



Circuits for the Hobbyist

For your electronics hobby entertainment; ENJOY!


































*It is assumed that you have **AT LEAST** the equivalent of a Basic Electronics certificate for the electronics projects listed on this page. Other projects require more advanced electronics. A lot of these circuits assume the latter so **I will no longer** answer the tons of emails in regards to that. If you wish to learn more about electronics there is enough of that available on the internet.*








[Circuits' Message Board](#) Ask your questions here. Someone may answer them.
















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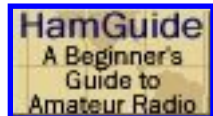
  "Green" means on-line, "Red" means off-line

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Info/Data

-  [Circuits Archive](#) - Older circuits. Most are working, some are not. Could be still useful.
-  [Radio Shack Partnumbers](#) - Most common order numbers for my circuits
-  [Tandy Corporation](#) - European/Australian counterpart of Radio Shack
-  [TUP/TUN/DUS/DUG](#) European transistor replacement system
-  [Tomi Engdahls' Page](#) - Solid electronics projects!
-  [Jan Freak's Page in the Netherlands](#) - Well thought out information. Dutch language only
-  [Bowden's Hobby Circuits](#) - Collection of circuits, for everyone.
-  [Circuit Exchange International](#) - Andy's website. Good selection of excellent circuits
-  [Electronic Tutorials](#) - Collection of electronics tutorials.
-  [Dolbowent.Com](#) - Electronic Surplus and Engineering Support.
-  [Jordan's Electronics Page](#) - Lots of good circuits here also.
-  [LED Webpage. White Led's everywhere](#) - Malcom's site in the UK.
-  [Guelph Amateur Radio Club](#) - GARC--Official Homepage 
-  [PA3BWK's Ultimate Morse Code Website](#) - Wilko Hollemans site in the Netherlands
-  [Larry's Robotics & Electronics Page](#) - Many good circuits
-  [ElectronicsZone](#) - Naveen's Website
-  [Spark Museum](#) - John D. Jenkins amazing collection of antique wireless & scientific instruments





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 lethal HV devices. Safety is a primary concern when working with high power circuits or con/inverters. Play it safe!

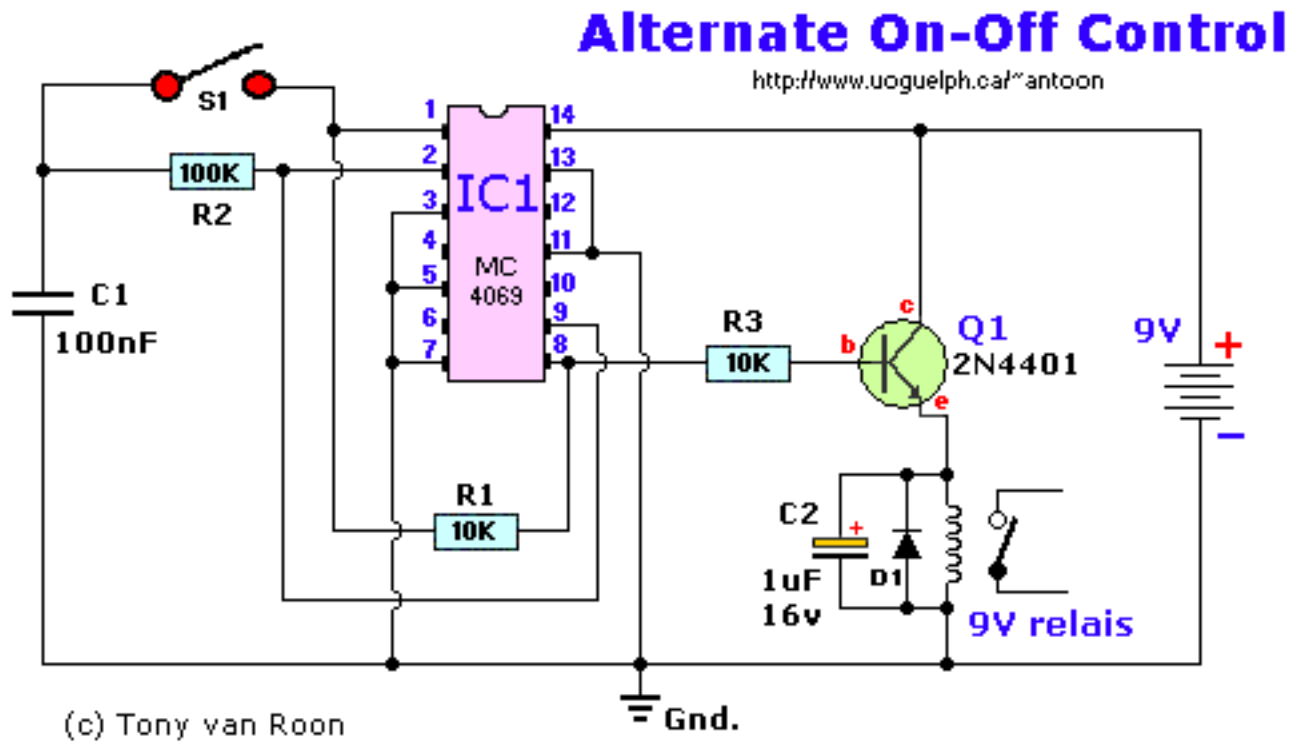
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Alternating ON-OFF Control

by Tony van Roon

Use this circuit instead of a standard on-off switch. Switching is very gentle. Connect unused input pins to an appropriate logic level. Unused output pins *MUST* be left open!. First 'push' switches ON, another 'push' switches OFF. You can use 1/4 watt resistors if they are metal-film type. Any proper substitute will work for Q1, including the european TUN's. For C2, if you find the relay acts not fast enough, leave it out or change to a ceramic cap between 10 and 100nF.



Parts List

All resistors are 1/2 Watt and 5% tolerance.

R1 = 10K

R2 = 100K

R3 = 10K

C1 = 0.1 μ F, Ceramic

C2 = 1 μ F/16V, Electrolytic

D1= 1N4001

Q1 = 2N4401 (ECG123AP, NTE123AP, etc.)

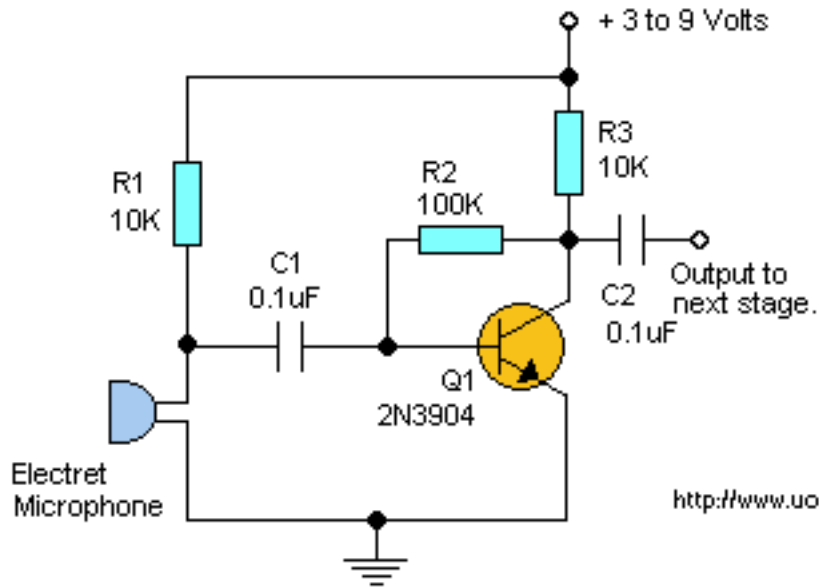
IC1 = 4069, CMOS, Hex Inverter (14069), or equivalent

S1 = Momentary on-switch

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Audio Pre-Amplifier



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.

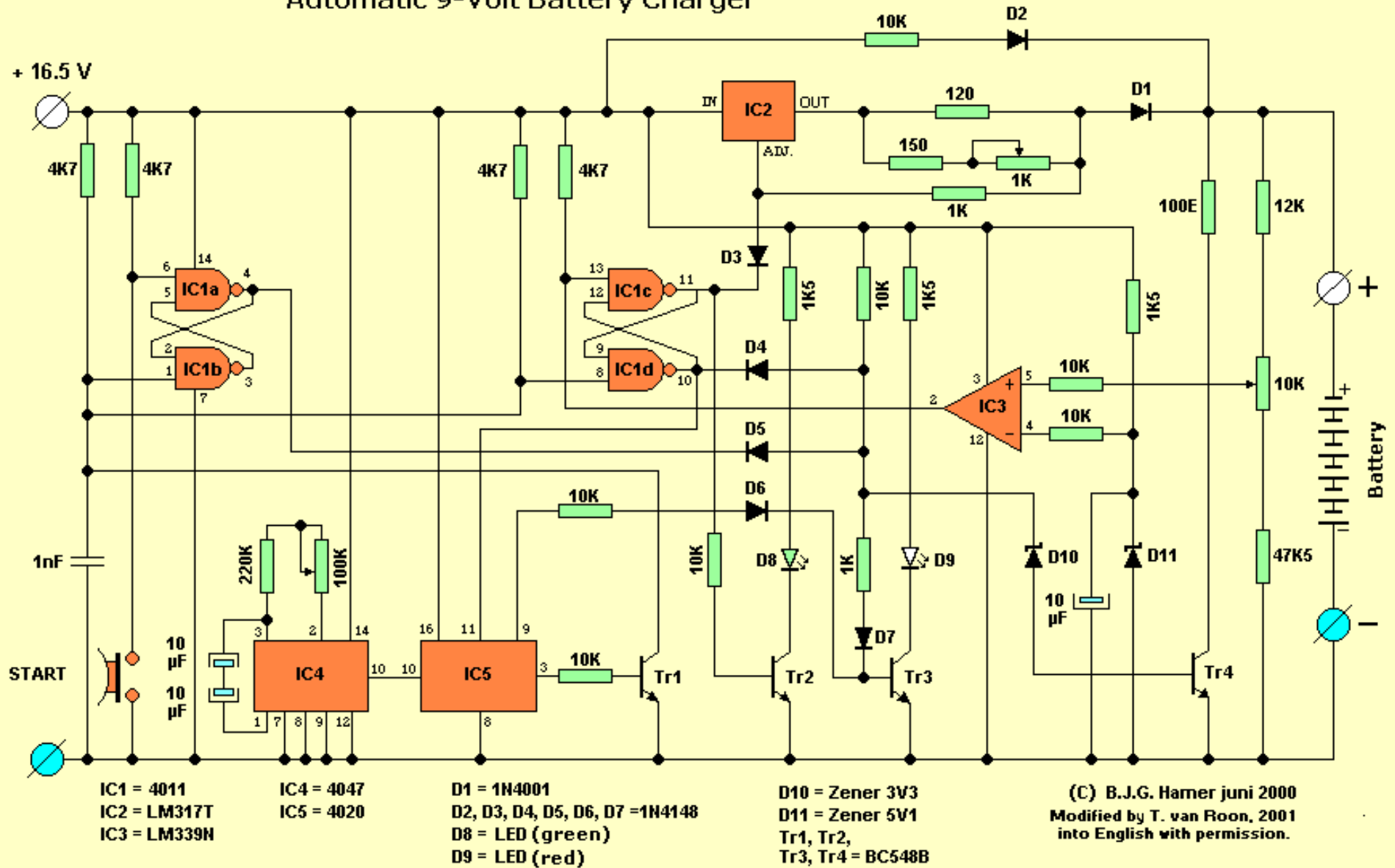
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[Additional Notes](#)

(N/A)

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Automatic 9-Volt Battery Charger



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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 circuit 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.

120E, 150E, 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 totally 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 LM317T is a TO-220 type and replaceable with a ECG956 or NTE956. The LM339N can be replaced with a ECG834 or NTE834

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 1nF 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. The 10K trimpot (at the right of the diagram) is adjusted in such a way that when the battery voltage dips below 7 volt, the output of IC3 goes LOW and the output pin 11 of IC1a HIGH. 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 divided 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 ($c/0.1$)).

At the same time the LOW of output pin 10 from IC1d starts the counter of the clock. On pin 9 of IC5 appear 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 8192 pulses ($\times 6.59 = 53985.28 \text{ sec} = 14.99 \text{ hours}$) 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 wiper of the 10K pot in the direction of the 12K resistor, ground connection point of 10K resistor/diode 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 100nF 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. Klick 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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Basic IC MonoStable Multivibrator

by Tony van Roon

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

BASIC LM555 MONOSTABLE CIRCUIT

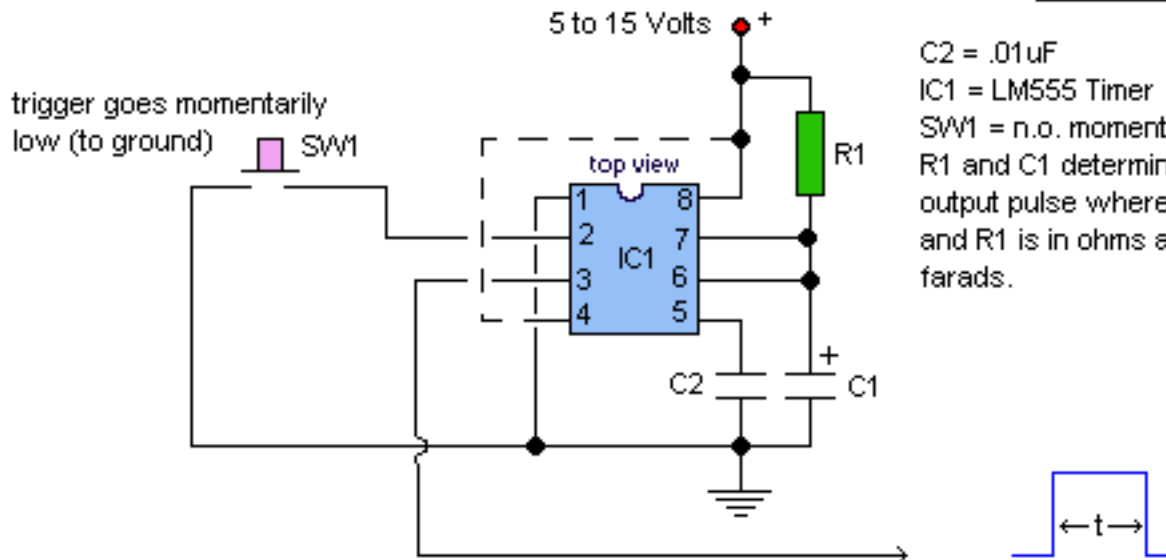
Parts List

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.

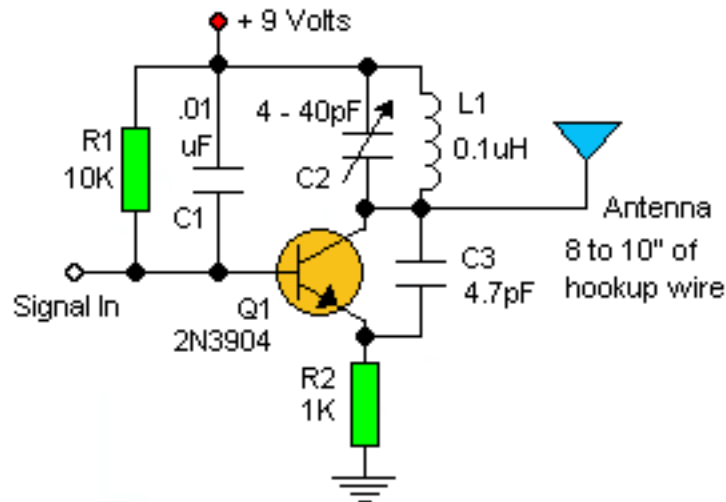


Pin 4 is the RESET. Leave it connected to +V during normal operation. Bring pin 4 AND pin 2 low at the same time to reset timing cycle.

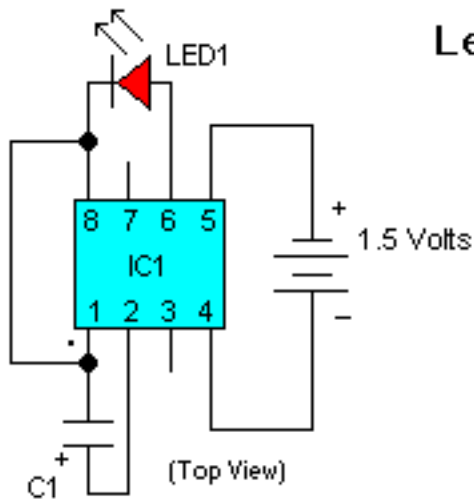
output goes high for length of time t where $t = R1 \times C1$ and R1 is in ohms and C1 is in farads

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.



Led Flasher with the LM3909 IC

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

PARTS LIST

C1 = 100uF electrolytic capacitor

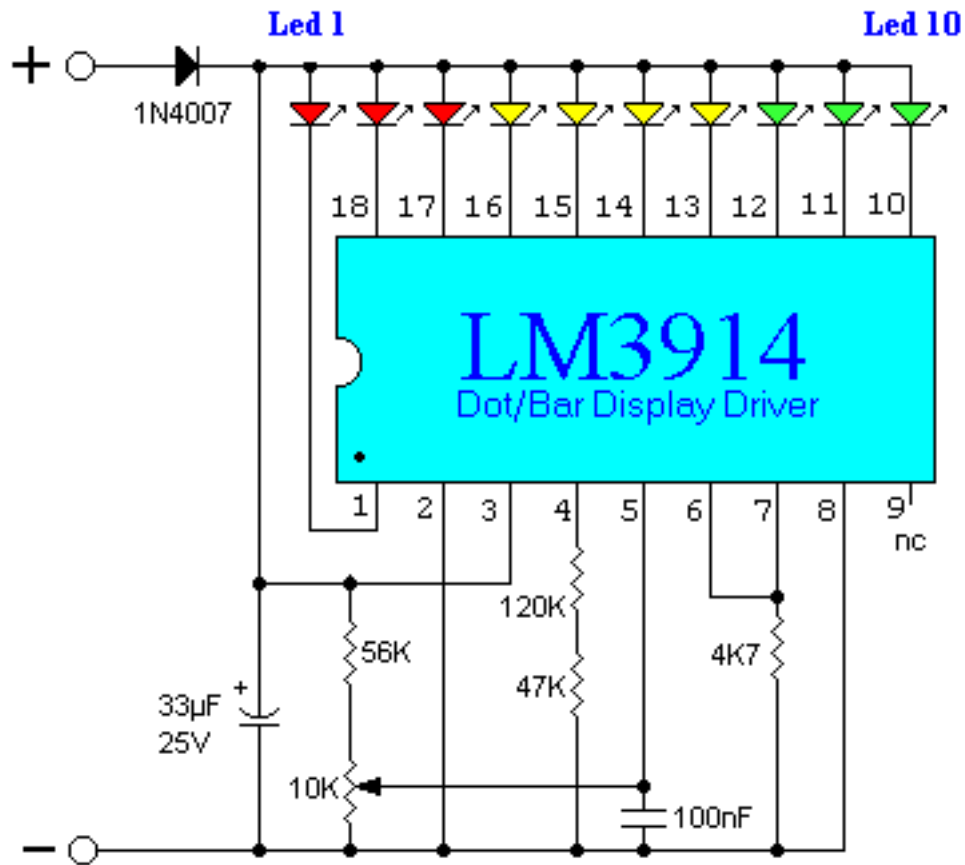
IC1 = LM3909 led flasher IC

LED1 = Red LED

Battery = 1.5 Volt AAA

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12 V Lead-Acid Monitor



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This simple circuit makes it possible to monitor the charging process to a higher level. 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 ground, 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 to 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 200K 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.

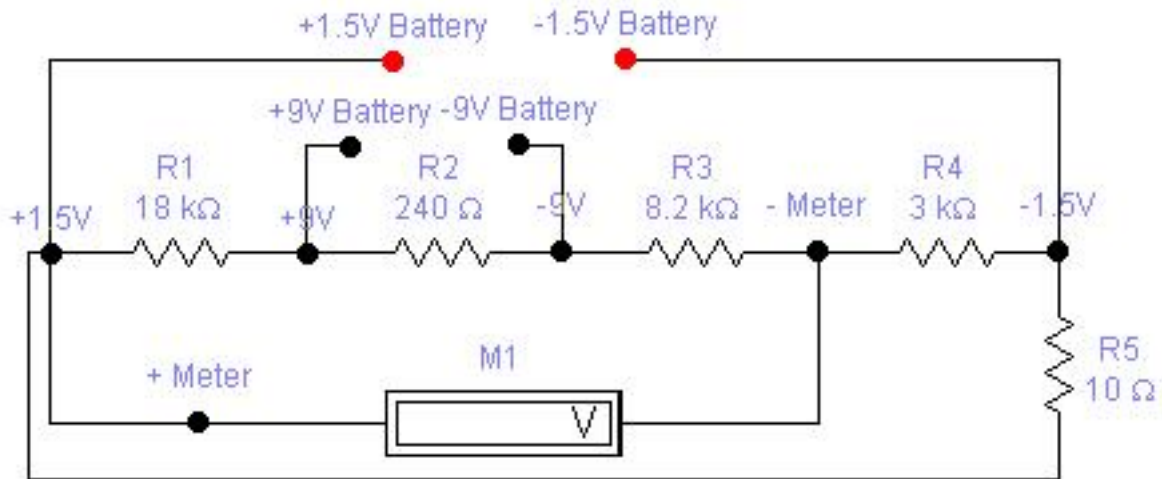
It is however strongly recommended to connect the monitor directly to the battery, in principle a connection to the cigarette lighter would suffice but for reasons unknown at this time the voltage at that point is 0.2 volt lower than the voltage measured directly on the battery. Could be some residual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

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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.](#)

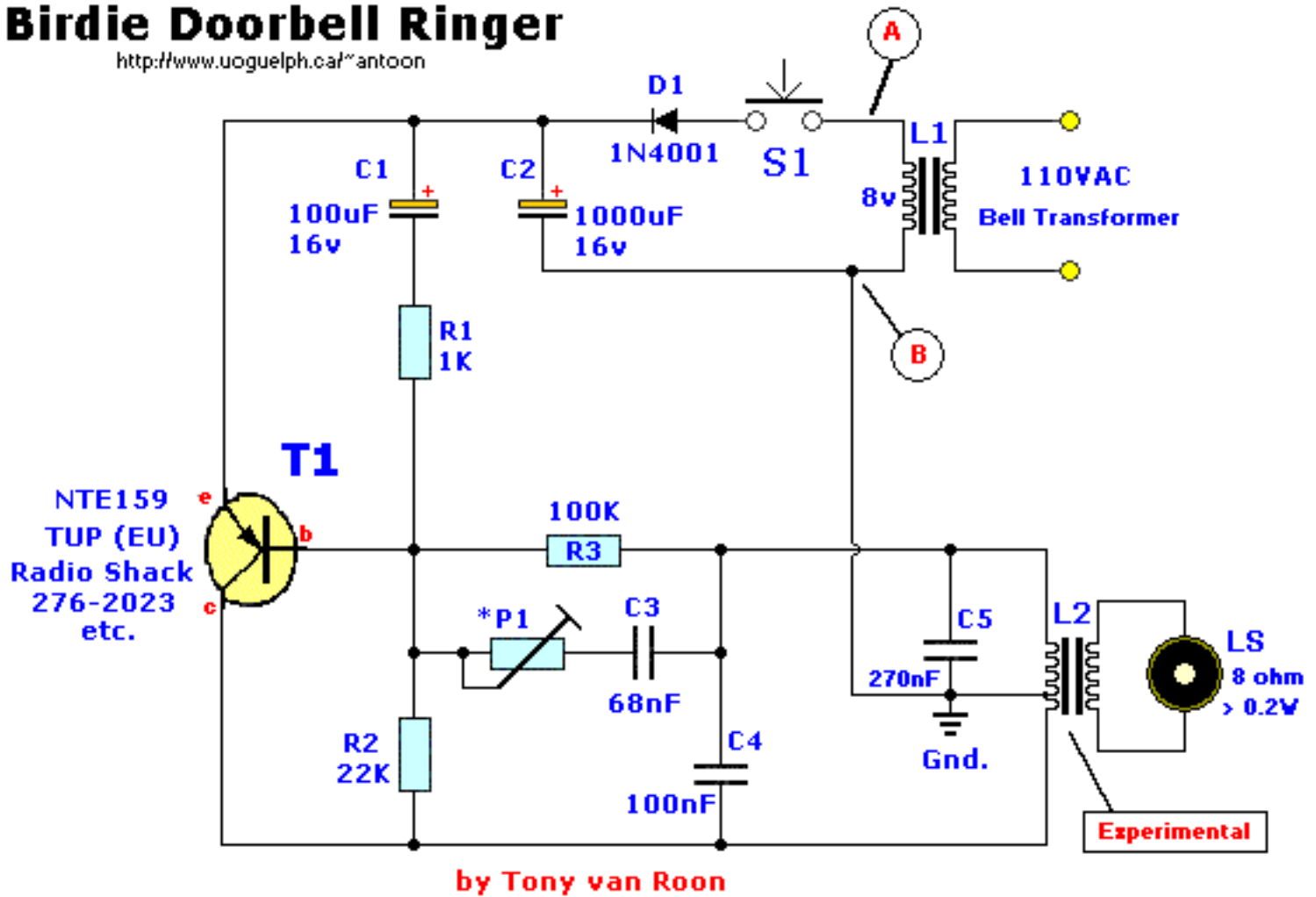
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Birdie Doorbell Ringer

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



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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by Tony van Roon

2 x 7413 or
74LS13



IC = SN7413 or SN74LS13 (2)

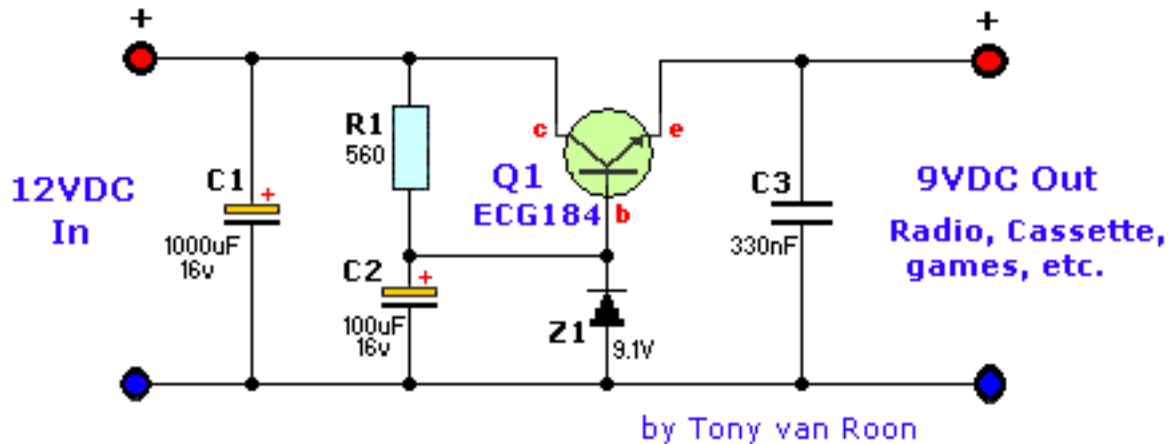
Please note: This circuit is not open for discussion. Although working perfectly, it was experimental. I will answer no emails in regards to this circuit.

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12Volt to 9Volt DC Converter

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



Parts List:

R1 = 560 ohm

C1 = 1000µF/16V, Electrolytic

C2 = 100µF/16V, Electrolytic

C3 = 330nF, Ceramic

Z1 = 9.1V, 0.4watt zener

Q1 = ECG184, NTE184

Notes:

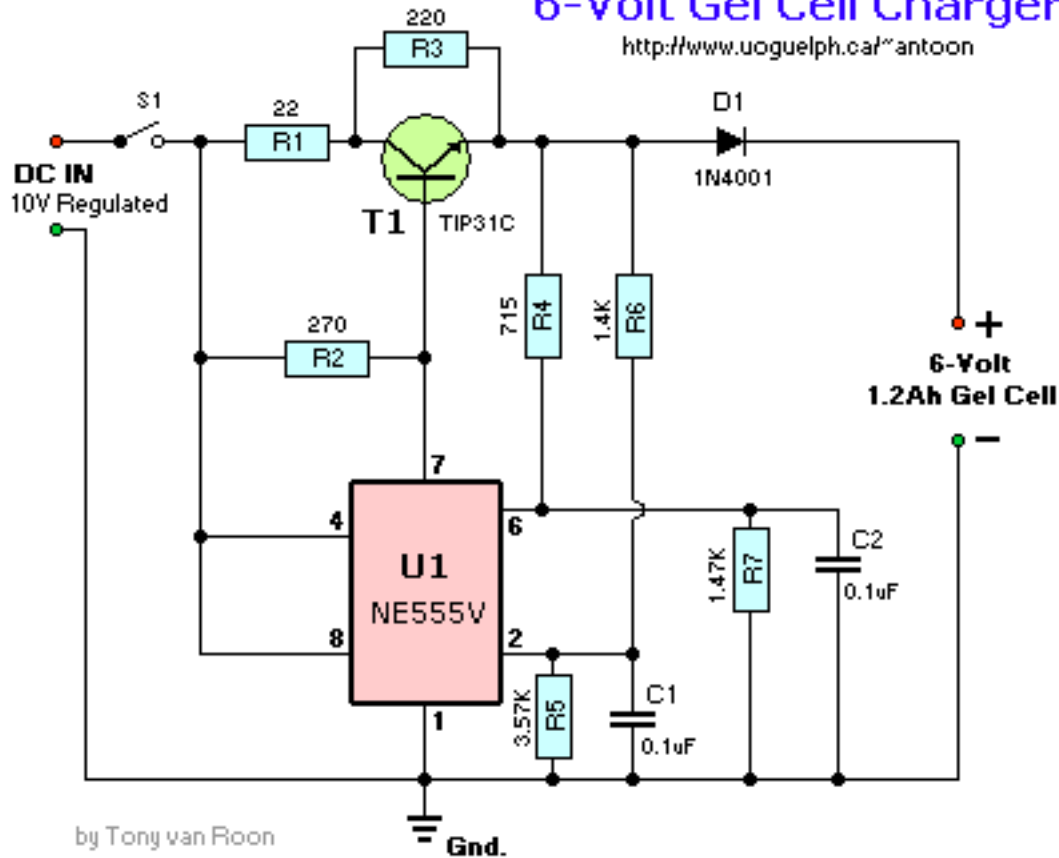
To get a more precise output voltage, replace zener diode Z1 with 10V and R1 with a 1Kilo ohm potentiometer. A Coolrib for Q1 is optional. Simple circuit to power your 9 volt cassette recorder and other stuff.

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6-Volt Gel Cell Charger

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



Parts List:

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

R1 = 22 ohm, 1W	C1 = 0.1 μ F, ceramic
R2 = 270 ohm	C2 = 0.1 μ F, 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 = 1.40K, 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!

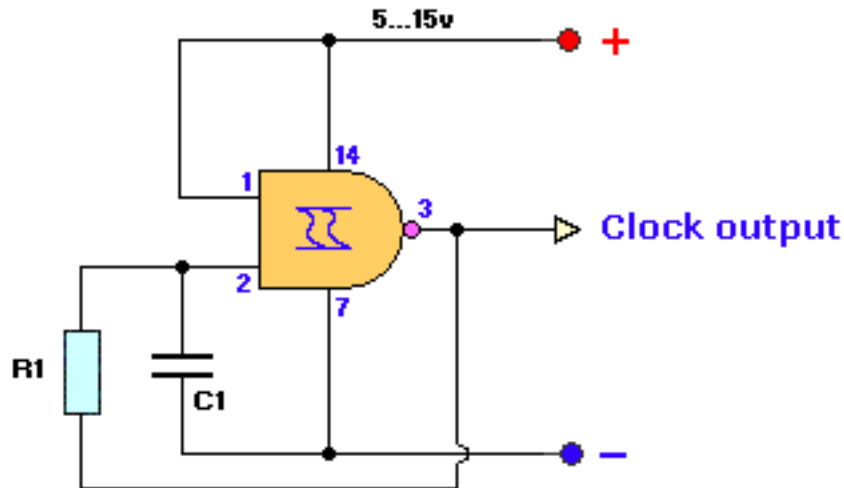
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Clock Generator

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 $47\mu F$.
- o - Fo is $\pm 1Kz$ 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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Christmas Lights Tester

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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.

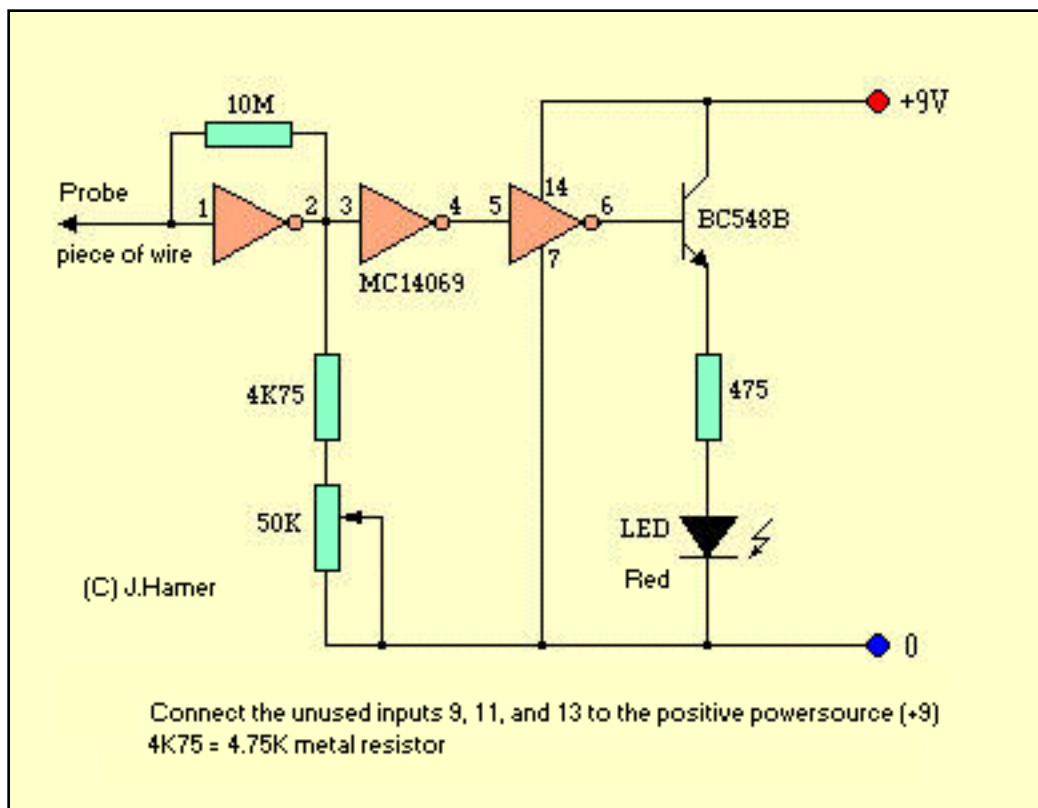
It was a crime trying to pull all the bulbs out of their sockets to measure them for continuity. Funny enough, and against the law of nature, it was not even the last bulb in the string of 50 which was defective, but number 41.

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 could not 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 moments 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 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 trimpotentiometer.

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 ofcourse 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.

