1M	SOT23
PMBTA14	p1N	SOT23
PMBTA42	p1D	SOT23
PMBTA43	p1E	SOT23
PMBTA55	p2H	SOT23
PMBTA56	p2G	SOT23
PMBTA63	p2U	SOT23
PMBTA64	p2V	SOT23
PMBTA92	p2D	SOT23
PMBTA93	p2E	SOT23
PMSS3904	t04	SOT323
PMSS3906	t06	SOT323
PMST2222	t1B	SOT323
PMST2222A	t1P	SOT323
PMST2369	t1J	SOT323
PMST2907A	t2F	SOT323
PMST3904	t1A	SOT323
PMST3906	t2A	SOT323
PMST4401	t2X	SOT323
PMST4403	t2T	SOT323
PMST5088	t1Q	SOT323
PMST5089	t1R	SOT323
PMST5401	t2L	SOT323
PMST5550	t1F	SOT323
PMST5551	tG3	SOT323
PMST6428	t1K	SOT323
PMST6429	t1L	SOT323
PMSTA05	t1H	SOT323
PMSTA06	t1G	SOT323
PMSTA42	t1D	SOT323
PMSTA43	t1E	SOT323
PMSTA55	t2H	SOT323
PMSTA56	t2G	SOT323
PMSTA92	t2D	SOT323
PMSTA93	t2E	SOT323
PUMB4	Bt4	SC-88
PUMD2	Dt2	SC-88
PUMD3	Dt3	SC-88

TYPE NUMBER	MARKING CODE	PACKAGE
PUMH11	Ht1	SC-88
PUMT1	FtF	SC-88
PUMX1	ZtZ	SC-88
PUMZ1	FtZ	SC-88
PXT2222A	p1P	SOT89
PXT2907A	p2F	SOT89
PXT3904	p1A	SOT89
PXT3906	p2A	SOT89
PXT4401	p2X	SOT89
PXT4403	p2T	SOT89
PXTA14	p1N	SOT89
PXTA27	A27	SOT89
PXTA42	p1D	SOT89
PXTA43	p1E	SOT89
PXTA64	p2V	SOT89
PXTA92	p2D	SOT89
PXTA93	p2E	SOT89
PZT2222A	ZT2222A	SOT223
PZT2907A	ZT2907A	SOT223
PZT3904	ZT3904	SOT223
PZT3906	ZT3906	SOT223
PZTA06	PZTA06	SOT223
PZTA14	PZTA14	SOT223
PZTA42	ZTA42	SOT223
PZTA43	ZTA43	SOT223
PZTA44	PZTA44	SOT223
PZTA45	PZTA45	SOT223
PZTA56	PZTA56	SOT223
PZTA64	PZTA64	SOT223
PZTA92	PZTA92	SOT223

Small-signal Transistors

Marking codes

MARKING CODE TO TYPE NUMBER

MARKING CODE	TYPE NUMBER	PACKAGE
01	PDTA143EE	SC-75
01	PDTA143EK	SC-59
01t	PDTA143EU	SC-70
02	PDTC143EE	SC-75
02	PDTC143EK	SC-59
03	PDTA114EE	SC-75
03	PDTA114EK	SC-59
04	PDTC114EK	SC-59
05	PDTA124EE	SC-75
05	PDTA124EK	SC-59
06	PDTC124EE	SC-75
06	PDTC124EK	SC-59
07	PDTA144EE	SC-75
07	PDTA144EK	SC-59
08	PDTC144EE	SC-75
08	PDTC144EK	SC-59
09	PDTC114EE	SC-75
11	PDTA114TE	SC-75
13t	BC847BPN	SC-88
1A	BC846AT	SC-75
1Ap	BC846A	SOT23
1At	BC846AW	SOT323
1B	BC846BT	SC-75
1Bp	BC846B	SOT23
1Bt	BC846BW	SOT323
1Dp	BC846	SOT23
1Dt	BC846W	SOT323
1E	BC847AT	SC-75
1Ep	BC847A	SOT23
1Et	BC847AW	SOT323
1F	BC847BT	SC-75
1Fp	BC847B	SOT23
1Ft	BC847BS	SC-88
1Ft	BC847BW	SOT323
1G	BC847CT	SC-75
1Gp	BC847C	SOT23
1Gt	BC847CW	SOT323
1Hp	BC847	SOT23
1Ht	BC847W	SOT323

MARKING CODE	TYPE NUMBER	PACKAGE
1J	BC848AT	SC-75
1Jp	BC848A	SOT23
1Jp	BCV61A	SOT143B
1Jt	BC848AW	SOT323
1K	BC848BT	SC-75
1Kp	BC848B	SOT23
1Kp	BCV61B	SOT143B
1Kt	BC848BW	SOT323
1L	BC848CT	SC-75
1Lp	BC848C	SOT23
1Lp	BCV61C	SOT143B
1Lt	BC848CW	SOT323
1Mp	BC848	SOT23
1Mp	BCV61	SOT143B
1Mt	BC848W	SOT323
1Vp	BF820	SOT23
1Vt	BF820W	SOT323
1Wp	BF821	SOT23
1Wt	BF822W	SOT323
1Xp	BF822	SOT23
1Yp	BF823	SOT23
23	PDTA114TK	SC-59
24	PDTC114TE	SC-75
24	PDTC114TK	SC-59
2Bp	BC849B	SOT23
2Bt	BC849BW	SOT323
2Cp	BC849C	SOT23
2Ct	BC849CW	SOT323
2Dp	BC849	SOT23
2Dt	BC849W	SOT323
2Fp	BC850B	SOT23
2Ft	BC850BW	SOT323
2Gp	BC850C	SOT23
2Gt	BC850CW	SOT323
2Hp	BC850	SOT23
2Ht	BC850W	SOT323
3A	BC856AT	SC-75
3Ap	BC856A	SOT23
3At	BC856AW	SOT323

Small-signal Transistors

Marking codes

MARKING CODE	TYPE NUMBER	PACKAGE
3B	BC856BT	SC-75
3Bp	BC856B	SOT23
3Bt	BC856BW	SOT323
3Dp	BC856	SOT23
3Dt	BC856W	SOT323
3E	BC857AT	SC-75
3Ep	BC857A	SOT23
3Et	BC857AW	SOT323
3F	BC857BT	SC-75
3Fp	BC857B	SOT23
3Ft	BC857BS	SC-88
3Ft	BC857BW	SOT323
3G	BC857CT	SC-75
3Gp	BC857C	SOT23
3Gt	BC857CW	SOT323
3Hp	BC857	SOT23
3Ht	BC857W	SOT323
3J	BC858AT	SC-75
3Jp	BC858A	SOT23
3Jp	BCV62A	SOT143B
3Jt	BC858AW	SOT323
3K	BC858BT	SC-75
3Kp	BC858B	SOT23
3Kp	BCV62B	SOT143B
3Kt	BC858BW	SOT323
3L	BC858CT	SC-75
3Lp	BC858C	SOT23
3Lp	BCV62C	SOT143B
3Lt	BC858CW	SOT323
3Mp	BC858	SOT23
3Mp	BCV62	SOT143B
3Mt	BC858W	SOT323
4Ap	BC859A	SOT23
4At	BC859AW	SOT323
4Bp	BC859B	SOT23
4Bt	BC859BW	SOT323
4Cp	BC859C	SOT23
4Ct	BC859CW	SOT323
4Dp	BC859	SOT23
4Dt	BC859W	SOT323

MARKING CODE	TYPE NUMBER	PACKAGE
4Ep	BC860A	SOT23
4Et	BC860AW	SOT323
4Fp	BC860B	SOT23
4Ft	BC860BW	SOT323
4Gp	BC860C	SOT23
4Gt	BC860CW	SOT323
4Hp	BC860	SOT23
4Ht	BC860W	SOT323
5Ap	BC807-16	SOT23
5At	BC807-16W	SOT323
5Bp	BC807-25	SOT23
5Bt	BC807-25W	SOT323
5Cp	BC807-40	SOT23
5Ct	BC807-40W	SOT323
5Dp	BC807	SOT23
5Dt	BC807W	SOT323
5Ep	BC808-16	SOT23
5Et	BC808-16W	SOT323
5Fp	BC808-25	SOT23
5Ft	BC808-25W	SOT323
5Gp	BC808-40	SOT23
5Gt	BC808-40W	SOT323
5Hp	BC808	SOT23
5Ht	BC808W	SOT323
6Ap	BC817-16	SOT23
6At	BC817-16W	SOT323
6Bp	BC817-25	SOT23
6Bt	BC817-25W	SOT323
6Cp	BC817-40	SOT23
6Ct	BC817-40W	SOT323
6Dp	BC817	SOT23
6Dt	BC817W	SOT323
6Ep	BC818-16	SOT23
6Et	BC818-16W	SOT323
6Fp	BC818-25	SOT23
6Ft	BC818-25W	SOT323
6Gp	BC818-40	SOT23
6Gt	BC818-40W	SOT323
6Hp	BC818	SOT23
6Ht	BC818W	SOT323

Small-signal Transistors

Marking codes

MARKING CODE	TYPE NUMBER	PACKAGE
97p	BCV65	SOT143B
98p	BCV65B	SOT143B
A27	PXTA27	SOT89
A51	BRY62	SOT143B
A5p	BRY61	SOT23
AA	BCX51	SOT89
AAp	BCW60A	SOT23
ABp	BCW60B	SOT23
AC	BCX51-10	SOT89
ACp	BCW60C	SOT23
AD	BCX51-16	SOT89
ADp	BCW60D	SOT23
AE	BCX52	SOT89
AG	BCX52-10	SOT89
AGp	BCX70G	SOT23
AH	BCX53	SOT89
AHp	BCX70H	SOT23
AJp	BCX70J	SOT23
AK	BCX53-10	SOT89
AKp	BCX70K	SOT23
AL	BCX53-16	SOT89
AM	BCX52-16	SOT89
AMp	BSS64	SOT23
AR1	BSR40	SOT89
AR2	BSR41	SOT89
AR3	BSR42	SOT89
AR4	BSR43	SOT89
AS1	BST50	SOT89
AS2	BST51	SOT89
AS3	BST52	SOT89
AT1	BST39	SOT89
AT2	BST40	SOT89
AtQ	2PD1820AQ	SC-70
AtR	2PD1820AR	SC-70
AtS	2PD1820AS	SC-70
B26	BF570	SOT23
B2p	BSV52	SOT23
BA	BCX54	SOT89
BAp	BCW61A	SOT23
BBp	BCW61B	SOT23

MARKING CODE	TYPE NUMBER	PACKAGE
BC	BCX54-10	SOT89
BCP51	BCP51	SOT223
BCP51/10	BCP51-10	SOT223
BCP51/16	BCP51-16	SOT223
BCP52	BCP52	SOT223
BCP52/10	BCP52-10	SOT223
BCP52/16	BCP52-16	SOT223
BCP53	BCP53	SOT223
BCP53/10	BCP53-10	SOT223
BCP53/16	BCP53-16	SOT223
BCP54	BCP54	SOT223
BCP54/10	BCP54-10	SOT223
BCP54/16	BCP54-16	SOT223
BCP55	BCP55	SOT223
BCP55/10	BCP55-10	SOT223
BCP55/16	BCP55-16	SOT223
BCP56	BCP56	SOT223
BCP56/10	BCP56-10	SOT223
BCP56/16	BCP56-16	SOT223
BCP68	BCP68	SOT223
BCP68/10	BCP68-10	SOT223
BCP68/16	BCP68-16	SOT223
BCP68/25	BCP68-25	SOT223
BCP69	BCP69	SOT223
BCP/10	BCP69-10	SOT223
BCP/16	BCP69-16	SOT223
BCP/25	BCP69-25	SOT223
BCp	BCW61C	SOT23
BD	BCX54-16	SOT89
BDL31	BDL31	SOT223
BDL32	BDL32	SOT223
BDP31	BDP31	SOT223
BDP32	BDP32	SOT223
BDp	BCW61D	SOT23
BE	BCX55	SOT89
BF720	BF720	SOT223
BF721	BF721	SOT223
BF722	BF722	SOT223
BF723	BF723	SOT223
BG	BCX55-10	SOT89

Small-signal Transistors

Marking codes

MARKING CODE	TYPE NUMBER	PACKAGE
BGp	BCX71G	SOT23
BH	BCX56	SOT89
BHp	BCX71H	SOT23
BJp	BCX71J	SOT23
BK	BCX56-10	SOT89
BKp	BCX71K	SOT23
BL	BCX56-16	SOT89
BM	BCX55-16	SOT89
BMp	BSS63	SOT23
BQ	2PB709AQ	SC-59
BR	2PB709AR	SC-59
BR1	BSR30	SOT89
BR2	BSR31	SOT89
BR3	BSR32	SOT89
BR4	BSR33	SOT89
BS	2PB709AS	SC-59
BS1	BST60	SOT89
BS2	BST61	SOT89
BS3	BST62	SOT89
BSP15	BSP15	SOT223
BSP16	BSP16	SOT223
BSP19	BSP19	SOT223
BSP20	BSP20	SOT223
BSP30	BSP30	SOT223
BSP31	BSP31	SOT223
BSP32	BSP32	SOT223
BSP33	BSP33	SOT223
BSP40	BSP40	SOT223
BSP41	BSP41	SOT223
BSP42	BSP42	SOT223
BSP43	BSP43	SOT223
BSP50	BSP50	SOT223
BSP51	BSP51	SOT223
BSP52	BSP52	SOT223
BSP60	BSP60	SOT223
BSP61	BSP61	SOT223
BSP62	BSP62	SOT223
BT1	BST15	SOT89
BT2	BST16	SOT89
Bt4	PUMB4	SC-88

MARKING CODE	TYPE NUMBER	PACKAGE
C1p	BCW29	SOT23
C2p	BCW30	SOT23
C7p	BCF29	SOT23
C8p	BCF30	SOT23
C96	BCV64B	SOT143B
CAC	BC868	SOT89
CBC	BC868-10	SOT89
CCC	BC868-16	SOT89
CDC	BC868-25	SOT89
CEC	BC869	SOT89
CGC	BC869-16	SOT89
CHC	BC869-25	SOT89
D1p	BCW31	SOT23
D2p	BCW32	SOT23
D3p	BCW33	SOT23
D7p	BCF32	SOT23
D8p	BCF33	SOT23
D95	BCV63	SOT143B
D96	BCV63B	SOT143B
DA	BF622	SOT89
DB	BF623	SOT89
DC	BF620	SOT89
DF	BF621	SOT89
DQ	2PB710AQ	SC-59
DR	2PB710AR	SC-59
DS	2PB710AS	SC-59
Dt2	PUMD2	SC-88
Dt3	PUMD3	SC-88
DtQ	2PB1219AQ	SC-70
DtR	2PB1219AR	SC-70
DtS	2PB1219AS	SC-70
ED	BCV28	SOT89
EE	BCV48	SOT89
EF	BCV29	SOT89
EG	BCV49	SOT89
F2p	BFS19	SOT23
F8p	BF824	SOT23
F8t	BF824W	SOT323
FDp	BCV26	SOT23
FEp	BCV46	SOT23

Small-signal Transistors

Marking codes

MARKING CODE	TYPE NUMBER	PACKAGE
FFp	BCV27	SOT23
FGp	BCV47	SOT23
FtF	PUMT1	SC-88
FtQ	2PA1576Q	SC-70
FtR	2PA1576R	SC-70
FtS	2PA1576S	SC-70
FtZ	PUMZ1	SC-88
G1p	BFS20	SOT23
H1p	BCW69	SOT23
H2p	BCW70	SOT23
H3p	BCW89	SOT23
Ht1	PUMH11	SC-88
K1p	BCW71	SOT23
K2p	BCW72	SOT23
K3p	BCW81	SOT23
K7p	BCV71	SOT23
K8p	BCV72	SOT23
K9p	BCF81	SOT23
LAp	BF550	SOT23
NCp	BF840	SOT23
NDp	BF841	SOT23
PZTA06	PZTA06	SOT223
PZTA14	PZTA14	SOT223
PZTA44	PZTA44	SOT223
PZTA45	PZTA45	SOT223
PZTA56	PZTA56	SOT223
PZTA64	PZTA64	SOT223
PZTA92	PZTA92	SOT223
T1p	BCX17	SOT23
T2p	BCX18	SOT23
T35	BSR20	SOT23
T36	BSR20A	SOT23
T7p	BSR15	SOT23
T8p	BSR16	SOT23
T92	BSR18A	SOT23
U1p	BCX19	SOT23
U2p	BCX20	SOT23
U35	BSR19	SOT23
U36	BSR19A	SOT23
U7p	BSR13	SOT23

MARKING CODE	TYPE NUMBER	PACKAGE
U8p	BSR14	SOT23
U92	BSR17A	SOT23
XQ	2PD602AQ	SC-59
XR	2PD602AR	SC-59
XS	2PD602AS	SC-59
YQ	2PA1774Q	SC-75
YR	2PA1774R	SC-75
YS	2PA1774S	SC-75
ZQ	2PC4617Q	SC-75
ZQ	2PD601AQ	SC-59
ZR	2PC4617R	SC-75
ZR	2PD601AR	SC-59
ZS	2PC4617S	SC-75
ZS	2PD601AS	SC-59
ZT2222A	PZT2222A	SOT223
ZT2907A	PZT2907A	SOT223
ZT3904	PZT3904	SOT223
ZT3906	PZT3906	SOT223
ZTA42	PZTA42	SOT223
ZTA43	PZTA43	SOT223
ZtQ	2PC4081Q	SC-70
ZtR	2PC4081R	SC-70
ZtS	2PC4081S	SC-70
ZtZ	PUMX1	SC-88
p01	PDTA143ET	SOT23
p02	PDTC143ET	SOT23
p03	PDTA114ET	SOT23
p05	PDTA124ET	SOT23
p07	PDTA144ET	SOT23
p08	PDTC144ET	SOT23
p09	PDTB114ET	SOT23
p10	PDTD114ET	SOT23
p11	PDTA114TT	SOT23
p12	PDTC114TT	SOT23
p16	PDTC114ET	SOT23
p17	PDTC124ET	SOT23
p1A	PMBT3904	SOT23
p1A	PXT3904	SOT89
p1B	PMBT2222	SOT23
p1D	PMBTA42	SOT23

Small-signal Transistors

Marking codes

MARKING CODE	TYPE NUMBER	PACKAGE
p1D	PXTA42	SOT89
p1E	PMBTA43	SOT23
p1E	PXTA43	SOT89
p1F	PMBT5550	SOT23
p1G	PMBTA06	SOT23
p1J	PMBT2369	SOT23
p1K	PMBT6428	SOT23
p1L	PMBT6429	SOT23
p1M	PMBTA13	SOT23
p1N	PMBTA14	SOT23
p1N	PXTA14	SOT89
p1P	PMBT2222A	SOT23
p1P	PXT2222A	SOT89
p1Q	PMBT5088	SOT23
p2A	PMBT3906	SOT23
p2A	PXT3906	SOT89
p2B	PMBT2907	SOT23
p2D	PMBTA92	SOT23
p2D	PXTA92	SOT89
p2E	PMBTA93	SOT23
p2E	PXTA93	SOT89
p2F	PMBT2907A	SOT23
p2F	PXT2907A	SOT89
p2G	PMBTA56	SOT23
p2H	PMBTA55	SOT23
p2L	PMBT5401	SOT23
p2T	PMBT4403	SOT23
p2T	PXT4403	SOT89
p2U	PMBTA63	SOT23
p2V	PMBTA64	SOT23
p2V	PXTA64	SOT89
p2X	PMBT4401	SOT23
p2X	PXT4401	SOT89
pG1	PMBT5551	SOT23
pO4	PMBS3904	SOT23
pO6	PMBS3906	SOT23
t02	PDTC143EU	SC-70
t03	PDTA114EU	SC-70
t04	PMSS3904	SC-70
t05	PDTA124EU	SC-70

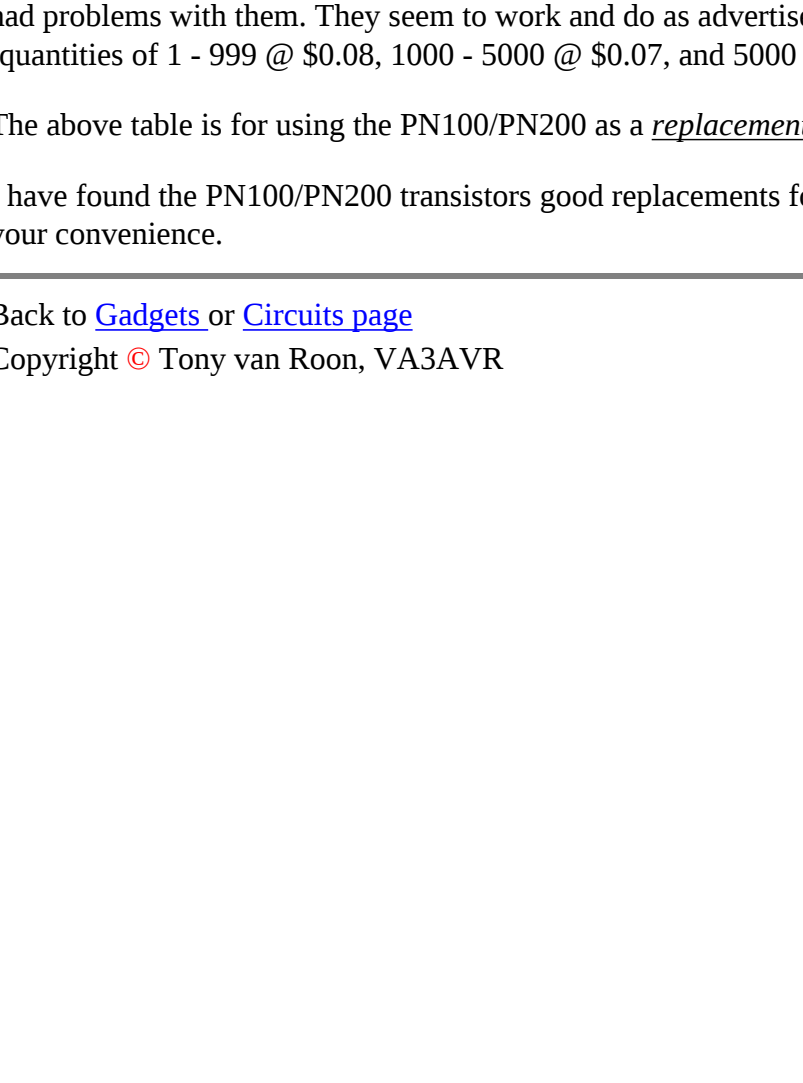
MARKING CODE	TYPE NUMBER	PACKAGE
t06	PDTC124EU	SC-70
t06	PMSS3906	SC-70
t07	PDTA144EU	SC-70
t08	PDTC144EU	SC-70
t09	PDTC114EU	SC-70
t1A	PMST3904	SOT323
t1B	PMST2222	SOT323
t1D	PMSTA42	SOT323
t1E	PMSTA43	SOT323
t1F	PMST5550	SOT323
t1G	PMSTA06	SOT323
t1H	PMSTA05	SOT323
t1J	PMST2369	SOT323
t1K	PMST6428	SOT323
t1L	PMST6429	SOT323
t1P	PMST2222A	SOT323
t1Q	PMST5088	SOT323
t1R	PMST5089	SOT323
t23	PDTA114TU	SC-70
t24	PDTC114TU	SC-70
t2A	PMST3906	SOT323
t2D	PMSTA92	SOT323
t2E	PMSTA93	SOT323
t2F	PMST2907A	SOT323
t2G	PMSTA56	SOT323
t2H	PMSTA55	SOT323
t2L	PMST5401	SOT323
t2T	PMST4403	SOT323
t2X	PMST4401	SOT323
tG3	PMST5551	SOT323

PN100 - PN200

Data sheet

General Purpose Substitutes for Medium Power Transistors
by Tony van Roon, VA3AVR

PN100 (NPN)						PN200 (PNP)					
PN2221	2N2219A	2N4123				PN2907	PN4250	2N4126			
PN2222	2N2222A	2N4124				PN2907A	PN4355	2N4291			
PN2222A	2N3414	2N4401				PN3638	PN4916	2N4402			
PN3565	2N3415	2N5088				PN3638A	PN4917	2N4403			
PN3568	2N3416	2N5510				PN3640	PN5910	2N5086			
PN3569	2N3417	ECG123AP				PN3644	2N2905A	2N5087			
PN3643	2N3700	NTE123AP				PN4121	2N3467	2N5447			
PN3646	2N3704					PN4143	2N3702	ECG159			
PN5133	2N3904					PN4248	2N3906	NTE159			
						PN4249	2N4125				
Type	BVceo (V)	Ic mA	hFE min	Ft MHz	Pd mW	I will add more types when they become available.					
PN100	45	500	100	250	625	(C) Tony van Roon					
PN200	45	1000	100	250	625						



The National Semiconductor TO-92 plastic cased PN100 (NPN), and the PN200 (PNP) are general purpose medium power transistors, and designed as general replacements devices. I have used these two type for the past many years and never had problems with them. They seem to work and do as advertised. Not only that, they are cheap and available in bulk (quantities of 1 - 999 @ \$0.08, 1000 - 5000 @ \$0.07, and 5000 and up @ \$0.05).

The above table is for using the PN100/PN200 as a replacement or substitute transistor, but not the other way around.

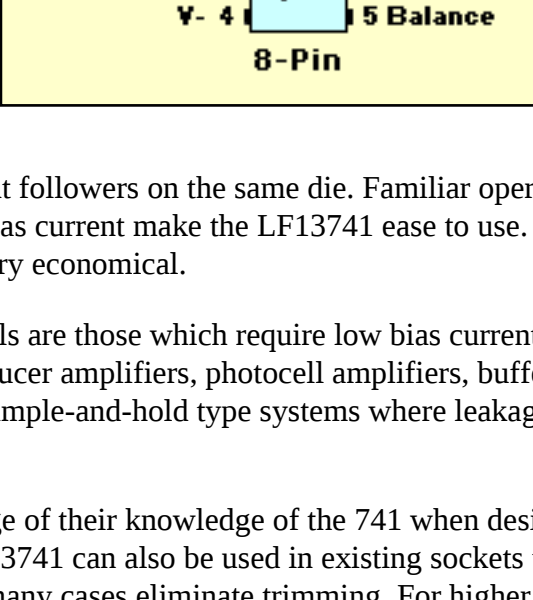
I have found the PN100/PN200 transistors good replacements for most applications and included the electrical data for your convenience.

LF13741N, Monolithic JFET Input Operational Amplifier

Data sheet

No Known Direct Replacements

by Tony van Roon



The LF13741N is a 741 with Bi-Fet input followers on the same die. Familiar operating characteristics--those of a 741--with the added advantage of low input bias current make the LF13741 ease to use. Monolithic fabrication makes this "drop-in-replacement" operational amplifier very economical.

Applications in which the LF13741 excels are those which require low bias current, moderate speed and low cost. A few examples include high impedance transducer amplifiers, photocell amplifiers, buffers for high impedance, slow to moderate speed sources and buffers in sample-and-hold type systems where leakage from the hold capacitor node must be kept to a minimum.

Systems designers can take full advantage of their knowledge of the 741 when designing with the LF13741 to achieve extremely rapid "design times." The LF13741 can also be used in existing sockets to make the "error budget" for input bias and/or offset sources negligible and in many cases eliminate trimming. For higher speed and lower noise use the LF155, LF156, LF157 series of Bi-Fet operational amplifiers.

- Features:**
- Low input bias current (50pA)
 - Input common-mode range to positive supply voltage
 - Low input noise current (0.01pA/rootHz)
 - High input impedance (5x10¹¹ ohm)
 - Familiar 741 operating characteristics

- Advantages:**
- FET inputs--741 operating characteristics
 - Low cost
 - Easy to use
 - Standard Supplies
 - Standard pin-outs
 - Non-rectifying input for RF environment
 - Rapid "design time"

- Applications:**
- Smoke detectors
 - Ito V converters
 - High impedance buffers
 - Low drift sample and hold circuits
 - Long time timers
 - Low drift peak detectors
 - Supply current monitors
 - Low error budget systems

- Absolute Maximum Ratings:**
- Supply voltage +18 volt dc.
 - Differential Input Voltage +30V dc.
 - T_J(MAX) 100°C.
 - Storage temperature range from -65 to +150 °C.
 - Lead temperature (soldering, up to 4 sec) 260 °C.

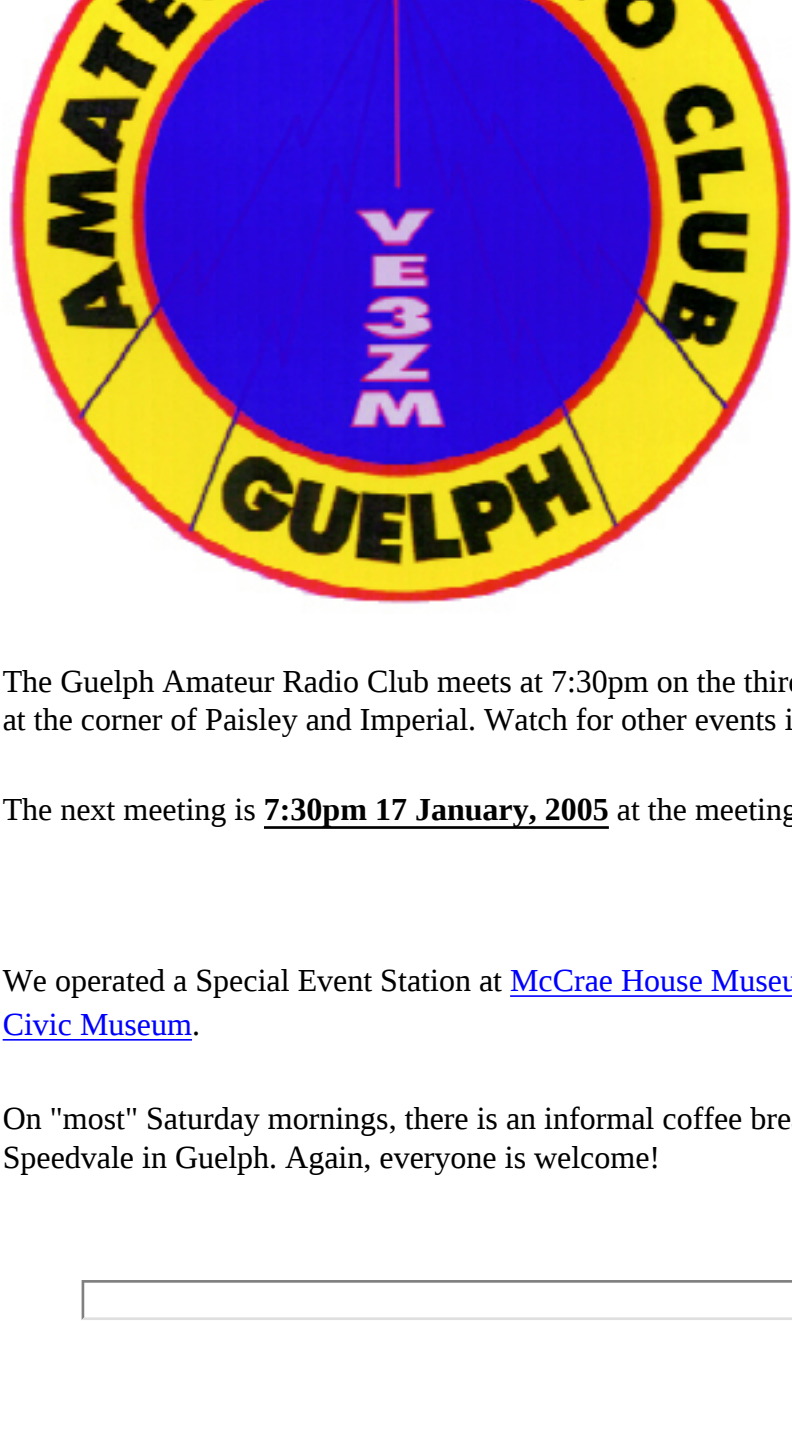
Notes:

- No special (static) handling precautions
- Applying reverse power will destroy this device.
- Unlike the regular 741, with the LF13741 you can take both inputs above the positive supply voltage by more than 0.1V before the amplifier ceases to function. This feature enables you to use the LF13741 to monitor and/or limit the current from the same supply used to power it. If you exceed the positive common-mode voltage limit on only one input, the output phase will remain correct. When you exceed the limit on both inputs, the output phase is unpredictable.

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The Guelph Amateur Radio Club's *official* Home Page



The Guelph Amateur Radio Club meets at 7:30pm on the third Monday of the month. The club meetings are held at Zehrs, at the corner of Paisley and Imperial. Watch for other events in the area.

The next meeting is **7:30pm 17 January, 2005** at the meeting room at Zehrs on the corner of Paisley and Imperial.

We operated a Special Event Station at [McCrae House Museum](#) November 4-11. Check out the Museum online at [Guelph Civic Museum](#).

On "most" Saturday mornings, there is an informal coffee break at Clubhouse Donuts at the corner of Victoria and Speedvale in Guelph. Again, everyone is welcome!

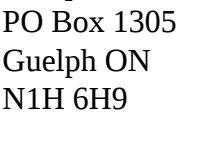
Local Repeaters

- VE3ZMG 145.210- (open auto-patch) Guelph
- VE3GEG 147.000+ (131.8Hz Tone in and out) Guelph
- VE3RKL 443.850+ Guelph
- VE3OVQ 147.540 (131.8hz tone on input) Guelph IRLP Node
- VE3RSS 147.030- (open auto-patch) Acton
- VE3RCK 146.865- Kitchener
- VE3KSR 146.970- Kitchener
- VE3KFM 442.000+ Kitchener
- VE3RBM 444.875+ Kitchener
- VE3BHR 447.075- Kitchener
- VE3WWV 146.835- Waterloo
- VE3WFM 147.090+ Waterloo
- VA3SED 53.370- Baden
- VE3WIK 53.110- Carlisle

Packet Frequencies

- VA3SED FBB BBS in Baden
- VE3UOW TCP/IP BBS with links to the internet
- VE3KSR 145.010 AX.25 in Baden
- VE3KWQ 145.090 AX.25 in Kitchener
- VA3OAT-1 145.050 AX.25 Packet Mailbox in Elora

For more information on *Amateur Radio in the Guelph Area*, send mail to [VE3MKY](#) (remove the 99. You know all about cutting down on spam?) Mike, or

 Getting started in Amateur Radio? Check this out.

[Radio Amateurs of Canada Home Page](#) to get lots more info on Amateur Radio.

or
[Bob Cooke the RAC Ontario South Regional Director's Web Page](#)

or
[HamRad's Web](#) Page which lists lot's of clubs, companies, etc...

or, try
[QSL DX Web](#) Page which gives excellent info on real-time propagation.

or
[SuperWinlog](#) Homepage an excellent FREEWARE windows logging program.

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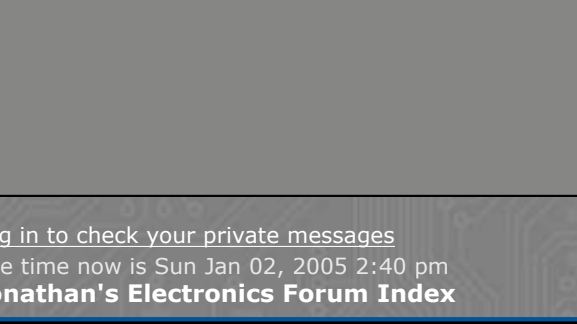
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The official GARC Home Page / Sunday 2 January, 2005



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From the Forum Administrator			
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Jokes This is a good place to put up some of those really funny jokes. Please, share with us!!! Moderators Opa , Nang	2	7	Sat Sep 11, 2004 12:01 pm Plaka
Circuits			
Looking for a circuit? Need help with a circuit? If you are looking for a particular circuit or just need help troubleshooting a circuit, post your questions here. Moderators Opa , Nang	25	53	Sat Jan 01, 2005 4:24 am sharanya
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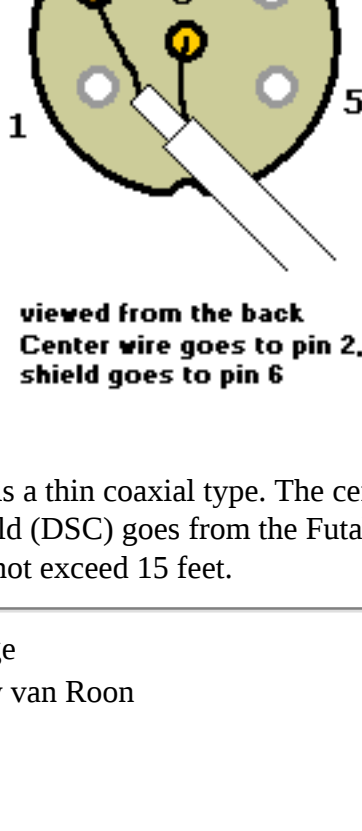
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Futaba to JR Cord

<http://www.uoguelph.ca/~antoon>

Futaba - 6-pin DIN plug



Japan Radio (JR) 3.5mm Mono Jack



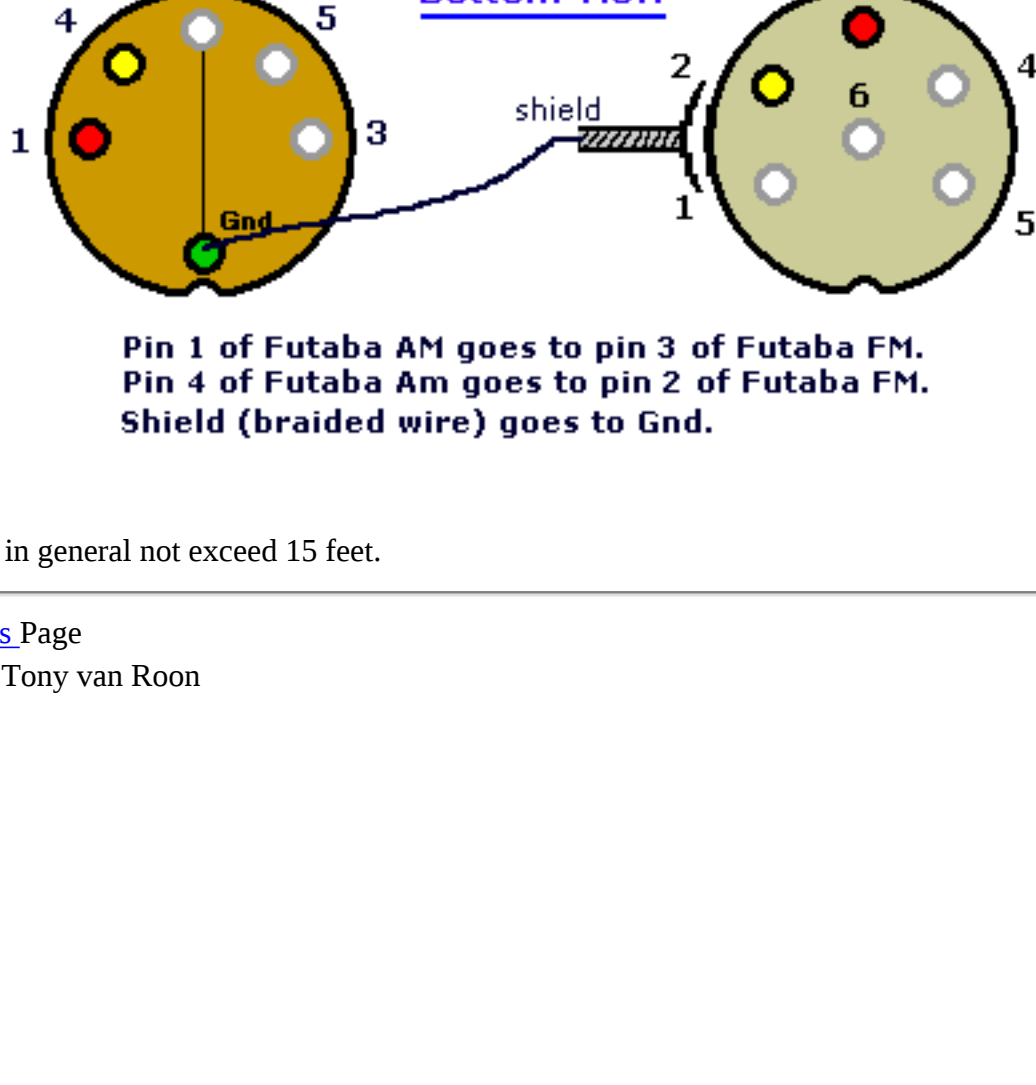
The JR buddy box cable is a thin coaxial type. The center pin goes from the center pin of the JR plug to pin 2 of the Futaba 6-pin DIN plug. The shield (DSC) goes from the Futaba pin 6 to the lapel connector of the JR plug. Easy as pie! Cable length should in general not exceed 15 feet.

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Futaba-AM to Futaba-FM

<http://www.uoguelph.ca/~antoon>



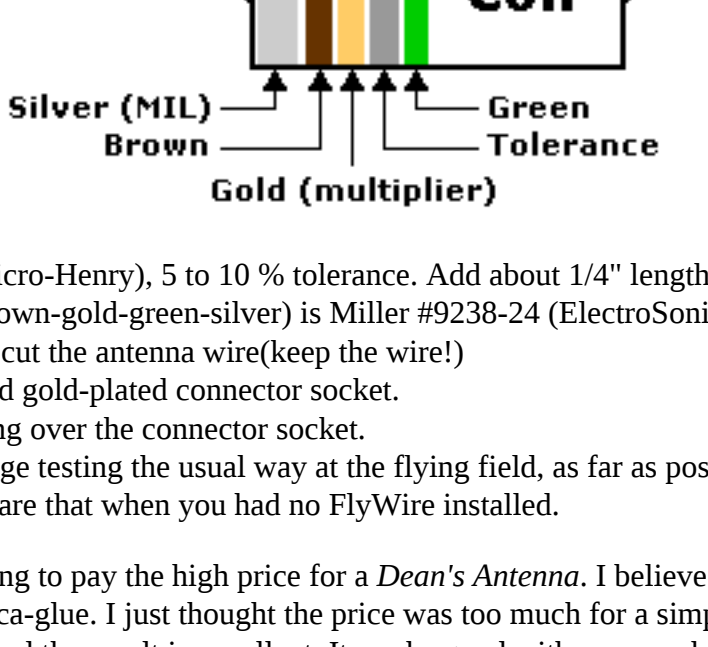
Cable length should in general not exceed 15 feet.

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Tony's FlyWire for Helicopter

by Tony van Roon



Description

- o Value of the coil is 1.5 μ H (micro-Henry), 5 to 10 % tolerance. Add about 1/4" length for soldering.
- o Part number for coil (silver-brown-gold-green-silver) is Miller #9238-24 (ElectroSonic).
- o Measure 4" from the receiver, cut the antenna wire(keep the wire!)
- o Solder or crimp on the supplied gold-plated connector socket.
- o Heatshrink the piece of sleeving over the connector socket.
- o Before flying, do adequate range testing the usual way at the flying field, as far as possible until you loose signal, and then compare that when you had no FlyWire installed.

At the time (1992) I was unwilling to pay the high price for a *Dean's Antenna*. I believe it was twenty bucks or something, money I very well good use for ca-glue. I just thought the price was too much for a simple design like that so I decided to put my own calculator to work and the result is excellent. It works good with my own heli's and safely assume the same for boats and cars. I have not tried it for airplanes but myself, I don't trust the FlyWire, Dean's Antenna or **ANYTHING ELSE** but the original receiver antenna in any **airplane!**

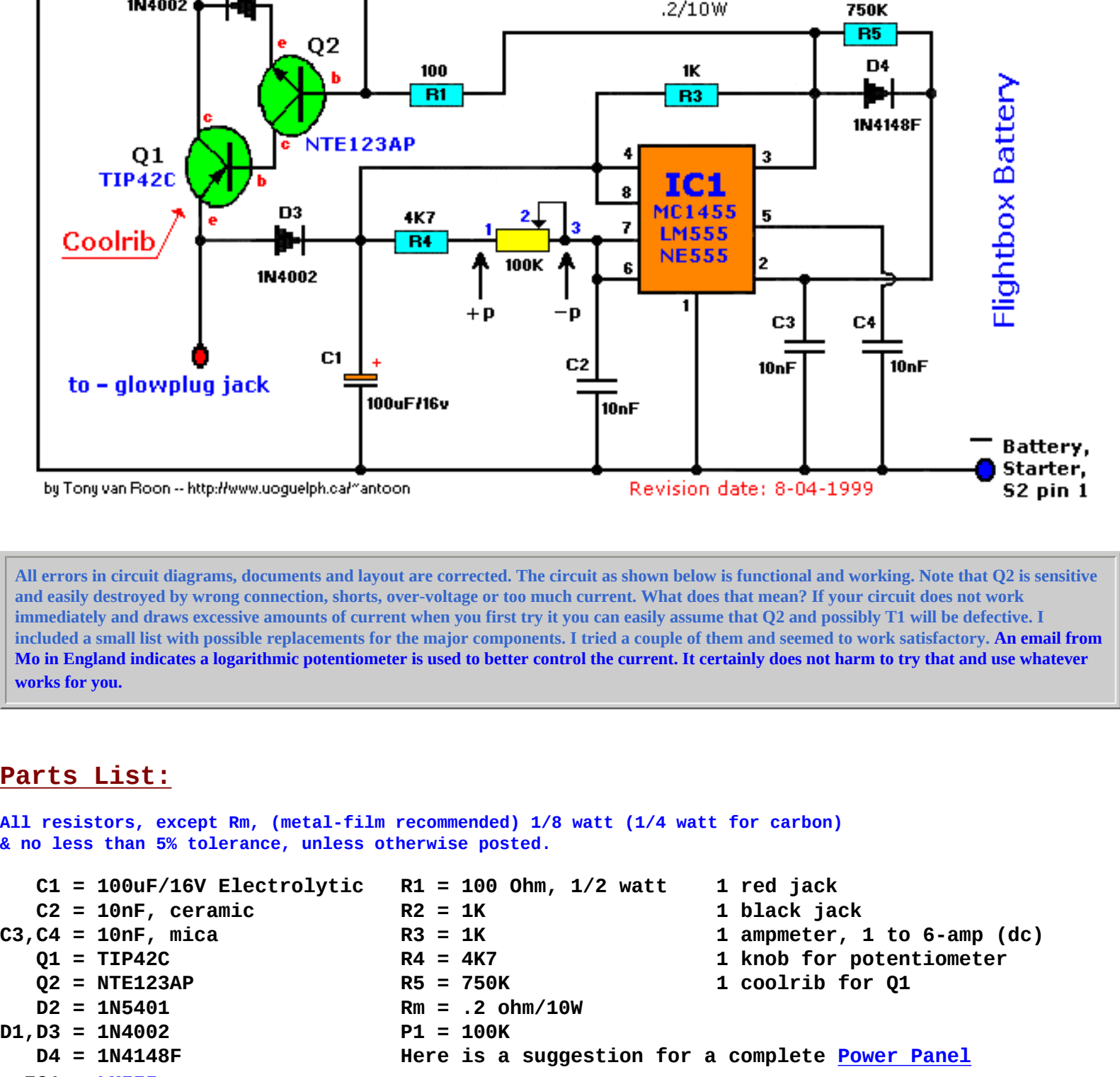


Part 'A' is 6 inches pianowire. Part 'B' is the 4-inches of wire coming from the receiver.

This unit tested **ONLY with Helicopter!!!**

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Glowplug Driver for R/C



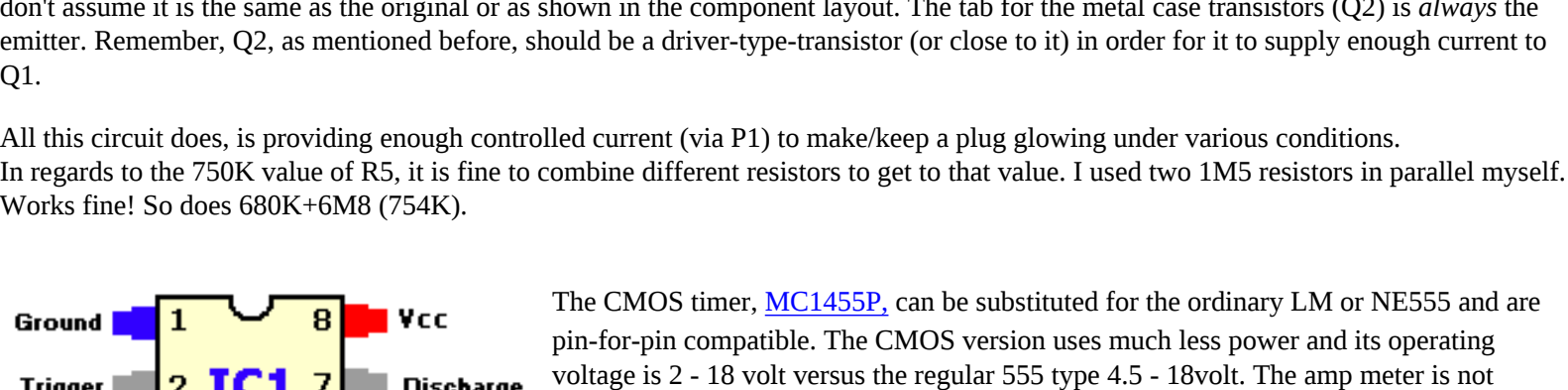
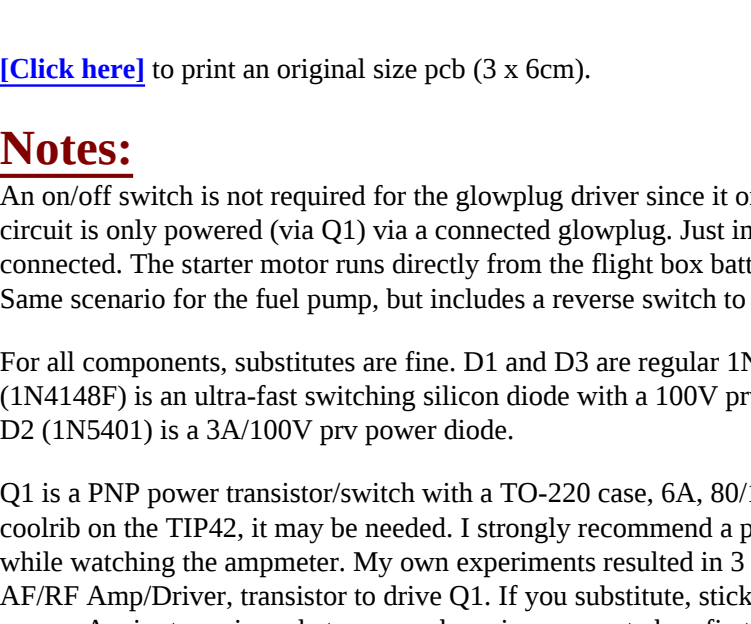
All errors in circuit diagrams, documents and layout are corrected. The circuit as shown below is functional and working. Note that Q2 is sensitive and easily destroyed by wrong connection, shorts, over-voltage or too much current. What does that mean? If your circuit does not work immediately and draws excessive amounts of current when you first try it you can easily assume that Q2 and possibly T1 will be defective. I included a small list with possible replacements for the major components. I tried a couple of them and seemed to work satisfactory. An email from **Me in England** indicates a logarithmic potentiometer is used to better control the current. It certainly does not harm to try that and use whatever works for you.

Parts List:

- All resistors, except Rm, (metal-film recommended) 1/8 watt (1/4 watt for carbon) & no less than 5% tolerance, unless otherwise posted.
- | | | |
|-----------------------------|------------------------|-----------------------------|
| C1 = 100uF/16V Electrolytic | R2 = 100 Ohm, 1/2 watt | 1 red jack |
| C2 = 10nF, ceramic | R3 = 1K | 1 black jack |
| C3, C4 = 10nF, mica | R4 = 4K7 | 1 ampmeter, 1 to 6-amp (dc) |
| Q1 = TIP42C | R5 = 750K | 1 knob for potentiometer |
| Q2 = NTE123AP | Rm = .2 ohm/10W | 1 coolrib for Q1 |
| D1, D3 = 1N5401 | P1 = 100K | |
| D4 = 1N4148F | | |
| IC1 = LM555 | | |
- Here is a suggestion for a complete [Power Panel](#)

A couple possible substitutes, use at your disgression, no guarantees:
For Q1: TIP32C, TIP42, TIP42A (or B), NTE332, ECG332.
For Q2: 2N3904, BC547, (or A or B), BC550, European TUN.
For D1,3: NTE116, ECG116, try others.
For D2: NTE5801, try others.
For D4: NTE519, ECG519, other 1N4148x types worked also.
For IC1: NE555, TLC555, MC1455, HC555, NTE955M, ECG955, etc.
The NTE123A did not seem to work and is not quite the same as the 'AP' type.
The 2N2222(A) did not work in the prototype and shorted out the circuit.

The ECG and NTE/ECG substitutes are made by Sylvania. I build two units and both working fine.



[\[Click here\]](#) to print an original size pcb (3 x 6cm).

Notes:

An on/off switch is not required for the glowplug driver since it only draws current when a glowplug is attached. As a matter of fact, the circuit is only powered (via Q1) via a connected glowplug. Just in case you were wondering how the positive (+) side of the circuit is connected. The starter motor runs directly from the flight box battery, via the jacks on the power-panel, and has it's own on/off switch. Same scenario for the fuel pump, but includes a reverse switch to pump the fuel in or out the tank/cannister.

For all components, substitutes are fine. D1 and D3 are regular 1N4002 diodes. You may substitute with the 1N4001, or 1N4003. D4 (1N4148F) is an ultra-fast switching silicon diode with a 100V prv. The regular and more familiar 1N4148 seems to work also. D2 (1N5401) is a 3A/100V prv power diode.

Q1 is a PNP power transistor/switch with a TO-220 case, 6A, 80/100V, 65 watts. Don't be afraid to experiment, and don't forget the coolrib on the TIP42, it may be needed. I strongly recommend a powersupply if you're gonna experiment and turn up the voltage slowly while watching the ampmeter. My own experiments resulted in 3 burned out glowplugs, 2 TIPs, and 2 NTE123AP. Q2 is a NPN silicon, AP/RF Amp/Driver, transistor to drive Q1. If you substitute, stick with the 'driver' type, other may burn-out the very second you apply power. Again, try using whatever you have in your parts-box first, but try to match the current/voltage parameters as close as you can and make sure it is able to drive Q1. Whatever transistor you use for Q1 or Q2, watch the orientation of the emitter, base and collector and don't assume it is the same as the original or as shown in the component layout. The tab for the metal case transistors (Q2) is *always* the emitter. Remember, Q2, as mentioned before, should be a driver-type-transistor (or close to it) in order for it to supply enough current to Q1.

All this circuit does, is providing enough controlled current (via P1) to make/keep a plug glowing under various conditions. In regards to the 750K value of R5, it is fine to combine different resistors to get to that value. I used two 1M5 resistors in parallel myself. Works fine! So does 680K+6M8 (754K).

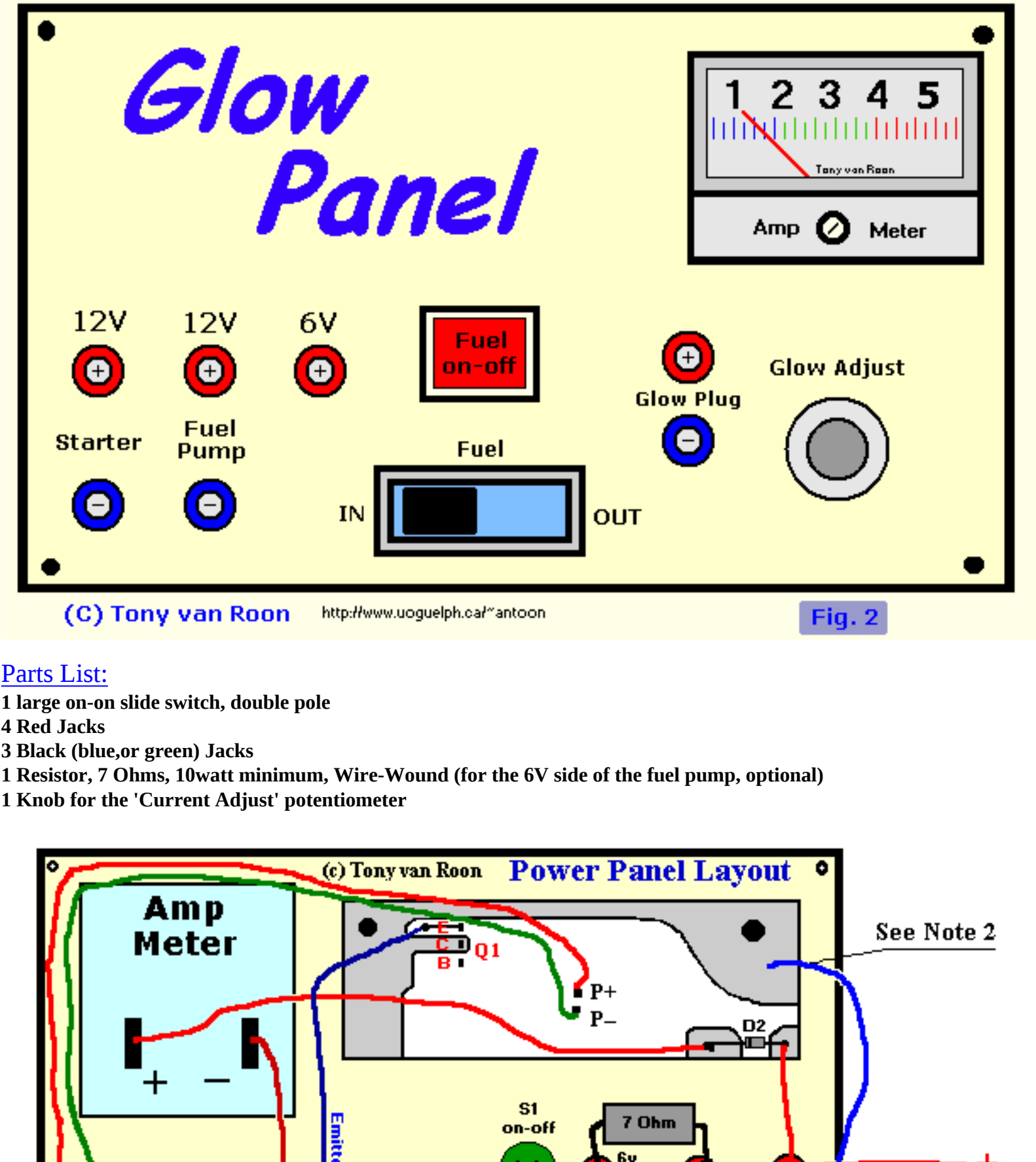
The CMOS timer, [MCI455P](#), can be substituted for the ordinary LM or NE555 and are pin-for-pin compatible. The CMOS version uses much less power and its operating voltage is 2 - 18 volt versus the regular 555 type 4.5 - 18volt. The amp meter is not mandatory, but gives you a nice visual indicator.

When a glowplug is hooked up (the plug act as an on/off switch to power the circuit), Q2 switches on and biases Q1, which in turn provides enough current, adjusted with potentiometer P1, to make the plug glow. C2, C3, & C4 are filtering capacitors while C1 keeps the voltage over the glowplug steady, like when the plug gets wet with fuel and diodes D1/D3 are feedback blocking diodes preventing signal feedback.

CAUTION! The '+' of the glow plug jack connects to the emitter of Q1 only!

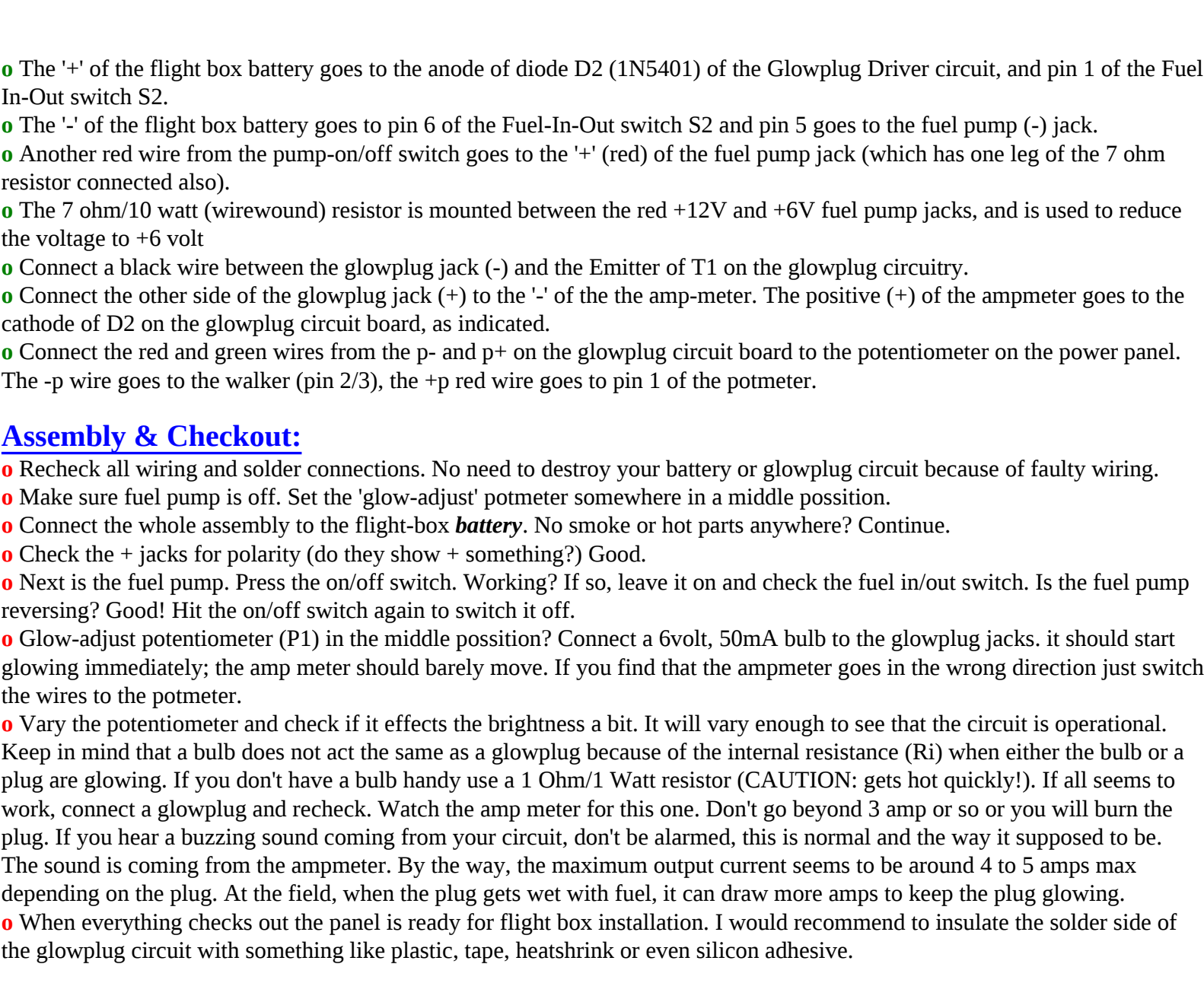
If you wish to incorporate the above into a complete [Power Panel](#) check here for a possible suggestion on how to do that.

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Parts List:

- 1 large on-on slide switch, double pole
- 4 Red Jacks
- 3 Black (blue,or green) Jacks
- 1 Resistor, 7 Ohms, 10watt minimum, Wire-Wound (for the 6V side of the fuel pump, optional)
- 1 Knob for the 'Current Adjust' potentiometer



* Note 1:

Cross-wire the 'Fuel In-Out' switch first before soldering the other wires to it. Pin 1 to pin 4 and pin 3 to pin 6. Use solid, insulated, wire like bell wire, or bend a thin paperclip in shape and solder that on (see Fig. 4). The two center contacts (2 & 5) are left open at this time (pin 5 is for negative (-) pump jack, pin 2 is for S1 pushbutton switch).

Solder also a piece of insulated, solid wire between Pins 2 & 3 of the Potentiometer P1.

Verify S2 to make sure the jumper wires between pins 1/4 and 3/6 are NOT touching each other!

o The '+' of the flight box battery goes to the anode of diode D2 (1N5401) of the Glowplug Driver circuit, and pin 1 of the Fuel In-Out switch S2.

o The '-' of the flight box battery goes to pin 6 of the Fuel-In-Out switch S2 and pin 5 goes to the fuel pump (-) jack.

o Another red wire from the pump-on/off switch goes to the '-' (red) of the fuel pump jack (which has one leg of the 7 ohm resistor connected also).

o The 7 ohm/10 watt (wirewound) resistor is mounted between the red +12V and +6V fuel pump jacks, and is used to reduce the voltage to +6 volt

o Connect a black wire between the glowplug jack (-) and the Emitter of T1 on the glowplug circuitry.

o Connect the other side of the glowplug jack (+) to the '-' of the amp-meter. The positive (+) of the ampmeter goes to the cathode of D2 on the glowplug circuit board, as indicated.

o Connect the red and green wires from the p- and p+ on the glowplug circuit board to the potentiometer on the power panel. The -p wire goes to the walker (pin 2/3), the +p red wire goes to pin 1 of the potmeter.

Assembly & Checkout:

- o Recheck all wiring and solder connections. No need to destroy your battery or glowplug circuit because of faulty wiring.
- o Make sure fuel pump is off. Set the 'glow-adjust' potmeter somewhere in a middle position.
- o Connect the whole assembly to the flight-box **battery**. No smoke or hot parts anywhere? Continue.
- o Check the + jacks for polarity (do they show + something?) Good.
- o Next is the fuel pump. Press the on/off switch. Working? If so, leave it on and check the fuel in/out switch. Is the fuel pump reversing? Good! Hit the on/off switch again to switch it off.
- o Glow-adjust potentiometer (P1) in the middle position? Connect a 6volt, 50mA bulb to the glowplug jacks. it should start glowing immediately; the amp meter should barely move. If you find that the ampmeter goes in the wrong direction just switch the wires to the potmeter.
- o Vary the potentiometer and check if it effects the brightness a bit. It will vary enough to see that the circuit is operational. Keep in mind that a bulb does not act the same as a glowplug because of the internal resistance (Ri) when either the bulb or a plug are glowing. If you don't have a bulb handy use a 1 Ohm/1 Watt resistor (CAUTION: gets hot quickly!). If all seems to work, connect a glowplug and recheck. Watch the amp meter for this one. Don't go beyond 3 amp or so or you will burn the plug. If you hear a buzzing sound coming from your circuit, don't be alarmed, this is normal and the way it supposed to be. The sound is coming from the ampmeter. By the way, the maximum output current seems to be around 4 to 5 amps max depending on the plug. At the field, when the plug gets wet with fuel, it can draw more amps to keep the plug glowing.
- o When everything checks out the panel is ready for flight box installation. I would recommend to insulate the solder side of the glowplug circuit with something like plastic, tape, heatshrink or even silicon adhesive.



Final Notes:

The Power-Panel can look very professional. I used rub-on lettering and a couple of (very) thin coats of protective spray to protect it from scratches and stuff. Too thick a coat of protective spray the first time may make your rub-on lettering run or produce tiny air bubbles. Covering can also be used successfully and looks also professional. Have fun with it!

If you only intend to use a 12-Volt fuel pump you can omit the 6-Volt red jack and the 7 ohm/10 watt resistor. It can always be added later, at a time convenient for you. However, I don't think it's worth it since the two items cost only a couple of quarters and I'm working on a Rx field charger which will possibly be connected to this 6-volt jack.

S1 in the prototype is a push on/off button, but basically any switch can be used. The push-on/off switch is just more convenient. Verify that the switch can handle the current; 1 or 2 amp should be fine.

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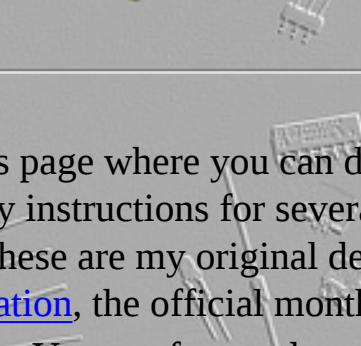
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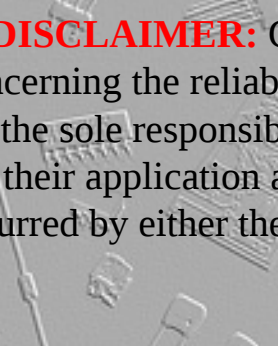
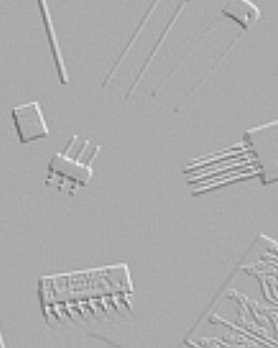
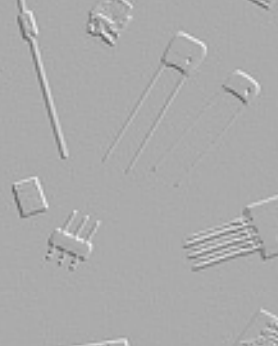
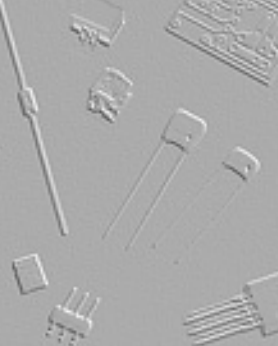
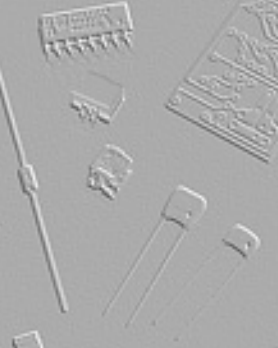


Welcome to Brent's R/C electronics page where you can download complete parts lists, schematics, and assembly instructions for several useful electronic projects for the R/C hobbyist. These are my original designs that have appeared as articles in [Model Aviation](#), the official monthly publication of the [Academy of Model Aeronautics](#). You are free to download and build the designs but commercial use is not permitted without a licensing agreement.