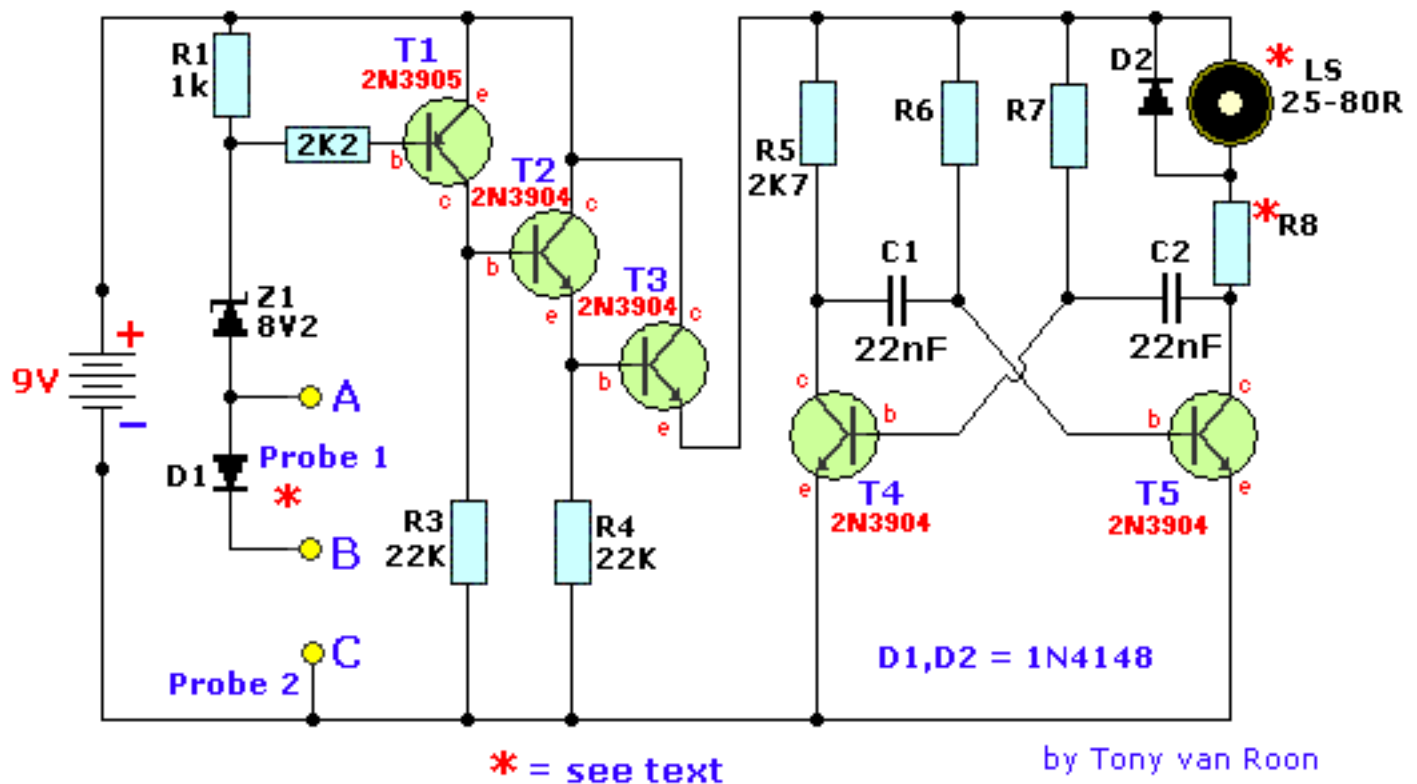
If you have questions about this circuit, please direct them to [Jan Hamer](#) or visit [his website](#) in the Netherlands (if you can read Dutch).

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Continuity Tester

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



Parts List:

R1 = 1K	D1,D2 = 1N4148
R2 = 2K2	Z1 = 8V2, 1/4 watt
R3,R4 = 22K	T1 = 2N3905 (PNP)
R5 = 2K7	T2,3,4,5 = 2N3904 (NPN)
R6,R7 = 56K	9volt Alkaline battery
R8 = *See text	suitable loudspeaker
C1,C2 = 22nF	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 $0.8/1,000 = 0.8 \text{ mA}$ 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 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 $R8 = 242 \text{ ohms}$.

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.

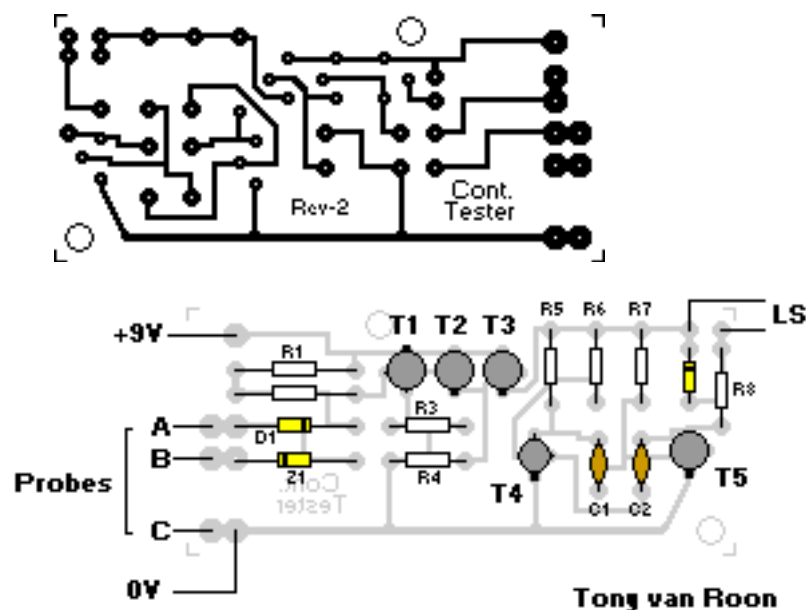
Zener diodes do not provide an absolutely constant volt-drop regardless of current; at the 0.8 mA design current an 8.2 volt diode will quite possibly give only about 8.0 volt drop since test current for zener selection and marking is typically 5 mA or more. A further possible source of error is the 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!



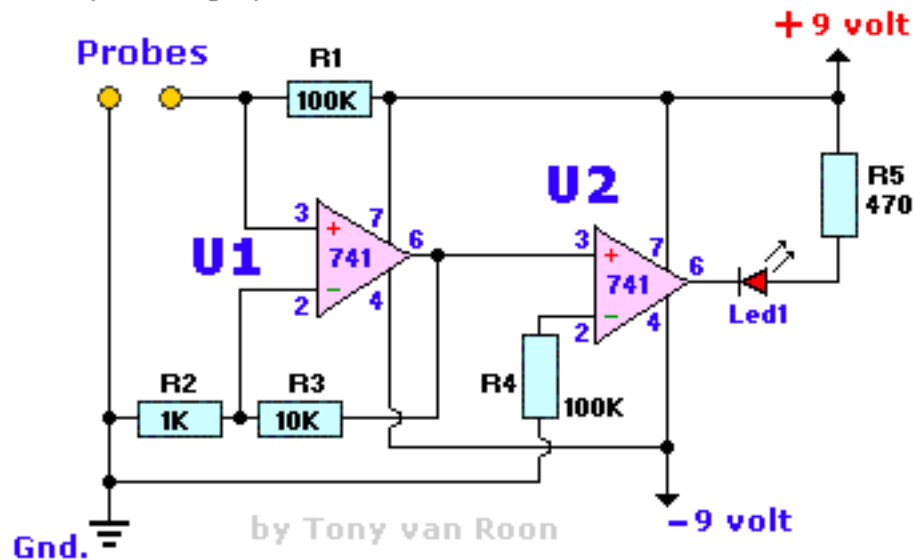
The pcb pattern above is shown full-size at 73mm x 33mm (2-7/8" x 1-1/4")

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Smart Continuity Tester

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



Parts List:

R1 = 100K

R2 = 10K

R3 = 1K

R4 = 100K

R5 = 500 ohm

Led1 = High Brightnes LED, RED, 5mm

IC1 = [LM741](#), OpAmp

9 volt Alkaline battery, case, probes

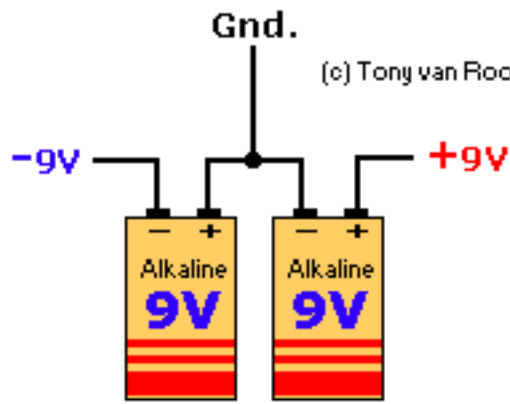
How it works:

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. They just don't know any better.

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 741 op-amps. It offers a short-circuit test current of less than 200uA. It detects resistance values of less than 10 ohms. Nicest of all, it will not break down a PN junction. The device has come in handy in my own shop for debugging electronic circuits.

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. 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.



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

(c) Tony van Roon Just in case you're just starting out in electronics, here is how to get the -9, +9, and 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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Continuity Tester, Latching

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."



A continuity tester is a must on every service bench for testing cables, pcboards, switches, motors, plugs, jacks, relays, and many other kinds of components. But there are times when a simple continuity test doesn't tell the whole story. For example, vibration-induced problems in automobile wiring can be extremely difficult to detect because a short or open is not maintained long enough for a non-latching tester to respond. This latching continuity tester detects intermittent (and steady state) opens and shorts. The tester will detect and latch on an intermittent condition with a duration of less than a millisecond. In addition, it provides both visual and (defeatable) audio indicators, uses only one inexpensive and easy-to-find IC, and can be built from all new parts for about \$35, or less if you have a well-stocked junkbox.

Circuit Elements:

The heart of the circuit is a 4093 quad two-input NAND Schmitt trigger, one gate of which is shown in Fig. 1-a. The gate functions as shown in Fig. 1-b.

Nothing happens until the *enable* input goes high. When that happens, the

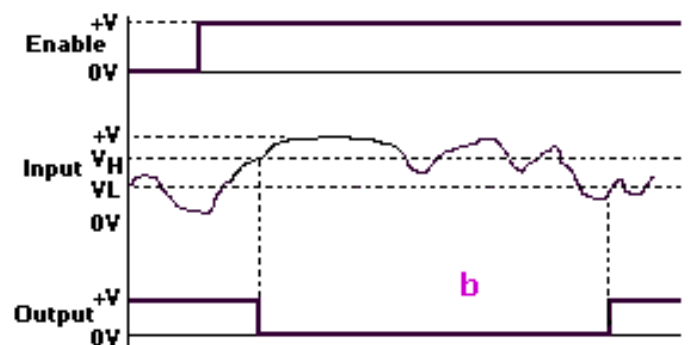
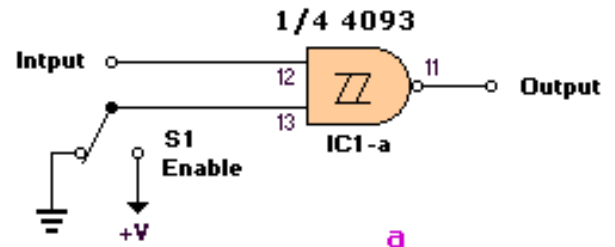


Fig. 1 -- A Schmitt Trigger (a) is insensitive to input signals between V_H and V_L (b). The output changes state only when the enable input is high.

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output responds to the input as follows.

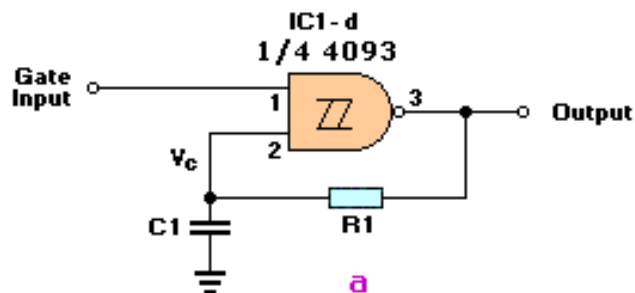
As long as the input voltage stays between V_H and V_L , the output stays high. But when the input goes above V_H , the output goes low. The output will not go high again until the input goes below V_L . That characteristic is what gives the Schmitt trigger its ability to "square-up" a slowly changing input signal. 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 is used to select whether the tester will provide output when it detects an open or a short. In the **OPEN** position, pin 12 is held low, so the output of the gate is normally high. When the test leads are connected across a short, 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_L , the output of the gate goes high, so C1 starts charging through R1. When V_C exceeds V_H , 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



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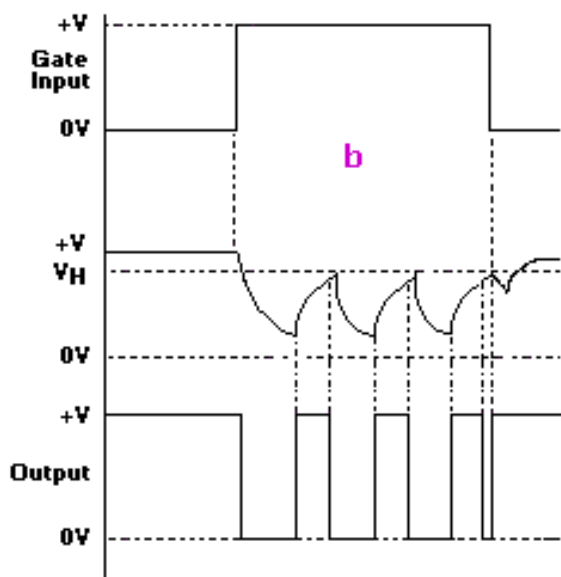


Fig. 2 -- An Astable Oscillator (a) may be built from a single gate, a resistor and a capacitor. The circuit oscillates at a frequency of about $1/R1C1$ whenever the gate input is high (b).



Construction:

Picture at the left shows the tester from the back. The hole is for the piezo buzzer. The circuit may be built on a piece of perfboard or Vero-board, or on a PCB. The PCB is designed to take board-mounted switches, which makes a neat package and 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.

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The circuit board is held approximately 1/2-inch from the cover by the shafts of the switches. The LED and the buzzer should be inserted in the appropriate holes in the pcb now. Then install the top cover, and adjust the height of the LED so that it protrudes through the top cover. Then solder its leads. Attach the buzzer to the top cover, using silicone rubber adhesive (RTV or double side foam tape).

We mounted a pair of banana jacks on the top of our prototype's case, but you could solder the wires directly to the appropriate points on the circuit board, tie strain reliefs in the wires, and then solder alligator clips to the ends of the wires. However, a set of good leads are really not all that expensive and it does give the tester more flexible usage as

you have the opportunity to use a variety of different leads to suit your purpose.

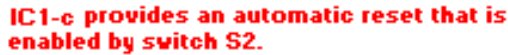
The nine-volt battery is secured to the side of the case with a clip or use a holder. Your completed pcb should appear as in Fig. 5.

Usage Hints:

Set S1 for *short* or *open* depending on the condition to be tested. Then connect the test leads across the circuit to be tested. If an intermittent condition is detected, the LED will illuminate, and the buzzer will sound (if S4 is on). If you don't remove the test leads (assuming if S2 is set for *AUTO Reset*, the LED will flash (very fast) and audio will warble at a rate determined by the reset circuit.

It is very important that the test leads make a positive connection with the circuit to be tested. In fact, clips should be used instead of test leads. There are good test leads available for about \$15 which are hardened stainless-steel and have sharpened points which were my personal choice. This detector is so sensitive that, when it is initially connected across a long length of parallel wires or traces, it may latch due to capacitance between the wires. As a matter of fact, it happens with my model all the time. Just press the reset switch S3 when that occurs.

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R1 = 10K
TE4093B/ECG4093B)

$$R2, R3 = 470K$$

R4 = 100K Trim-pot

R5 = Not used

R6 = 1.8K (1800 ohm)

S1 = DPDT, miniature toggle, pcb mount

R7 = 1M Potmeter (Lin)

S2,S4,S5 = SPDT, miniature toggle, pcb mount

R8 = 10M

S3 = SPST, momentary push, normally open

C1 = 0.1 μ F, ceramic

Additionally: IC socket, plastic case (4.75" x 2.5"

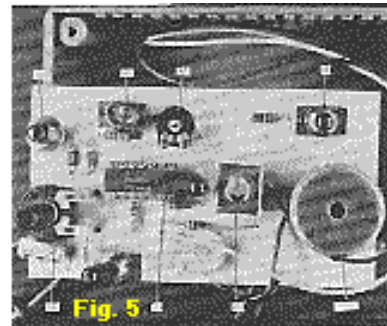
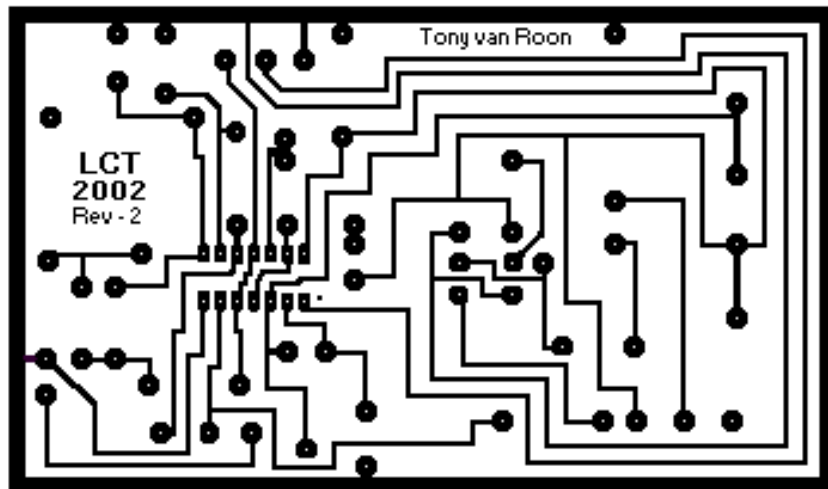
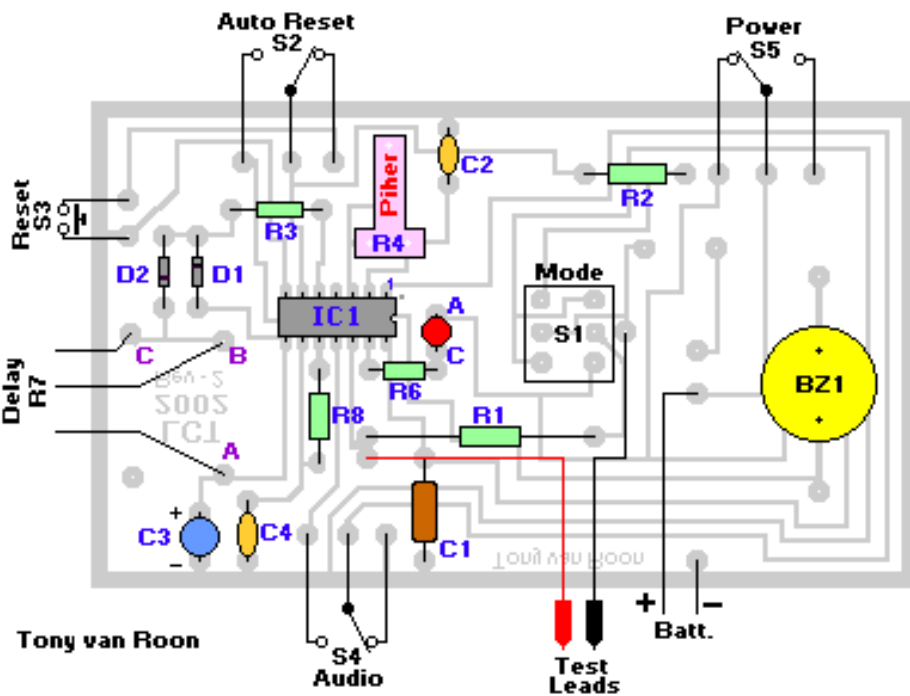
1.5"), banana jacks,

C2,C4 = 0.01 μ F ceramic

wire, solder, battery clip, couple cold

beers.

C3 = 4.7 μ F, 16V, Elec.



The assembled pcb reveals the low parts-count and easy assembly of the continuity tester

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.

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

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house.

Some of the hottest action to come over the airwaves 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 auxilliary 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 listed to the tape. A speaker in/out switch is provided to allow monitoring (via the circuit's build-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 high 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.

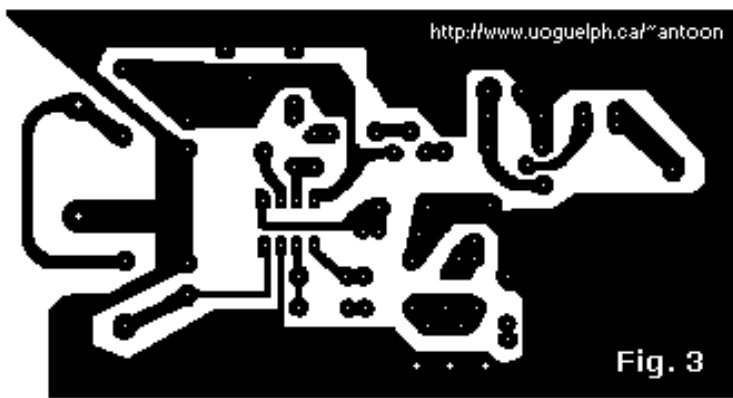
With an LM1458 Op-Amp, and its relatively low input impedance a C2 value of 0.1uF provides an ideal discharge rate.

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.

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.



ScanMate
Revised 1999
by Tony van Roon

Fig. 3

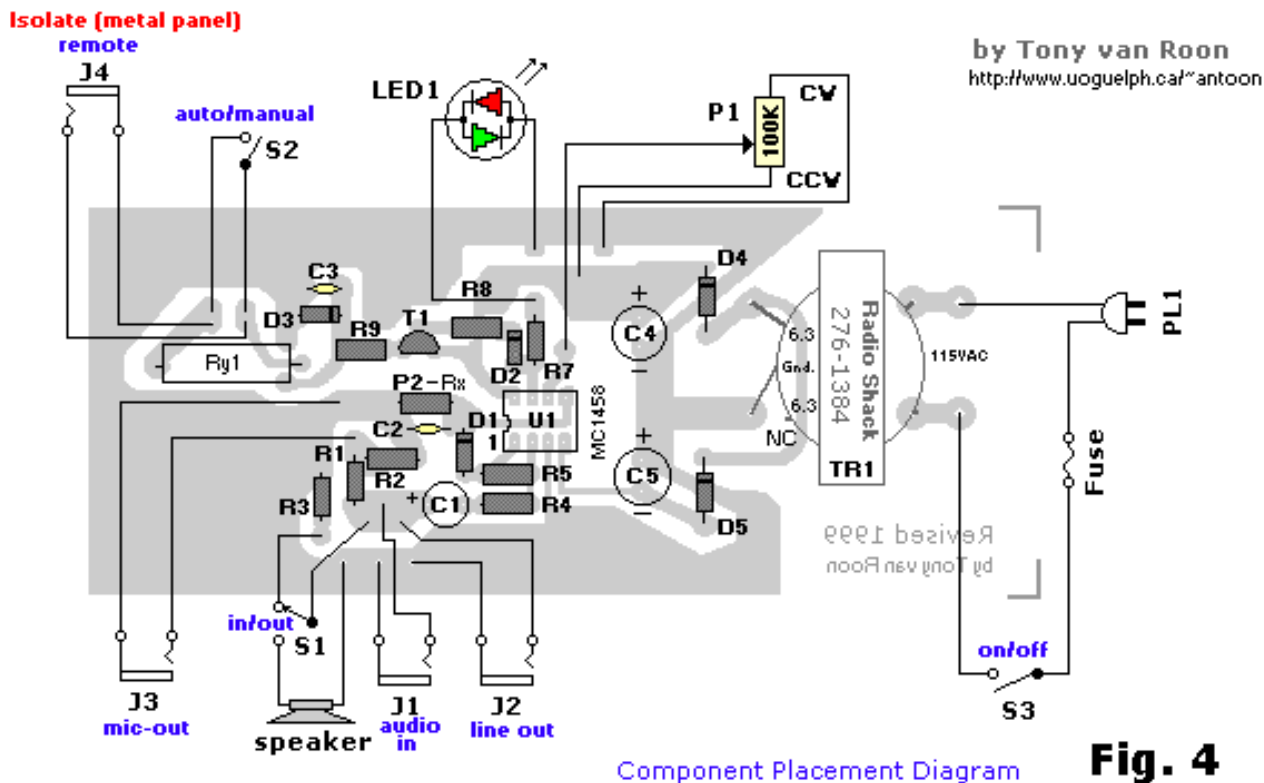


Fig. 4

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 LED's. 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 powersupply 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 heatshrink, 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, ofcourse, 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.

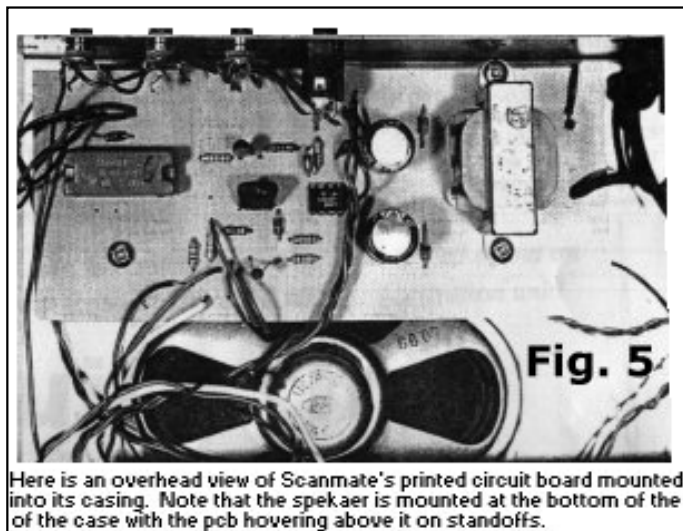
TR1 is a pc-mountable 12.6volt/300mA Center Tapped transformer. I purchased mine at Radio Shack: #276-1385. Some modifications were required to the PCB-layout to make the transformer fit nicely. Just in case you don't have a lot of experience with electronics and you're wondering why the schematic shows 6.3V and the parts list 12.6V. The transformer is a so-called 'center-tapped' model wich means 6.3V - 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 Elektuur (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 as the #273-1384 6.3v/300mA. Use what's available in your area.



Here is an overhead view of Scanmate's printed circuit board mounted into its casing. Note that the spekaer is mounted at the bottom of the of the case with the pcb hovering above it on standoffs.



ScanMate viewed from the back. The fuse as well as the Remote, input, Mic-output, Line-out and Audio input jacks are located on the rear panel of the enclosure. All connections to and from the ScanMate's unit are through those jacks.

Fig. 6

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-clock-wise. 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.

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.

Copyright and Credits:

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.

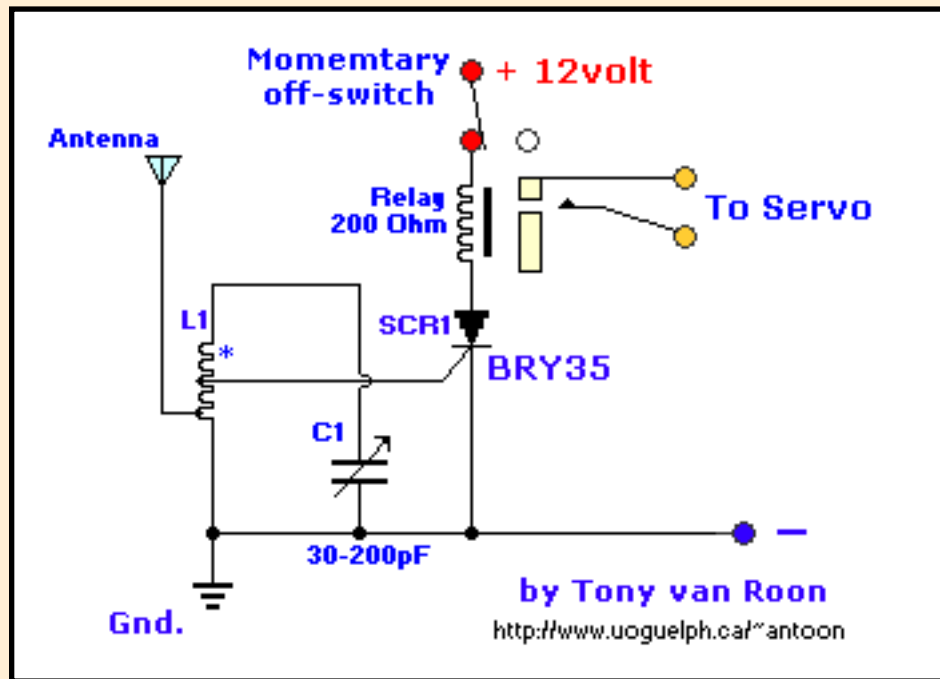
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Simplest R/C Circuit

by Tony van Roon



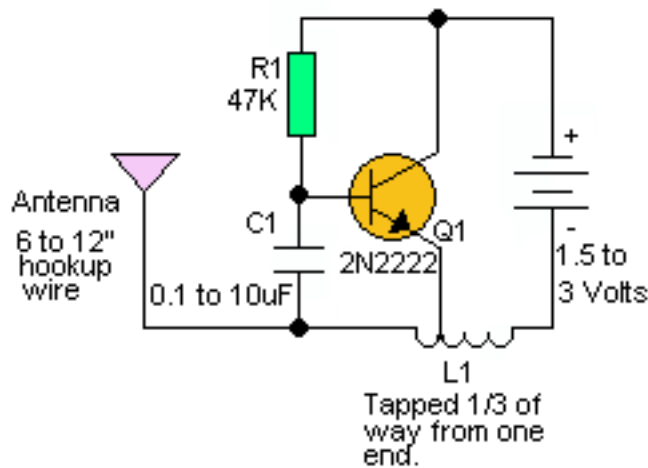
A simple and effective receiver for actuating garage doors, starter motors, alarms, warning systems and numerous other possibilities. The SCR, which has a very low trigger current of 30 uA is typical -- it requires an input power of only 30 uW to activate the relay. A high Q tuned antenna circuit assures 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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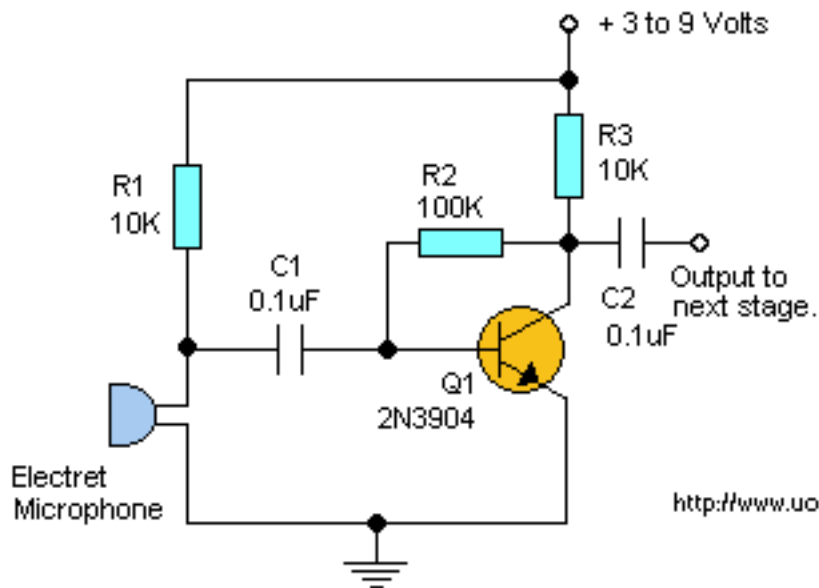
Simplest RF Transmitter

<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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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>

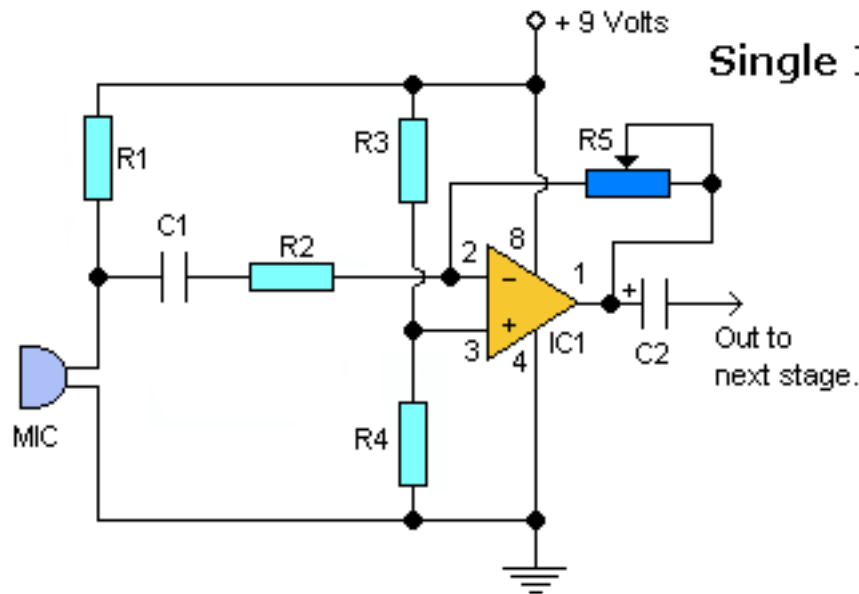
Additional Notes

None of the parts are critical. Use whatever you have. Again, note that the microphone is an "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](#)

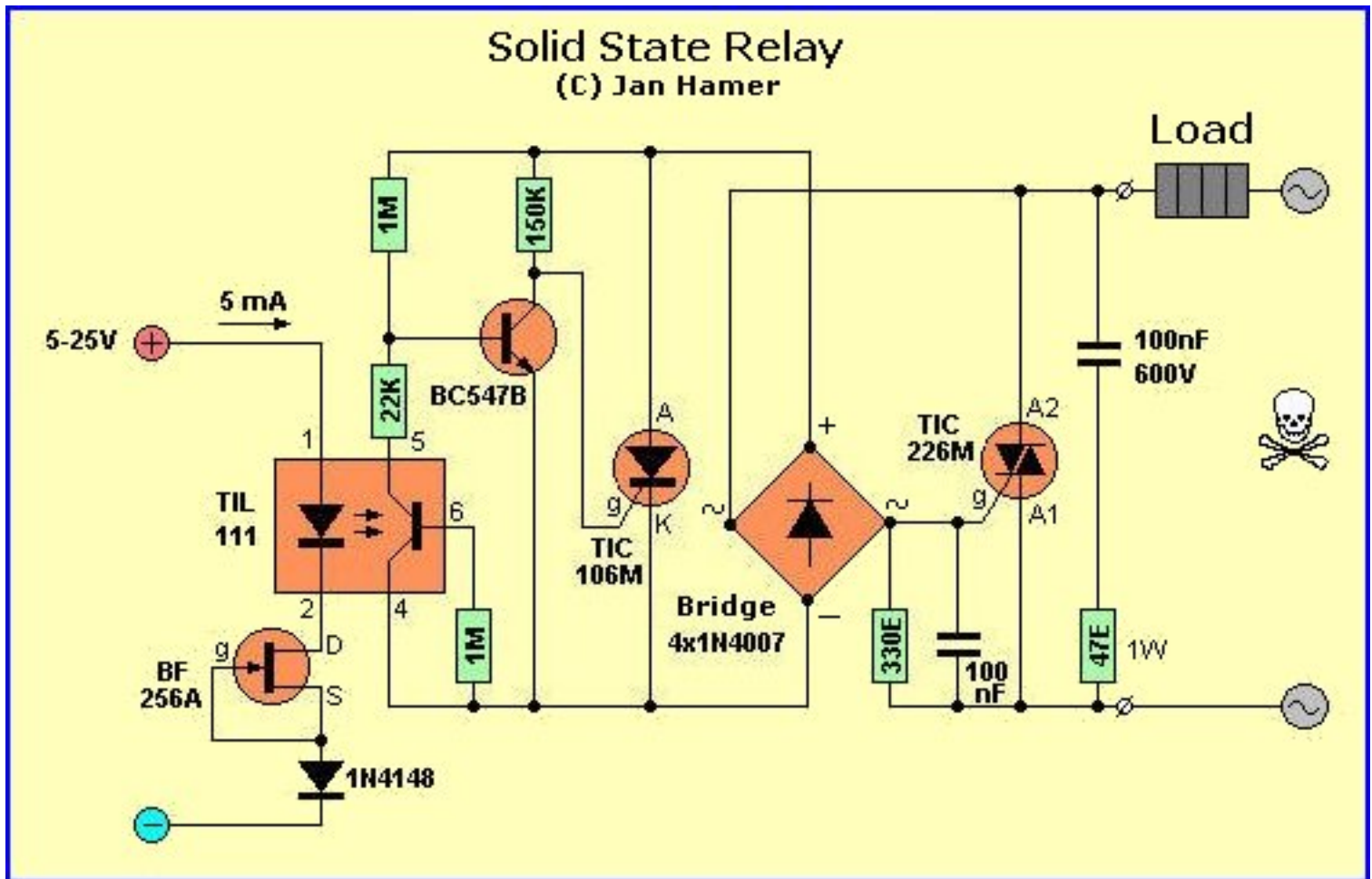
Parts are non-critical components and available from most Radio Shack stores.