I also try to keep a very complete list of links to other [R/C electronic hobby sites](#) from around the world. Please [contact me](#) with suggestions to keep this list current!

Fly fast, fly smooth, fly low, and enjoy these circuits!

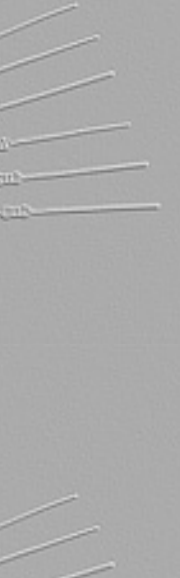
End of an era! After over six years and several thousand kits, I have to move on! It was fun and I enjoyed sharing. Didn't get your order in? Don't despair. Take a close look at the very detailed [PDF project files](#), including even instructions on making your own printed circuit boards. You can do it!

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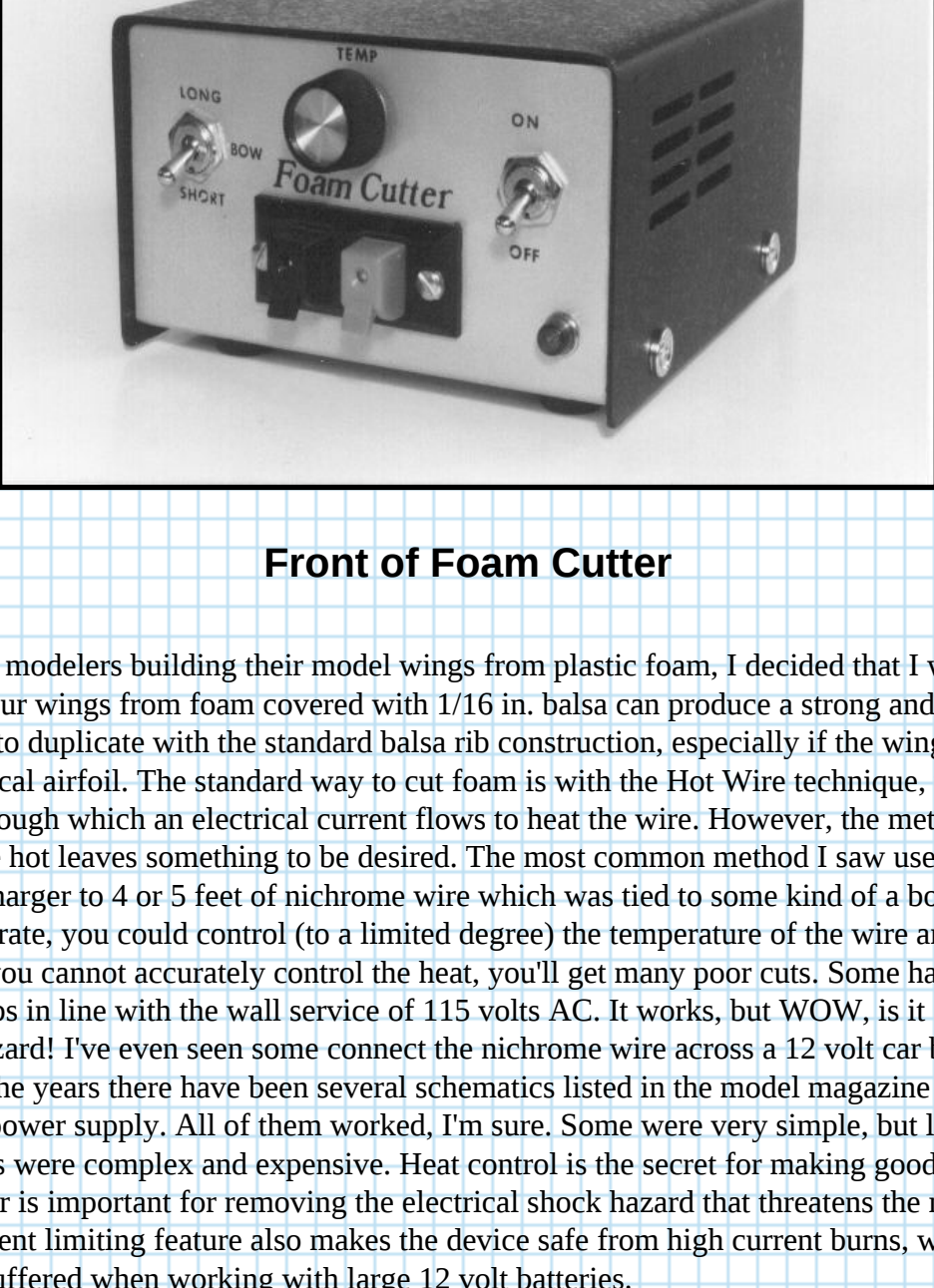
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Foam Cutting Power Supply

A "do it yourself" Project



Front of Foam Cutter

After seeing other modelers building their model wings from plastic foam, I decided that I wanted to do the same. Building your wings from foam covered with 1/16 in. balsa can produce a strong and light wing that could be difficult to duplicate with the standard balsa rib construction, especially if the wing had a duel tapered, symmetrical airfoil. The standard way to cut foam is with the Hot Wire technique, using steel or nichrome wire through which an electrical current flows to heat the wire. However, the methods that many use to get the wire hot leaves something to be desired. The most common method I saw used was to connect a 12volt battery charger to 4 or 5 feet of nichrome wire which was tied to some kind of a bow. Using the variable charging rate, you could control (to a limited degree) the temperature of the wire and thus the speed of the cut. But if you cannot accurately control the heat, you'll get many poor cuts. Some have connected a series of light bulbs in line with the wall service of 115 volts AC. It works, but WOW, is it ever dangerous! Terrible shock hazard! I've even seen some connect the nichrome wire across a 12 volt car battery, also very dangerous. Over the years there have been several schematics listed in the model magazine for building a hot wire foam cutter power supply. All of them worked, I'm sure. Some were very simple, but left little heat control, and others were complex and expensive. Heat control is the secret for making good foam cuts. Also a good transformer is important for removing the electrical shock hazard that threatens the modeler in his shop. A good current limiting feature also makes the device safe from high current burns, which some auto mechanics have suffered when working with large 12 volt batteries.

The following [circuit](#) is a simplification of several older designs. This design uses readily available parts, is easy to build, has total temperature control for both a long bow (48") and a short bow (24"), and has served me well for the last 15 years. Many of the planes that I fly are my own design and I build most of them with foam wings, foam turtle decks, foam stabs, etc, usually with dual tapered, symmetrical designs. The short bow is valuable for sculpting foam pieces into various shapes, as it can be held in one hand and the foam sample in the other.

The first step in building one of these foam cutters is to take the [Bill of Materials](#) to your local Radio Shack and search for the parts. I picked this source because of shopping convenience and the total cost is a little above \$30. Also get a small copper clad circuit board (CB), about 3 by 4 inches or larger in size. If you chose not to make the circuit board, you can solder the parts together using electrical stand-offs. The first order of business is to mount the switches, the potentiometer, the Red and Black electrical posts (#274-662), and the red indicator light on the [front panel](#) of the component box according to the picture and illustration. Next mount the transformer (#273-1512), fuse holder (#270-364), and electrical cord (#278-1255) in the box as shown in [photo](#). Put some rubber feet on the bottom of the box (also from Radio Shack) so that it won't scratch your wife's end table when you take it to show her what a great craftsman you are.

The circuit is a simple AC Triac voltage control circuit similar to the ones used to control house lamps. The transformer provides the electrical isolation the makes this item safe to operate. The voltage at the bow will tingle a little, but will not harm the operator. The OFF/ON switch is a simple s.p.s.t. switch (#275-651). The "Long/Short" Bow selector switch is the same part number. Across the primary side of the transformer is mounted an indicator "ON" lamp (#272-712) which will light up when the unit is turned on. The temperature control is through the 5k ohm potentiometer R2 (#271-1714). The Triac gate current is controlled by R3, a 470 ohm, 1 watt resistor. This resistor is not part of radio Shack's inventory, therefore it may be required to solder two 1k ohm, 10 watt resistors in parallel. The capacitor, C1, is a 0.22microF disk (#272-1070). The 5 ohm, 20 watt resistor R1 is made of two 10 ohm, 10 watt resistors in parallel. They are large ceramic resistors mounted side by side. These resistors drop the voltage when the short 24" bow is being used. These resistors will get hot, don't touch!

Enclosed in this article is a actual size drawing of the [circuit board](#) (CB, 2.5" x 4"). Cut out this drawing and use it as a template, and paste it on the side opposite of the copper on the CB (circuit board) with some rubber cement. Next use a center punch to mark the center of each hole. Then drill the holes with the CB held tightly to some wood backing, making the four corner holes a 1/8" in dia and all the rest about 1/16" in dia. These smaller holes will be where you solder the components and wires. The larger holes are for the mounting bolts to hold the CB to the case. Cut the CB to the exact size as shown on the template (2.5" x 4"). Then, print out the copper side [drawing](#) and paste it on the copper side of the board. Use a sharp X-acto knife to remove thin strips of copper as shown. This will isolate the copper soldering pads from one another. Remove the paper. Insert the components in the CB on the side opposite the copper. Where the component leads stick out on the copper side, solder the component leads to the board being careful not to allow solder to bridge the cut lines in the copper. Cut off any excessive lead after soldering it. Bolt the Heat Sink on to the Triac with the fins pointing out. The Triac should be mounted in a vertical position, perpendicular to the CB. Next mount the CB in the box with 6-32 x 1" bolts and stand-offs. Finish soldering the connecting wires to the board before tightening the bolts. Drill 3 or 4 vent holes (1/4" dia) in the top of the box in the area above the Triac heat sink.

N.B. The main problem that people are having is the placement of the TRIAC. On the board drawing, there is a letter "G" next to one TRIAC pin. That G stands for the Gate. Once they understand this, it becomes easier to insert the TRIAC into the board. They need to read the paper that came with the TRIAC so they know which pin is the Gate pin. I had made a comment that it is possible to substitute a different TRIAC if they could not get the specified one. Well, I was wrong. It seems that some of the fellows are inserting TRIACs that are very different than that specified, and of course, it won't work. As it turns out, Radio Shack is no longer a good source for electronic components. Ahhh, for the good old days when you could find electronic shops and Ham radio stores all over town. It's all history now.

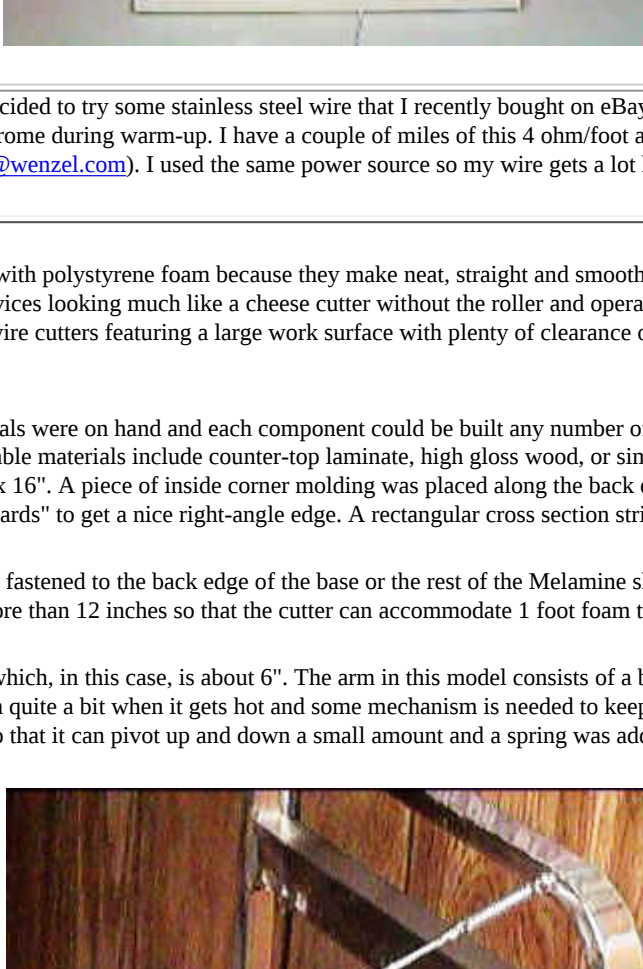
Plug the nichrome wire bow leads into the dual plug speaker connectors. It is best to trim the wire insulation on the wires back about 1/2 in, then tin the wire ends. After the wires are plugged in, turn the unit on and with the temperature control at half point and the heat switch set up to long. The wire should get hot to the touch almost immediately. If it doesn't, then examine the construction on the circuit board and wiring, and fix any errors found. After the unit is finished, bolt the top on and your and you're done.

When you use the foam cutter, be sure that the Bow switch is in the correct position. The switch must be in the "Short" position (down) if the 24" bow is used. Otherwise you may blow the fuse. Leave the unit in the "Long" bow position at all times unless you are using the short bow and you should have no problems. Before you turn the Foam Cutter on, turn the temperature (TEMP) control fully counter-clockwise, to minimum temperature. Turn the unit on with a bow plugged in and increase the temperature by turning the TEMP knob clockwise. The temperature of the wire increases almost immediately. With a piece of foam, test for the foam cutting temperature. Reduce the TEMP control until the cut is smooth with little foam evaporation around the wire. Remember, the smoothest cuts are made slowly. Spend some time practicing until your cuts are smooth. You will never go back to balsa ribs!

Enjoy.
Tom Weedon, AMA 2537, NSRCA 733

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Large Dimension Hot-Wire Foam Cutter



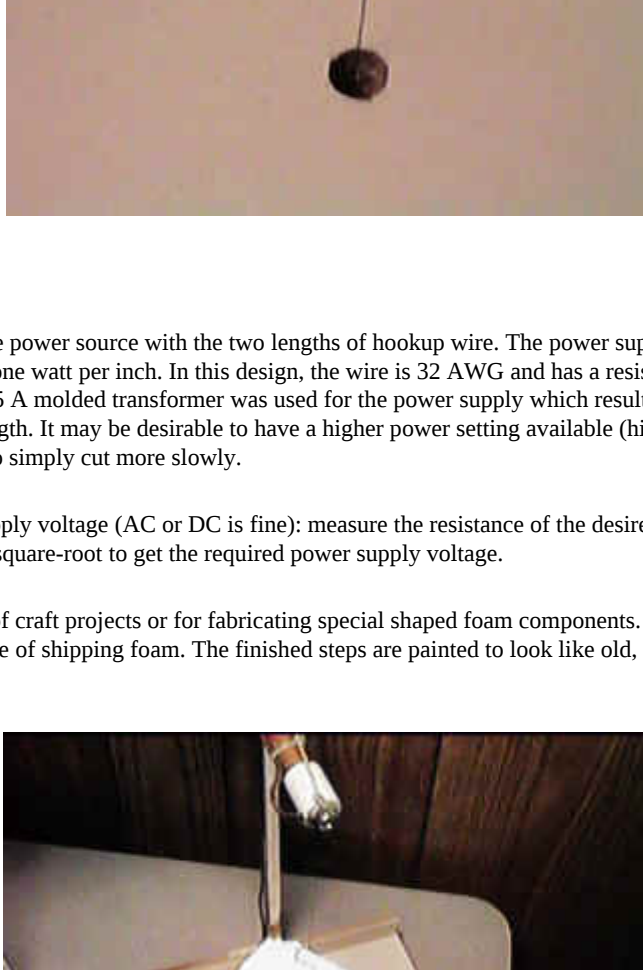
Update: My nichrome wire finally broke so I decided to try some stainless steel wire that I recently bought on eBay. This new wire is superior! It is very strong and it doesn't stretch nearly as much as the nichrome during warm-up. I have a couple of miles of this 4 ohm/foot and it would be a trivial matter to stick a few feet in an envelope if you would like some (charles@brenzel.com). I used the same power source so my wire gets a lot hotter than with the 10 ohms/foot nichrome but it doesn't seem to mind.

Hot wire foam cutters are a must when working with polystyrene foam because they make neat, straight and smooth cuts that simply cannot be duplicated with any other type of saw. Most cutters are hand-held devices looking much like a cheese cutter without the roller and operate a bit like a jig saw. The foam cutter described here is more like the "table saw" version of hot wire cutters featuring a large work surface with plenty of clearance on all sides and with generous height for cutting thick pieces.

The cutter was made from whatever scrap materials were on hand and each component could be built any number of ways. The base surface should be smooth so that the foam can be easily manipulated and suitable materials include counter-top laminate, high gloss wood, or simply a piece of Melamine shelving as was used in this version. The base dimensions are about 12" x 16". A piece of inside corner molding was placed along the back edge of the base to act as a cutting guide for straight cuts. The molding is glued down "backwards" to get a nice right-angle edge. A rectangular cross section strip of wood would serve the same purpose.

The vertical support could be a piece of plywood fastened to the back edge of the base or the rest of the Melamine shelf. This design uses a metal handle from an old electronic instrument. Make the height a little more than 12 inches so that the cutter can accommodate 1 foot foam thickness.

An arm extends out about 1/2 of the base depth which, in this case, is about 6". The arm in this model consists of a block of wood, a long phenolic standoff, and a ceramic insulator. The nichrome wire will stretch quite a bit when it gets hot and some mechanism is needed to keep the wire taut. The block of wood is fastened loosely to the vertical support with two screws so that it can pivot up and down a small amount and a spring was added to pull up on the arm.



The phenolic standoff and ceramic insulator were held together with short piece of threaded rod made by cutting the head off of #8 bolt. First, the threaded rod was screwed into the ceramic insulator until it bottomed out and then the other end was screwed into the standoff using the ceramic insulator as a handle. The top wire connection is made with a screw in the end of the ceramic insulator. The hookup wire has a solder lug termination and the nichrome wire was simply wound around the screw a couple of turns. During assembly, the arm is held down as the screw is tightened. A little bit of experimentation will be necessary to get the spring resistance right when the wire is hot.



A 3/16" hole was drilled directly beneath the arm for the other end of the hot wire. In order to keep the hot wire from touching the wood, the hole was partially drilled out to 1/4" from the bottom side and a short 1/4" O.D. metal standoff was tapped into the hole from the bottom. The standoff should be much shorter than the thickness of the base so that it does not act as a heat sink for the cutting portion of the wire. In this design the bottom electrical connection was made by inserting a piece of hookup wire into the standoff with the nichrome wire and then forcing in a sheet metal screw. The nichrome is difficult to solder so some sort of mechanical crimp or weld is needed.



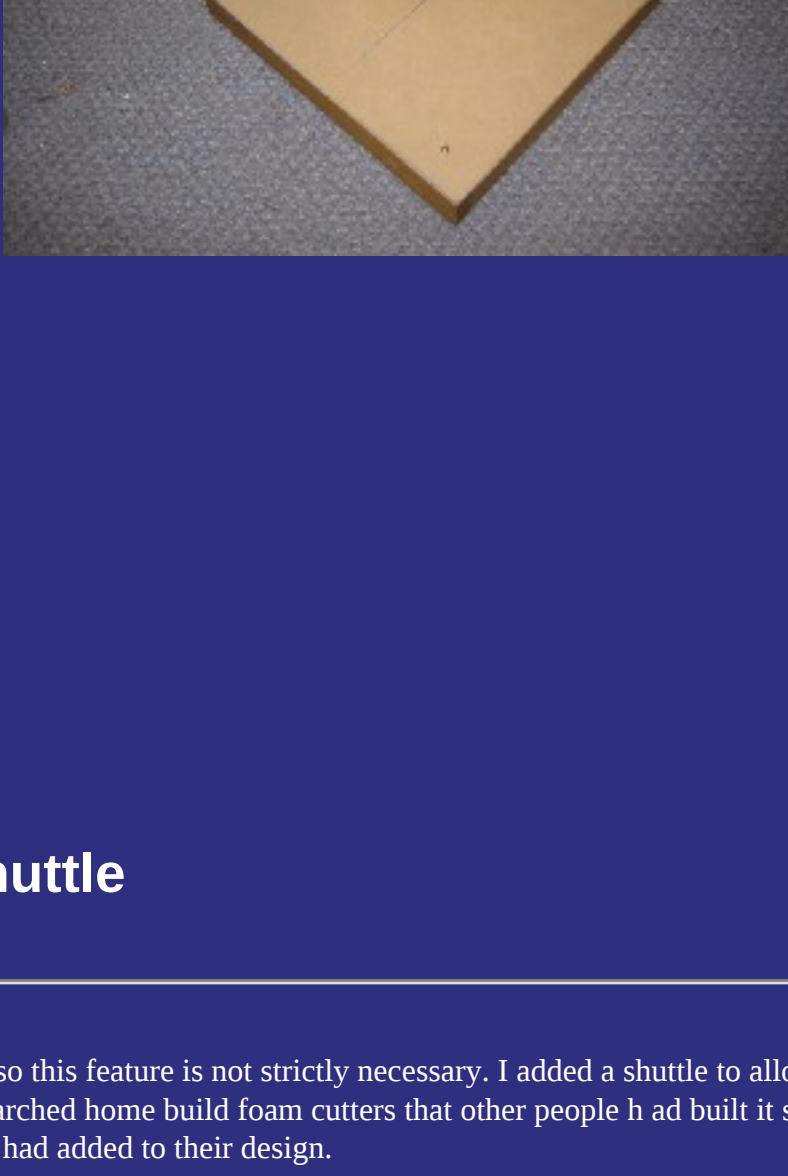
The two ends of the hot wire are connected to the power source with the two lengths of hookup wire. The power supply for the hot wire will depend upon the gauge of wire and the length. Plan on supplying about one watt per inch. In this design, the wire is 32 AWG and has a resistance of about 10 ohms per foot making the total resistance about 13 ohms. A surplus 13 VAC, 1.5 A molded transformer was used for the power supply which results in about 1 amp of current and about 13 watts of power which is just perfect for the 13 inch length. It may be desirable to have a higher power setting available (higher supply voltage) but the wire can become excessively hot when it is not cutting. It is best to simply cut more slowly.

Here is how to calculate the necessary power supply voltage (AC or DC is fine): measure the resistance of the desired length of nichrome wire and multiply this resistance by the length in inches. Now take the square-root to get the required power supply voltage.

This tall cutter will come in handy for a variety of craft projects or for fabricating special shaped foam components. An example of a difficult cut is shown below where a "staircase" is being cut from a thick piece of shipping foam. The finished steps are painted to look like old, cracked concrete - a perfect application for the surface texture the cutter leaves behind!



Building a Hot Wire Foam Cutter



Hot wire foam cutters work by heating special wire to the point where it vaporize foam it is brought in contact with. It is a technique commonly used commercially and hot wire foam cutters are available for any where to several hundred to several thousand dollars. Heck, I will happily sell you mine for a fraction of that but you should probably know that it only cost me \$4 to buy the resistance wire or nichrome plus maybe \$15 - 20 dollars in scrap stock I already had.

I leave it to the reader to supply their own power supply. I am using a supply from an old external SCSI drive. My cutter runs from the five volt supply and 25cm of nichrome wire pulls about 900mA or 4.5 watts. That is actually running a little hot and I plan on building a temperature control circuit shortly. I have read that the key to successfully hot wire cutting of foam is apparently "slow and cool". After my initial experiences I believe it.

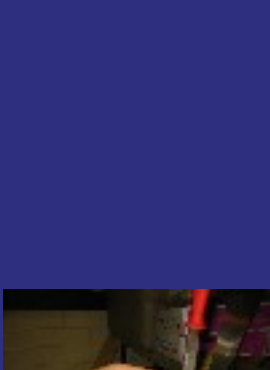
My design is pretty simple and breaks down into four parts; base, top, shuttle, and cutting arm. Each piece is described below.

Shuttle

Ok, so this feature is not strictly necessary. I added a shuttle to allow for a variable cut angle on the cutter. When I researched home build foam cutters that other people had built it seemed to be one of the big features everyone wished they had added to their design.

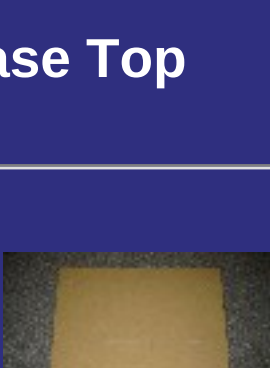


A small hook extending from the base of the shuttle bar holds one end of the heated wire. The shuttle is driven to a desired position along a lead screw. Adjusting the position of the shuttle bar along the screw allows for an adjustable cut angle. Recall from your Trig that the higher your support arm the further your shuttle will have to move to reach the desired cut angle. For the default bar on my cutter for example, which is 20cm high, a maximum cut angle of only 30 degrees can be achieved. That can of course be increased by lowering the cutting arm. With this design it is simple to have multiple interchangeable support arms with differing heights.



The bar is driven along the lead screw while a piece of steel rod is used as a guide. The rod keeps the threaded rod from taking the entire load. Probably overkill for this application but it is simple to add and ensures the shuttle keeps working without binding.

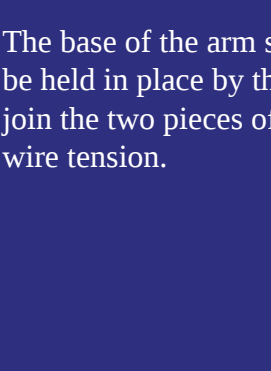
I used 1/8 inch 24tpi threaded rod and 3/16 inch steel stock but only because that was what I had in my scrap box. The loads here are so light that any straight steel rod will work for the guide or lead screw. As a suggestion you should probably look for the lowest TPI on the lead screw you can find.



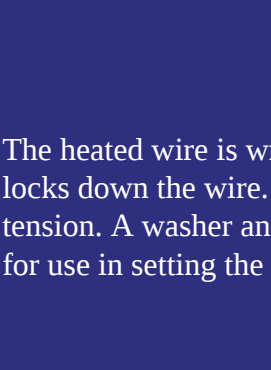
The screw that you see running into the block is used to attach a ground wire to the shuttle. This ground complements the positive terminal on the support arm.

Base

My base was built around an old wooden monitor stand. Pretty much any sturdy wooden base should work with this style of design. I would recommend finding one that will fit your intended power supply so that your cutter will be self contained.



Since I was using a thin top I cut out four blocks and glued them into the corners of the base. These blocks were then drilled and formed the seat into which the base's top gets screwed down.



Both the threaded and steel rod are seated in 5cm wide pieces of brass stock mounted to aluminium bar stock. Both brass and aluminium stock in this type are commonly available at most hardware stores. The steel bar is friction fit and trapped in the base by the walls. The threaded rod on the other hand needs to extend beyond the case walls.

I used a small piece of brass tube stock as an insert to the hole in the side of the box through which the lead screw extends. This keeps the action of the screw from fraying the wood. The screw is held in place by a small clip on the inside of the brass support. If you don't have any car-clips at hand you can saw cut the file and washer as I did. I would suggest that the aluminium bar stock should be screwed into the base as soon as possible in construction, even if it has to be removed later, in order to provide a fixed reference to work with.



If you are like me and don't have a lathe you can make the notches needed to clip in the threaded rod with either a warding or milling file and a triangular file and a hand drill. Set up the base and mark off where the clip is to fit the screw with felt tip pen. You will likely have to do this several times so keep things handy.

By chucking up the threaded rod you can "slowly" work the rod along the edge of a file. Make sure you move the rod back and forth along the file so that wear on the file is even. If you don't you will ruin the file. Start with the triangle file to cut the edges to your notch and then remove the bulk of the material between the notches with a milling, warding, or similar file.



Again if you don't have a lathe you can flatten the ends of round stock by chucking it in a hand drill and slowly working it against a file. Use wood blocks to sandwich your file in a bench vice. Then slowly work the rod across the file. The averaged out surface will be close to flat and tangential to the axis of the rod's rotation.



The last piece to add to the base is the "u" shaped support block that holds the support bar. The support bar on this design is friction fit. The fit needs to be tight enough to firmly hold the arm in place yet loose enough that the arm can be removed for storage or to change arms. Not hard to do just a lot of filing and measuring to get it right.

Base Top



The base is cut to size to match the base. Then four holes are drilled to match the pilot holes in the corners of the base. Use counter sink screws and bevel the edge of the holes so that the face of the screw sits flush with the table top.

Since the support arm is friction fit once the screw holes have been added attach the top and mark arm. Make sure that you under cut the measured mark slightly and then repeatedly file and measure the opening to get a tight friction fit.

The slot for the nichrome wire needs to be measured, marked, and cut after the shuttle is finished. If you don't have a table saw or router to make this cut you can mark a line then drilled repeatedly along that line removing the excess material with a file. It is not ideal but it is what I did here and if you are careful it will yield reasonable results.

Cutting Arm



The base of the arm sits on the outside of the box with a toe extending through the top to be held in place by the "u" shaped support block. I used a mortise and tenon to quickly join the two pieces of the arm together. A spring loaded bolt mounted on the arm provides wire tension.



The heated wire is wrapped around a screw on the tensioning clip. Tightening the screw locks down the wire. The spring loaded bolt in the arm is screwed into the clip providing tension. A washer is used below the support arm both to retain the spring loaded bolt and for use in setting the initial tension level on the clip.

Using the Foam Cutter



So a friend of mine Ross immediately suggested that we try cutting one of those wooden model / toy dinosaurs out of foam. Actually he suggested that we cut it out of foam and then try pouring it in aluminium with a lost foam process this weekend. Ross is known for these sorts of cool and slightly eccentric sort of ideas.



So I used some packing foam that a monitor was shipped in. I the foam into blocks small enough to feed to the hot wire foam cutter with a hacksaw. Those blocks were then measured, marked, and cut into sheets of foam. I then marked out the outline of the pattern of the various pieces and then cut out and assembled the pieces. The total construction time was about 40 mins and most of that just experimenting and playing. Another head could likely be built from scratch in about half the time.

Hot Wire foam cutting Links to get you started...

Ok, here is a [quick and dirty design](#) and another [with a cool idea for power](#) and yet another [basic design](#). A ll look functional and the first two have good ideas for a rip / guide fence; something that my design lacks.

I would say that this is a [nicer looking design with cut angle selection](#) It certainly influenced me. It even has an indicator for the cut angle the support arm is set at. The only thing I didn't like about it was the method for locking down the support arm.

This site is an excellent resource. His pages walk you through his [hot wire cut foam research and design process](#) from start to finish in making high precision foam cut parts for making linear bearings. Especially look at phase three as it shows his CNC hot wire cutter.



LOST FOAM CASTING

Lost Foam casting makes it possible to cast some parts that would require some very intricate wood patterns. I use foam for those types of castings. If it does not turn out, cut some more foam! Actually, it is great for some "quick and dirty" castings as well. If surface finish is not critical, lost foam can produce "one off" castings faster than making wood patterns. To date, the few lost foam castings I have done all turned out as hoped. These castings are normally done in "loose sand", no ramming, and the sand is dry. The only place for some moist sand might be around the sprue so it does not collapse. Using thin aluminum tubes (soda cans, etc), for sprue holes, makes it easier. I am using fine grit sandblasting sand at present. My first lost foam was done in Petrobond, but the burned foam does not do much good for the Petrobond sand. There is much more to be said regarding lost foam, I would suggest checking some of the excellent websites out there. Thats what I did.

Using foam for patterns requires a means to cut it. A "hot wire" cutter is the most popular, so I built one. It has some nice features, and others that I should include if I ever make another. It would be nice to be able to tilt the cutter wire for angles, as well as adding a good fence to guide the foam as it is being cut. Presently I clamp a straight edge to the table, OK but not very repeatable.

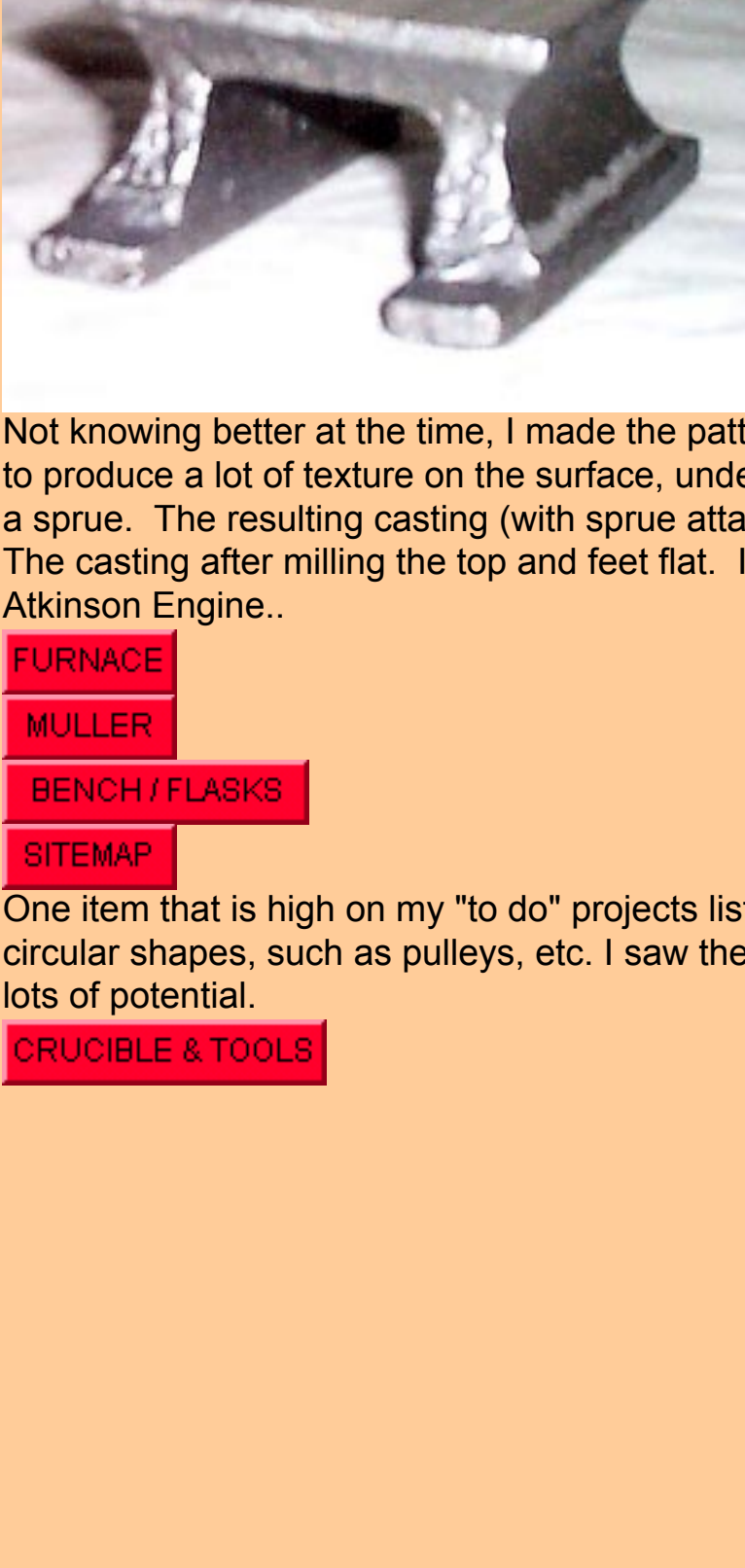
The wire is connected to an adjustable spring loaded nut. The spring keeps tension constant, the knurled knob adjusts tension.

This is an auxillary cutter made from heavy wire, to cut curved shapes. The wire is easily replaceable, and the loop can be adjusted vertically.

The power supply uses a Variac, 0 to 56 Volts, and a 24 V transformer for isolation. The Variac was left from a project abandoned long ago, finally has a good use. I presently have screw terminals to connect the cutter, but will be putting some sockets for jacks as a better method of connecting.

I used lost foam castings for both my IC engines ; there are pics of them on those pages.

Shown below is my very first lost foam casting.



Not knowing better at the time, I made the pattern of white "bead styrofoam". It has a tendency to produce a lot of texture on the surface, undesirable in most cases. This pattern still needs a sprue. The resulting casting (with sprue attached) is shown on the right.

The casting after milling the top and feet flat. It was used as a base for the water jacket on my Atkinson Engine..

- [FURNACE](#)
- [MULLER](#)
- [BENCH / FLASKS](#)
- [SITEMAP](#)

One item that is high on my "to do" projects list is a small lathe to hold foam pieces for cutting circular shapes, such as pulleys, etc. I saw the concept for one on another website, and it has lots of potential.

- [CRUCIBLE & TOOLS](#)

Hotwire Foam Cutter

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I recently finished my hotwire foam cutter and am happy with the way it turned out. I plan on using this to simplify the production of patterns for lost foam casting (see the foundry pages for more information on this technique). I lucked out and had most of the bits and pieces that I needed for this project leftover from some other projects.

The power supply I used is a little more involved than what is required but it works well and I had the pieces. I used a PWM (Pulse Width Modulator) to control the heat to the wire. This is a simple electronic control that essentially turns the power to the wire on and off very fast and you can control this rate. I used a 12.6 volt, 3 amp transformer to provide the power, a bridge rectifier to convert the AC power to DC power, and a large capacitor to filter the DC power. The filtered power was then fed to the PWM pcb. The output from the pcb goes to the cutting wire. There is a rheostat which controls the wire heat and an on off switch (with an led power indicator) located in the little project box attached to the lower front of the cutter, it is visible in the picture below.



I don't know if there will be any requirement for it but I also decided to make the unit so the cutting wire could be tilted to make angled cuts. It will tilt up to 45° either side of vertical and the bar that clamps it in place is engraved so you can set a given angle, this can also be seen in the picture below. I used my CNC Taig mill to do the engraving.



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Feedback

on 11/17/2004, John Grywalski wrote:

What's New

Hot Wire Foam Cutter

I built this tool because I needed to develop a way to shape a big block of Styrofoam when I built [The Happy Birthday Party Napkin Rocket of the Apocalypse](#). The photos here are from that project, but I've utilized this concept in the construction of a variety of items.

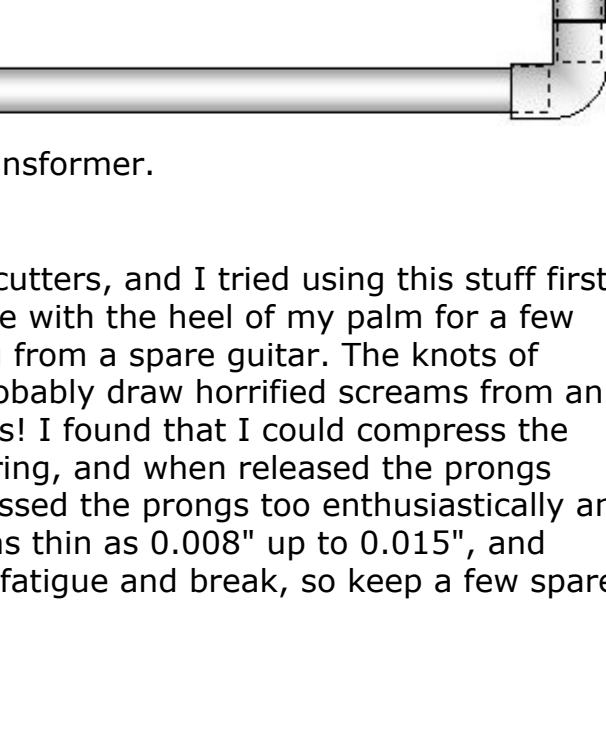
Hot wire foam cutters are used by hobbyists of all stripes to contour Styrofoam into a vast array of shapes for a wide variety of uses. Model railroad builders shape foam into landscapes. RC plane builders shape foam into aircraft wings and fuselages. Stagehands shape foam for theatrical sets and props. And because Fiberglas can be applied over the shaped foam to create a rugged and lightweight structure, rocket builders can shape foam for use as nose cones or airframes.



There's more than one way to shape foam. You can sand it, cut it with a saw, sculpt it with a knife -- I even know some rocket makers who use a hand router to shape large nose cones. Different tools work better for different craftsmen, but the tool that has worked best for me is a homemade contraption that uses a heated wire to easily melt its way through the foam. Small hot-wire tools can be purchased at hobby stores for thirty to forty dollars, but these are really too small to use on anything but the smallest model rockets. The good news is that you can make a hot-wire tool for only a few bucks that is big enough and burly enough to make Tim 'The Tool Man' Taylor grunt in approval.

Parts List

- Louis Marx Model #1229 50 Watt Transformer, 13 volts variable (or similar)
- Two (2) 10-inch lengths of 1.25-inch PVC
- Two (2) 2-inch lengths of 1.25-inch PVC
- Two (2) 18-inch lengths of 1.25-inch PVC (this length is up to you -- more or less will change the working area of your tool)
- Two (2) 90-degree elbow fittings for 1.25-inch PVC
- Two (2) T-joint fittings for 1.25-inch PVC
- PVC Cement
- Two (2) 10-32 eyebolts with wing nuts and washers
- 10 feet of heavy stranded wire (16 gauge or thicker)
- 0.008 to 0.015-inch (thickness) single-wire steel guitar strings (available at your local music store)

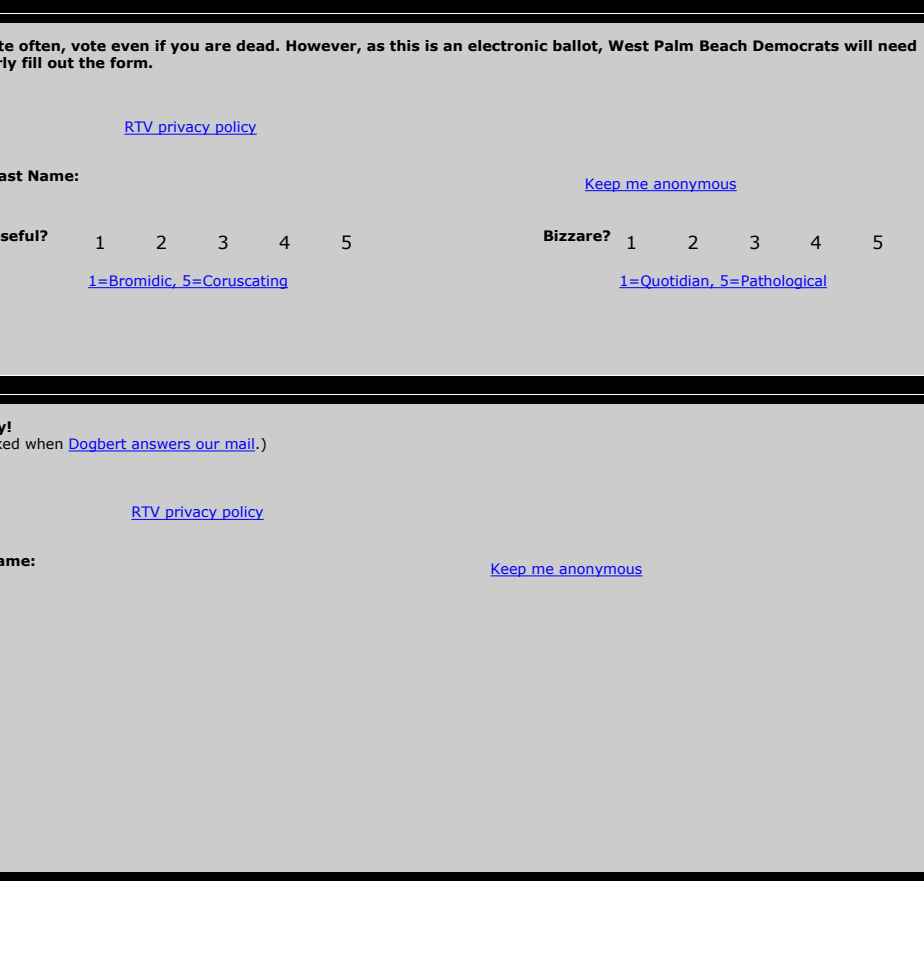


Power Supply

I purchased my vintage model train transformer on eBay for \$7. You may have a better alternative for a power source, but I recommend you use one with a variable voltage control. Also, newer models have circuit breakers built into them that disqualify them for use in this application, so older power supplies seem to work best.

Cutting Bow

Assemble the 'bow' of the hot-wire cutter as shown in the drawing. Drill holes in the ends of the prongs for the eyebolts and attach with wing nuts and washers. (You don't need to cut the ends at an angle as shown -- I added the angled cuts when my third foam project was too wide for the bow I'd made for my previous two foam projects). Attach the stranded wire to the eyebolts with the wing nuts and tape the wire to the bow to keep it out of the way. Use heavy wire (like power cord or hefty speaker wire) to minimize current loss from the transformer.



Cutting Wire

Hobby stores sell nichrome wire specifically for hot wire cutters, and I tried using this stuff first. It broke immediately. After knocking myself in the temple with the heel of my palm for a few minutes, I ran into the house and pulled a steel 'E' string from a spare guitar. The knots of twisted wire I used to attach it to the eye bolts would probably draw horrified screams from an Eagle Scout, but they held together and I was in business! I found that I could compress the prongs of the bow together when attaching the guitar string, and when released the prongs pulled the wire to just the right tension (unless I compressed the prongs too enthusiastically and the string broke when I let go). I've used guitar strings as thin as 0.008" up to 0.015", and decided I prefer the thicker ones. The strings eventually fatigue and break, so keep a few spares around when you're working on bigger projects.

Tips

1. Use safety glasses and try not to stab yourself in the finger when twisting the guitar string onto the eyebolts. The ends are really sharp.
2. Attach the stranded wire to the transformer before trying to cut foam. It is possible to skip this step and generate heat by rubbing the guitar string rapidly back and forth, but it is not recommended. The wire will emit a slight hum when current is applied, and will continue to hum until you teach it the words.
3. Increase voltage incrementally and test the heated wire on a spare piece of foam. Add power if the wire doesn't cut easily through the foam. Back off on the power if the foam instantly vaporizes. Also back off on the power if the wire vibrates uncontrollably or spontaneously plays the theme from *Shaft*.
4. Don't bother trying to use wound strings or nylon strings. If you do, don't complain to me that your tool doesn't work.
5. This tool really works well in conjunction with the [Styrofoam Shaping Fixture](#).



Click [\[HERE!\]](#) to go to the Construction Index

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Hot wire foam cutting

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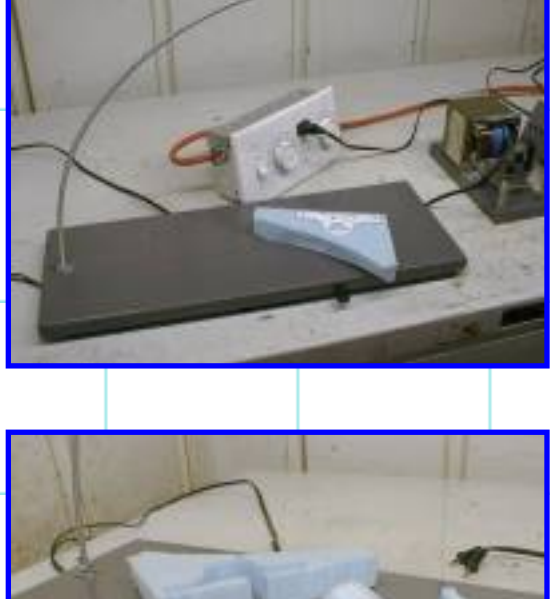
The foam cutting lathe

Here is a homebuilt foam turning lathe!! This is made from a window motor adapted and appropriately painted for the application. The pillow blocks that the rotating shaft bear in were made from foam patterns and cast using the above mentioned techniques. The two dials on the electrical box are light dimmers with simple numerical 10 through 100 markings for remembering settings. One is for the wire heat, the other controls motor speed. The object that is being turned on the lathe is a step pulley pattern. The picture below shows a similar pattern and a resulting pulley casting!



Foam cutting table and bow

Here I am cutting out a pillow block pattern for a lost foam casting. The paper stencil was designed using DeltaCad 3.2 and simply cut out with scissors. The curved rod is a 1/4-20 threaded rod with brass nuts to position the top wire terminal for varying cutting angles. It is a bit tricky to set it perfectly square with the cutting table. The transformer on the right is controlled by one of the light dimmers, center. The transformer is a modified microwave oven transformer with several taps for different lengths and sizes of cutting wire. The wire is not easily visible in the photo, it is a fairly fine wire, a violin "e" string.



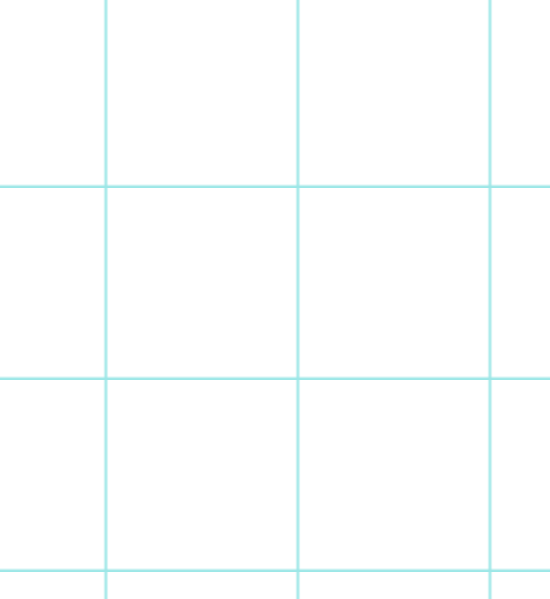
Better view of foam cutting table

Note the knob for loosening the wire.



Pillow block template was made using DeltaCAD

Here the pattern is done except for the hole in the center for the shaft. To cut the hole, I loosen the knob at lower right to release the cutting wire. Then a reamer or punch is used to make a hole in the foam pattern, the cutting wire is fed through this hole, and re-tightened. The power is turned back on and the hole cut out. Then the wire is again released and the plug is removed from the hole. The pattern is ready to cast. Instead of making a core to form a hole in the casting, I simply put a 5/8" shaft through the hole and cast the metal right on it. After cooling, the shaft is driven out. This forms a nice smooth hole without ever machining it.



Step pulley pattern cut from foam

Notice the rough round glues blanks in the center background. These get foam together to form a blank large enough to turn a foam step pulley pattern from. Also, note the mold lines on the aluminum step pulley casting. This casting was not done with lost foam techniques, but by traditional molding techniques using a split foam pattern! Foam as you can see is a very versatile pattern material. It is, of course more fragile than wood and is harder to get a good surface finish like with wood patterns.



TECHIE STUFF !! (what you really came for...)

Now, here is the more technical notes concerning hot wire foam cutting techniques. These notes were inspired in part by email communications that I had with David Wimberley, the author of the David Wimberley Forge plans, available through Lindsay publications, (www.lindsaybks.com) David happened across this site sometime around August of 1999, and told me of his plans to begin experimenting with foam cutting. At that time, we had an inactive (coming soon) link that was bringing a few "foam cutting" hits, and after conversing at some length with him concerning this art, or sport, or whatever, decided it was time to address the matter.

Wire for hot wire cutting

First the wire. Any wire will do that can remain taut under heat. If the wire is low grade steel, for example galvanized picture wire, it won't last long because it gets soft with the heat -- even the low temp of foam cutting -- and snaps. David's choice of guitar wire is probably good. I have used stainless MIG welding wire, and I've used violin "e" string wire. I don't know what guitar wire is made of, but I do know that it is a very springy type of wire, and made to handle tension. I have used mandolin wire also (practically the same thing as guitar) and it worked quite well. The size of the wire is also noteworthy. The smaller wire diameter, the finer the cut you can make.



Schematic for dimmer, doorbell transformer foamcutter

Power supply

Getting the power from your 110 volt receptacle to a suitable foam cutting format presents several problems. A standard light dimmer can be successfully used to vary the heat, but it can't heat the wire in a direct circuit. With a light dimmer powered by straight line current, you are taking a great risk of electric shock. Also, a guitar string is not going to be longer than about 2-3 feet (unless you get it bulk). But then how long of a wire are you planning to cut with? If the wire is too short (like only a foot or two) the light dimmer won't be able to go low enough and may self destruct from excessive current, or it may light the wire up orange hot and snap it.

What I recommend for a power supply is a bell transformer. They are available at your local Kmart, Walmart, or Home Depot for about 15 dollars, and are intended for doorbells. They put out 24 volts nominal, and they can be operated with most light dimmers to vary the current. I haven't found a light dimmer yet that doesn't vary a transformer. This despite the warnings that you shouldn't use a dimmer with a transformer. (But don't try to vary the speed of your ac-adaptor powered tape recorder with this arrangement.) The bell transformer also isolates the resistance wire voltage from line current so that if you do come in contact with the wire or it's terminals that you aren't a short circuit to ground. Also, there's less voltage there to hurt you should you happen to touch both ends of the wire at once. I don't mean to be simplistic about safety, just extra cautious, as I am not a professional, but a hobbyist.

An alternative to bell transformers: I use transformers that come out of old power supplies for radios, office equipment, etc. These can have varying voltages, allowing for longer wires for cutting, etc. If you do end up needing a higher voltage for longer cuts, just gang up two or more bell transformers in series. Or, need more current? Gang them up in parallel. Just make sure you get the polarity right. No, transformers don't have a plus or minus, but when you have two windings (four wires) they do have polarity with respect to each other.

Wire Temperature

The cutting wire should not get red hot to cut foam. It does get hot enough to smoke, however. The power supply ideally should be capable of heating up the wire well above the cutting temperature, and the reason is covered here. Getting the wire red hot isn't all bad. I find that being able to heat the wire up well beyond cutting temperature is helpful in cleaning the wire. When the wire gets gummed up with residue, it can easily be cleaned by heating up the wire till it starts to smoke, then wipe a cloth over it and it comes nice and clean. The trouble with residue is that it leaves little blobs on the finished cut. However, getting the wire red hot takes the temper out of it, and too much red heat on your cutting wire will fatigue it and cause it to fail, possibly at an important stage of a complicated cut.

Cutting Speed

The speed that your cutting wire moves through the workpiece is noteworthy. If you try to cut too fast, the wire will make a distorted cut because it is pulled into an arc in the midsection of the workpiece. If you cut too slow, the wire will cause the foam to shrink back from the heat, and also droplets of melted foam will adhere to the wire and leave hard little knots in the surface of the cut. It is important to understand what the wire is doing as it cuts foam.

Some important events take place when the wire initially heats up, when you start into the workpiece, and when you come to a corner or a detail in your stencil. One thing I have discovered is that after you turn on your power supply and dial it to the desired heat setting, the wire has already gotten too hot. But at very same setting is too cold once you've cut an inch or two and cutting goes SLOW. This is a problem that I have been thinking about for sometime, and am on the verge of an invention with.

The Bow

Taut-hot-wire foam cutting requires some kind of bow, or hoop, or frame, to keep the wire tight and straight. These can be any thing your imagination can cook up. It should meet a few simple requirements, however, to make the technique as trouble free and practical as possible.

The bow needs to allow wiring or other system of electrical conduction to the wire, to heat it, of course.

The bow needs to exert some tension on the wire to keep it straight.

The bow needs to have sufficient throat to accommodate desired depth of cuts.

The bow needs to be able to be handled, or to be fixed to a stationary surface in such a way to allow the workpiece to be moved across it.

If you do much foam cutting, you will find that soon you have an array of bows, each for a slightly different type of cut. The bow that I prefer to use for small lost foam patterns has a table that keeps the workpiece square with the cutting wire. This allows nice square cuts, perpendicular to the flat surface of the foam sheet. The next section will cover shaped wire holders, which have their own special type of wire holder, different from the bow in that it does not exert tension to the wire, but rather holds it in a fixed position, maintaining the intended shape of the wire.

Shaped Wire Cutting

This technique was employed in the making of the step pulley patterns. Here, stiff, heavy wire was bent into a shape that was to be applied to the workpiece: V-grooves. The factors that need to be considered here are the actual shape desired from the wire shape (they're not equal), and the cutting resistance of the foam. There may be other factors, as well. Almost any hot wire cut will show signs of the foam shrinking back from the hot wire. This may mean that in order to cut a 1/4" groove, you may need to bend up a wire shape that reflects more of a 3/16" groove. Bending wire shapes to cut a predetermined shape in foam is an art, and I have not mastered it, but have certainly had a lot of fun experimenting with it. That's all for now, folks!

Questions? Comments? Send me a note!

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Scripture Verse:

"Have not I commanded thee? Be strong and of a good courage; be not afraid, neither be thou dismayed: for the LORD thy God is with thee whithersoever thou goest."

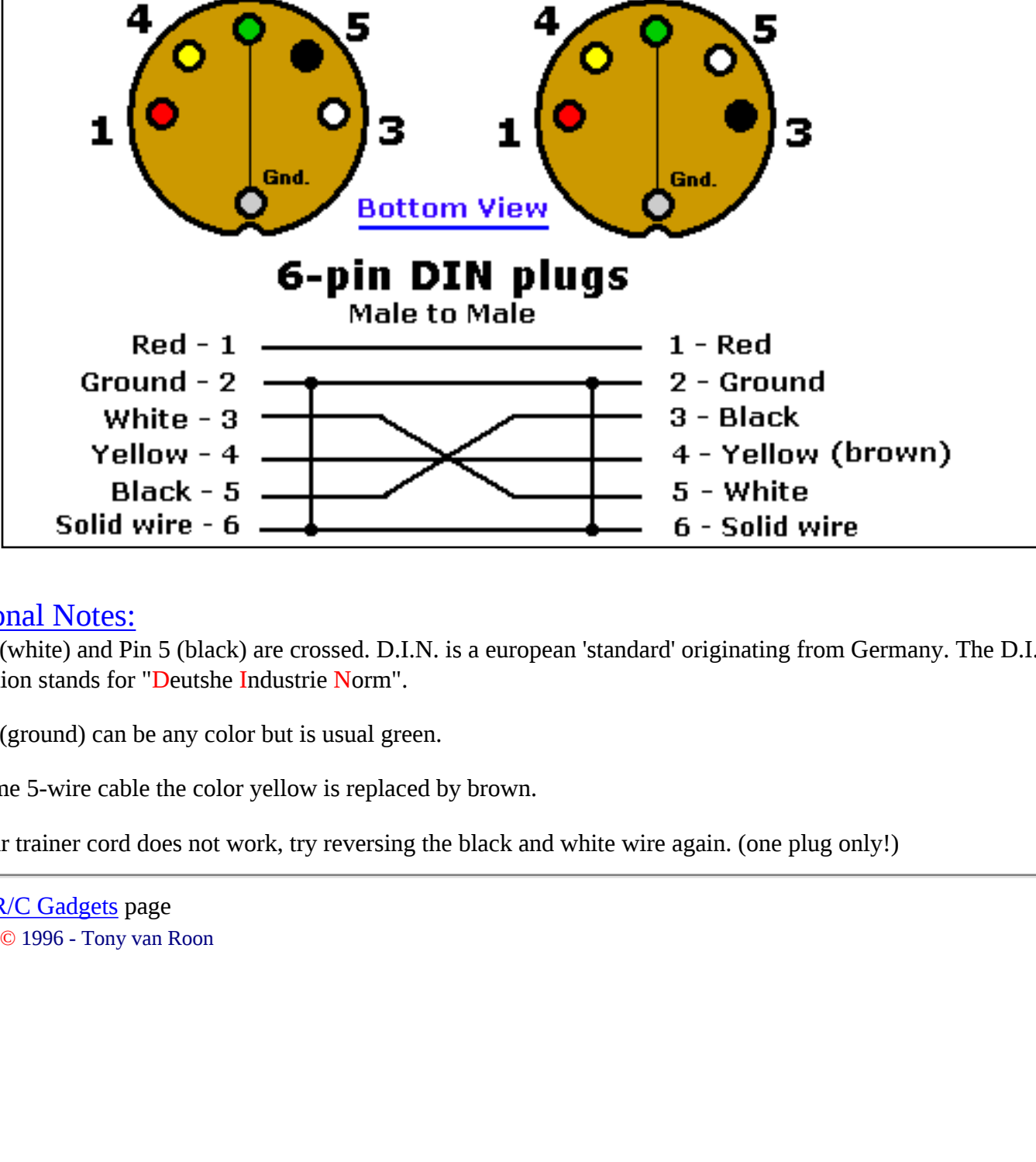
- Joshua 1:9

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Airtronics (AM/FM) Trainer Cord

by [Tony van Roon](#)



Additional Notes:

1 - Pin 3 (white) and Pin 5 (black) are crossed. D.I.N. is a european 'standard' originating from Germany. The D.I.N. abbreviation stands for "**D**eutsche **I**ndustrie **N**orm".

2 - Pin 2 (ground) can be any color but is usual green.

3 - In some 5-wire cable the color yellow is replaced by brown.

4 - If your trainer cord does not work, try reversing the black and white wire again. (one plug only!)

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Automatic Device Locator

http://www.uoguelph.ca/~antoon

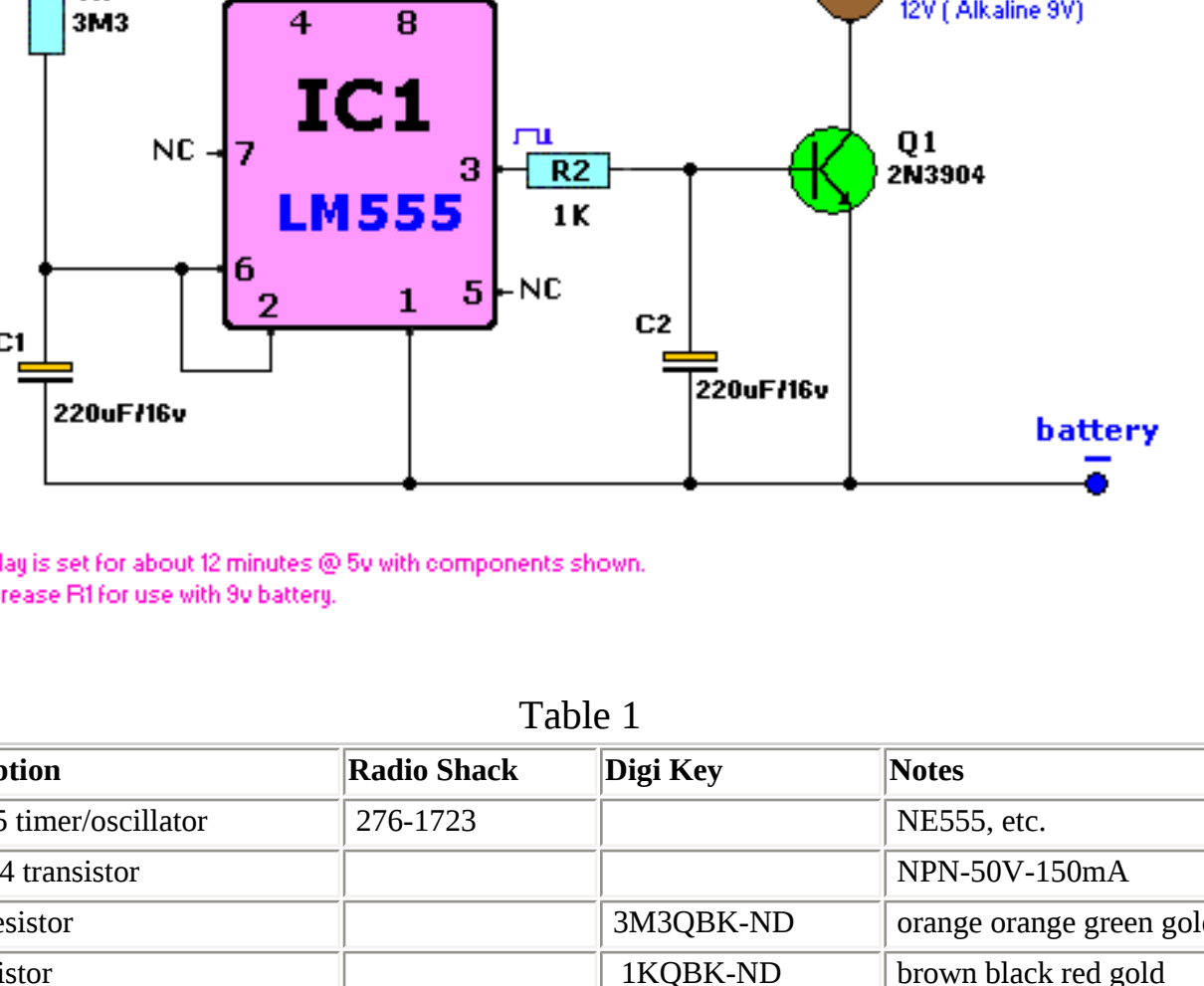


Table 1

Part	Description	Radio Shack	Digi Key	Notes
IC1	LM555 timer/oscillator	276-1723		NE555, etc.
Q1	2N3904 transistor			NPN-50V-150mA
R1*	3M3 resistor		3M3QBK-ND	orange orange green gold
R2	1K resistor		1KQBK-ND	brown black red gold
C1*	220µF, 16V capacitor			electrolytic (see text)
C2	220µF, 16V capacitor			electrolytic

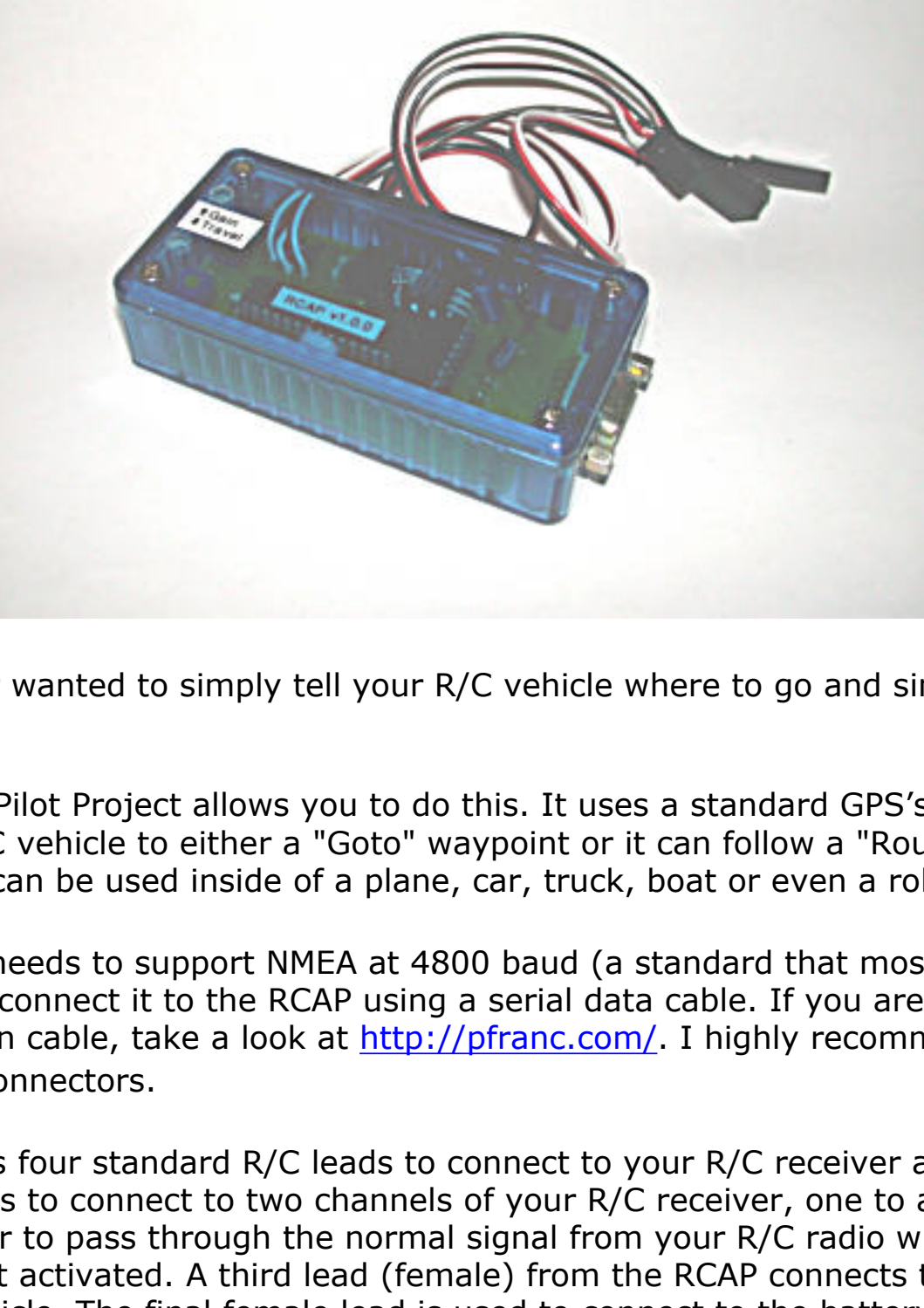
A Couple of Final Notes:

- o All partnumbers are Radio Shack/Tandy or DigiKey unless otherwise indicated.
- o All resistors are minimum 5%, 1/4 watt, carbon, unless otherwise indicated. It's okay to use metal film or other precision types. 3M3(R1) is the same as 3.3M
- o With this circuit you can find your aircraft easily in high grass, corn fields, soybeans or whatever. As soon as you power on your receiver the timer will start to count down.
- o If you power the unit via the receiver battery, make sure to purchase a 3 - 6 volt buzzer! Remember that in the case of a crash (heaven forbid!) the receiver may loose its power from the battery pack because of the force of impact. It would be safer to provide the ADL with a 9-volt Alkaline battery + on/off switch and wrap the whole thing in 1/4" SIG latex rubber.
- o The timer, with the components shown above, goes off in about 18 minutes at 9-volt. To increase the delay, increase the value of **R1**. Also, R1 could be made adjustable with a 5-Mega-ohm trimpot of the proper wattage.
- o A CMOS version of the [555](#) timer is available ([MC1455P1](#)), and preferred, which will cut the powerdrain on battery powered circuits. The MC1455P1 is pin-compatible with the NE555, and most other 555 chips. C1 and C2 are electrolytic capacitors (or tantalum) so watch the '+' and '-' orientation. T1 (2N3904) can be most any substitute so it's not critical; just watch the position of the emitter/collector as some european type have them reversed (like the BC types).
- o The ADL can be used for all forms of R/C equipment, the only thing needed may be to adjust the delay to tailor your needs.
- o This device is tested for interference with JR, Futaba, HiTec, Airtronics, Hobbico, and ACE radio equipment. None were found and none are expected when used with other brands of Radio equipment.

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R/C Auto Pilot Project



Have you ever wanted to simply tell your R/C vehicle where to go and simply let it do the rest.

The R/C Auto Pilot Project allows you to do this. It uses a standard GPS's waypoints to navigate a R/C vehicle to either a "Goto" waypoint or it can follow a "Route" of waypoints. It can be used inside of a plane, car, truck, boat or even a robot.

The GPS unit needs to support NMEA at 4800 baud (a standard that most GPSs do support). You connect it to the RCAP using a serial data cable. If you are looking to make your own cable, take a look at <http://pfranc.com/>. I highly recommend them for Garmin GPS connectors.

The RCAP uses four standard R/C leads to connect to your R/C receiver and battery. Two male leads to connect to two channels of your R/C receiver, one to activate the RCAP the other to pass through the normal signal from your R/C radio while the autopilot is not activated. A third lead (female) from the RCAP connects to a servo to steer your vehicle. The final female lead is used to connect to the battery.

Once a waypoint is activated on your GPS, it will start sending data to the RCAP. (Meaning you MUST have a Goto or Route active at all times on the GPS for the RCAP to function properly when activated). The RCAP will ignore this data and simply pass through your R/C radios instructions while it is not activated. Once activated, by using a spare switch on your R/C radio (gear switch for example) it will then read in the [\\$GPRMB](#) and [\\$GPRMC sentences](#) from your GPS to determine the heading needed to remain on course for the currently active waypoint.

There are 3 adjustments that need to be set on the RCAP.

- Servo direction.
- Max. servo travel
- Course correction gain

Servo direction (slide switch S1) simply allows you to reverse the direction a servo turns while the RCAP is activated. You should test this out before actually putting the RCAP into your vehicle to make sure it matches the expected response.

Max Servo Travel (Variable resistor R2) allows you to set a maximum end point that you will allow a servo to travel. This is especially important when installing the RCAP into an aircraft. I recommend starting with a minimal setting and increasing it slowly.

Course Correction Gain (Variable resistor R3) allows you to adjust how aggressively you want RCAP to remain on course. A low setting means that the RCAP will slowly turn toward the current course. A high setting will have the turns perform much quicker. The amount of correction used is also proportional to the amount off course the vehicle is, the greater the amount off course, the greater the correction is. I would recommend starting with a minimal setting and increasing it slowly.

The RCAP needs it's own power source of 6V. A 5-cell R/C receiver battery works well. I will be testing some 2-cell lithium ion polymere batteries shortly and will report on its use in the discussion forums at <http://groups.yahoo.com/group/rcpilot/>.

When using the RCAP inside of an aircraft, the recommended method would be connecting the planes rudder to the RCAP. An additional method of stabilizing the plane is needed as well. RCAP has been tested with Futaba's PA-1 and FMA Co-Pilot. Both of these work well with RCAP. Please ensure the method used for correcting your planes stabilization has been tested before installing the RCAP.

Building the RCAP

You may obtain all the necessary files in one of two ways.

You can [download a complete archive of version 1.1](#).

or you may browse the CVS repository at [SourceForge](#)

The RCAP is based on MicroChip's PIC series of microcontrollers. It uses the PIC16F876.

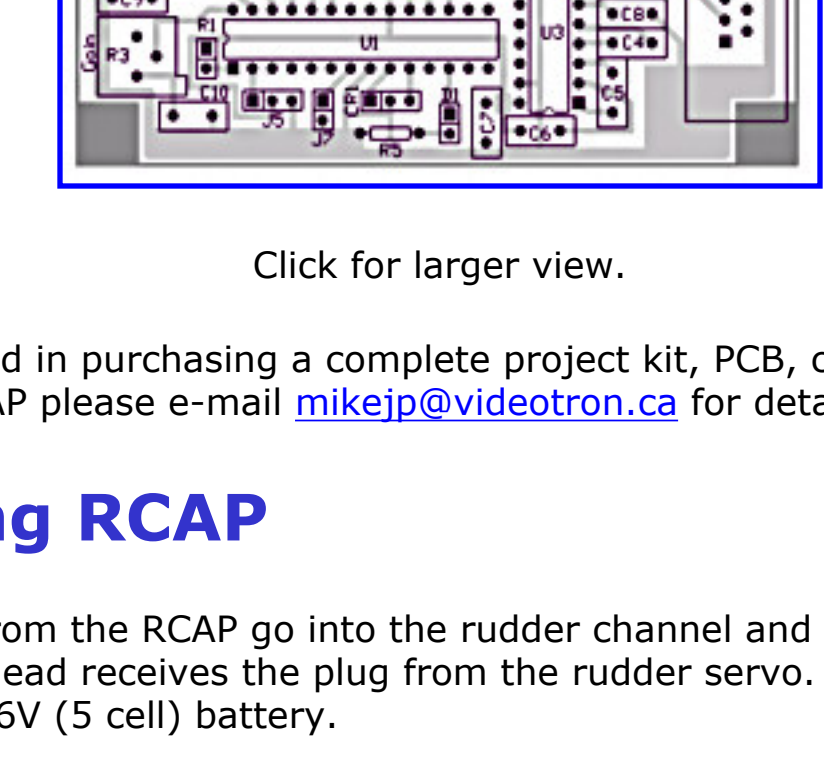
You need to either compile the code using Micro Engineering Lab's PicBasic Pro or download the HEX file and burn the microcontroller using a PIC programmer that can program 28 pin PICs.

A pre-programmed microcontroller is also available at http://www.rconline.ca/catalog/product_info.php?products_id=122

Next you will need to make a printed circuit board.

You may either use the .PCB file found in the circuit folder or the bw-art file. The .PCB file is in Traxmaker format.

A professionally produced PCB is also available at http://www.rconline.ca/catalog/product_info.php?products_id=123



The rest simply involves soldering the correct components into place.



Click for larger view.

If you are interested in purchasing a complete project kit, PCB, case, components or a pre-assembled RCAP please e-mail mikejp@videotron.ca for details.

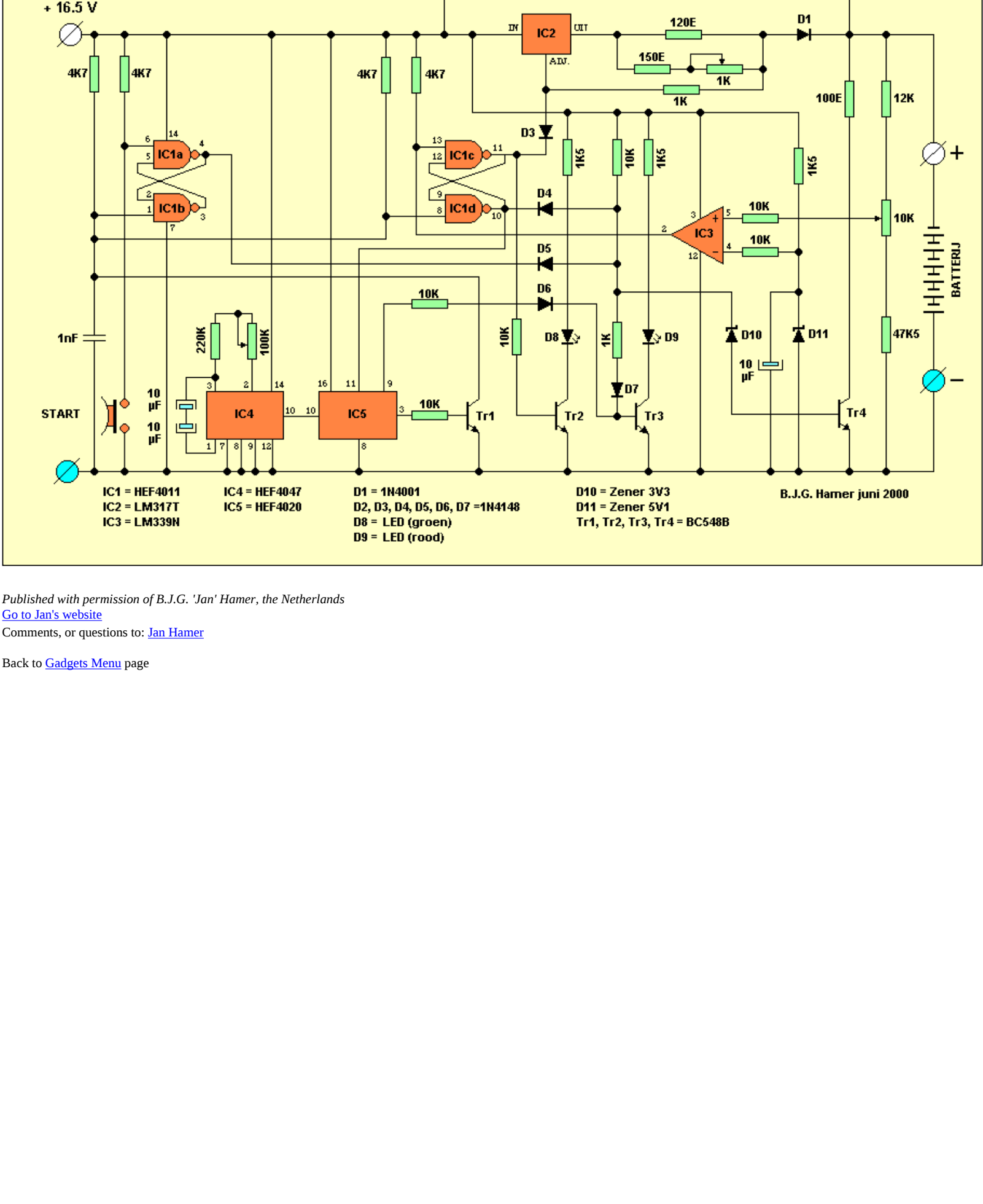
Connecting RCAP

The 2 male leads from the RCAP go into the rudder channel and an auxiliary channel. The 3-wire female lead receives the plug from the rudder servo. The 2-wire female lead connects to a 6V (5 cell) battery.



Automatic 9-Volt Nicad Charger

by Jan Hamer



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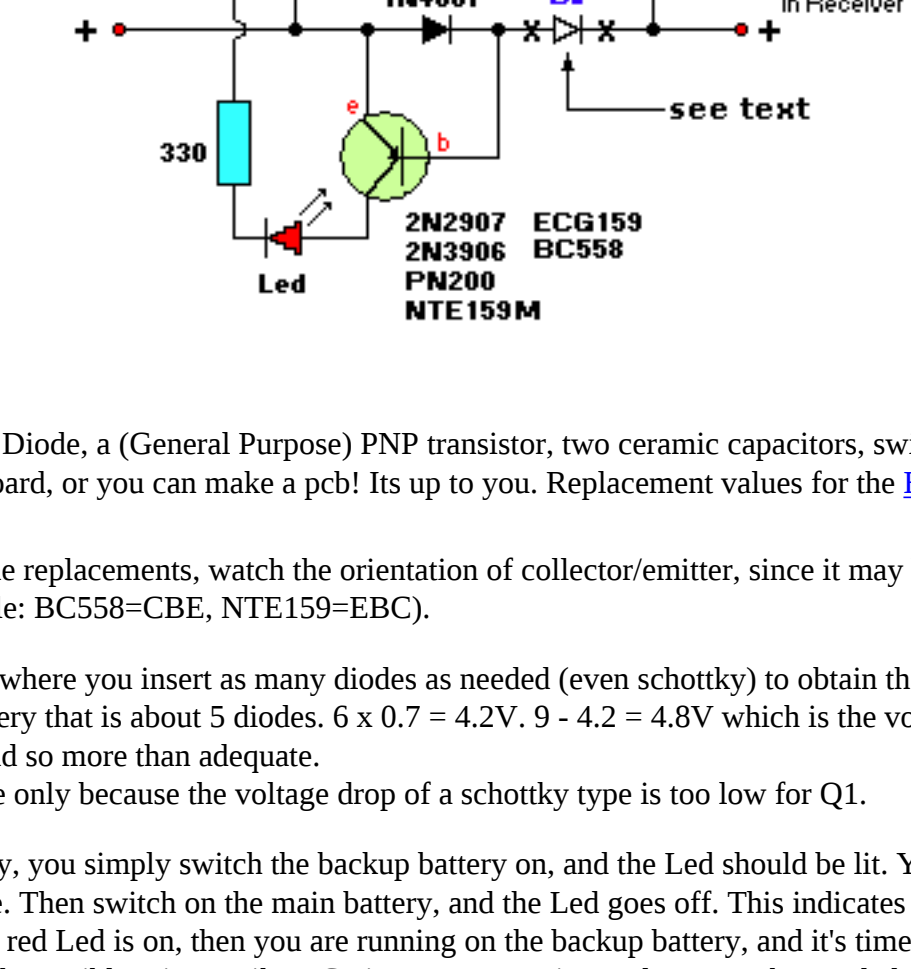
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9V Backup Power for R/C Aircraft

by [Tony van Roon](#)



A Couple Notes:

You will need a 1N4007 Diode, a (General Purpose) PNP transistor, two ceramic capacitors, switch harness, buzzer, and a small amount of Vero Board, or you can make a pcb! Its up to you. Replacement values for the [BC558](#) are [NTE159](#), [ECG159](#), etc.

CAUTION: If you use the replacements, watch the orientation of collector/emitter, since it may be reversed from the european format (example: BC558=CBE, NTE159=EBC).

Diode(s) **Dx** is the place where you insert as many diodes as needed (even schottky) to obtain the required voltage drop. For a 9-volt alkaline battery that is about 5 diodes. $6 \times 0.7 = 4.2V$. $9 - 4.2 = 4.8V$ which is the voltage drop when the backup is switched on and so more than adequate.

D1 must be a silicon type only because the voltage drop of a schottky type is too low for Q1.

To test the backup battery, you simply switch the backup battery on, and the Led should be lit. You should have power to the receiver via the diode. Then switch on the main battery, and the Led goes off. This indicates that the main battery is ok. Should you land, and the red Led is on, then you are running on the backup battery, and it's time to go home.

The two capacitors absorb possible micro-spikes; C1 is extra protection and may not be needed depending on the quality of your receiver. However, it cost almost nothing and does no harm.\

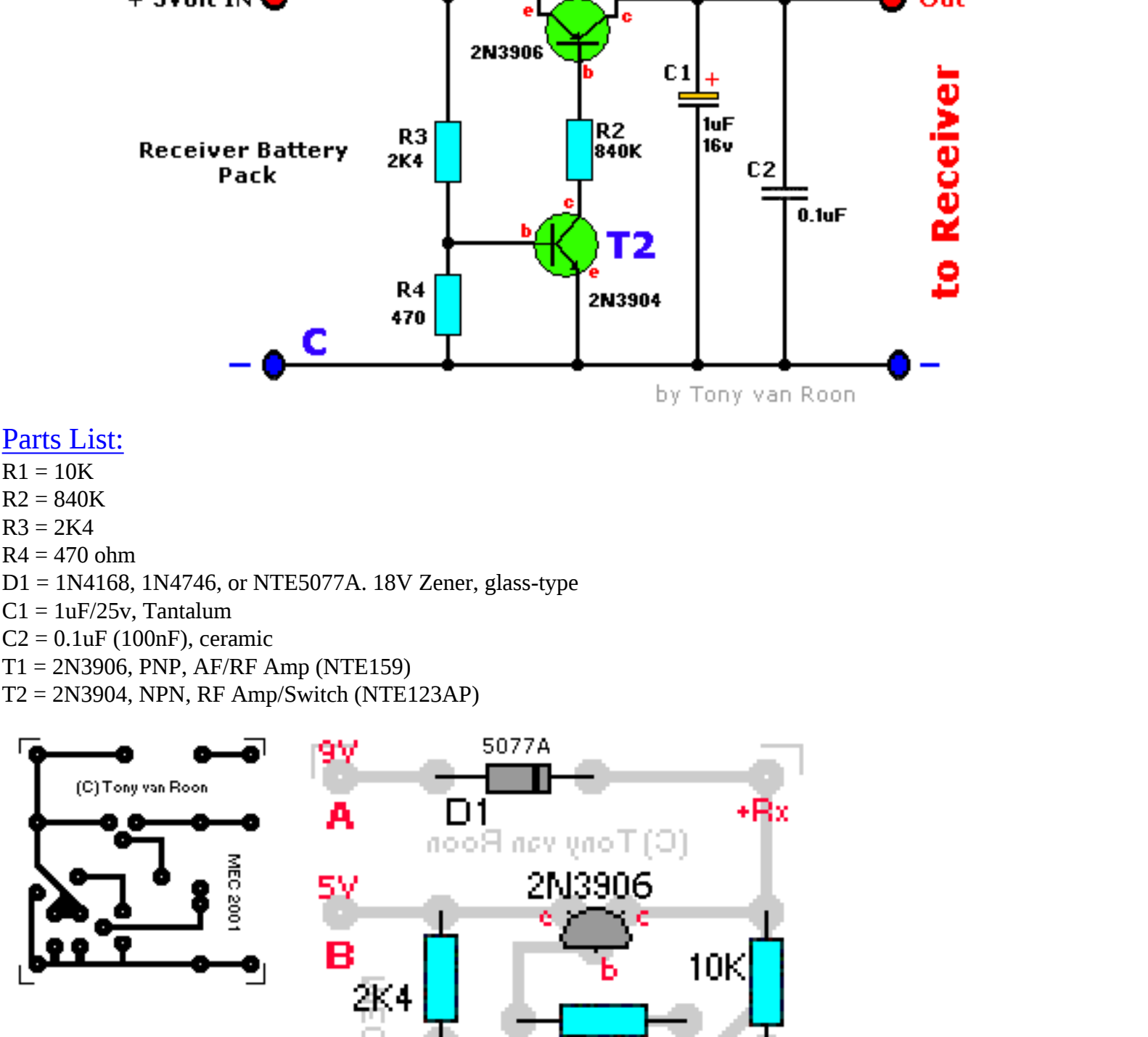
TEST THE CIRCUIT before hooking it up to your (expensive) receiver!

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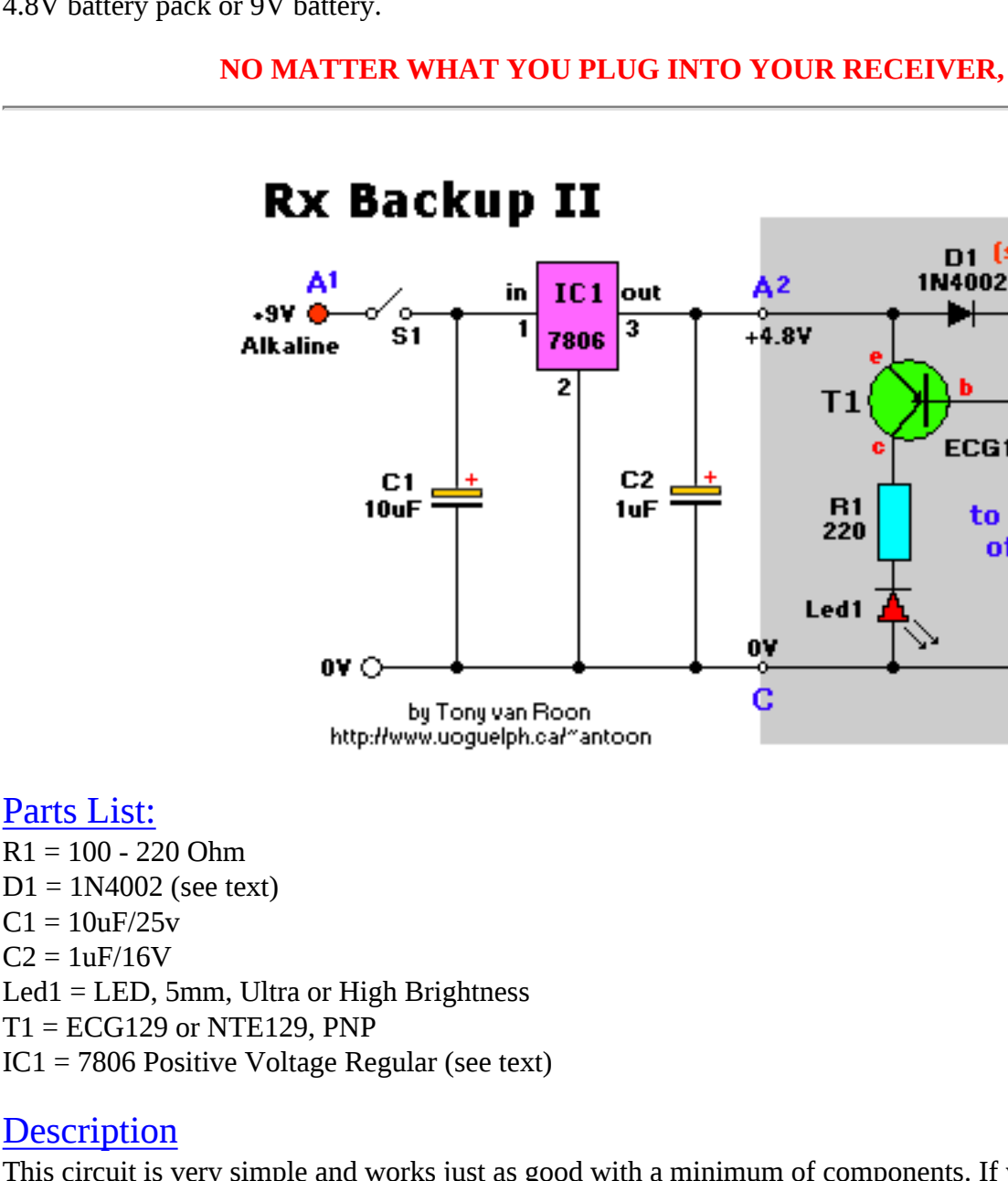
Receiver Backup Power

by Tony van Roon



Parts List:

- R1 = 10K
- R2 = 840K
- R3 = 2K4
- R4 = 470 ohm
- D1 = 1N4168, 1N4746, or NTE5077A. 18V Zener, glass-type
- C1 = 1uF/25v, Tantalum
- C2 = 0.1uF (100nF), ceramic
- T1 = 2N3906, PNP, AF/RF Amp (NTE159)
- T2 = 2N3904, NPN, RF Amp/Switch (NTE123AP)



Description

You will also need a 9v battery + battery clip. Nicad or Alkaline works fine. Keep in mind that the so-called '9-volt' NiCad battery does not actually contain 9-volts but rather between 7.6 and 8volts. Adjust R1 to 8K2 if you are using the 9-volt NiCad type. For backup power the normal 9volt Alkaline battery is just fine. A PCB is provided but not really necessary since this circuit can easily be built on vero-board or the 'Experimenters PCB' from Radio Shack.

As long as there is enough power supplied to the +Vcc input, T1 and T2 are biased and filter out to '+ Out' while blocking the 9-volt via D1 and R1. The purpose of R1 is only to bring the 9-volt to an acceptable voltage-level for the receiver. When the battery-pack gets below 4.8V, the voltage divider over T2 will be reversed biased and make T1 block the '+Vcc In'. This will allow D1 via R1 to bias and provide the necessary backup power. For T1, a NTE129 may work also. One more thing about T2, the replacement type is NTE123AP. The regular 'A' type will not work.

In the event you are unable to obtain the transistors above, I have included a second version (below) for either a second 4.8V battery pack or 9V battery.

NO MATTER WHAT YOU PLUG INTO YOUR RECEIVER, TEST IT FIRST!



Parts List:

- R1 = 100 - 220 Ohm
- D1 = 1N4002 (see text)
- C1 = 10uF/25v
- C2 = 1uF/16V
- Led1 = LED, 5mm, Ultra or High Brightness
- T1 = ECG129 or NTE129, PNP
- IC1 = 7806 Positive Voltage Regular (see text)

Description

This circuit is very simple and works just as good with a minimum of components. If you wish to use a 9-Volt Alkaline battery you just build the whole circuit as shown. If you wish to use it with a second 4.8 battery back, you can eliminate C1, C2 and IC1 and go directly to the circuit in the gray-shaded area.

The backup-battery starts to activate when the main battery pack falls below 4.7 volt, and provides full power at 4.6 volt. This fact is indicated by the illumination of Led1 via R1. Depending on the type of LED you're using, you may need to experiment with the value of R1. The Ultra-Bright LED I'm using required a 220-ohm resistor for R1. Select a value anywhere between 100 - 330 ohm.

You can use a 3-volt buzzer also instead, just replace Led1 & R1 with the buzzer. Another diode and capacitor may be needed over the '+v' and '-' of the buzzer to filter out transients. A 1N4148 diode and a 100nF ceramic capacitor will most likely be sufficient. I personally favor the high brightness Led since I fly helicopter and wouldn't be able to hear the buzzer anyway. Your choice.

In regards to transistor T1, which is a general purpose fast-switch/driver; the ECG129/NTE129 worked fine. I noticed while experimenting that not all transistors behave the same in regards to activating the backup-battery at a certain voltage level. Any PNP fast-switch type will probably work. Check [ECG & NTE](#) for reference information.

The IC1 regulator is a 6-volt type in a TO-220 case. The general purpose 1N4002 (D1) takes a voltage drop of 0.7V making the output a total of 5.3V. Okay for most receivers but check yourself. Some receivers have a max of 5V. If your receiver can handle 6 volt, change D1 for a schottky diode which has a lower voltage drop.

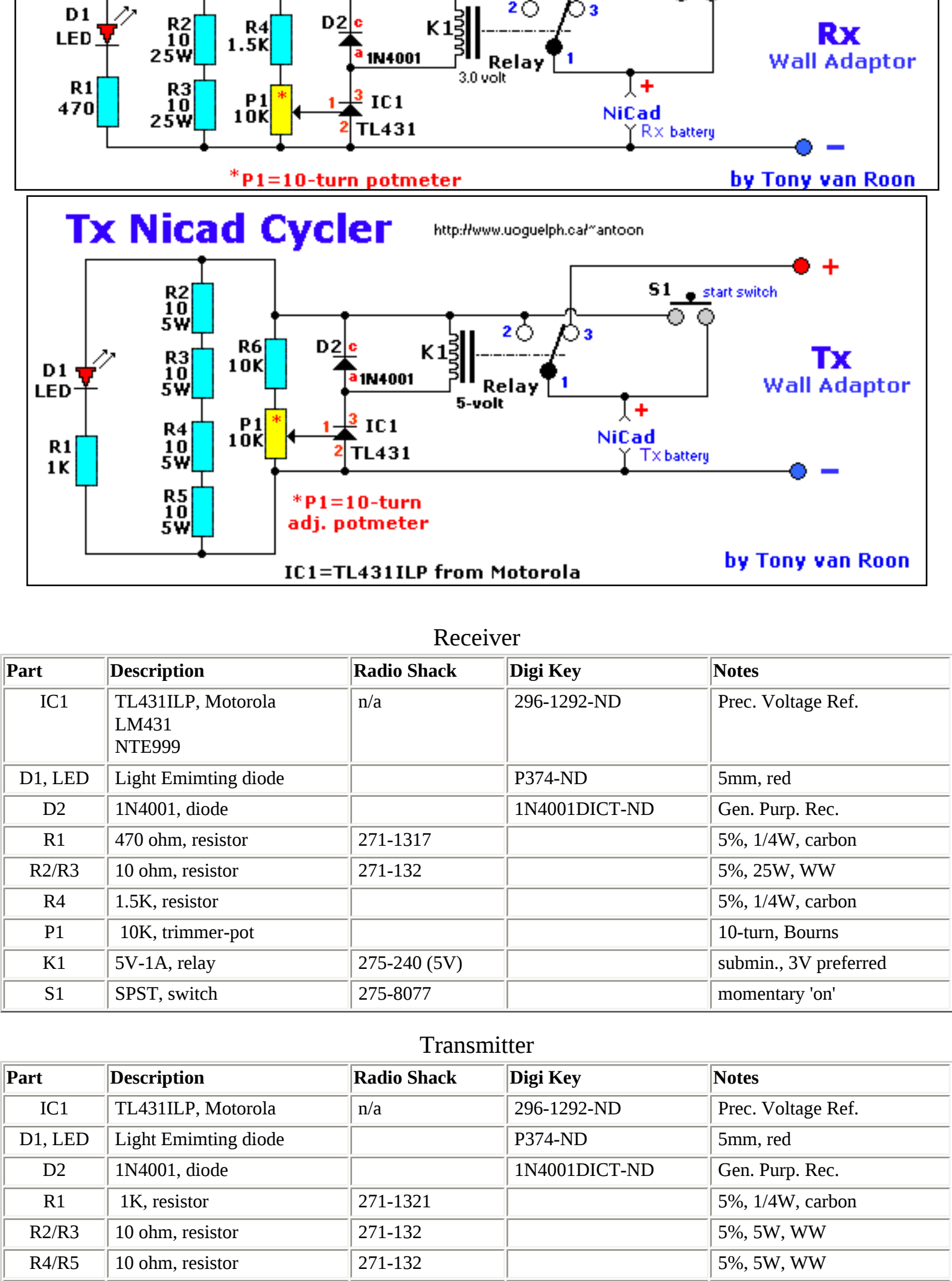
The 9-volt Alkaline battery is connected between the 'A1' point and '0' volt. A regular 4.8 volt battery pack is connected to 'A2' and '0' volt and components not shown in the gray-shaded area eliminated. Point 'B' and '0' volt goes into a spare slot of your receiver.

To check the working of your backup circuit, make sure both the main and backup packs are plugged into the receiver. If you switch the main battery pack off (via the switch harness) the led will light and indicate that 'backup is provided'. Ofcourse, you should have another switch for the backup battery otherwise your receiver would be always 'on'.

Because of the simplicity of this circuit, there is no need for a circuit board. Use vero-board or something.

AGAIN -- NO MATTER WHAT YOU PLUG INTO YOUR RECEIVER, TEST IT FIRST!

NiCad Battery Cycler for Rx & Tx



Receiver				
Part	Description	Radio Shack	Digi Key	Notes
IC1	TL431ILP, Motorola LM431 NTE999	n/a	296-1292-ND	Prec. Voltage Ref.
D1, LED	Light Emitting diode		P374-ND	5mm, red
D2	1N4001, diode		1N4001DICT-ND	Gen. Purp. Rec.
R1	470 ohm, resistor	271-1317		5%, 1/4W, carbon
R2/R3	10 ohm, resistor	271-132		5%, 25W, WW
R4	1.5K, resistor			5%, 1/4W, carbon
P1	10K, trimmer-pot			10-turn, Bourns
K1	5V-1A, relay	275-240 (5V)		submin., 3V preferred
S1	SPST, switch	275-8077		momentary 'on'

Transmitter				
Part	Description	Radio Shack	Digi Key	Notes
IC1	TL431ILP, Motorola	n/a	296-1292-ND	Prec. Voltage Ref.
D1, LED	Light Emitting diode		P374-ND	5mm, red
D2	1N4001, diode		1N4001DICT-ND	Gen. Purp. Rec.
R1	1K, resistor	271-1321		5%, 1/4W, carbon
R2/R3	10 ohm, resistor	271-132		5%, 5W, WW
R4/R5	10 ohm, resistor	271-132		5%, 1/4W, WW
R6	10K, resistor	271-1335		5%, 1/4W, carbon
P1	10K, trimmer-pot			10-turn, Bourns
K1	7V-2A, relay	275-005 (7V)		submin., 5V preferred
S1	SPST, switch	275-8077		momentary 'on'

Technical Notes: This NiCad cycler is based on the Motorola Solid-State precision voltage reference device, [TL431\(ILP\)](#). The trip point (adjustable with P1 for both units) can be set to 4.4volt for the receiver pack and 8.8volt for the transmitter pack or whatever else you prefer as trip-point for your battery packs. Radio Shack can order this part in I was told.

TL431ILP senses the preset voltage reference and trips the relay when that control voltage point is reached, adjusted with the 10-turn trimmer pots, which in turn activates the charger. The resistors used in this circuit provide an approximate discharge rate of 250mA. Since the remainder of the circuits power is also provided by the battery being discharged, an additional 50mA or so is discharged from the NiCad battery packs. The relay is configured as latch so that once the unit trips from discharge to charge, the unit cannot be recycled until the start switch is pressed. The component values, setting up the discharge values and trip points can be adjusted to handle any size or battery voltage up to the 30 volt maximum rating of the TL431. Remember, the relay coil voltage must also be taken into consideration when changing the operating voltage of the circuit. All components listed in the circuit can be easily obtained from your local electronics store or Tandy/Radio Shack, although the TL431 may have to be ordered in. If you find a significant drop in discharge time you have a clue that something is going bad with your pack and close examination or a new purchase may be needed.

Description and Calibration: When you have completed building the cycler, go back and make sure that all your connections are soldered solidly and that all connections are correct. If you're not sure, try to get help from someone with electronics experience. Although highly unlikely, it is possible to destroy the TL431 by reversing the positive/negative connections so try to make sure this particular device is hooked up correctly. Take your time checking your wiring and connections, the last thing you want is damage to your charger.

To calibrate this unit you need 6 regular (1.5v) dry cells, it does not matter what size they are, AA, C or D cells are all good. Just make sure they are **new**. NiCads will not work for this step in the process. [I used an adjustable Power Supply instead since I can simulate depletion of a battery pack, by adjusting the voltage, to the point I prefer the relays to trip.]

Your goal in calibrating the cycler is to adjust the trimmer pots in such a way that the unit will change from 'discharge' to 'charge' when the cells reach 1.1 volts per cell. On the receiver battery pack this will be 4.4 volts. On the transmitter pack this is 8.8 volt.

Preset the trimmer controls all the way to one end. If you followed the parts list above you will have about 10-turns to go from one end to the other, and believe me, with the regular trimpot adjusting the cycler is almost impossible. A 10-turn trimmer is a necessity!

Okay, on with it. Connect 3 of the dry cell in series, giving you 4.5 volts total. This is just above the voltage you want the receiver pack to change over from 'cycle' to 'charge'. Connect the dry cell combination across the receiver battery leads of the cycler. Press and release the start button. If the LED lights and stays lit, turn the control all the way to the other end, and repeat the step above. Not turn the trimmer potentiometer back 1/8 turn, in the opposite direction you turned it to get the LED to go off. Press and release the start button one more time. IF the LED stays on, the receiver battery adjustment portion of the cycler is complete. If the LED still goes out, turn the trimmer an additional 1/8 turn back. Now the LED should stay lit when the start button is pressed and released. If it does not, or the relay seems to 'rattle' when you press the start button recheck your wiring; something is not connected right.

For the transmitter section of the cycler use the same calibration method as described above but now use all 6 cells. At 1.5volts per cell this will add to 9 volts and again is just above the 8.8 volt trip level to change over from cycle to charge. **CAUTION: Do NOT** plug your wall charger in during the calibration procedure. It should only be plugged in when the NiCads are connected to the cycler!

Once you completed the adjustments, connect your fully charged NiCad packs to the cycler. Plug in the wall charger. The LED's on your wall charger should be on indicating the packs are being charged. If not, check your wiring again. Now press and release the start button. The Led's on the cycler should go on and the led's on the wall charger go out. This state indicates your battery packs being 'discharged'. When the led's on the wall charger are on, the batteries are being charged. About 16-hours after the cycler has switched from discharge to charge, your batteries are ready for use.

Remember, you **must** allow the batteries to fully charge before flying. I don't need to remind you to check the battery voltage with your expanded scale voltmeter *before* each flight.

Also note that the adjustments can be bit tricky, more so for the Rx part and especially if you're using a 5 volt relay for the receiver part, a 3 volt relay is much easier to work with. So just take your time and be **patient**.

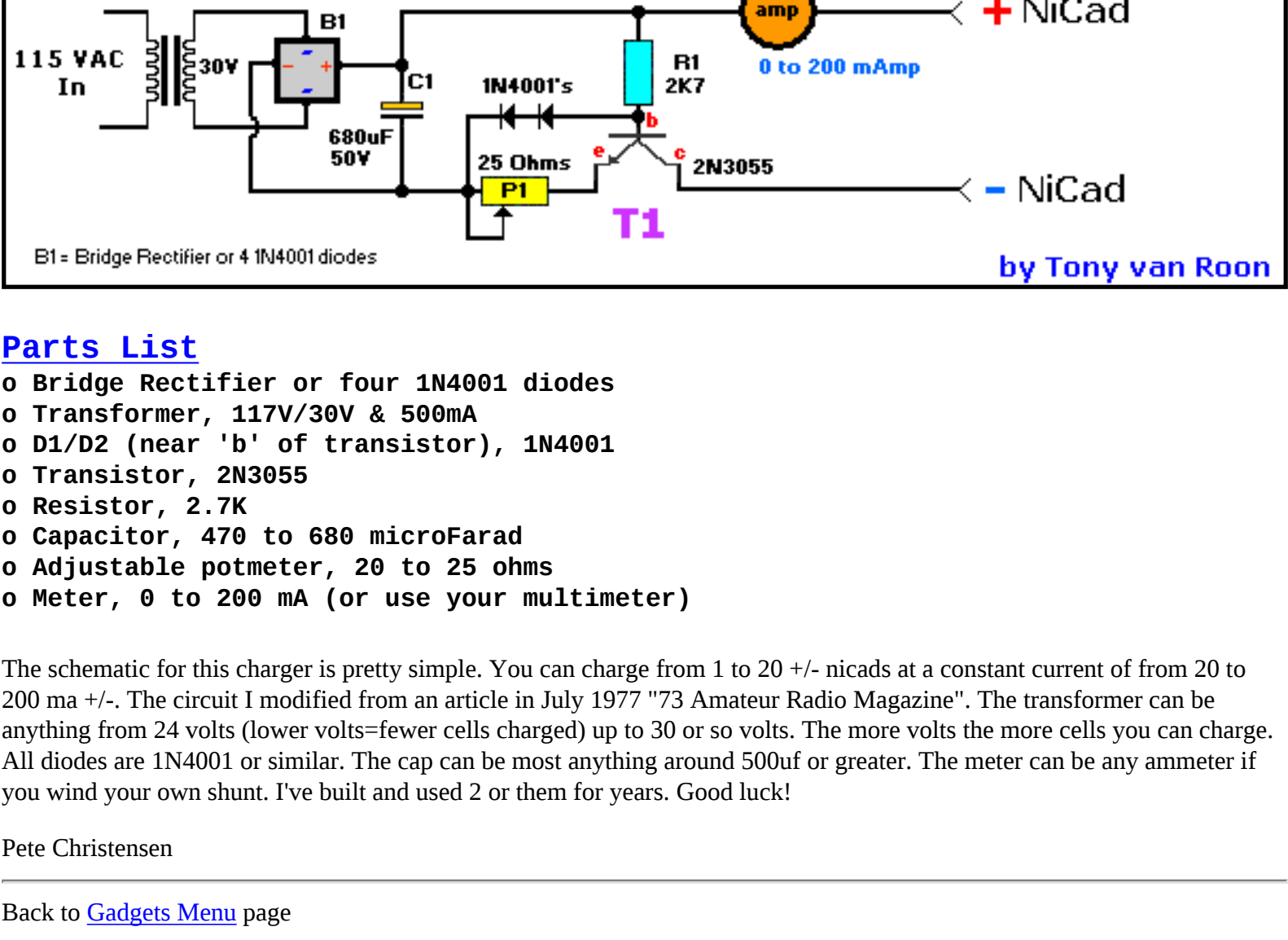
Personal note: If you have problems with the relay actuation (RX only), try a different relay, like the preferred 3.0 volt type instead. The TL431 drawing is shown front-view. My personal settings for the threshold cut-off is for Rx @ 3.8volt and Tx @ 7.6volt, which is 0.95volt-per-cell. I like to 'deep-cycle' the battery packs. Why? For the simple reason that as soon as the threshold is reached the charge cycle starts so there is absolutely no harm done. I have used this cycler for 8 years and combined the rx/tx in a 3"x4"x1.5" plastic case. I cycle once per month no matter if I fly or not.

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Make a Constant Current Nicad Charger

by Pete Christensen



Parts List

- o Bridge Rectifier or four 1N4001 diodes
- o Transformer, 117V/30V & 500mA
- o D1/D2 (near 'b' of transistor), 1N4001
- o Transistor, 2N3055
- o Resistor, 2.7K
- o Capacitor, 470 to 680 microFarad
- o Adjustable potmeter, 20 to 25 ohms
- o Meter, 0 to 200 mA (or use your multimeter)

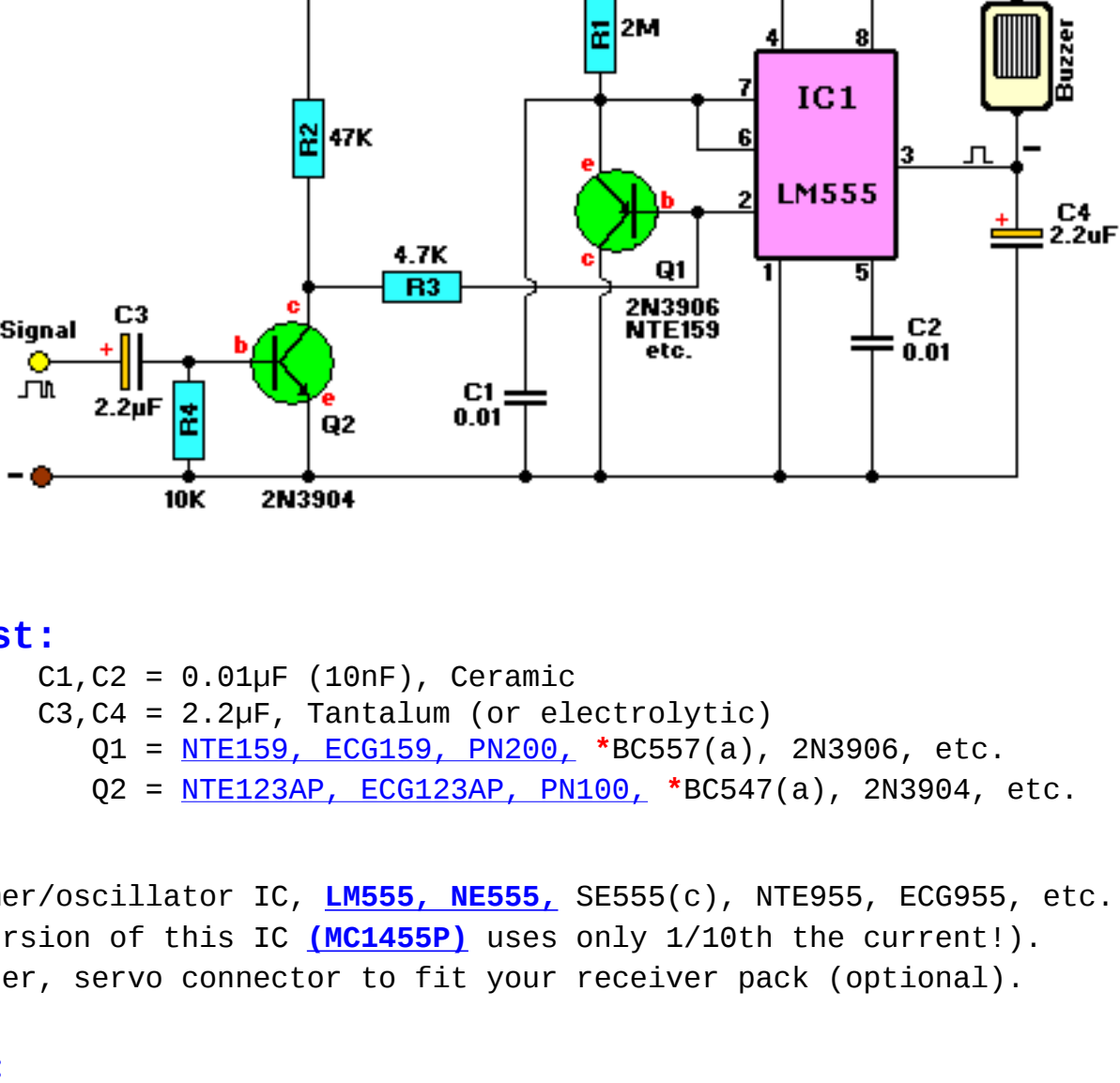
The schematic for this charger is pretty simple. You can charge from 1 to 20 +/- nicads at a constant current of from 20 to 200 ma +/-, The circuit I modified from an article in July 1977 "73 Amateur Radio Magazine". The transformer can be anything from 24 volts (lower volts=fewer cells charged) up to 30 or so volts. The more volts the more cells you can charge. All diodes are 1N4001 or similar. The cap can be most anything around 500uf or greater. The meter can be any ammeter if you wind your own shunt. I've built and used 2 or them for years. Good luck!

Pete Christensen

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Crashed Aircraft Beacon

http://www.uoguelph.ca/~antoon



Parts List:

R1 = 2M C1,C2 = 0.01uF (10nF), Ceramic
R2 = 47K C3,C4 = 2.2uF, Tantalum (or electrolytic)
R3 = 4.7K Q1 = NTE159, ECG159, PN200, *BC557(a), 2N3906, etc.
R4 = 10K Q2 = NTE123AP, ECG123AP, PN100, *BC547(a), 2N3904, etc.
U1 = LM555

U1, the timer/oscillator IC, LM555, NE555, SE555(c), NTE955, ECG955, etc.
The CMOS version of this IC (MC1455P) uses only 1/10th the current!).
3 volt buzzer, servo connector to fit your receiver pack (optional).

Final Notes:

Most every R/C'er knows how hard it is to find a crashed or downed plane in high grass, thick brush, corn or soy fields. Many aircraft are probably still laying there waiting to be found. This circuit will help you to find your aircraft/rocket easily. It is easy to build and does not require special parts. Using replacements is just fine. If you opt for a separate 9-volt battery (don't forget an on/off switch) the buzzer should be approx. 6-volt. Do *NOT* connect the + of the 9-volt battery to your receiver! Serious damage will occur! In my prototype I put silicon gel around all the electronic components, immediately put the hole thing in heat-shrink and left to dry overnight. It now is vibration-proof. The circuit was still working when my Goldberg Falcon Mark III folded the wings from a height of about 400 feet and slammed into the ground (at full throttle) and dug itself in almost 6 inches deep.

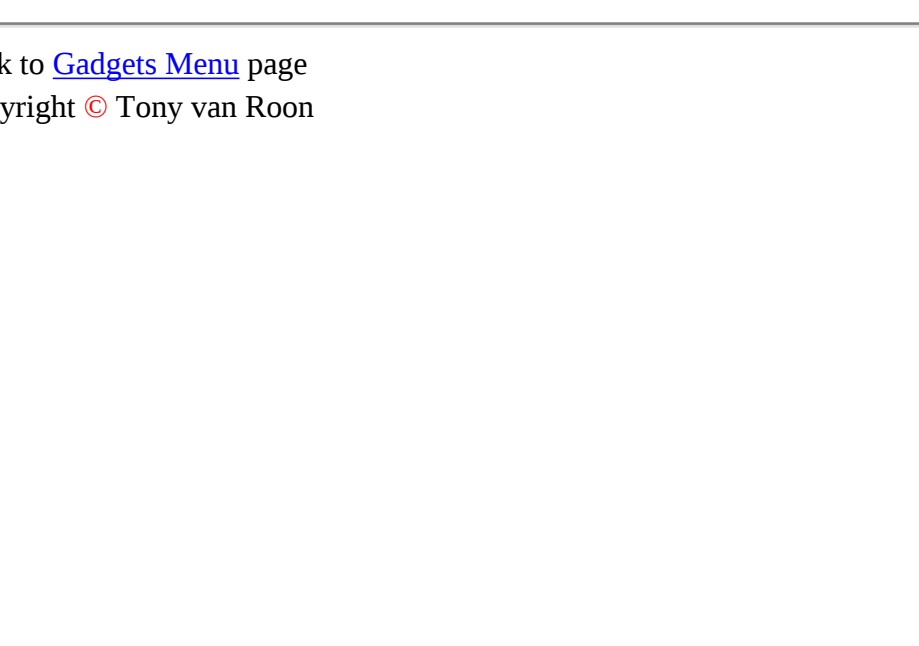


Fig. 2

Just in case you're wondering how to hookup the 9-volt alkaline battery: Fig. 2
The negative (-) of the 9-volt battery and the rx-battery pack are tied together. Keep in mind, if you hookup the battery incorrectly you may damage your receiver, so be careful. Can you use the receiver's battery power? Yes ofcourse. It will just drain your receiver battery a lot faster. If you are into slope soaring, gliders, or any other area of R/C with long-duration of your radio/receiver batteries, I strongly recommend to use a separate 9 volt battery. To save on weight, NiMH would

A transmitter provides every 20 milliseconds a set of pulses, which in turn sends your receiver a separate pulse to each of the servos at the same interval. The circuit above is a so-called **missing-pulse-detector**. An alarm will sound when your receiver no longer receives the set of pulses from your radio. So, to locate your aircraft, all you have to do is switch your transmitter off and the locator will start to beep. Easy huh? If you wish, you may even use point-to-wiring on vero board or something. The tantalum capacitors are polarized so watch the + and - sides. This circuit works best when just plugged into an empty position of the Receiver. I do not use the 9-volt battery setup myself, since I only fly 15 minutes with my heli at a time.
If you need more information and data on the 555 timer/oscillator IC, click [NE555](#) here.

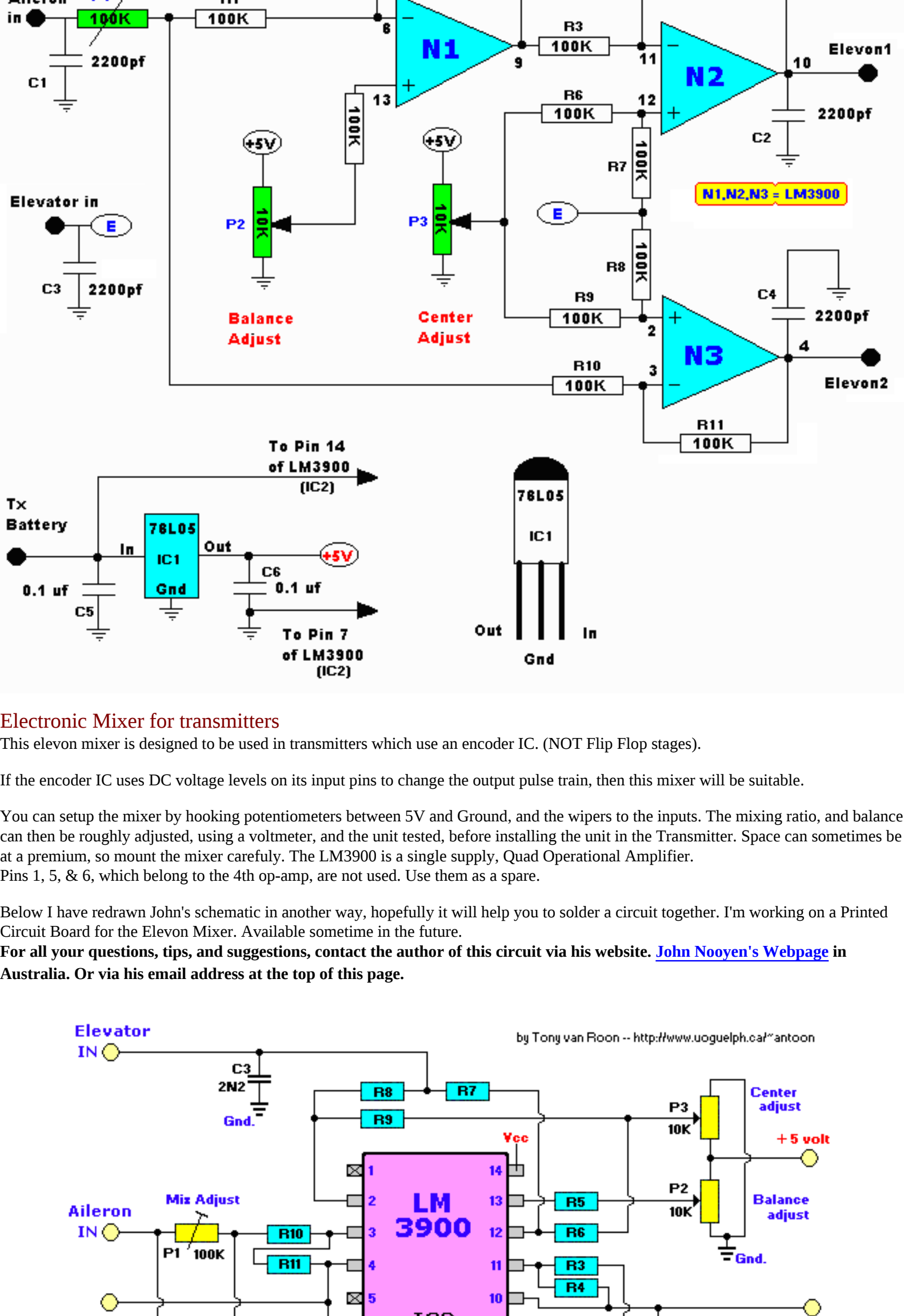
***CAUTION:** The European BCxxx type transistors have their emitter/collector reversed in most cases. Check for proper pinout first to make sure it is so.

This device is tested for interference with JR, Futaba, HiTec, Airtronics, and ACE radio equipment. None were found and none are expected when used with other brands of Radio equipment.

Elevon Mixer for Transmitters

by [John Nooyen](#)

Author John Nooyen



Electronic Mixer for transmitters

This elevon mixer is designed to be used in transmitters which use an encoder IC. (NOT Flip Flop stages).

If the encoder IC uses DC voltage levels on its input pins to change the output pulse train, then this mixer will be suitable.

You can setup the mixer by hooking potentiometers between 5V and Ground, and the wipers to the inputs. The mixing ratio, and balance can then be roughly adjusted, using a voltmeter, and the unit tested, before installing the unit in the Transmitter. Space can sometimes be at a premium, so mount the mixer carefully. The LM3900 is a single supply, Quad Operational Amplifier. Pins 1, 5, & 6, which belong to the 4th op-amp, are not used. Use them as a spare.

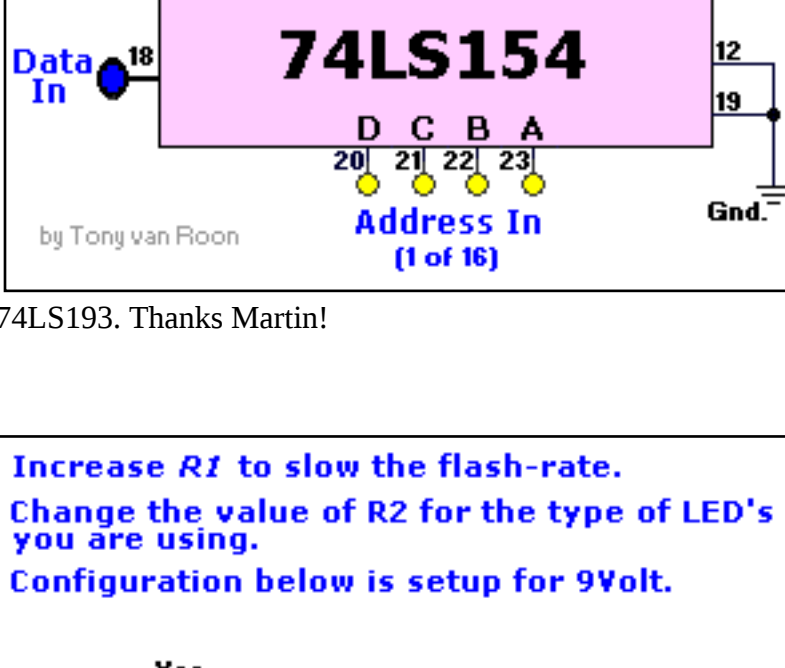
Below I have redrawn John's schematic in another way, hopefully it will help you to solder a circuit together. I'm working on a Printed Circuit Board for the Elevon Mixer. Available sometime in the future.

For all your questions, tips, and suggestions, contact the author of this circuit via his website. [John Nooyen's Webpage in Australia](#). Or via his email address at the top of this page.



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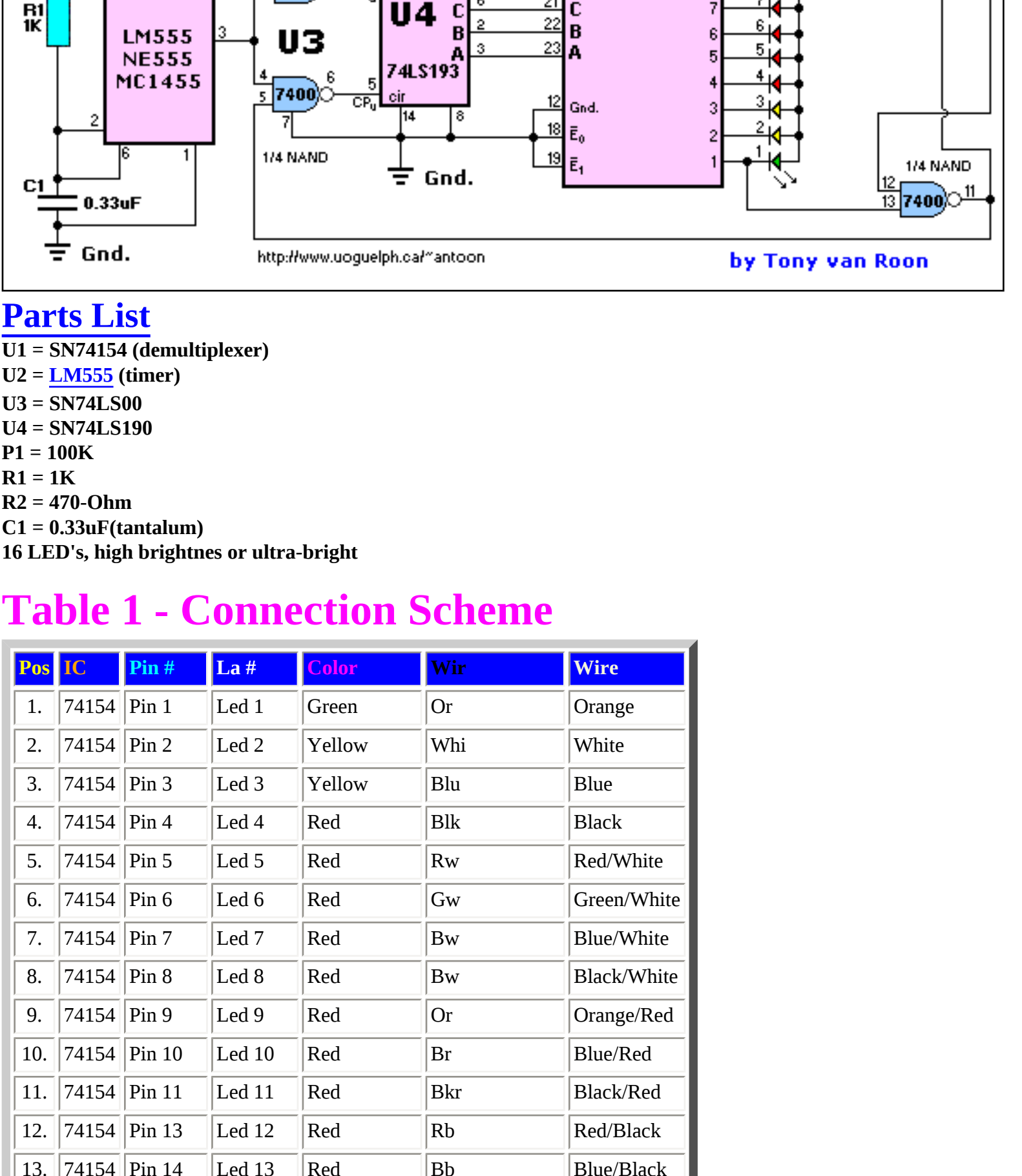
Back and Forth Flasher



by Tony van Roon

1-to-16 Demultiplexer - Selected output is low when Data IN is low. If Data IN is high, then selected output is high also. Each 4-bit address drives one output low. All others stay high. Enable inputs (E1 & E2) must be low. If one or both are high, all inputs go low.

An error was found by Martin in regards to two pin 3's on the 74LS193. Corrected! Pin 6(7400) goes to pin 5 of the



Parts List

- U1 = SN74154 (demultiplexer)
- U2 = [LM555](#) (timer)
- U3 = SN74LS00
- U4 = SN74LS190
- P1 = 100K
- R1 = 1K
- R2 = 470-Ohm
- C1 = 0.33uF(tantalum)
- 16 LED's, high brightness or ultra-bright

Table 1 - Connection Scheme

Pos	IC	Pin #	La #	Color	Wir	Wire
1.	74154	Pin 1	Led 1	Green	Or	Orange
2.	74154	Pin 2	Led 2	Yellow	Whi	White
3.	74154	Pin 3	Led 3	Yellow	Blu	Blue
4.	74154	Pin 4	Led 4	Red	Blk	Black
5.	74154	Pin 5	Led 5	Red	Rw	Red/White
6.	74154	Pin 6	Led 6	Red	Gw	Green/White
7.	74154	Pin 7	Led 7	Red	Bw	Blue/White
8.	74154	Pin 8	Led 8	Red	Bw	Black/White
9.	74154	Pin 9	Led 9	Red	Or	Orange/Red
10.	74154	Pin 10	Led 10	Red	Br	Blue/Red
11.	74154	Pin 11	Led 11	Red	Bkr	Black/Red
12.	74154	Pin 13	Led 12	Red	Rb	Red/Black
13.	74154	Pin 14	Led 13	Red	Bb	Blue/Black
14.	74154	Pin 15	Led 14	Yellow	Gb	Green/Black
15.	74154	Pin 16	Led 15	Yellow	Pi	Pinkk
16.	74154	Pin 17	Led 16	Green	Pu	Purple
17.	Gnd	12/18/19	Common	to everything	Gnd everything	Green
18.	Vcc+	24 and	anodes	5.5V to 7.5V	Re 5 - 7.5 V	Red
19.	n/a					
20.	n/a					
21.	n/a					
22.	n/a					
23.	n/a					
24.	n/a					

A Couple of Final Notes

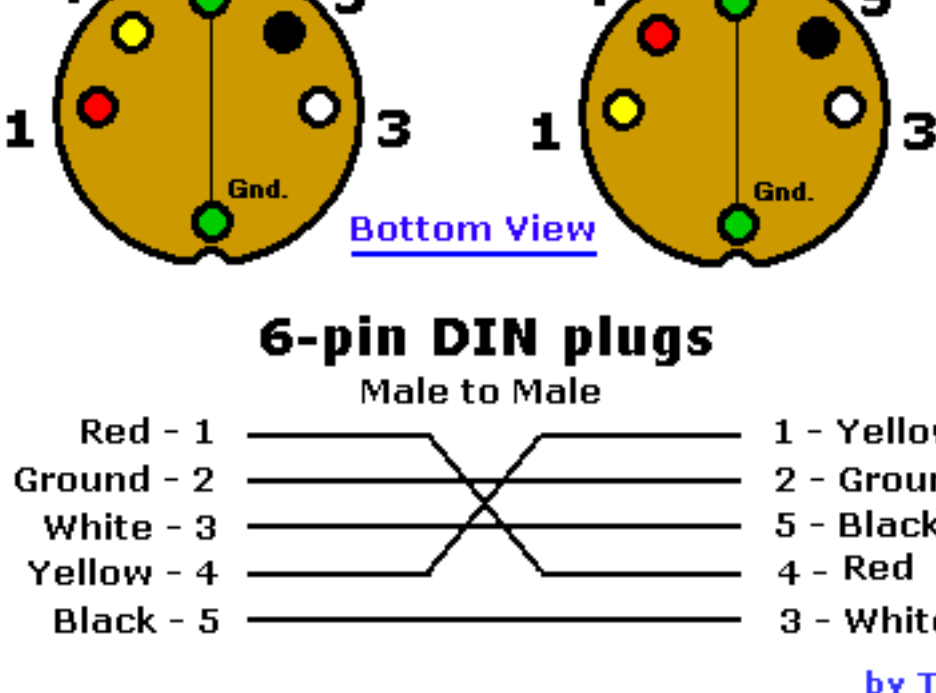
Click here >>[LM555](#) << for more information and data on the 555 timer/oscillator IC. Keep wires as short as possible since too long wires coming from the 74154 to the led's will give trouble getting them 'running' properly. I had this circuit installed in the nose of my helicopter before I sold it and the circuit was working good. This circuit is for those electronics persons with experience only. In either case, it is definately a good learning experience. Have fun!

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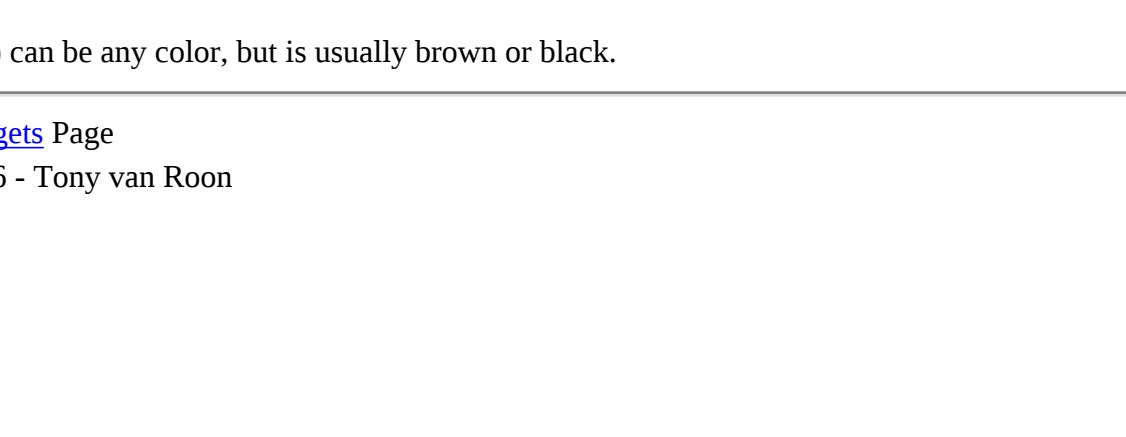
Futaba AM Cord

<http://www.uoguelph.ca/~antoon>



6-pin DIN plugs

Male to Male



by [Tony van Roon](#)

[Additional Notes](#)

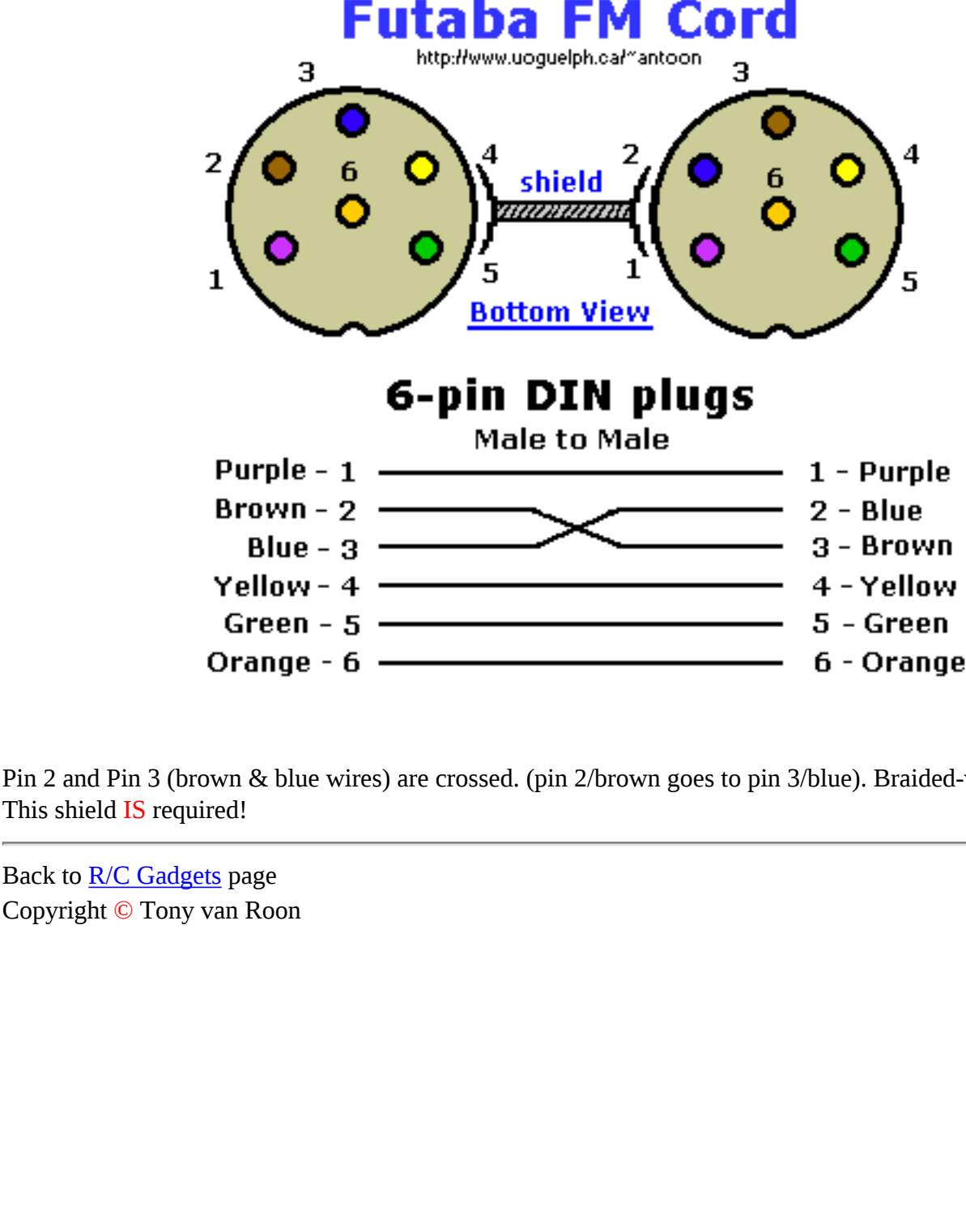
1 - Pin 1 and Pin 4 (red & yellow wires) are crossed. D.I.N. is a european 'norm' originating from Germany. The D.I.N. abbreviation stands for "**D**eutsche **I**ndustrie **N**orm" and means translated "German Industry Standard".