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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 ofcourse). 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.

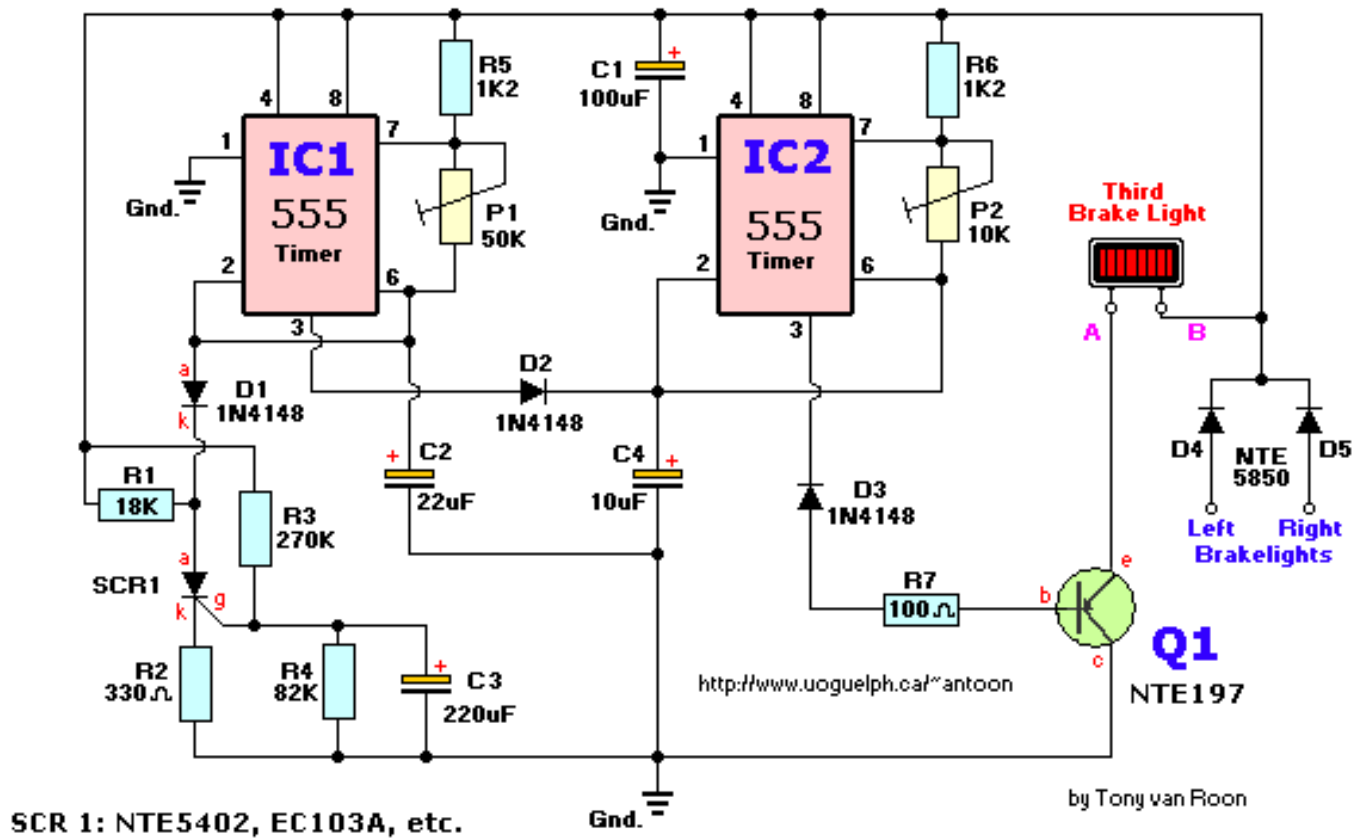
(Tony: The NTE replacements for this circuit are 600volt types which is more than sufficient for our 110/115VAC.) Also, if you decide to make a pcb for this circuit, to create sufficient space between the AC lines and don't make these AC tracks too narrow.

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Pulsing Third Brake Light



Caution: I'm checking into the legalities of this particular circuit at this time. Any type of flashing light on the **main** brakelights is prohibited and illegal in *most* states of the U.S.A. I'm verifying for the same here in Canada. In the mean time, use this circuit at your own risk and be aware that the possibility exists to be stopped by law enforcement if you implement this circuit in your vehicle.

Use in my motorcycle: Several years ago these flashers were introduced in the automotive industry as part of the third brake light (and were flashing continuously) but got abandoned sometime later because of the 'strobe' effect (some of them kept flashing continuously) it has on some people. However, there is a major difference between this flasher and the ones from the automotive industry and others. This flasher gives 3 or 4 flashes, at reduced intensity, and then goes solid. They do not have the 'strobe' effect in any way or form, in my opinion. My main concern, when driving my motorcycle, is to be seen early enough. Seems to work.

Parts List

Semiconductors:

IC1, IC2 = 555 Timer, RS #276-1723

SCR1 = NTE/ECG5402, RS #276-1067, EC103A, MCR104, etc.

Q1 = NTE/ECG197, SK3083, TIP125, or equivalent

D1, D2, D3 = 1N4148, 1N914, NTE/ECG519, RS #276-1122

D4, D5 = 1N5400, NTE/ECG5850, RS #276-1141, or equivalent

Resistors:

R1 = 18K (Brown-Gray-Orange)

R2 = 330 ohm (Orange-Orange-Brown) (RS #271-1315)

R3 = 270K (Red-Violet-Yellow)
R4 = 82K (Gray-Red-Orange)
R5,R6 = 1K2 (Brown-Red-Red) (1200 ohm)
R8 = 100 ohm (Brown-Black-Brown) (RS# 271-1311)
P1 = 50K, 10-turn
P2 = 10K, 10-turn

Capacitors:

C1 = 100 μ F/16V (RS# 272-1016)
C2 = 22 μ F/16V (RS# 272-1014)
C3 = 220 μ F/16V (RS# 272-1017)
C4 = 10 μ F/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 100vrms, 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, 50prv types, cathode case. The 60vrms 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 you 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 brake light via the emitter of Q1, at the rate determined by P2, R6, and C4. That oscillation continues until the gate-threshold voltage of SCR1 is reached, causing it to fire and pull IC1's trigger (pin 2) low. With its trigger low, IC1's output is forced high, disabling IC2's trigger. With triggering disabled, IC2's output switches to a low state, which makes Q1 conduct turning on the 3rd Brake Light until the brakes are released. Obviously, removing the power from the circuit at any time will reset the Silicon Controlled Rectifier SCR1, but the RC network consisting of R4 and C2 will not discharge immediately and will trigger SCR1 earlier. So, frequent brake use means fewer flashes or no flashes at all. But I think that's okay. You already have the attention from the driver behind you when you used your brakes seconds before that.

The collector/emitter voltage drop across Q1 together with the loss over the series fed diodes D4/D5, will reduce the maximum available light output, but if your car's electrical system is functioning normally in the 13 - 14volt range, these losses are not noticeable.

Building Tips: You can easily build this circuit on perfboard or on one of RS/Tandy's experimentors boards (#276-150), or 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 heat sink is highly recommended. Verify that the scr is the 'sensitive gate' type. In incandescent bulbs, there is a time lag between the introduction of current and peak brightness. The lag is quite noticeable in an automotive bulb, so the duration of a squarewave driving such a bulb should be set long enough to permit full illumination. For that reason, and because lamps and car electrical systems vary, adjustment via P1 and P2 is necessary to provide the most effective pulse

timing for your particular vehicle.

The reason that the third light is connected to both brake lights is to eliminate the possibility of a very confusing display when you use your turn signal with the brakes applied.

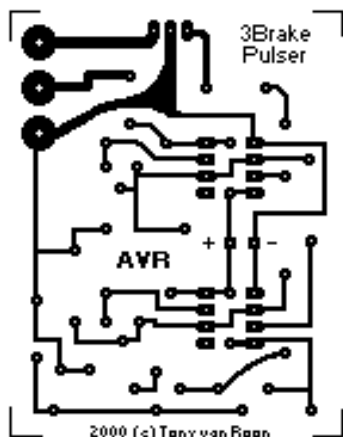
The cathode of D4 and D5 are tied together and go to point 'B' of the third brake light in the component layout diagram. Point 'A' goes to the other leg of the third brake light. Most if not all third brake lights in Canada & USA have two wires, the metal ones also have a ground wire which obviously goes to ground. I don't know the wiring scheme for Australian and European third brake lights.

Don't forget the three jumpers on the pcb; two jumpers underneath IC1/IC2 between pin 4/8 and the one near Q1/R6. If you use a metal case, don't forget to insulate the D4/D5 diodes. (For motorcycle you can eliminate D5).

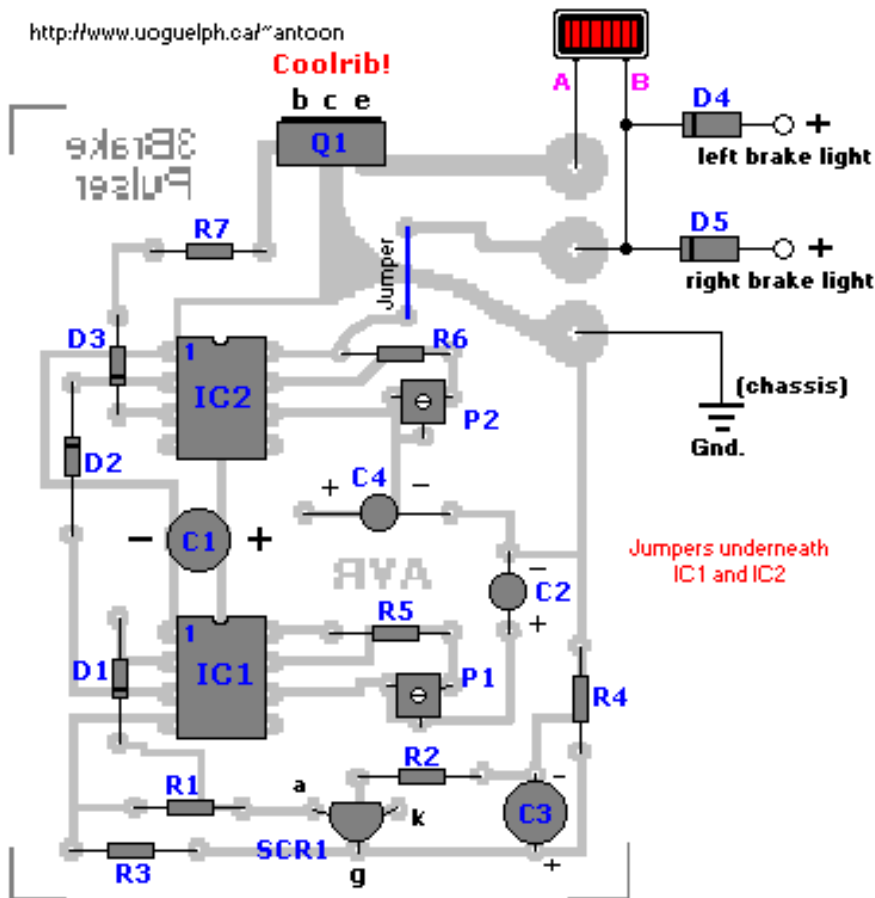
Some 90's cars, like my 1992 Mercury Sable, have two bulbs inside the third brake light, each bulb is hooked up seperately to the left and right brake light for reasons only Ford knows. [Click here](#) for a possible 2-bulb hookup. It shows how I modified mine to get it working; and that was easier than I expected. Current draw with the two bulbs was measured at 1.85Amps (1850mA). Even with double the current none of the circuit components were getting hot. I had to re-adjust the two pots to make it flash since the bench testing was done with one bulb.

Bench Testing:I tested different semiconductors like the 1N5401/1N5404, NTE153, and 4A type powerdiodes for D4/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 darlingtontons like the TIP125 and the TIP147. I eventually settled for the TIP125 myself because I had it available but any thing with 5A or more will do fine.

The actual third brake bulb is a lot smaller. Adjusting the trimpots (P1/P2) may take a bit of patience but really fine-tunes the circuit well. The only drawback of this circuit is the discharge lag coming from the electrolytic capacitor C2 and the R4 resistor. Especially if the brakes are used often or at short intervals the third brake light will not flash or maybe flash once or twice. Again, this is because the R-C combo does not have enough time to discharge in between braking. It takes about 12 seconds to discharge C2.



The pcb measures 2 x 2.5 inch (5 x 6.4cm or 170 x 200 pixels) at 2 colors and is shown smaller when you print these pages. If you need a direct, full size copy of the pcb I suggest to load the gif file into a program like Paint Shop Pro or one of the many gif viewers available. This pcb was modified by Bert Vogel and eliminates the jumpers. [Click Here](#) Good stuff; thanks Bert.



The layout is enlarged a bit for a better component view. Note that Q1 is drawn soldered on the pcb but if you have a metal case you can put it anywhere on the metal case (as a coolrib) and use havy duty wiring between Q1 and the PCB.

CORRECTION: SCR1's anode/kathode were shown reversed (fixed: 2-26-2000).

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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 application today is filtering. 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.](http://www.bytemark.com)

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.

Red E Cores: 500Khz - 30Mhz ($\mu=10$)			
Core	OD	ID	H (in inches)
T12-2	0.125	0.06	0.05
T25-2	0.25	0.12	0.09
T37-2	0.37	0.21	0.12
T50-2	0.50	0.30	0.19
T68-2	0.68	0.37	0.19
T80-2	0.80	0.50	0.25
T94-2	0.94	0.56	0.31
T200-2	2.00	1.25	0.55

(c) Tony van Roon

Black W Cores: 30Mhz - 200Mhz ($\mu=7$)

Core	OD	ID	H (in inches)
T12-10	0.125	0.06	0.05
T25-10	0.25	0.12	0.09
T37-10	0.37	0.21	0.12
T50-10	0.50	0.30	0.19

(c) Tony van Roon

Yellow SF Cores: 10Mhz - 90Mhz ($\mu=8$)

Core	OD	ID	H (in inches)
T12-6	0.125	0.06	0.05
T26-6	0.25	0.12	0.09
T50-6	0.50	0.30	0.19
T68-6	0.68	0.37	0.19
T80-6	0.80	0.50	0.25
T94-6	0.94	0.56	0.31

(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-114	1.142	0.750	0.295

(c) Tony van Roon

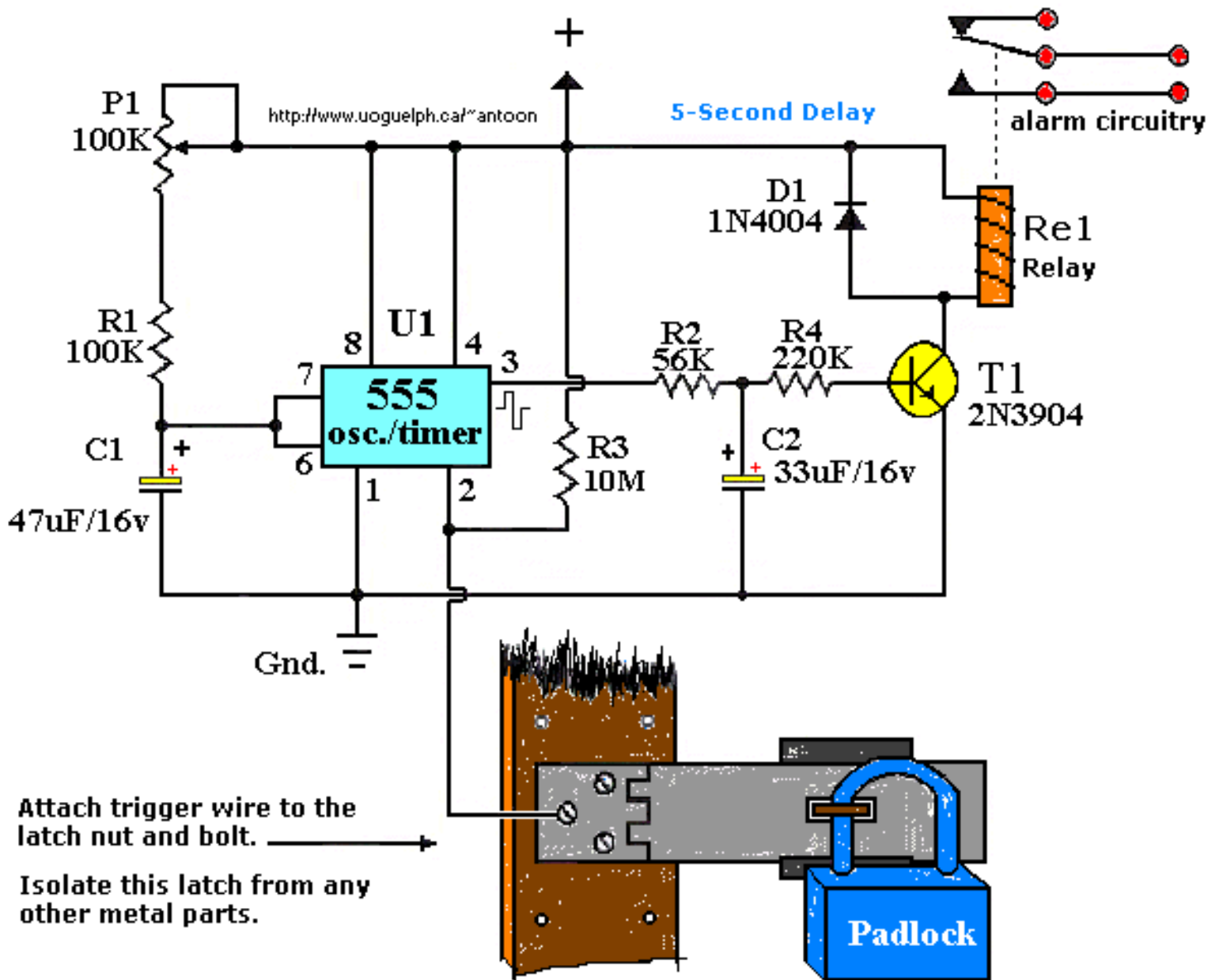


The photograph at left shows a Toroid Red 'E' Iron core and is used in a CW-transmitter (morse-code) application in the 30-meter band.

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Touch Activated Alarm System

by Tony van Roon



Parts List

R1 = 100K	D1 = 1N4004	U1 = <u>555 Timer*</u>
R2 = 56K	C1 = 47μF/16V**	
R3 = 10M	C2 = 33μF/16V**	
R4 = 220K	T1 = 2N3904, or equivalent	
P1 = 100K	Re1 = Relay***	

Additional Notes

Not much to tell here as the circuit speaks for itself. *The 555 can be a LM, NE, or MC(cmos) type, they are

all pin-compatible. ****C1/C2's** working voltage should be increased to 25V if you decide to go with a 12V power source. 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 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.

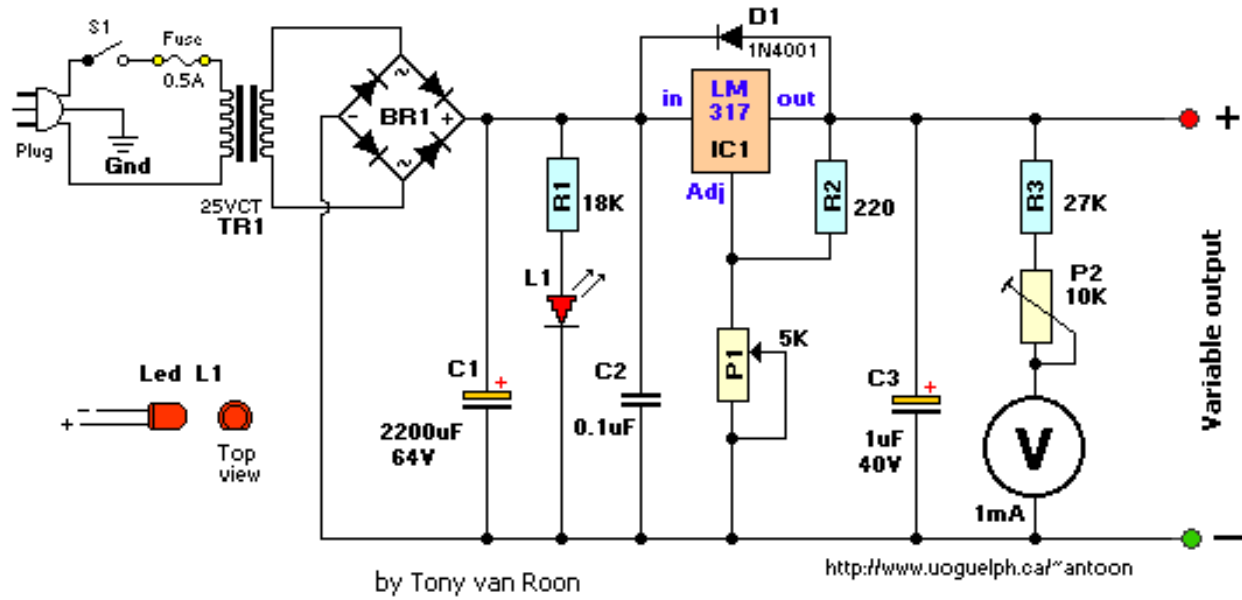
AGAIN, make sure the latch is not touching anything 'ground' or the circuit just keeps resetting itself and so will not work. My shed has wooden doors so works fine. If you can not get yours to work, check the trigger input, verify there is some sort of signal coming from output pin 3 play with the value of R3. 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](#)

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Variable Regulated Power Supply

1.2 to 30Volts @ 1.5 Amps.



Parts List

BR1 = Bridge Rectifier, 100V - 3A

IC1 = LM317, adjustable regulator

V = Meter, 30V, $R_i = 85 \text{ ohm}$

TR1 = Transformer, 25V, 2A

R1 = 18K, 5%

R2 = 220 ohm, 5%

R3 = 27K, 5%

P1 = 5K, potentiometer

P2 = 10K, 10-turn trim-pot

C1 = 2200 μF , 63V

C2 = 0.1 μF

C3 = 1 μF , 40V

Plug = 3-wire plug & cord

S1 = On-Off toggle switch

D1 = 1N4001

Fuse = 110V, 500mA, slow-blow

FuseHolder, wire, solder, case, knob for P1

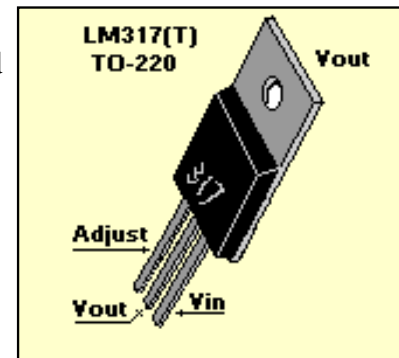
Red & Black Banana Jacks

Some 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 perferated or vero board. Or buy one of Radio Shack/Tandy's experimentors 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...

All 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. 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 30volts 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 potentiometer. 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. If you have or obtained a meter with a different Ri (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!

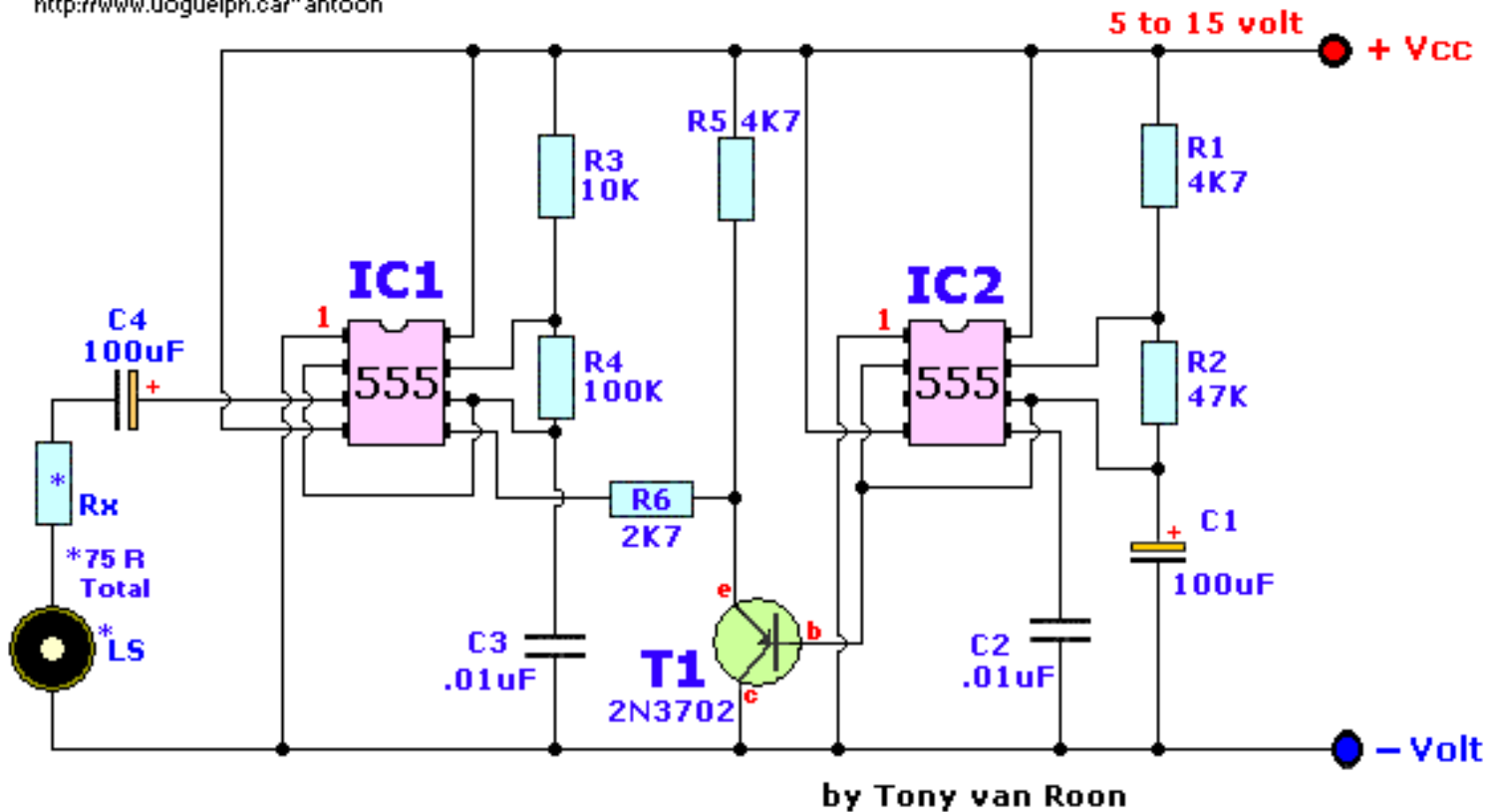
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Wailing Alarm Siren

by Tony van Roon

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



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 = LM/NE555, MC1455P, etc
Rx = *Notes	LS = Loudspeaker. *Notes

Notes:

This circuit provides a wailing 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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and Control Cir

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

Parts List

Fuse = Slow-blow, 2 amp.

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!



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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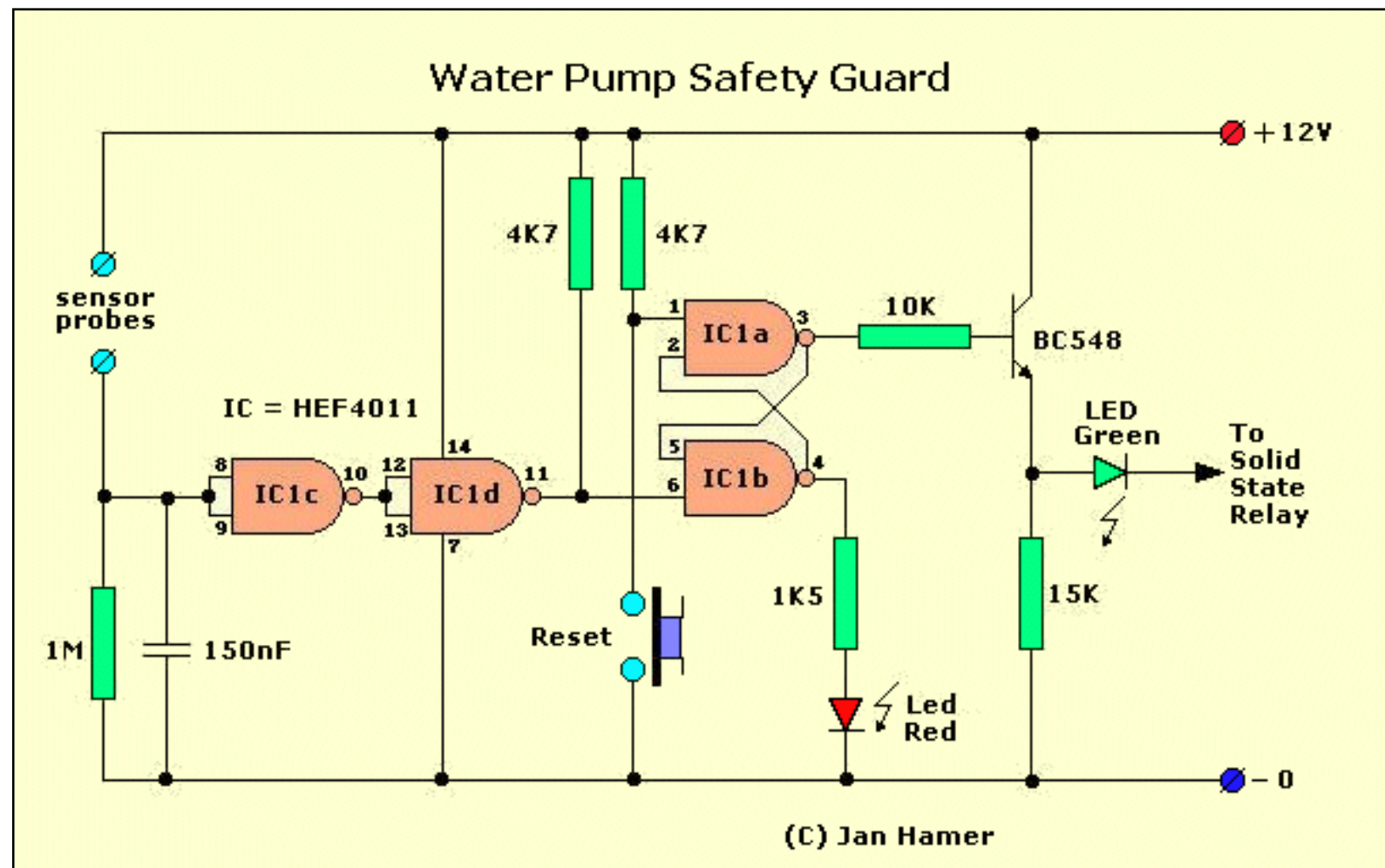
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Waterpump Safety Guard for Fish-pond

© 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

WLC100 One day you switch on your soldering station. You flick the switch and the red light comes "ON", indication power is okay. Ten minutes later you get ready to solder and find the soldering pencil is not hot at all. What?! After the usual frustration period of confusion and bad words you decide to investigate and fix the problem. After all, you are a techie or technical inclined and you can fix anything.

Well, read on. I was in a similar situation and in for a 'quick-fix'; NOT! Not thinking of checking out the soldering pencil first (dumb,dumb,dumb) I started to take the one visible screw out from the bottom cover plate. The other two screws are hidden underneath the rubber feet at the left edge. As mentioned before, the circuit board is small. I pulled the knob off and unscrewed the nut holding the switch to the body. I marked the wiring on a piece of paper and took the pcb out all the way. We had brownouts and power-failures that afternoon so my first thought was a defective diac but after a quick test with the Huntron Tracker it proved to be good (see diagram below).

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. Darn 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.

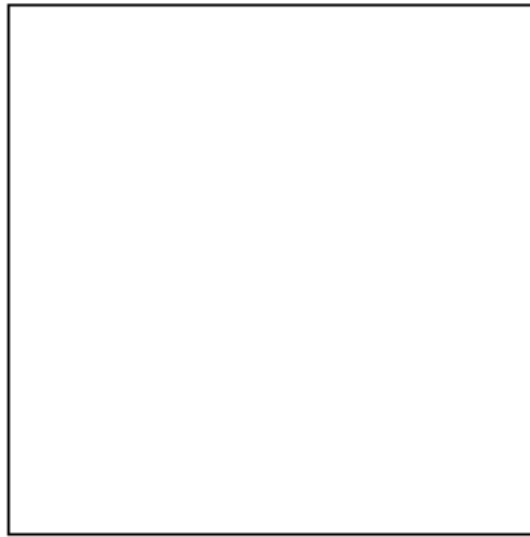
This station lasted about 6-years of 7-hour a-day use, so really fantastic. Unable to order replacement parts for this model I was forced to purchase a new station, not really expensive though, they are around \$55.00 Canadian in my area so a good buy.

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 may help you in repairing your own station if the time comes.





Drawn by Tony van Roon (2002)



Parts List:

R1 = 15 Kilo-Ohm, brown-green-orange, 1/8 Watt, 5%

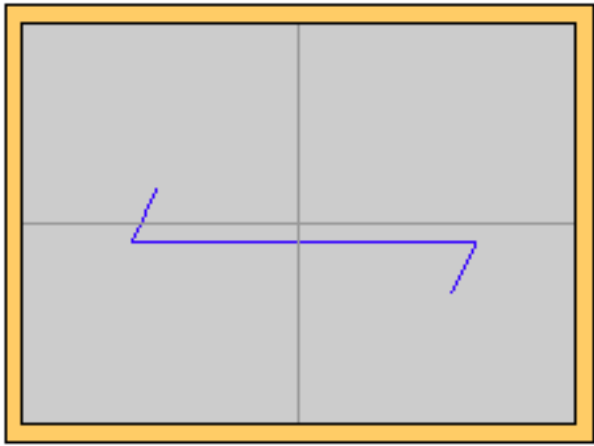
P1 = 220K potentiometer

C1 = 823K, 250V

D1,D2 = 1N4007

D3 = Diac, bilateral trigger type

Q1 = *Q4012LPH, Triac, 400V/25A, Manufactured by Teccor

**Notes:**

The Diac I tested with an instrument called a "Huntron Tracker". It showed okay. Look at the picture at the left what a 'good' signature is for a diac.

Newer 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.

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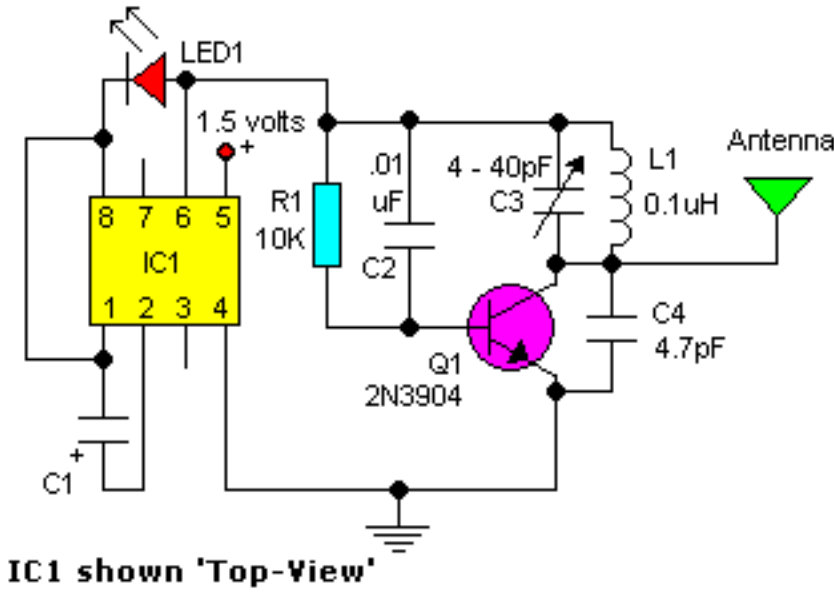
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1.5 Volt Tracking Transmitter

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

Parts List

C1 = 100 uF electrolytic capacitor
C2 = .01 uF 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.



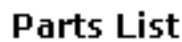
Additional Notes

- 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.

The current draw for this tracker is 3.7mA, so the 1.5V button cell will last awhile. 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 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 is a nice project. The 12-inch antenna can be anything, it is not really that critical. I used a piece of 22 gauge flexible wire. I haven't checked the range but will do that shortly. Have fun with it. -- Tony

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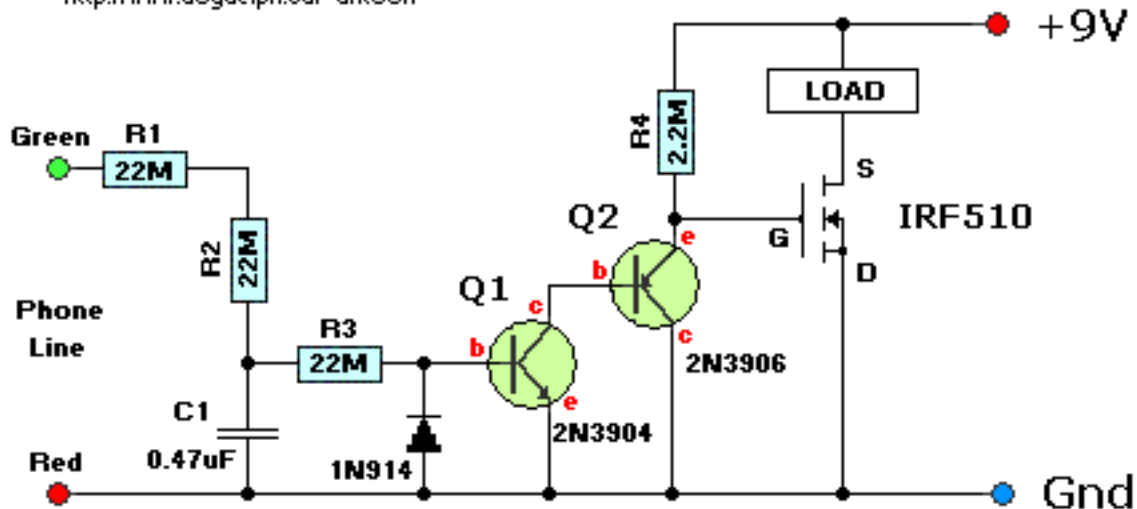
C5 = .001 uF disc cap

L1 = 4 to 5 turns of 22 ga. magnet wire close wound around 1/8" non-conductive core.

Antenna = 10 to 12" hookup wire.

Cut Phone Line Detector

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



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:

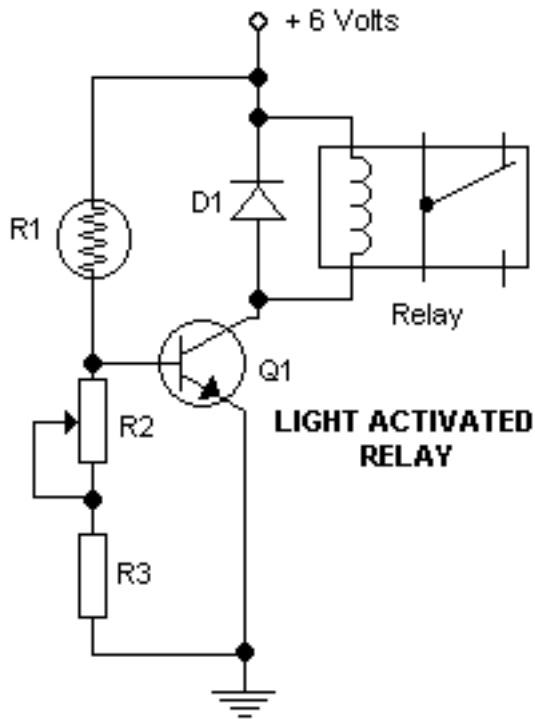
This circuit speaks for itself. When the phone line is okay, Q1 acts as a short with a very high ohms value via R1, R2, and R3 for a total of about 66 MegaOhm so very high. When the phone line is cut (open), it activates the MosFet (Q3) via transistor Q2 to drive the load. Substitutes are fine, none of the components are critical.

The '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...

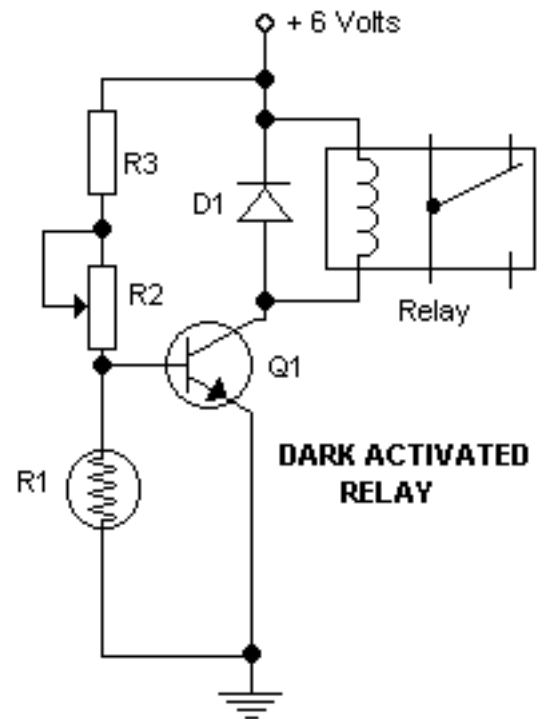
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Dark/Light Activated Relay



Parts List

D1 = 1N914 diode
Q1 = 2N2222 or similar NPN transistor
R1 = photoresistor
R2 = 50K variable resistor
R3 = 1K
Relay = 5 to 6 volt relay.



[Additional Notes](#)

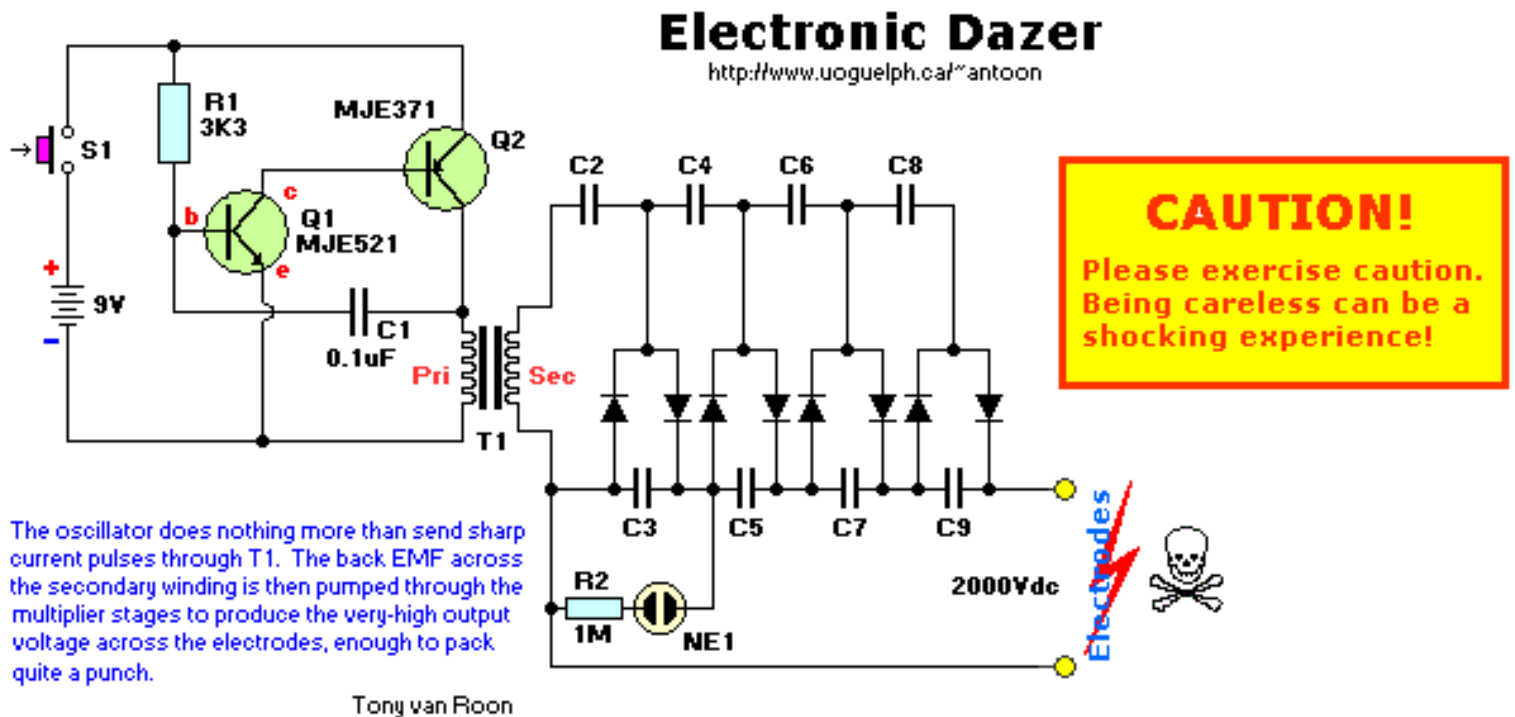
None of the parts are critical and easy available. The potmeter adjust the trigger 'on' level. The diode in the diagram shows to be 1N914. This is ok if you have a light-duty relay, also the 1N914 is a signal diode so actually does not qualify. Use a 1N4001 (or better) instead. A couple of substitutes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

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Electronic Dazer

By Rick Duker & Tony van Roon (circuit diagrams)

Never walk in fear with this one-evening project. It won't kill, but it is an effective way to say "Leave me alone!"



Parts List

- R1 = 3K3, 5%
- R2 = 1M, 5%
- C1 = 0.1 μ F, monolythic capacitor
- C2-C9 = 0.01 μ F 400 volt polyester capacitors
- D1-D8 = 1N4007, 1KVolt diodes
- NE1 = Type NE-2 neon bulb
- Q1 = MJE521 NPN power transistor
- Q2 = MJE371 PNP power transistor
- T1 = 1200 to 8 ohm audio power transformer
- 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 NE-1, circuit board standoffs (optional), hookup wire, solder, etc.

Substitutes:

After several emails from readers I have found direct possible replacements for Q1/Q2. If I come across suitable others I will add them on a future occasion.

Q1, MJE521: The NTE184 or 2N5190 will work.

Q2, MJE371: The NTE185 or 2N5193 will work.

T1, 1200:8 ohm. Have not experimented with the 1000:8 type. Try it.



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 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, 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. The device develops about 2,000 volts. Higher voltages may be attained by adding additional multiplier stages, but it should be noted that those stages 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 battery, either NiCad or alkaline. (Editor's Note: the so-called 9-V NiCad actually provides only about 7.5V. Why? NiCad cells only give 1.25 per cell. 6 cells in a 9volt battery gives it 7.5V and so the Alkaline type would be a better choice).

The high voltage is applied to two electrodes which require only light contact to be effective. When touched with the Dazer, the victim 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 a cheap induction-type cattle prod. 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 generates VERY High Voltage of around 15,000V AC pulses, 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.)

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 and C9, and D1 to D8. The final output is approximately 2000 volts. The neon

bulb NE1 is used as a charge indicator and indicates that the unit is charge and operating properly.

Check out fig. 1 at the right; these are standard voltage doublers found in many data books and others like the NTE or Electro Sonic catalogue. 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'.

General Voltage Doubler

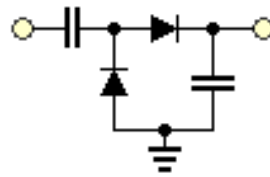
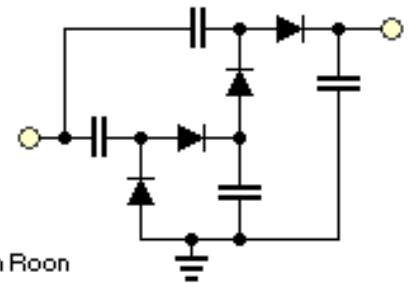


Fig. 1

Voltage Quadriplier



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

Construction:

As with all projects start out by laying out and indentifying. 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 NE1. 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, NE1, and output electrodes. Be sure that the output electrodes are about a cm or greater apart. Connect the output wires tot the electrodes and insert them trthought 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. 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 battery (do NOT connect 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. NE1 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.

Operation and Use:



Activate the unit by pressing S1. NE1 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 powerfull 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!**

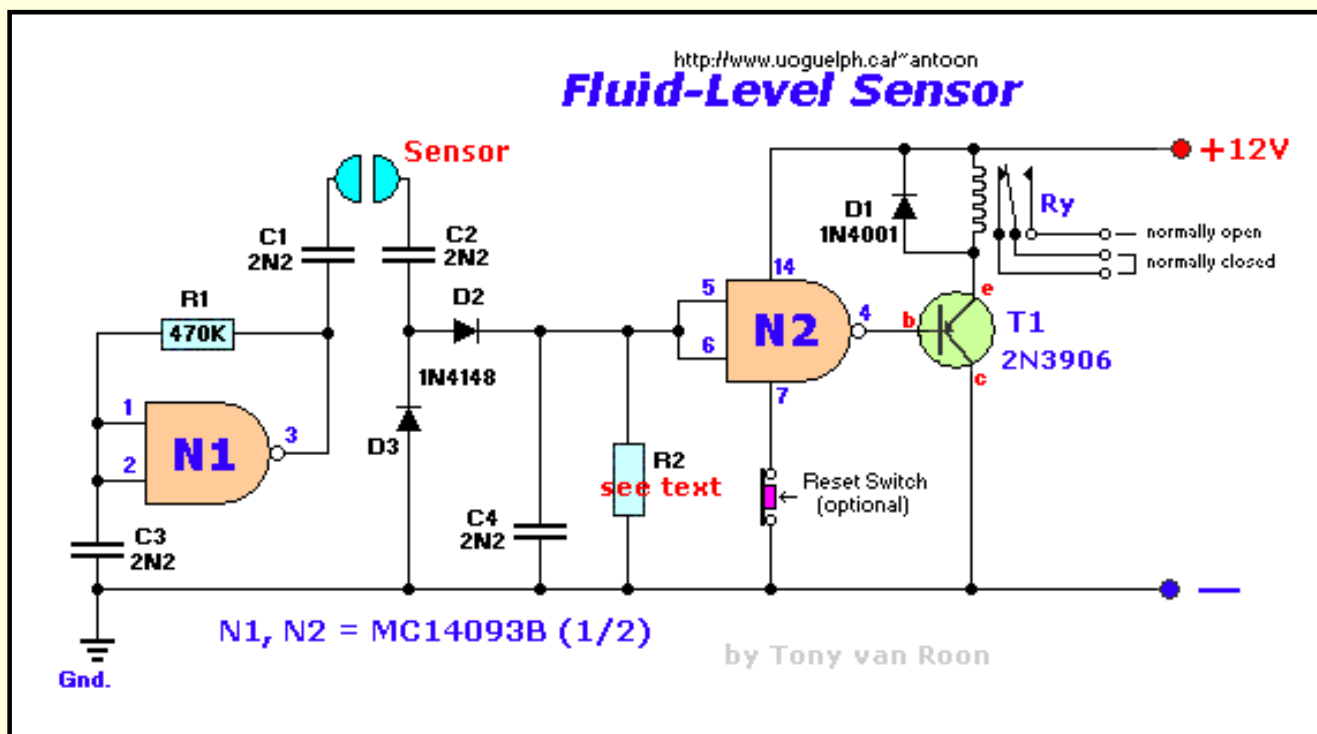
Another use for this device is as a high voltage DC power supply. It may be constructed as avariable power supply if output taps are taken from various stages of the voltage multiplier section. Remember, always disconnect the battery and fully discharge the capacitors before working with the circuitry.

Note that if you decide to 'Turbo-charge' your unit, you have to use diodes which can handle the voltage. This unit can easily be damaged (and stops working) by incorrect parts choice. So be careful and watch yourself.

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 possesion or the construction of this project. I take no responsibility, whatsoever, for the use and/or experimentation with this circuit and other lethal high voltage projects.

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Parts List:

R1 = 470K

R2 = 15M*

C1 - C4 = 2N2 (2.2nF)

D1 = 1N4001

D2,3 = 1N4148

N1,N2 = MC14093B

T1 = 2N3906 (these will work also: PN200, 2N4413)
(NTE159, ECG159, BC557, BC157, TUP)

Ry = Relay (12V or matching supply voltage)

Sensor = Stainless Steel probes, brass, chrome, etc.

The above circuit uses an ac-sensing signal to eliminate electrolytic corrosion on the probes. The ac signal is rectified and used to drive Transistor T1 that drives the relay. The relay the 12-V type of your choice.

Transistor T1 can also be a TUP. Check out the [TUP/TUN](#) document for a large selection of European transistors and what this system is all about.

Diodes D2 and D3 are both small signal diodes (1N4148). Diode diode D3 (1N4001) eliminates transients and possible sparking over the relay coil. Do not use a signal diode for this but a rectifier diode like the 1N4001 or other types of the 1N400x series.

Resistor R2 controls the sensitivity. Also your choice. Select one between 10 and 22 Mega-ohm, or use a trim-pot.

The MC14093B is a mos p-channel quad 2-input NAND schmitt trigger. The supply voltage can be between 3.0 and 18Vdc. It is pin-for-pin compatible with the CD4093. The capacitors are standard ceramic types but try others if you have them available.

The unused inputs **MUST** be tied to an appropriate voltage level, either ground or +12V. In this case, tie input pins 8, 9, 12, and 13 to either ground or +12v. The unused outputs (10 & 11) **MUST** be left open. You can use them as spares when needed.

In regards to the sensor, use your imagination. Stainless steel would be preferred but try other materials too. Depending on what type of fluid you use it for you naturally would choose your type of sensor which would resist corrosion for that particular fluid. I often use chromed bicycle spokes with very good success.

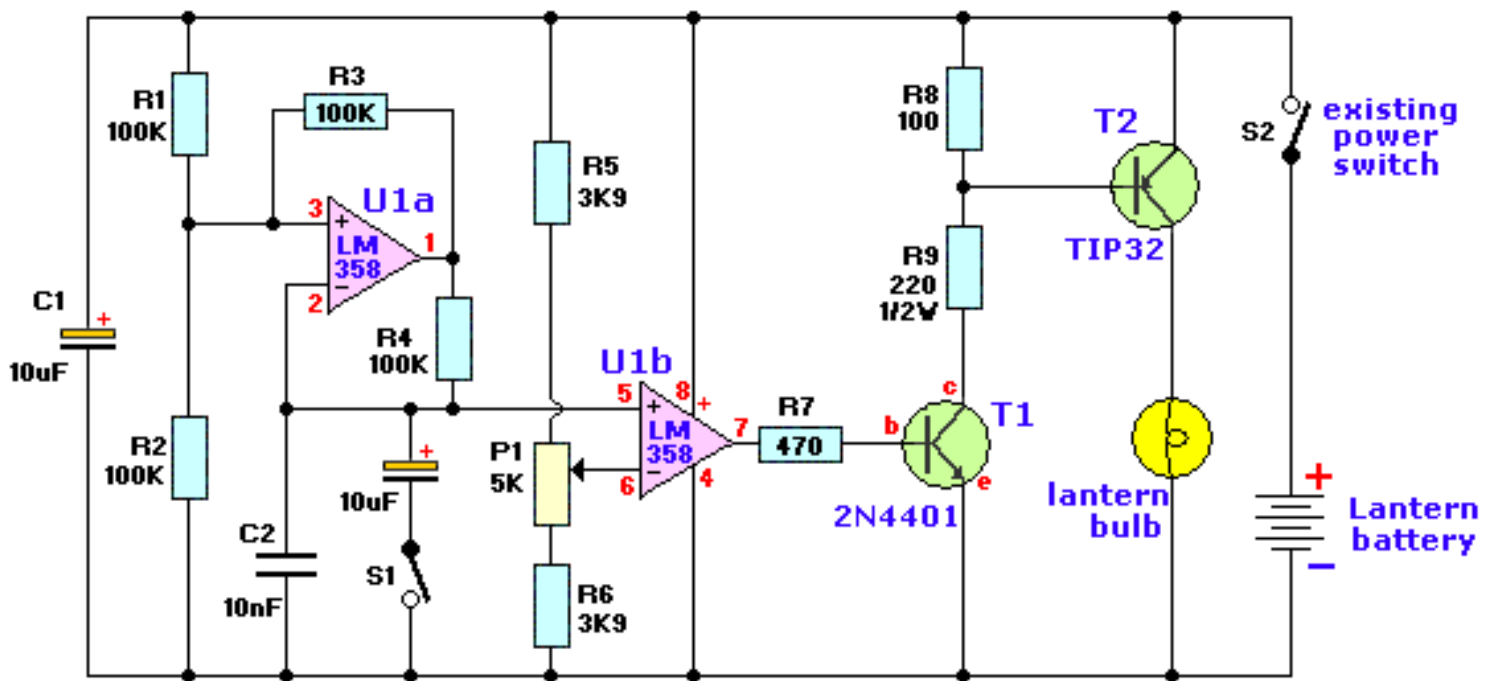
The "RESET" switch in the circuit is optional. The relay can be replaced with anything you like; buzzer, lamps, other relays, etc. A small capacitor of about 10nF (nanoFarad = 0.01uF)

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Lantern Dimmer/Flasher

by Tony van Roon



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

by Tony van Roon

Parts List

R1 = 100K	C1, C3 = 10uF/16V
R2 = 100K	C2 = 0.01uF, ceramic
R3 = 100K	T1 = 2N4401
R4 = 100K	T2 = TIP32
R5 = 3K9	U1 = LM358
R6 = 3K9	L1 = Lantern Bulb
R7 = 470	S1 = On-Off Switch
R8 = 100	
R9 = 220, 1/2 watt	
P1 = 5K	

Additional Notes

ALL resistors are 1/4 watt, 5% tolerance, unless otherwise posted.

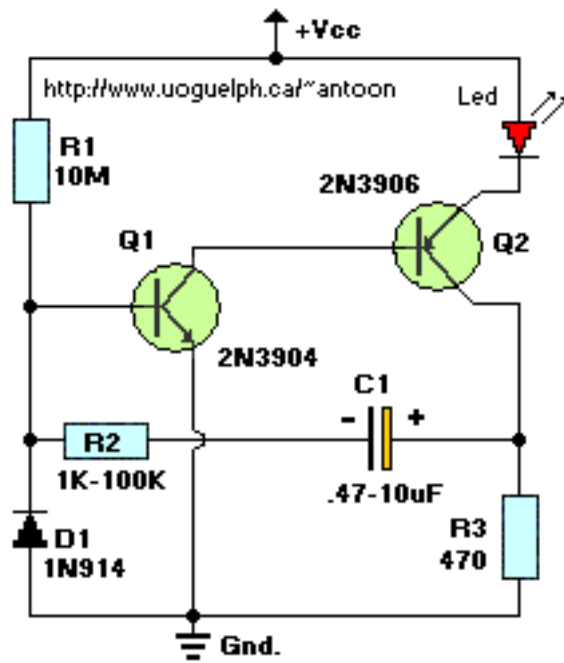
P1 is the dimmer potentiometer. S1 is an additional switch to activate the 'Flashing' mode. R9 has to be a half-watt type. T1 is a NPN audio amp transistor and can be substituted with a NTE123AP, the BC547, Elector's (Elektuur) TUN. T2 is a PNP power amp and can be substituted with a NTE197. Try others, they

also may work.

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2-Transistor Led Flasher



Parts List

R1 = 10M, 5%

R2 = 1K - 100K, 5%

R3 = 470, 5%

C1 = 0.47 μ F - 10 μ F/25V

D1 = 1N914

Q1 = 2N3904

Q2 = 2N3906

Led = High Brightness Red LED

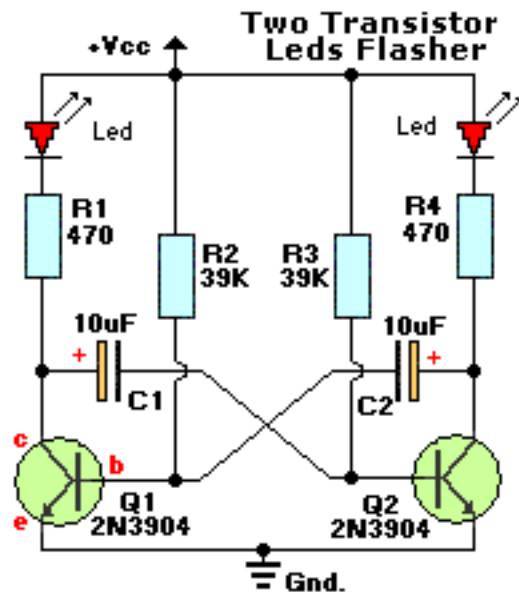
Volts	R1	R2	R3	C1	Approx. Flash Rate
12	10 Meg	22 K	470	0.47 uF	140 per minute
12	10 Meg	10 K	470	1.0 uF	60 per minute
9	6.8 Meg	1 K	390	6.8 uF	15 per minute
6	3.3 Meg	10 K	220	1.0 uF	80 per minute
3	1.5 Meg	10 K	51	1.0 uF	120 per minute
3	3.3 Meg	47 K	51	0.47 uF	140 per minute

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 ($3 \cdot R2 \cdot C1$). 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 ommited 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.

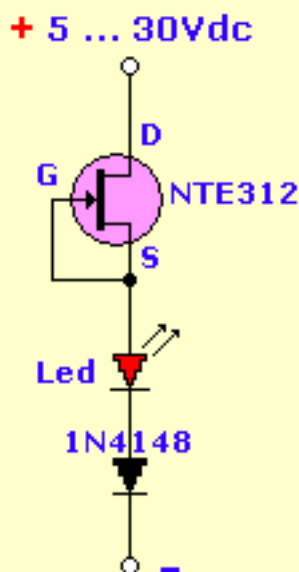
Obviously, the 470 ohm resistor determines the LED's brightness and limits the current flow to about 20mA. 390 ohm can also be used as a save value. If you decide to go with a green or yellow led, which draw more current, you may want to replace the 470 ohm with 270 or 330 ohm values. Flash rate is determined 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



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, try others. The ones mentioned I had available.

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.

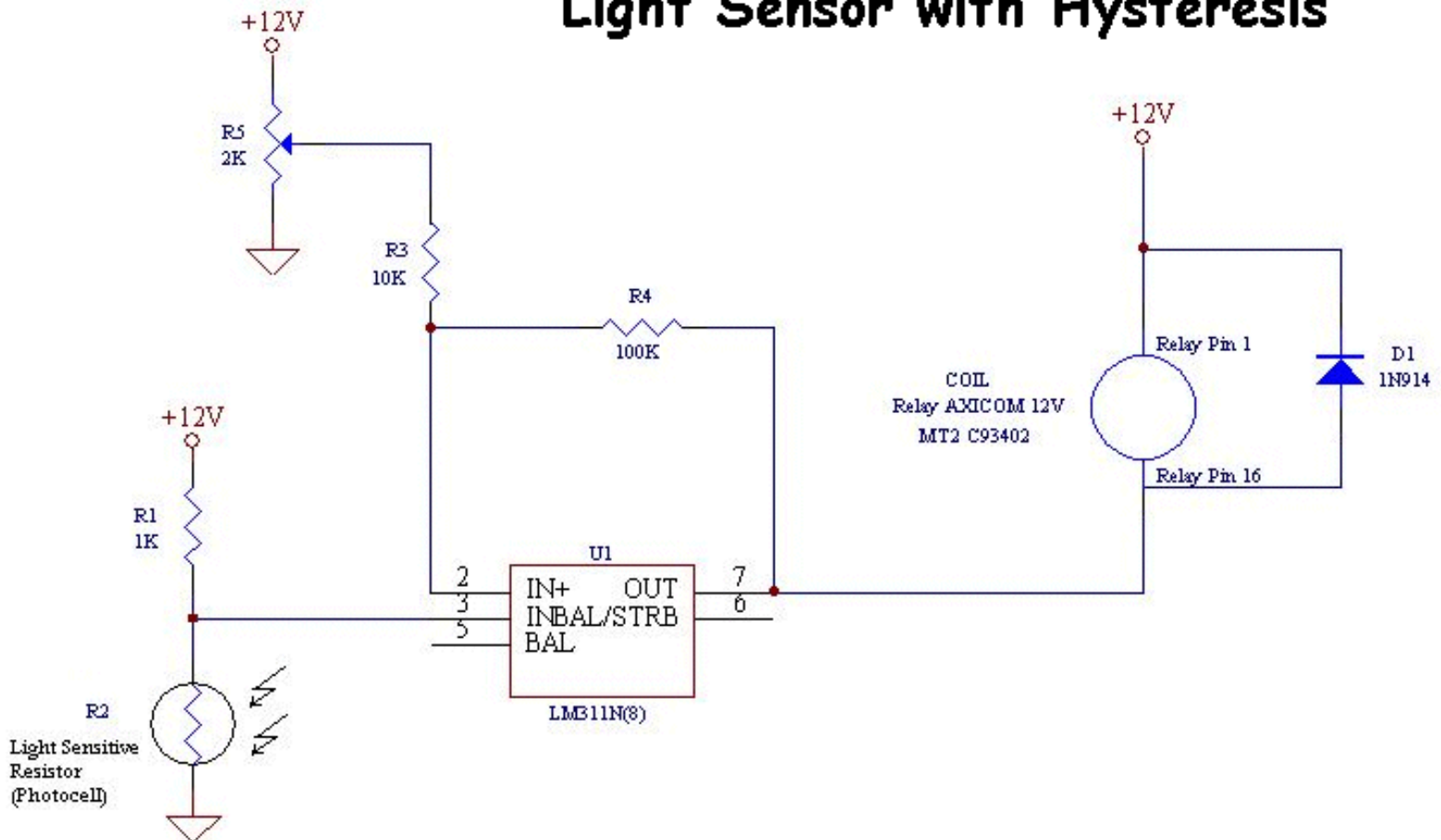
If a diode is added (the 1N4148 is optional) this circuit is protected against polarity reversal and can be connected to a AC source of 5 to 20 Vac.

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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.

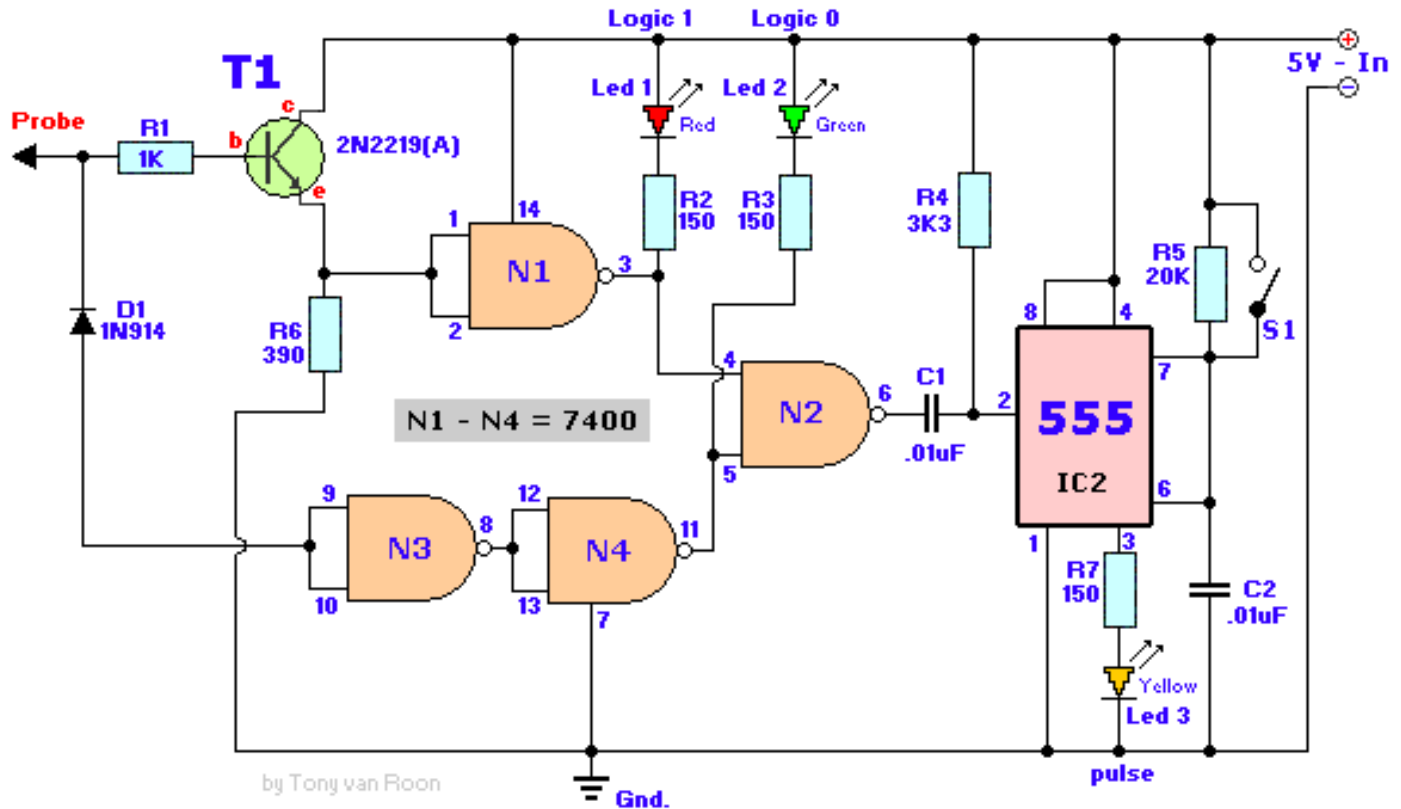
So, if you use it to control outdoor lightings for example, it will produce a single clean trigger from on to off ... It will turn off one at dawn and will turn back on only once in the morning when light will be strong enough to energize the comparator. This is quite good because it avoids the relay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

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

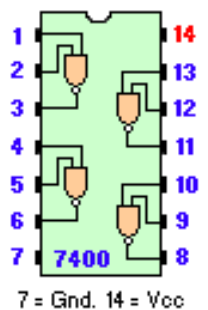


by Tony van Rooy

Parts List:

R1 = 1K	C1,C2 = 0.01uF (10 nanoFarad)
R2 = 150 ohm	T1 = 2N2219(A), NTE123, or TUN
R3 = 150 ohm	D1 = 1N914
R4 = 3K3	IC1 = 7400, quad 2-input NAND gate
R5 = 20K	IC2 = 555, timer/oscillator
R6 = 390 ohm	Led 1,2,3 = Red,Green, Yellow. Ultra bright, 3mm
R7 = 150 ohm	S1 = Switch, on-off

Top View



7 = Gnd. 14 = Vcc

Error Fix: The position of the toggle switch (S1) was repositioned to before the 20K resistor R5. I have not tried this modification myself. Fix was suggested by [Steve Main](#) from [Caspan Scripts](#) who indicated that this was the only way the circuit would work as described below.

Description:

One of the most frustrating problems with experimenting is not be able to check the logic state of TTL or CMOS ic's without the use of a triggered oscilloscope. The schematic diagram above shows a simple and inexpensive way of building a 'Logic Probe' yourself. It will provide you with three visible indicators; "Logic 1" (+, red led), "Logic 0" (-, green led), and "Pulse" (yellow led).

The yellow or 'pulse' led comes on for approximately 200 mSec to indicate a pulse without regards to its width.