2 - Each of the 5 wires have an individual (stranded) shield.

3 - Pin 2 (ground) can be any color, but is usually brown or black.

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Pin 2 and Pin 3 (brown & blue wires) are crossed. (pin 2/brown goes to pin 3/blue). Braided-wire is going to plug-shield.
This shield **IS** required!

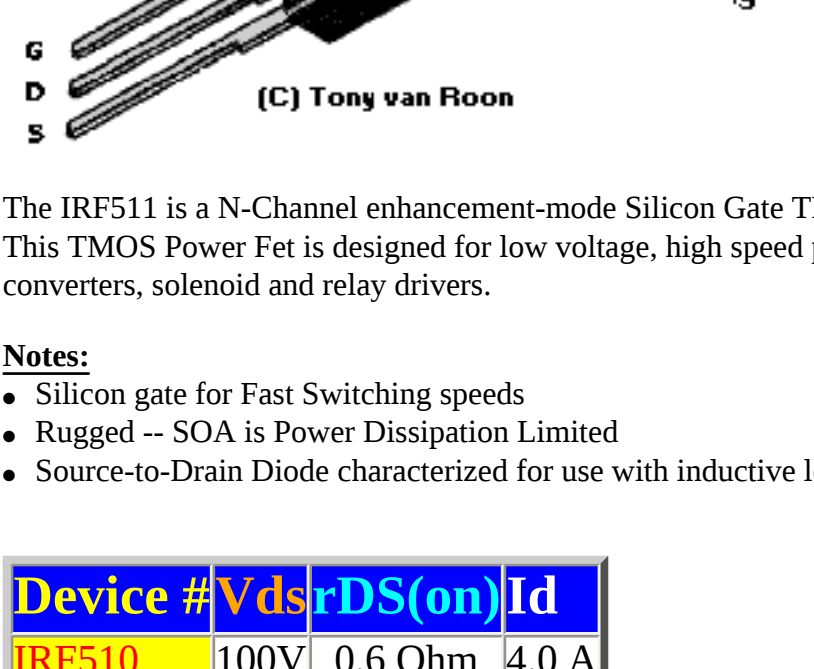
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IRF511 TMOS Power FET

Data sheet

Direct substitute for NTE66, ECG66

by Tony van Roon



The IRF511 is a N-Channel enhancement-mode Silicon Gate TMOS Power Field Effect Transistor in a TO-220 package. This TMOS Power Fet is designed for low voltage, high speed power switching applications such as switching regulators, converters, solenoid and relay drivers.

- Notes:
- Silicon gate for Fast Switching speeds
 - Rugged -- SOA is Power Dissipation Limited
 - Source-to-Drain Diode characterized for use with inductive loads

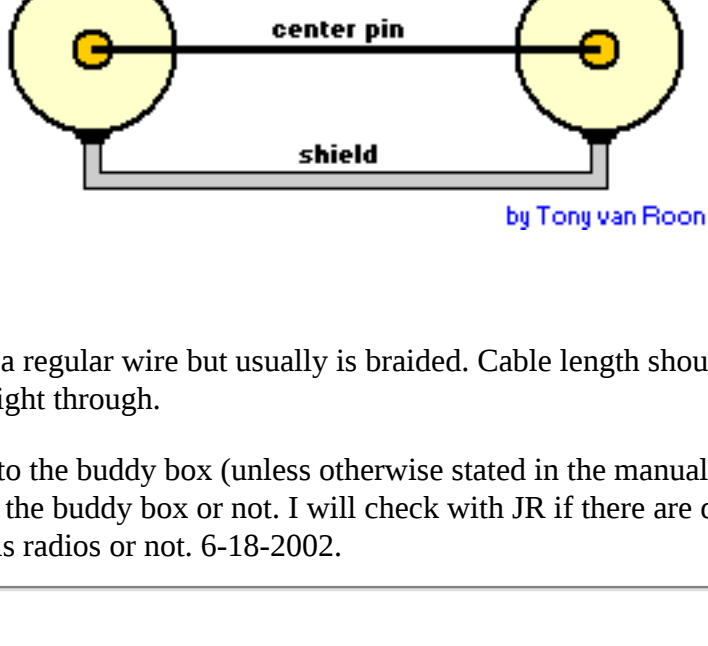
Device #	Vds	rDS(on)	Id
IRF510	100V	0.6 Ohm	4.0 A
IRF511	60V	0.6 Ohm	4.0 A
IRF512	100V	0.8 Ohm	3.5 A
IRF513	60V	0.8 Ohm	3.5 A

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JR (Japan Radio) FM Trainer Cord

by [Tony van Roon](#)



[Couple Notes](#)

The ground (or shield) wire can be a regular wire but usually is braided. Cable length should not exceed 15 feet. Wire and Shield are connected straight through.

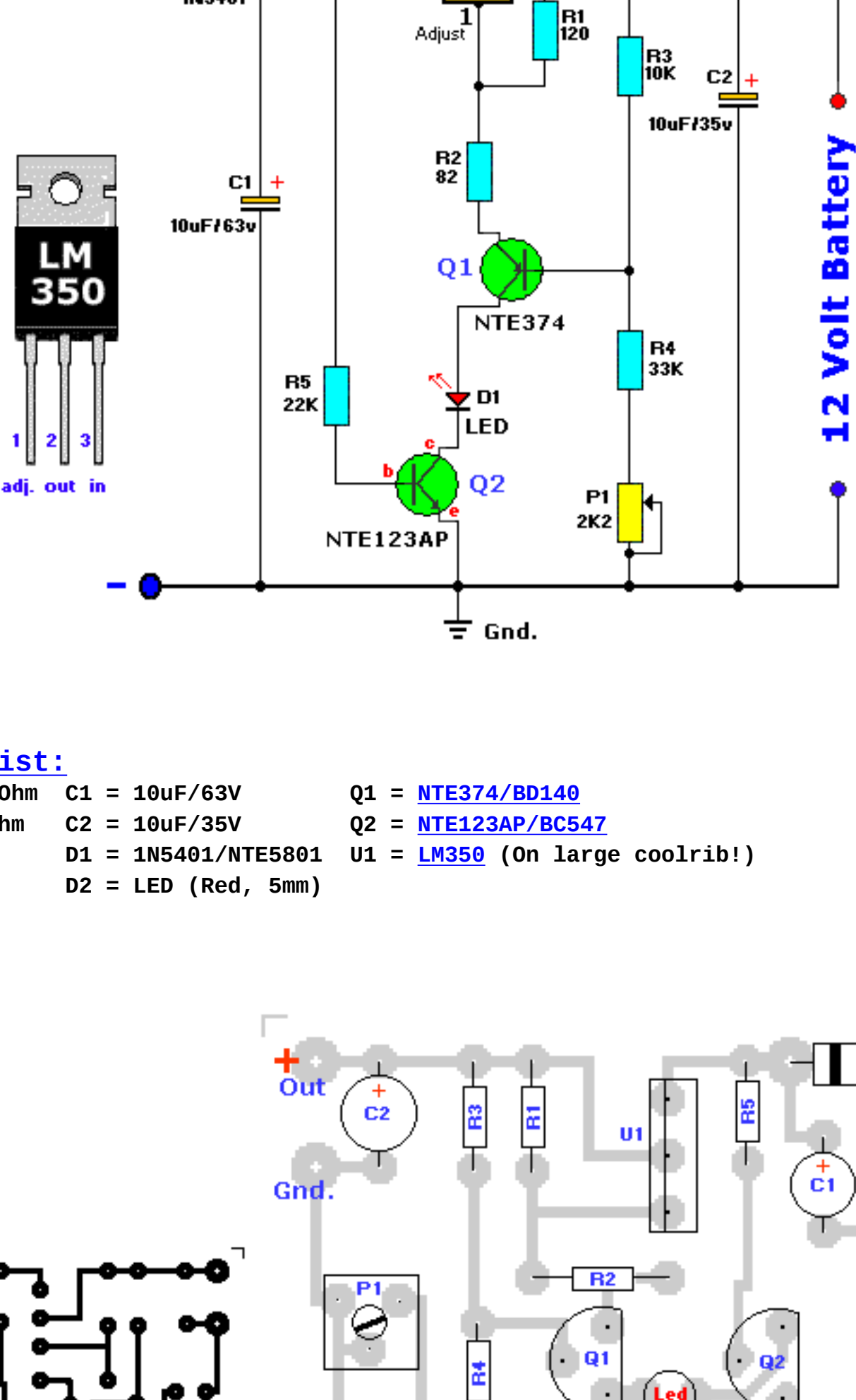
Do NOT add a battery of any kind to the buddy box (unless otherwise stated in the manual). Check your manual or ask your dealer if you need a battery in the buddy box or not. I will check with JR if there are different configurations for the cables in regards to different models radios or not. 6-18-2002.

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Lead Acid Battery Charger

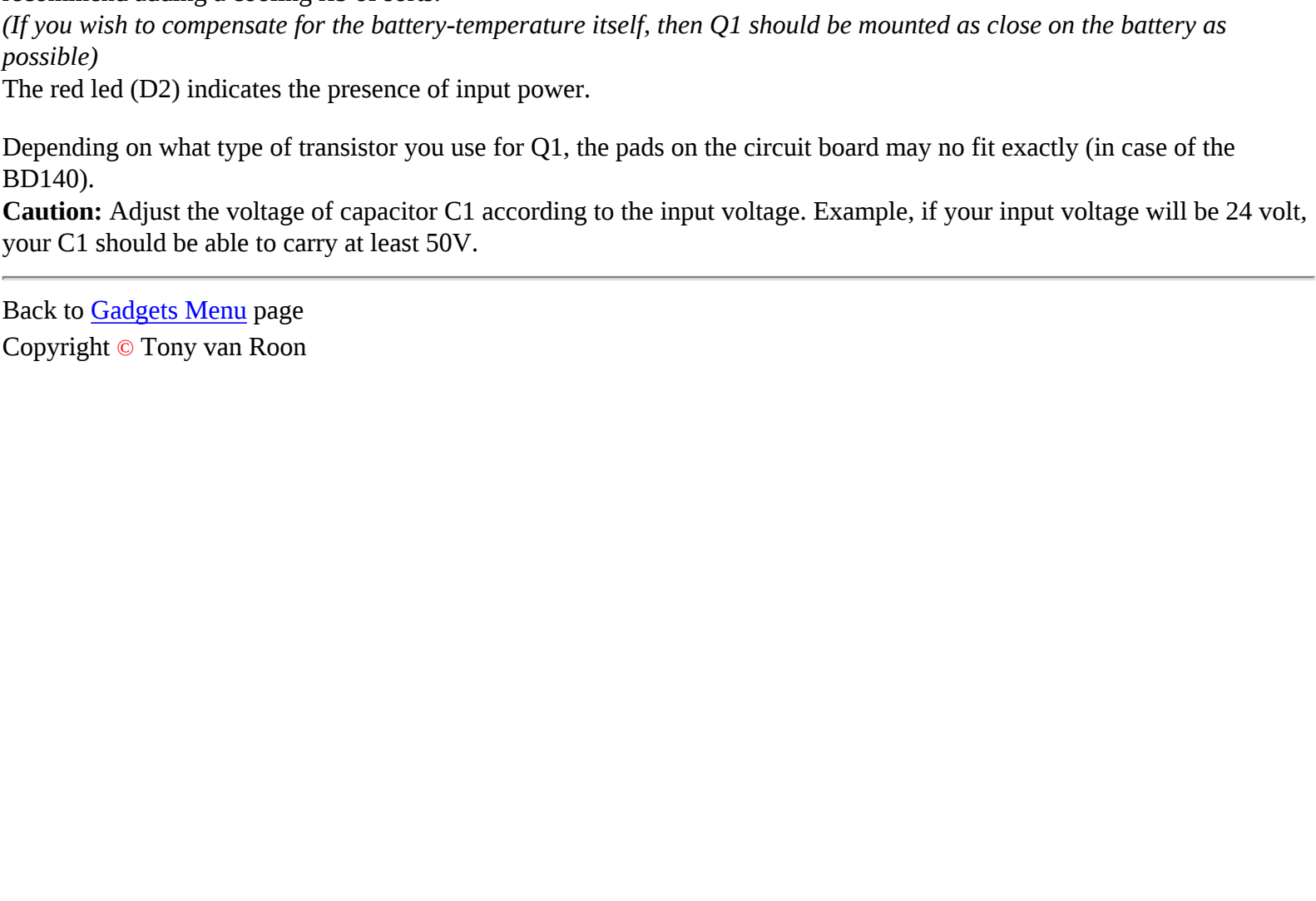
by Tony van Roon



Parts List:

R1 = 120 Ohm C1 = 10uF/63V Q1 = NTE374/BD140
R2 = 82 Ohm C2 = 10uF/35V Q2 = NTE123AP/BC547
R3 = 10K D1 = 1N5401/NTE5801 U1 = LM350 (On large coolrib!)

R4 = 33K
R5 = 22K
P1 = 2K2



How it works:

Except for use as a normal Batter Charger, this circuit is perfect to 'constant-charge' a 12-Volt Lead-Acid Battery, like the one in your flight box, and keep it in optimum charged condition. This circuit is **not recommended for GELL-TYPE batteries** since it draws too much current. The above circuit is a precision voltage source, and contains a temperature sensor with a negative temperature coefficient. Meaning, whenever the surrounding or battery temperature increases the voltage will automatically decrease. Temperature coefficient for this circuit is -8mV per °Celsius. A normal transistor (Q1) is used as a temperature sensor. This Battery Charger is centered around the **LM350** integrated, 3-amp, adjustable stabiliser IC. Output voltage can be adjusted with P1 between 13.5 and 14.5 volt. T2 was added to prevent battery discharge via R1 if no power present. P1 can adjust the output voltage between 13.5 and 14.5 volts. R4's value can be adjusted to accommodate a bit larger or smaller window. D1 is a large power-diode, 100V PRV @ 3 amp. Bigger is best but I don't recommend going smaller.

The LM350's 'adjust' pin will try to keep the voltage drop between its pin and the output pin at a constant value of 1.25V. So there is a constant current flow through R1. Q1 act here as a temperature sensor with the help of components P1/R3/R4 who more or less control the base of Q1. Since the emitter/base connection of Q1, just like any other semiconductor, contains a temperature coefficient of -2mV/°C, the output voltage will also show a negative temperature coefficient. That one is only a factor of 4 larger, because of the variation of the emitter/basis of Q1 multiplied by the division factor of P1/R3/R4. Which results in approximately -8mV/°C. To prevent that sensor Q1 is warmed up by its own current draw, I recommend adding a cooling rib of sorts.

(If you wish to compensate for the battery-temperature itself, then Q1 should be mounted as close on the battery as possible)

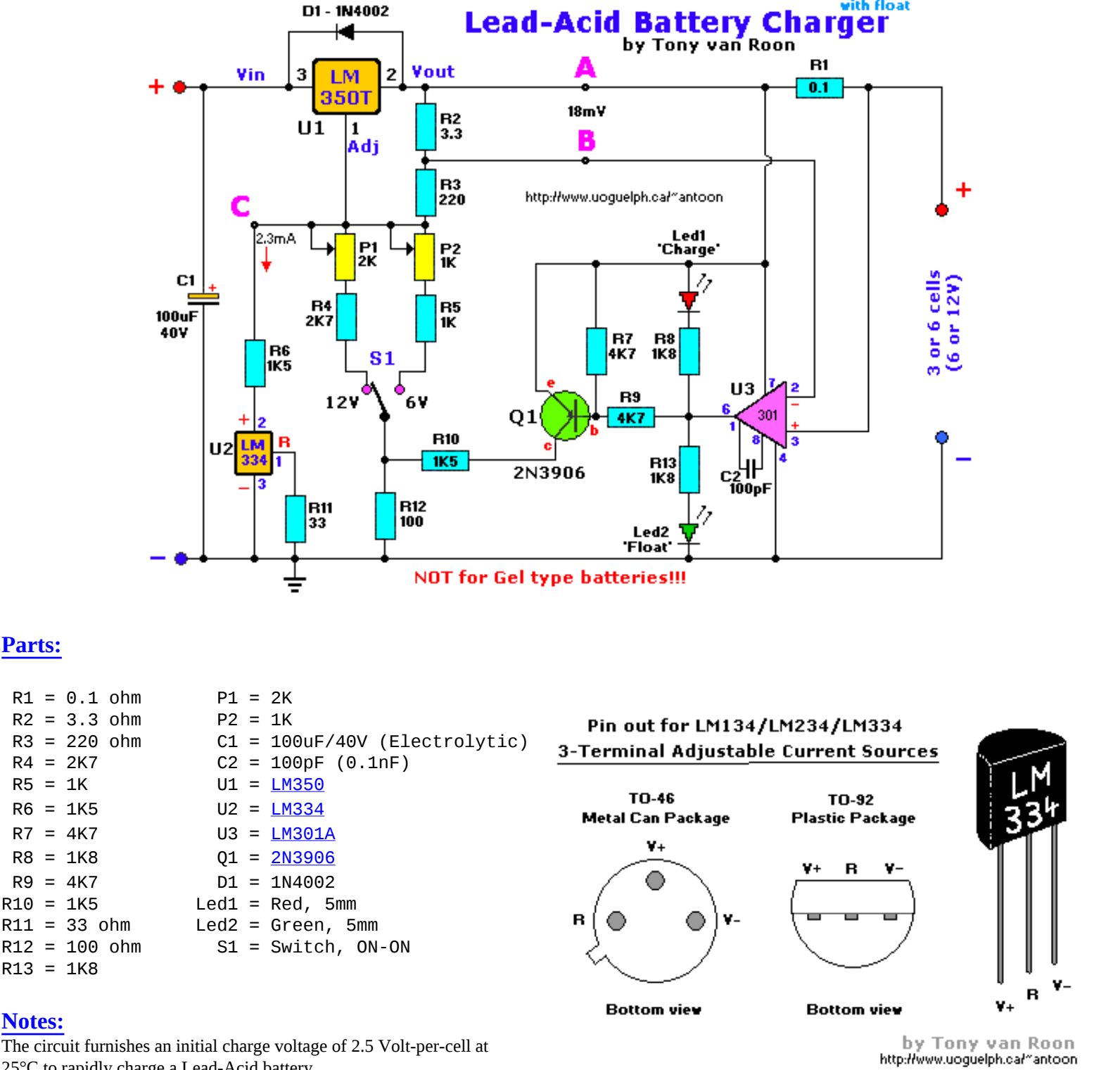
The red led (D2) indicates the presence of input power.

Depending on what type of transistor you use for Q1, the pads on the circuit board may no fit exactly (in case of the BD140).

Caution: Adjust the voltage of capacitor C1 according to the input voltage. Example, if your input voltage will be 24 volt, your C1 should be able to carry at least 50V.

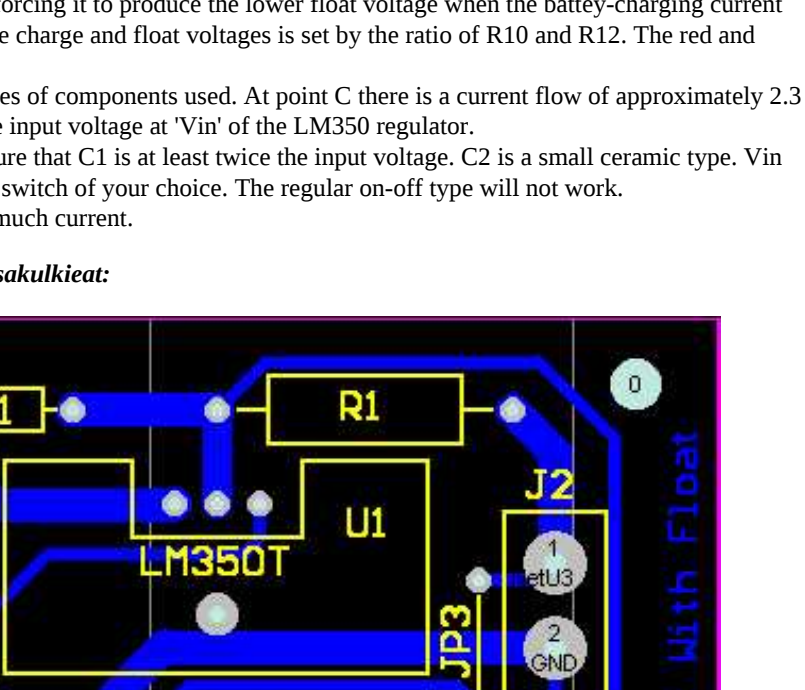
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Parts:

- | | |
|---------------|-------------------------------|
| R1 = 0.1 ohm | P1 = 2K |
| R2 = 3.3 ohm | P2 = 1K |
| R3 = 220 ohm | C2 = 100uF/40V (Electrolytic) |
| R4 = 2K7 | C2 = 100pF (0.1nF) |
| R5 = 1K | U1 = LM350 |
| R6 = 1K5 | U2 = LM334 |
| R7 = 4K7 | U3 = LM301A |
| R8 = 1K8 | Q1 = 2N3906 |
| R9 = 4K7 | D1 = 1N4002 |
| R10 = 1K5 | Led1 = Red, 5mm |
| R11 = 33 ohm | Led2 = Green, 5mm |
| R12 = 100 ohm | S1 = Switch, ON-ON |
| R13 = 1K8 | |



Notes:
The circuit furnishes an initial charge voltage of 2.5 Volt-per-cell at 25°C to rapidly charge a Lead-Acid battery. The charging current decreases as the battery charges, and when the current drops to about 180mA, the charging circuit reduces the output voltage to 2.35 Volt-per-cell, floating the battery in a fully charged state. This lower voltage prevents the battery from overcharging, which would shorten its life. The LM301A (U3) compares the voltage drop across R1 with an 18-mV reference set by R2. The comparator's output controls the voltage regulator, forcing it to produce the lower float voltage when the battery-charging current passing through R1 drops below 180mA. The 150mV difference between the charge and float voltages is set by the ratio of R10 and R12. The red and green Led's show this state of the circuit.
At points A and B you would see approximately 18mV depending on the types of components used. At point C there is a current flow of approximately 2.3 milli-amps, again, depending on your choice of components and of course the input voltage at 'Vin' of the LM350 regulator.
Led1 is a red led, and for Led2 you can also use a yellow or red one. Make sure that C1 is at least twice the input voltage. C2 is a small ceramic type. Vin is at least 18-20volt max about 30V. Switch S1 is a toggle or slide (ON-ON) switch of your choice. The regular on-off type will not work.
This circuit is **not recommended for GEL-TYPE batteries** since it draws too much current.

Below are the layout and pcb for this project, with thanks to *Chaisaeng Euesakulkiat*:





Modifying a Servo

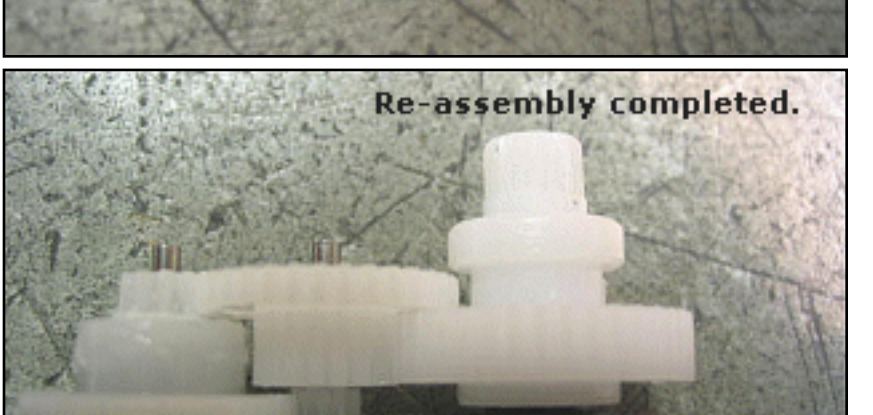
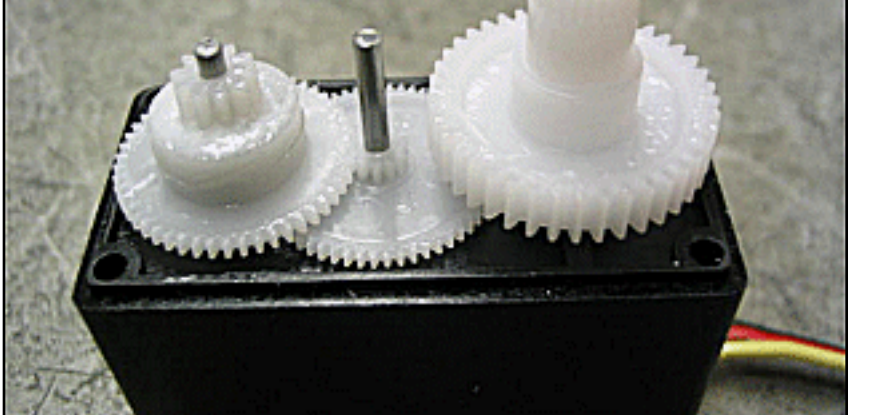
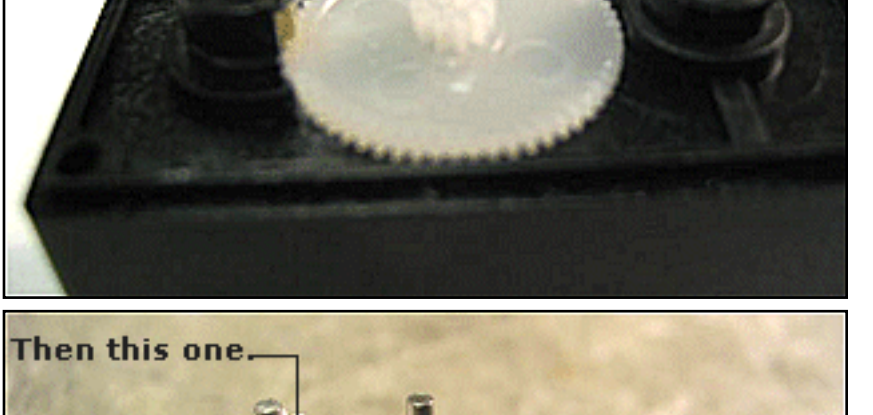
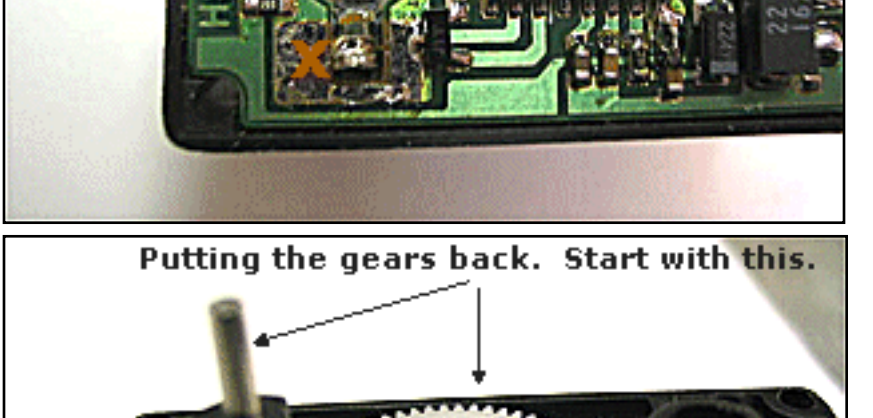
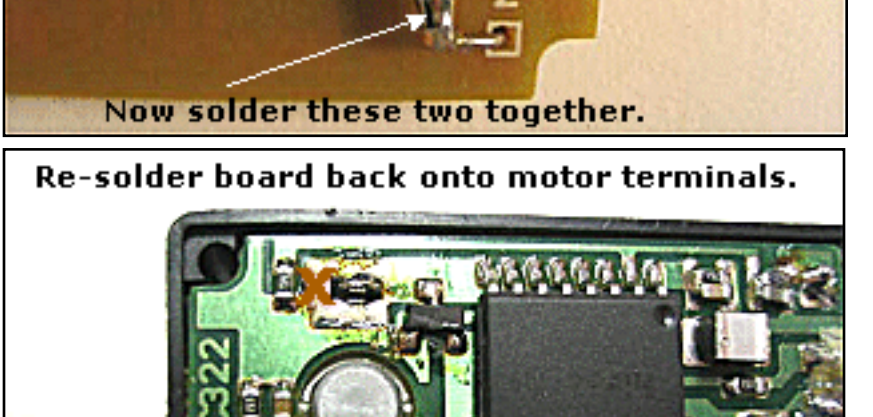
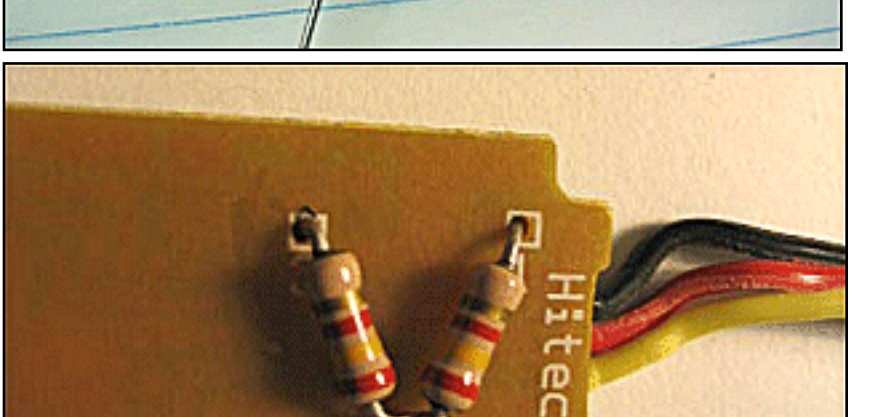
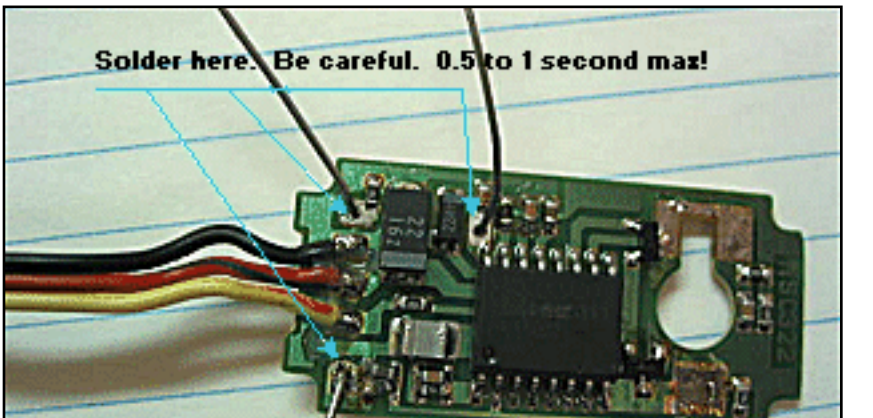
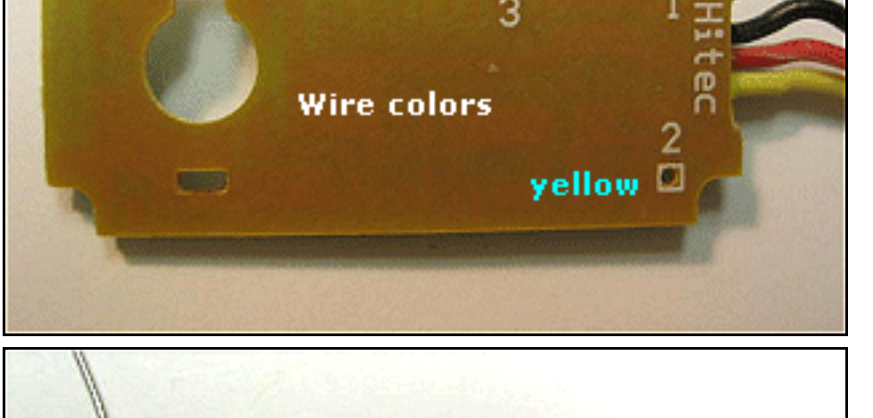
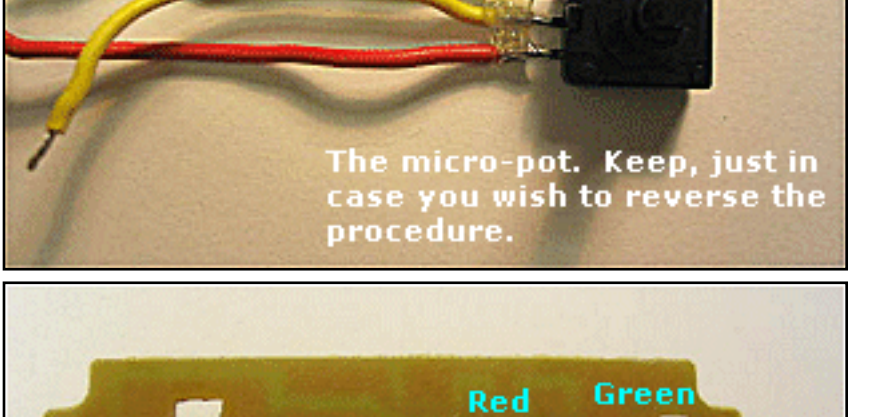
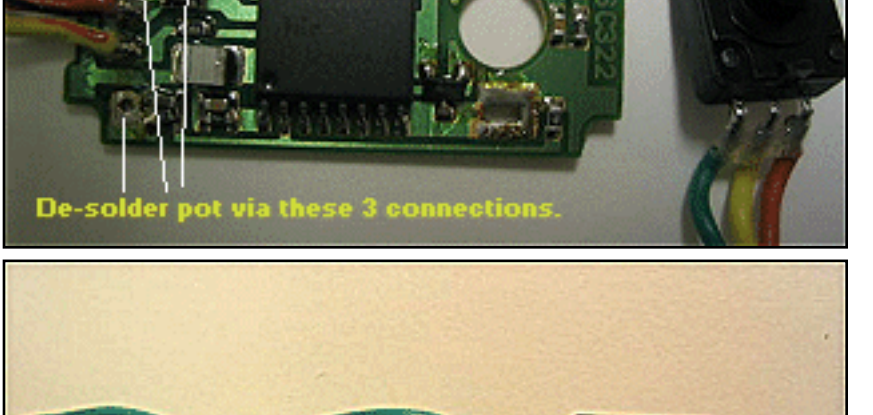
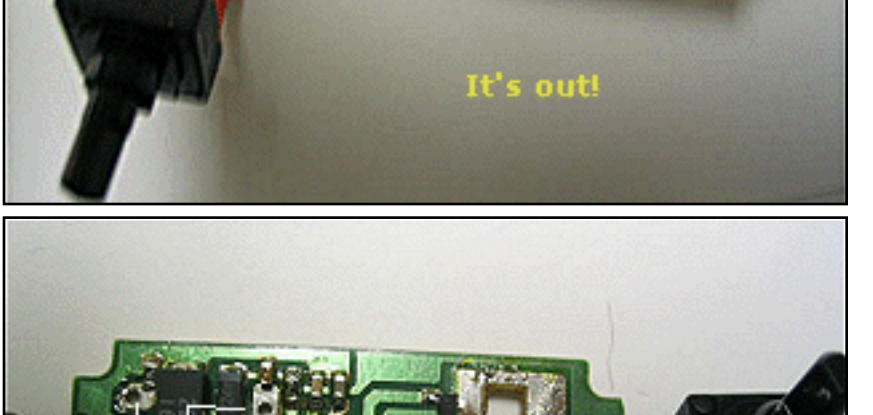
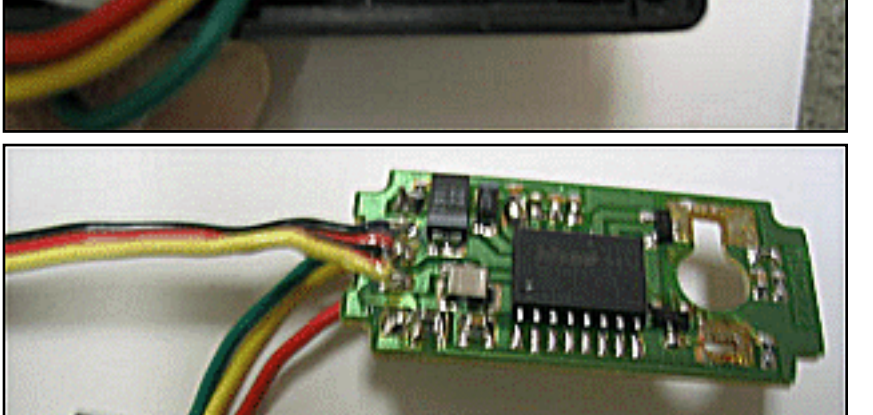
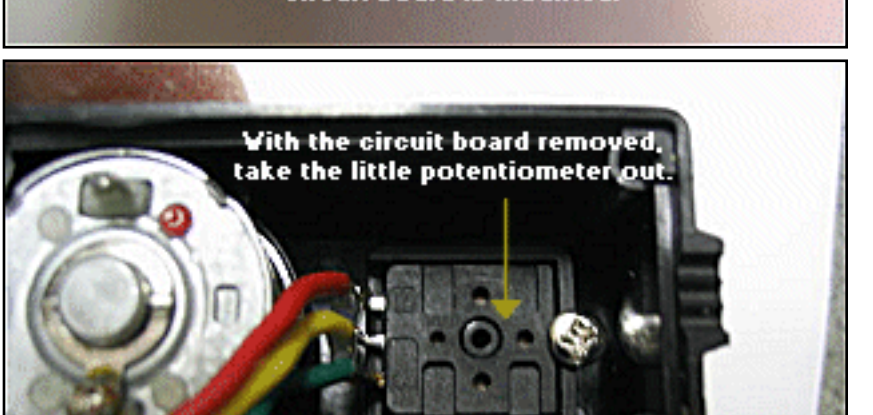
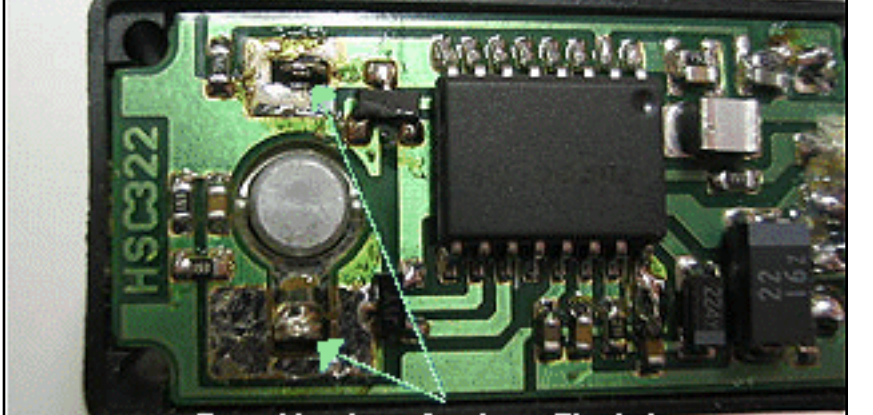
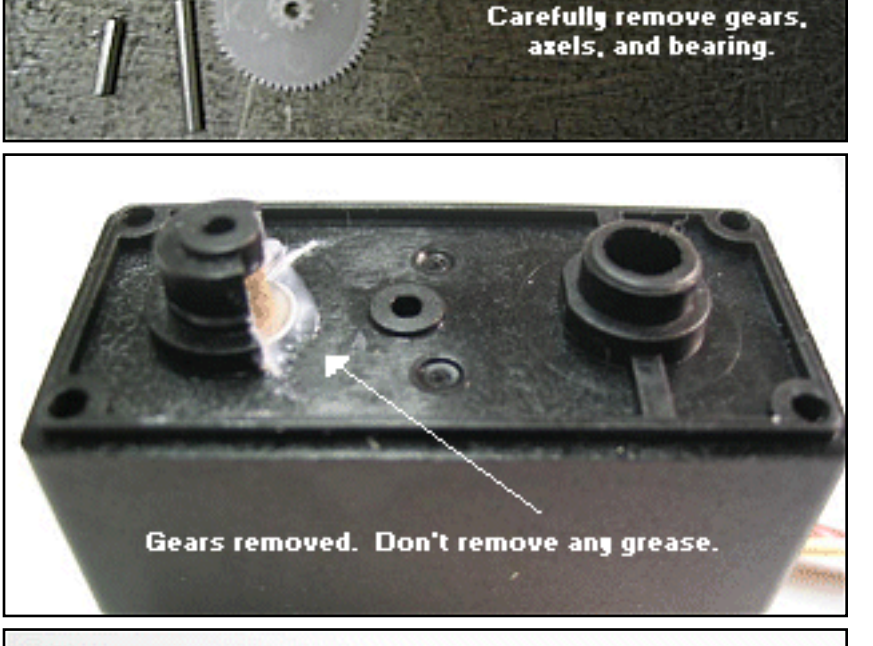
by Tony van Roon

Project Background Info:

I was in need to modify four expensive JR-DS8231 Ultra Digital servos to rotate 360° instead of the standard 130° or equipment is mounted underneath the blimp on a special fabricated aluminum cage and is radio controlled (R/C). I choose a digital 10-channel radio transmitter merely for the needed channels and reliability of JR products. The project was handed to me by our local "Land Resources" department, for my extensive experience with all sorts of radio control systems and products.

Since modifying the digital servos was not gone work, I opted for four cheapie analog servos, Hobbyco C60 (made by HiTec). The little pot inside the servo is 5K and so has to be replaced with 2.5K resistors each. Since 2.5K is not standard stock, I opted for 2.4K resistors. Worked out fine. (I thought maybe publishing my findings could possibly assist in helping someone else obtain the same goals). Check the pictures at the bottom of the page for the modification sequence. I soldered a couple days later two small ceramic capacitors (0.01uF) over the servo motor power connections to eliminate 'servo-creep' on a Futaba servo. Worked fine. See picture 16-a down below. Also, remove the notch (or stopper) from the gear with the bearing. Snip it off with a cutting plier and then use an exacto knife to clean up the rest.

Underneath this blimp is a system with 2 infra-red cameras which takes a variety of pictures from the soil at different locations. The different colors of the soil in the pictures are then analyzed in regards to soil looseness, clay, (hot)rock, type, etc. The system which houses these cameras had to extremely safe. The 2 cameras alone are expensive at a cost of \$35K each and weigh almost 4 pounds each plus the battery packs and R/C equipment and weight of the aluminum frame (cage) itself. Total weight to be carried by the blimp, at one time, was about 15 pounds (Can). Cameras can be switched with Infra-red cameras or night vision, etc.



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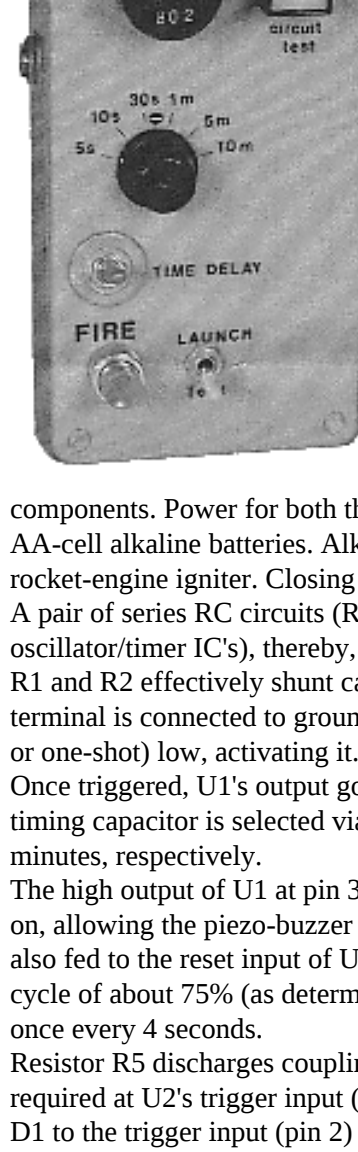
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Last updated September 16, 2004

A Time Delayed Model Rocket Launch Control

By Tony van Roon

"Add a touch of class and safety with this deluxe model-rocket launch control circuit."



Since the introduction of low-cost model rocket engines in the 1950's, building and launching small scale model rockets have been popular pastimes. While designing and finishing high-performance models is both interesting and challenging, it is also fun to design and build electronic gadgets to go along with them. One such gadgets is the *Time Delayed Launch Control* in this article.

With the Time Delayed Launch Control, you press the fire switch to initiate a launch sequence, then the circuit begins to count-down, giving you plenty of time to step back so that you can view the impending event from a safe distance, record the launch, or prepare to monitor experiments during the flight. At the end of a preset period, the circuit ignites the rocket's engine, sending it skyward.

The circuit has six preset delay intervals: 5, 10, and 30 seconds, and 1, 5, and 10 minutes. The circuit also contains a piezo-electric buzzer that beeps every few seconds as the system counts down to launch.

As a safety feature, a launch sequence can be aborted at any time, simply by shutting off the system or by switching to the test-mode. The main function of the test mode, however, is to verify, via a front panel indicator, that the ignition circuit is properly wired. The circuit is powered from its own internal battery pack, which also provides power to the rocket-engine igniter.

Circuit Description:

A schematic diagram of the Time Delayed Launch Control is shown in Fig. 1. The circuit—which gives a choice of 6 delay settings—is comprised of three 555 timer/oscillators (U1, U2, U3), a pair of transistors (Q1 and Q2), four switches (S1 - S4), a piezo electric buzzer (BZ1), and a few support components. Power for both the control circuit and the rocket-engine igniter is provided by a 6-volt power source that is comprised of 4 AA-cell alkaline batteries. Alkaline batteries are specified because other types are incapable of supplying the 1-3 amps required to fire a rocket-engine igniter. Closing switch S1 feeds power to the launch control circuit, but does not initiate a launch sequence.

A pair of series RC circuits (R4/C3 and R8/C12, respectively) are used to debounce the reset inputs (pins 4) of U1 and U2 (a pair of 555 oscillator/timer IC's), thereby, preventing false triggering from occurring during power-up or when switching modes. Pull-up resistors R1 and R2 effectively shunt capacitor C1, keeping it discharged until S2 (Fire) is momentarily closed. When S2 is closed, C1's negative terminal is connected to ground through the trigger, momentarily pulling pin 2 of U1 (which is configured as a monostable multivibrator, or one-shot) low, activating it.

Once triggered, U1's output goes high for an interval that's determined by R3 and one or six timing capacitors (C2 through C8). The timing capacitor is selected via *Delay Selector* switch S3. Positions 1 through 6 of S3 give intervals of 5, 10, or 30 seconds or 1, 5, or 30 minutes, respectively.

The high output of U1 at pin 3 is fed through current-limiting resistor R12 to the base of Q2, forward biasing it, which causes Q2 to turn on, allowing the piezo-buzzer (BZ1) to turn on when the proper signal is applied to BZ1's negative terminal. Monostable U1's output is also fed to the reset input of U3 (which is configured as an astable multivibrator or oscillator) at pin 4, causing it to oscillate with a duty cycle of about 75% (as determined by C14, R10, and R11). As long as the output of U1 is high and the astable is oscillating, BZ1 beeps once every 4 seconds.

Resistor S3 discharges coupling capacitor C10 whenever U1's output goes high, while R6 maintains the normally high bias voltage required at U2's trigger input (pin 2). At the end of the selected time delay, U1's output goes low. That low is coupled through C10 and D1 to the trigger input (pin 2) of U2, which (like U1) is configured as a monostable multivibrator.

Components R7 and C11 set U2's high-output interval to approximately 3 seconds. During that 3-second interval, U2's high output at pin 3 is fed to Darlington transistor Q1 through R9 (which limits the bias current to the device to less than 40 mA). With S4 in the *Launch* position, Q1 grounds one end of the engine igniter, effectively connecting it to the battery's negative terminal. During that 3-second interval, approximately 1-3 amps passes through the engine igniter, causing it to glow and burn.

For a detailed description, workings, and pins of the 555 timer/oscillator, please [click here](#).

Construction:

To assemble the launch-control circuit, you will need all of the components listed in the parts list. You will probably want to customize the project, so pick out switches, a lamp, and a piezo buzzer that will give our launch control an interesting and personalized appearance. Start with the enclosure. The enclosure must be large enough to accommodate the printed circuit board and all of the front panel controls, and still leave room for the quad AA-cell battery pack. The overall dimensions of the enclosure should be about 6 x 3 inches. It is recommended that the circuit be housed in a brightly-colored ABS plastic enclosure. A plastic enclosure is recommended because you will have to drill about ten holes in it, and ABS plastic is much easier to work with than steel or aluminum.

Choose a convenient location on the front panel for the test lamp (I1), the piezoelectric buzzer (BZ1), and the four switches (S1-S4). Mark and drill the mounting holes for those components. Then drill a hole in the side of the enclosure for the phono jack J1. It should be located about 2 inches from the end of the enclosure where the battery pack will go. Clean any burrs from the holes and check all front-panel components for a proper fit, but do not mount them yet.

If you are unable to find a properly colored enclosure, you can spray-paint the one you choose after all the mounting holes have been drilled and deburred. If you must paint the enclosure, apply 2 or 3 thin coats of primer (or white), followed by 2 thin coats of a bright-colored primer. Give each coat a couple hours to dry before applying the next coat, then let it set overnight. Just a word of caution; make sure the color you are using is compatible with your final paint.

With that done, use dry-transfer (rub-on) lettering to label each switch position according to its function—the rotary switch with its delay times should be marked at each stop—and test the lamp.

After labeling, protect the dry transfer lettering by applying one of two coats of clear lacquer. Allow all coats to dry several hours or overnight. The front panel is now ready for assembly. Mount BZ1, I1, and S1-S4, and J1 to the enclosure, and don't forget to install a knob on the shaft of S3.

Since the control circuit contains only three IC's and two transistors, you can easily assemble it on a small piece of perforboard or 'Vero-board' using wire-wrap or point-to-point wiring techniques. However, the author's prototype was assembled on a printed circuit board that measures about 2 by 2-13/16 inches. A full-size template of that pcb lay-out is shown in Fig. 2. Once you have etched the board, drill all holes with a No. 67 bit. That bit size will accommodate all of the component leads and the 22 & 26 AWG hookup wire that will be used for the interconnections between the board and the panel mounted components.

Following the parts placement diagram shown in Fig. 3, install the capacitors, making sure that they are all flush to the board, while observing their polarity. Likewise, install the resistors flat against the board. That minimizes lead lengths and give a neater appearance. Install an 8-pin DIP socket at all IC, (U1-U3) locations. That helps eliminate the possibility of damaging the IC's which are static sensitive during soldering. Next, install transistors Q1 and Q2, taking care to properly align the emitter, base, and collector leads. Then, using hookup wire, or the excess leads clipped from the resistors, install the 5 jumper connections in the locations shown.

Cut six 8-inch lengths of 26 AWG stranded hookup wire. Twist pairs of wires together, making three pairs in all. Next, cut five 8-inch lengths of 22AWG stranded hookup wire. Twist three of these wires together to make a 3-lead set for S4, and then twist the remaining pair together for S1. Once that is done, strip about an 1/8th inch of insulation from the ends of all the leads.

Solder one 26 AWG pair to the two printed circuit pads that are identified as BZ1 in Fig. 3. Being careful to observe the correct polarity, solder the other ends of those leads to BZ1. Similarly, install the other two 26 AWG leads between the printed circuit board and lamp I1, and the printed circuit board and S2. Next, install the 3-conductor 22 AWG wire set between the printed circuit board and S4. Be careful to identify each of the three printed circuit pads corresponding to the appropriate terminals of S4. Then solder the remaining 22 AWG pair between the printed circuit board and S1.

Rotary switch S3 requires a 7-conductor cable. Use either 26 AWG or 28 AWG ribbon cable for S3. Cut an 8-inch length of 7-conductor cable and strip 1/8th inch from all ends. Following that, solder the cable to the appropriate printed circuit board pads. Next, solder the other end of the cable to the rotary switch, making sure that **lead number seven connects to the wiper**. Install and solder the two leads coming from the battery holder to the printed circuit board. Again, be certain to identify the correct polarity of each lead and each printed circuit pad.

For the engine-igniter leads, cut two 3-foot or more lengths of 22 AWG stranded hookup wire. The actual length of this wire set depends on how far you want to place the control box from the launch pad—mine are about 3 feet. Once you have decided on the length, twist them together and strip about an 1/8th inch insulation from both ends of each conductor. Solder a micro clip to one end of each lead. Push the other ends of the leads through the phone-plug sleeve, solder the two free ends to the tip and ring terminals of the phono plug, and then install the sleeve.

Finally, fasten the printed circuit board to the enclosure using a 1-inch length of double-sided foam tape between the bottom of the printed circuit board and the inside of the enclosure. That is easier than using mounting hardware, and gives a neater overall appearance. Works just as good.

Test and Use:

Set S3 to the 30 S position, S4 to the *Test* position, and install 4 AA Alkaline batteries in the quad battery holder. Attach an engine igniter to the two micro clips and insert phone-plug PL1 into jack J1; the test lamp, I1, should light. Now switch S4 to the *Launch* position, turn on S1 and press S2, *Fire*. The piezo buzzer (BZ1) should begin to beep every few seconds. After about 30 seconds, the beeping stops, and the igniter fires.

Warning: Always pull the phone plug from its jack before attaching the micro clips to a live engine! Also **do not** allow the micro clips to short during a launch or test; otherwise transistor Q1 could be damaged.

Should any of the above tests fail, troubleshoot the circuit using a DC voltmeter. To do so, attach the meter's negative probe to ground, turn S1 on, and measure the voltage at pin 8 of each 555 timer—you should get a reading of approximately 6 volts. If so, check the controls, and still leave room for the quad AA-cell battery pack. The overall dimensions of the enclosure should be about 6 x 3 inches. It is recommended that the circuit be housed in a brightly-colored ABS plastic enclosure. A plastic enclosure is recommended because you will have to drill about ten holes in it, and ABS plastic is much easier to work with than steel or aluminum.

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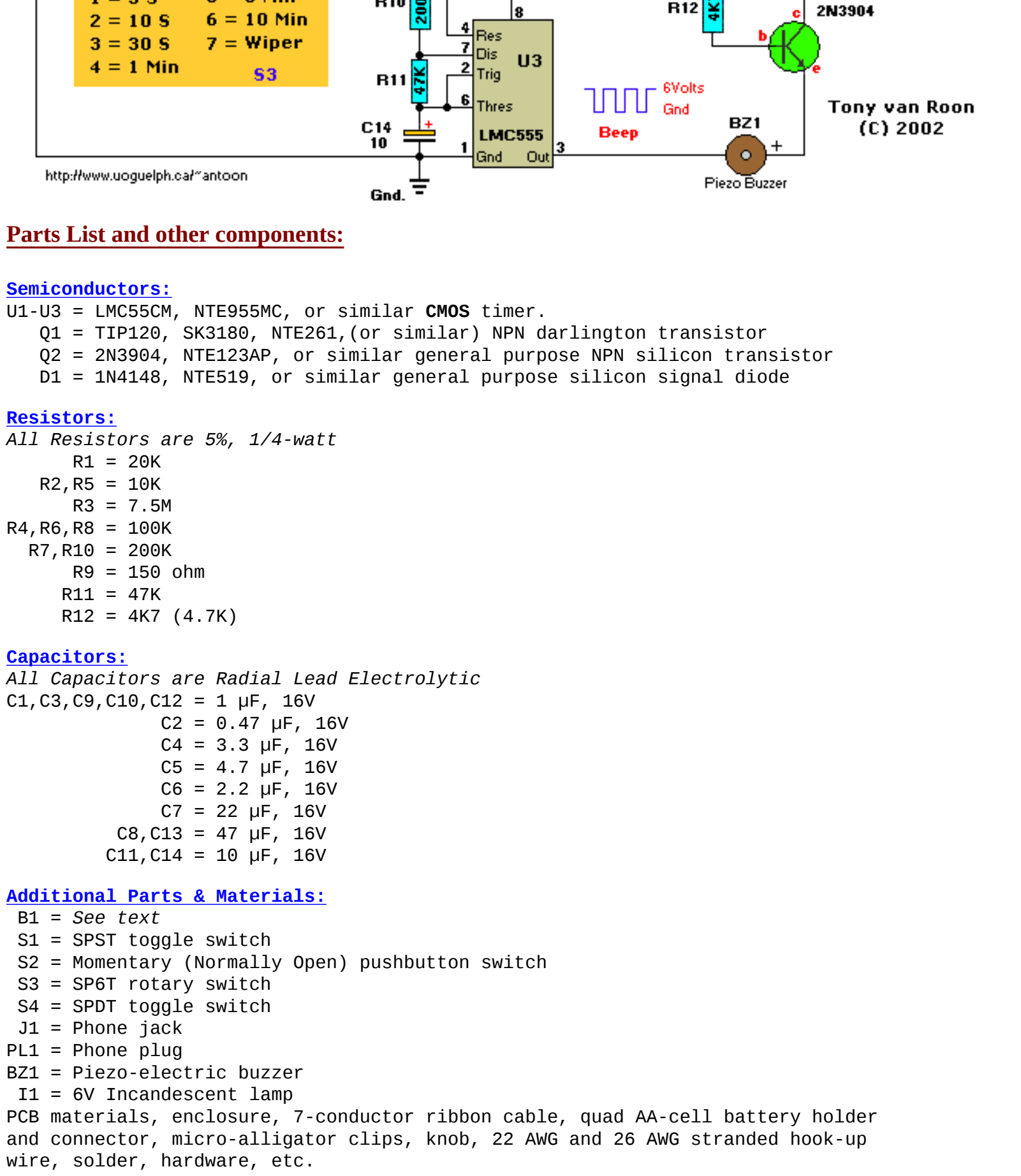
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Parts List and other components:

Semiconductors:

- U1-U3 = LMC555, NTE955MC, or similar CMOS timer.
- Q1 = TIP120, SK3180, NTE261, (or similar) NPN darlington transistor
- Q2 = 2N3904, NTE123AP, or similar general purpose NPN silicon transistor
- D1 = 1N4148, NTE519, or similar general purpose silicon signal diode

Resistors:

All Resistors are 5%, 1/4-watt

- R1 = 20K
- R2, R5 = 10K
- R3 = 7.5M
- R4, R6, R8 = 100K
- R7, R10 = 200K
- R9 = 100 ohm
- R11 = 47K
- R12 = 4K7 (4.7K)

Capacitors:

All Capacitors are Radial Lead Electrolytic

- C1, C3, C9, C10, C12 = 1 µF, 16V
- C2 = 0.47 µF, 16V
- C4 = 3.3 µF, 16V
- C5 = 4.7 µF, 16V
- C6 = 2.2 µF, 16V
- C7 = 22 µF, 16V
- C8, C13 = 47 µF, 16V
- C11, C14 = 10 µF, 16V

Additional Parts & Materials:

- B1 = See text
- S1 = SPST toggle switch
- S2 = Momentary (Normally Open) pushbutton switch
- S3 = SP6T rotary switch
- S4 = SPDT toggle switch
- J1 = Phone jack
- BZ1 = Piezo-electric buzzer
- I1 = 6V Incandescent lamp
- PCB materials, enclosure, 7-conductor ribbon cable, quad AA-cell battery holder and connector, micro-alligator clips, knob, 22 AWG and 26 AWG stranded hook-up wire, solder, hardware, etc.

For Radio Shack part numbers click on this [RS data sheet](#).



Fig. 3. Following this layout diagram, assemble the Time-Delayed Launch Control, keeping in mind that the polarized components must be installed with the proper orientation.



[Click Here for the PCB Diagram](#)

I fully support this project. Most parts can be obtained via your local Radio Shack or Tandy store. I will answer all questions but via the message forum only. **Tony's Message Forum** can be accessed via the main page, [gadgets](#), or [circuits](#) page.

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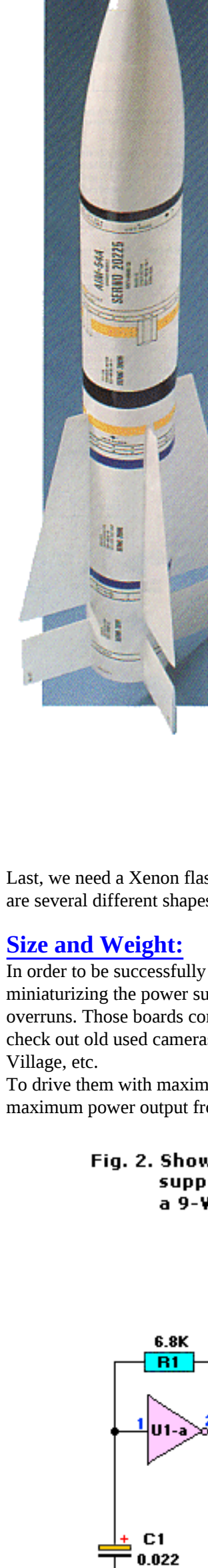
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Model Rocket Strobe Light

By Tony van Roon

"Launch a model rocket on the darkest night, and find it in a flash no matter where it lands!"



"I shot an arrow in the air, it fell to earth I don't know where". When Longfellow penned those words in the 1800's, he must have been thinking about my model rocketry career! The bane of a model rocket or r/c airplane hobbyist is losing a carefully constructed and painstakingly finished model in shrubbery, or trees. But those days are over. Our *Rocket Strobe* sends out a highly visible S.O.S. for up to 2 hours, providing ample time to locate and recover the model. It also makes dramatic night launches a reality, with the blue-white flash of the Strobe visible throughout the flight sequence.

Seeing the Light:

Invented in 1923 by Dr. Harold E. Edgerton, Xenon flash lamp is the light-producing device for our Strobe. Flash lamps produce a short-duration, high-intensity pulse of light by converting energy stored in a capacitor to visible light. Each flash of the Strobe lasts about 500 micro-seconds. For that brief instant, the flash is as bright as a 4KW (4000 Watt) lamp! It is the high intensity of the light pulse that produces long-range visibility--yet, the Strobe requires very little energy input.

Basic Strobe Circuit:

A strobe circuit has four basic parts. (See Fig. 1). The first is the power supply, which must be capable of producing about 300 volts from a 9-volt battery. That high voltage is required to sustain the arc within the lamp after triggering. Second, we need a capacitor to store energy. The luminescence provided by the Strobe is directly related to the value of the capacitor, or to the amount of energy that the capacitor can store. Third, we need a triggering circuit to produce a very high voltage pulse to ignite the lamp. A typical ignition pulse has an amplitude of 4000-volts, and is several microseconds in duration. The trigger pulse is capacitively couple to the Xenon gas inside the lamp. When enough atoms are ionized by the pulse, and if the capacitor has enough charge on it, the gas fully conducts. Light output begins after conduction, and continues until the charge on the capacitor drops to about 50 volts. The lamp shuts itself off at that point, to renew the cycle after the voltage build up again.

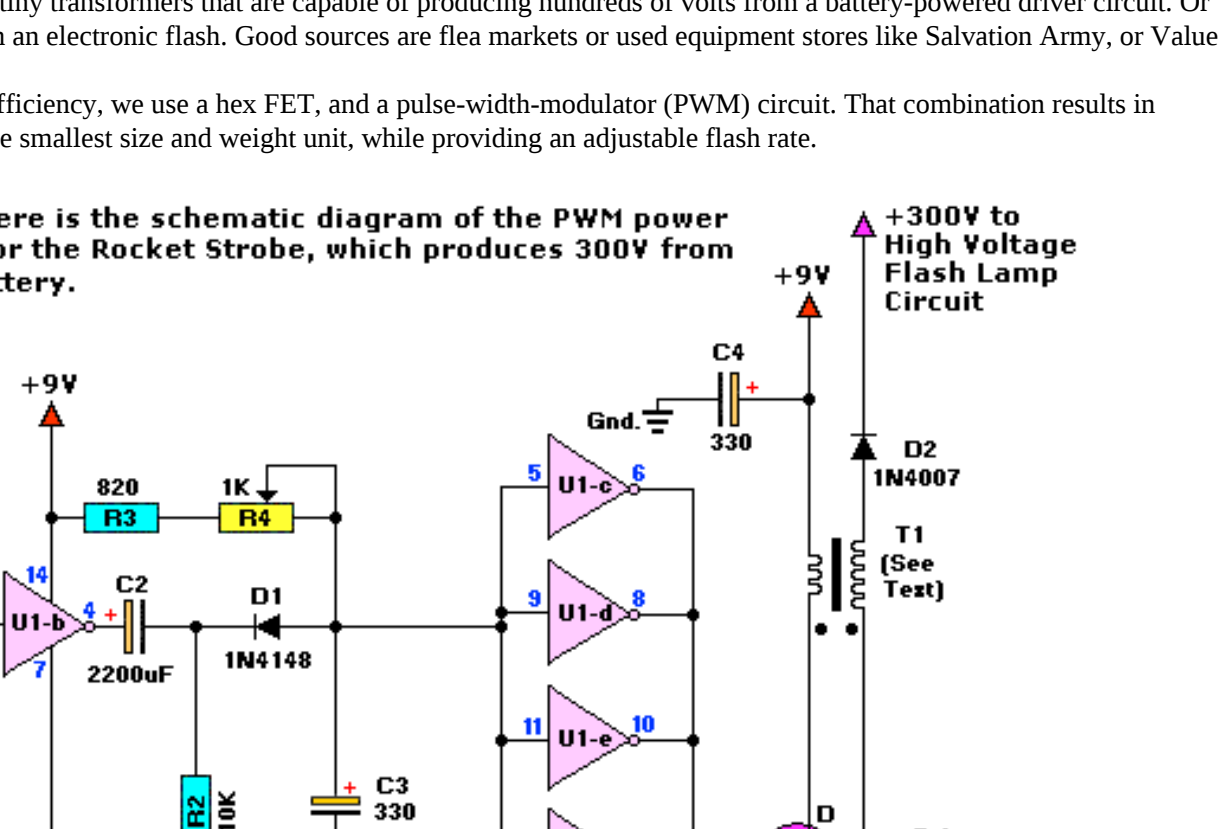


Fig. 1. Here is a block diagram of the basic strobe circuit, which consists of a power supply, storage device (the capacitor), triggering circuit, and a Xenon flash lamp.

Last, we need a Xenon flash lamp; which is available at Radio Shack/Tandy and other outlets or use one from an old camera flash. There are several different shapes and designs of flash lamps. We shall use a small, straight type in our Strobe.

Size and Weight:

In order to be successfully lifted, our Strobe needs to be small, efficient, and light. Weight and size saving is accomplished by miniaturizing the power supply. Surplus electronics suppliers often have camera electronic flash boards left over from manufacturing overruns. Those boards contain tiny transformers that are capable of producing hundreds of volts from a battery-powered driver circuit. Or check out old used cameras with an electronic flash. Good sources are flea markets or used equipment stores like Salvation Army, or Value Village, etc.

To drive them with maximum efficiency, we use a hex FET, and a pulse-width-modulator (PWM) circuit. That combination results in maximum power output from the smallest size and weight unit, while providing an adjustable flash rate.

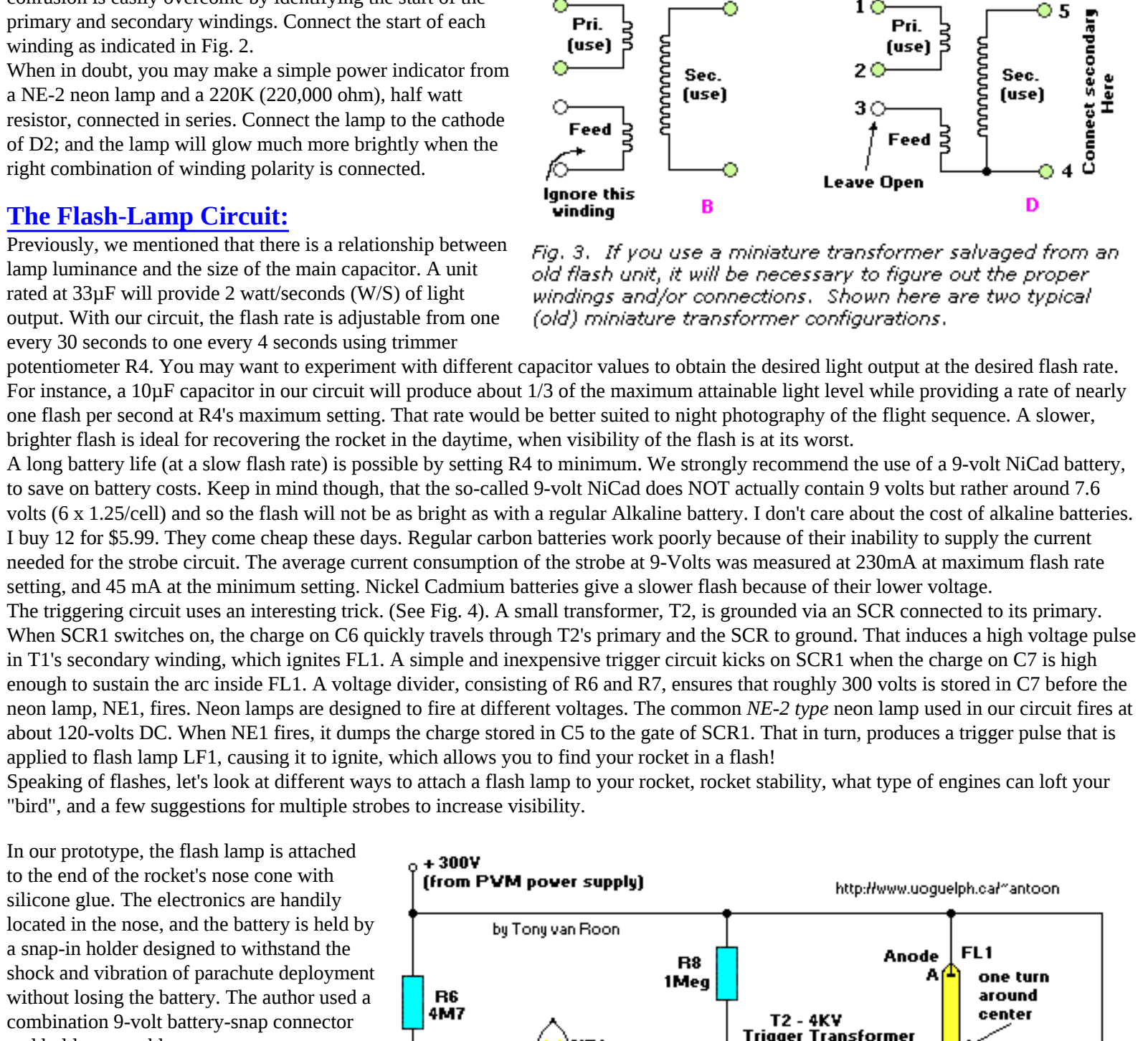


Fig. 2. Shown here is the schematic diagram of the PWM power supply for the Rocket Strobe, which produces 300V from a 9-V battery.

Strobe Circuit Construction:

Referring to Fig. 2, gate U1-a (one-sixth of a CD4584 CMOS Schmitt Trigger) is configured as an oscillator. With the values shown, the oscillator operates at 6 KHz. You may need to experiment with different frequencies by using the different values of C1 and R1 to obtain maximum output at 6 KHz. Use a transformer other than the one specified in the Parts List. Gate U1-b squares up the output of U1-a and feeds a square wave to C2, C2, R2, R3, D1, and R4. Trimmer potentiometer R4 controls the duty cycle of the resulting pulse. When R4 is set to its maximum resistance, the maximum pulse-width and power is available from the circuit.

The remaining gates (U1-c, U1-d, U1-e, and U1-f) serve to amplify and invert the output of the PWM (Pulse Width Modulator) part of the circuit. The amplified pulse is fed to the IRFZ20 Hex FET, whose upper low on-state resistance of only 0.07 ohm switches the primary of T1 with great force. Pull down resistor R5 keeps the IRFZ20 totally off during the logic '0' state of gates U1-c to U1-f. The output is rectified by D2, and is used to power the Strobe's flash lamp circuit.

A word is needed about miniature transformers. Most units have an accessory winding used in self oscillation circuits powered by bipolar transistors. That winding is not needed, since we have our own on-board PWM oscillator circuit. A simple test with an ohmmeter will reveal that low-resistance feedback winding. Do not confuse it with the low resistance, heavy gauge primary winding. Typical transformer configurations are shown for you in Fig. 3, as examples.

Another consideration is that lots of transformers are constructed by European and Oriental active-negative circuits. (Akin to driving the wrong side of the road to us!) That confusion is easily overcome by identifying the start of the primary and secondary windings. Connect the start of each winding as indicated in Fig. 2.

When in doubt, you may make a simple power indicator from a NE-2 neon lamp and a 220K (220,000 ohm), half watt resistor, connected in series. Connect the lead to the cathode of D2, and the lamp will glow much more brightly when the right combination of winding polarity is connected.

The Flash-Lamp Circuit:

Previously, we mentioned that there is a relationship between lamp luminance and the size of the main capacitor. A unit rated at 33uF will provide 2 watt/seconds (W/S) of light output. With our circuit, the flash rate is adjustable from one every 30 seconds to one every 4 seconds using trimmer potentiometer R4. You may want to experiment with different capacitor values to obtain the desired light output at the desired flash rate. For instance, a 10uF capacitor in our circuit will produce about 1/3 of the maximum attainable light level while providing a rate of nearly one flash per second at R4's maximum setting. That rate would be better suited to night photography of the flight sequence. A slower, brighter flash is ideal for recovering the rocket in the daytime, when visibility of the flash is at its worst.

A long battery life (at a slow flash rate) is possible by setting R4 to minimum. We strongly recommend the use of a 9-volt NiCad battery, to save on battery costs. Keep in mind though, that the so-called 9-volt NiCad does NOT actually contain 9 volts but rather around 7.5 (7.5 x 1.25 cell) and so the flash will not be as bright as using a regular Alkaline battery. I don't care about the cost of alkaline batteries. I buy 12 for \$5.99. They come cheap these days. Regular carbon batteries work poorly because of their inability to supply the current needed for the strobe circuit. The average current consumption of the strobe at 9-Volts was measured at 230mA at maximum flash rate setting, and 45 mA at the minimum setting. Nickel Cadmium batteries give a slower flash because of their lower voltage.

The triggering circuit uses an interesting trick. (See Fig. 4). A small transformer, T2, is grounded via an SCR connected to its primary. When SCR1 switches on, the charge on C6 quickly travels through T2's primary and the SCR to ground. That induces a high voltage pulse in T1's secondary winding, which ignites FL1. A simple and inexpensive trigger circuit kicks on SCR1 when the charge on C7 is high enough to sustain the arc inside FL1. A voltage divider, consisting of R6 and R7, ensures that roughly 300 volts is stored in C7 before the output of D2, and the lamp will glow much more brightly when the right combination of winding polarity is connected.

A flash lamp must be attached to the rocket's nose, body, or fins. Be aware that the delicate flash lamp needs breakage protection. A rigid clear piece of plastic tubing around the lamp affords additional breakage protection. Plug the open end with a tapered balsa or plastic plug to preserve the rocket's aerodynamic sleekness. Use of a short, sturdy flash lamp, cushioned in Silicone may work fine, as it did with our model.

The parachute must be increased to compensate for the added weight; 40 square inches of parachute area per ounce of weight is recommended. All told, our rocket weighed 13.5 ounces, so 540 square inches of chute area was needed. We replaced the 18-inch chute that we had with the model with two 24-inch ones. That gave about 900 square inches, which gently delivers the model to earth. If you need to move more than one chute, attach each chute's shroud lines to a snap swivel (which can be found at the fishing tackle shops). Those handy little gizmos reduce the chance of the line tangling (which can lead to disaster) and enables you to clip on or remove chutes in a jiffy. More than one parachute means you will have to pack each carefully. Try not to wind the lines too tightly around the chutes, and use plenty of flame-proof wadding between the chutes and engine. Dusting the chutes with plain talcum powder lets them slide out freely during the engine's ejection phase and they unravel quicker when in the air.

The finished model's weight is an important consideration in engine selection. To launch successfully, the model must be less than the Maximum Lift Weight (MLW) of the engine type selected. Weight can really creep up on you (as all divers know!). Our model, called the Phoenix, weighed 11.6 ounces, with the engine and strobe installed. After it was painted, the paint added 1.9 ounces! That put the total weight at 13.5 ounces, very close to the MLW of the strobe we used.

In the prototype, the flash lamp is attached to the end of the rocket's nose cone with silicone glue. The electronics are handily located inside the nose, and the battery is held by a snap-in holder designed to withstand the shock and vibration of parachute deployment without holding the battery. The author used a battery-snap connector and solderless assembly.

A balsa wood plug is held securely in place by silicone, which also seals the components inside the nose cone, and as providing an anchor point for the parachute, and shock-absorbing rubber cord leading to the rocket's body.

Strong assembly techniques are needed for the nose-cone/electronics package. The nose cone must withstand considerable force at the apex of flight when the rocket engine activates its ejection charge. There is nothing gently about the hefty charge of black powder that pops off the nose cone and deploys the parachute. Fig. 5 shows the parts of a rocket engine, and their function. Be sure to use enough silicone (without disturbing vertical, rotational balance) for good strength.

Weight must be minimized to allow your bird to lift off, and attain maximum height. Soft grades of balsa wood are the lightest, and weight savings may be gained by careful assembly of the electronics on a small board, using a minimum of solder. All said, our Strobe added 3-1/2 ounces to the rocket's weight. You may also save weight by not painting the model with too many coats of finish if it's to fly a Strobe.

You may make a pcb, or wire the electronics on perboard (which we did). A universal printed-circuit-board worked fine. As you assemble the circuit, be mindful of the need to minimize weight. Use just enough solder to make a good joint. Trim away excess space on your mounting board.

Wherever possible, use miniature (or smt) components. A NiCad or NiMH battery will save you quite a bit of weight (1.25 ounces versus almost 2 ounces for an alkaline unit). The NiCad gives a good 15 minutes of flashing at high rate, and over 1 hour on slow. Even better results with the NiMH type.

The power supply layout is not critical, but you must pay attention to the high-voltage output of the trigger transformer. That little guy puts out over 4,000 volts, and while it does not look too dangerous it packs quite a nasty wallop!

Dress the secondary leads away from other components; a half inch is recommended. The wires leading to capacitor C7 and the trigger transformer should be short, and if on the outside of the rocket, glued flat to avoid excess air drag. If you run the wires inside the body, make sure that they won't become tangled in the recovery system! Also, the ejection gases will quickly rot the insulation on wires; if they are in an exposed area, jacket and seal them in heat shrink tubing or the kind of plastic tubing sold for aquarium air lines.

Wire size is not critical; we had fine luck with #26 stranded hook-up wire. Make sure flash-lamp polarity is observed. The end with the large round electrode is the cathode, which is always connected to ground. Some flash lamps have a trigger-wire already attached to one end, but on those that don't, one wrap of bare wire around the lamp's center will do the trick. Secure the wire with a tiny dab of epoxy or Crazy glue to the glass.

Make sure that the leads to the lamp are well insulated at the splices. A connector is handy to have in the circuit leading to the lamp. That way, the electronics can be quickly disconnected for testing or adjustment. Eventually, the lamp burns out and has to be replaced, but only after many, many flashes. The author calculates the lamp listed in the Parts List will last around 20,000 flashes. That's over 20 hours of continuous static, and represents many rocket flights.

To get the best efficiency, it's necessary to keep C4 close to Q1 (see Fig. 2). That ensures a "reservoir" of current to draw from as Q1 switches. Usually, Q1 does not need any heatsink on N1 if it gets too hot to comfortably hold. Sometimes, due to winding differences, you will need to increase C4 to 470uF or 680uF in order for the PWM circuit to work efficiently. A 16-volt capacitor is satisfactory for use with a 9-volt battery.

Build the PWM part of the circuit first. You should test it before installing the hex FET and T1. That is easily accomplished by using a small speaker with a 10-uF capacitor attached to one lead. Connect the other lead to ground, and the free end of the capacitor to pins 5, 8, 10, and 12 of U1. By adjusting R4, you will be able to hear the volume of the tone getting louder or quieter as R4 varies the pulse width. Once the PWM circuit works, attach the mini transformer, using Figs. 2 and 3 as a guide to polarity. Use proper precautions to minimize static, and install Q1. The +300-volt output may be tested with a neon lamp. Resistor R4 varies the brightness of the lamp.

Put together the Strobe section of the circuit (see Fig. 4) keeping in mind the high-voltage output of T2. Once you have all the parts assembled, it is a good idea to give the finished board and components several light coats of an insulating spray to prevent shorts and high-voltage arcing. A product such as "Acrylic Coating" (which has a dielectric strength of 2,000 volts per 0.001 inch) or other material for coating printed-circuit boards works well. Don't coat R4, or it won't work anymore! Also, don't spray anything on the flash lamp, although you may insulate the ends to prevent arcing outside the flash tube.

Testing:
Before installing the electronics in the rocket, and gluing everything down, check to see that the Strobe is operating correctly. With a 9-volt input and using the parts specified, you should see a flash every 4 seconds on the high setting, and about 30 seconds on the low setting of R4. **You'll note the first flash takes quite a while to appear (depending on the quality of C7), usually 10-15 seconds on high, and a few minutes on low.**

The reason for that is that C7, the large electrolytic that stores the energy to light the flash lamp, has to "polarize" if it has been sitting idle for a long while. Leakage within the capacitor is maximum when voltage is first applied, and it has to charge and discharge several times before leakage subsides and absorbs less power. If that problem exists, run the Strobe from another 9-volt battery before launch and wait until the flash rate goes up. Then, you may install your flash battery, and let 'er rip!

If you can get accurate specifications, select C7 for low leakage. Most miniature, recent-style capacitors work fine. In our prototype Strobe, we left out an on/off switch, opting instead to simply install the 9-volt battery when launching. You may install a switch, or leave it out as desired.

Finally, remember to observe safety practices when flying your rocket! If it gets caught in a power line, or high in a tree, leave it! No project is worth risking one's life! Fly in clear areas, especially for night launches, and observe wind direction, launch angle, expected trajectory, and landing site to optimize your changes of successful recovery. Happy Flying!

Parts List and other components:

Semiconductors:
Q1 = IRFZ20 Hex FET (Digi-Key IRFZ20ND)
D1 = 1N4148, general purpose silicon signal diode
D2 = 1N4007, 1A, 1000-PIV, general purpose rectifier diode
U1 = CD4584 Hex Schmitt Trigger, IC
SCR1 = T106D1, C106D1, EGCS457, NTE5457, etc. 400-volt/4-amp, sensitive gate Silicon Controlled Rectifier

Resistors:
All Resistors are 5%, 1/4-watt, unless otherwise noted.
R1 = 6800 ohm (same as 6K8)
R2 = 10,000 ohm (same as 10K)
R3 = 820
R4 = 1000 ohm, trimmer potentiometer
R5 = 1000 ohm (same as 1K)
R6 = 4.7 Megohm (same as 4M7)
R7 = 3.3 Megohm (same as 3M3)
R8 = 1 Megohm (1M)

Capacitors:
C1 = 0.022 uF, 10% stable temperature coefficient. (DigiKey P1016 or equivalent)
C2 = 2200 pF, 20% stable temperature coefficient. (DigiKey P3222 or equivalent)
C3 = 330 pF, ceramic disc (DigiKey P4106 or equivalent)
C4 = 330 to 680 uF, 16WVDC, miniature electrolytic
C5 = 0.033 uF, 250 WVDC (DigiKey E2333 or equivalent)
C6 = 0.047 uF, 400 WVDC (DigiKey E4473 or equivalent)
C7 = 33 uF (or value to suit, see text) 350 WVDC miniature electrolytic

Additional Parts & Materials:
FL1 = Xenon Flash Lamp
NE-2 = NE-2 type, 120 volt neon lamp
T1 = see text
T2 = 4KV trigger transformer
Printed Circuit Board or perboard materials, 9-volt alkaline battery, battery holder, wire, solder, enclosure or shrink sleeving, etc.

For Radio Shack part numbers click on this [RS data sheet](#).

I fully support this project. Most parts can be obtained via your local Radio Shack or Tandy store. I will answer all questions but via the message forum only. **Tony's Message Forum** can be accessed via the main page, gadgets, or circuits page.

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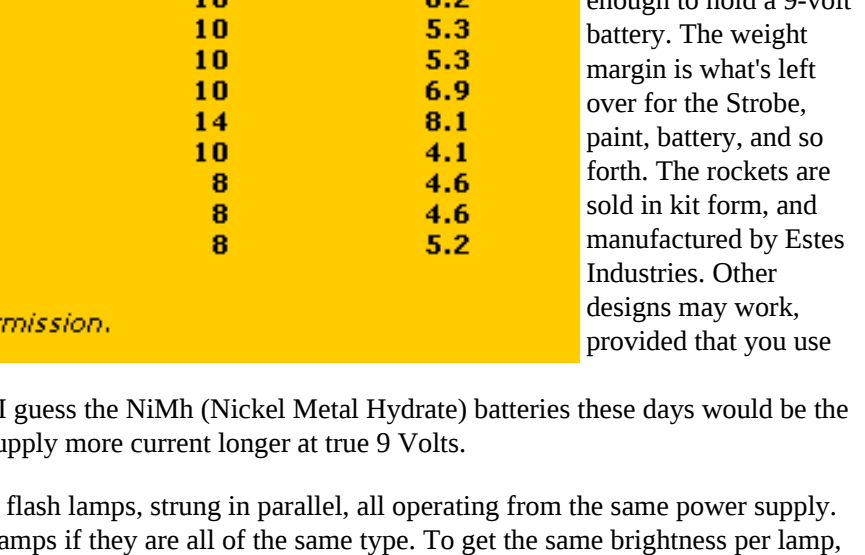


Fig. 3. If you use a miniature transformer salvaged from an old flash unit, it will be necessary to figure out the proper windings and/or connections. Shown here are two typical (old) miniature transformer configurations.

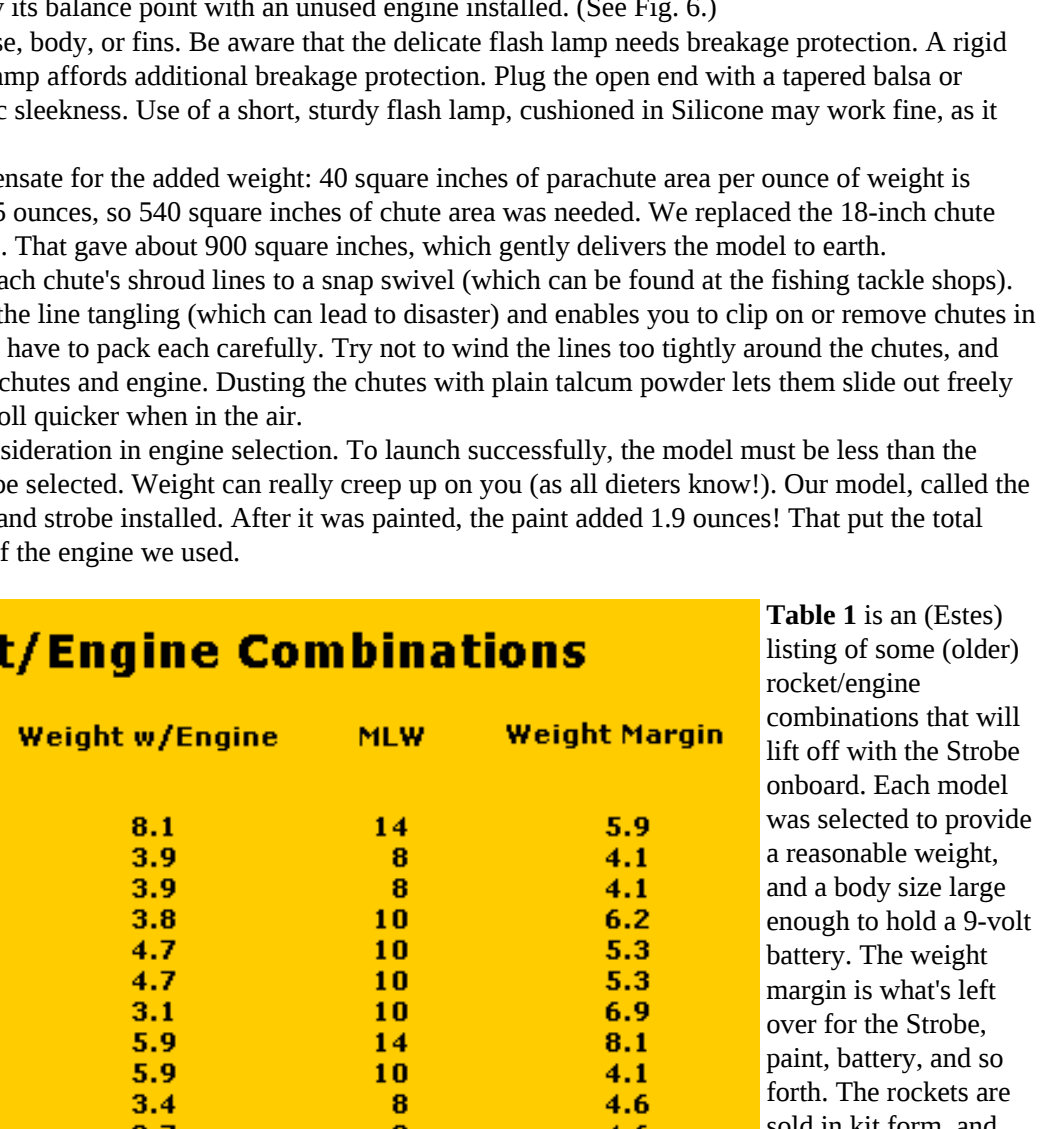


Fig. 4. The triggering circuit uses a small voltage transformer that is grounded via a SCR which, when triggered, induces the high-voltage pulse that ignites the flash lamp.



Fig. 6. If the electronics are forward of the model's Center of Gravity, the Rocket should fly fine with the added weight.



Fig. 5. Here is the flight sequence of the rocket along with a cut-away showing its engine components and their functions.

Table 1 is an (Estes) listing of some (older) rocket/engine combinations that will lift off with the Strobe onboard. Each model was selected to provide a reasonable weight, and a body size large enough to hold a 9-volt battery. The weight margin is what's left over for the Strobe, paint, battery, and so forth. The rockets are sold in kit form, and manufactured by Estes Industries. Other designs may work, provided that you use

lightweight batteries, and built the rocket and Strobe using minimal-weight methods. I guess the NiMH (Nickel Metal Hydrate) batteries these days would be the best choice. Not only are they much lighter than NiCads, they supply more current longer at true 9 Volts.

Multiple strobes add a very interesting touch. We used up to six flash lamps, strung in parallel, all operating from the same power supply. The light output appears to be equally divided among multiple lamps if they are all of the same type. To get the same brightness per lamp, you will have to increase the value of electrolytic capacitor C7 (see Fig. 4). For instance, with 3 lamps, C7 would need to be three times larger to provide each lamp with a high brightness, but the total light output would be tripled. Increase C6 to 0.1uF when using more than one lamp in parallel. The higher capacitance causes a greater charge to be dumped across T1's primary (and hence, a larger secondary current), and guarantees the ignition of all lamps.

Construction:
Well, by now you are an expert on power supplies, strobes, rockets, and aerodynamics; so let's roll up our sleeves, and get to work! You may make a pcb, or wire the electronics on perboard (which we did). A universal printed-circuit-board worked fine. As you assemble the circuit, be mindful of the need to minimize weight. Use just enough solder to make a good joint. Trim away excess space on your mounting board.

Wherever possible, use miniature (or smt) components. A NiCad or NiMH battery will save you quite a bit of weight (1.25 ounces versus almost 2 ounces for an alkaline unit). The NiCad gives a good 15 minutes of flashing at high rate, and over 1 hour on slow. Even better results with the NiMH type.

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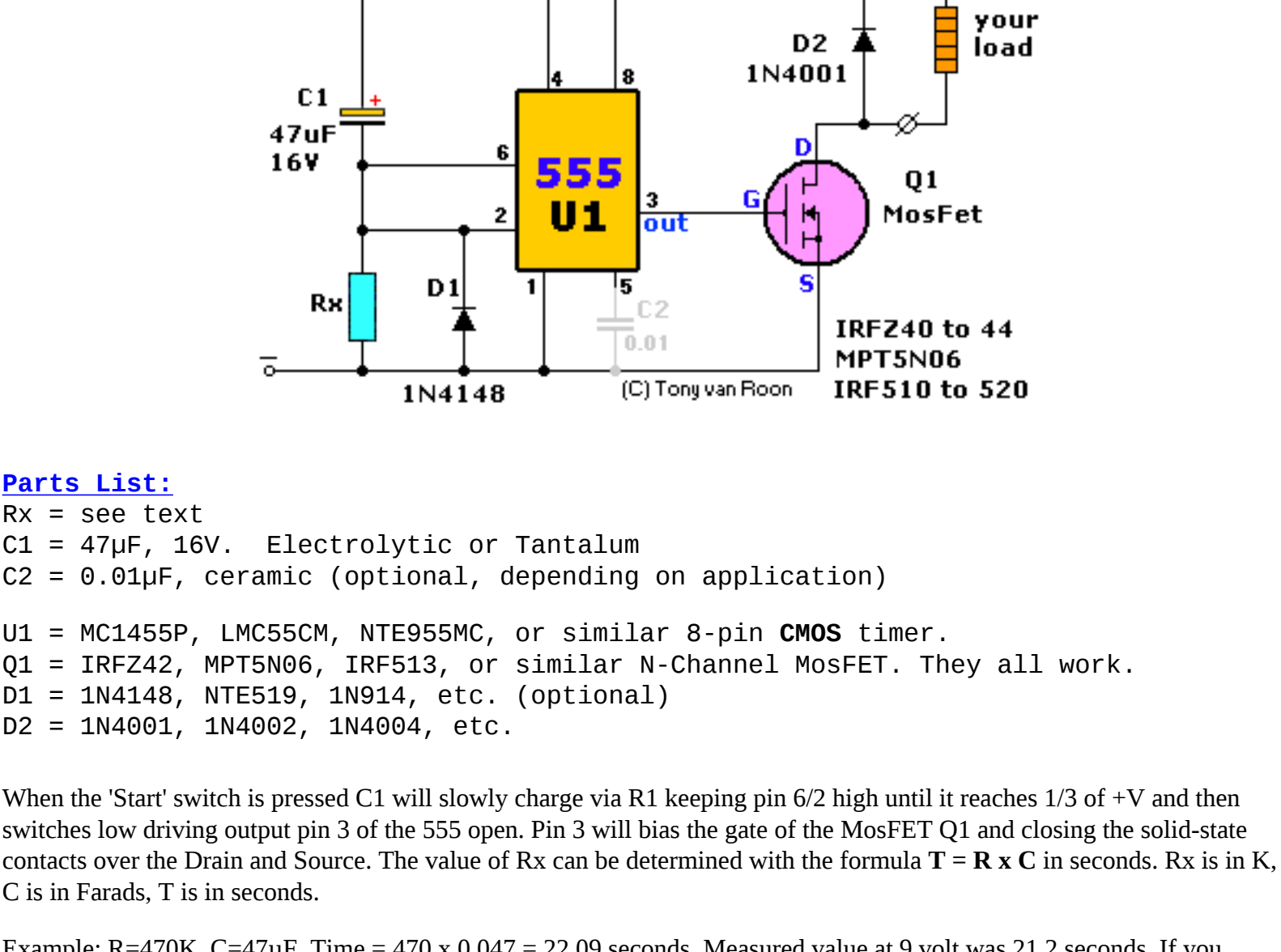
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Chute Control for Model Rockets

by Tony van Roon

"Deploy your rocket parachute after a pre-set, adjustable, time delay. This device is similar to the STX-10"



Parts List:

- Rx = see text
- C1 = 47µF, 16V. Electrolytic or Tantalum
- C2 = 0.01µF, ceramic (optional, depending on application)
- U1 = MC1455P, LMC555CM, NTE955MC, or similar 8-pin **CMOS** timer.
- Q1 = IRFZ42, MPT5N06, IRF513, or similar N-Channel MosFET. They all work.
- D1 = 1N4148, NTE519, 1N914, etc. (optional)
- D2 = 1N4001, 1N4002, 1N4004, etc.

When the 'Start' switch is pressed C1 will slowly charge via R1 keeping pin 6/2 high until it reaches 1/3 of +V and then switches low driving output pin 3 of the 555 open. Pin 3 will bias the gate of the MosFET Q1 and closing the solid-state contacts over the Drain and Source. The value of Rx can be determined with the formula $T = R \times C$ in seconds. Rx is in K, C is in Farads, T is in seconds.

Example: R=470K, C=47µF. Time = $470 \times 0.047 = 22.09$ seconds. Measured value at 9 volt was 21.2 seconds. If you know the time you can calculate the resistor value: $R = T.C$ (Resistor value = seconds divided by capacitance). A note on using the correct battery type: An regular 9 volt Alkaline battery is suggested. A 9 volt NiCad is not really 9 volt but rather 7.5 volt (1.25 per cell x 6).

The variation between calculated and measured value is due to component tolerances. To find an almost perfect match, use a 1Mega-ohm, 10-turn trimmer potentiometer and adjust the delay until you find the setting of your choice. Then measure the ohm's value of the trimmer pot and replace with a permanent resistor with a 2% (or better) tolerance. Use a metal-film if you can, they are more temperature stable and more precise. Same for the capacitor. A tantalum type is preferred if you need a precise delay time.

C2 is a regular 0.01µF (10 nanoFarad) filter capacitor but may not be needed. It is used to filter off noise in some applications like spikes coming from the brushes of an electric motor.

Use a low-power CMOS type for the timer to make the battery last longer. The regular 555 will also work, just needs more power. D2, the 1N400x diode, is a **must**. Otherwise backcross EMF flutter between the Drain and +V may cause accidental activation of the 'load'. You can fold this MosFet over the D2 diode to keep everything as flat as possible. This circuit can be powered by any voltage between +5 and +15V.

Only if you find that there is too much signal on the gate, insert a 150 ohm or so resistor between pin 3 and the gate of Q1. Below are the PCB and Lay-out for your convenience. I'm considering making a SMT version which shrinks the whole thing to less than the smallest postal stamp and very light.



I fully support this project. Most parts can be obtained via your local Radio Shack or Tandy store. I will answer all questions but via the message forum only. **Tony's Message Forum** can be accessed via the main page, gadgets, or circuits page.

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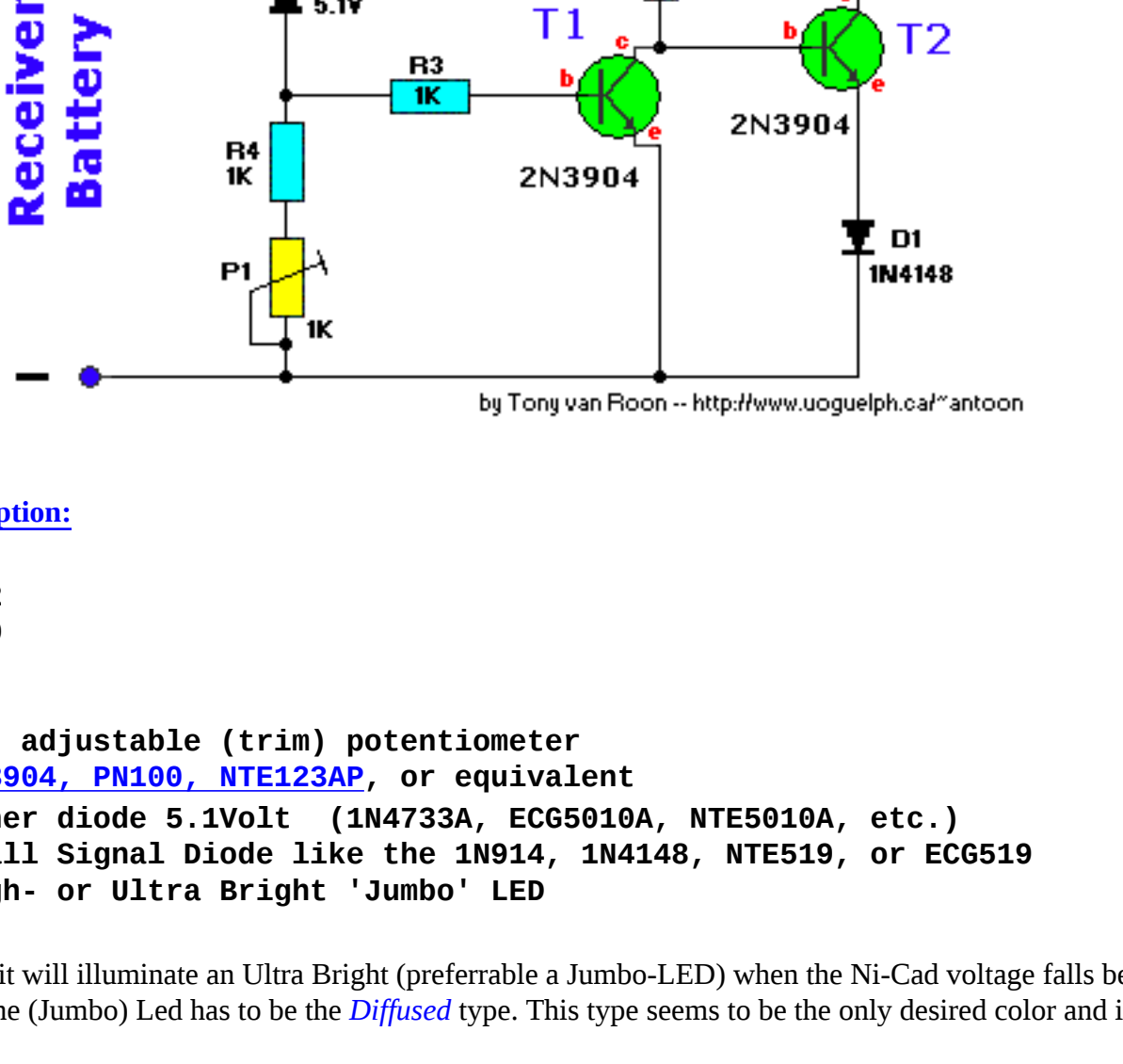
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Ni-Cad Sensor for Heli

by Tony van Roon



Parts & Description:

- R1 = 2K2
- R2 = 100
- R3 = 1K
- R4 = 1K
- P1 = 1K, adjustable (trim) potentiometer
- T1, T2 = 2N3904, PN100, NTE123AP, or equivalent
- D1 = Zener diode 5.1Volt (1N4733A, ECG5010A, NTE5010A, etc.)
- D2 = Small Signal Diode like the 1N914, 1N4148, NTE519, or ECG519
- Led = High- or Ultra Bright 'Jumbo' LED

The above circuit will illuminate an Ultra Bright (preferable a Jumbo-LED) when the Ni-Cad voltage falls below a preset voltage level. The (Jumbo) Led has to be the *Diffused* type. This type seems to be the only desired color and is visible in daylight.

Cut-off point is adjustable with trimpot P1 somewhere between 4.2 and 5.2 volts, depending on your choice of components. However, I recommend a point between 4.6 - 4.8 volt. Circuit was designed to work with an application I used for my KALT helicopter, but ofcourse this sensor will work for anything else which use the standard 4.8volt nicad battery pack. Current draw is approximately 12 mA when the LED is on, standby current is 2mA or less. These specs are for the Red Led only.

The LED shoud be mounted where it is visible when the Heli is in-flight (hover). The circuit should be protected from the usual contaminants like fuel, oil and other dirt. Heat shrink and silicon adhesive are an excellent choice.

Parts are not critical but keep resistor tolerance at 5% or less.

I noticed that some types of Ultra- or High brightness Led's have their 'flat' side as anode instead of kathode so if you don't see any action from the led, just reverse. In general, the short leg or flat side of a led is the kathode. No damage will occur if the led is connected the wrong way.

Simple Night Blades

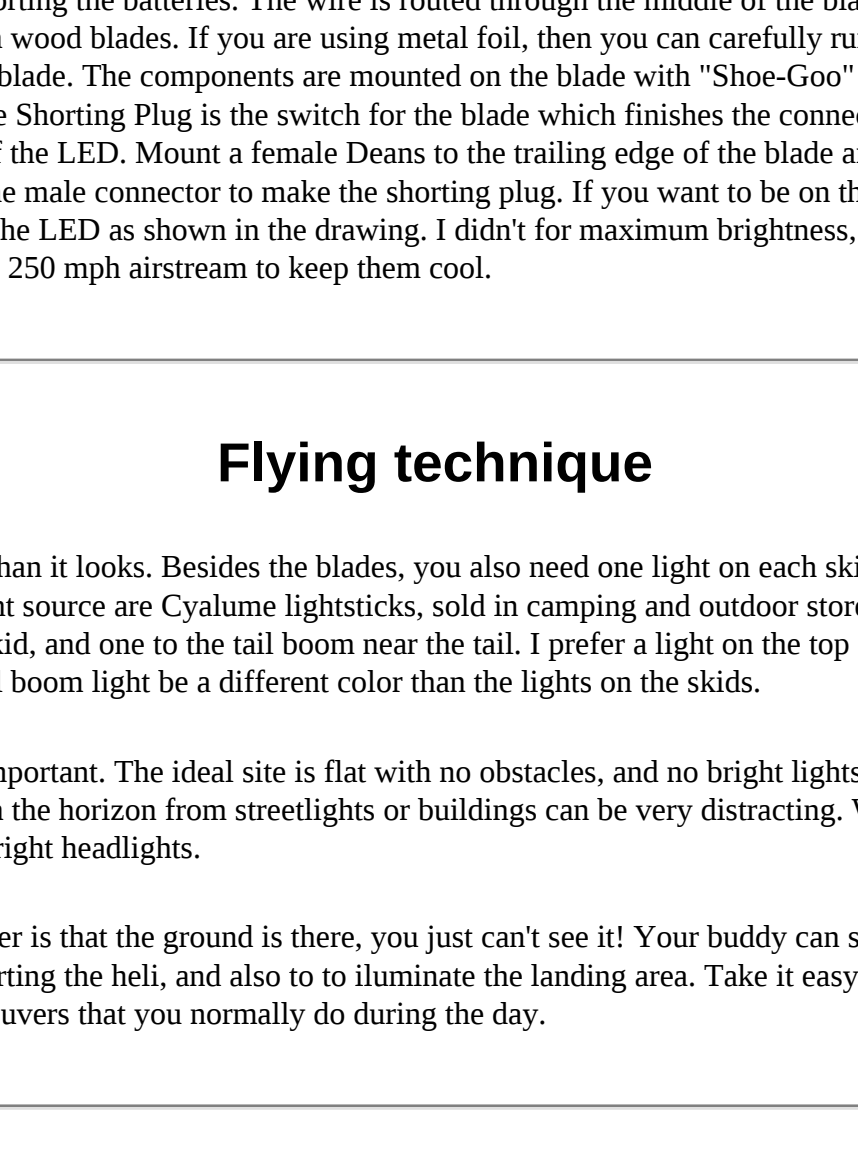
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A set of very bright night blades can be made with the following components

Parts Needed

- Two lithium coin-type batteries - Eveready 2032 calculator cells work well.
- Several feet of adhesive metal foil tape for fiberglass blades, or thin wire for wood or G-Blades.
- Two Radio Shack "Super Bright" LEDs - Part #276-087
- Fiberglass blade, "G-Blade", or a set of uncovered wood blades.
- Two Female Deans connectors. Each package contains two connectors
- Four Male Deans connectors. That's two packages.
- 1/8" heat-shrink tubing.
- Optional - Micro pushbutton momentary on switch.
- Optional - 2" of lead wire, leftover blade weight works great
- Optional - plastic tubing that will fit over the end of pushbutton switch and allows a 1" lead wire to slide freely.



Be very careful to avoid shorting the batteries. The wire is routed through the middle of the blade if using G-Blades, or through a shallow trench on wood blades. If you are using metal foil, then you can carefully run it along the top and bottom leading edge of the blade. The components are mounted on the blade with "Shoe-Goo" style cement, and covered with heat shrink tubing. The Shorting Plug is the switch for the blade which finishes the connection between the + side of the battery and the anode of the LED. Mount a female Deans to the trailing edge of the blade and solder a short wire across the two matching pins on the male connector to make the shorting plug. If you want to be on the safe side, then add a 220 ohm resistor in series with the LED as shown in the drawing. I didn't for maximum brightness, and I haven't burned out an LED yet. The LED's have a 250 mph airstream to keep them cool.

Flying technique

Night flying is a lot easier than it looks. Besides the blades, you also need one light on each skid, and at least one on the tail boom. The simplest light source are Cyalume lightsticks, sold in camping and outdoor stores. Use nylon zip-ties to fasten a Cyalume to each skid, and one to the tail boom near the tail. I prefer a light on the top of the boom and one on the bottom. I also prefer the tail boom light be a different color than the lights on the skids.

Selection of flying site is important. The ideal site is flat with no obstacles, and no bright lights nearby. The darker it is outside the better. Lights on the horizon from streetlights or buildings can be very distracting. Watch out for nearby roads which offer the hazard of bright headlights.

The major thing to remember is that the ground is there, you just can't see it! Your buddy can stand by with a flashlight to illuminate the area when starting the heli, and also to to illuminate the landing area. Take it easy at first, and in no time you'll be doing all the maneuvers that you normally do during the day.

Is that too difficult? How about the 10 minute Night Blade!

Warning, this will not work in cold weather

Items Needed

- "G-Blade" fiberglass blades, preferably yellow-green color for maximum brightness.
- 1 high intensity green or yellow Cyalume chemical lightstick.
- 1cc syringe and needle (talk to your pharmacist)

The G-Blade is the key to simplicity. Gary Wright flew a magnificent flight at the IRCHA Jamboree, grabbing first place using the procedure outlined here. What makes the G-Blade so special is that it's transparent and hollow, and it's actually designed to be able to hold a milliliter or so of liquid that can be injected through a pre-drilled hole in the root of the blade. 1cc of Cyalume liquid injected into the blade will collect at the tip when the rotor speeds up, and light the blade tips enough to show a clearly visible "Hula-Hoop" on a dark night. You should also attach a Cyalume lightstick to each of the skids, and at least one to the tail fin. This will provide the visual cue so you will always know the orientation of the helicopter.

Steps for G-Blades

- Activate the Cyalume light stick by cracking it and shaking it.
- Using a knife to cut off the top of the plastic shell.
- Draw 1cc of liquid with the syringe. It stains clothing so be careful.
- Inject at most 1cc into each blade just prior to flying.

For additional information contact Mark Johnson via E-Mail at mjohnson@minn.net or Compuserve user 73377,1302.

Anonymous FTP at <ftp://minn.net/usr/mjohnson>

Webmaster's comment: If you have questions or need more info on this project, please contact the author [Mark Johnson](#). The information contained in this document is the soul responsibility of the author and those who participate. Be advised that, unless done properly and great care is given, fiddling with the rotorblades can result in injury. Blades spin up to about 7500 rpm (or more) and anything improperly mounted on or near the blade tips **WILL** come off...with 'g-force'!

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Please follow this link. You will be sent there in 2 seconds.

R/C Plane Locator and Voltage Watch (PPM & PCM)

beacon and flashing an LED. Listen for the sound and you will have an aid in locating your vehicle. Don't wait until you've lost a plane to build one, by then it's too late.

What makes the RCPL different then other Plane Locator devices? Well most importantly is that it will work with PCM receivers. So far, all of the ones currently on the market or plans on the web do not. It also incorporates a low voltage detector. When the battery goes below 4.4V and longer tri-notie audio beacon will sound and the LED will flash to let you know it's time to land.

When in "plane down" mode, the beacon will sound every 5 seconds as long as the batteries remain fully charged (4.8V and over). As the battery goes down in voltage the period between beacons is extended, saving battery power

Setting up the RCPL for PCM requires the use of a spare channel on your R/C receiver. Insert the servo lead into a spare channel. Go to the settings mode of your R/C transmitter and raise the endpoint and sub-trim for that channel to its maximum setting. In the failsafe (F/S) setting, set that channel to go to the maximum when F/S is engaged.

Now you will have two ways to engage the RCPL. First by simply raising the channel's control to the maximum setting or by turning off your radio.

There is one small issue when burning the 12F675 with the hex file. A calibration value for the internal oscillator is stored in the last word of code space by Microchip when it leaves the plant. That word needs to be read from the

All files are available for download via a web interface to the anonymous cvs server at: [SourceForge](#).

R/C Plane Locator & Voltage Watch (PCM/PP

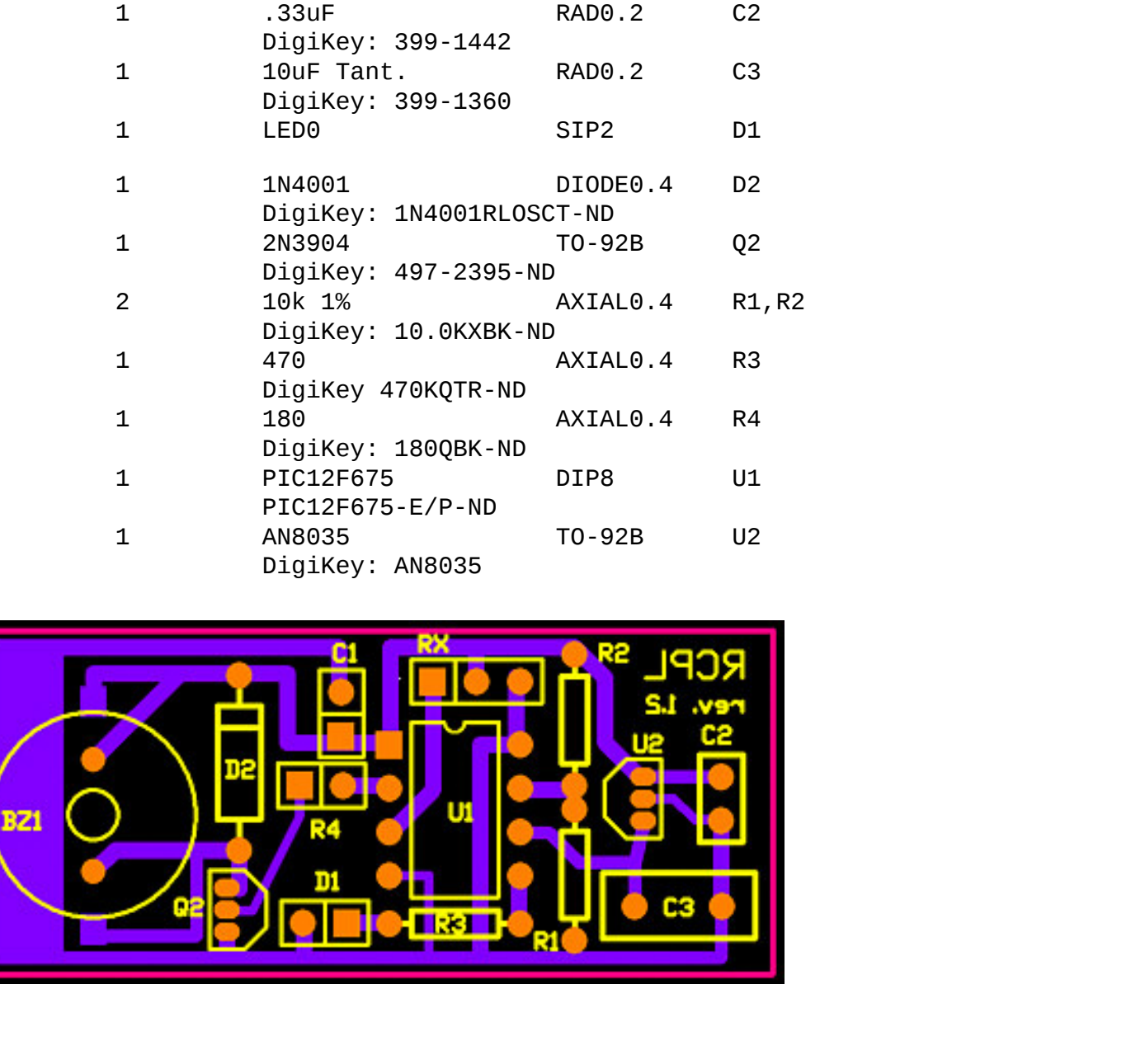
From RX

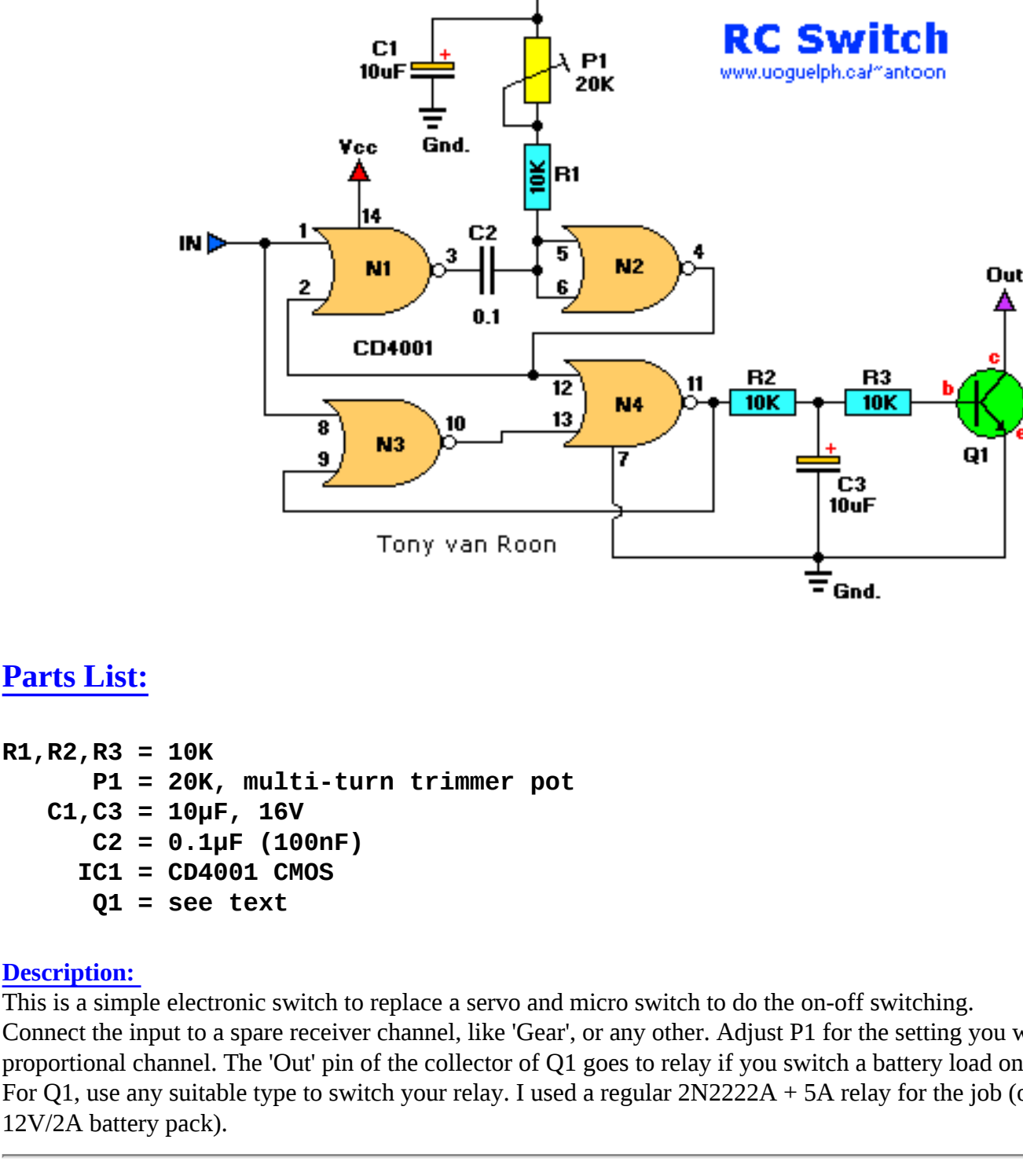
Sig

V-

Project : R/C Pilot Project
 Module : R/C Plane Locator
 By : Michael J. Pawlows

Count	Label-Value	Attributes	Designation
1	CD-1206	SIP2	BZ1





Parts List:

R1, R2, R3 = 10K
P1 = 20K, multi-turn trimmer pot
C1, C3 = 10uF, 16V
C2 = 0.1uF (100nF)
IC1 = CD4001 CMOS
Q1 = see text

Description:

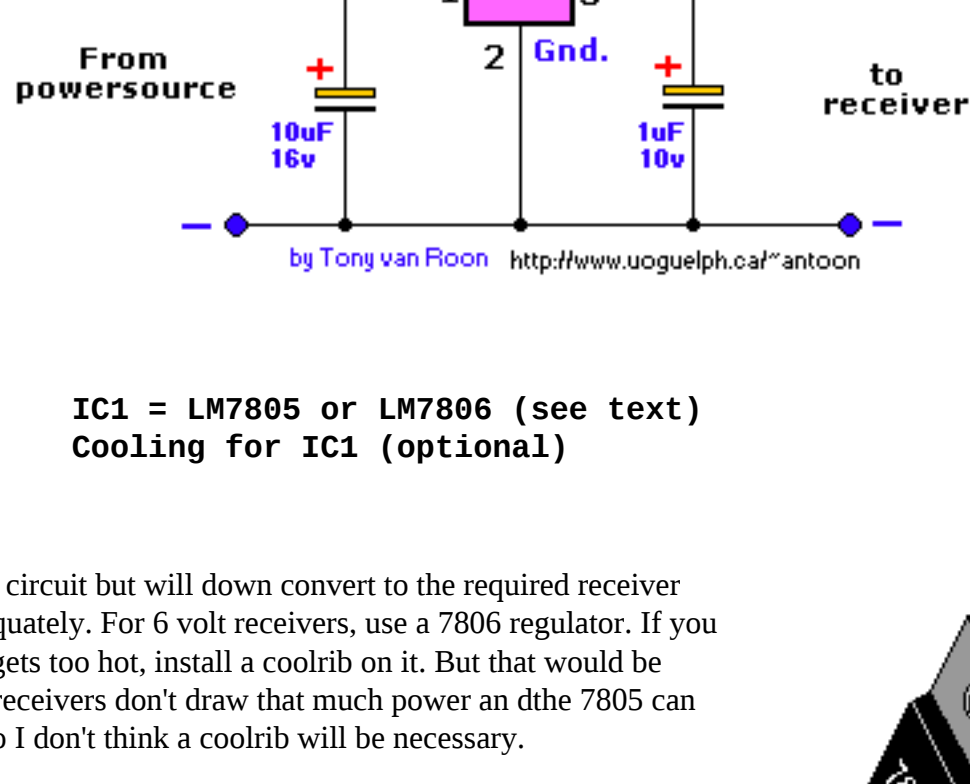
This is a simple electronic switch to replace a servo and micro switch to do the on-off switching. Connect the input to a spare receiver channel, like 'Gear', or any other. Adjust P1 for the setting you want on any proportional channel. The 'Out' pin of the collector of Q1 goes to relay if you switch a battery load on/off. For Q1, use any suitable type to switch your relay. I used a regular 2N2222A + 5A relay for the job (on/off switching a 12V/2A battery pack).

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Receiver (Rx) Regulator

by Tony van Roon



Parts List:

C1 = 10µF/16V IC1 = LM7805 or LM7806 (see text)
C2 = 1µF/10V Cooling for IC1 (optional)

A Couple Notes:

o This is a very simple circuit but will down convert to the required receiver voltage more than adequately. For 6 volt receivers, use a 7806 regulator. If you feel that the regulator gets too hot, install a coolrib on it. But that would be highly unlikely, since receivers don't draw that much power and the 7805 can easily handle 1 amp, so I don't think a coolrib will be necessary.

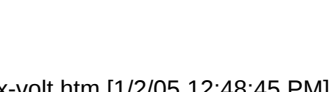
o Designed for an electric aircraft. To save on weight and eliminate the extra rx-battery, the receiver is fed from the same battery (8 cell, 9.6v) as the electric motor. The two capacitors are used to filter-out possible spikes when the electric motor is switched on or off. A BEC or similar device is highly recommended. In fact, this simple circuit was created per request of a club member who uses this device in combination with a bec.

o Note: The 7805 regulator may not give exactly 5 volt but rather something around 4.5 - 4.9 volts. Depending on the receiver (can it handle 6v?) I would recommend a LM7806 instead. This will give between 5.56 and 5.9V depending on the manufacturer. All other components values remain the same.



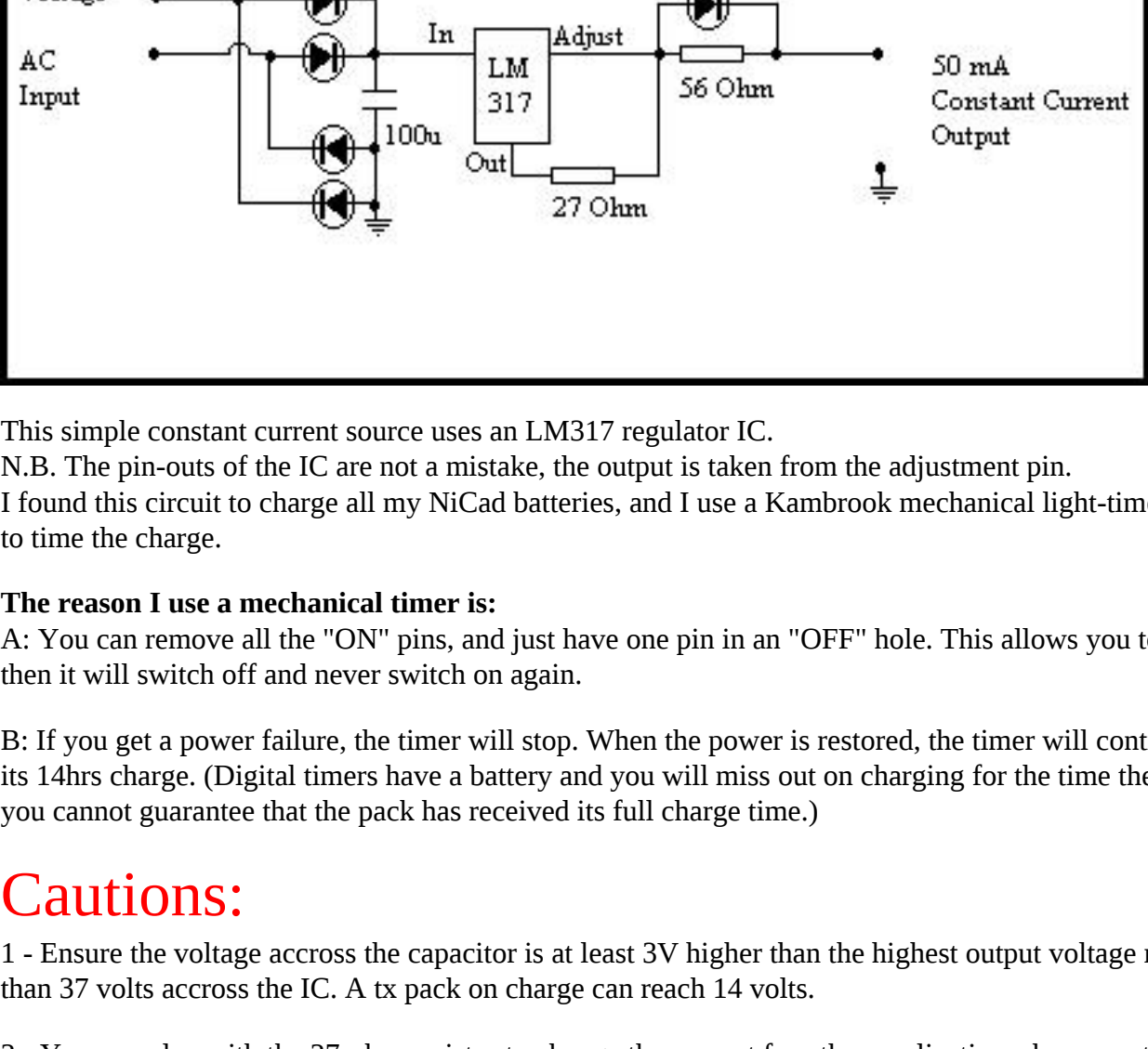
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Simple Constant Current Source

by John Nooyen



This simple constant current source uses an LM317 regulator IC.

N.B. The pin-outs of the IC are not a mistake, the output is taken from the adjustment pin.

I found this circuit to charge all my NiCad batteries, and I use a Kambrook mechanical light-timer (or equiv.) for 110vac to time the charge.

The reason I use a mechanical timer is:

A: You can remove all the "ON" pins, and just have one pin in an "OFF" hole. This allows you to set the timer for 14 hrs, then it will switch off and never switch on again.

B: If you get a power failure, the timer will stop. When the power is restored, the timer will continue and the pack will get its 14hrs charge. (Digital timers have a battery and you will miss out on charging for the time the power is interrupted, so you cannot guarantee that the pack has received its full charge time.)

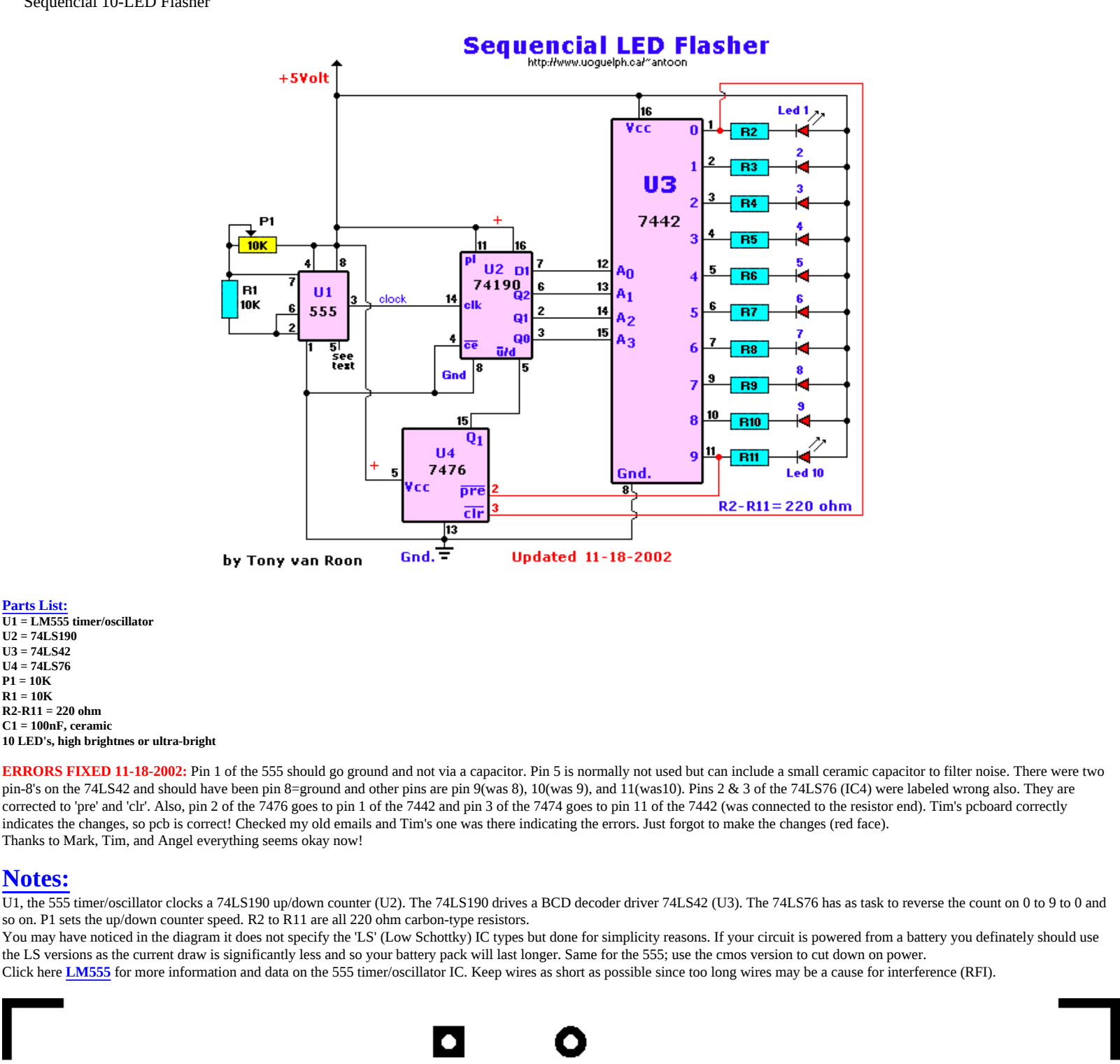
Cautions:

1 - Ensure the voltage across the capacitor is at least 3V higher than the highest output voltage required, and no higher than 37 volts across the IC. A tx pack on charge can reach 14 volts.

2 - You can play with the 27-ohm resistor to change the current for other applications, however the 56 Ohm should also be changed so that the voltage across the LED is 1.5 volts. (So you don't get a SED (smoke emitting diode))!

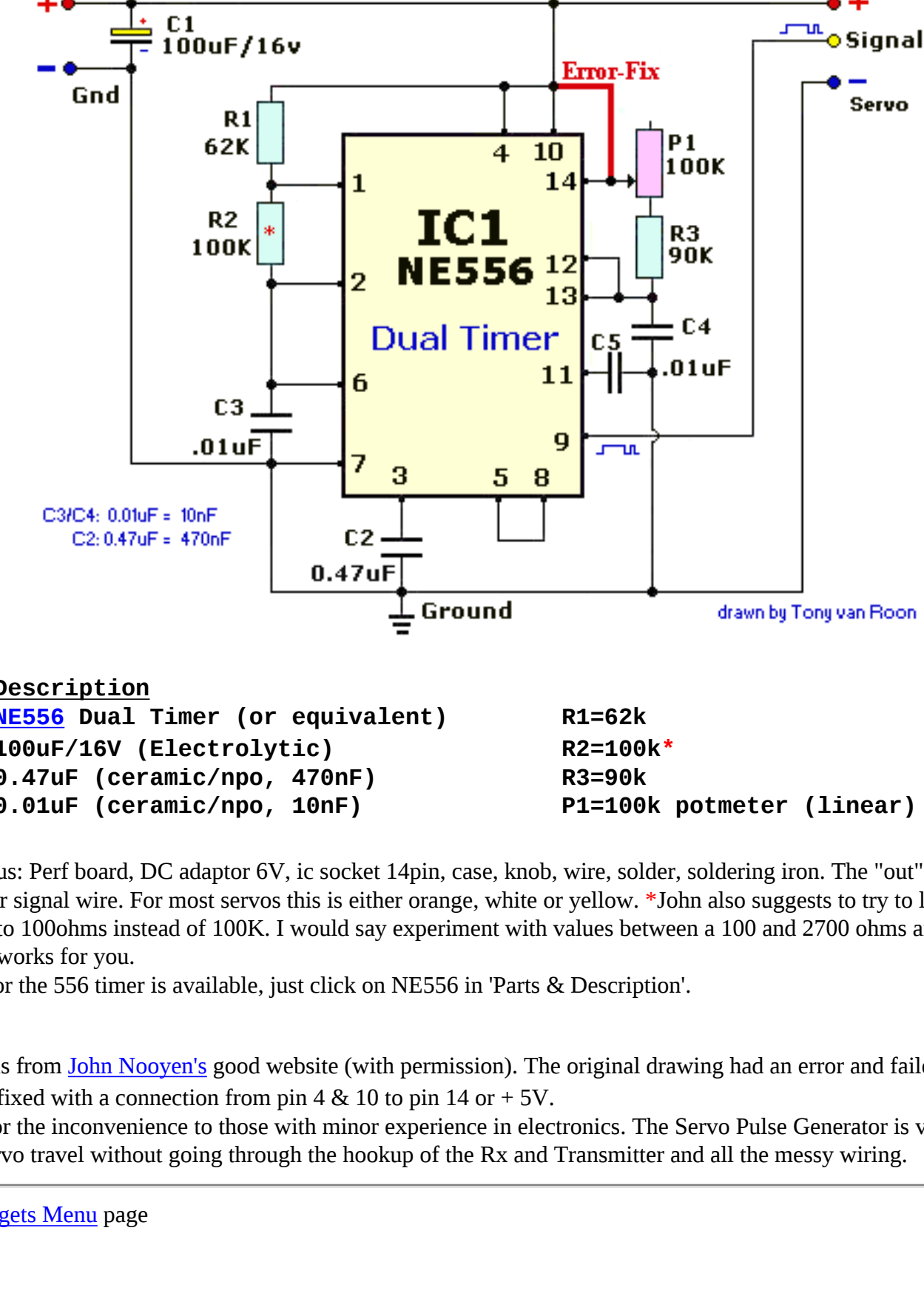
3 - Mount the IC on an adequate heatsink for the power it will be dissipating.

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Servo Pulse Generator

by [John Nooyen](#)



Parts & Description

IC1= NE555 Dual Timer (or equivalent)	R1=62k
C1= 100uF/16V (Electrolytic)	R2=100k *
C2= 0.47uF (ceramic/npo, 470nF)	R3=90k
C3, 4, 5= 0.01uF (ceramic/npo, 10nF)	P1=100k potmeter (linear)

Miscellaneous: Perf board, DC adaptor 6V, ic socket 14pin, case, knob, wire, solder, soldering iron. The "out" pin(5, 9) is the control or signal wire. For most servos this is either orange, white or yellow. *John also suggests to try to lower the value of R2 to 100ohms instead of 100K. I would say experiment with values between a 100 and 2700 ohms and stick with the one that works for you.

Data sheet for the 555 timer is available, just click on NE555 in 'Parts & Description'.

Notes:

This circuit is from [John Nooyen's](#) good website (with permission). The original drawing had an error and failed to pulse. This is now fixed with a connection from pin 4 & 10 to pin 14 or + 5V.