This feature enables one to observe a short-duration pulse that would otherwise not be seen on the logic 1 and 0 led's. A small switch (subminiature slide or momentary push) across the 20K resistor can be used to keep this "pulse" led on permanently after a pulse occurs.

In operation, for a logic 0 input signal, both the '0' led and the pulse led will come 'ON', but the 'pulse' led will go off after 200 mSec. The logic levels are detected via resistor R1 (1K), then amplified by T1 (NPN, Si-AF Preamplifier/Driver), and selected by the 7400 IC for what they are. Diode D1 is a small signal diode to protect the 7400 and the leds from excessive inverse voltages during capacitor discharge. The 7400 can also be a 'LS' type or whatever or any replacement.

For a logic '1' input, only the logic '1' led (red) will be 'ON'. With the switch closed, the circuit will indicate whether a negative-going or positive-going pulse has occurred. If 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.

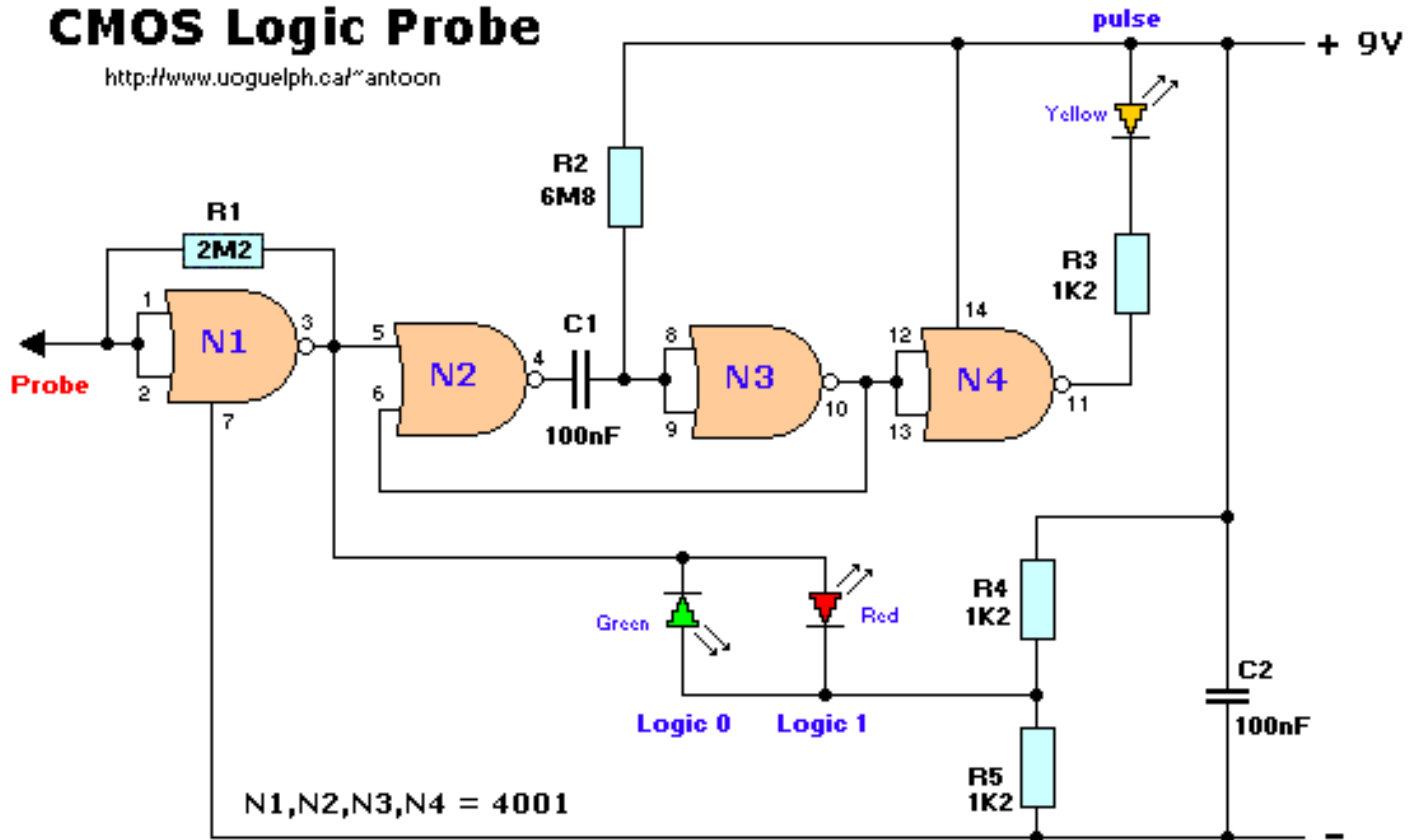
I have build mine into a short, but thick, magic-black marker. The probe-tip is made of a piece of piano wire. Have fun building it and make it part of your trouble-shooting equipment. Mine has been in operation since 1987!

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CMOS Logic Probe

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



Parts List:

R1 = 2M2
R2 = 6M8
R3 = 1K2
R4 = 1K2
R5 = 1K2

C1,C2 = 0.1uF (100 nanoFarad)

IC = 4001 (CMOS)

Leds = D1-Red, D2-Green, D3-Yellow. Ultra bright, 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 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 on indicator lighting up very vrightly 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 ouput 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.

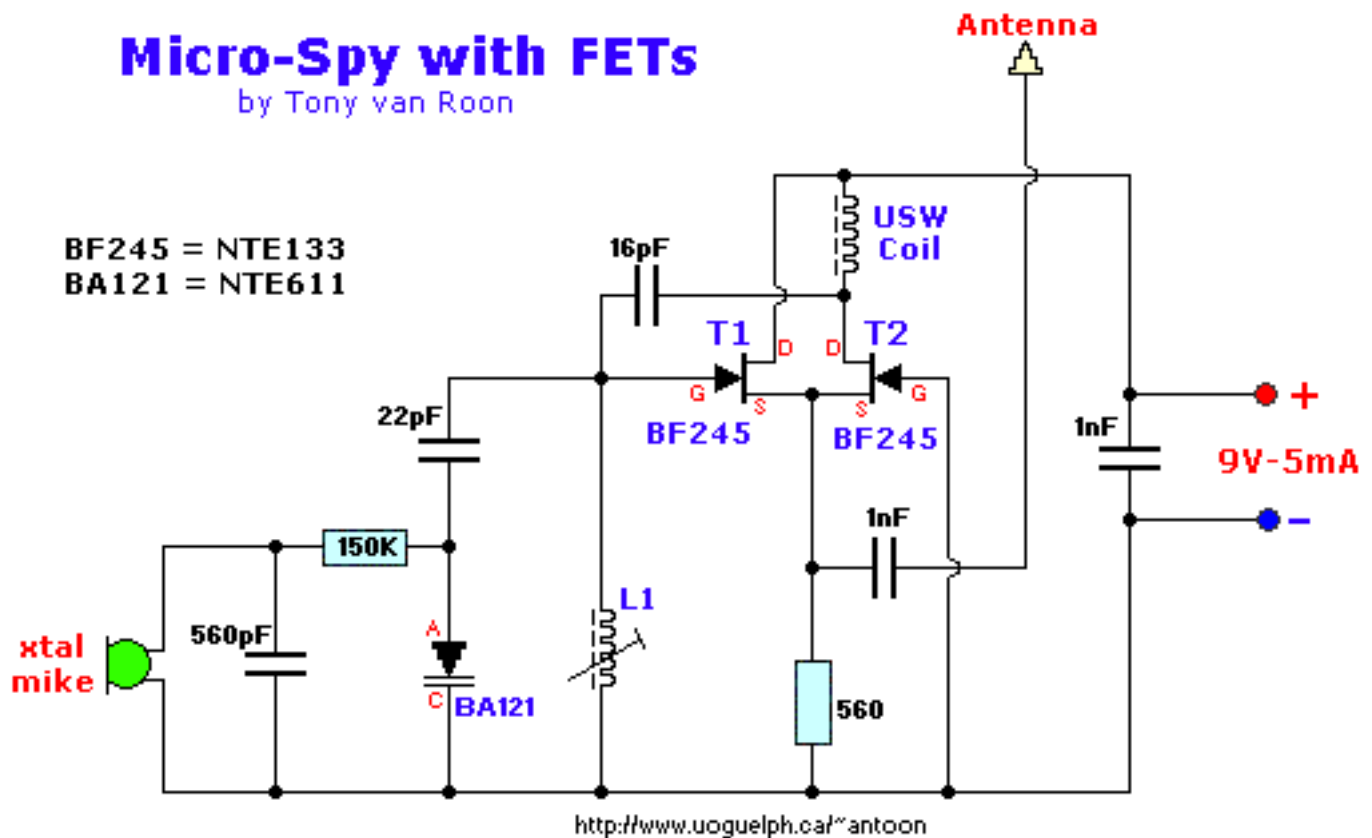
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by Tony van Roon

BF245 = NTE133

BA121 = NTE611



- 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 Silverwire 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!

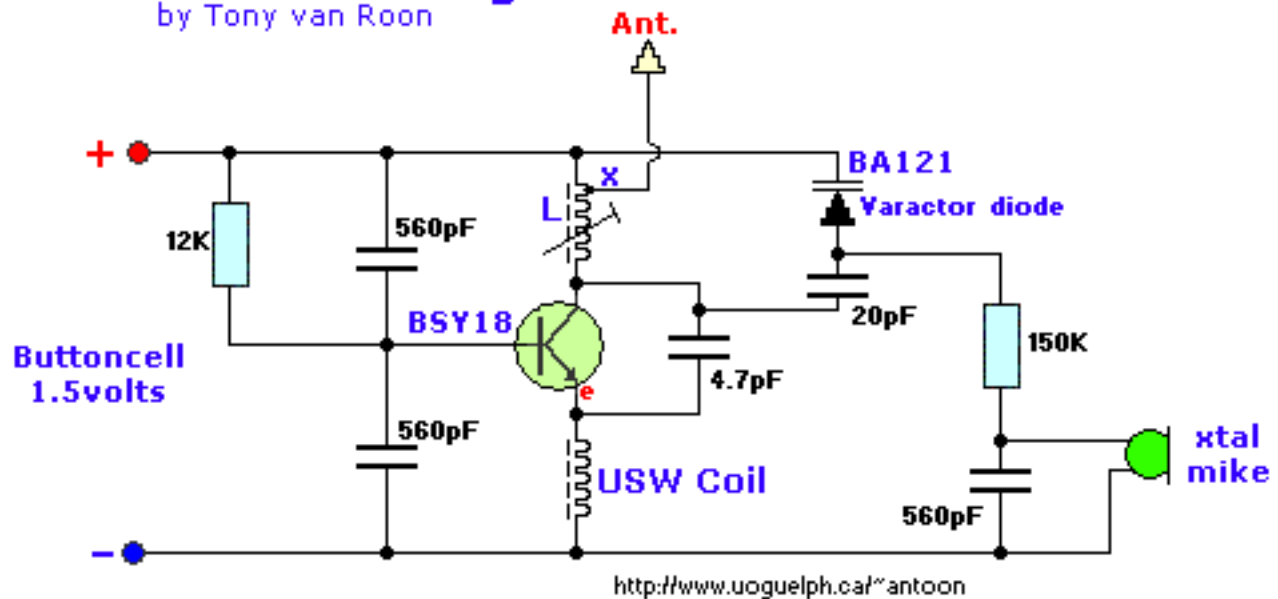
Please note: This circuit is not open for discussion; do with it as you please (but no copyright violations). I will answer no emails in regards to this circuit.

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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 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.

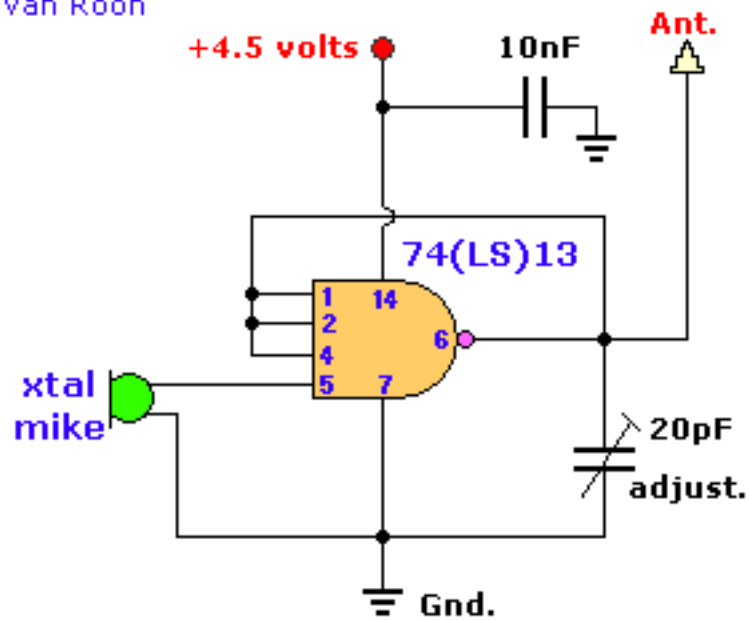
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TTL Micro-Spy

by Tony van Roon

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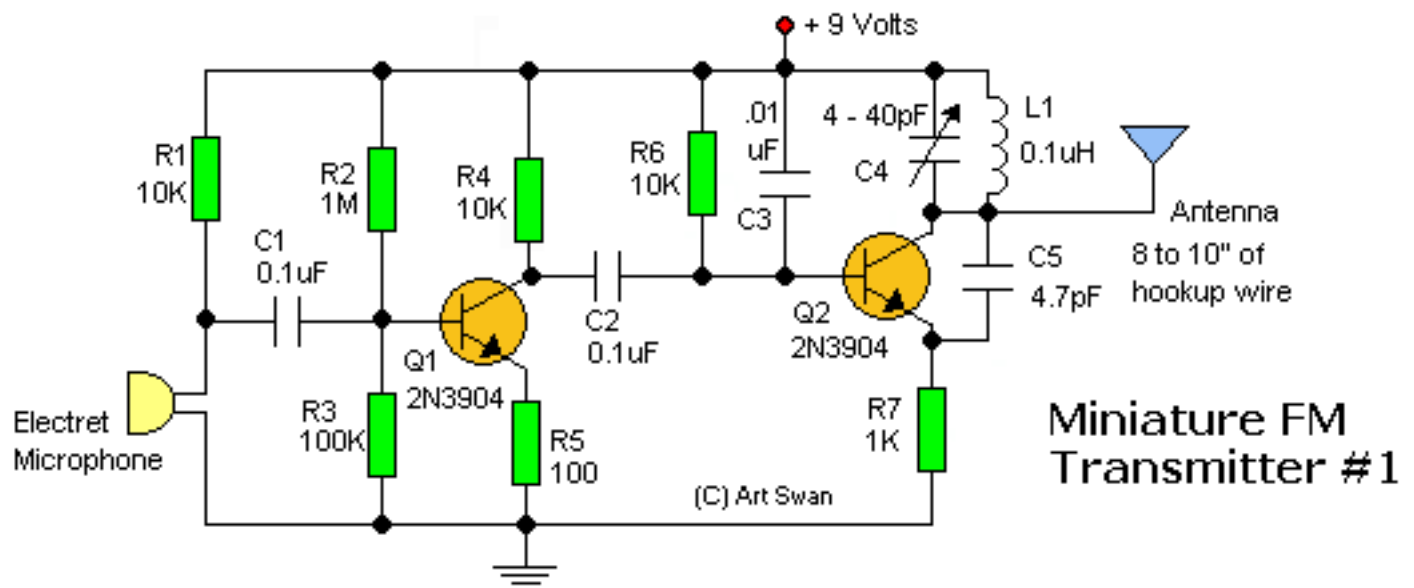


100 Mhz max. (3rd harmonics)

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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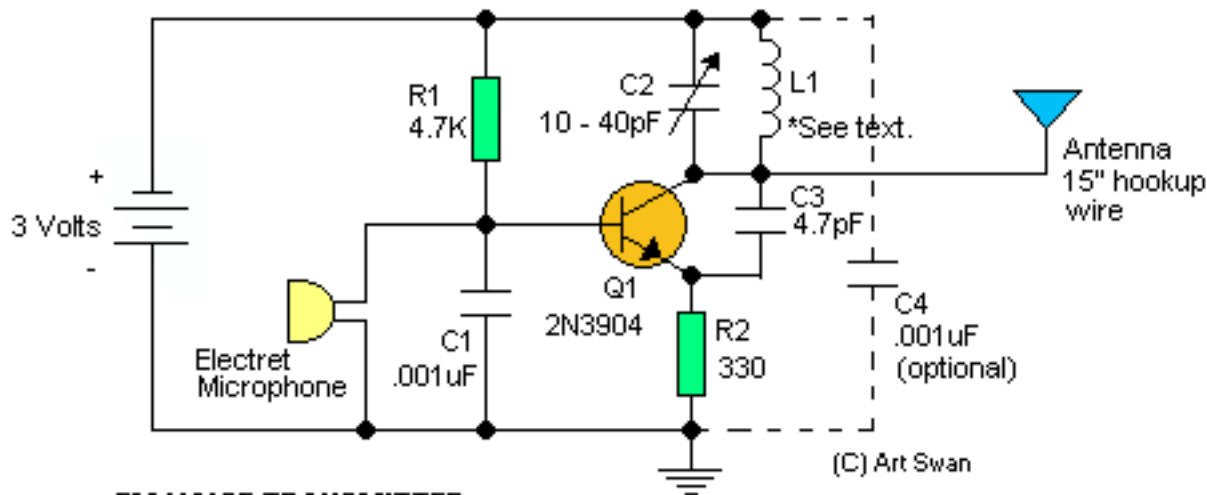
This miniature transmitter is easy to construct and its transmissions can be picked up on any standard FM receiver. It has a range of up to 1/4 of a mile or more. It is great for room monitoring, baby listening, nature research, etc. L1 is 8 to 10 turns of 22 gauge hookup wire close wound around a non-conductive 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



FM VOICE TRANSMITTER

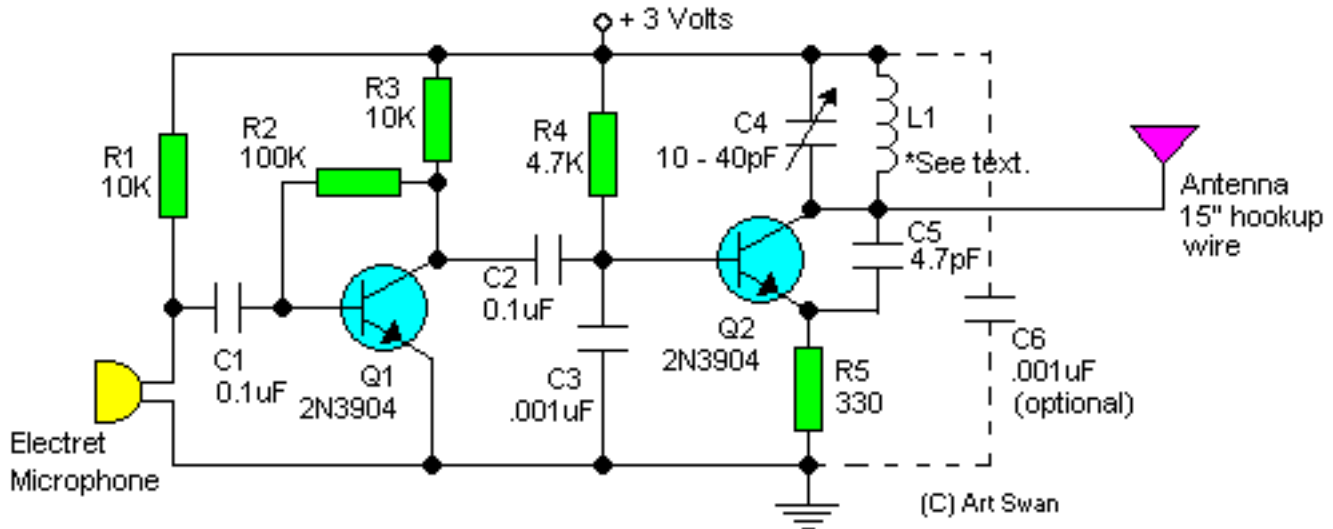
This is another easy-to-build miniature FM transmitter that uses a minimum of parts. Construction is straightforward and non-critical. Although this design uses a 3 volt power source (such as a lithium coin cell), a 9 volt battery can be used, instead, by increasing the value of R1 to 15K and R2 to 1K. 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 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



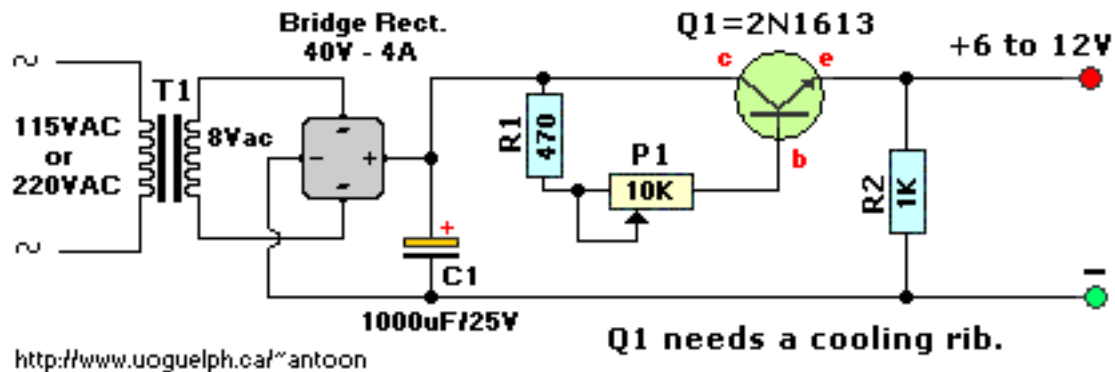
* L1 = 0.1 uH, 6 to 8 turns of 22 ga. hookup wire close wound around a 1/4 inch diameter non-conductive core such as a pencil.

[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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Mini-drill Adjustable Powersupply (c) Tony van Roon



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>

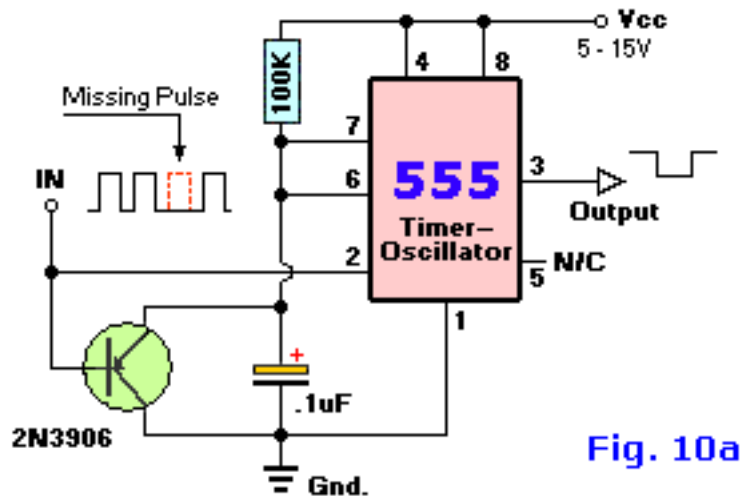


Fig. 10a

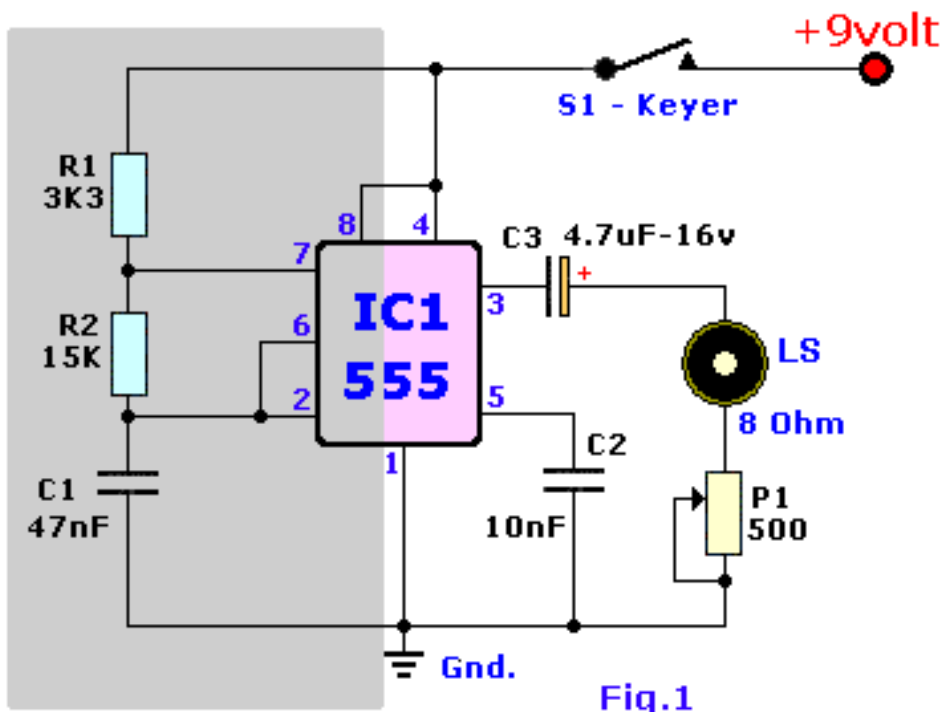
This circuit is a one-shot that is continually retriggered by incoming pulses. A missing pulse that prevents retriggering before a timing cycle is complete, causes pin 3 to go low until a new input pulse arrives. R1 & C1 control the response time. Use in alarms, continuity testers, beacons, R/C, etc.

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Morse Code Practice Oscillator

by Tony van Roon



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

Fig.1

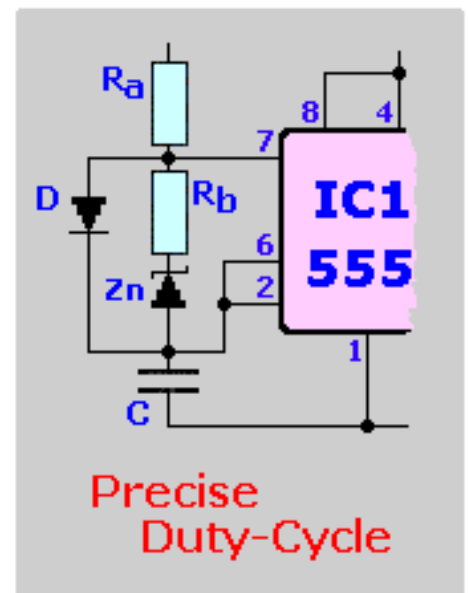


Fig.2

by Tony van Roon

Parts List

R1 = 3K3

R2 = 15K

P1 = 500 ohm

C1 = 0.047uF (47nF)

C2 = 0.01uF (10nF)

C3 = 4.7uF/16v

IC1 = 555 Timer IC

S1 = Morse Keyer

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.

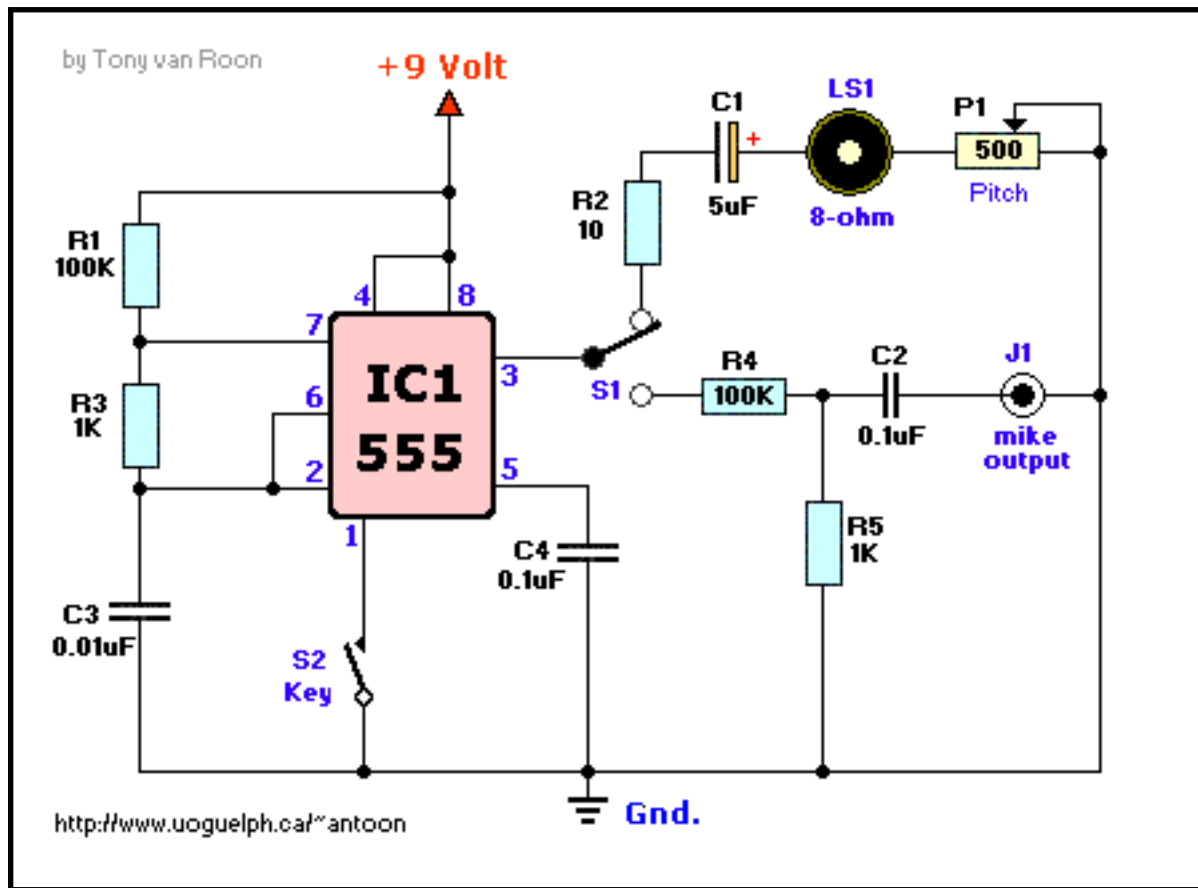
And obviously, S1 is your Morse-keyer. To get a more precise duty-cycle replace the components within the shaded gray area from Fig. 1 with the ones in Fig. 2. The diode can be 1N4148 or equivalent. The zenerdiode is between 5.2 and 5.8 volt. Ra and Rb are experimental to suit your personal taste. C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

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Morse Code Keyer (2)

by Tony van Roon



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 a 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](#),

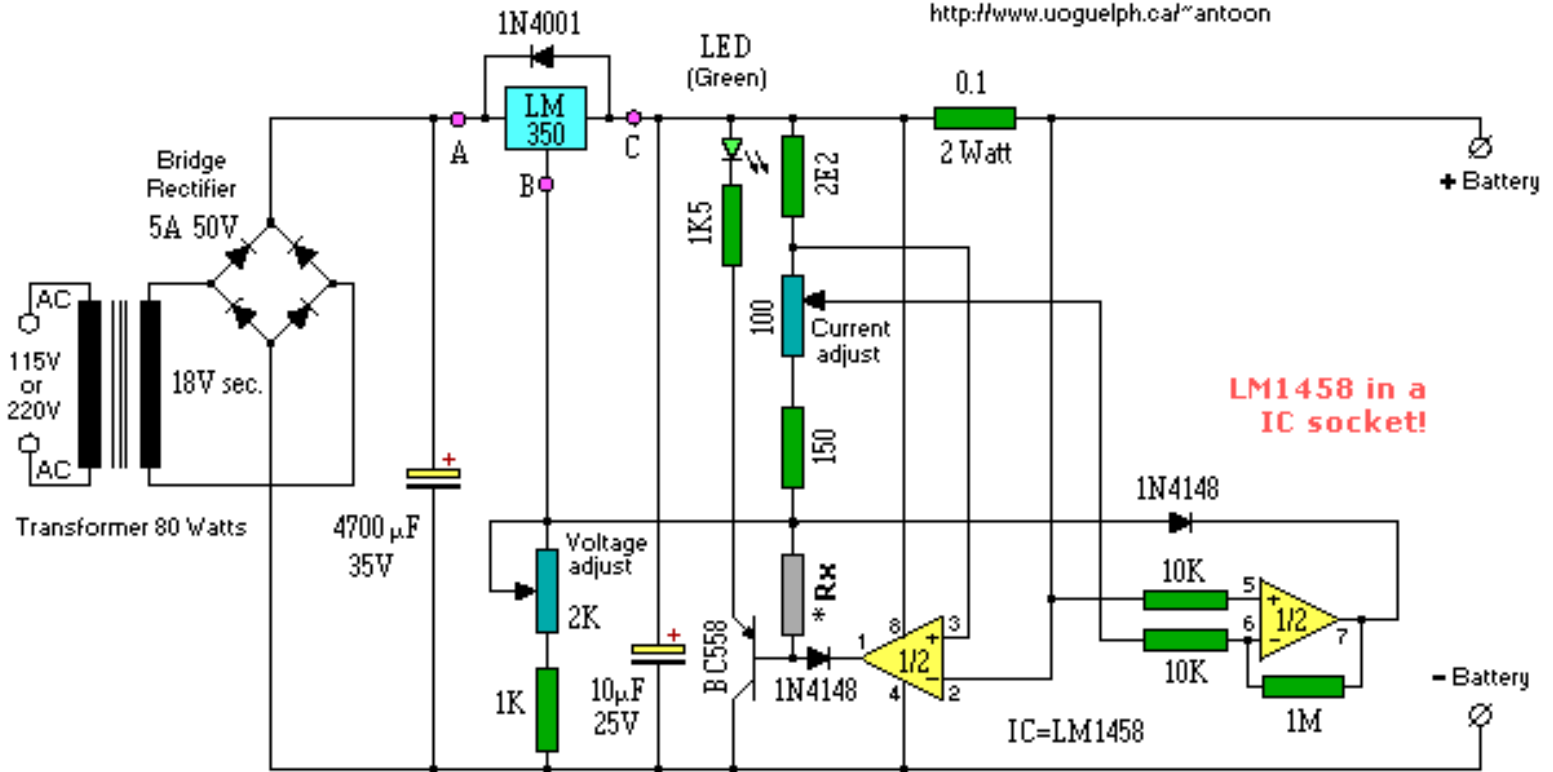
[NE555](#), etc. are fine too and are pin-for-pin compatible with each other. The timing circuit is formed by R1, R3, and C3. Resistors R4 & R5 are a voltage divider to reduce the microphone output to a safe level. Potentiometer P1 can be used to control the 'Pitch'. Capacitor C5 is used as a bypass 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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Motorcycle Battery Charger

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



B.J.G. Hamer maart 2000

Modified into English by Tony van Roon, August 2001

Error fix: Moved 1M from pin 5 to pin 6 on 1458. (5-22-2002)

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

ERROR FIX: The 1M resistor was connected to the wrong pin (5) on the second 1/2 of the 1458. Updated schematic correctly showing connection to pin 6. Apologies for any inconvenience.

This 3A charger was originally designed to work with small batteries like those used in motorcycles. In principle it can be used to charge car batteries also but will take a lot longer.

The charger below charges a battery with a constant current to 14.1 volt. When this level is reached, the current charge drops automatically to a safer level (13.6V) and keeps charging at this slower rate until the LED lights up indicating a fully charged battery. This project looks very much alike with the Gel cell II charger elsewhere posted in the 'Circuits' section. The difference is the IC, namely a LM1458 instead of a LM301A. Nice job Jan!

Description:

The LM350 is an adjustable voltage regulator and keeps the voltage between points C and B at 1.25 Volt. By adding a 1K resistor between point B and gnd (-) you can, as it were, lift up the output voltage. To accurately control the output voltage we add to this resistor, in series, a 2K adjustable 10-turn potentiometer. As soon as a battery is connected a current flow occurs, controlled by the right half of the LM1458. The current through the 0.1 ohm resistor causes a voltage drop. This drop is compared with the voltage on the wiper of 100-ohm pot. The moment this drop is greater than the one adjusted with the potentiometer will cause the output of the LM1458 IC to go low and a small current starts to flow through the diode and this in effect will reduce the

current through the series resistors 1K + 2Kpot. The current is hereby stabilized.