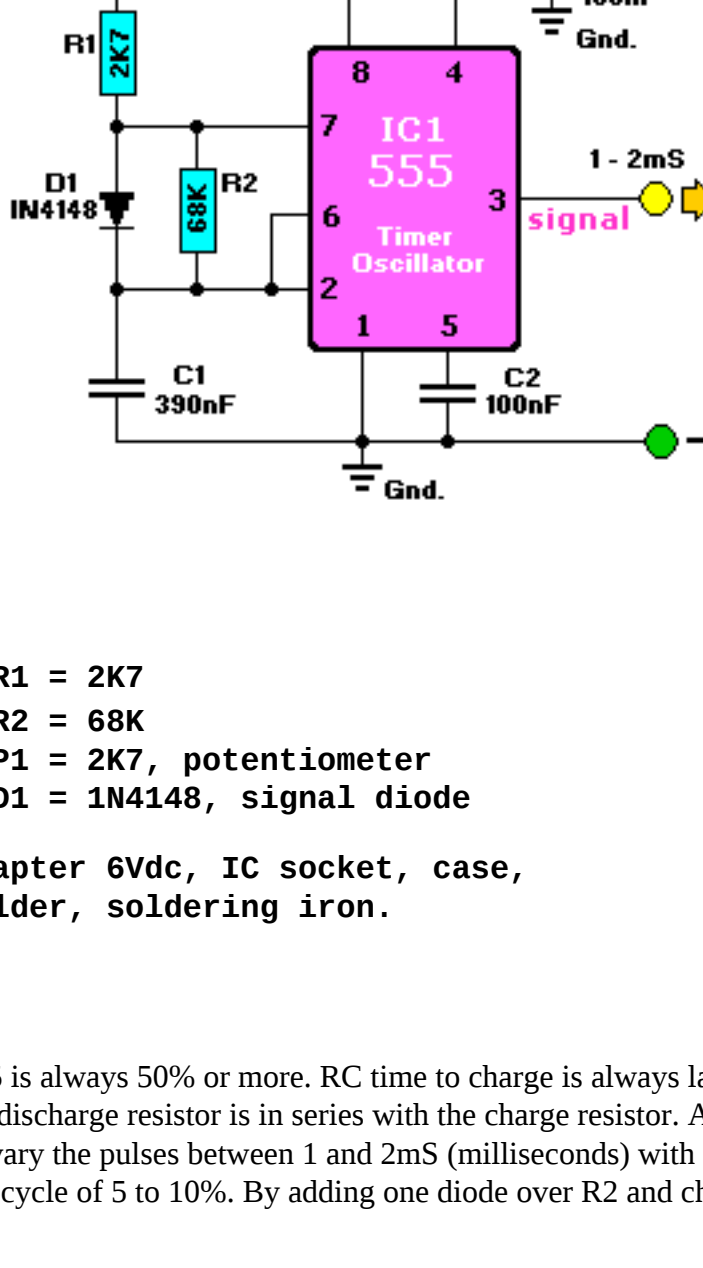
Apologies for the inconvenience to those with minor experience in electronics. The Servo Pulse Generator is very handy to judge the servo travel without going through the hookup of the Rx and Transmitter and all the messy wiring.

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Servol Pulser

by Tony van Roon

<http://www.uoguelph.ca/~antoon>



Parts

IC1 = [LM555](#) Timer R1 = 2K7
C1 = 390nF R2 = 68K
C2 = 100nF P1 = 2K7, potentiometer
C3 = 100nF D1 = 1N4148, signal diode

Misc: Perf board, adapter 6Vdc, IC socket, case,
knob, wire, solder, soldering iron.

Description

The normal duty-cycle for a 555 is always 50% or more. RC time to charge is always larger than the discharge time, because during charge-time the discharge resistor is in series with the charge resistor. A servo however needs less than a 50% duty-cycle so that we can vary the pulses between 1 and 2mS (milliseconds) with a repeat frequency of 50Hz. (One periode equals 20mS) so a duty-cycle of 5 to 10%. By adding one diode over R2 and changing position of the charge resistor this problem is solved.

The charge-time, and therefore the time that the output is 'high' ("1") is set by P1 & R1 and the discharge-time is set by R2. They can be choosen independently from each other. The circuit is designed in such a way that varying the resistance (over D1) from 2K7 to 5K4 a pulsewidth gives from 1.0 to 2.0 mS by adjusting potmeter P1. The output pin(3) is where the signal wire goes. For most servos this is either orange, white or yellow.

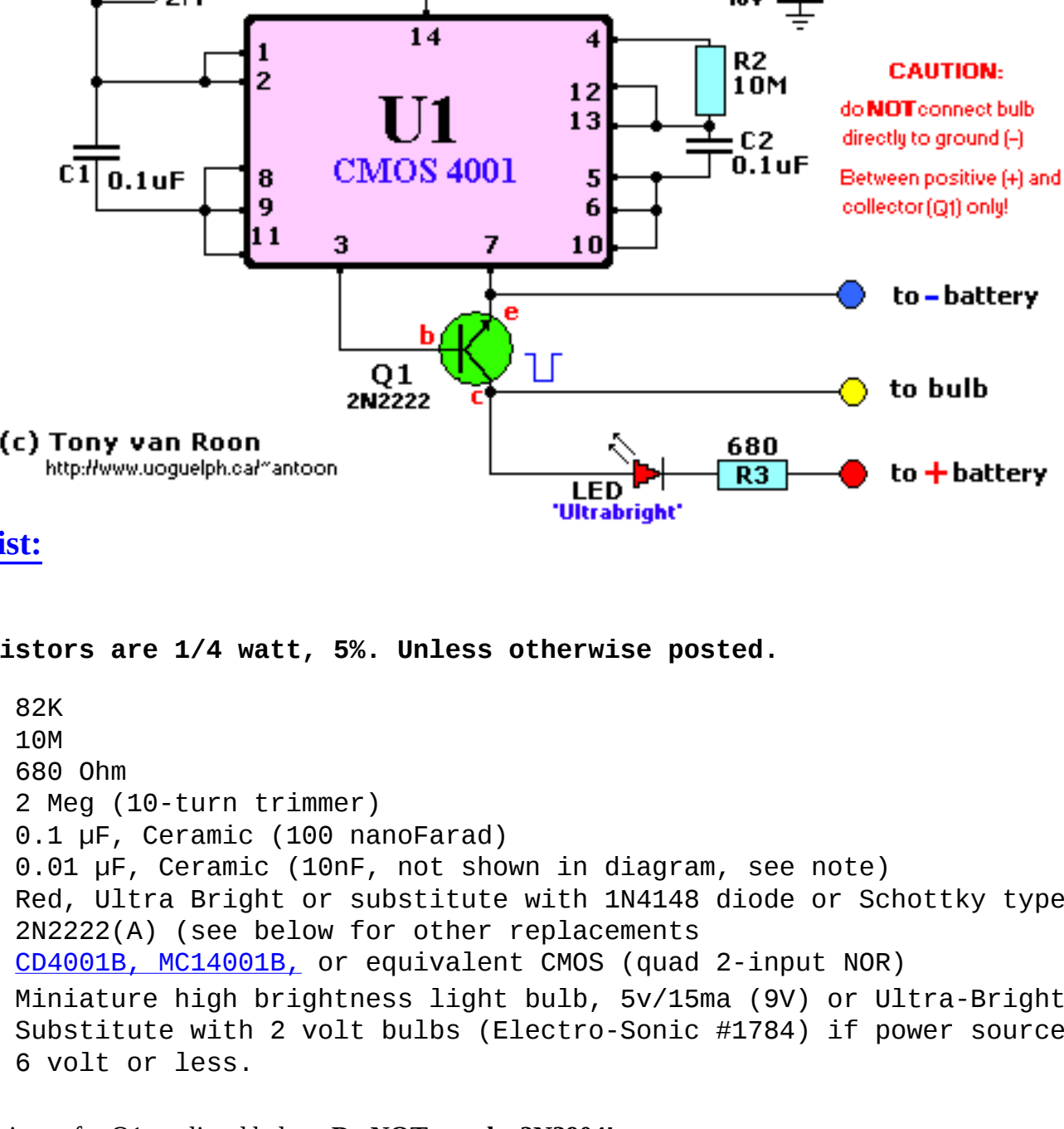
The red wire of the servo, and the battery, goes to '+' and the black or brown servo wire, and the battery, goes to '-'.

Data sheet on the LM555 timer is available, just click on LM555 in 'Parts & Description' section.

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Tail Anti-Collision Light

by Tony van Roon



Parts List:

All resistors are 1/4 watt, 5%. Unless otherwise posted.

- R1 = 82K
- R2 = 10M
- R3 = 680 Ohm
- P1 = 2 Meg (10-turn trimmer)
- C1/C2 = 0.1 μ F, Ceramic (100 nanoFarad)
- C3 = 0.01 μ F, Ceramic (10nF, not shown in diagram, see note)
- LED = Red, Ultra Bright or substitute with 1N4148 diode or Schottky type
- Q1 = 2N2222(A) (see below for other replacements)
- U1 = CD4001B, MC14001B, or equivalent CMOS (quad 2-input NOR)
- BULB = Miniature high brightness light bulb, 5v/15ma (9V) or Ultra-Bright LED's. Substitute with 2 volt bulbs (Electro-Sonic #1784) if power source is 6 volt or less.

Other substitutes for Q1 are listed below. **Do NOT use the 2N3904!**
PN100, ECG128/NTE128, GE18, ECG123AP/NTE123AP, PN3646, 2N4401, MPSA14, etc.

Description:

Naturally this circuit is not the same as a strobe circuit and don't flashes as bright as a strobe, but pretty close. I used a reflector out of an old miniature camera I picked up from the surplus store and mounted it inside the tail after re-modeling the reflector a bit to suit the style of the tail.

The above circuit will support 1 or 2 bulbs and look like the real thing....CHEAP! Pulse brightness is adjustable with P1 and Flash rate is steady at 50 flashes per minute or so. An Ultra Bright led is required.
LED's may be used instead of bulbs, but make sure P1 is turned CCW **BEFORE** applying power to the circuit or LED's will burn to a crisp. I did some testing with several types of LED's and different colors. Personally I prefer just the bulbs. If you need a red or green light just use some transparent paint on them. Works! **Do NOT** connect the lights directly to ground! Which means, don't connect directly to '+' and '-' but only '+' and 'c' of Q1.
Battery power can be from 4.8 to 15 volt, but 9 or 12 volt would be preferred. A standard 9-v alkaline battery should work for a long time. Also, in the parts list, I mentioned that the 2mm red led can be substituted by a 1N4148 'signal' diode. However, the led gives a visible indication of the proper operation of the circuit. Looking at the diagram, the voltage 4.8 - 16volt mentioned shows the flexibility of the cmos IC, the bulbs work better between 9-12volt. (remember to get different bulbs if voltage is less than 6v).
This device was tested for interference with JR, Futaba, HiTec, Airtronics, and ACE radio equipment. None were found. I suggest, however, to keep the device away from receiver and servos
I do not recommend using your receiver pack (4.8v) to power both receiver and this circuit. Use a 9V setup for best results. Click here to see the data sheet on the [MC14001B](#).

Note:

Also, you can use a decoupling capacitor close to the IC. Solder a 10nF ceramic type (0.01) between pins 7 and 14.

Testing and Setup

Before hooking up the lights and all the wires and what not, you should pre-test the circuit for proper operation as I know by experience that depending on the led type it (cathode/anode) may have to be reversed. Meaning, if the led does not flash, desolder the led connections and put it the other way (cathode to base of Q1). As mentioned before, an "Ultra-Bright" or "High-Brightness" type of LED is needed. The reason for this is that the current pulse coming from the led triggers the base of Transistor Q1 and the collector of Q1 is feeding your lights which determines the intensity of the flash, with a regular led there is not enough power to bias Q1. My personal preference are the miniature bulbs. Anyways, enjoy!

Trouble Shooting

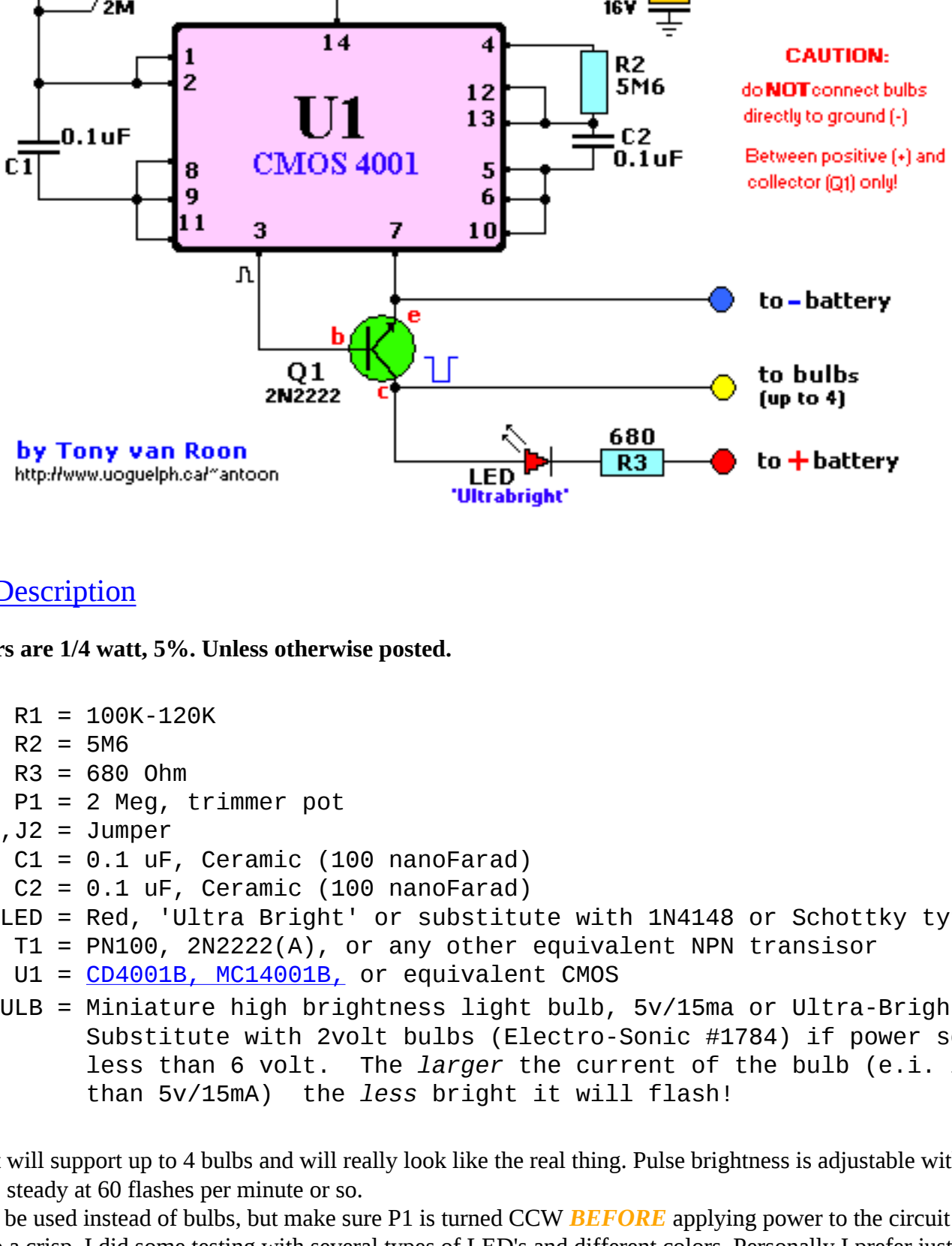
Hope it does not get to this point but it happens and is possible. Most 'does-not-work' circuit problems come from wiring errors, missing a connection, or damaging/destroying a cmos device while handling and/or soldering it in place.
See if you get a pulse from pin 3. No? Disconnect the battery and desolder the led. Connect the battery again and check for a pulse on pin 3. Yes? You have something connected wrong after pin 3, maybe the led leads need to be reversed. No? You either made a wiring error or damaged the 4001 cmos ic. Check all your wiring carefully. Before replacing the 4001 cmos ic make sure to remove the power and all static from your hands by touching ground for a couple seconds...

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Wingtip Navigation Lights

by Tony van Roon



Parts & Description

All resistors are 1/4 watt, 5%. Unless otherwise posted.

R1 = 100K-120K

R2 = 5M6

R3 = 680 Ohm

P1 = 2 Meg, trimmer pot

J1, J2 = Jumper

C1 = 0.1 uF, Ceramic (100 nanoFarad)

C2 = 0.1 uF, Ceramic (100 nanoFarad)

LED = Red, 'Ultra Bright' or substitute with 1N4148 or Schottky type diode

T1 = PN100, 2N2222(A), or any other equivalent NPN transistor

U1 = CD4001B, MC14001B, or equivalent CMOS

BULB = Miniature high brightness light bulb, 5v/15ma or Ultra-Bright LED's. Substitute with 2volt bulbs (Electro-Sonic #1784) if power source is less than 6 volt. The larger the current of the bulb (e.i. larger than 5v/15mA) the less bright it will flash!

This circuit will support up to 4 bulbs and will really look like the real thing. Pulse brightness is adjustable with P1 and Flashrate is steady at 60 flashes per minute or so. LED's may be used instead of bulbs, but make sure P1 is turned CCW **BEFORE** applying power to the circuit or LED's will burn to a crisp. I did some testing with several types of LED's and different colors. Personally I prefer just the bulbs. If you need a red or green light just use some transparent paint on them. Works! Do **NOT** connect the lights directly to ground! Which means, don't connect directly to '+' and '-' but only '+' and 'c' of T1. Battery power can be from 4.8 to 15 volt, but 9 or 12 volt would be preferred. A standard 9V Alkaline battery should work for a long time. Also, in the parts list, I mentioned that the 2mm red led can be substituted by a 1N4148 'signal' diode. However, the led gives a visible indication of the proper operation of the circuit. Looking at the diagram, the voltage 4.8 - 16volt mentioned shows the flexibility of the cmos IC, the bulbs work better in the 9 to 12V range. (remember to get different bulbs if voltage is less than 6V). This device was tested for interference with JR, Futaba, HiTec, Airtronics, and ACE radio equipment. None were found. I suggest, however, to keep the device away from receiver and servos. **I do not** recommend using your receiver pack (4.8v) to power both receiver and this circuit. Stick with an alkaline 9V setup. To see the datasheet on the [MC14001B](#), just click on it.

Testing and Setup

Before hooking up the lights and all the wires and what not, you should pre-test the circuit for proper operation as I know by experience that depending on the led type it (cathode/anode) may have to be reversed. Meaning, if the led does not flash, desolder the led connections and put it the otherway (cathode to base of T1). As mentioned before, an "Ultra-Bright" or "High-Brightness" type of LED is works best. My personal preference are the miniature bulbs. Anyways, enjoy!

(C) Tony van Roon

(C) Tony van Roon

Notes

Also, you can use a decoupling capacitor close to the IC. Solder a 10nF ceramic type (0.01) between pins 7 and 14.

Trouble Shooting

Hope it does not get to this point but it happens and is possible. Most 'does-not-work' circuit problems come from wiring errors, missing a connection, or damaging/destroying a cmos device while handling and/or soldering (too hot too long) it in place.

See if you get a pulse from pin 3. No? Disconnect the battery and desolder the led. Connect the battery again and check for a pulse on pin 3. Yes? You have something connected wrong after pin 3, maybe the led leads need to be reversed. Still No? Disconnect everything from pin 3. If you still don't get a pulse you either made a wiring error or damaged the 4001 cmos ic. Check all your wiring carefully. Before replacing the 4001 cmos ic make sure to remove all static from your hands by touching ground for a couple seconds.

Power up the circuit again with a new IC. Before connecting Q1 back to pin 3 check for a pulse first and then disconnect the battery and solder the base of Q1 back to pin 3.

Below is another way of drawing the diagram, have a look.



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Chapter 10: Getting the Most from your Batteries

A common difficulty with portable equipment is the gradual decline in battery performance after the first year of service. Although fully charged, the battery eventually regresses to a point where the available energy is less than half of its original capacity, resulting in unexpected downtime.

In many ways, a rechargeable battery exhibits human-like characteristics.

Downtime almost always occurs at critical moments. This is especially true in the public safety sector where portable equipment runs as part of a fleet operation and the battery is charged in a pool setting, often with minimal care and attention. Under normal conditions, the battery will hold enough power to last the day.

During heavy activities and longer

than expected duties, a marginal battery cannot provide the extra power needed and the equipment fails.

Rechargeable batteries are known to cause more concern, grief and frustration than any other part of a portable device. Given its relatively short life span, the battery is the most expensive and least reliable component of a portable device.

In many ways, a rechargeable battery exhibits human-like characteristics: it needs good nutrition, it prefers moderate room temperature and, in the case of the nickel-based system, requires regular exercise to prevent the phenomenon called ‘memory’. Each battery seems to develop a unique personality of its own.

Memory: myth or fact?

For clarity and simplicity, we use the word ‘memory’ to address capacity loss on nickel-based batteries that are reversible.

The word ‘memory’ was originally derived from ‘cyclic memory’, meaning that a NiCd battery can remember how much discharge was required on previous discharges. Improvements in battery technology have virtually eliminated this phenomenon. Tests performed at a Black &

Decker lab, for example, showed that the effects of cyclic memory on the modern NiCd were so small that they could only be detected with sensitive instruments. After the same battery was discharged for different lengths of time, the cyclic memory phenomenon could no longer be noticed.

The problem with the nickel-based battery is not the cyclic memory but the effects of crystalline formation. There are other factors involved that cause degeneration of a battery. For clarity and simplicity, we use the word ‘memory’ to address capacity loss on nickel-based batteries that are reversible.

The active cadmium material of a NiCd battery is present in finely divided crystals. In a good cell, these crystals remain small, obtaining maximum surface area. When the memory phenomenon occurs, the crystals grow and drastically reduce the surface area. The result is a voltage depression, which leads to a loss of capacity. In advanced stages, the sharp edges of the crystals may grow through the separator, causing high self-discharge or an electrical short.

Another form of memory that occurs on some NiCd cells is the formation of an inter-metallic compound of nickel and cadmium, which ties up some of the needed cadmium and creates extra resistance in the cell. Reconditioning by deep discharge helps to break up this compound and reverses the capacity loss.

The memory phenomenon can be explained in layman’s terms as expressed by Duracell: “The voltage drop occurs because only a portion of the active materials in the cells is discharged and recharged during shallow or partial discharging. The active materials that have not been cycled change in physical characteristics and increase in resistance. Subsequent full discharge/charge cycling will restore the active materials to their original state.”

When NiMH was first introduced there was much publicity about its memory-free status. Today, it is known that this chemistry also suffers from memory but to a lesser extent than the NiCd. The positive nickel plate, a metal that is shared by both chemistries, is responsible for the crystalline formation.



New NiCd cell.

The anode is in fresh condition (capacity of 8.1Ah). Hexagonal cadmium hydroxide crystals are about 1 micron in cross section, exposing large surface area to the liquid electrolyte for maximum performance.



Cell with crystalline formation.

Crystals have grown to an enormous 50 to 100 microns in cross section, concealing large portions of the active material from the electrolyte (capacity of 6.5Ah). Jagged edges and sharp corners may pierce the separator, which can lead to increased self-discharge or electrical short.



Restored cell.

After pulsed charge, the crystals are reduced to 3 to 5 microns, an almost 100% restoration (capacity of 8.0A). Exercise or recondition are needed if the pulse charge alone is not effective.

Figure 10-1: Crystalline formation on NiCd cell.

Illustration courtesy of the US Army Electronics Command in Fort Monmouth, NJ, USA.

In addition to the crystal-forming activity on the positive plate, the NiCd also develops crystals on the negative cadmium plate. Because both plates are affected by crystalline formation, the NiCd requires more frequent discharge cycles than the NiMH. This is a non-scientific explanation of why the NiCd is more prone to memory than the NiMH.

The stages of crystalline formation of a NiCd battery are illustrated in Figure 10-1. The enlargements show the negative cadmium plate in normal crystal structure of a new cell, crystalline formation after use (or abuse) and restoration.

Lithium and lead-based batteries are not affected by memory, but these chemistries have their own peculiarities. Current inhibiting pacifier layers affect both batteries — plate oxidation on the lithium and sulfation and corrosion on the lead acid systems. These degenerative effects are non-correctible on the lithium-based system and only partially reversible on the lead acid.

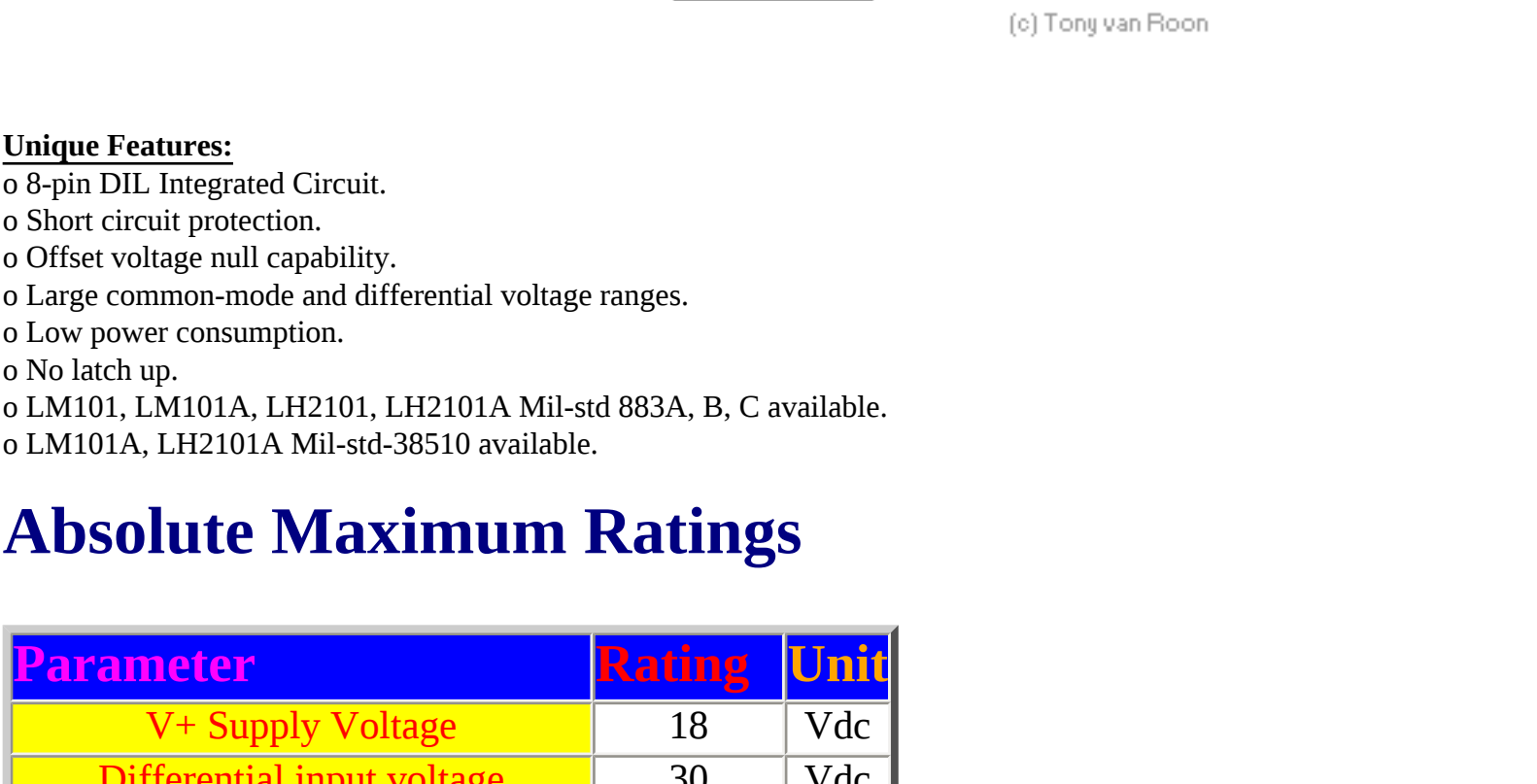
LM301A Op-Amp

Data sheet

Direct substitute(s): NTE975 (DIP), NTE1171 (Metal Can)

By Tony van Roon

Description:
The LM301A is a high performance operational amplifier featuring high gain, short circuit protection, simplified compensation and excellent temperature stability.



- Unique Features:**
- o 8-pin DIL Integrated Circuit.
 - o Short circuit protection.
 - o Offset voltage null capability.
 - o Large common-mode and differential voltage ranges.
 - o Low power consumption.
 - o No latch up.
 - o LM101, LM101A, LH2101, LH2101A Mil-std 883A, B, C available.
 - o LM101A, LH2101A Mil-std-38510 available.

Absolute Maximum Ratings

Parameter	Rating	Unit
V+ Supply Voltage	18	Vdc
Differential input voltage	30	Vdc
Input voltage (I)	15	Vdc
Power Dissipation	500	mW
Output short-circuit duration	indefinite	
Operating temperature range	0 to +70	°C
Storage temperature range	-65 to +150	°C
Lead temperature (soldering, 10sec)	300	°C

Note (1): For supply voltages less then 15V, the absolute maximum input voltage is equal to the supply voltage.

LM334 - Adjustable Current Source

Data sheet

Direct substitute(s): LM134/LM234

Tony van Roon, ©

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act as both re

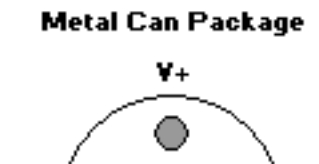
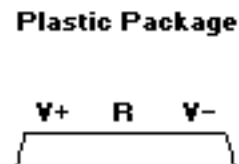
act as both resistor and current source in AC applications. The LM334 was designed to operate at current levels from 1µA to 10mA, as set by the external resistor. Since it operates as a true two-terminal current source, no extra power, as mentioned before, and no input signals are required. Regulation is typically 0.02%/V and terminal-to-terminal voltage can range from 800mV to 30V. Because the operating current is directly proportional to absolute temperature in degrees Celsius, the LM334 will also find wide applications as a temperature sensor. The temperature dependence of the operating current is $\approx 0.336\%/^{\circ}\text{C}$ at room temperature. For example, a device operating at 259µA will have a temperature coefficient of $+1\mu\text{A}/^{\circ}\text{C}$. The temperature dependence is extremely accurate and repeatable. If a zero temperature coefficient current source is required, this is easily achieved by adding a diode and a resistor.

This is easily achieved by adding a diode and a resistor.

The LM334 is guaranteed over a temperature range of 0°C to +70°C. This device is available in TO-46 hermetic, TO-92 (most common), and SO-8 plastic packages.

Pin out for LM134/LM234/LM334

3-Terminal Adjustable Current Sources

TO-46 Metal Can Package	TO-92 Plastic Package
 Diagram of TO-46 Metal Can Package: A circular package with three pins. The top pin is labeled V+, the bottom-left pin is labeled R, and the bottom-right pin is labeled V-.	 Diagram of TO-92 Plastic Package: A small package with three pins. The top-left pin is labeled V+, the top-right pin is labeled R, and the bottom pin is labeled V-.



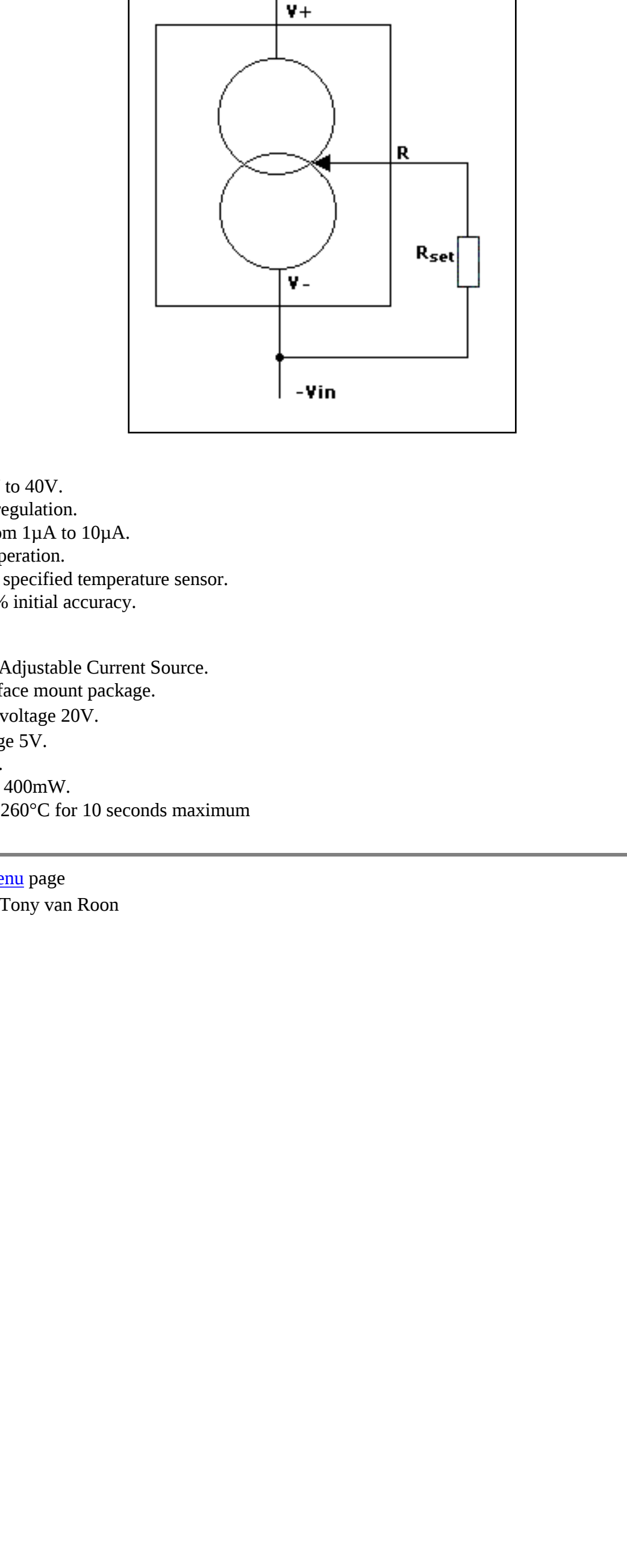
LM334P





Bottom view Bottom view V^+ R V^-

by Tony van Roen
http://www.uoguelph.ca/~antonio



LM3914 Dot/Bar Display Driver

Data sheet

Direct substitute(s): NTE1508, ECG1508

by [Tony van Roon](#)

Pin #	Pin Function	
1	Led 1 (on/off)	1
2	V- (Ground)	2
3	V+ (Vdc)	3
4	Divider Low	4
5	Signal Input	5
6	Divider High	6
7	Reference Output	7
8	Reference Adjust	8
9	Mode (Dot/Bar)	9
10	Led 10	10
11	Led 9	11
12	Led 8	12
13	Led 7	13
14	Led 6	14
15	Led 5	15
16	Led 4	16
17	Led 3	17
18	Led 2	18



The diagram shows the LM3914 Dot/Bar Display Driver in an 18-pin package. The pins are numbered 1 through 18. The package is labeled 'LM3914 Bargraph' and 'Dot/Bar Display Driver'. The pinout is as follows:

Pin #	Pin Function
1	Led 1 (on/off)
2	V- (Ground)
3	V+ (Vdc)
4	Divider Low
5	Signal Input
6	Divider High
7	Reference Output
8	Reference Adjust
9	Mode (Dot/Bar)
10	Led 10
11	Led 9
12	Led 8
13	Led 7
14	Led 6
15	Led 5
16	Led 4
17	Led 3
18	Led 2

Look at all these features:

- o 18 pin Dual-In-Line (DIL) Integrated Circuit.
- o Drives LEDs, LCDs or vacuum fluorescents
- o Bar or Dot display mode externally selectable by user.
- o Expandable to displays of 100 steps.
- o Internal voltage reference from 1.2 to 12V.
- o Operates on single supply of less than 3V.
- o Supports 10 Led's, directly driven, all colors.
- o 10-step DOT/BAR driver for linear scale.
- o Only a couple of external components required.
- o Works with voltages between 3 and 25Vcc.
- o Inputs operate down to ground.
- o Output current programmable from 2 mA to 30 mA.
- o No multiplex switching or interaction between outputs.
- o Input withstands approximately 35V without damage or false outputs.
- o LED driver outputs are currents regulated, open collectors.
- o Outputs can interface with TTL or CMOS logic.
- o The internal 10-step divider is floating and can be referenced to a wide range of voltages.

The LM3914 is a monolithic integrated circuit that senses analog voltage levels and drives 10 LEDs, providing a linear analog display. A single pin (9) changes the display from a moving dot to a bar graph. Current drive to the LEDs is regulated and programmable, eliminating the need for resistors. This feature is one that allows operation of the whole system from less than 3V.

The system contains its own adjustable reference and accurate 10-step voltage divider. The low-bias-current input buffer accepts signals down to ground, or V-, yet needs no protection against inputs of 35V above or below ground. The buffer drives 10 individual comparators referenced to the precision divider. Indication non-linearity can thus be held typically to 1/2%, even over a wide temperature range.

Versatility was designed into the LM3914 so that controller, visual alarm, and expanded scale functions are easily added on to the display system. The circuit can drive LEDs of many colors, or low-current incandescent lamps. Many LM3914's can be "chained" to form displays of 20 to over 100 segments. Both ends of the voltage divider are externally available so that 2 drivers can be made into a zero-center meter.

The LM3914 is very easy to apply as an analog meter circuit. A 1.2V full-scale meter requires only 1 resistor and a single 3V to 15V supply in addition to the 10 display LEDs. If the 1 resistor is a pot, it becomes the LED brightness control.

When in "DOT" mode, there is a small amount of overlap or "fade" (about 1mV) between segments. This assures that at no time will all LEDs be "OFF", and thus any ambiguous display is avoided. Various novel displays are possible. Much of the display flexibility derives from the fact that all outputs are individual, DC regulated currents. Various effects can be achieved by modulating these currents. The individual outputs can drive a transistor as well as a LED at the same time, so controller functions including "staging" control can be performed. The LM3914 can also act as a programmer, or sequencer.

The LM3914 is rated for operation from 0°C to +70°C. The LM3914N is available in an 18-lead molded (N) package.

With pin 9 not connected (floating), it is functioning in 'DOT' mode. Meaning, it will light up one led at a time. If you wish to use the 'BAR' mode, then connect pin 9 to the positive supply rail, but obviously with increased current consumption. This chip is pretty versatile and can handle a lot of abuse, just don't exceed the manufacturer's voltage maximum. If the leads of the LEDs are longer than 6 inches, a 10µF electrolytic capacitor is needed over the Anodes of the LEDs and pin 2. A 2.2µF Tantalum capacitor can be used instead of the electrolytic.

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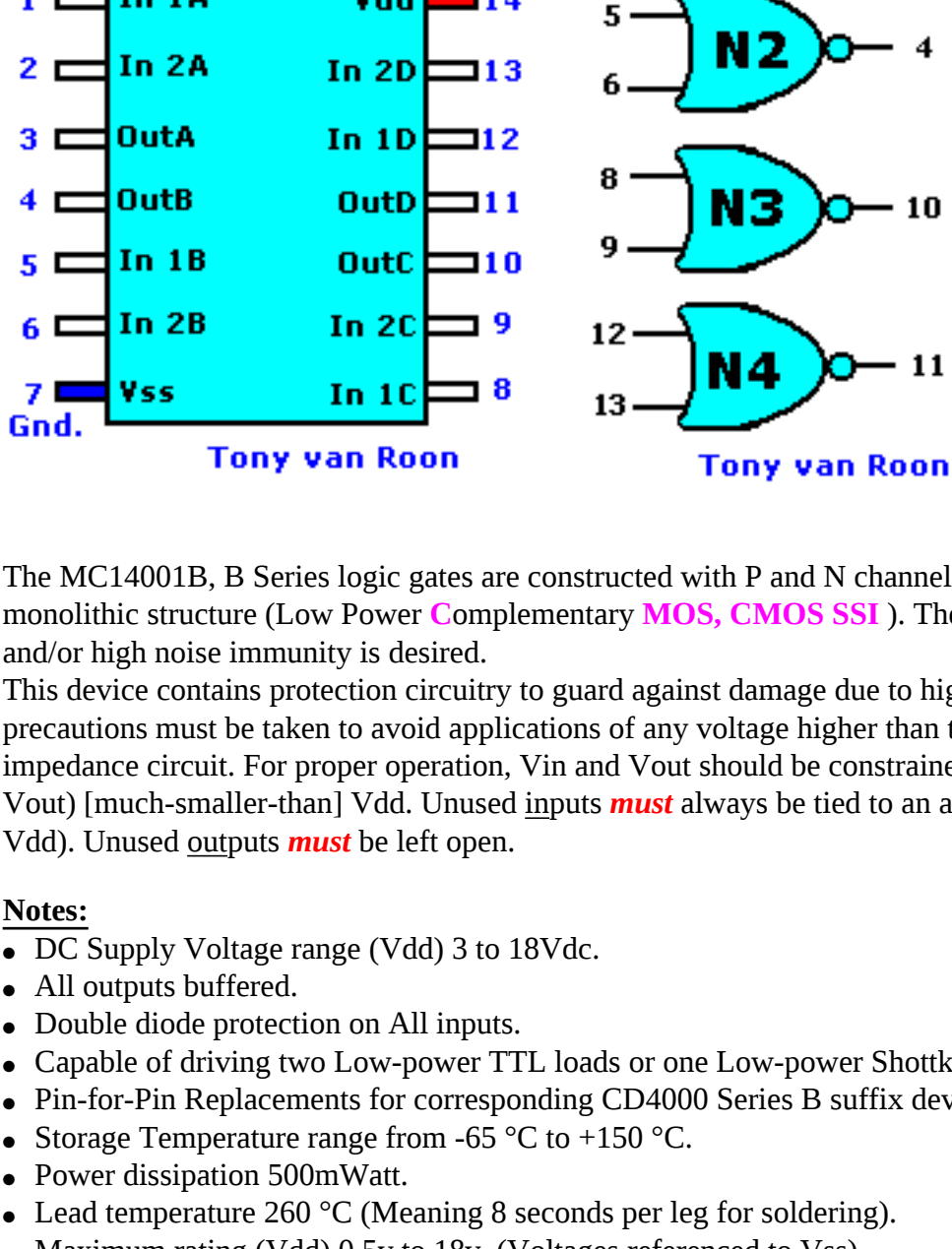
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MC14001B Quad 2-input NOR

Data sheet

Direct Replacement for CD4001(B)

By Tony van Roon



The MC14001B, B Series logic gates are constructed with P and N channel enhancement mode devices in a single monolithic structure (Low Power Complementary MOS, CMOS SSI). Their primary use is where low power dissipation and/or high noise immunity is desired. This device contains protection circuitry to guard against damage due to high static voltage or electric fields. However, precautions must be taken to avoid applications of any voltage higher than the maximum rated voltages to this high-impedance circuit. For proper operation, Vin and Vout should be constrained to the range Vss [much-smaller-than] (Vin or Vout) [much-smaller-than] Vdd. Unused inputs **must** always be tied to an appropriate logic voltage level (e.g. either Vss or Vdd). Unused outputs **must** be left open.

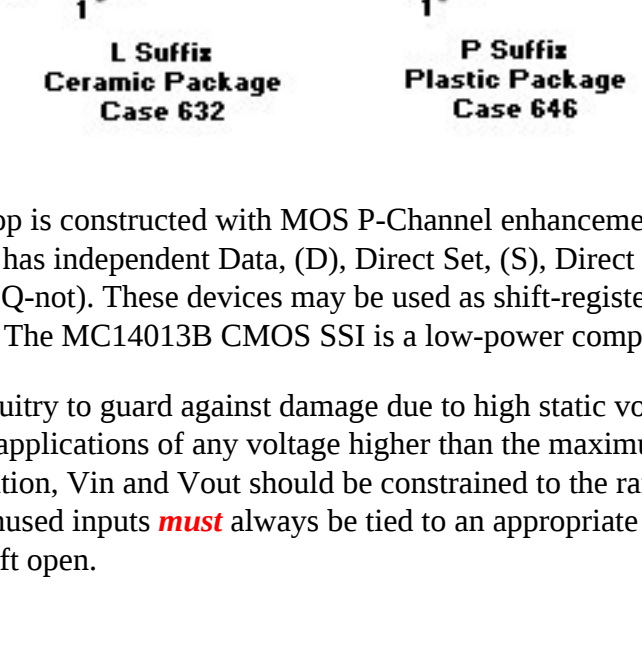
- Notes:**
- DC Supply Voltage range (Vdd) 3 to 18Vdc.
 - All outputs buffered.
 - Double diode protection on All inputs.
 - Capable of driving two Low-power TTL loads or one Low-power Shotky TTL load over the rated temperature range.
 - Pin-for-Pin Replacements for corresponding CD4000 Series B suffix devices.
 - Storage Temperature range from -65 °C to +150 °C.
 - Power dissipation 500mWatt.
 - Lead temperature 260 °C (Meaning 8 seconds per leg for soldering).
 - Maximum rating (Vdd) 0.5v to 18v, (Voltages referenced to Vss)
 - Input or Output Voltage (DC or Transient) 0.5 to Vdd +0.5.
 - Input or Output Current (DC or Transient), per Pin: Plus or Minus 10mA.

MC14013B Dual Type D Flip-Flop

Data sheet

Direct substitute for CD4013B

By Tony van Roon



The MC14013B dual type D flip-flop is constructed with MOS P-Channel enhancement mode devices in a single monolithic structure. Each flip-flop has independent Data, (D), Direct Set, (S), Direct Reset, (R), and Clock, (C), inputs and complementary outputs (Q and Q-not). These devices may be used as shift-register elements or as type 'T' flip-flops for counter and toggle applications. The MC14013B CMOS SST is a low-power complimentary MOS.

This device contains protection circuitry to guard against damage due to high static voltage or electric fields. However, precautions must be taken to avoid applications of any voltage higher than the maximum rated voltages to this high-impedance circuit. For proper operation, Vin and Vout should be constrained to the range Vss [much-smaller-than] (Vin or Vout) [much-smaller-than] Gnd. Unused inputs *must* always be tied to an appropriate logic voltage level (e.g. either Vcc or Gnd). Unused outputs *must* be left open.

Block Diagram

Truth Table

Inputs				Outputs	
clock [†]	data	reset	set	Q	Q̄
	0	0	0	0	1
	1	0	0	1	0
	X	0	0	Q	Q̄
X	X	1	0	0	1
X	X	0	1	1	0
X	X	1	1	1	1

X = Don't Care
† = Level Change

Notes:

- DC Supply Voltage range (Vcc) 3 to 18 volt.
- Static operation.
- Diode protection on All inputs.
- Logic Edge-Clocked flip-flop design -- Logic state is retained indefinitely with clock level either high or low; information is transferred to the output only on the positive going edge of the clock pulse.
- Capable of driving two Low-power TTL loads or one Low-power Shotkly TTL load over the rated temperature range.
- Pin-for-Pin Replacement for the CD4013B.
- Storage Temperature range from -65 °C to +150 °C.
- Power dissipation 500mWatt.
- Lead temperature 260 °C (Maximum 8 seconds per leg for soldering).
- Maximum rating (Vcc) 0.5v to 18v. (Voltages referenced to Gnd)
- Input or Output Voltage (DC or Transient) 0.5 to Vdd +0.5.
- Input or Output Current (DC or Transient), per Pin; Plus or Minus 10mA.

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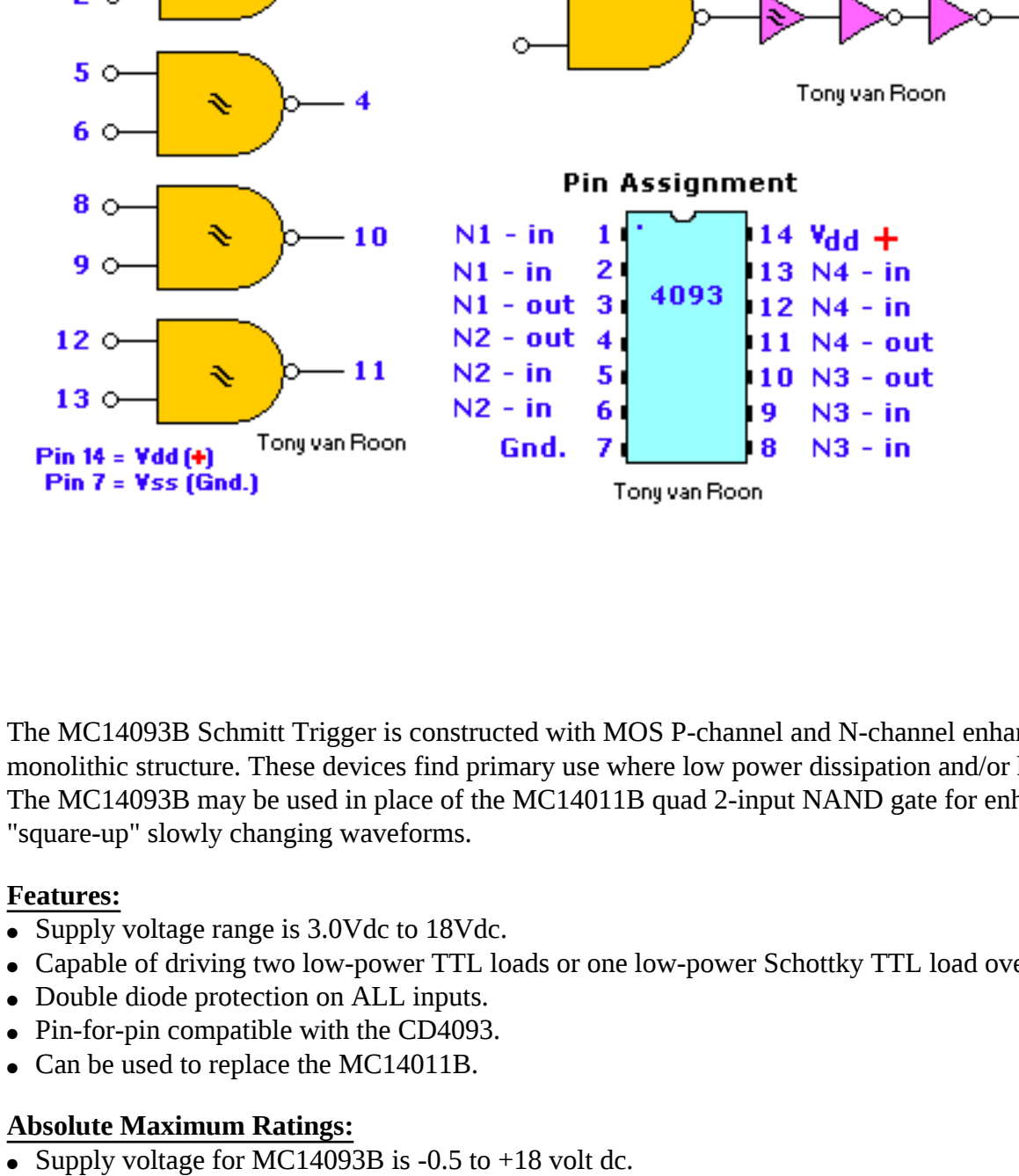
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MC14093 (CMOS) Quad 2-Input NAND Schmitt Trigger

Data sheet

Direct Replacement for CD4093, MC14011B

ivalent Circ



- The unused inputs always to an appropriate voltage level like +Vcc or Ground. Unused outputs must remain open.
- The MC1493B contains protection circuitry to guard against damage due to high static voltages or electric field.

However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltage to this high impedance circuit. For proper operation, V_{in} and V_{out} should be constrained to the range V_{SS} smaller than V_{DD} .

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NE555 Timer/Oscillator

Data sheet

Similar to: LM555-SE555C-MC1455P1-NTE955M-ECG955M

by Tony van Roon

The NE555 silicon monolithic timing circuit is a highly stable controller capable of producing accurate time delays, or oscillation. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For a stable operation as an oscillator, the free running frequency and the duty cycle are both accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms, and the output structure can source or sink up to 200 mA.

Features:

- Turn off time less than 2 micro seconds.
- Maximum operating frequency greater than 500KHz.
- Timing from microseconds to hours.
- Operates in both astable and monostable modes.
- High output current.
- Adjustable duty-cycle.
- TTL compatible.
- Temperature stability of 0.005% per °C.
- Rise and Fall times of output is 100ns typical.
- The MC1455 (cmos) has a normally "on" or normally "off".
- The MC1455 (cmos) has a normally "on" or normally "off".
- The MC1455 (cmos) can also drive MTTL circuits.
- The MC1455 (cmos) is direct pin-compatible with the NE555 timers.

Some Applications:

- Precision Timing.
- Pulse generation.
- Sequential timing.
- Time delay generation.
- Pulse width modulation.
- Pulse position modulation.
- Missing Pulse Detector (used in *Crashed Aircraft Locator* article).

Absolute Maximum Ratings:

- Supply voltage for SE555 +18 volt. For NE555 & SE555C +16 volt.
- Discharge current (pin 7) is 200mA.
- Power dissipation 600 milliWatts. For the MC1455 is that 680mW.
- Operating temperature range for NE555 0 to 70 °C, for SE555 & SE555C -55 to -125 °C.
- Storage temperature range from -65 to -150 °C.
- Lead temperature (soldering, up to 60 sec) 300 °C.

Suffix's:

- The 'G' suffix (e.i. xx555G) stands for Metal package (can), case 601-04.
- The 'P' suffix stands for Plastic package (the most common), case 626-05.
- The 'U' suffix stands for Ceramic package (mostly used in the Industry), case 693-02.
- The 'L' suffix stands for Ceramic package (mostly used in the Industry), case 632-08.
- The 'D' suffix stands for Surface Mount, Plastic package, case 751-02 or SO-8.
- The 'D, N, or FE' suffix can be found for the 8-pin dip packages.
- The 'F' suffix is the 14 pin version of the 8-pin dip. Pins 2,5,7,9,11, and 13 are not connected.

Notes:

- Supply current when output high typically 1mA or less.
- Tested at Vcc=5V and Vce=15V.
- This will determine the maximum value of Ra+Rb, for 15V operation, the max total R = 10 megohm, and for 5V operation, the max total of R = 3.4 megohm.
- Specified with trigger input high.
- Time measured from a positive going input pulse from 0 to 0.8 x Vcc into the threshold to the drop from high to low of the output. Trigger is tied to threshold.

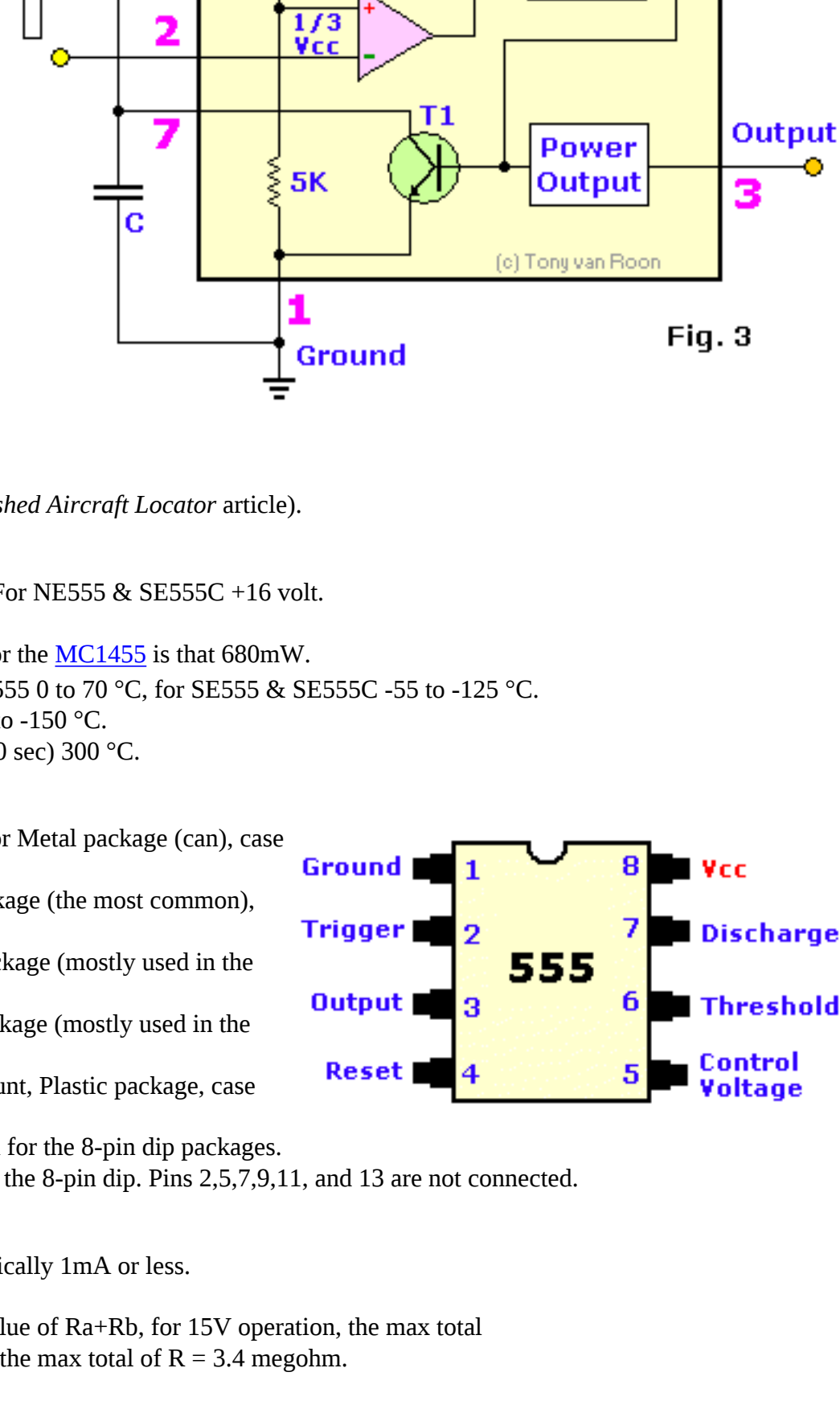


Fig. 3

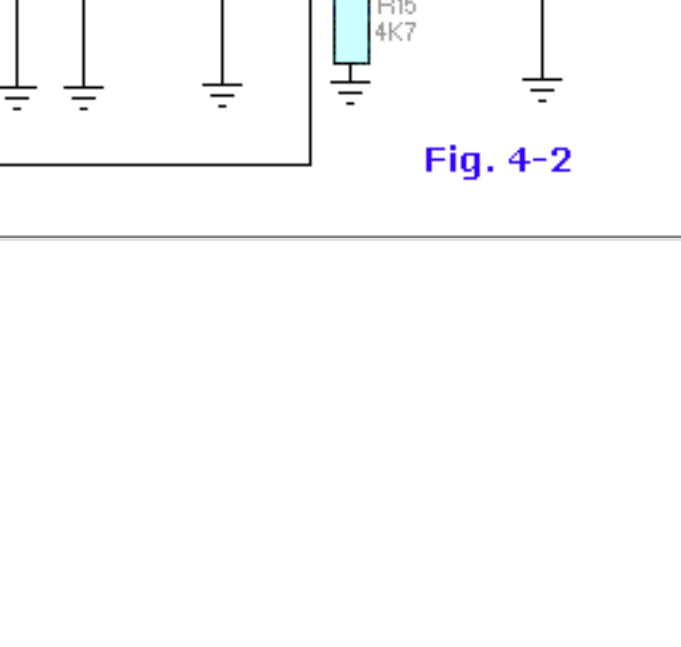


Fig. 4-2

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Fig. 4-2

NE556 Dual Timer/Oscillator

Data sheet

Similar to: LM556-SE556C-MC3453-MC3556-NTE978-ECG978
by [Tony van Roon](#)

The 556 Dual Monolithic timing circuit is a highly stable controller capable of producing accurate time delays, or oscillation. The 556 is simply a dual [555](#). Timing is provided by an external resistor and capacitor for each timing function. The two timers operate independently of each other sharing only Vcc and Ground. The circuit may be triggered and reset on falling waveforms, and the output structure may source or sink up to 200 mA.

Features:

- The NE556/SE556 timers can be directly replaced by the CMOS types [MC3456/MC3556](#).
- Timing from microseconds to hours.
- Supply voltage from +4.5V (min) to +18V (max).
- Replaces two [555](#) timers.
- Maximum operating frequency greater than 500Khz.
- Operates in both astable and monostable modes.
- High output current.
- Adjustable duty-cycle.
- TTL compatible.
- Temperature stability of 0.005% per °C.
- Rise and Fall times of output is 100nS typical.
- SE556 type MIL STD 883A, B, C is available.

Some Applications:

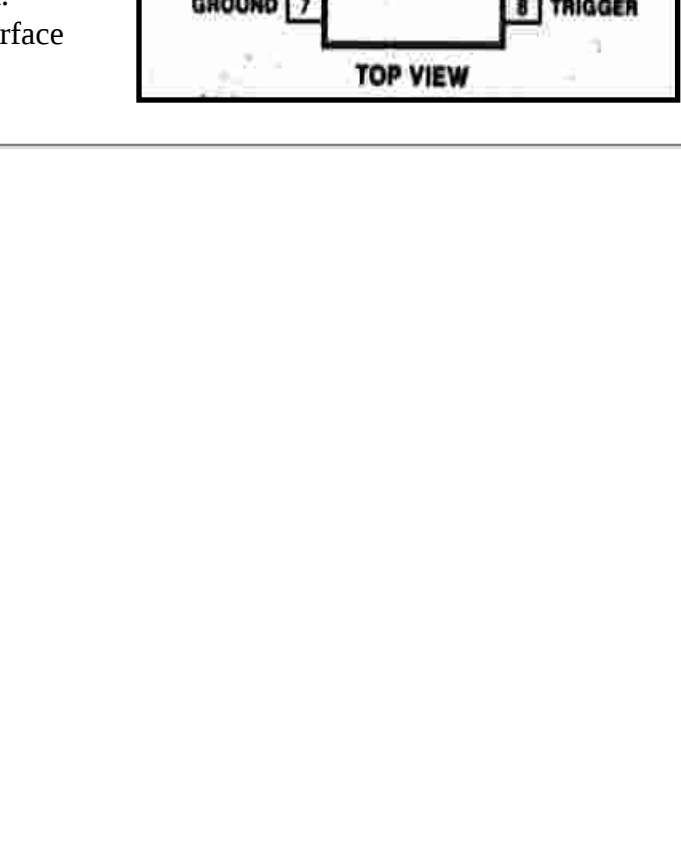
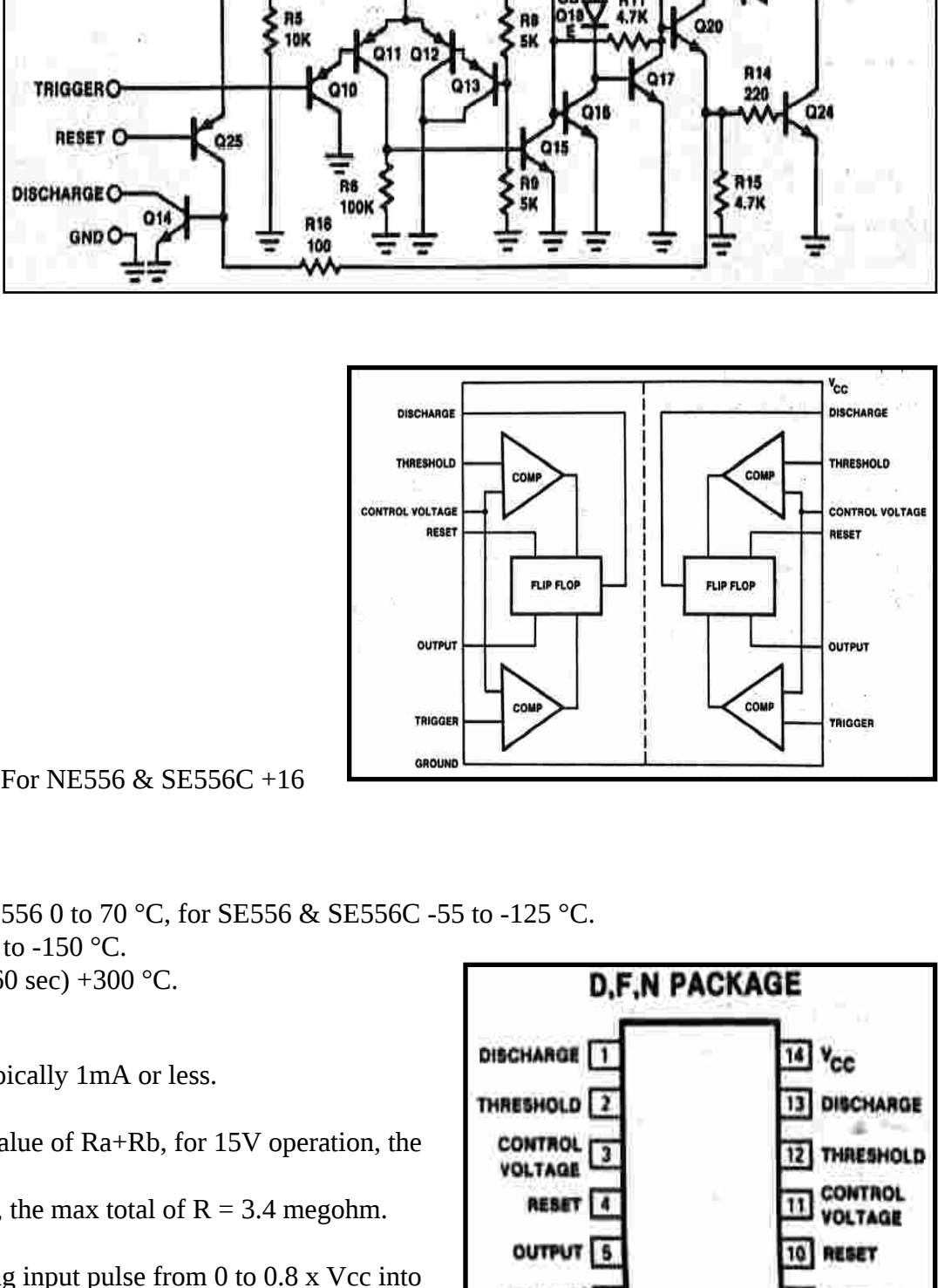
- [Precision Timing](#).
- [Pulse shaping](#).
- Pulse generation.
- Sequential timing.
- Time delay generation.
- Pulse width modulation.
- Pulse position modulation.
- Missing Pulse Detector.
- Tone burst generator.
- Appliance timing.
- Traffic light control.
- Touch tone decoder.

Absolute Maximum Ratings:

- Supply voltage for SE556 +18 volt. For NE556 & SE556C +16 volt.
- Discharge current (pin 7) is 200mA.
- Power dissipation 600 milliWatts.
- Operating temperature range for NE556 0 to 70 °C, for SE556 & SE556C -55 to -125 °C.
- Storage temperature range from -65 to -150 °C.
- Lead temperature (soldering, up to 60 sec) +300 °C.

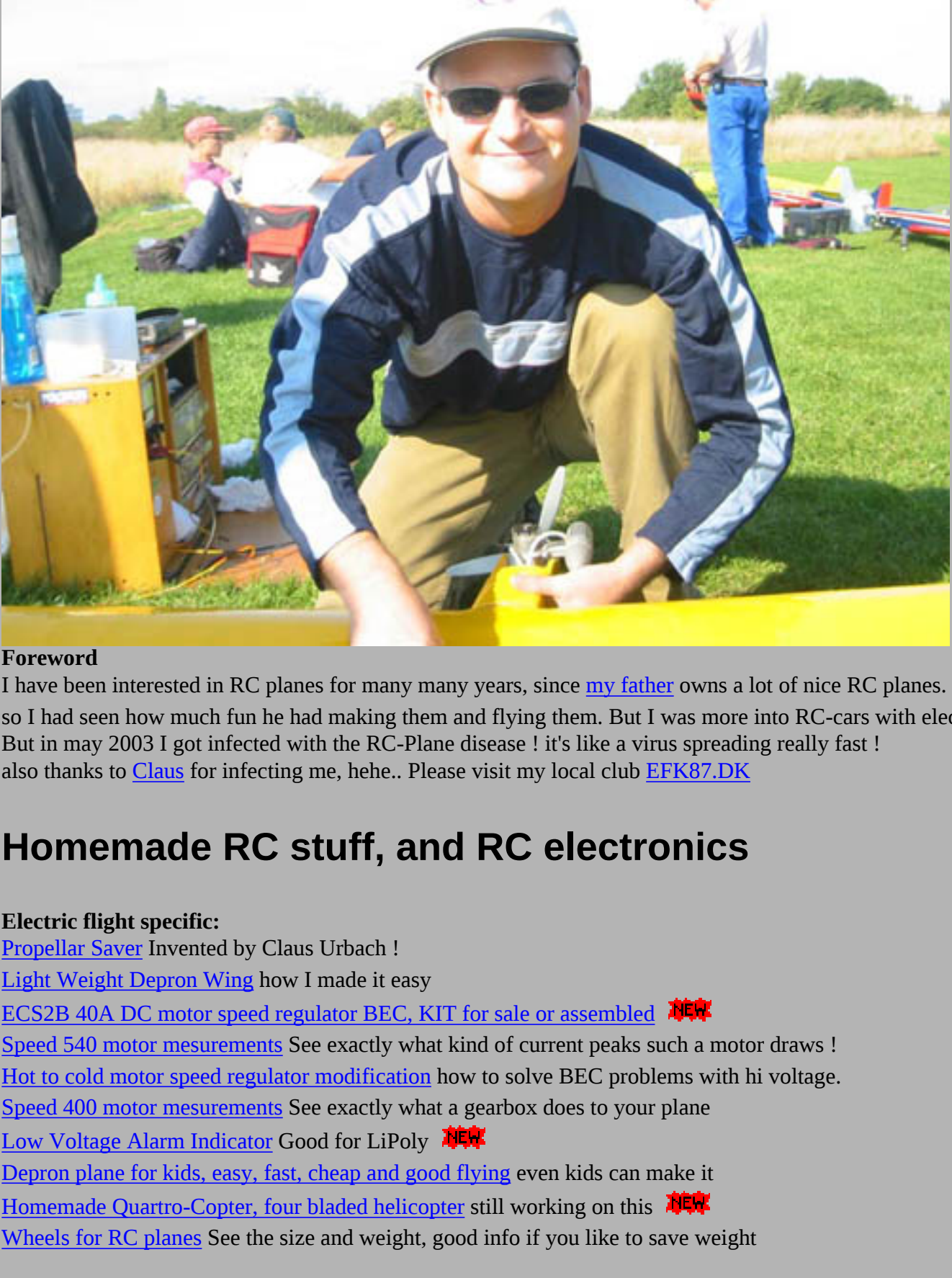
Notes:

- Supply current when output high typically 1mA or less.
- Tested at Vcc=5V and Vcc=15V.
- This will determine the maximum value of Ra+Rb, for 15V operation, the max total R = 10 megohm, and for 5V operation, the max total of R = 3.4 megohm.
- Specified with trigger input high.
- Time measured from a positive going input pulse from 0 to 0.8 x Vcc into the threshold
- to the drop from high to low of the output. Trigger is tied to threshold.
- Available in D, F, N, plastic packages. 'D' suffix being the SO-8 surface mount type.



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Foreword
I have been interested in RC planes for many many years, since [my father](#) owns a lot of nice RC planes.
so I had seen how much fun he had making them and flying them. But I was more into RC-cars with electric motors.
But in may 2003 I got infected with the RC-Plane disease ! it's like a virus spreading really fast !
also thanks to [Claus](#) for infecting me, hehe.. Please visit my local club [EFK87.DK](#)

Homemade RC stuff, and RC electronics

Electric flight specific:
[Propellar Saver](#) Invented by Claus Urbach !
[Light Weight Depron Wing](#) how I made it easy
[ECS2B 40A DC motor speed regulator BEC, KIT for sale or assembled](#) ~~NEW~~
[Speed 540 motor mesurements](#) See exactly what kind of current peaks such a motor draws !
[Hot to cold motor speed regulator modification](#) how to solve BEC problems with hi voltage.
[Speed 400 motor mesurements](#) See exactly what a gearbox does to your plane
[Low Voltage Alarm Indicator](#) Good for LiPoly ~~NEW~~
[Depron plane for kids, easy, fast, cheap and good flying](#) even kids can make it
[Homemade Quattro-Copter, four bladed helicopter](#) still working on this ~~NEW~~
[Wheels for RC planes](#) See the size and weight, good info if you like to save weight

Glowplug motor flight specific:
[Electric starter](#) A cheap way to start your glow engine
[Old Glow Engines](#) funny old stuff I have on stock, most of them I have tested works fine.
[On board glowplug driver](#) to make idle more smooth or easy start at the field ~~NEW~~
[Glowplug driver](#) Voltage compensated PWM LM555 and FET ~~NEW~~
[Powerpanel](#) With glowplug driver, RX charge, TX charge, pump switch, starter plug ~~NEW~~
[Fieldbox](#) My fieldbox ~~NEW~~

Transmitter/Receiver stuff in general:
[Transmitter/battery modification](#) soldering on NiMH cells will prevent loose connections
[FMS Simulator PIC serial interface](#)
[UHF data link](#) Realtime serial data download.
[Trainer for EVO transmitter](#) Old transmitter modified easy for trainer.
[Wireless Trainer for Multiplex EVO transmitter](#) old 40MHz TX for 35MHz teacher system.
[Video transmitter amplifier](#) Wireless 1GHz video, adds fun to the RC hobby.
[Multiplex Cockpit trainer and student](#) how to modify this cheap transmitter for trainer mode.

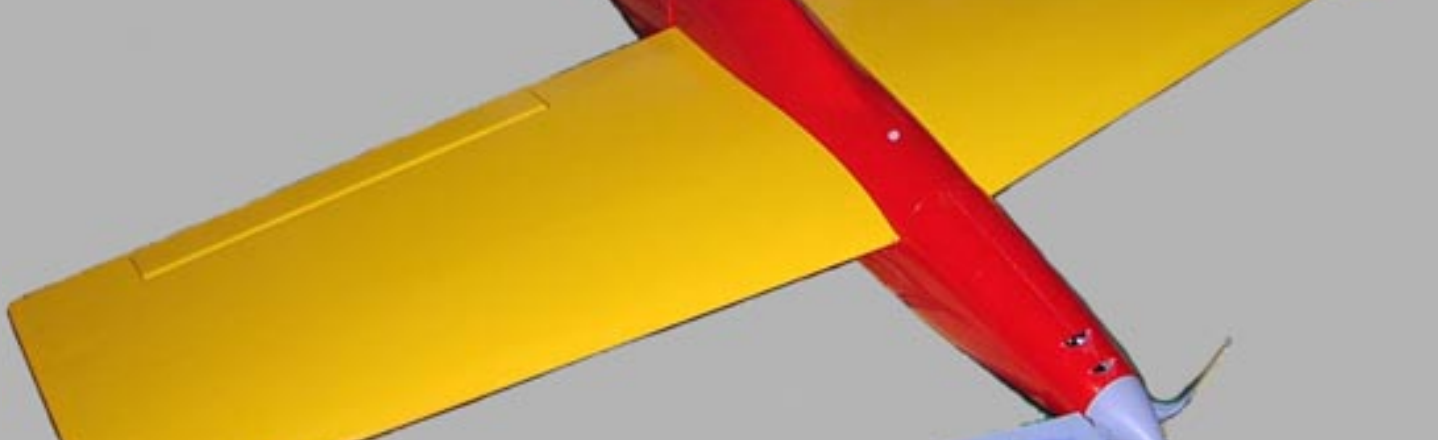
Charger/Battery stuff in general:
[Battery Discharge Automatic Switch](#) Cheap and simple discharger for large cells after flying ~~NEW~~
[Computer battery charger](#) with Z80 and large 2x40 LCD
[KAN 1050 NiMH battery pack](#) to save money or to make special designs.

[KAN 1050 NiMH battery capacity measurements](#) see some curves.. a 1050 is not 1050mAh at all..
[AAA NiMH battery pack](#) to save money or to make special designs.
[ISLG-330 Modifications](#) Serial port, sound ON/OFF, Dual boot, Name in display

miscellaneous:
[Planeholder](#) See how an easy cheap plane and wing holder can be made
[Battery finder](#) for EL planes.
[Plane finder](#), turn off TX then plane will give audio alarm. More info about this later.
[My trip to Hamburg modelbauwelt 2003](#)
[My trip to Hamburg modelbauwelt 2004](#)
[My trip to Crete, Chania AirModelling Club 2004](#) ~~NEW~~
[DANSK RC POLL](#) Sjov afstemning om modellflyvning hobby, kik ind og stem
[My Plane Crash page](#), ohh no.. dont look here..

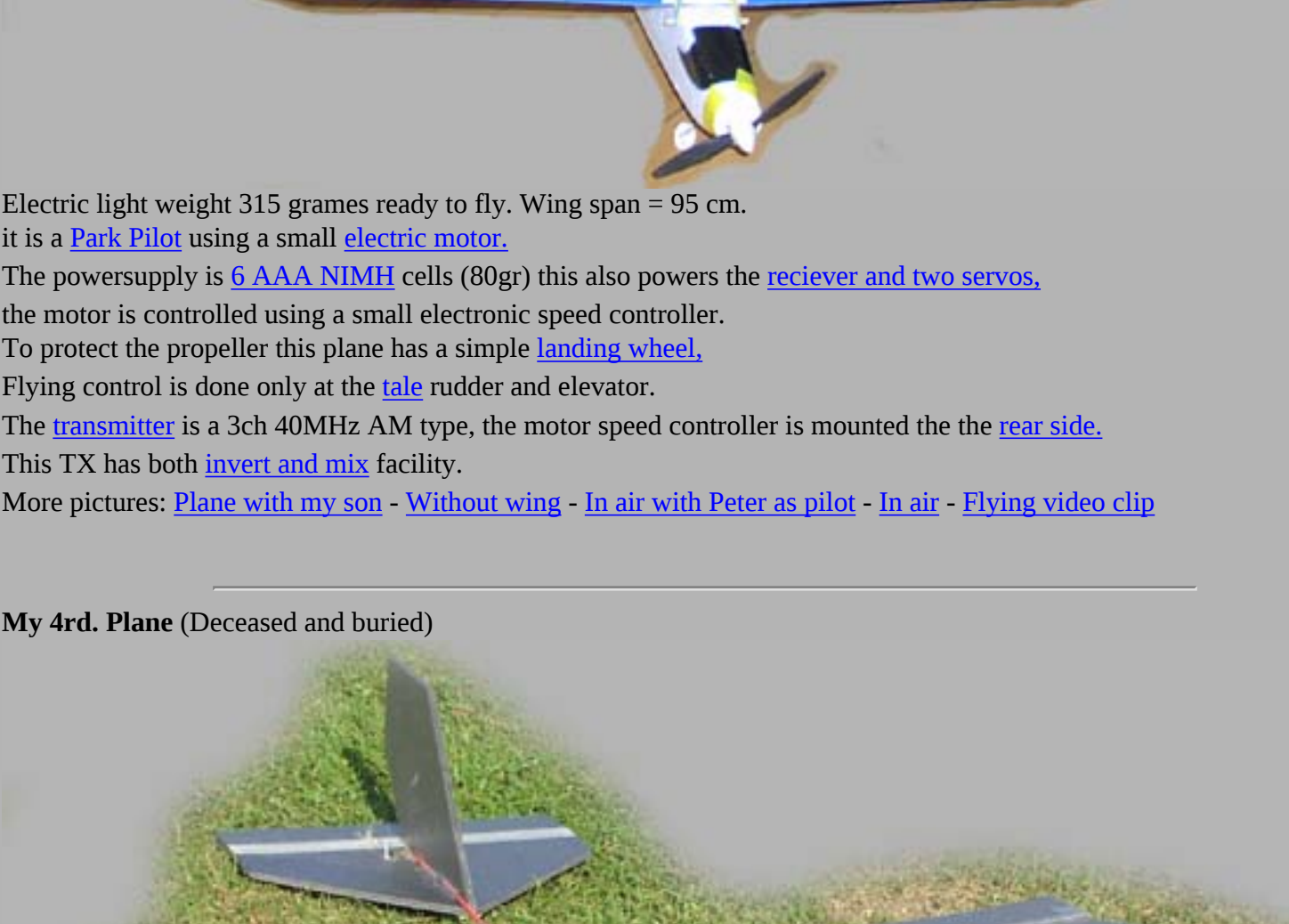
My own RC planes

My 1st. Plane (Deceased and buried)



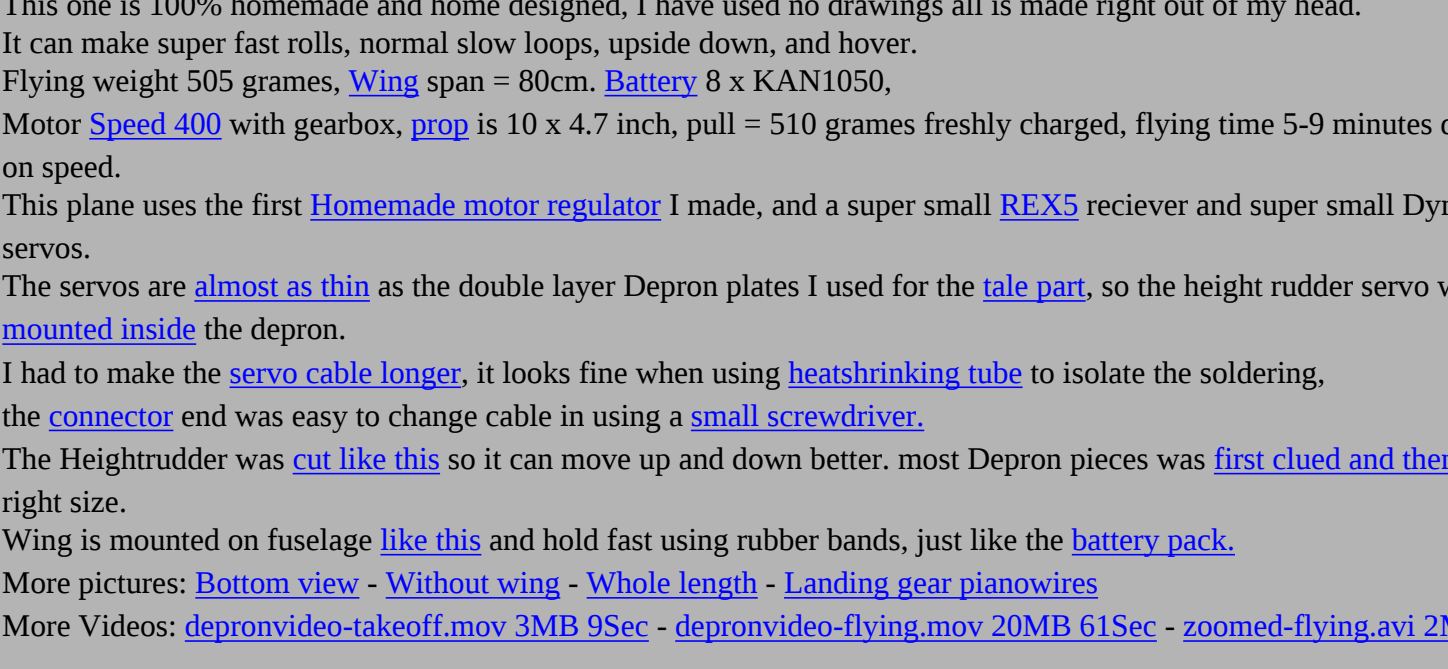
Nice yellow Chico Graupner model, with OS 15 glow plug engine, was a gift from my dad !
This model was HOT in 1977 but this one still works in 2004 !!
Wing span = 99cm, weight = 1230 grams RTF but no fuel in tank.
The original OS 0.15 Engine did work in 2003, but after a crash, I have changed the motor to a Magnum 0.25
This new motor is 75 gram more weight, but then I changed the Gas servo from 50 to 10 gr, and the receiver from 40 to 10 gr.
I also changed the battery pack of 4 x AA 105 gr to 4 x AAA 50 gr. Total weight is now 1170 gr and double engine power.
The bottom side of the plane has black stripes both on the body and wing.
[plane with wife - engine closeup](#) - [Empty servo room](#) - [servo room first two](#) - [all 3 mounted](#)
[RX and all servo - more servo closeup](#)
[battery and fuel tank - power sw charge plug](#)
At the field Pictures: [My is on the sticks](#) - [Trying to start motor](#) - [motor started](#)
Videos: [Take off 1](#) 671kb 3 sec. - [Take off 2](#) 1Mb 6 sec. - [Take off 3 and some fun](#) 1.6MB 29 sec. - [Having hi speed fun](#)
18MB 3minutes.
[Landing](#) 1Mb 15 sec. - [Fly Hi like hell](#) 350kb 8 sec.
Graupner Catalog Chico from 1977: [page 1](#) - [page 2](#) - [page 3](#)

My 2nd. Plane



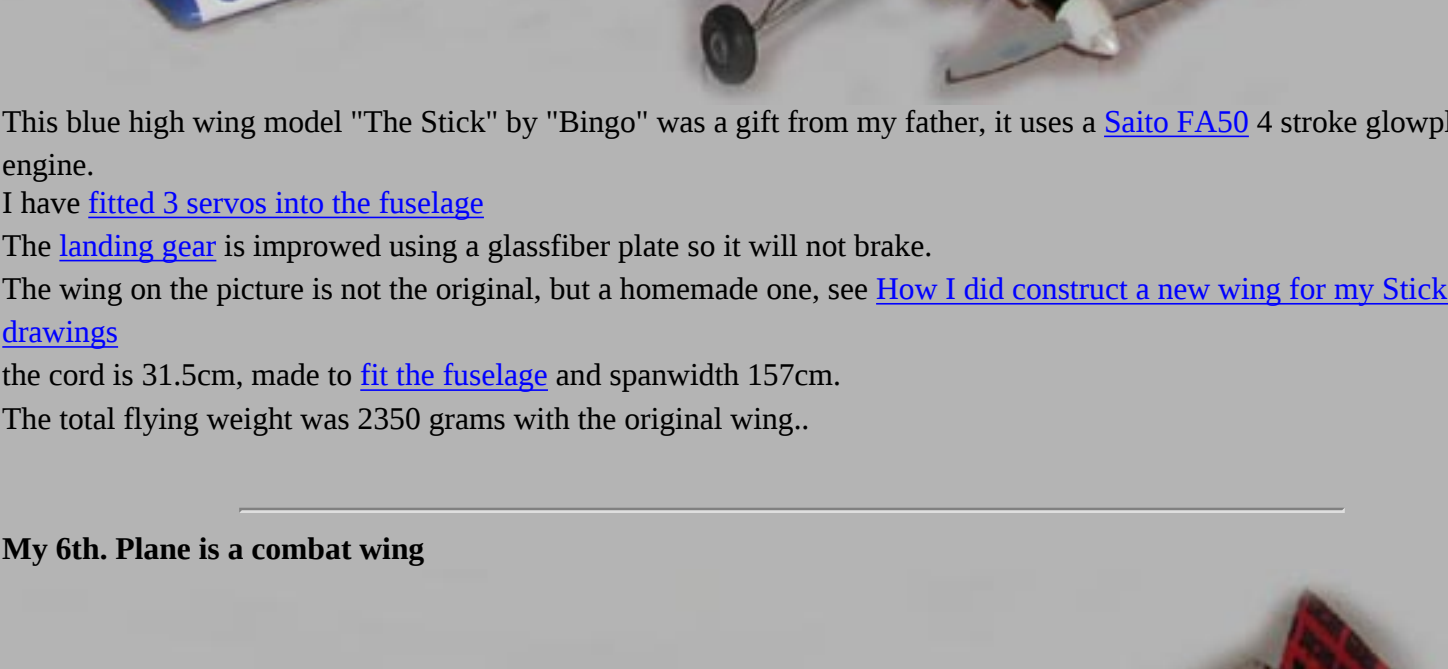
[DARA 20 FLAIR Model](#).
[See all the pictures from the complete plane construction](#)
Electric conversion of old glow-motor plane. Wing span = 92cm, Corde = 24cm, Length = 77cm
Total weight with two 8 cells KAN1050 battery packs = 1130 grams.

My 3rd. Plane



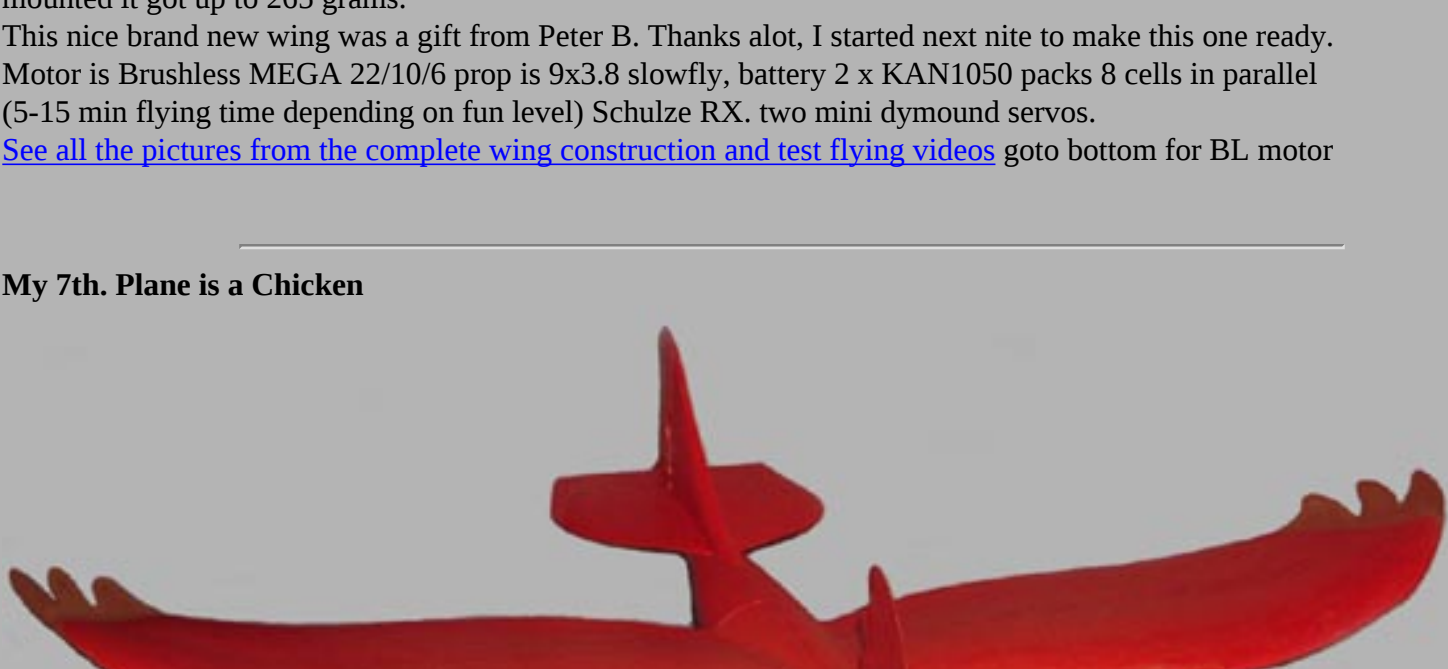
Electric light weight 315 grammes ready to fly. Wing span = 95 cm.
it is a [Park Pilot](#) using a small [electric motor](#).
The powersupply is [6 AAA NIMH](#) cells (80gr) this also powers the [receiver and two servos](#),
the motor is controlled using a small electronic speed controller.
To protect the propeller this plane has a simple [landing wheel](#).
Flying control is done only at the [tale](#) rudder and elevator.
The [transmitter](#) is a 3ch 40MHz AM type, the motor speed controller is mounted the [rear side](#).
This TX has both [invert and mix](#) facility.
More pictures: [Plane with my son](#) - [Without wing](#) - [In air with Peter as pilot](#) - [In air](#) - [Flying video clip](#)

My 4rd. Plane (Deceased and buried)



This one is 100% homemade and home designed, I have used no drawings all is made right out of my head.
It can make super fast rolls, normal slow loops, upside down, and hover.
Flying weight 505 grammes, [Wing span](#) = 80cm, [Battery](#) 8 x KAN1050,
Motor [Speed 400](#) with gearbox, [prop](#) is 10 x 4.7 inch, pull = 510 grammes freshly charged, flying time 5-9 minutes depending on speed.
This plane uses the first [Homemade motor regulator](#) I made, and a super small [REX5](#) reciever and super small Dymond servos.
The servos are [almost as thin](#) as the double layer Depron plates I used for the [tale part](#), so the height rudder servo was [mounted inside](#) the depron.
I had to make the [servo cable longer](#), it looks fine when using [heatshrinking tube](#) to isolate the soldering,
the [connector](#) end was easy to change cable in using a [small screwdriver](#).
The Heighttrudder was [cut like this](#) so it can move up and down better, most Depron the servos was [first clued and then cut](#) into right size.
Wing is mounted on fuselage [like this](#) and hold fast using rubber bands, just like the [battery pack](#).
More pictures: [Bottom view](#) - [Without wing](#) - [Whole length](#) - [Landing gear planowires](#)
More Videos: [depronvideo-takeoff.mov](#) 3MB 9Sec - [depronvideo-flying.mov](#) 20MB 61Sec - [zoomed-flying.avi](#) 2MB 16Sec

My 5th. Plane



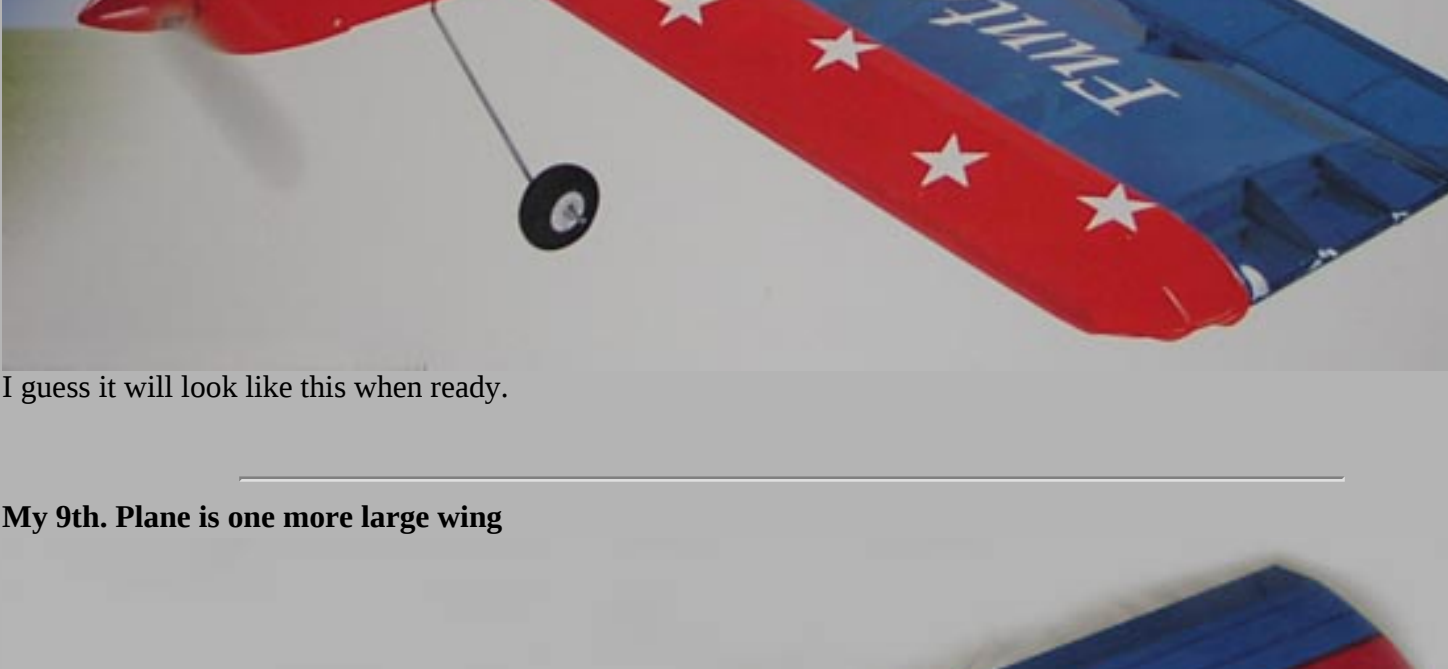
This blue high wing model "The Stick" by "Bingo" was a gift from my father, it uses a [Saito FA50](#) 4 stroke glowplug engine.
I have [fitted 3 servos into the fuselage](#)
The [landing gear](#) is improwised using a glassfiber plate so it will not brake.
The wing on the picture is not the original, but a homemade one, see [How I did construct a new wing for my Stick using no drawings](#)
the cord is 31.5cm, made to [fit the fuselage](#) and spanwidth 157cm.
The total flying weight was 2350 grams with the original wing..

My 6th. Plane is a combat wing



Note the nice covering tape ! it was a nice sponsor gift from my work.
Spanwidth = 119cm, corde = 39cm, width at tip = 23cm. 160 grams bare foam. after gluing, coating and carbon sticks was mounted it got up to 265 grams.
This nice brand new wing was a gift from Peter B. Thanks alot, I started next nite to make this one ready.
Motor is Brushless MEGA 22/10/6 prop is 9x3.8 slowlyfly, battery 2 x KAN1050 packs 8 cells in parallel (5-15 min flying time depending on fun level) Schulze RX. two mini dymond servos.
[See all the pictures from the complete wing construction and test flying videos](#) goto bottom for BL motor

My 7th. Plane is a Chicken

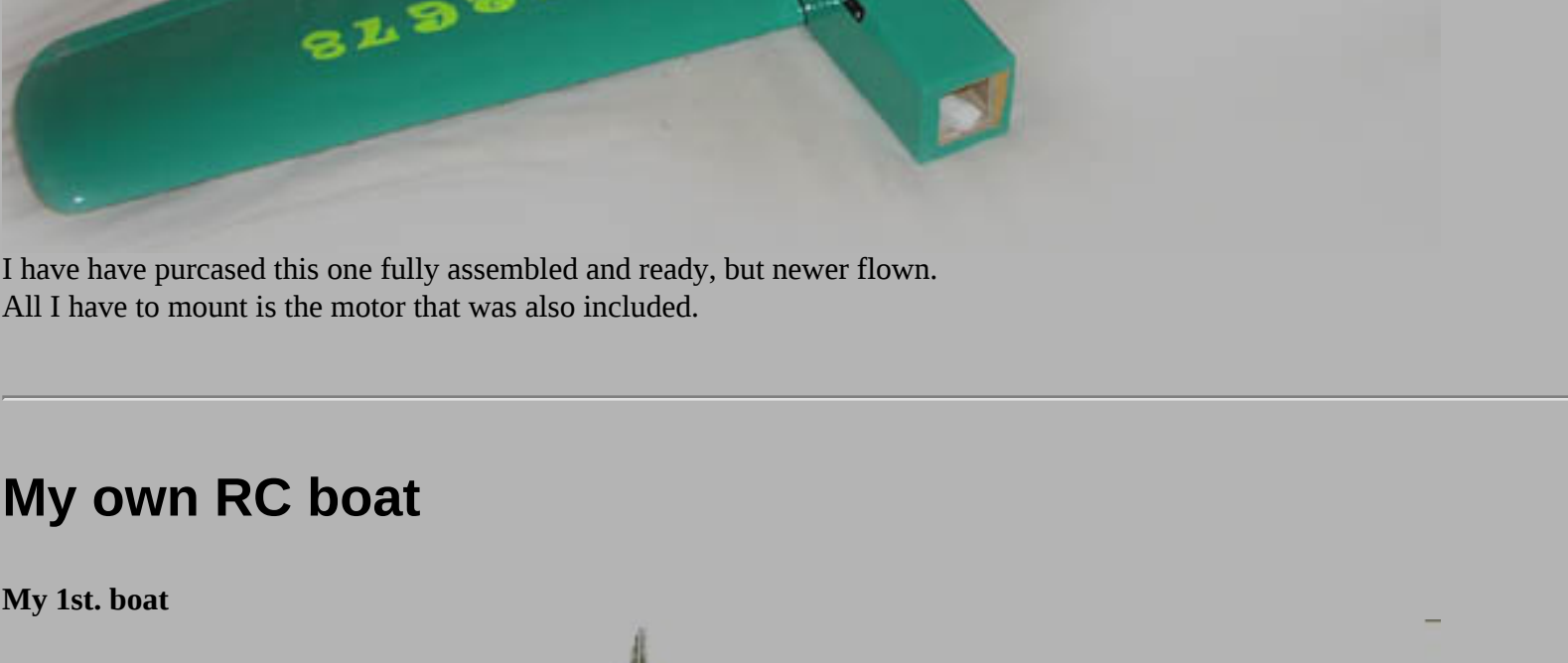


Wing span = 105cm, Length = 71cm,
Weight without battery = 380 grams after painting (25 grams of paint in total)
Weight with 8 KAN1050 900mAh = 565 grams
Weight with 4 LIPO1050 2000mAh = 485 grams

My 8th. Plane is a FunTastic 3D



It is just unpacked... maybe it will be assembled in a few days..



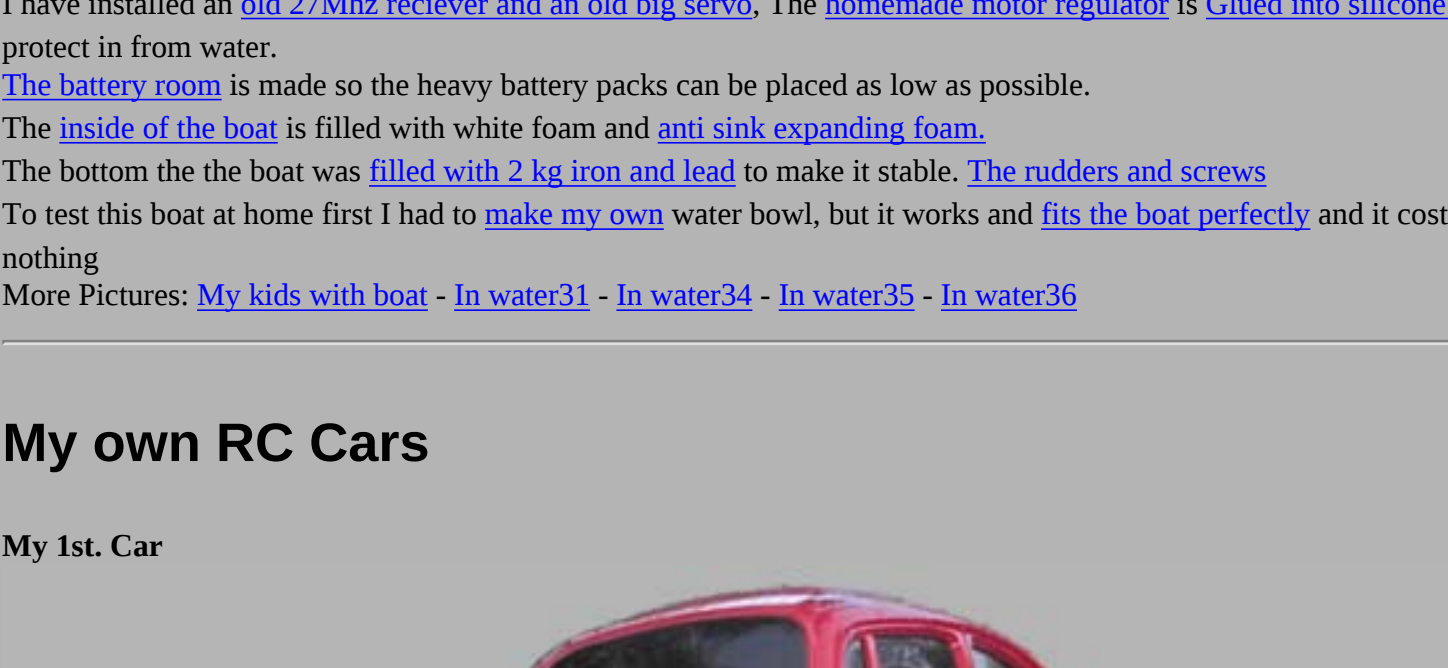
I guess it will look like this when ready.

My 9th. Plane is one more large wing



I have just made the covering, but I will make it ready soon..

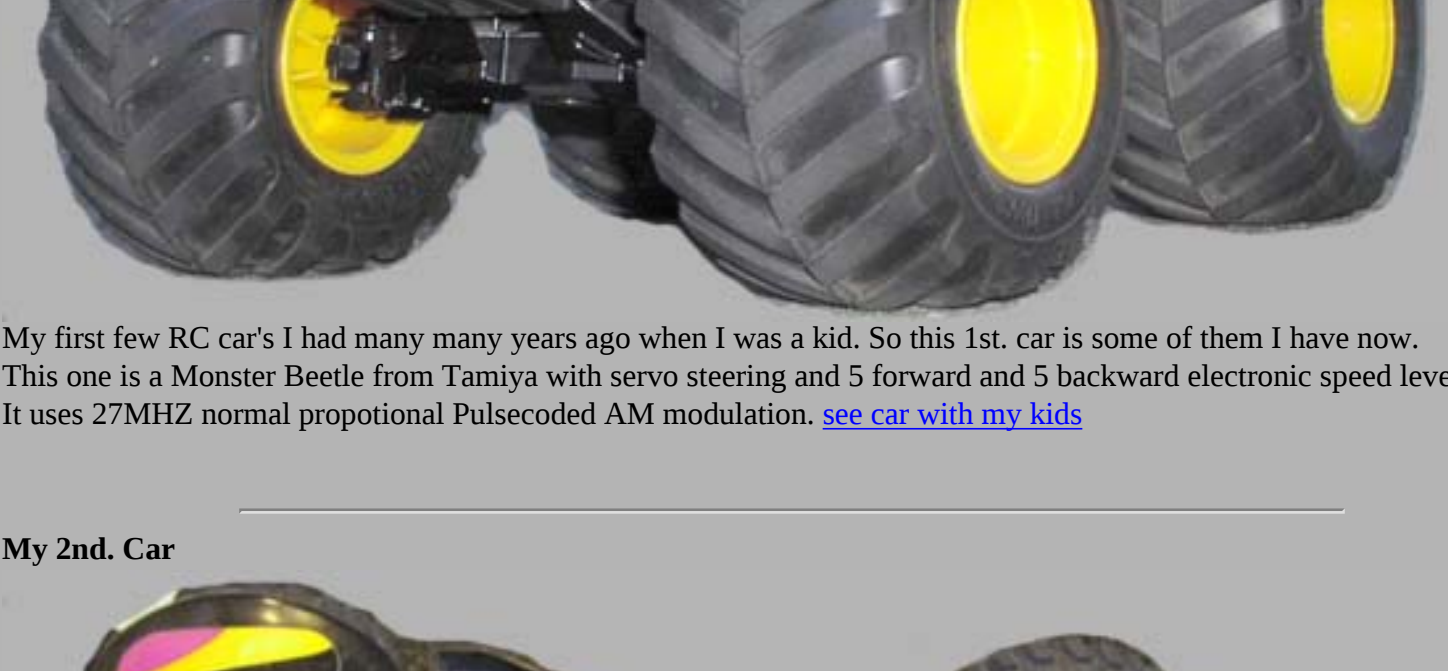
My 10th. Plane is a Kobra



I have purchased this one fully assembled and ready, but newer flown.
All I have to mount is the motor that was also included.

My own RC boat

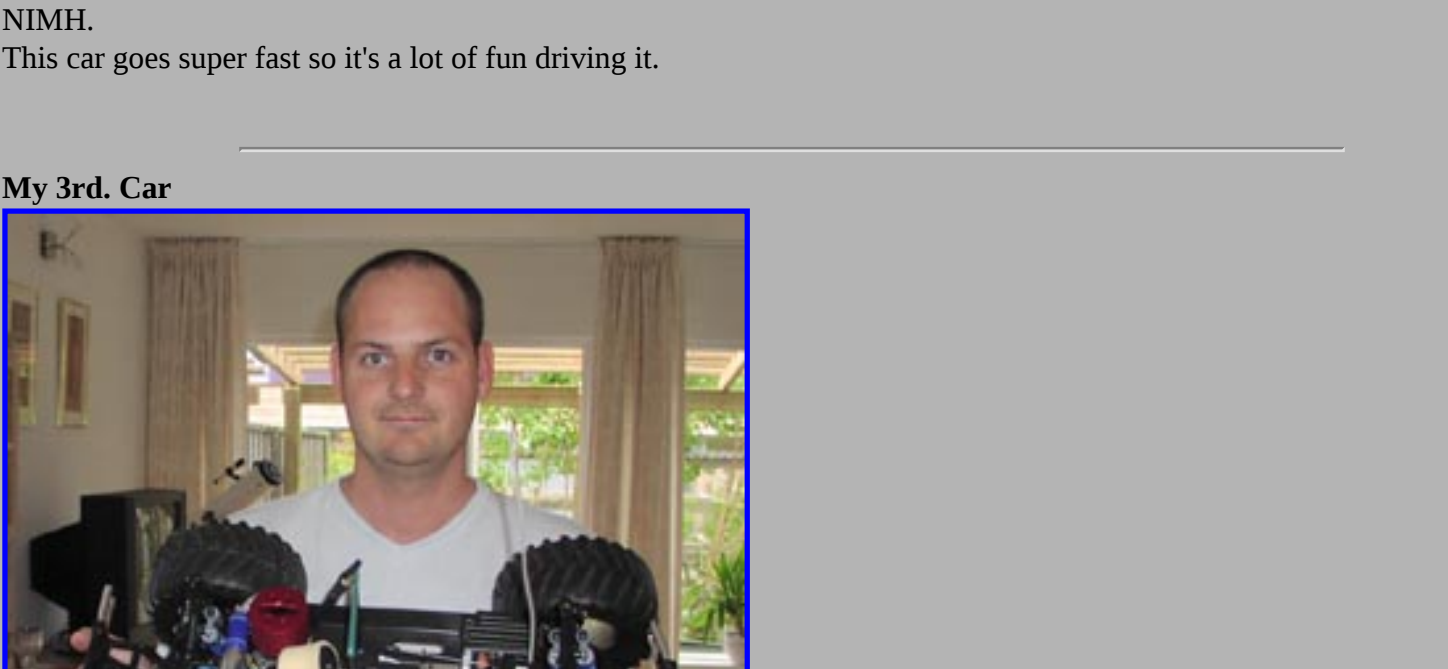
My 1st. boat



[This one](#) was a gift to me and my kids, it's a Robbe RP3 really huge 92cm long, a lot of details was made super nice
The radar is connected to a motor with gear so it can rotate. The little rescue boat can be lifted into water.
I have installed an [old 27Mhz reciever and an old big servo](#). The [homemade motor regulator](#) is [Glued into silicone glue](#) to protect in from water.
[The battery room](#) is made so the heavy battery packs can be placed as low as possible.
The [inside of the boat](#) is filled with white foam and [anti sink expanding foam](#).
The bottom the of the boat was [filled with 2 kg iron and lead](#) to make it stable. [The rudders and screws](#)
To test this boat at home first I had to [make my own](#) water bowl, but it works and [fits the boat perfectly](#) and it costed nothing
More Pictures: [My kids with boat](#) - [In water31](#) - [In watec34](#) - [In water35](#) - [In water36](#)

My own RC Cars

My 1st. Car



My first few RC car's I had many many years ago when I was a kid. So this 1st. car is some of them I have now.
This one is a Monster Beetle from Tamiya with servo steering and 5 forward and 5 backward electronic speed levels.
It uses 27MHZ normal proportional Pulsecoded AM modulation. [see car with my kids](#)

My 2nd. Car



I got this crap toy car from a flea market for almost nothing, then I modified the steering to real servo control.
[Servo mod1](#) - [mod2](#) - [mod3](#) - [mod4](#) - [mod5](#)
I added my own [homemade motor regulator](#) with [brake option](#).
The motor size was almost a Speed 300 so I changed the motor to a SP300 7.2 Volt, the battery pack is 10 Cells AA 1600 NIMH.
This car goes super fast so it's a lot of fun driving it.

My 3rd. Car

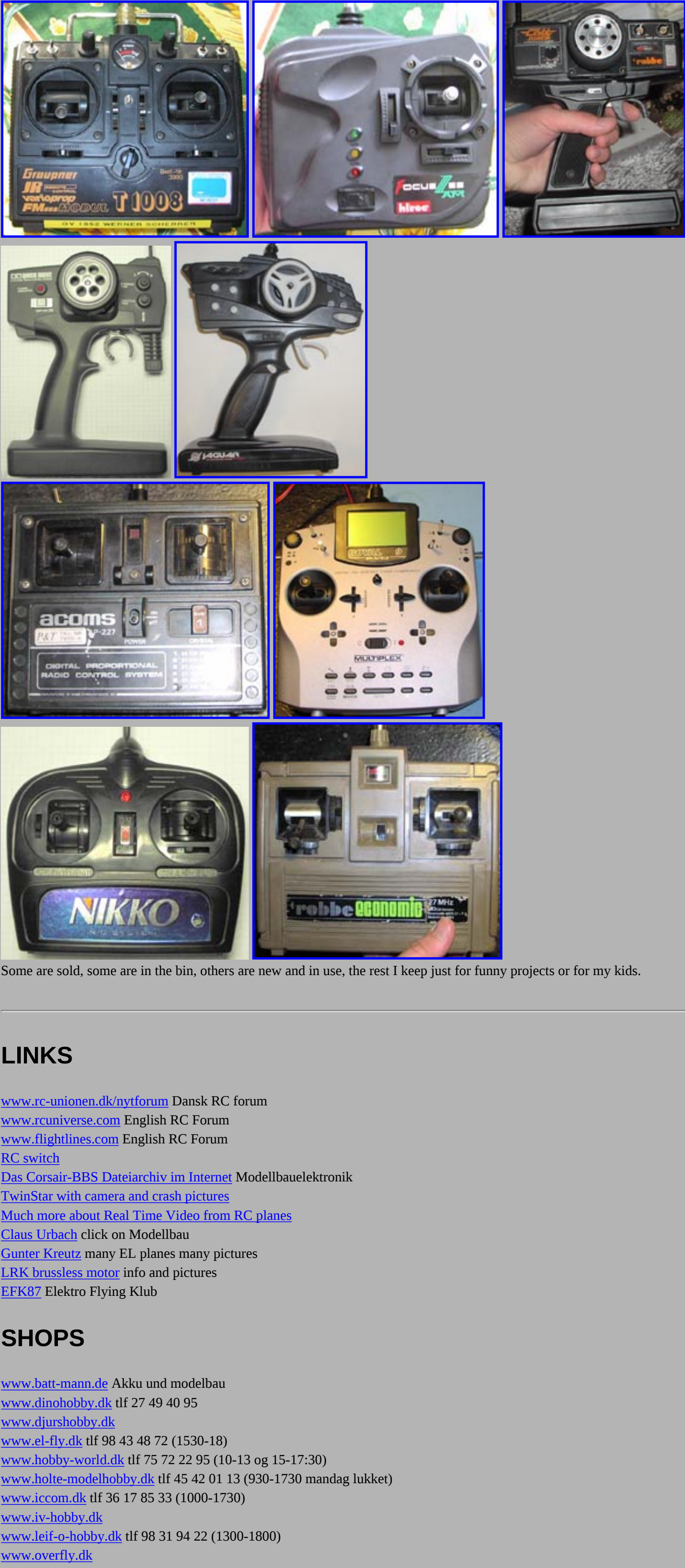


This is a brandnew (August 2004) Thunder Tiger 3.5cm metalon offroad monstertruck (MTA-4)
It is read4r dWD with automatic speed controlled 2 speed gearbox. Forward/reverse made using a 3rd servo.
Pictures: [At the field](#) - [Ready to jump](#) - [C-Fash !](#) [alot of times](#) - [Speeding up](#) - [Fuel Refilling](#) - [Flying Hi speed !](#) - [Repair simple](#)

Play the videos at 1:1 scale else they will look bad due to hi compress.
Videos: [Hi speed](#) - [Lucky landing](#) - [Jump and curve](#) - [Jump and hi wife !!](#) - [Good jump but too fast](#)
Modifications: [Cooling Holes](#) - [Jump and curve](#) - [Reso and original](#) - [Shock absorber original](#) - [Socks added 1](#) - [Socks added 2](#)
Adding the Tuned reso pipe # PD0418 from Thunder Tiger did not lower the noise or boost performance when I was running on 16% nitro

Later that day I changed to 25% nitro fuel, NOW I could see and fell more acceleration and a bit more top speed.
I dont know if this performance gain would have been the same with the original pipe.. but it is still TOO noisy !!
After changing from 16% to 25% nitro I could lower the idle rpm and still keep it stable, it also starts better.
Adding socks prevent dirt and dust from coming into the shock absorbers, giving them a lot longer lifetime.
The braking spring was WAY to long and too thin, I have changed it to 20mm fuel hose, now the brake system works.

Some of my remote control transmitters



Some are sold, some are in the bin, others are new and in use, the rest I keep just for funny projects or for my kids.

LINKS

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ServoGoSlow
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Servotester
Modelfinder
Receiver
Batterytester

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Welcome to my

RC Electronics Page

For those
who not only fly,
but also like to build
electronic circuits



Speedy-Brushless

SBL-Micro
BL Controller for Slowflyer

Last update: 2004

Deutsche Version



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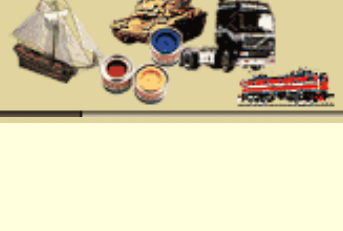
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5 of 5 stars **THE R/C book to read!**, July 6, 2000

Reviewer: **Mark Cayouette** from Anchorage, AK USA

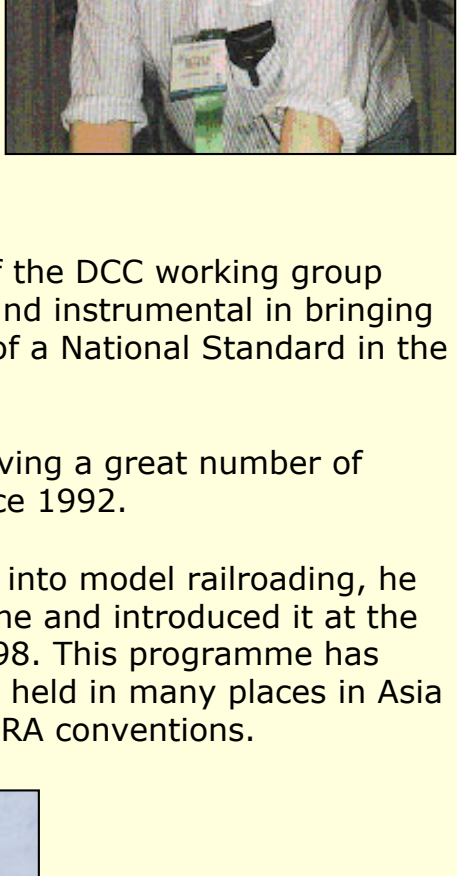
Excellent material. I was into R/C several years ago and was looking for a refresher. This book has it all from basic flying skills (takeoffs and landings) to intermediate skills (dreaded cross winds takeoffs and landings). It also mentions the differences in flying trike gear or tail gear and how to do both effectively and prevent crashes. Multi engines, pylon racing, acrobatics, scale, engine performance are all covered. Gliders and Ducted fan are also covered. Most complete book R/C book I have come accross. Highly recommended for those thinking about R/C, new R/C pilots and those requiring a refresher.



Welcome to Rutger Friberg's world of

Model Railroad Electronics

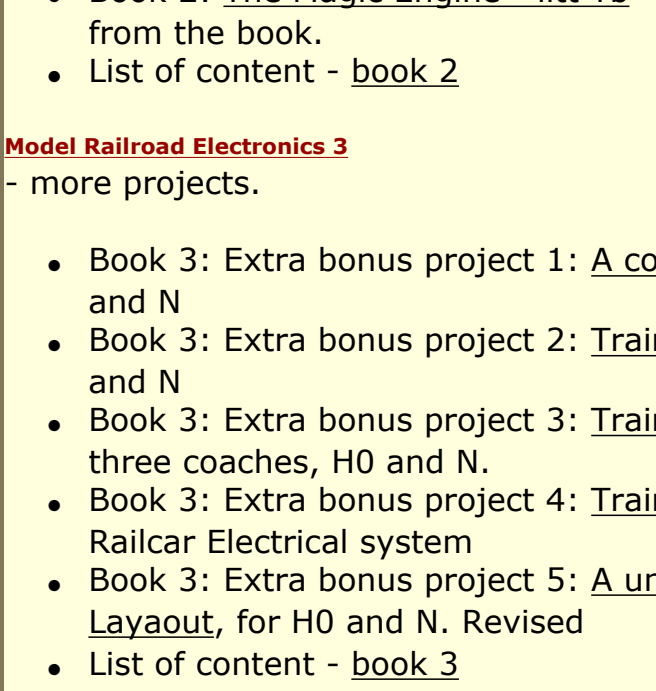
Rutger Friberg is Model Railroad and Electronics editor in the leading Scandinavian MR Magazine "Allt om Hobby" since more than 20 years. Rutger is also author of a series of books in the area of MR Technology as well as co-author of Hobby and Technology books in Scandinavia. For many years (since1988) Rutger has also on a regular basis been giving seminars and workshops for broader audiences around the MR and technology topics.



Since1991 Rutger has been member of the DCC working group within the NMRA technical committee and instrumental in bringing the Digital control system to the level of a National Standard in the US.

In this context Rutger has also been giving a great number of clinics at each National Convention since 1992.

Rutger is working hard to get new kids into model railroading, he developed the Junior Collage Programme and introduced it at the NMRA Convention in Kansas City in 1998. This programme has since then been very popular and been held in many places in Asia and Europe as well as yearly at the NMRA conventions.



Books by Rutger:

Model Railroad Electronics 1

- many easy projects for both beginners and more advanced.

- Updates to book 1
- Extra bonus project 1: [Blinking lights](#)
- Extra bonus project 2: [Flashing railroad crossings](#)- two versions
- Extra bonus project 3: [Flashing lights](#) - for a roadwork warning and a train shop sign.
- List of content - [book 1](#)

Model Railroad Electronics 2

- the book about digital trains. A must for everybody.

- Book 2: Extra bonus project 1: [F1-F4 functions tester](#)
- Book 2: Extra bonus project 2: [Engine code tester](#)
- Book 2: Extra bonus project 3: [Sound control decoder](#) - a sound system built from an electronic greeting card.
- Book 2: [The Magic Engine - litt Tb](#) - a DIY-project: extract from the book
- List of content - [book 2](#)

Model Railroad Electronics 3

- more projects.

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- Book 3: Extra bonus project 2: [Train Electrical system 1](#), H0 and N
- Book 3: Extra bonus project 3: [Train Electrical system 2](#) - for three coaches, H0 and N.
- Book 3: Extra bonus project 4: [Train Electrical system 3](#) - Railcar Electrical system
- Book 3: Extra bonus project 5: [A universal Track tester for the Layout](#), for H0 and N. Revised
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Model Railroad Electronics 4

- Book 4: Extra bonus project 1: [Booster and Interface with Feedback](#)
- Book 4: Extra bonus project 2: [The Märklin 7051 Crane converted to DCC](#)
- List of content - [book 4](#)

Model Railroad Electronics 5

- Book 5: Extra bonus project 1: [Turnout Position Indicator](#)
- Book 5: Extra bonus project 2: [Digital Turnout Indicator](#)
- List of content - [book 5](#)

Model Railroad Electronics 6



- Book 6: Extra bonus project 1: [KRAFT 3 decoder for turnouts with trackbed](#)
- Book 6: Extra bonus project 2: [KRAFT 3B for electric uncoupler](#)
- Book 6: Extra bonus project 3: [Replacement for LDE 20 Integrated Circuits](#)
- Book 6: Extra bonus project 4: [Updated DCC Panel with Status Indicator](#)
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The comprehensive guide to Digital Command Control



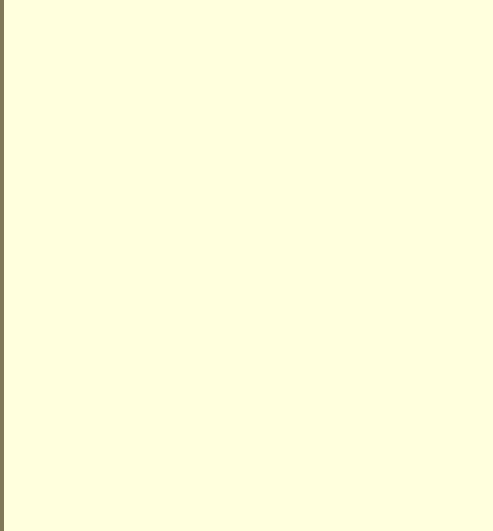
... by Stan Ames, Rutger Friberg & Ed Loizeaux - was published in July 1998 and updated one year later. This book is a a must for all model railroaders, written by the three leading experts in this field.

Read what the readers write about the books

More to read ...

- A complete list of articles about model railroading written by Rutger Friberg and published in Swedish. Sorry but this information is in Swedish but you can expect that some of it will be translated and published later in a special edition.
- Stay tuned to this page for more information, updates and maybe some new extra bonus projects.

How to order special components



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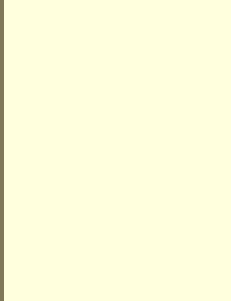
In the US you can buy these books from many Märklin dealers, from Highland Station (Model Railroading Magazine) and from some other well-stocked model railroad shops, see the list!

Normal retail price in the US is \$ 18,75 each for book 1, 2, 3,4, 5 and 6. Same price for **Digital Command Control**.

If you live outside the US you can order direct from Sweden or from a local distributor. Order via fax to int + 46 899 8866 or by e-mail to the publisher. Mention your Visa/Mastercard/AMEX number and expire date.

If you are in Stockholm you can visit the shop Hobbybokhandeln at Pipersgatan 25 (behind Hotel Amaranter) where all of our books are on sale.

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Peak Electronics, Inc. provides top quality battery maintenance products and radio accessories to the discriminating modeler.

Peak Electronics, Inc. was formed in March 2000 for the express purpose of purchasing "Sirius Electronics", which we acquired in April 2000. We moved the business from Beaverton, Oregon to Poway, CA.

In April 2001 we acquired "Custom Electronics" of Higginsville, MO and moved it to our facility in Poway, CA.

We continued to operate the businesses from that location until Oct. 2003, at which time we moved the operation to Gilbert, AZ. We are continuing to operate and grow from this facility.

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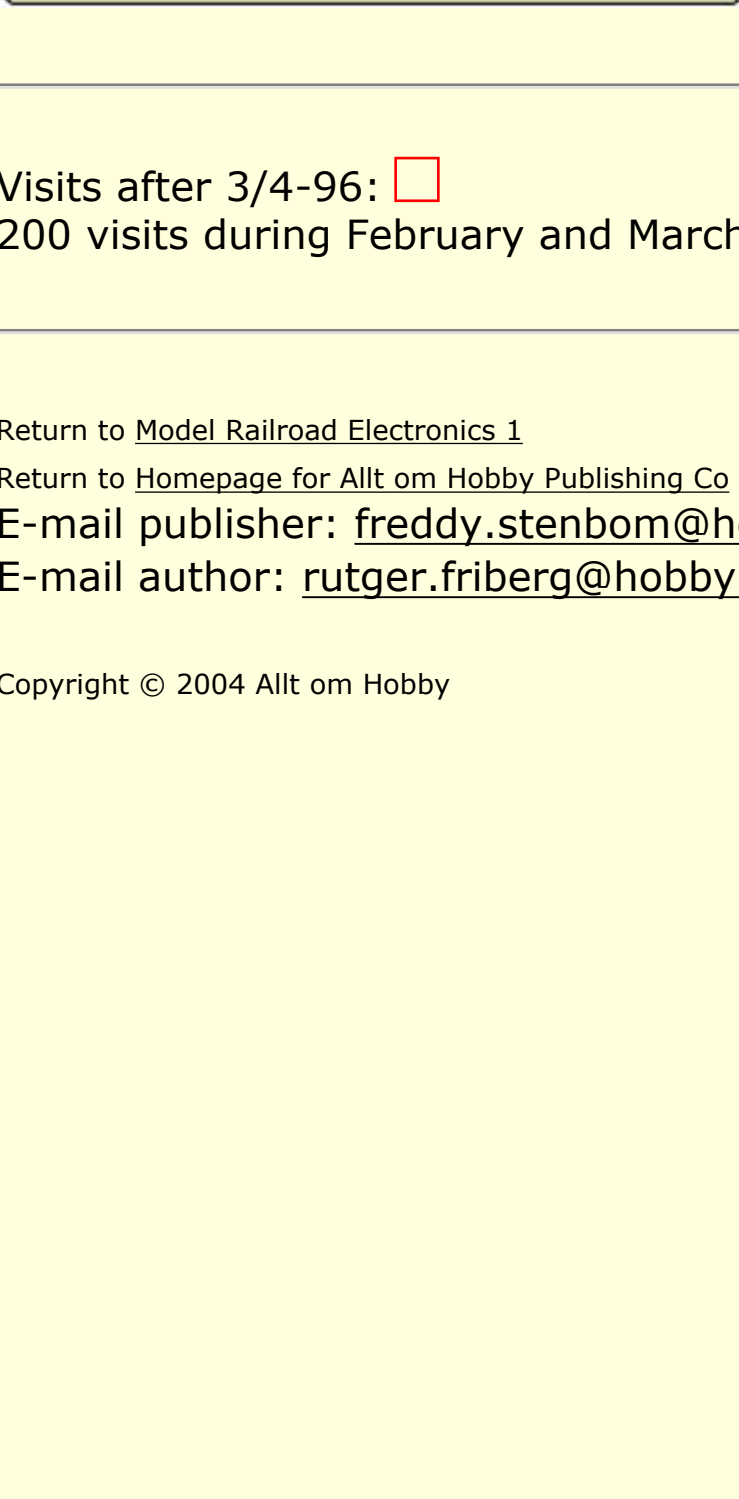
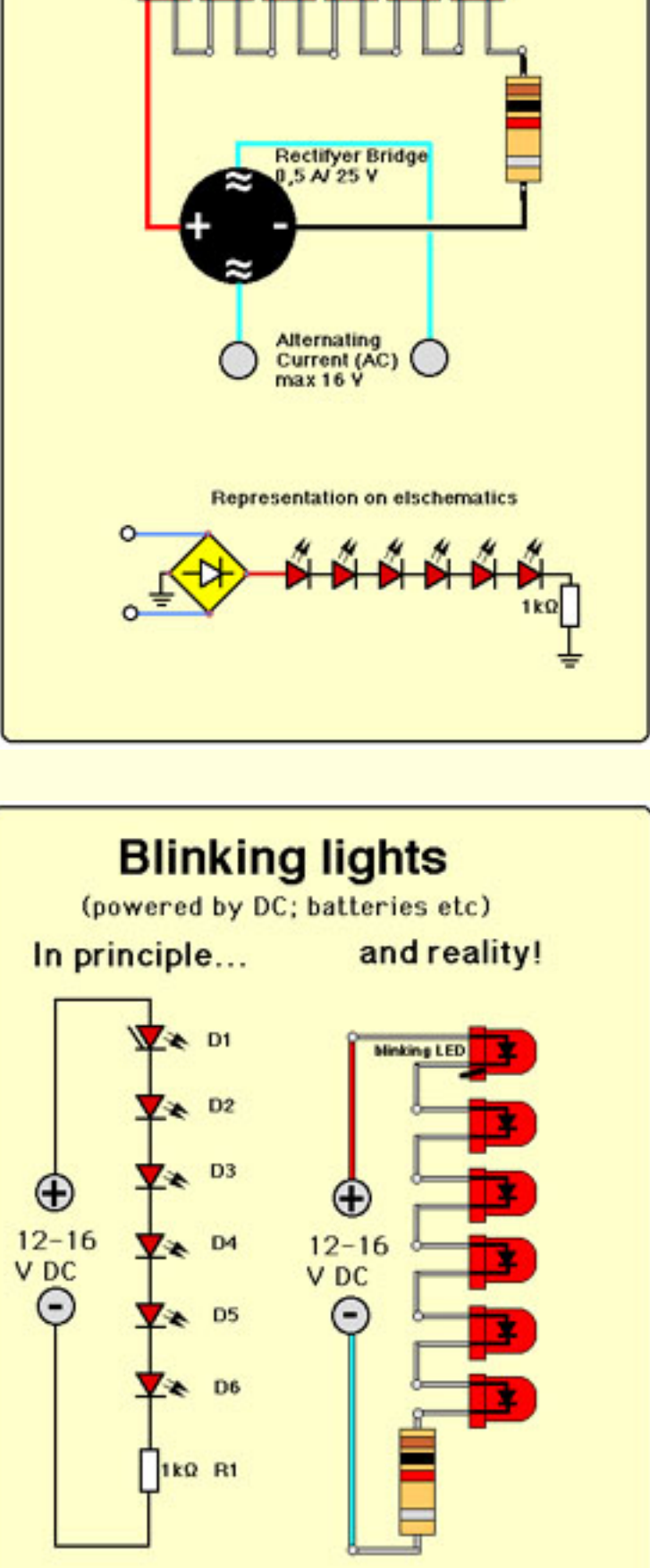
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Demonstration project no 1

- extra bonus project for buyers of Model Railroad Electronics 1

Blinking lights

powered by AC, DC and batteries



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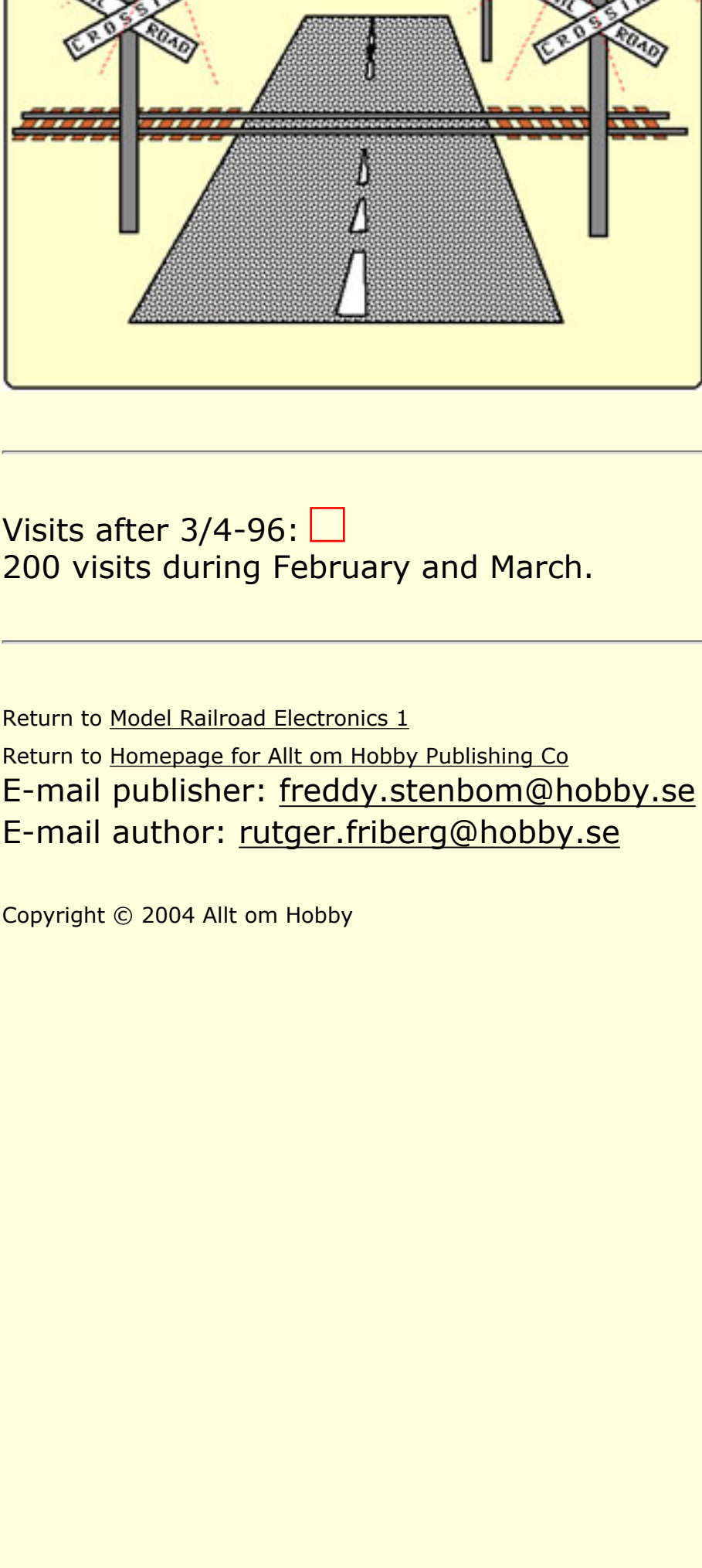
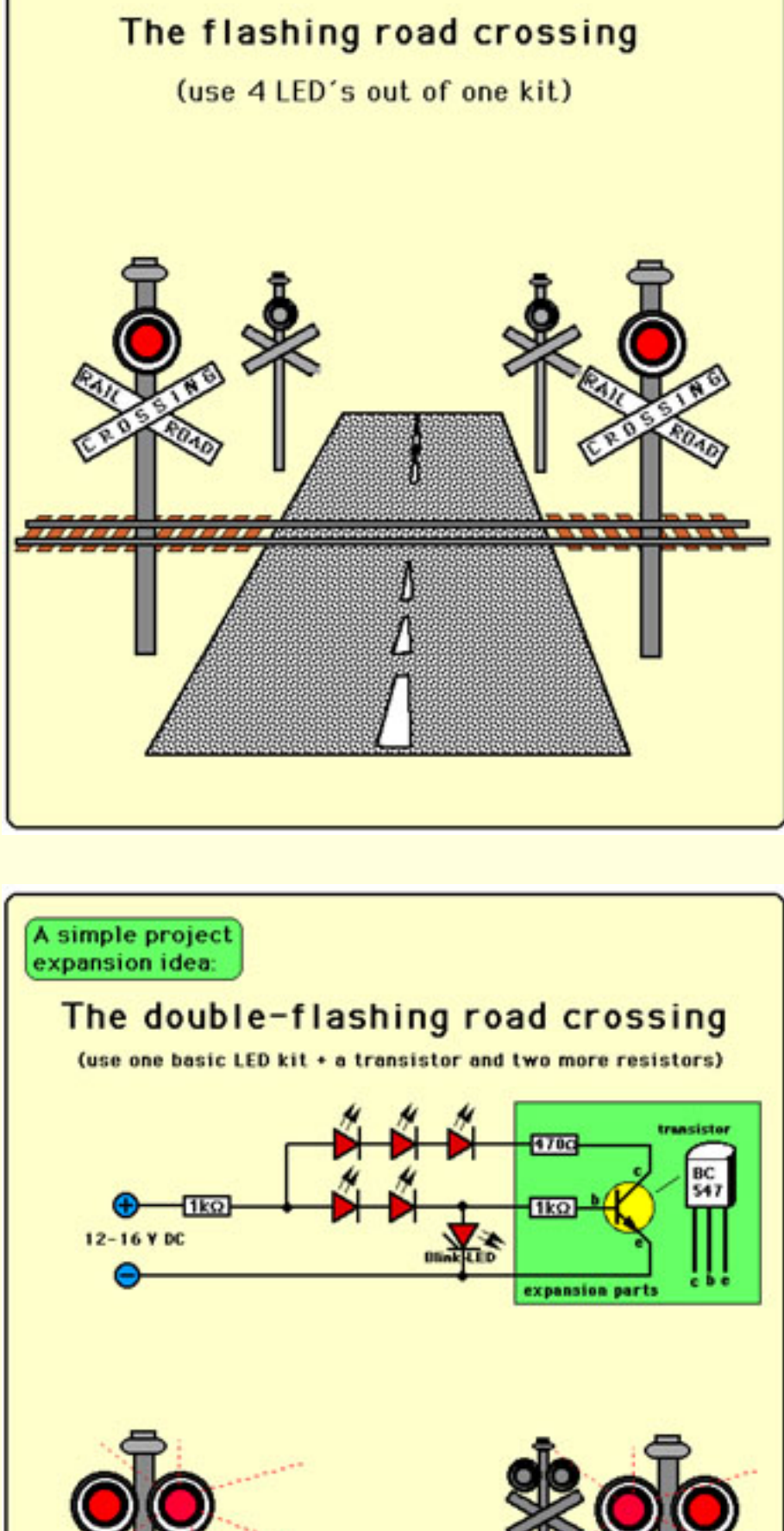
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Demonstration project no 2