The point between C and B is divided by three resistors; 2.2 ohm, 100 ohm pot, and the 150 ohm. 2.2 ohm and the 100 ohm potentiometer are connected to the non-inverting input (+) of the LM1458 IC. The inverting input (-) is connected to the 0.1 ohm wire-wound resistor in series with the output. As long as the voltage drop, caused by the current-flow over this resistor is greater than the voltage drop over the 2.2 ohm resistor the output of the LM1458 will stay high and in turn block the BC558 transistor. But as soon as the charge current falls below a specific value the 1458 will go low and turn on this transistor which will activate the LED. At the same time a small current will flow thru the 'Rx' resistor, which will cause that the output voltage of the charger switches to 13.6 Volt. This is a very safe output voltage, and does not cause overcharging to the battery and remains fully charged (trickle).

Rx should be an experimental value determined below; a mathematical calculation is possible but the exact value is determined by the tolerances of your specific components.

The voltage regulator LM350 has to dissipate a lot of energy so make sure to mount it on a large cooling fin. (e.i. 3.3°C/Watt) Diode 1N4001 over the input/output is necessary to prevent damage to the regulator in case the input voltage gets interrupted.

The LM350 can be substituted with a NTE970, and the BC558B with a NTE159 if you wish.

The adjustments for this charger are really simple and the only thing needed is digital multimeter. The LM1458 should **NOT** be in the socket while doing the first adjustment. When no battery is connected there is no current flow thru the 0.1 ohm resistor and therefore pulling the output low. So no IC yet in the socket. Do **NOT** connect a battery also. I know that is obvious to most of us, but some people... :-)

Okay, here we go:

1. Connect the multimeter (set for Volt DC) to the '+' and '-' battery output and adjust with the 2k trimmer the output voltage to 14.1 Volt.
2. Switch the power off. Discharge the capacitors (short them out with a piece of wire).
3. Now insert the LM1458 IC carefully (check no pins are bent underneath the chip).
4. Switch the power back on and make the resistor marked **R_x** such a value that the output voltage reads 13.6 volt exactly.
5. Switch the multimeter to 'Amp-dc'. Turn the 100-ohm trimmer all the way CCW. Connect the 'to-be-charged-battery' (e.i. NOT a fully charged battery) and turn back the trimmer until the current load is 0.1 X the battery capacity (max 3A). Example: A 16Amp battery adjusting to 1.6A. If you don't have an Amp meter on your multimeter you can use the 2-volt setting on your meter and connect it over the 0.1 ohm resistor. The current is volt divided by 0.1, so for 3A the meter should read 0.3 volt.

That's it. To get the Rx value you could also use a trimmer until you get the 13.6volt and then read the ohm's value of the trimmer and replace with a resistor. In my opinion this resistor should be a metalfilm type at 1 or 2% tolerance.

+--+--+--+--+--+--+--+

The Technical bits:

For those of you interested in how the value of essential components was calculated, read on. You may be

able to design your own charger for use with a different current or voltage (like 6-volt).

Calculations origin from the voltage between points C and B of the LM350 regulator. When a resistor is connected between these two points, enough current starts to flow that the voltage over this resistor measures 1.25 volt. In our case, the resistor total is $2.2 + 100 + 150 = 252.2$ ohm. Because we deal with very small currents the calculations are performed in milliamps and the calculations of resistance in Kilo-Ohms. Thus, the current thru this resistor is $1.25 / 0.2522 = 4.9564$ mA. The same current also flows thru the 1K & 2K series resistors. We want the output voltage to be 14.1 volt, meaning the voltage drop over these series resistors must be $14.1 - 1.25 = 12.85$ Volt.

The total resistance value thus must be $12.85 / 4.9564 = 2.5926$ Ohms. To enable us to adjust it to this value, one of the resistors is chosen as a 10-turn trimpot (trimmer potentiometer). Together with the 1K in series (making it a total of 3K) we can adjust it to this correct value.

The **R_x** value is calculated this way; In this scenario we like to have a output voltage of 13.6 volt, in other words, the voltage on the connection point between the 1K/2Kpot should be $13.6 - 1.25 = 12.35$ volt. This means that the current thru the 'voltage-divider' will be $12.35 / 2.5926 = 4.7635$ mA and the leftover current should be $4.9564 - 4.7635 = 0.1929$ mA thru R_x and also cause a voltage drop of $12.35 - 2.78 = 9.57$ volt. Measuring this calculated value at the base of the BC558 transistor was 2.78 volt after the output of the LM1458 had become low. With the current of 0.1929 mA the result has become $9.47 / 0.1929 = 49.611$ Kilo-Ohm. A resistor of 47K would come close enough. Ofcourse you could also use a 50K trimpot to adjust the value even more accurately. The 1K5 (1500 Ohm) resistor in series with the LED is to limit the current thru the LED below 20 mA.

The only thing left is to calculate the value of the series resistor which determines the switch-over from charge to float condition. This occurs when the voltage drop over the 0.1 ohm (wire-wound) resistor at the positive leg smaller is than over the 2.2 ohm resistor. This value is $2.2 \times 4.9564 = 10.9$ mV. The resistance is 0.1 ohm, to get a voltage drop over this resistor of 10.9 mV is the current $10.9 \times 0.1 = 109$ mA. The second this charge current becomes lower then 109 mA, the LM1458 triggers over to the float condition.

The adjustment with the 100-ohm trimpot determines the maximum charge current. The voltage on the wiper of this trimpot varies between 10.9 mV - 506.54 mV. The current is this way made adjustable between 0.1A - 5A, but we should not go that far because the LM350K can not handle anything over 3Amp. If we chose a trimpot with a value of 50 ohm, then on the other hand the 3A can not be obtained. So, careful adjustment is the remedy. Take your time!

With this information it is a simple task to calculate the dissipation values of the resistors. In other words, the product of the resistance multiplied with the current in square ($I^2 \times R$).

The only resistor which gets it difficult is the 0.1 ohm, but then again, not by much $3 \times 3 \times 0.1 = 0.9$ Watt. Rest us to calculate the power. For that we have add a couple of voltages. We have the input voltage of 14.1, the voltage drop over the resistor, $0.1 \times 3 = 0.33$ volt, and 3 volt minimum over the LM1458 for proper function, total 17.43 volt. The transformer provides 18V (effective). With ideal rectifying this should total $18 \times 1.41 = 25.38$ volt. There are however losses via the diodes and bridge rectifier so there is about 23.88 volt remaining. Not much tolerance to play with, on the other hand, too much causes energy loss in the form of heat anyway.

The voltage drop over the buffer capacitor may not be lower than 17.43 volt, meaning, the ripple voltage may reach about $23.88 - 17.43 = 6.45$ volt. By double-fase rectifying is the ripple voltage equal to $I / (2 \times f \times C)$ whereby I is the discharge current, f is the supply frequentie and C is capacity of the buffer capacitor in Farad. Exchanging places this would give $C = 3 / (2 \times 50 \times 6.45) = 0.004651$ Farad, or 4651 uF. A standard

value of 4700 uF with a minimum voltage value of about 35-40 Volt. The other capacitor is not very critical and is only there to kill small voltage spikes which could influence the operation of this charger otherwise.

The bridge rectifier gets a good workout also and it is therefore recommended to chose NOT a too light a unit. A 5A rectifier is often too small, better to take a 8 or 10A type. These are readily available everywhere.

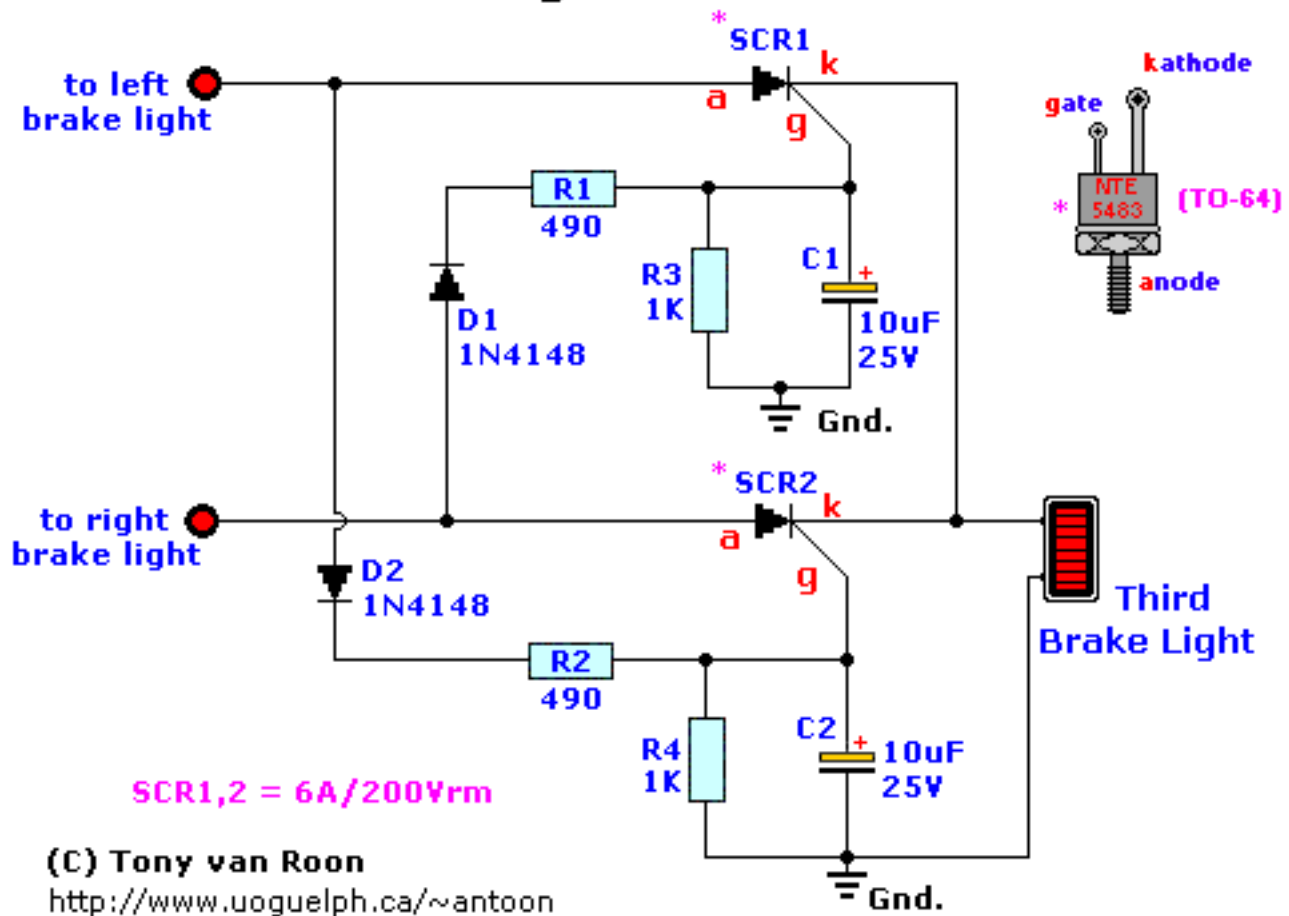
Last but not least, the transformer. The buffer capacitor has approximately 25 volt accros. The current is 3A. This calculates to a power of $25 \times 3 = 75$ watt. This transformer has its own problems with powerloss (naturely occuring) and so a unit of about 80 watt is acceptable.

Never attempt to charge a 6 volt battery with a 12 volt charger; you are asking for trouble. Good luck all!

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

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Third Brake Light



Additional Notes

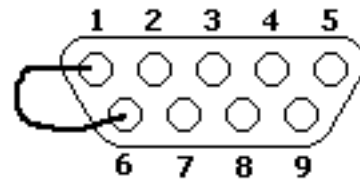
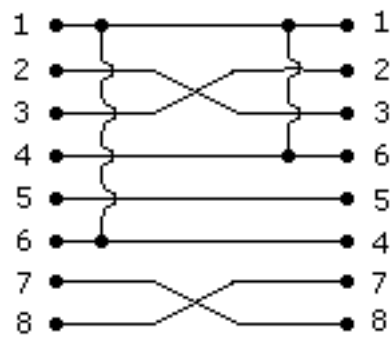
What's so special about this circuit? Well, the first third-brake light I installed I had to pull a wire from the Third Brake Light all the way to the brake pedal switch and I thought it would be easier to pluck the signal of both brakelights via the trunk. Bench-test your circuit first and apply power 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 coolribs on them. I used the NTE5483 which is a 8A, 200Vrm type.

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Nullmodem (9-9) Cable

9-pin to 9-pin female



**Seen from the back
(solder side)**

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

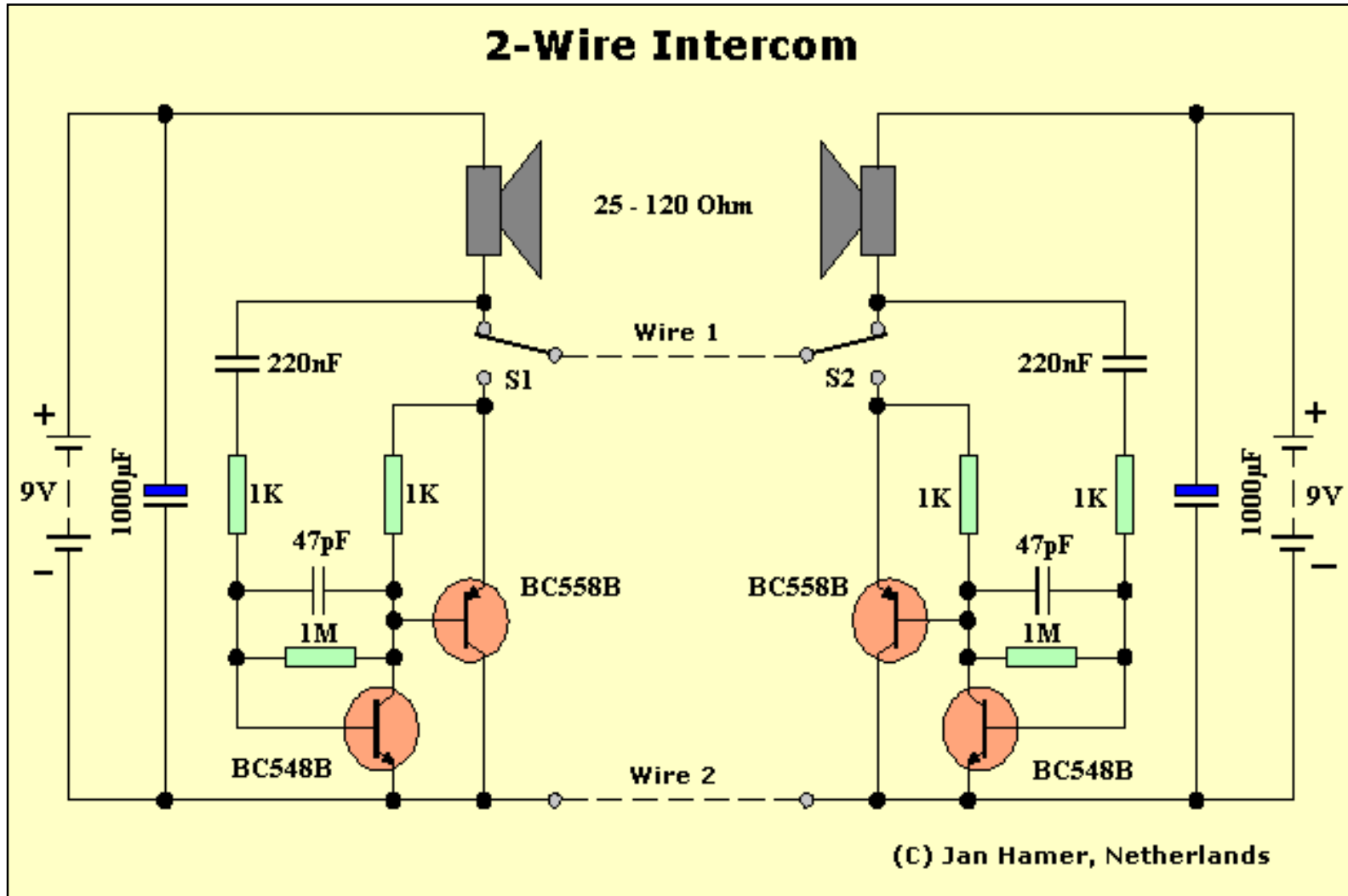
Signal Description

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 simulate 'on-line' status.
This Nullmodem configuration is also for gameply like
Westwood's Command & Conquerer "Tiberian Sun".**

© 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

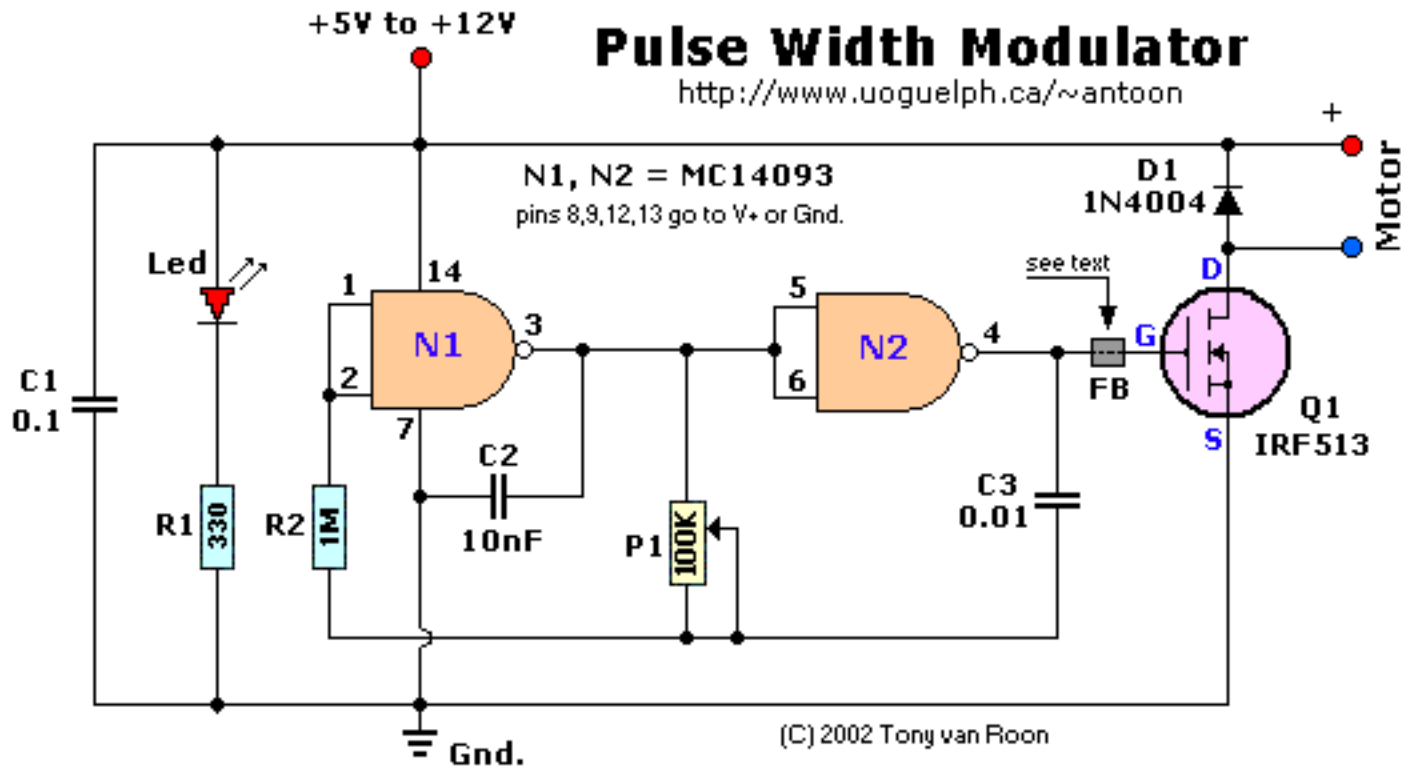
This Intercom is powered by two 9volt batteries and uses only current when the Intercom is used. Both units are connected via a two-wire little cable or simply two wires (dotted lines). The loud speakers act both as loudspeaker and as a microphone. When you press S1 and speak into the loudspeaker then 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 = 330 ohm
 R2 = 1MegaOhm
 P1 = 100K potentiometer
 C1 = 0.1 μ F, ceramic
 C2 = 10nF, ceramic
 C3 = 0.01 μ F, ceramic
 D1 = 1N4004 (or faster 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 coolrib, 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 $R_{ds\text{on}}$

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.

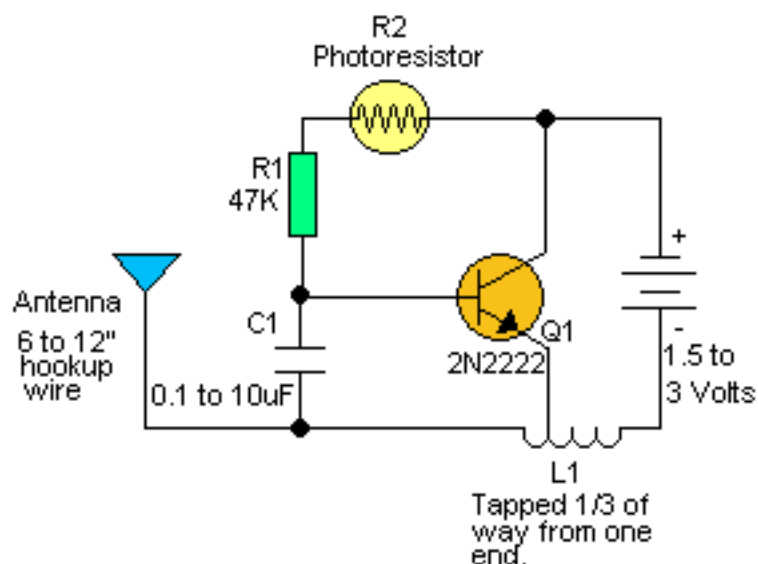
The yellow & green wires are the speed sensor and the red & blue wires are the positive/negative. It also has an extra aluminum shield around the motor-housing to keep rf interference to a minimum. Who wouldn't like a motor like that? If you can get your hands on them, take it!

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Light Sensing RF Transmitter

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



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.

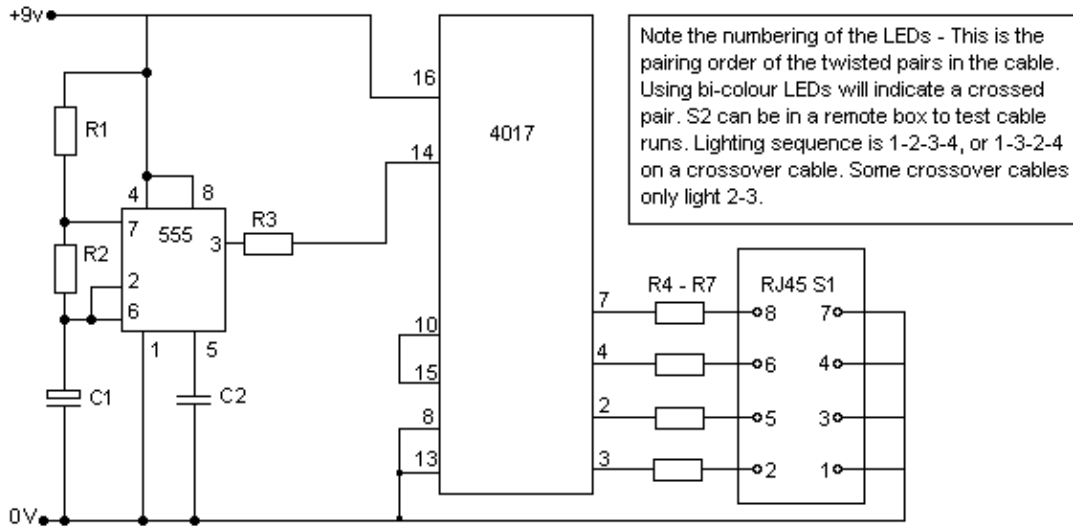
The user should be able to pick up the signal from this transmitter on any regular FM or VHF receiver. By increasing the number of turns on L1, the RF frequency can be dropped down all the way into the AM broadcast band.

RJ45 Network Cable Tester

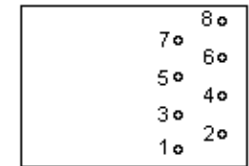
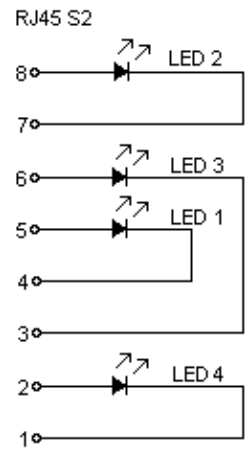
By Paul Hancock

Paul Hancock
Feb 2002

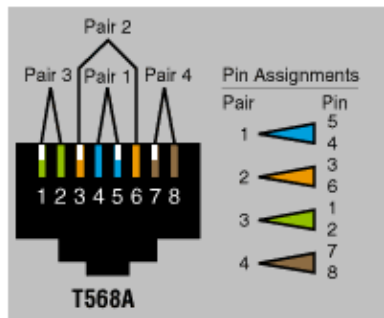
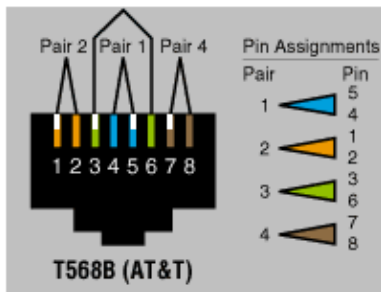
NETWORK CABLE TESTER



R1 = 3k9
R2 = 10k
R3 = 1k
R4 - R7 = 1k
C1 = 10uF/16V elect
C2 = 10nF



RJ45 Socket view from base.



Paul Hancock
Feb 2002

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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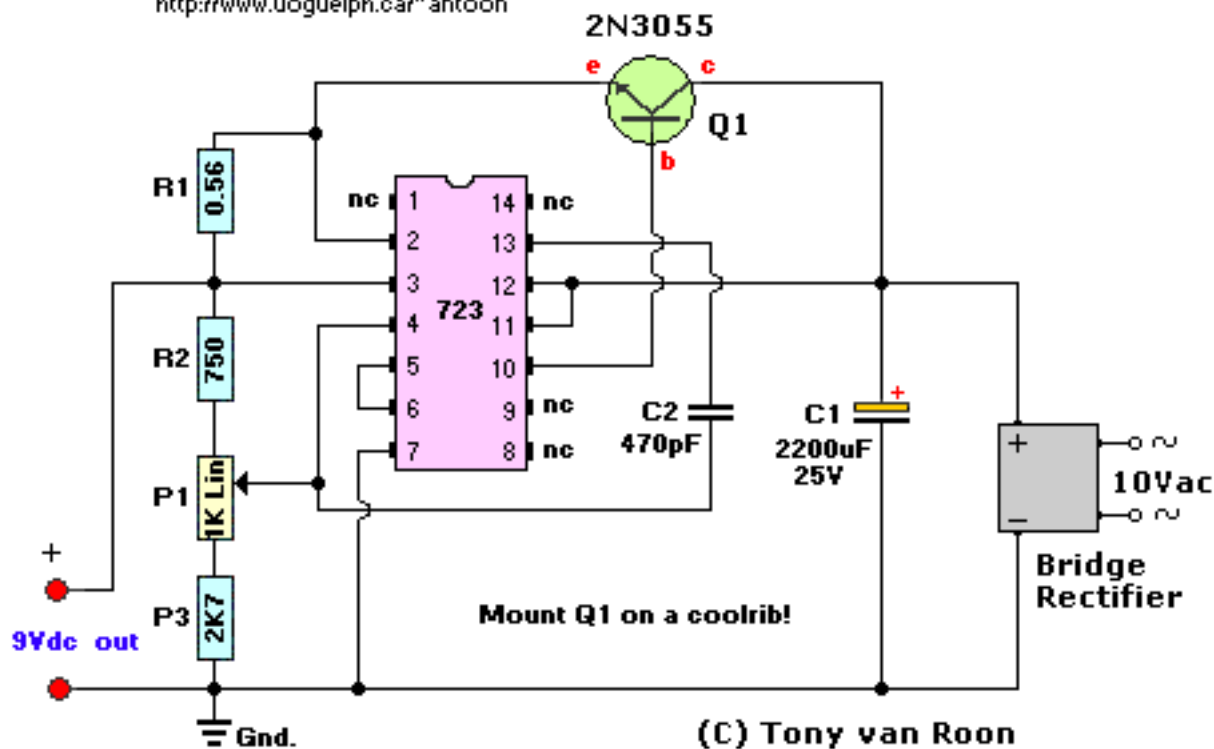
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Stabilized 9-V Power Supply

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



Parts List:

T1 = 115/10 VAC transformer. Center Tap not needed.

IC1 = μ A723, LM723, or equivalent.

Q1 = 2N3055, NTE130, or substitute. (TO-3 case) Mount on a coolrib!

BR1 = 40V-5A

R1 = 0.56 Ohm, 1 Watt, 5%

R2 = 750 Ohm, 5%

R3 = 2K7 (2700 ohm)

P1 = potentiometer, 1K, Linear

C1 = 2200uF, 25V

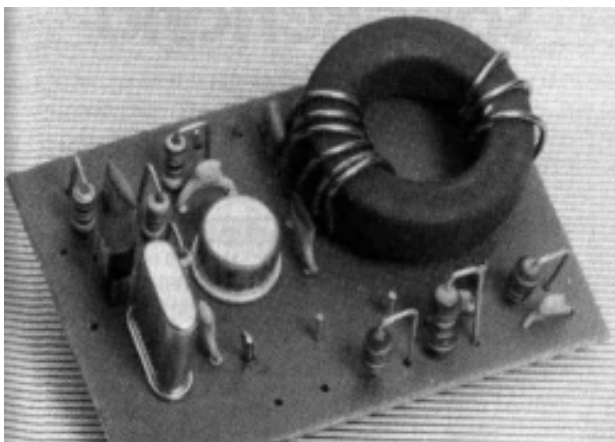
C2 = 470pF

Notes:

C1 filters the noise and spikes off the ac. Adjust the circuit for 9 V output voltage with the P1 potentiometer.

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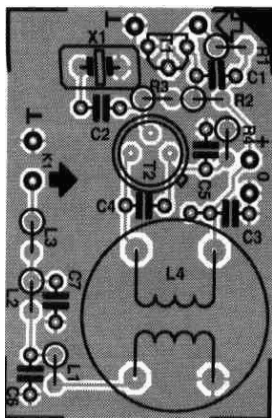
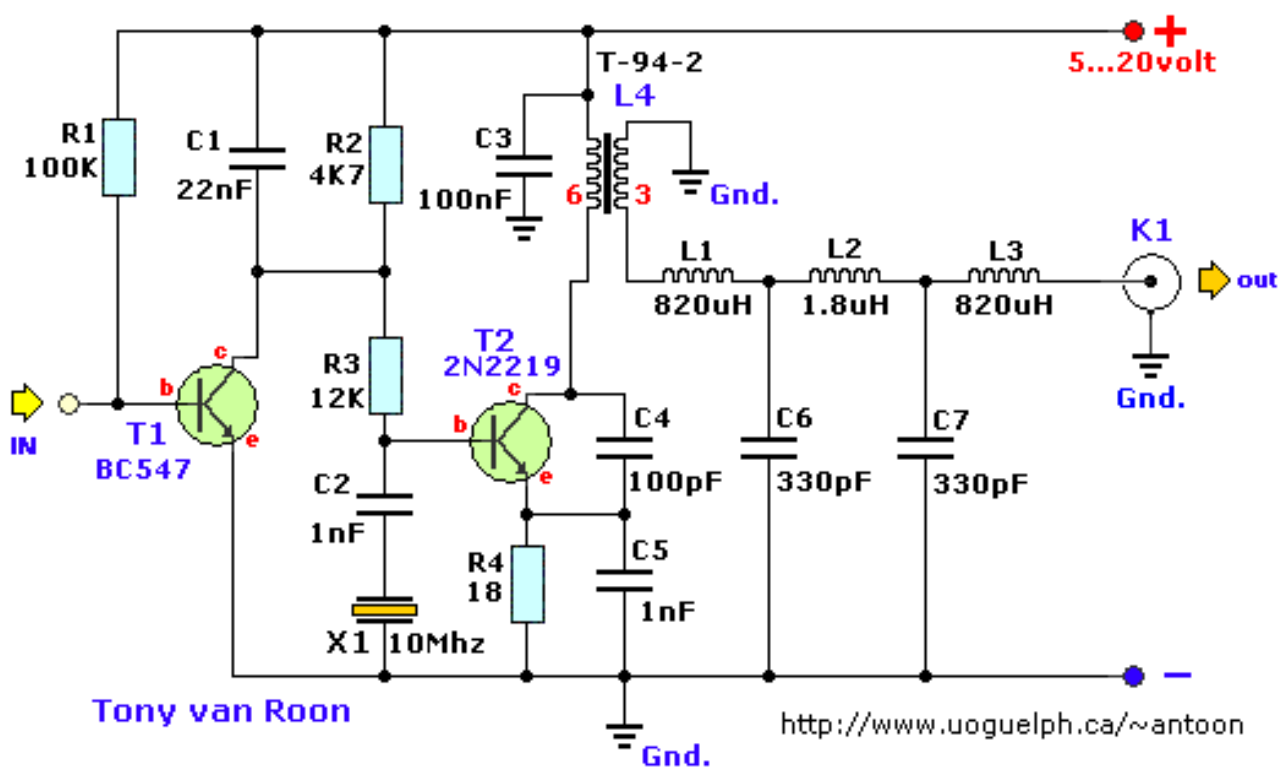
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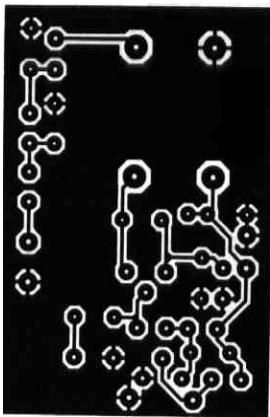
30-Meter QRP (CW)

by P. Wyna, 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 = 1.8μH	Coolrib for T2
R3 = 12K	C3 = 100nF	L4 = T-94-2 (Amidon)	Morse-key, single pole
R4 = 18 Ohm	C4 = 100pF	T1 = BC547	All-metal case
xtal = 10Mhz	C6 , C7 = 330pF	T2 = 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 T2 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 T1, which biases as long as the morse-key is open and the base of T1 is at ground level. By keying the morse-key T1 is blocked and allows T2 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 84μH per 100 turns and permeability of 10. T2 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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555 Timer/Oscillator Tester

by Tony van Roon

On-Off Switch



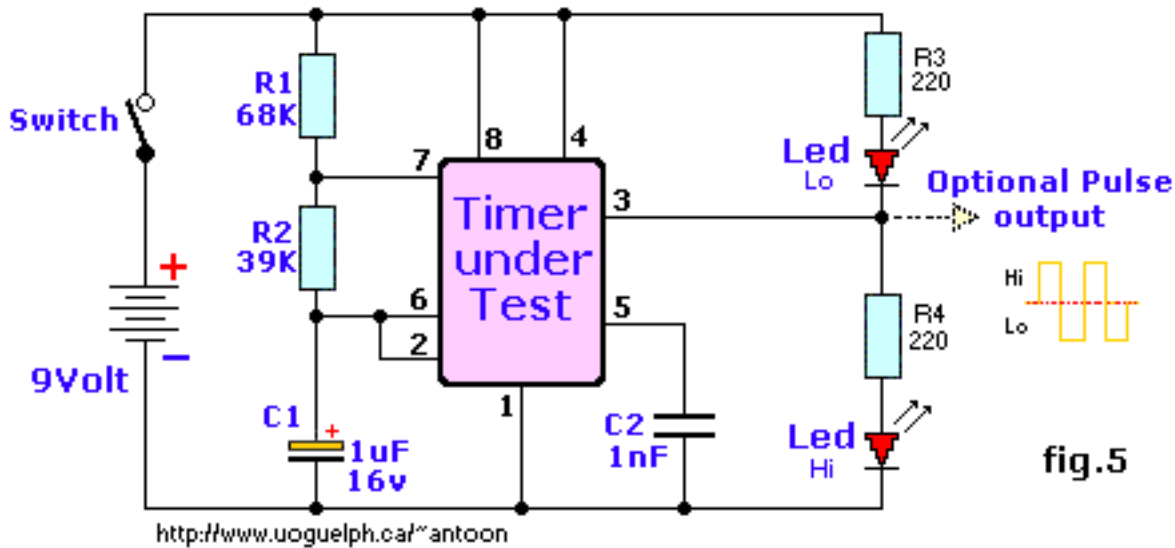
Description 555 Tester:

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 0.01 μ F, but the latter is the most common value. The datasheet for the 555 documention specifies to use a general purpose ceramic 0.01 μ F 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 posible. 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.

555 Timer Tester



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)

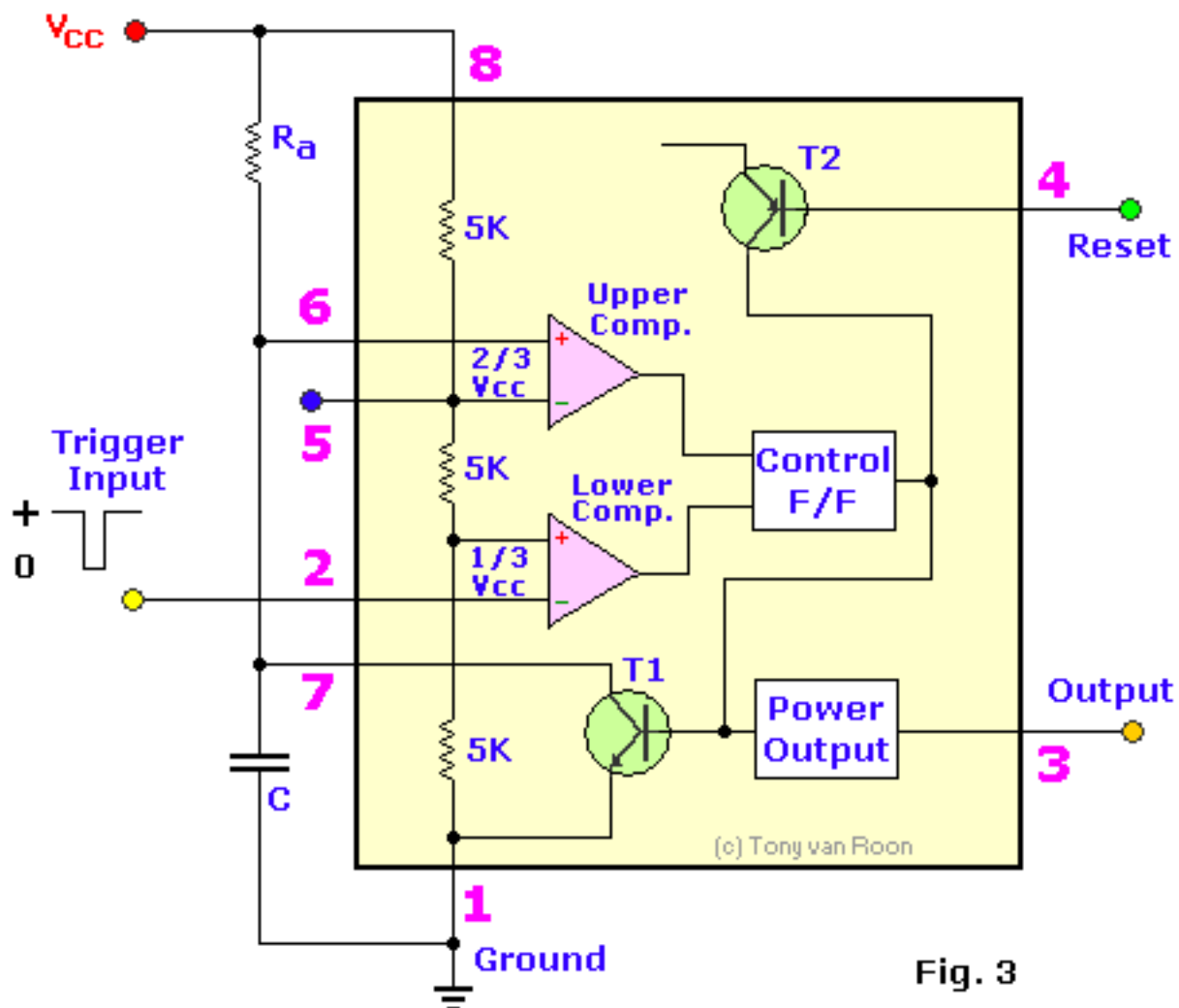
Two led's, red or green.

8-pin dip socket

On-off switch or momentary 'push=on'

switch

Solderless breadboard (if you wish) = Radio Shack #276-175



Description 555 Timer/Oscillator:

Have a look at the block diagram above. To make the 555 work, a trigger pulse at pin 2 initially sets the 555's internal flip-flop 'on'. It does so by comparing the input pulse to $1/3$ of the supply power to a second comparator. This turns off the transistor across the timing capacitor and allows the timing capacitor to start the charge cycle. The 555 stays 'on' until this timing cycle turns it 'off' again by resetting the control flip-flop.

The timing cycle can be made to start over again by applying a pulse to pin 4 (reset). This turns on the transistor that discharges the timing capacitor, and so delaying the charge from reaching $2/3$ Vcc.

In some applications, the reset (pin 4) is connected to the trigger input (pin 2) so that each new input trigger signal restarts the timing cycle.

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.

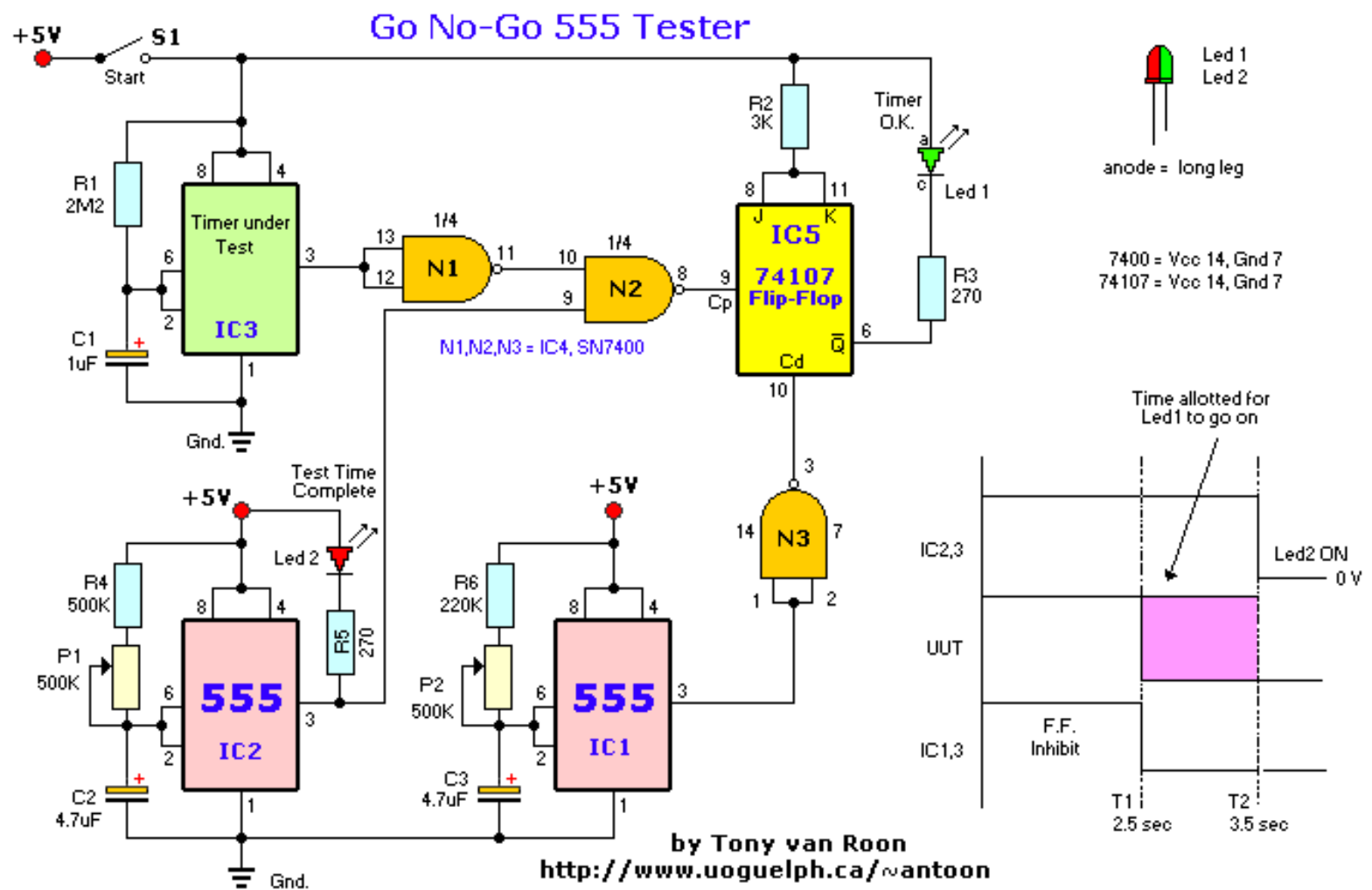
The 555's output circuit includes two high current transistors, each capable of handling at least 200mA. One transistor is connected between the output pin 3 and Vcc, and the other between pin 3 and ground.

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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Parts List

R1 = 2M2 IC1,IC2,IC3 = 555 Timer/Oscillator
 R2 = 3K IC4 = SN7400
 R3,R5 = 270 ohm IC5 = SN74107
 R4 = 500K Led1,Led2 = 5mm, Red/Green, high brightness
 R6 = 220K S1 = On-Off switch, push button
 P1,P2 = 500K, Trimpots
 C1 = 1 μ F, 10V
 C2,C3 = 4 μ F, 10V

Description:

This is a more advanced unit with a precise timed testing procedure.

R1 (2M2) is same as 2.2 MegOhm.

The two timers determine the allowable accuracy for the timer IC under test. Potentiometers P1 and P2 permit ready adjustment for the desired range.

With power applied, all timers switch to the high state and begin their cycles. The output of IC1 inhibits the flip-flop for the interval T1. At T2, the output of IC2 goes low and inhibits any signal from the timer under test. The period between T1 and T2 is the time allotted for IC3, the timer under test, to complete its cycle and produce a low output. Only during this time can a high-to-low transition from IC3 trigger the Flip-Flop IC5 so that Led 1 (timer ok), which indicates a good IC, lights up. Led 2 lights up when the test is completed.

Although there can be a few milliseconds of contact bounce when S1 is first closed, thereby causing a delay in capacitor charging, the delay appears across all of the IC's. But since the ratio of delay times among all three timers is the same, the effect on test accuracy is nil.

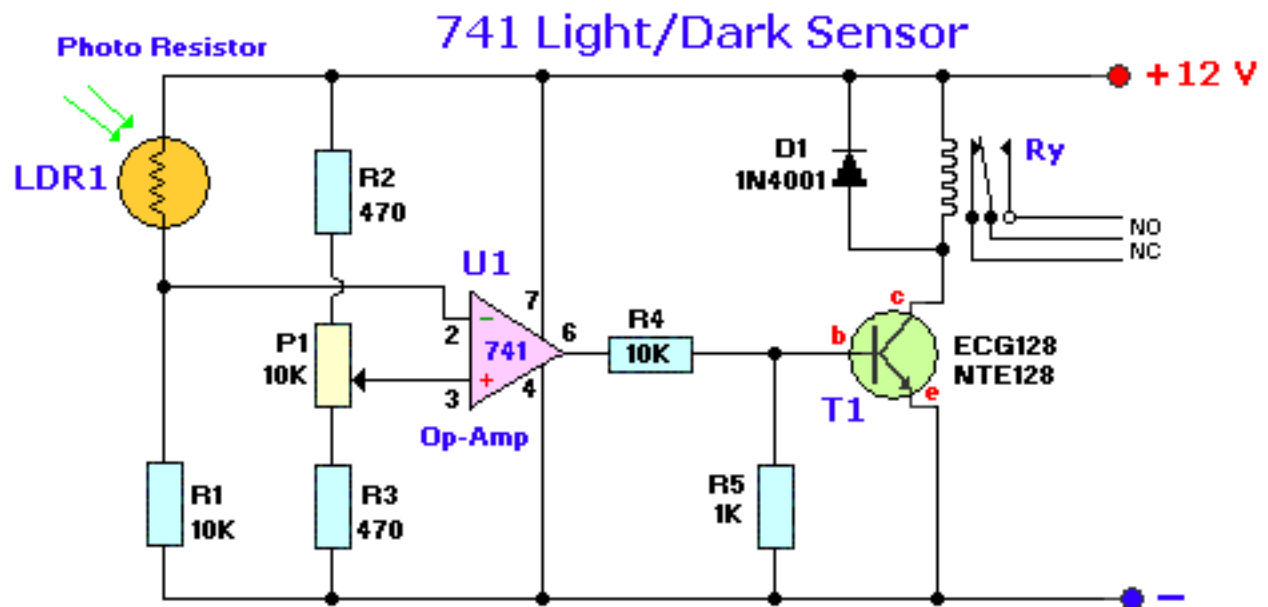
How you get to the 5 volt supply power is up to you. Supply power should be between 4.5V (min) and 5.5 (max). Probably three 1.5V alkalines will total about 4.8V because they are never exactly 1.5 V but always between 1.56 and 1.59V or so, and will do the job until the voltage drops below 4.5V. A simple stabilized 5V power supply would be better choice, or use a 5 volt regulator with a 9 volt battery, works also. Do not forget to connect power to the 7400 and 74101 IC's (see circuit diagram). Standard procedure is that if they are not drawn, they are assumed. You can get the LS types (low schottky) which draw less current. At this time I'm bench testing the cmos types.

Note: While bench testing I found that older timers like the μ A555 and the MC1455, although good, were difficult to test. I tried extending the testing period (in seconds) by adjusting trimpot P2 and got an ok from led2 for the MC1455 but no such luck with the μ A555. The LM555 and NE555 testing were excellent. I will test a couple more, including the cmos versions, and post my findings here. If I can find the time I will modify the power supply for use with a regular 9 volt battery instead of the bit awkward 5 volt supply...

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

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
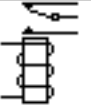






















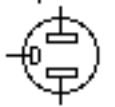

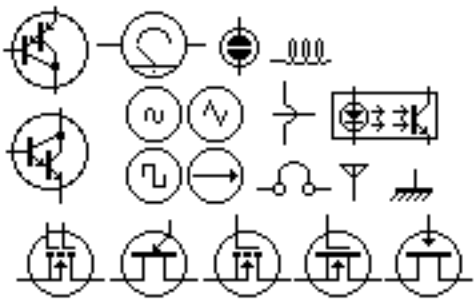



- Relais closes when no light falls on LDR1
- For reversed action, exchange LDR1 and R1
- Sensitivity can be adjusted with P1
- D1 prevents sparking of relay-coil when it opens

Fig. 12

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Electronic Component Template

	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		Diodes		Crystal
	Connectors		Diodes		MosFet
	120V plug		Resistors	<div>Misc Parts</div> 	
			Resistors		
			Photoresistor		
			Buzzer		

[Additional Notes](#)

(N/A)

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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.*

[Inverter](#) - 12V-DC to 115V-AC. Problems with tantalum caps blowing or getting hot

[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

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to home page

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Last Updated: May 27, 2002



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_{ce0} (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 minumum specifications have to be met, in Table 1a above, before you can call it a 'TUP' or a 'TUN'.

Table 1b. Diodes						
	Type	U_R (max)	I_F (max)	I_R (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 minumum 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	BC307	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	


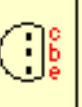
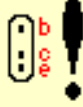

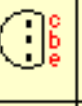

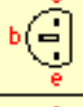


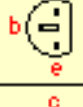

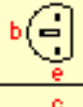





In the above tables, Table 2 and Table 3, you can use several different transistor types for a TUP or a TUN. Obviously the tables are not complete. It would be almost impossible to list all available transistor types available today. From the above listed types are all A, B, or C types usable.

Table 4.		
DUS		DUG
BA127	BA318	OA85
BA217	BAX13	OA91
BA218	BAY61	OA95
BA221	1N914	AA116
BA222	1N4148	
BA317		

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) = h_{fe} 125 to 260 (B) = h_{fe} 240 to 500 (C) = h_{fe} 450 to 900		

The most important parameters of the BC107...BC109 and the BC177...BC179. These transistors have been choosen 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
BC107 BC108 BC109	BC177 BC178 BC179		BC317 BC318 BC319	BC320 BC321 BC322	 $I_{Cmax} = 150\text{ mA}$	BC467 BC468 BC469		 $P_{max} = 220\text{ mW}$
BC147 BC148 BC149	BC157 BC158 BC159	 $P_{max} = 250\text{ mW}$	BC347 BC348 BC349	BC350 BC351 BC352		BC167 BC168 BC169	BC257 BC258 BC259	 100/250: $I_{Cmax} = 50\text{ mA}$
BC171 BC172 BC173	BC251 BC252 BC253	 251...253 Noise Free	BC382 BC383 BC384			BC547 BC548 BC549	BC557 BC558 BC559	 $P_{max} = 500\text{ mW}$
BC182 BC183 BC184	BC212 BC213 BC214	 $I_{Cmax} = 150\text{ mA}$	BC407 BC408 BC409	BC417 BC418 BC419	 $P_{max} = 250\text{ mW}$	BC582 BC583 BC584	BC512 BC513 BC514	 $I_{Cmax} = 200\text{ mA}$
BC207 BC208 BC209	BC204 BC205 BC206		BC413 BC414	BC415 BC416	 Noise Free		BC261 BC262 BC263	 Noise Free
BC237 BC238 BC239	BC307 BC308 BC309		BC437 BC438 BC439		 $P_{max} = 220\text{ mW}$	http://www.uoguelph.ca/~antoon		

The letter after the transistor indicates the hfe.

Example: BC107**A**, hfe = 125 ... 260

BC107**B**, hfe = 240 ... 500

BC107**C**, 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).

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Oscillators

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Simple variable frequency oscillator [Click here for the circuit diagram](#)

This is a very simple circuit utilising a 555 timer IC to generate square wave of frequency that can be adjusted by a potentiometer.

With values given the frequency can be adjusted from a few Hz to several Khz.
To get very low frequencies replace the 0.01uF capacitor with a higher value.

The formula to calculate the frequency is given by:

$$1/f = 0.69 * C * (R1 + 2*R2)$$

The duty cycle is given by:

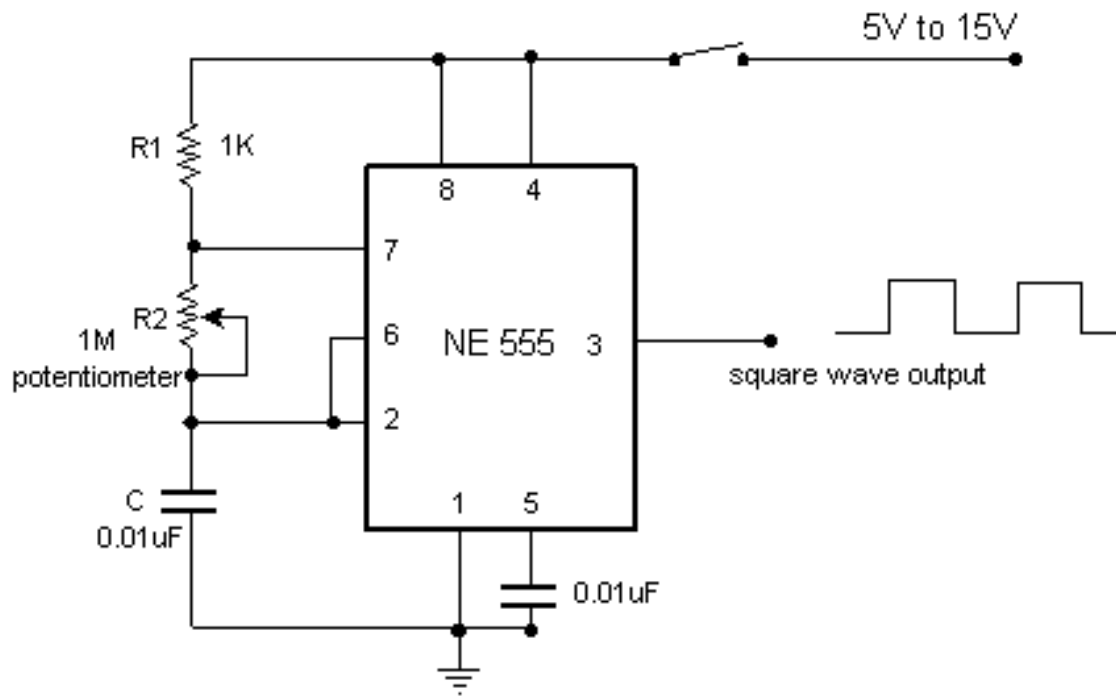
$$\% \text{ duty cycle} = 100 * (R1 + R2) / (R1 + 2 * R2)$$

In order to ensure a 50% (approx.) duty ratio, R1 should be very small when compared to R2. But R1 should be no smaller than 1K.
A good choice would be, R1 in kilohms and R2 in megaohms. You can then select C to fix the range of frequencies.

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Radio Circuits

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Long range FM transmitter

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The power output of most of these circuits are very low because no power amplifier stages were incorporated.

The transmitter circuit described here has an extra RF power amplifier stage, after the oscillator stage, to raise the power output to 200-250 milliwatts. With a good matching 50-ohm ground plane antenna or multi-element Yagi antenna, this transmitter can provide reasonably good signal strength up to a distance of about 2 kilometres.

The circuit built around transistor T1 (BF494) is a basic low-power variable-frequency VHF oscillator. A varicap diode circuit is included to change the frequency of the transmitter and to provide frequency modulation by audio signals. The output of the oscillator is about 50 milliwatts. Transistor T2 (2N3866) forms a VHF-class A power amplifier. It boosts the oscillator signals' power four to five times. Thus, 200-250 milliwatts of power is generated at the collector of transistor T2.

For better results, assemble the circuit on a good-quality glass epoxy board and house the transmitter inside an aluminium case. Shield the oscillator stage using an aluminium sheet.

Coil winding details are given below:

L1 - 4 turns of 20 SWG wire close wound over 8mm diameter plastic former.

L2 - 2 turns of 24 SWG wire near top end of L1.

(Note: No core (i.e. air core) is used for the above coils)

L3 - 7 turns of 24 SWG wire close wound with 4mm diameter air core.

L4 - 7 turns of 24 SWG wire-wound on a ferrite bead (as choke)

Potentiometer VR1 is used to vary the fundamental frequency whereas potentiometer VR2 is used as power control. For hum-free operation, operate the transmitter on a 12V rechargeable battery pack of 10 x 1.2-volt Ni-Cd cells. Transistor T2 must be mounted on a heat sink. Do not switch on the transmitter without a matching antenna. Adjust both trimmers (VC1 and VC2) for maximum transmission power. Adjust potentiometer VR1 to set the fundamental frequency near 100 MHz.

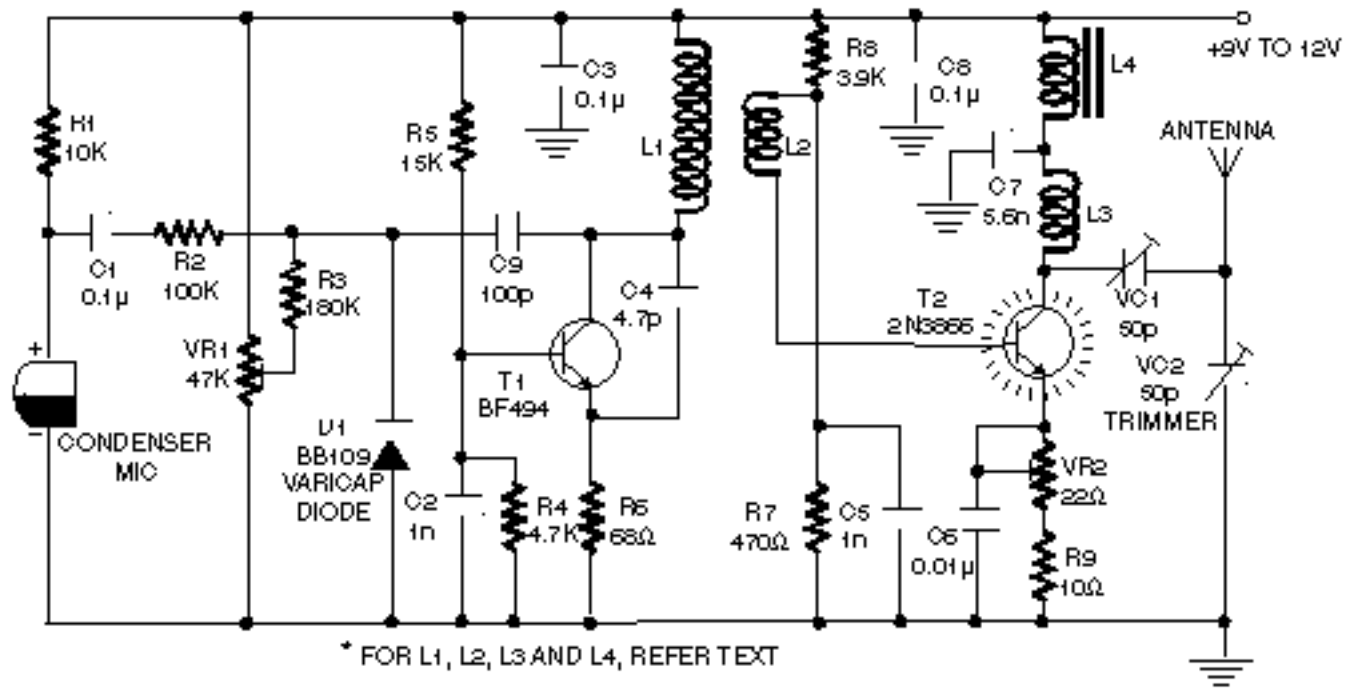
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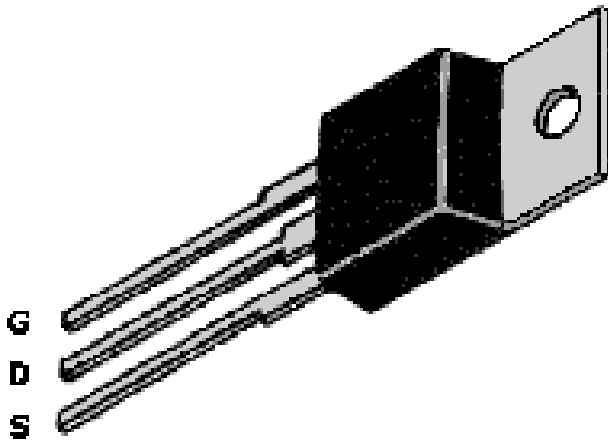
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Testing a MOSFET

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'.

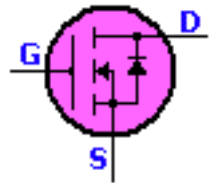
3) Now move the positive probe to the 'Drain'. You should get a 'low' reading. The MosFet's internal capacitance on the gate has now been charged up by the meter and the device is 'turned-on'.

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 12 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

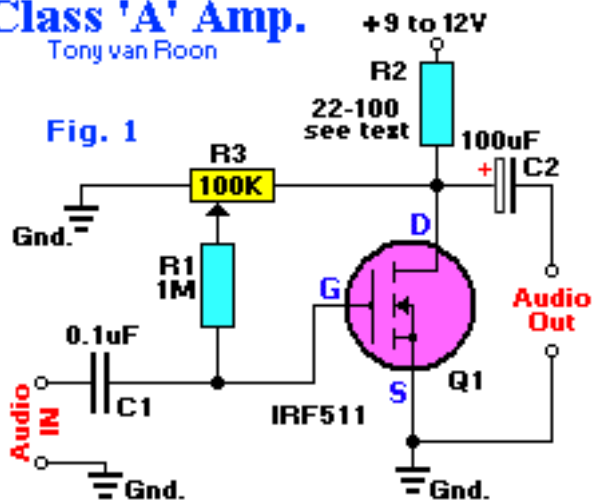
input impedance to remain very high. If a 100-MegaOhm resistor cannot be located, just tie 5 22-MegaOhm resistors in series and use that combination for R2. In fact, R2 can be made even higher in value for added sensitivity.

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 obtainin 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.

Class 'A' Amp.

Tony van Roon

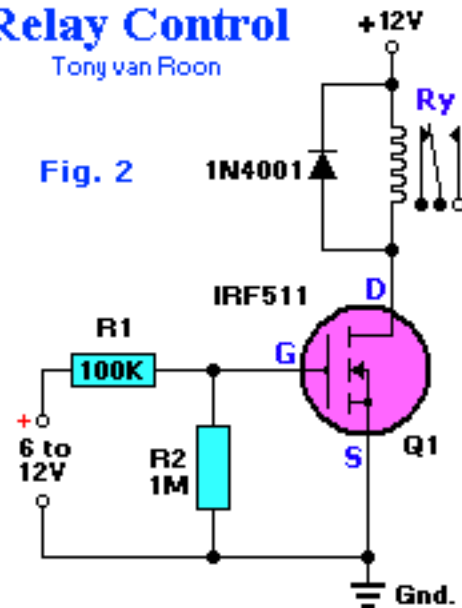
Fig. 1



Relay Control

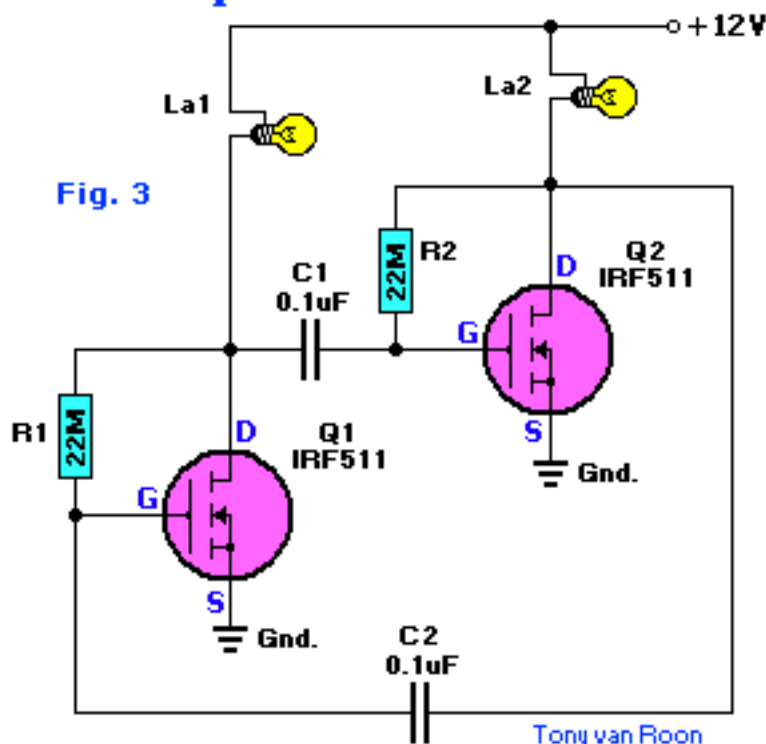
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Fig. 2



"Lamp Flasher"

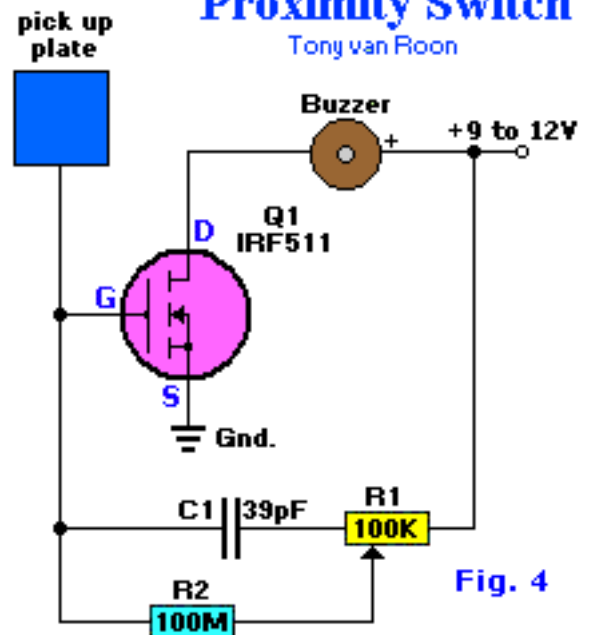
Fig. 3



Proximity Switch

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Fig. 4



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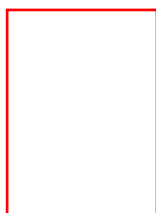
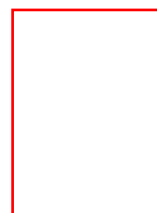
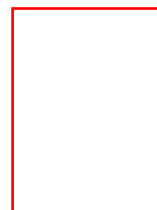
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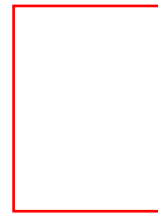
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Testing a Triac

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

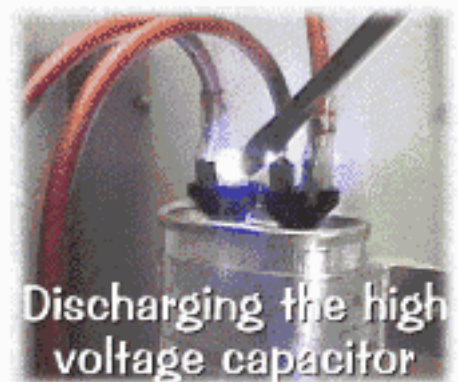


Working on a microwave oven is a VERY dangerous task. Therefore, BEFORE performing any tests, troubleshooting, or repairs, for your personal safety, I strongly urge you to carefully read, fully understand and be prepared to follow the very important safety precautions.

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,

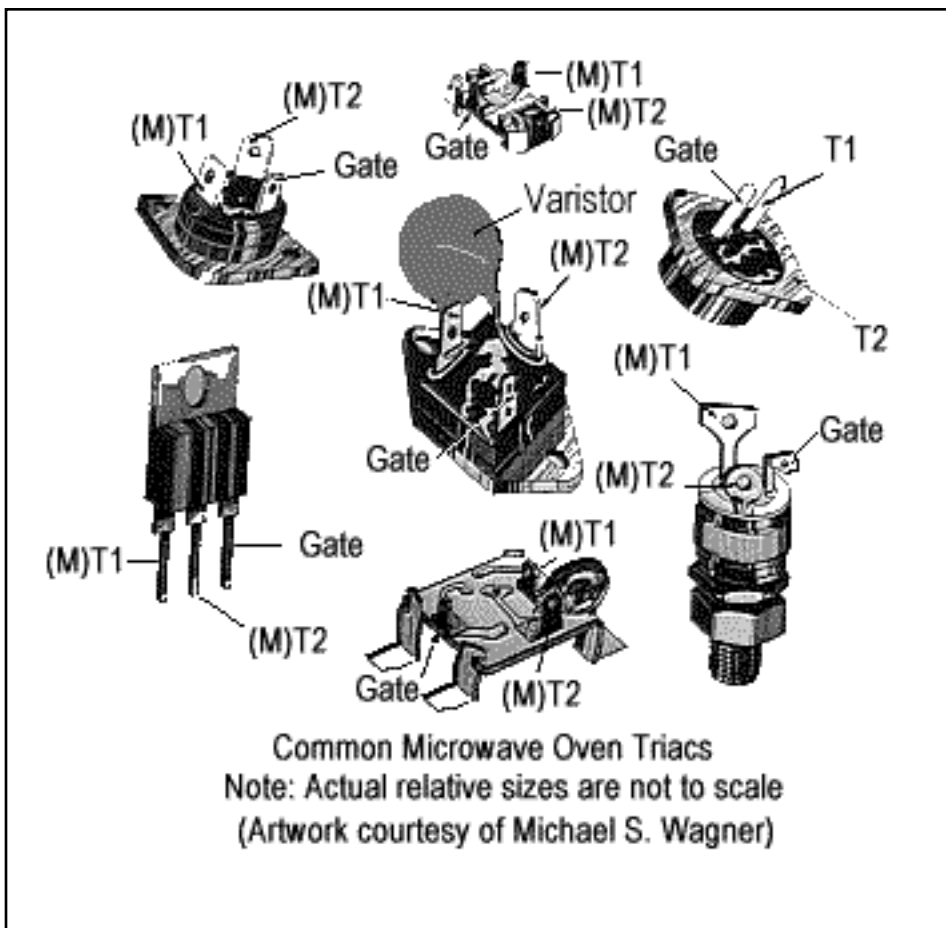


because, while the electric shock is painful, the real punishment comes when you reflexively yank your hand out leaving behind layers of skin on razor-like edges that are there as a reminder to never again forget to discharge the high voltage capacitor.