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Flashing railroad crossing



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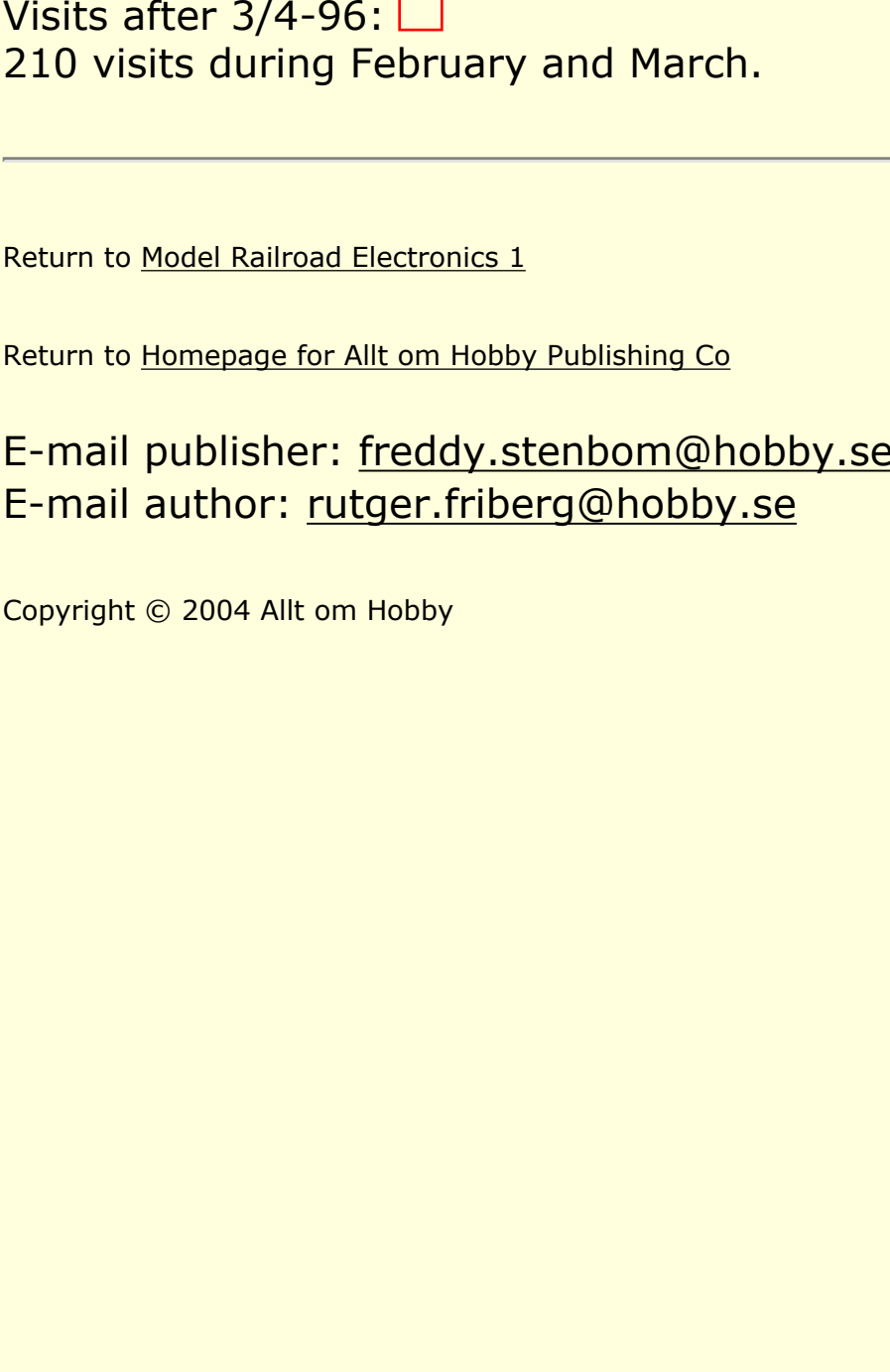
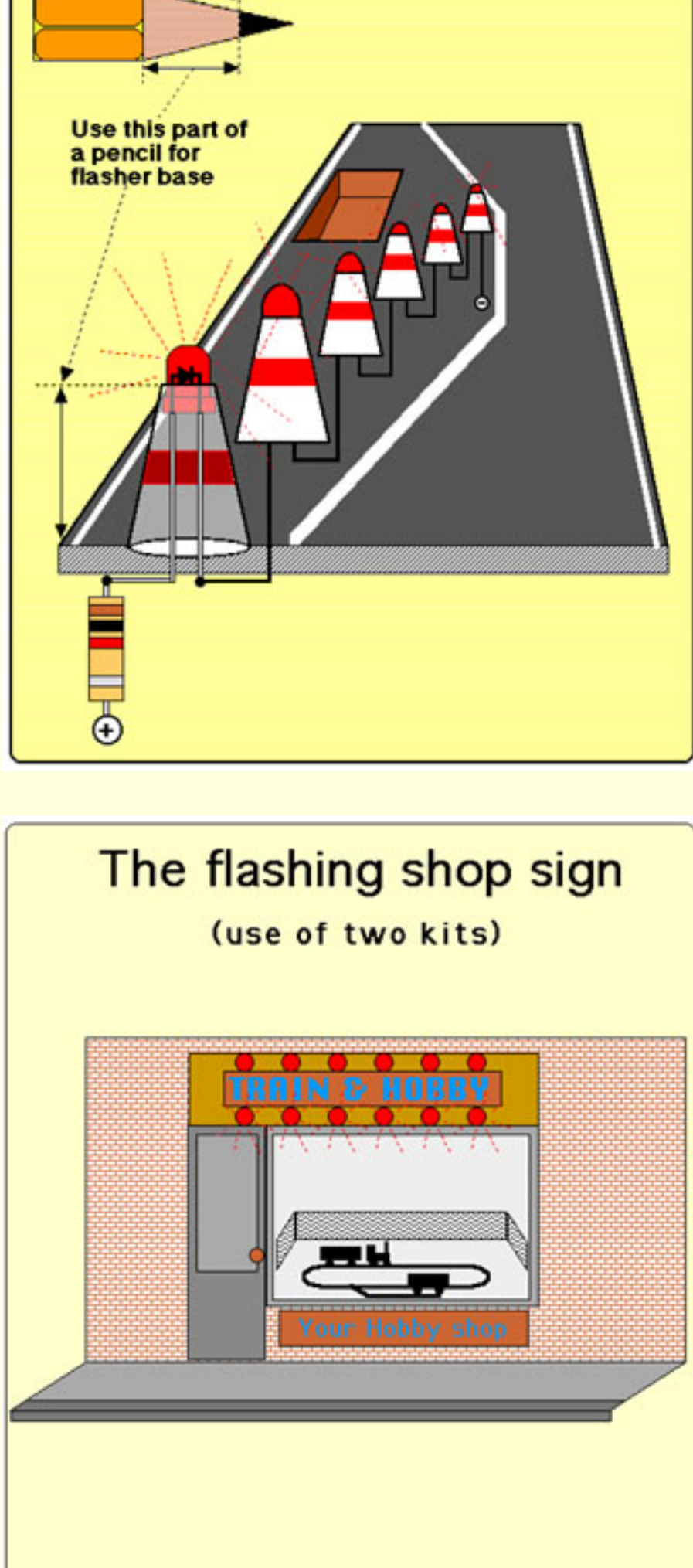
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Demonstration project no 3

- extra bonus project for buyers of Model Railroad Electronics 1

Flashing lights

for roadwork warning and shop sign



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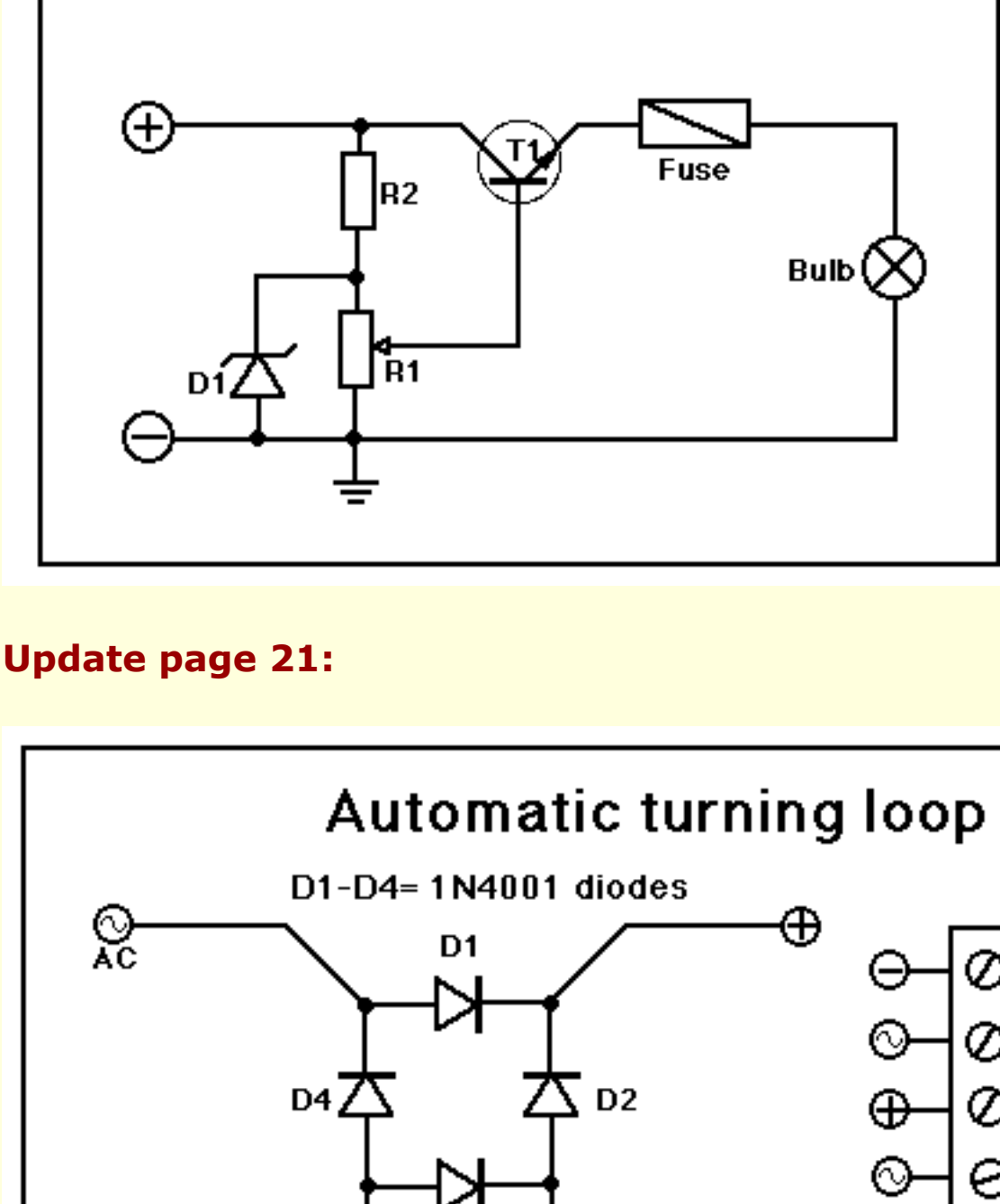
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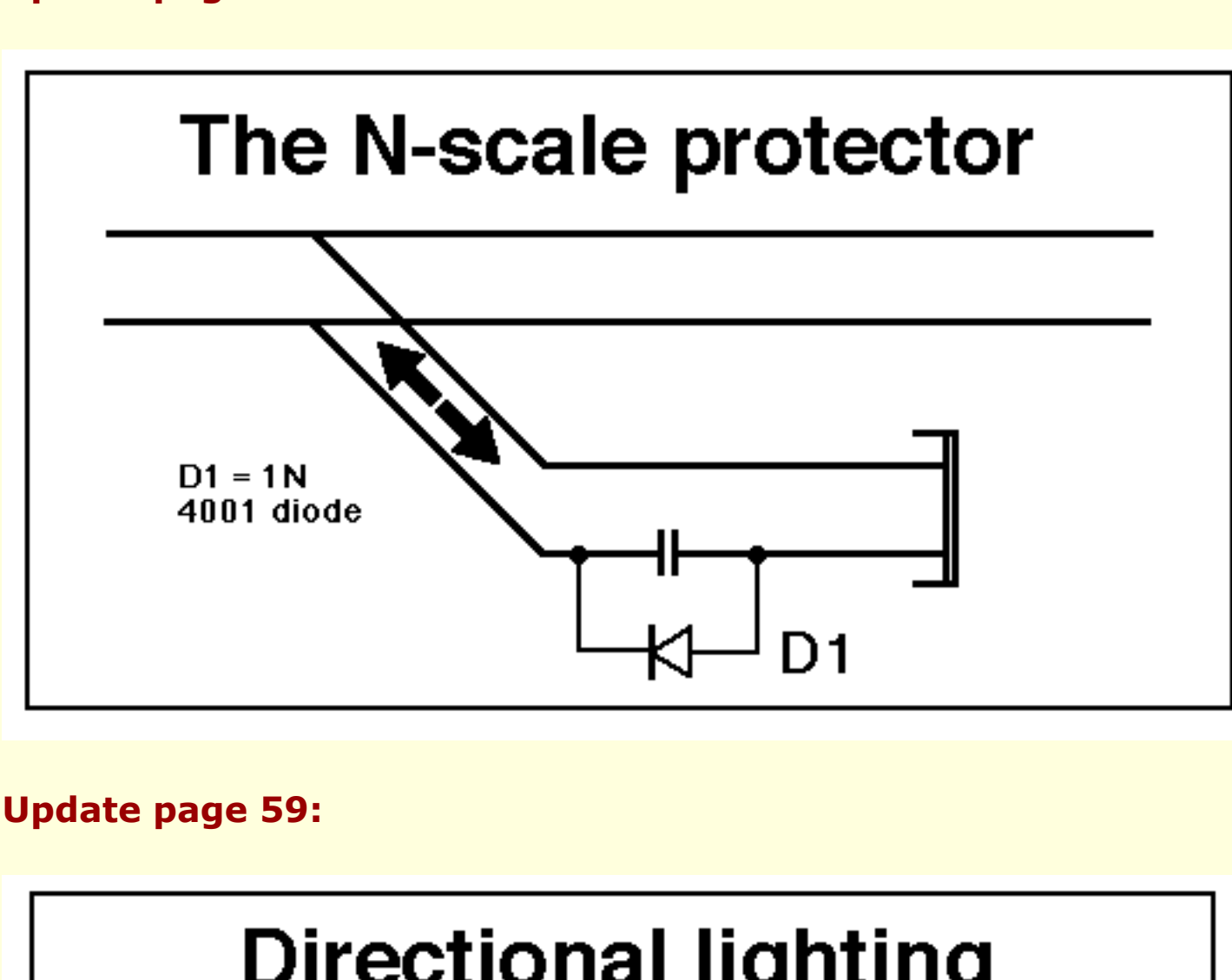
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12 Current limiter
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18 Status indicator and reverser
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80 Signal construction
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89 **COMPONENT DESCRIPTIONS**

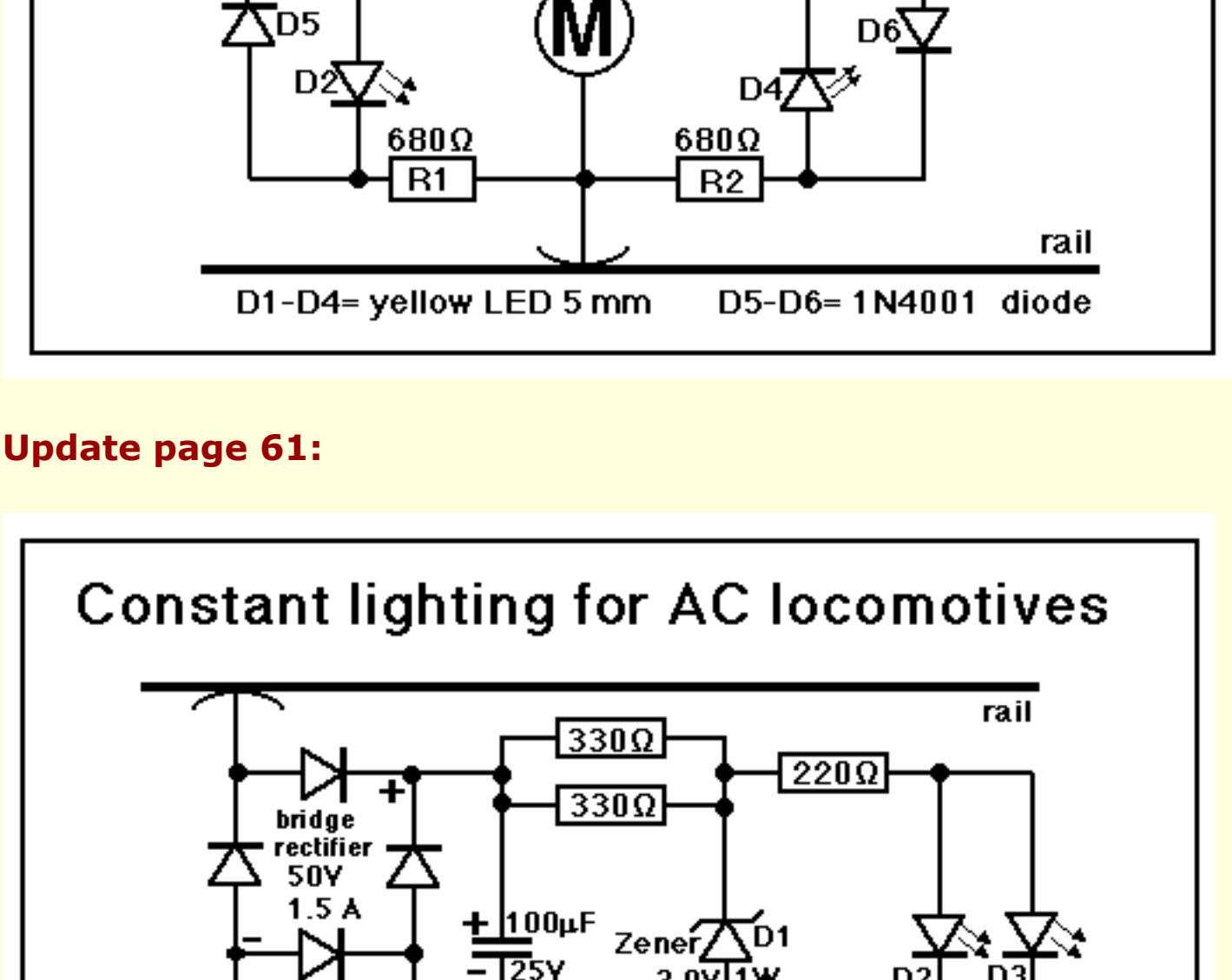
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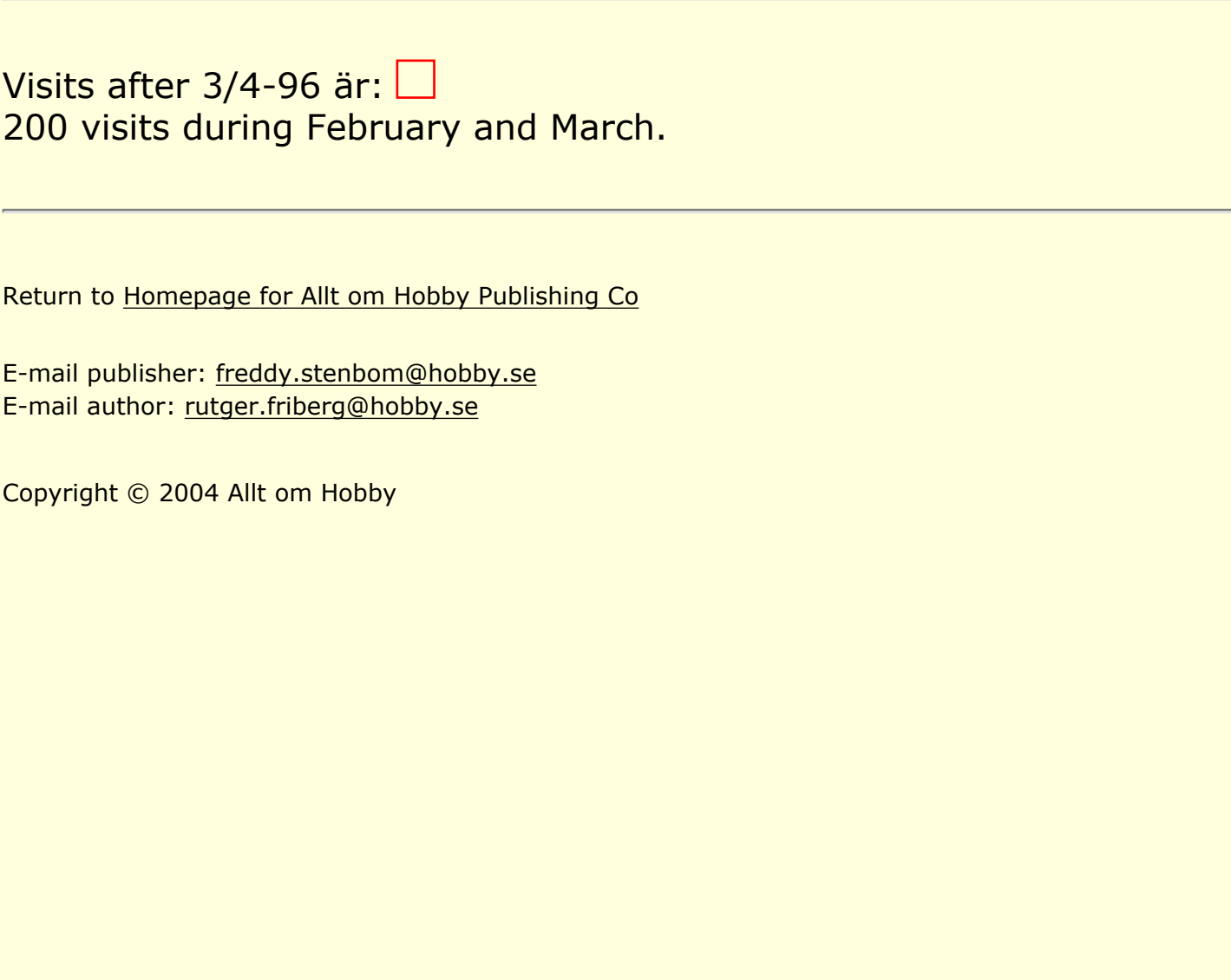
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Demonstration project no 1

- extra bonus project for buyers of Model Railroad Electronics 2

F1-F4 Functions Tester

As remarked earlier there is in the book an extensive tester T80 for the Marklin digital system in H0. It is one of the major projects and it is supposed to be assembled on a premade PCB.

This project , which comes additional to the DIY-projects in the book has unique testing capability in that it can extract the extra functions signals from the engine code and indicate those in a simple manner. So it is a complement to the T80 and very simple to build. Totally 16 discrete components and an IC are soldered together on a piece of experimental board (i.e. Veroboard) and you get this module to operate.

The DIL selector is electrically a 4 times SPDT which gives the input pins 1-4 each a choice of signal ground (= logic LOW), or open, or IC-plus (= logic HI). That corresponds to the selector of the T 80 and more theoretical explanations may be found in that section of the book. There is also a complete code guide in the book should you have lost the one that came with the Marklin central control unit. Please note that in this project the pin #5 of IC1 is connected to IC-plus.

To get the right voltage level for the module there is a zener diode D1 parallel to a capacitor C1. Additional voltage drop is achieved through D2 (also rectifying the power) and R4. In order to get correct timing for the IC there are two oscillators R2-C3 and R3-C2. More detailed theory on how to calculate their values is found at the end of the book in the components section.

Finally to four of the outputs there are LED ´s connected and two current limiting resistors in series with them.

How to use the tester

Start with power off and connect each clip to appropriate rail (red to center rail and brown to one of the outer rails on the track).

Next power up the system to be tested. Now is a good time to select the correct engine code both on the tester and on the central control / control 80f. If power is correctly distributed to the track (red light on central unit is lit) and you have matching codes, you should now be able use the F1 through F4 function keys on the control 80f and get appropriate LED on the tester to be lit. Any combination should be possible to lite up. By this "signature" of light you will get a feedback from track that a matching address code is distributed and that wanted data commands also get through. So it is likely that the code and power is correct. If nothing shows on the display do check that the transmitted engine code (selected via the keys 0-9 on control 80f-unit) is the same as the received code (selected via the DIL-switch on the tester). If that still doesn't help then the code is simply not present for the tester to read.



Parts List - Functions Tester

IC1 MC 145027 Motorola chip
D1 8.2 V Zener Diode 0.4 W
D2 1N4001 Diode

D3-D6 5 mm red LED
C1 10V / 16V electrolythic Cap
C2 2.2 nF Capacitor
C3 4.7 nF Capacitor

R1-R2 270 kOmega 1/8 W Resistor
R3 12 kOmega 1/8 W Resistor
R4 2.7 kOmega 1/8 W Resistor
R5-R6 150 Omega 1/8 W Resistor

ECS Selector DIL-switch
PCB Experimental PC-board

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Demonstration project no 2

extra bonus project for buyers of Model Railroad Electronics 2

Engine Code Tester

The book reveals a full flavour all functions tester T80 for the Marklin digital system in H0. That is one of the major projects and it is supposed to be assembled on a premade PCB.

This project comes additional to the DIY-projects in the book. It is an economy version of the T80 and very simple to build. Totally 15 discrete components and an IC are soldered together on a piece of experimental board (i.e. Veroboard) and you get this module to operate.

The DIL selector is electrically a 4 times SPDT which gives the input pins 1-4 each a choice of signal ground (= logic LOW), or open, or IC-plus (= logic HI). That corresponds to the selector of the T 80 and more theoretical explanations may be found in that section of the book. There is also a complete code guide in the book should you have lost the one that came with the Marklin central control unit. Please note that in this project the pin #5 of IC1 is grounded.

To get the right voltage level for the module there is a zener diode D1 parallel to a capacitor C1. Additional voltage drop is achieved through D2 (also rectifying the power) and R4. In order to get correct timing for the IC there are two oscillators R2-C3 and R3-C2. More detailed theory on how to calculate their values is found at the end of the book in the components section.

Finally to three of the outputs there are LED´s connected and current limiting resistors in series with them.

How to use the tester

Start with power off and connect each clip to appropriate rail (red to center rail and brown to one of the outer rails on the track).

Next power up the system to be tested. Now is a good time to select the correct code both on the tester and on the central control / control 80f. If power is correctly distributed to the track (red light on central unit is lit) and you have matching codes the orange LED should be ON. You should now be able to rotate the speed knob and get various light combinations on the green and red LED´s. A reverse command by the knob should produce a red light, and most speedsteps will be indicated.

By this "signature" of light you will get a feedback from track that a matching address code is distributed and that various data commands also get through. So it is likely that the code and power is correct. If nothing shows on the display do try the OFF- Light key on the central unit. If that still doesn't help then the code is simply not present for the tester to read.

Engine CodeTester-El

Parts List - Engine Code Tester

IC1 MC 145027 Motorola chip
D1 8.2 V Zener Diode 0.4 W
D2 1N4001 Diode
D3 5 mm red LED
D4 5 mm green LED
D5 5 mm orange LED
C1 10V / 16V electrolytic Cap
C2 2.2 nF Capacitor
C3 4.7 nF Capacitor
R1-R2 270 kΩ 1/8 W Resistor
R3 12 kΩ 1/8 W Resistor
R4 2.7 kΩ 1/8 W Resistor
R5 470 Ω 1/8 W Resistor
R6 150 Ω 1/8 W Resistor
ECS Selector DIL-switch
PCB Experimental PC-board

Visits after 3/4-96:
200 visits during February and March.

Return to Model Railroad Electronics 2

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Demonstration project no 3

- extra bonus project for buyers of Model Railroad Electronics 2

Sound Control Decoder

from a Hallmark greating card

There are several decoders in the book as Do-It-Yourself projects. Perhaps no-one is as simple as the one revealed here. Certainly this project is unique by its sound performance. Today on the market there are several electronic greeting cards (EGC's), intended for you through your recorded voice and via mail to reach someone to hear it and be celebrated.

This project , which comes additional to the DIY-projects in the book, makes use of the most common EGC on the market, the Hallmark greeting card, the so called Chipcorder with unique voice and sound recording IC from ISD Technology (US). For this project the EGC:s for about 8 USD. Totally 9 discrete components , an IC and parts from the EGC are soldered together on a piece of expermental board (i.e. Veroboard) and you get this module to operate.

The DIL selector is electrically a 4 times SPDT which gives the input pins 1-4 each a choice of signal ground (= logic LOW), or open, or IC-plus (= logic HI). That corresponds to the selector of most of the decoders in the book and more theoretical explanations are frequently found in the book. There is also a complete code guide in the book should you have lost the one that came with the Marklin central control unit. Please note that in this project the pin #5 of IC1 is connected to IC-plus.

In order to make the decoder as compact as possible you might want to omit the selector and make a once-for all choice of the code. Once you have done that selection simply connect each of the pins #1-4 to appropriate logic level.

To get the right voltage level for the decoder there is a zener diode D1 parallel to a capacitor C1. Additional voltage drop is achieved through D2 (also rectifying the power) and R4. In order to get correct timing for the IC there are two oscillators R2-C3 and R3-C2. More detailed theory on how to calculate their values is found at the end of the book in the components section.

How to connect the electronic greeting card The first thing to do is to record the sound you later want to be able to remote control. It might be a voice message. But it may also be a specific sound that you already have recorded on tape or (the best) on a CD.

Let's assume that you have the wanted sound recorded "onboard". For your information the EGC comes with a small battery pack of 4 x 1.5 V button cells, and the recorded sound will not disappear even if the power is disconnected for very long periods of time.

Disassemble the EGC and save the EGC- module together with loudspeaker and battery pack. Note that the activator when opening the card has one black lead and one green. Those two are to be connected to our decoder, as shown on the elschematics. If you are familiar with electronics you can also make a power connection via a 7805 voltage regulator IC and thereby omitting the battery pack. However you should know that the pack is very powerful and will give you a substantial number of "sound shots".

Also note that we in this project use the F1-key which is equal to the pin #15 connection. You might want to use any of the other keys F2-F3 then instead selecting pins # 12-14.

How to use the decoder

Before installing the decoder just make a simple test. Connect it to where it is most easy on the layout. This might just be directly to the outputs of the central unit /central control. Be sure to match correct colors on the clips, since the IC 1 (although not getting lost) is particular about polarity.

Let us for a second assume that on the selector of the decoder you left all pins # 1-3 open and only grounded pin #4. That is then equivalent as engine code 26. So on control 80f you should now key in #26 and then use the F1 key.

If it works as intended you should now hear the sound, and it will be played through one full cycle (about 10 seconds). Certain sounds, such as whistles and bells, you might want to control in length of playing time. Simply by pressing the F1 key once more the sound will stop immediately, and it is on the spot ready to be played from start again by yet another press on the F1-button.

The tiny combination of decoder and sound module may be mounted within cars and coaches, as well as stationary anywhere on the layout. Simply make sure that it is connected to the digital bus coming from the Marklin Central unit (= nearest track). You may want to select a smaller loudspeaker to be able to mount it inside a car or coach. In that case use a 8 ohm loudspeaker and try to glue it firmly to the chassi of the car, not leaving too much of open holes around it where vibrating "air" can spill through from front to back of the membrane (you loose sound power that way).



Parts List - Sound Control Decoder

- IC1 MC 145027 Motorola chip
- IC2 Hallmark Electronic Greeting Card (Chipcorder)
- D1 8.2 V Zener Diode 0.4 W
- D2 1N4001 Diode
- C1 10V / 16V electrolytic Cap
- C2 2.2 nF Capacitor
- C3 4.7 nF Capacitor
- R1-R2 270 kOmega 1/8 W Resistor
- R3 12 kOmega 1/8 W Resistor
- R4 2.7 kOmega 1/8 W Resistor
- ECS Selector DIL-switch
- PCB Expermental PC-board
- LS Your choice of Loudspeaker

Visits after 3/4-96: ☐
210 visits during February and March.

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E-mail publisher: reddy.stenbom@hobby.se
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Welcome to Rutger Friberg's world of Model Railroad Electronics

The Magic Engine - litt Tb

Extract from the book "Model Railroad Electronics 2" A unique model of litt Tb from Swedish Rail:

88 tons and a built-in turntable

Wintertime i Northern Sweden, above the Arctic circle. Snow depth is well over 1,5 meter. The export route via rail for iron ore to Narvik i Norway must be kept open. That's the task for the Tb-engine!

Litt TB is unique. It´s a giant engine with plows and it is the only loco in the world with built-in jack-up turntable to actually turn around on the track and settle for homebase if it gets stuck in to heavy snow.

The model is unique. It´s built in H0 and has the same functions as the original - remotely controlled from the manoeuvre panel. The model is scratch built and one of its kind. The project was only possible through use of latest fine mechanics, new driveline ideas and the Märklin Digital technology.

This has always been my dream project No.1. I have kept it for years in my "secret drawer" and it has until now not been possible to realise from a technical point of view.

First there was no H0-model from any manufacturer. Second there was no design for a built-in jackup turntable in H0; third reason was that electronic components used to be too big, and last but not least; the need for a DCC (digital command control) remote control system such as Märklin Digital.

Finally there is SMD, the surface mount technology with very small components. But still big enough for a hobbyist to build control modules yourself with normal available tools and soldering station. And with the help of the eminent Märklin Digital it was possible to build in very tiny modules to control not least than 3 electric motors, normal front and tail lights, and special side flash lights.



The dream formula is found

I am not a true modeler. I don't have the skills and patience to sculpture every rivet and bolt, every bar and handle that have to be there. Still I wanted to realise this project and therefore with some help made a prototype out of plexi and glued the parts together. Now professionally made H0-models of the Tb are found in Swedish hobby shops, and they are in fact much better detailed than my prototype. My model is hand painted and all details are simulated via "Lettraset" and "Formaline Graphic Art Tape".

The most critical mechanical problem was to design the jackup turntable, using one Robbe (Kleinstgetriebemotor) motor No. 4125 for the lifting operation and a Graupner motor with gear ratio 1670 :1 (6V) for the turntable. Total inner width was only 18 mm, thereby creating difficulties since the motors had almost same size and needed to be mounted off centre in order to let gears be positioned correctly.

The Swedish company NOHAB manufactured the litt Tb based upon chassi from T43, a classic diesel engine of the Swedish Rail. So I also based my model on the same original. Luckily enough Lima has a T43 in its standard stock and parts from such a sample were used. Photos enclosed to this article show how the chassi was cut in half and prolonged via a brass middle section, hosting the jackup turntable.

No space for the driveline motor!

The original Lima design uses a rather big electric motor inside the cockpit of the turntable, since this is the only part being in design and cockpit is too far front to allow space for the motor and the weight of it.

The solution was a powered low profile motortruck from Tenshodo, that would fit under the chassi, letting the interior space for electronics The second truck was used as is, mainly hosting the pickup shoe for the middle rail in the Märklin system.

Early tests of the lifting and turning mechanisms were conducted with all electronics exterior to the engine itself (see pictures). Suddenly a new problem was identified in that the current supply was cut in that very moment when the pickup shoe was lifted high enough to leave the middle rail. All functions died and it wasn't even a simple task to bring the engine down again. A separate wire had to be connected until a more permanent solution was found.

A second pickup shoe was designed and mounted on the lower crossbar of the turntable, since this is the only part being in contact with the track during the turning operation.

Further the lifting mechanism had to be redesigned during the building process since the ordinary pickup shoe, hanging down a few millimetres extra to make good contact with the lower middle rail, otherwise would make a short circuit towards the outer rail when the loco was being turned around. From a demonstration point of view it is the worst thing to happen if getting a short at this point.

Specially designed decoder

Having moved the main motor down to the truck itself made it possible to host a Märklin C81 decoder inside the cover in the aft part. Still there were two other motors that needed remote control and this created new problems to be solved due to following reasons. One is obvious since the space was very limited. The other was about voltage. Märklin decoder output is around 17 volts and the available motors only accepted 6 volts. Besides that the C81 decoder uses PWM (pulse width modulation) output, meaning that pulses of full voltage occur always, even when motor should run very slowly. That's perfect for ordinary motors, but disastrous for these tiny motors. Finally there was another obstacle. Let's pretend that each motor was controlled via a C 81 decoder. When operating the Control 80 f that would mean having to change address number all the time on a single control unit, or investing in several (at least three) units for this operation.

So the solution was to build a unique and very tiny decoder with capacity to control two motors and operated via the Keyboard. The keyboard offers rapid change of commands, but you need to adjust the voltage output in such a way that the ON-OFF operation is acceptable for a smooth turntable operation. Maybe in the future I can revert to this topic and show the special decoder in another editorial.

Some experiences from frequent demonstrations

Let me briefly address a few of the problems that have occurred and needed special attention. Flashlights on each side of the loco are supposed to be kept on during the whole turnaround progress. So I needed one more extra function and a bistable minirelay inside to provide that. This was a difficult task to perform since it was an add-on coming afterwards.

Secondly you must keep the trucks absolutely aligned throughout the whole lifting and turnaround process. Otherwise the wheels wont fit onto the track but will stay aside of the rails. after many different experiments I found a simple but reliable solution. A very tiny spring (in fact the smallest Märklin spring for a coupler) has enough force to pull the truck in line when in the air, but still when the engine is normally running, let the truck turn in curves.

For full information about this project and components list - please consult the book!

Click [here](#) to get additional information and graphics about this project (will take some time to load).

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Visits after 3/4-96: ☐
100 visits during March.

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THE PROJECT SHOP

- Line car with an animated platform
- Hopper with TELEX couplers
- RR crane project
- Remote control car illumination
- Additional ideas

COMPONENT DESCRIPTIONS

This prop saver was invented by [Claus Urbach](#) from Germany ! Thanks a lot for the idea !
 It will save the propellar and motor shaft when landing harder than expected,
 on some electric models landing gear is not an option so this saver is the only way.
 This prop-saver can be used with brushless and normal electric motors. **DANGER: NEWER WITH GLOW ENGINES !!!**



Here is the idea sheet, approved be the inventor him self.
 remember to cover the M3 thread with some heatshrinking tube, to protect the rubber gasket that holds the prop.



The M3 screws I used are 10mm length



The top part where the prop is fitted is made so the prop fits exactly !
 remember to make it so the prop is easy to bend over to the side



Note the bottom part is hollowed out so the edge can touch the motor base
 This is also important in serious crashes.



See the plastic tube pressed over the screws, where the thick rubber gasket is mounted.



Mounted on small Speed 300 motor



make sure there is a gap from the saver to motor, about 0.2mm



Important: When you press on the saver, it will touch the motor base part, not the bearing.



Little 5.7 x 3 prop mounted.



See this looks really prof.



Close up from top.



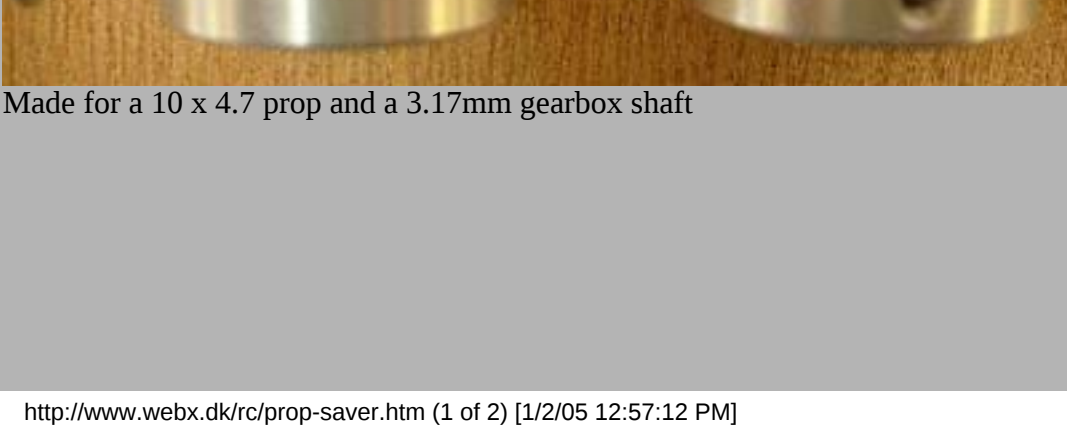
The black type is a bit more strong, and not so elastic; compared to the red one.



24mm diameter



25mm diameter, measured at center.



Prop mounting area is 13mm diameter.

Prop mounting area height is 5.6mm.

The propellar I use for this example is a Robbe 5.7 x 3 (cost about 5 EUR)

Motor shaft is 2.0 mm diameter.

Warning: When working with propellers extra caution must be taken !
 if your prop does for fit perfectly or your rubber band is old, REPLACE and fix it !!
 Else you might injure somebody with a flying prop or parts from it !
 Use the information found on this page at your own risk, it is your responsibility to make it safe.
 Also make sure battery power is DISCONNECTED before you get your fingers near a prop on a plane,
 Just shutting OFF or GAS=None with your transmitter is NOT save.
 Imagine what happens if a radio disturbance suddenly gives a max speed code to your reciever !!
 Think Think and Think again; about all the possible things that maybe can go wrong what ever you do.

Made June 2003 OZ2CPU.

Some examples from flying planes:
 Pictures and planes property Claus Urbach.

Brushless.

Brushless 10 x 4.7 prop.

Made for a 10 x 4.7 prop and a 3.17mm gearbox shaft

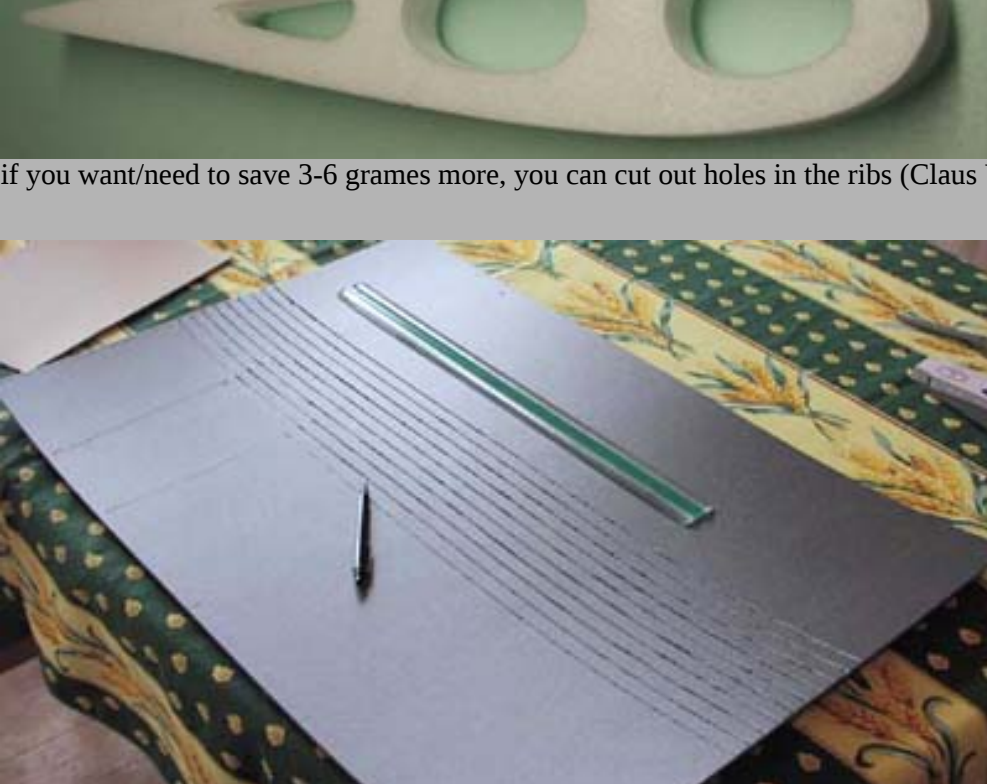


Speed 400 with gearbox:





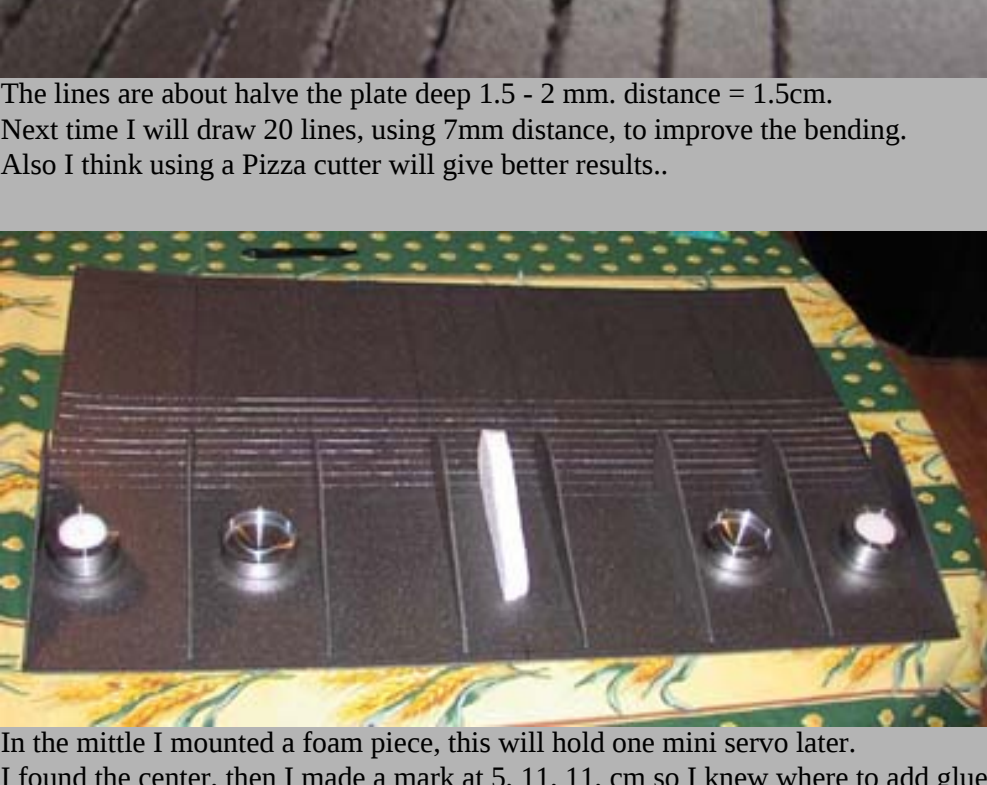
You need a lot of space.



Be carefull when cutting out all the wing ribs, I use 8 so I get extra crash protection :-)
Others that know how to fly and land safe, can use 3-4 ribs.



if you want/need to save 3-6 grames more, you can cut out holes in the ribs (Claus Urbach)



I just draw 10 deep lines using a pen, so the Depron plate can bend without cracking.



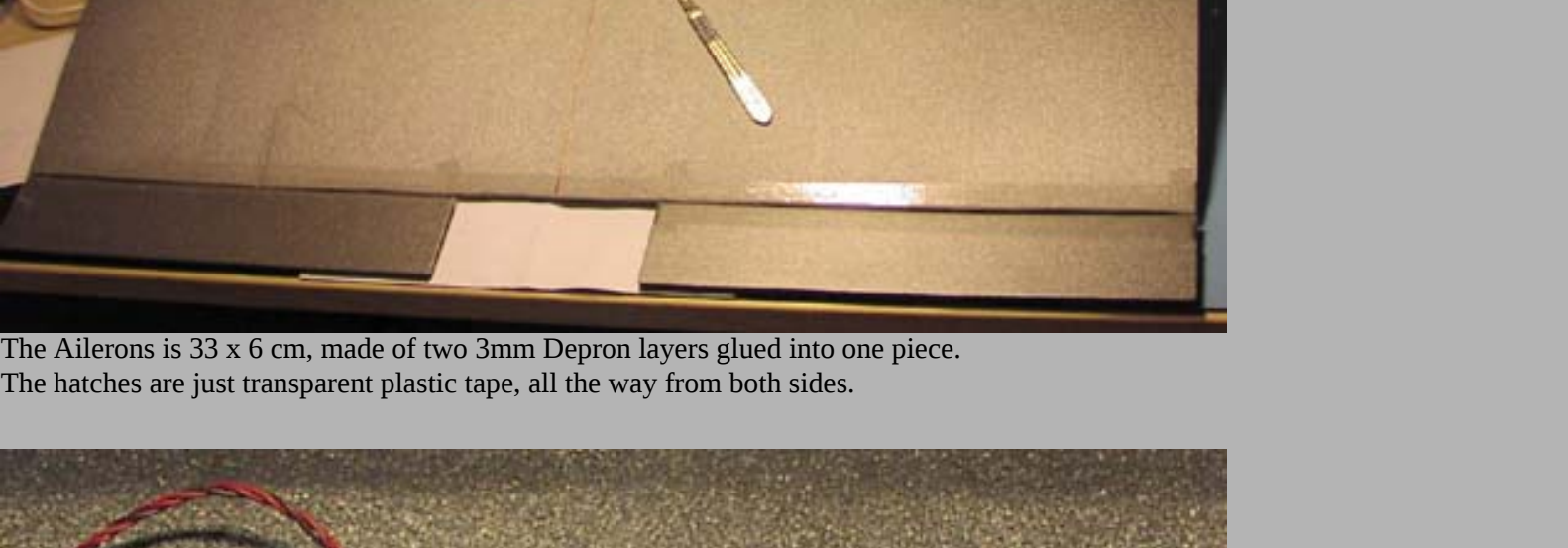
The lines are about halve the plate deep 1.5 - 2 mm. distance = 1.5cm.
Next time I will draw 20 lines, using 7mm distance, to improve the bending.

Also I think using a Pizza cutter will give better results..

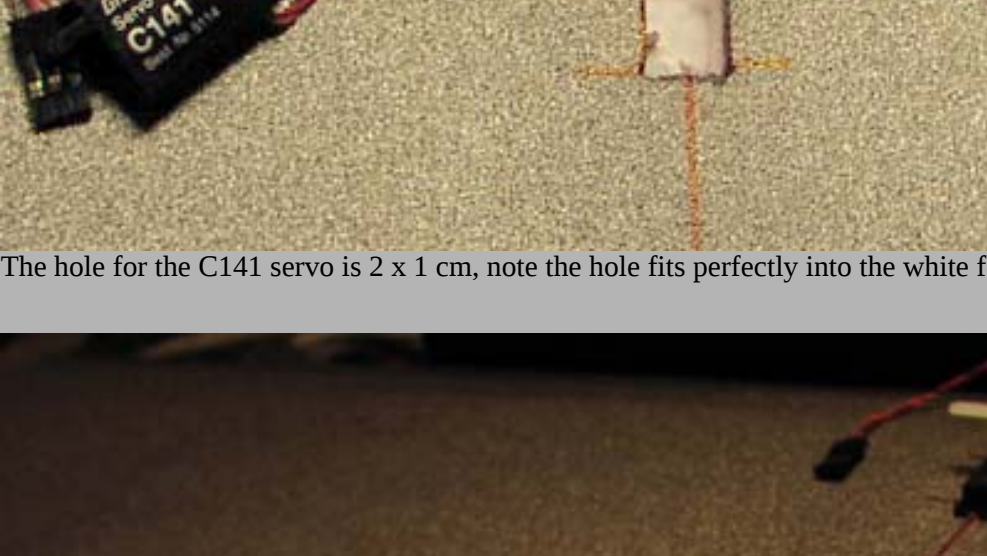


In the mittle I mounted a foam piece, this will hold one mini servo later.

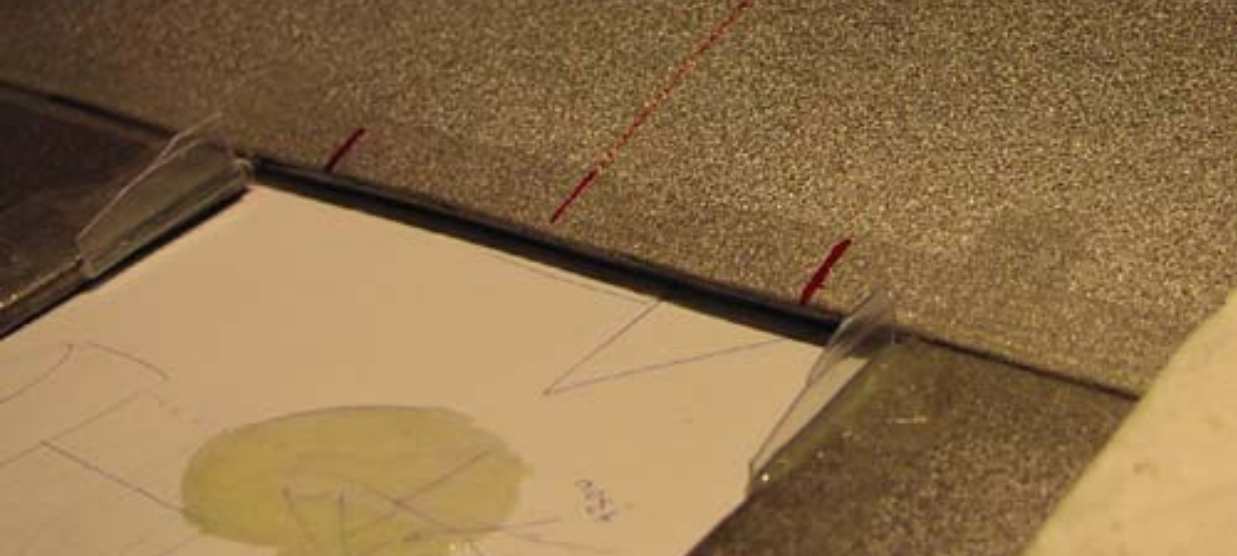
I found the center, then I made a mark at 5, 11, 11, cm so I knew where to add glue later.



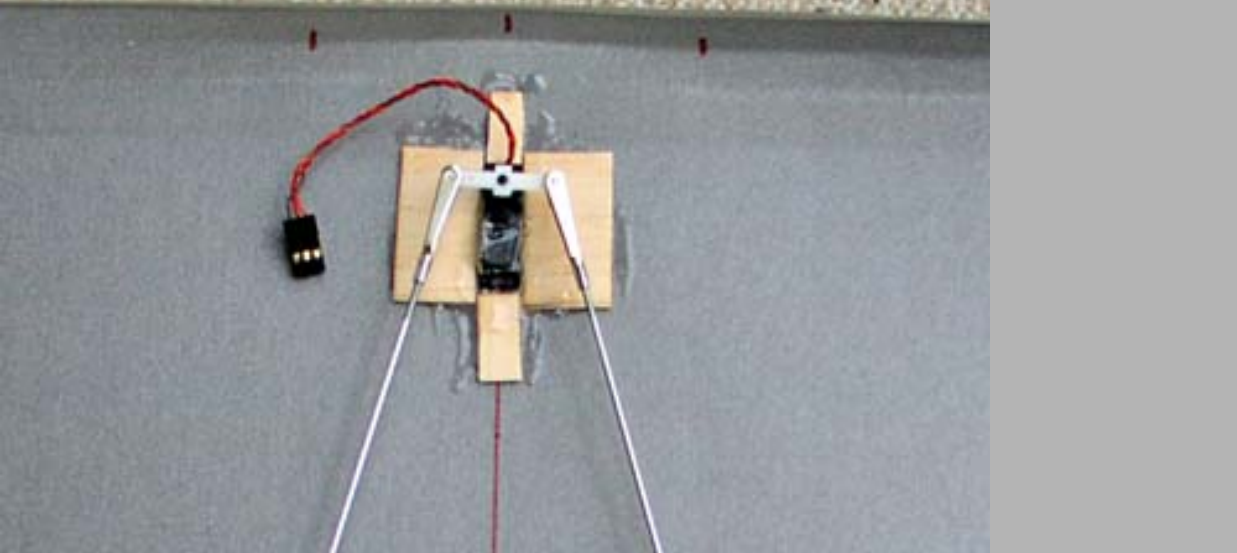
After gluing and bending I just took whatever closest to me to hold it for a while.
This wing weight = 65 Grames, Spanwidth = 80 cm, Length = 25, Thickness max = 6 cm



This parkpilot wing weight 75 Grames, I have tried to let them both fall down from 2m height;
the Depron wing falls at almost double the time !!, so more area and less weight is important
when you want to design a plane that can fly slow and save battery power :-)



The Ailerons is 33 x 6 cm, made of two 3mm Depron layers glued into one piece.
The hatches are just transparent plastic tape, all the way from both sides.



The hole for the C141 servo is 2 x 1 cm, note the hole fits perfectly into the white foam inside.



At the inside edge of both ailerons I glued two small pieces of thin plastic using epoxy,
two long piano wires will connect to this point from each side of the servo.
The red markings indicate that here are ribs inside, I will offcourse mount the rubberbands here later.



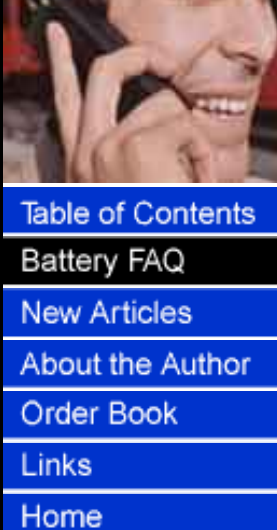
Servo is covered with tape before adding epoxy, if I later need the servo for another project it is easy to save it.
The small balsa wood is to make the servo mounting more strong.

I will glue small balsa pieces onto the red mounting marks to make it much stronger.



Complete wing all included = 100 Grames. A bit more than expected. But still fine, I hoped for 90 grames.

[video clip Quicktime](#) 800kb See how fast and good it works, incl transmitter stick movement



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BATTERIES
IN A PORTABLE WORLD
Handbook on
Rechargeable
Batteries for
Non-Engineers

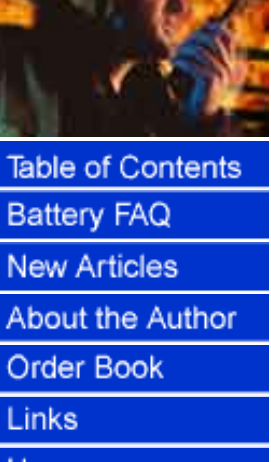


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Chapter 2: Battery Chemistries

Battery novices often argue that advanced battery systems are now available that offer very high energy densities, deliver 1000 charge/discharge cycles and are paper thin. These attributes are indeed achievable — unfortunately not in the same battery pack. A given battery may be designed for small size and long runtime, but this pack would have a limited cycle life. Another battery may be built for durability, but it would be big and bulky. A third pack may have high energy density and long durability, but would be too expensive for the commercial consumer.

Battery manufacturers are well aware of customer needs and have responded by offering battery packs that best suit the specific application. The mobile phone industry is an example of this clever adaptation. For this market, the emphasis is placed on small size and high energy density. Longevity comes in second.

The mention of NiMH on a battery pack does not automatically guarantee high energy density. A prismatic NiMH battery for a mobile phone, for example, is made for slim geometry and may only have an energy density of 60Wh/kg. The cycle count for this battery would be limited to around 300. In comparison, a cylindrical NiMH offers energy densities of 80Wh/kg and higher. Still, the cycle count of this battery will be moderate to low. High durability NiMH batteries, which are intended for industrial use and the electric vehicle enduring 1000 discharges to 80 percent depth-of-discharge, are packaged in large cylindrical cells. The energy density on these cells is a modest 70Wh/kg.

Similarly, Li-ion batteries for defense applications are being produced that far exceed the energy density of the commercial equivalent. Unfortunately, these super-high capacity Li-ion batteries are deemed unsafe in the hands of the public. Neither would the general public be able to afford to buy them.

When energy densities and cycle life are mentioned, this book refers to a middle-of-the-road commercial battery that offers a reasonable compromise in size, energy density, cycle life and price. The book excludes miracle batteries that only live in controlled environments.

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BATTERIES

IN A PORTABLE WORLD

Handbook on Rechargeable Batteries for Non-Engineers

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Chapter 6: The Secrets of Battery Runtime

Is the runtime of a portable device directly related to the size of the battery and the energy it can hold? In most cases, the answer is yes. But with digital equipment, the length of time a battery can operate is not necessarily linear to the amount of energy stored in the battery.

In this chapter we examine why the specified runtime of a portable device cannot always be achieved, especially after the battery has aged. We address the four renegades that are affecting the performance of the battery. They are: declining capacity, increasing internal resistance, elevated self-discharge, and premature voltage cut-off on discharge.

Declining Capacity

The amount of charge a battery can hold gradually decreases due to usage, aging and, with some chemistries, lack of maintenance. Specified to deliver about 100 percent capacity when new, the battery eventually requires replacement when the capacity drops to the 70 or 60 percent level. The warranty threshold is typically 80 percent.

The energy storage of a battery can be divided into three imaginary sections consisting of available energy, the empty zone that can be refilled and the rock content that has become unusable. Figure 6-1 illustrates these three sections of a battery.

In nickel-based batteries, the rock content may be in the form of crystalline formation, also known as memory. Deep cycling can often restore the capacity to full service. Also known as 'exercise', a typical cycle consists of one or several discharges to 1V/cell with subsequent discharges.



EMPTY ZONE
can be refilled

AVAILABLE ENERGY

UNUSABLE
can no longer store energy

Figure 6-1: Battery charge capacity.
Three imaginary sections of a battery consisting of available energy, empty zone and rock content.

With usage and age, the rock content grows. Without regular maintenance, the user may end up carrying rocks instead of batteries.

The loss of charge acceptance of the Li-ion/polymer batteries is due to cell oxidation, which occurs naturally during use and as part of aging. Li-ion batteries cannot be restored with cycling or any other external means. The capacity loss is permanent because the metals used in the cells are designated to run for a specific time only and are being consumed during their service life.

Performance degradation of the lead acid battery is often caused by sulfation, a thin layer that forms on the negative cell plates, which inhibits current flow. In addition, there is grid corrosion that sets in on the positive plate. With sealed lead acid batteries, the issue of water permeation, or loss of electrolyte, also comes into play. Sulfation can be reversed to a certain point with cycling and/or topping charge but corrosion and permeation are permanent. Adding water to a sealed lead acid battery may help to restore operation but the long-term results are unpredictable.

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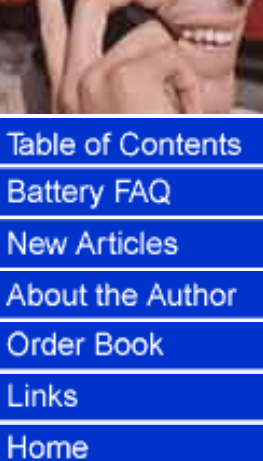


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Chapter 8: Choosing the Right Battery

What causes a battery to wear down — is it mechanical or chemical? The answer is 'both'. A battery is a perishable product that starts deteriorating from the time it leaves the factory. Similar to a spring under tension, a battery seeks to revert to its lowest denominator. The rate of aging is subject to depth of discharge, environmental conditions, charge methods and maintenance procedures (or lack thereof). Each battery chemistry behaves differently in terms of aging and wear through normal use.

What's the best battery for mobile phones?

When buying a replacement battery, the buyer often has the choice of different battery chemistries. Li-ion and Li-ion polymer batteries are used on newer phones, whereas the NiMH and NiCd are found in older models. If the buyer has a choice, the sales person may advise a customer to go for the highest capacity rating and to stay away from the NiCd because of the memory effect. The customer may settle for the slim-line NiMH because it offers relatively high capacity in a small package and is reasonably priced.

Similar to a spring under tension, a battery seeks to revert to its lowest denominator.

Seemingly a wise choice, an analysis in this chapter reveals that other chemistries may have served better. The NiMH offers good value for the price but falls short in expected cycle life. Although excellent when new, the performance trails off quickly after about 300 cycles due to decreased capacity and rising internal resistance. In comparison, the Li-ion can be used for about 500 cycles. The best cycle count is achieved with NiCd. Properly maintained, the NiCd delivers over 1000 cycles and the internal resistance remains low. However, the NiCd offers about 30 percent less capacity compared to the NiMH. In addition, the NiCd is being removed from the mobile phone market because of environmental concerns.

Switching to environmentally friendlier batteries is fitting, especially in the mobile phone market where the NiMH performs reasonably well and can be economical. The battery disposal issue is difficult to control, particularly in the hands of a diverse user group.

The NiMH and NiCd are considered high maintenance batteries.

The NiMH and NiCd are considered high maintenance batteries, which require regular discharge cycles to prevent what is referred to as 'memory'. Although the NiMH was originally advertised as memory-free, both NiCd and NiMH are affected by the phenomenon.

The capacity loss is caused by crystalline formation that is generated by the positive nickel plate, a metal shared by both systems.

Nickel-based batteries, especially NiCd's, should be fully discharged once per month. If such maintenance is omitted for four months or more, the capacity drops by as much as one third. A full restoration becomes more difficult the longer service is withheld.

It is not recommended to discharge a battery before each charge because this wears down the battery unnecessarily and shortens the life. Neither is it advisable to leave a battery in the charger for a long period of time. When not in use, the battery should be put on a shelf and charged before use. Always store the battery in a cool place.

Is the Li-ion a better choice? Yes, for many applications. The Li-ion is a low maintenance battery which offers high energy, is lightweight and does not require periodic full discharge. No trickle charge is applied once the battery reaches full charge. The Li-ion battery can stay in most chargers until used. The charging process of a Li-ion is, in many ways, simpler and cleaner than that of nickel-based systems, but requires tighter tolerances. Repeated insertion into the charger or cradle does not affect the battery by inducing overcharge.

On the negative side, the Li-ion gradually loses charge acceptance as part of aging, even if not used. For this reason, Li-ion batteries should not be stored for long periods of time but be rotated like perishable food. The buyer should be aware of the manufacturing date when purchasing a replacement battery.

The Li-ion is most economical for those who use a mobile phone daily. Up to 1000 charge/discharge cycles can be expected if used within the expected service life of about two to three years. Because of the aging effect, the Li-ion does not provide an economical solution for the occasional user. If the Li-ion is the only battery choice and the equipment is seldom used, the battery should be removed from the equipment and stored in a cool place, preferably only partially charged.

So far, little is known about the life expectancy of the Li-ion polymer. Because of the similarities with the Li-ion, the long-term performance of both systems is expected to be similar. Much effort is being made to prolong the service life of lithium-based systems. New chemical additives have been effective in retarding the aging process.

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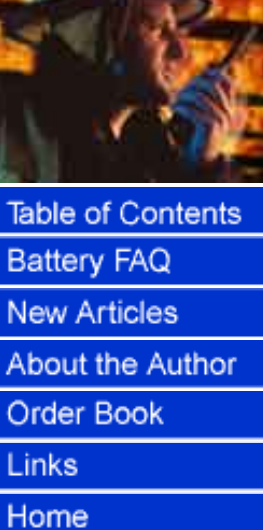


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Chapter 15: Caring for Your Batteries from Birth to Retirement

It is interesting to observe that batteries cared for by a single user generally last longer than those that operate in an open fleet system where everyone has access to, but no one is accountable for them. There are two distinct groups of battery users — the personal user and the fleet operator.

It is interesting to observe that batteries that are cared for by a single user generally last longer than those that operate in an open fleet system.

A personal user is one who operates a mobile phone, a laptop computer or a video camera for business or pleasure. He or she will most likely follow the recommended guidelines in caring for the battery. The user will get to know the irregularities of the battery.

When the runtime gets low, the battery often gets serviced or replaced. Critical failures are rare because the owner adjusts to the performance of the battery and lowers expectations as the battery ages.

The fleet user, on the other hand, has little personal interest in the battery and is unlikely to tolerate a pack that is less than perfect. The fleet user simply grabs a battery from the charger and expects it to last through the shift. The battery is returned to the charger at the end of the day, ready for the next person. Little or no care is given to these batteries. Perhaps due to neglect, fleet batteries generally have a shorter service life than those in personal use.

How can fleet batteries be made to last longer? An interesting contrast in the handling of fleet batteries can be noted by comparing the practices of the US Army and the Dutch Army, both of which use fleet batteries. The US Army issues batteries with no maintenance program in place. If the battery fails, another pack is issued. Little or no care is given and the failure rate is high.

The Dutch Army, on the other hand, has moved away from the open fleet system by making the soldiers responsible for their batteries. This change was made in an attempt to reduce battery waste and improve reliability. The batteries are issued in the soldier's name and the packs become part of their personal belongings. The results are startling. Since the Dutch Army adapted this new regime, the failure rate has dropped considerably and, at the same time, battery performance has increased. Unexpected down time has almost been eliminated.

It should be noted that the Dutch Army uses exclusively NiCd batteries. Each pack receives periodic maintenance to prolong service life. Weak batteries are systematically replaced. The US Army, on the other hand, uses NiMH batteries. They are evaluating the Li-ion polymer for the next generation battery.

Because of the high failure rate of fleet batteries and the uncertain situations such failures create, some organizations assign a person to maintain batteries. This person checks all batteries on a scheduled basis, exercises them for optimum service life, and replaces those that fall below an accepted capacity level and do not recover with maintenance programs. Batteries perform an important function; giving them the care they deserve is appropriate.

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