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 readings 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 readings are approximate and may vary with manufacturer, but generally speaking, any results that are significantly different would point to a defective Triac.



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".

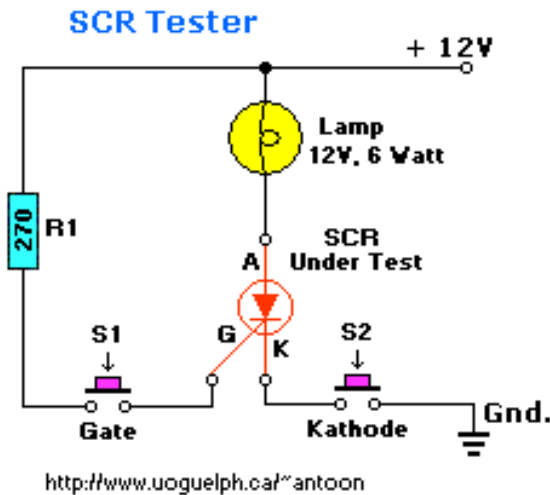
The graphics and most of the text courtesy of *Microtech Electronics*. If you have any question(s), please ask the author of this testing sequence: [J. Carlton Gallawa](#) or visit his website at ["Microtech Electronics"](#) to learn more about high voltage, microwaves or how to become a seasoned microwave technician!

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

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 (50V/4A)	C106F1 (50V/4A)
C106B (200V/4A)	CSM2B2 (100V/4A)
T106D1 (400V/4A)	NTE5402 (100V/0.8A)
TIC106M (600V/8A)	NTE5457 (400V/4A)
TIC126M (600V/25A)	CR6AM-8 (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 TRIACS 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)

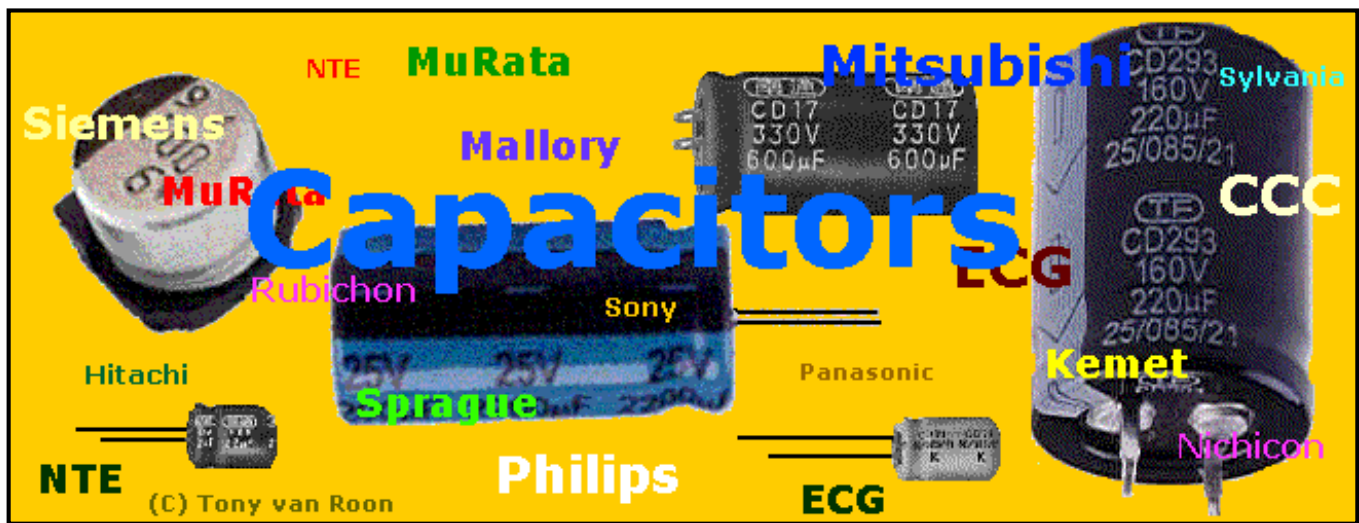
Again, in all cases the tester was correct. I compared the results of the two defective Triacs with the results of a very expensive commercial SCR/Triac tester. On the commercial tester you can set the actual VRM (volt) of a Triac and check for leakage and what not but I found the end result the same; "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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What Exactly Is A Capacitor?

Like my other tutorials, let's start with a bit of interesting history first to understand where the 'capacitor' or condenser came from and how it was developed and then work our way up to our century.



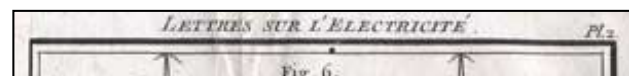
In 1745 a new physics and mathematics professor at the University of Leyden (spelled *Leiden* in modern Dutch), *Pieter van Musschenbroek* (1692 - 1791) and his assistants Allmand and Cunaeus from the Netherlands invented the 'capacitor' (electro-static charge or capacitance actually) but did not know it at 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 as insulating stopper (cork) in the neck of the jar and contacts 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 which 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 'no 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 Musschebroek 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 his staff to delay announcing for 11 months, especial given the potential claim to prior discovery by Von Kleist.

Look at the picture at the right; the worlds first illustration of the working of a



Leyden Jar, by Abbe Jean-Antoine Nollet!

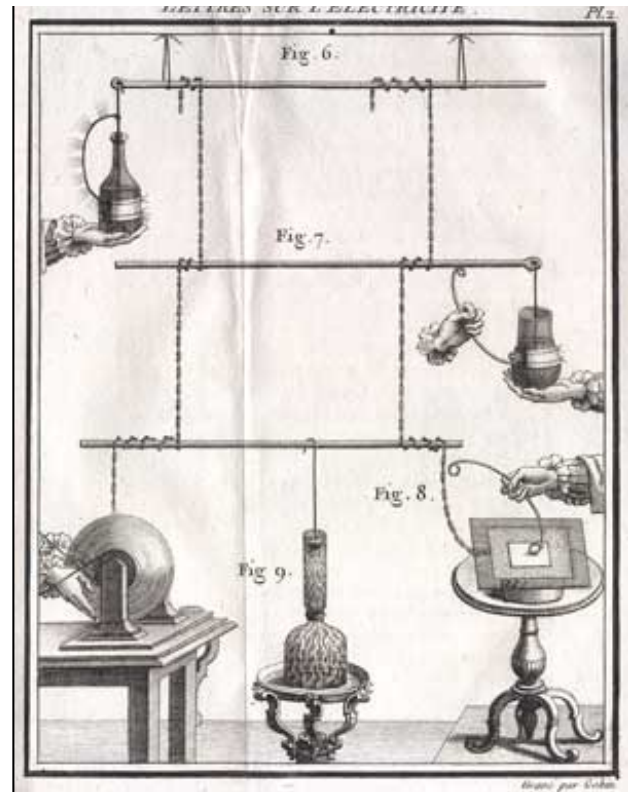
Trembley's letter is fascinating as it is one of the earliest first-hand accounts of this new discovery. He happened to be in Holland about the time of the discovery and his letter was the first word to England of the marvelous new jar.

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 *Anreas Cunaeus* who frequently visited one the laboratories at the University of Leiden, was trying to electrify 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 fact in around 600 BC by charging up Lodestone with a piece of amber and a sheeps skin. Lodestone (sometimes called *incorrectly* Loadstone) was used in ancient times for navigation at sea. Another Greek philosopher, Theophrastus, stated that this power is possessed by other substances about three centuries later.

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.



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, Electrolyte, 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 μ Farad (μ means 'micro'). Voltage levels can range from a couple to a substantial couple hundred thousand volts. The largest capacitor in my own collection is 150.000 μ F at 10Volts. A big sucker measuring about 10 x 5 inches! Does it still work? You bet! It will still zap the soles of your shoes... I use it on occasion to recondition shorted NiCad batteries which I use for my Radio Control gear.

The basic unit of capacitance is the **Farad**. Clumsy and not very practical to work with, capacitance is usually measured in microFarads, abbreviated μ F, or picoFarads (pF). The unit Farad *is* used in converting formulas and other calculations. A μ F (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

positive plate
insulator

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: $W = V^2 * C / 2$ 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, etc.



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" long (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. One paperclip/strip aluminum foil is designated 'Positive' and other one 'Negative'. Carefully roll up (all at once) the strips. One 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 to 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 *tightly as possible* secure it with tape or an elastic band or whatever.

Take a 9-volt battery and attach 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 short the 'capacitor' and you should see a little 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.

Capacitor Value Codes

Fig. 2

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, 7	Not Used	M	20 %
8	.01	P	+100, -0 %
9	.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 values are in the range from 1.8pF to 120pF, unless manufactured with different values for Military and/or industrial purposes on special request. They feature 2% tolerance which comes down to about 0.25pF variation, and all are 100V types. You may sometimes find NPO-type caps marked with the EIA (Electronic Industrial Association) code "COG". The EIA has an established set of specifications for capacitor temperature characteristics (EIC 384/class 1B). Thus, a capacitor labeled "Y5P" would exhibit a plus/minus tolerance of 10% variation in capacitance over a temperature range of -30°C. to +85°C. Or it may say N12 which translates to 120pF. Or 2P2 (2.2pF). I'm sure you get the idea...

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%
	G	12 pF	--
NPO	H	15 pF	--
	S	20 pF	--
	K	22 pF	--
	L	27 pF	--
	-	33 pF	--
	P	47 pF	--
N750	Q	56 pF	--
	S	82 pF	--
	-	100 pF	--
	-	150 pF	--
	J	180 pF	--
N150	K	220 pF	--
	L	270 pF	--
	M	330 pF	--
	N	390 pF	--
	A	470 pF	--
	Q	560 pF	--
	R	680 pF	--
	F	1KpF	10% (1.0nF)
N1500	-	1N5	10% (1.5nF)

Fig. 3a

EIA CLASS II CAPACITOR CODE						Fig. 3b
Letter Symbol	Low Temp. Requirement	Number Symbol	High Temp. Requirement	Letter Symbol	Max. Capacitance Change Over TEp. rating	
Z	+10°C	2	+45°C	A	± 1.0%	
				B	± 1.5%	
				C	± 2.2%	
Y	-30°C	4	+65°C	D	± 3.3%	
				E	± 4.7%	
				F	± 7.5%	
X	-55°C	5	+85°C	P	± 10.0%	
				R	± 15.0%	
				S	± 22.0%	
X	-55°C	6	+105°C	T	± 22% - 33%	
				U	± 22% - 56%	
				V	± 22% - 82%	
X	-55°C	7	+125°C			

Dielectric Constant of Materials

Air	1.00	Paper	3.00
Alsimag 196	5.70	Plexiglass	2.80
Bakelite	4.90	Polyethylene	2.30
Cellulose	3.70	Polystyrene	2.60
Fiber	6.00	Porcelain	5.57
Formica	4.75	Pyrex	4.80
Glass	7.75	Quartz	3.80
Mica	5.40	Steatite	5.80
Mycalex	7.40	Teflon	2.10

Fig. 4

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 electrodes 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 one which is twice 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 exist but may be hard to obtain. Largest in my own collection is 220 μ F/35V, beige color.



Super Capacitors - The Electric Double Layer capacitor is a real miracle piece of work. Capacitance is 0.47 Farad (470,000 μ F). 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 such large capacitance that, without precautions, it would destroy part of a powersupply such as the bridge rectifier, volt regulators, 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 than polyester caps can offer. This polypropylene film is the dielectric.

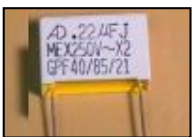
Very little change in capacitance when these capacitors are used in applications within frequency range 100KHz.

Tolerance is about 1%.

Very small values are available.



Polystyrene - Is used as a dielectric. Constructed like a coil inside so 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 very small. 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. Typically used to by-pass high frequency signals to ground. They are shaped like a disk, available in very small capacitance values and very small sizes. Together with the electrolytics the most widely available and used capacitor around. Comes in very small size and value, very cheap, reliable. Subject to drifting depending on ambient temperature. NPO types are 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 0.1 μ F/50V caps for example resonate around 30MHz. The effect of this resonance is effectively no apparent capacitance near the resonant 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 dimes.



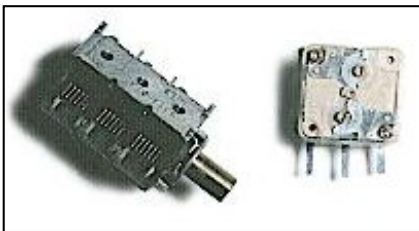
plastic

ceramic

Adjustable Capacitors - Also called trimmer capacitors or variable capacitors. It uses ceramic or plastic as a dielectric.

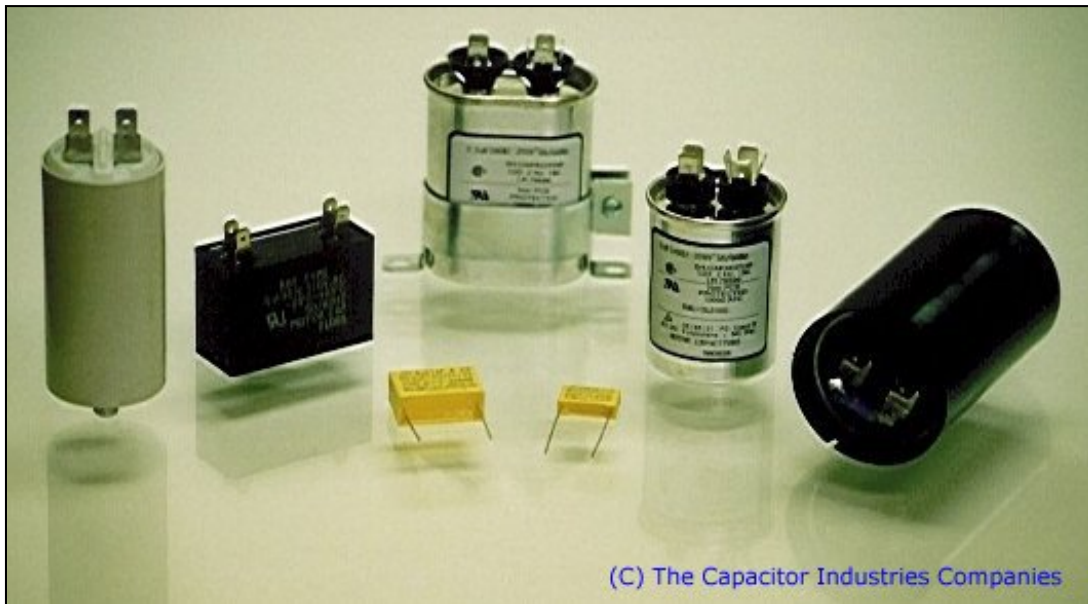
Most of them are color coded to easily recognize their tunable size. The ceramic type has the value printed on them. Colors are: yellow (5pF), blue (7pF), white (10pF), green (30pF), brown (60pf). There are a couple more colors like red, beige, and purple which are not listed here.

Anyways, you get the idea...



Tuning or 'air-core' capacitors.

They use the surrounding air as a dielectric. I have seen these variable capacitor types 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 axel 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.

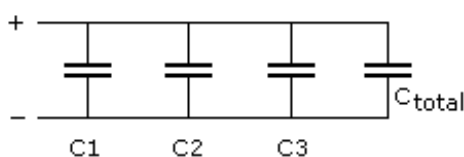


(C) The Capacitor Industries Companies

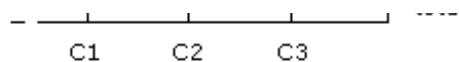
Combining Capacitors & Formula's:

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



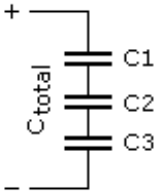
Capacitors connected in parallel, which is the most desirable, have their capacitance added together, which is just the opposite of parallel resistors. It is an excellent way of increasing the total storage capacity of an electric charge:



$$C_{\text{total}} = C_1 + C_2 + C_3$$

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. As a matter of fact, and 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.

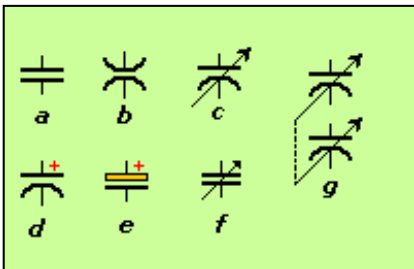
For a regular two capacitor series combo use this simple formula: $C_{\text{total}} = \frac{C_1 C_2}{C_1 + C_2}$

If you have two identical capacitors in series the formula is simplicity itself: $C_{\text{total}} = \frac{1}{2} C$

microFarads (μF)		nanoFarads (nF)		picoFarads (pF)
0.000001μF	=	0.001nF	=	1pF
0.00001μF	=	0.01nF	=	10pF
0.0001μF	=	0.1nF	=	100pF
0.001μF	=	1nF	=	1000pF
0.01μF	=	10nF	=	10,000pF
0.1μF	=	100nF	=	100,000pF
1μF	=	1000nF	=	1,000,000pF
10μF	=	10,000nF	=	10,000,000pF
100μF	=	100,000nF	=	100,000,000pF

Table 1. Capacitance Conversion

Capacitors in Schematics:



Capacitors in schematics are represented as a pair of plates. Sometimes the plates are drawn as straight lines (a), sometimes as curved ones (d), and sometimes as a combination of the two. Past electronic magazines such as **Radio Electronics**, **Hands-on Electronics**, and **Popular Electronics** used the symbols in fig. (a), (d), (c), and (g). While european magazines such as the Dutch **Elektuur** (Elektor) uses symbols as depicted in (a), (e), and (f).

Symbol in (c) is a variable capacitor like a trimmer cap, and (g) is a ganged variable capacitor such as a air-plate capacitor as used in radios.

Electrolytic capacitors are frequently indicated by a symbol with one straight and one curved line (d) or the european way of drawing this symbol in (e). A '+' sign is placed at the straight line to indicate the anode. Occasionally an electrolytic is drawn as two straight lines, but the plus sign is always included to indicate its polarity.

When a capacitor is shown as one straight line and one curved one, the curved line, which represents the outer case or electrode of the device, is assumed to be at a lesser potential than the straight one. Thus, since signal flow in a schematic diagram is usually from left to right, capacitors are drawn with their curved ends facing left or, if that is not possible, facing down, which is the direction usually used to represent ground. Electrolytics, especially, are depicted with the curved place facing downward.

Variable capacitors are usually depicted as shown in © and (f). The arrow is the conventional symbol used to indicate that a device may

be adjusted over a range of values. A multi-section variable device may be shown with one symbol for each section, with dashed lines (g) to show that both of the sections are ganged together.

In schematics, capacitor values are usually indicated in microFarads unless a note specifies that things are otherwise. Voltage ratings, if they are given, are usually indicated in microFarads (uF) unless a note specifies that things are otherwise. Voltage ratings, if they are given, are usually presented as part of a "fraction." A label of "4.7uF/35V" or "4.7/35" would indicate a capacitor with a value of 4.7uF with a working voltage of 35 volts.

MicroFarads are indicated with the greek letter 'u' (μ). Don't make the mistake of writing uF as mF. 'm' Stands for 'milli' and is definitely not the same.

Things Capacitors Don't Like:

Capacitors are very finicky devices. There are any number of conditions they don't like. Many types, 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 (AC) either. It makes them overheat and--before they self-destruct--operate inefficiently. AC in particular is hard on capacitors because of the sinusoidal switching effect. For that reason it is of utmost importance to select a capacitor type with the correct dielectric, temperature coefficient, capacitance, and working voltage. As a rule-of-thumb in DC applications, select a capacitor of at least twice the supply power.

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 encased 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 the 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 tuned 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 devices used in subatomic-particle research are also met by capacitors--rooms 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 involved is still big enough to boggle the mind.

Bypassing:

The phrase "bypass" or "decoupling" is referred to filtering noise off the power rails caused by switching of TTL IC's, MosFets, Transistors, etc. Especially TTL (Transistor-Transistor-Logic) IC's create a lot of noise and so this has to be cleaned up. Mounting a 100nF (0.1uF) ceramic bypass capacitor over the power rails and as close to the IC as possible and keeping the capacitor leads as short as you can, will clean up noise nicely. This has to be done on all IC's and power rails on a printed circuit board with this kind of digital logic. Noise can cause all sorts of problems such as false triggering, cross-talk, change to an undesirable logic state, etc. Decoupling is used where the supply voltage cannot be lowered, i.e., if one needed a noise free +12V on a PC bus, for example. You could get a "clean" +12 volts with a voltage regulator... if only there was +15 volts or higher to start with. But such is not the case. So you use a high "Q" inductor or RFC choke along with the proper bypass capacitor to effectively lowpass filter the +12 volt supply rail. For a real noisy supply you can use more than one inductor: a "pie" network for example.

As digital becomes faster and faster, it looks more like analog than digital. It would be an asset to have a good understanding of the analog/RF properties of high speed digital. Careful layout of a groundplane and proper decoupling and bypass requires close attention of a circuit design to maintain the integrity of the power distribution.

Excessive lead length will void the purpose of a bypass capacitor so keep the leads short.

Couple of Bypass Suggestions:

If needed, attempt the following as stated below.

- Use 0.1uF (=100nanoF) or greater, ceramic capacitor, surface mount technology or SMT preferred.
- One capacitor per SSI, MSI TTL, device.
- The capacitors should be connected over the Vcc and Gnd with the shortest path possible.
- Ceramic disc capacitors have the best high frequency characteristics and the least self inductance.
- Only in RF applications it is appropriate to mix different type caps together to filter at different freq's.
- Substituting a tantalum for a ceramic type will not work, but they can work together very well.

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 designated 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.

CAPACITOR NOMENCLATURE -- by Dean Huster

The questions of reading capacitor values, tolerances and their units of measure come up often on various Internet forums and have hit the old "Q & A" column that I wrote for Poptronics magazine (formerly Electronics Now and Popular Electronics magazines) during its last two years of existence. Here's an attempt at a global treatise on the subject.

The Farad, Microfarad and Picofarad

Capacitors have always had farad as the unit of measure, abbreviated "F". Since this is a very large unit of measure for most practical capacitors or for most uses of capacitance, you'll find that a millionth of a farad or a million-millionth of a farad are the more common units found on capacitors. Yes, these days we can find capacitors with ratings in the tens and hundreds of farads, but those are usually reserved for extremely high-current, low-voltage switching supplies or for a more frivolous use as energy-storage tanks for use with high-power automotive audio power amplifiers. This treatise is for "normal" capacitors.

In scientific notation, we would write 1 millionth of a farad as 1×10^{-6} farad. In electronics, since we deal with so many component values and circuit values on even the smallest schematic or product, the metric prefix form is used for an electronic shorthand to keep the scribbling to a minimum. That prefix form uses letter symbols to take the place of the scientific notation--or more accurately, the engineering notation--that would otherwise accompany a unit of measure. The metric prefix form replaces the engineering notation [Note 1] that would otherwise be used in front of the unit of measure. That list follows.

Metric Prefix	Symbol	Power of 10 (multiplier)
giga [Note 2]	G	$\times 10^9$
mega	M	$\times 10^6$
kilo	K	$\times 10^3$
(none)		$\times 10^0$ (same as 1 or unity)
milli	m	$\times 10^{-3}$
micro	f	$\times 10^{-6}$
nano	n	$\times 10^{-9}$
pico	p	$\times 10^{-12}$

This list does extend farther in either direction, but those larger and smaller multipliers are not as commonly used in electronics. But using this list, you'll find that the common capacitor multipliers in the United States will be f (micro) and p (pico). A capacitor with a value of 3.3fF is the same as a capacitor with a value of 3.3×10^{-6} farads or 0.0000033 farads. "f", by the way, is the lower-case Greek letter "mu", properly written as our Roman lower case "u" with a leading descender much as a "y" has a trailing descender.

Antique Capacitors and Schematic Diagrams

Prior to the 1960s, capacitors were called "condensers". Same part, same function, different name. You'll still hear the old name used by auto mechanics when they speak of the condenser in the ignition system on an older vehicle.

That earlier list of prefixes, although valid in the hayday of the vacuum tube, was used even less extensively back then. Mega (M) was the largest prefix commonly used and micro (f) was the smallest. To achieve larger or smaller multipliers, the prefixes were doubled up just like multiplying two numbers together. So, a small capacitor value might be 47ffF ("forty-seven micromicro farads") which was saying $47 \times 10^{-6} \times 10^{-6}$, which is the same as 47×10^{-12} , or 47pF. So, anytime you see "ff", just think "p" in your head. [Note 3] You'll also hear some old timers use the rather ridiculous term mickey-mikes instead of saying micromicrofarads. Makes me glad that we went to using pico.

To make it even worse, the symbol for micro, m, was not used often before 1970 except for expensive physics and engineering texts. It was not a common character to find in a print shop and impossible to find on a typewriter, unless you had the special "symbol" typeball for the IBM Selectric. So, the lower case "u" was usually used in its place. That means that on schematics of the 1950s, a capacitor that was listed as 68uF is the same as one today listed as 68fF. In addition, the components themselves rarely had even the "u" listed. The actual part could have any one of the following printed on it:

68 mF 68 MF 68 mfd 68 MFD

It was always understood that "mF", "MF", "mfd" or "MFD" ALWAYS meant microfarad. Microfarad or micromicrofarad were the only units used for capacitors back then, so no one would ever even consider that "mfd" might mean "millifarad" or that "MFD" might mean "megafarad"! Even today, you'll still see "MFD" on capacitors, especially on motor start or motor run capacitors.

In addition, antique capacitors did not hold to today's standard value system. More on that later.

The Europeans

Even while we had nanoseconds and millihenries and other such measurements in the United States, capacitor values were only given in microfarads and picofarads (micromicrofarads) and that holds true even today. I have yet to ever find anyone or any source that can give the reason for that. I'm afraid that "because we've always done it that way" will be the only reason you'll ever hear. The practice thwarts the rules of engineering notation [**Note 1**], resulting in capacitor values written as 0.0068fF or 6800pF, both of which are the same value and either of which is correctly written in the engineering or metric prefix systems of notation. In addition, in this world of large computer-grade caps, you'll also find values of 180,000fF. Some companies preferred to use the latter of the two forms of notation just to keep the decimal point out of print so that there would be no confusion, preferring for instance, 6800pF over 0.0068fF

Meanwhile in Europe, and later Asia, the electronics folks there would have no problem at all referring to that same value of 0.0068 fF or 6800pF as 6.8nF (6.8 nanofarads). So, on diagrams from the U.K., don't be surprised to see both millifarads and nanofarads used extensively. And that's OK. It makes a lot more sense and it's easier to write. The only problem is that we Yanks have to learn to convert or at least get used to working with milli and nano when dealing with capacitors. The 180,000fF cap mentioned earlier would be more-correctly rendered as 180mF by someone in Germany.

Cryptic Capacitor Markings

In the 1960s, capacitors were marked with their value. Plain and simple. But nevertheless, it was a poor system as decimal points and zeros often got lost. Paper capacitors often had a wax coating on the outside that obscured the markings and these same markings could be accidentally "edited" when scraping the wax away for a better view.

Similarly, ceramic disc caps also often had a wax coating, possibly just from being next to waxy paper cap in a warm television set. A cap might be marked as ".0047MFD" or simply as ".22" and without that leading zero, there could be problems if the decimal point disappeared. You had to use a little common sense when reading these values. If the value was in decimal form (e.g., ".047"), you assumed the value to be in microfarads. If it was a whole number (e.g., "470"), you had to determine what type of capacitor you had. If it was an electrolytic type, you assumed the value to be in microfarads. If it was a small ceramic cap, it was in picofarads. You knew that a small ceramic or plastic cap couldn't possibly be as large as 470fF and that an electrolytic would nearly always have a value larger than 1fF.

During the 1970s, manufacturers began to mark the caps in a way similar to the way resistors were done, but without the color code. Rather than colors, they just used the actual printed digits, and the value was marked on the cap as two significant digits and a multiplier, the value being in picofarads. So, a cap marked "221" doesn't mean 221fF or 221pF. It means 22 + 1 zero or 220pF. "684" is decoded as 680,000 (68 + 4 zeros) pF or 0.68fF. Capacitor values smaller than 100pF might be printed as just two digits, such as "33" for 33pF or as

two digits with a zero multiplier, as in 330 for 33pF.

This method of marking caps takes care of a lot of problems with disappearing decimal points and large numbers (e.g., .0047MFD) that would otherwise be difficult to print on small parts. But it did put in a bit of confusion when compared to the older way of marking. What did "100" mean? If it was an older cap, it meant 100pF. If it used the newer marking system, it meant 10pf (10 with no zeros added). So, you need to know which system is in use and that can be tricky.

That's why it's nice to have a digital capacitance meter or a capacitance bridge at hand. You can get a "ballpark" check of the value to determine where to go from there.

Later, manufacturers took a hint from the Europeans and begin to mark their capacitors like the Brits marked them on schematics. This took care of ALL the problems of marking as well as problems associated with schematic value markings. In the Euro system, you revert to the engineering form, but replace the decimal point with the metric prefix multiplier. So, the oldest "4.7MFD" capacitor that was updated to "4.7fF" and then to "475" (picofarad) with the later system was now marked as "4f7". Presto! The "f" shows the location of the decimal point AND gives the metric prefix, all at the same time! This is really the best system in the world, both for marking the components themselves and for marking the values on schematics. If a decimal point disappears because of wear or poor printing, it can mess things up in the old system. An entire character would have to disappear in the newest system.

You will find plenty of folks, especially here in the U.S. who don't like the Euro way of marking. But these same folks don't like change. As a matter of fact, a lot of these old clowns will still use a "33 em-em-eff condenser to set the frequency of their 4.5 megacycle" oscillator. Just ignore them!

Tolerances

Value tolerances used to be marked on the capacitor in percentage. An older cap might be marked as ".05 10%", meaning 0.05fF, q10%. Newer caps use a letter for the tolerance, and that will seem confusing right at first. A common value might be ".1M" which means 0.1fF, q20%. A little newer cap might be marked as "332K" and that drives some folks nuts. After all, "K" is a standard metric prefix multiplier and they automatically think they have a 332,000fF cap on their hands. In reality, they have a 3300pF (33 + 2 zeros, in pF) with a q10% tolerance. The letters on these caps correspond to the following list. I've marked the tolerances that you'll find to be the most common with an asterisk.

B	=	q0.1pF
C	=	q 0.25pF
D	=	q0.5pF
E	=	q0.25%
F	=	q1.0%
G	=	q2%
H	=	q2.5%
J	=	q5% *
K	=	q10% *
L	=	q15%
M	=	q20% *
N	=	q30%
P	=	-0, +100%
S	=	-20, +50%
W	=	-0, +200%
X	=	-20, +40%
Z	=	-20, +80% *

You'll find that the "Z" tolerance of -20, +80% to be common for aluminum electrolytic caps and for disc ceramic caps that are used for what is known as "bulk capacitance" in applications such as power supply bypassing or filtering. These kinds of capacitors are used where it's OK for the value to be a lot larger than nominal, but they don't want it to go very far below that value.

If you do a lot of analog circuit design and building where you attempt to get frequency-dependent circuits to be as accurate as possible, you'll see or want to find Mylar caps with a "G" or "F" tolerances of q2% or q1% respectively. They're harder to find in catalogs, but if you watch the electronics surplus catalogs, you can find them on a sporadic basis. The tolerances of "B" through "E" are in pF vs. percent

and are normally used on small caps of around 10pF or less.

Standard Values

When the numbers on a capacitor begin to rub off because of age, and you need to know the value, it may help to know that at least in more modern times, manufacturers have adhered to a set of standard values for capacitors. Typically, these will be the same list of standard values used for 20% tolerance fixed resistors, each decade having six possible values. This simply means that the significant digits of any capacitor value will be either 10, 15, 22, 33, 47 or 68. You'll find that 10, 22, 33 and 47 are the most-commonly used. This set of standard values applies whether the capacitor has a tolerance of 20%, 10% or 5%.

Why not have the full 24-per-decade range of values for the 5% capacitors just like we do for resistors? In most cases where tolerance might be a factor, a capacitor is used against a resistor for setting some type of timing or frequency of a circuit. There's no sense having all of those values for both components. So, since the capacitor is a lot more expensive to manufacture and is prone to larger tolerance variations, they limit the number of values to six per decade. A designer will then choose the value of capacitor most closely suited to the application and then "fine tune" the actual RC time constant by choosing one of the 24-per-decade resistor values. If the circuit is to be very accurate and stable, the designer will choose a 2% or 1% tolerance capacitor with a low temperature coefficient and then use a 1% metal film resistor for the resistive element where there are 96 possible values per decade.

All this is to say that if you're trying to decide if that capacitor you're trying to replace in a radio is marked "65" or "68" because the last digit is all scratched up, choose "68" since that's a standard value and is most likely the marked value. This is not to say that a capacitor will always hold to the standard value table. Older capacitors had values such as 0.03fF or 0.05fF. These were made before extensive standardization. And then there are specially made caps for the telephone industry. I've seen values such as 0.1746fF with a 2% tolerance. All those significant figures with a 2% tolerance is foolish since even the "4" can move up or down by almost three digits and still be within tolerance. And some manufacturers will feel the need to "fill in" the table by providing values that conform to the 12-per-decade table of 10% components, but that's OK.

Just don't expect it for all capacitors.

Voltage Ratings

In addition to value and tolerance, a capacitor is often marked with a voltage rating. These may simply be noted as "50V" or "50VDC" or some such other voltage as appropriate. Voltage ratings are sometimes incorporated into a capacitors "coded description". For instance, the value code "2A104K" has a "2A" prefix which translates to a voltage rating of 100V. The "104K" part, as you now know, translates to 100,000pF or 0.1fF or 100nF with a tolerance of 10%. Voltage prefixes include:

1E	25V
1H	50V
2A	100V

Since this seems to be European in nature, these voltage markings are new territory for me. I would appreciate more information on this so that I can flesh out this article and make it more accurate. My *e-mail* address appears in the "Wrapup" section following in case you would like to contact me with some of this information. I try to be accurate, so please make sure that you include source material rather than depending upon hand-me-down folklore!

Temperature Coefficient

Capacitors, most notably ceramic capacitors, have temperature coefficients ("tempco" or TC). That is, their value will change with a change in temperature. Some "bulk" ceramic capacitors (those "M" tolerance things) can change over 10 or 20 percent with a 20 degree shift in temperature, so are unsuitable for use in circuits that are frequency-dependent, such as oscillators or filters. Capacitance changes are not necessarily linear or even directly proportional at all times for a particular type of capacitor.

You'll see markings on a cap such as "Z5U". That's a temperature coefficient. The "Z" part has nothing to do with the tolerance. I have no intention of going into tempcos here since it has nothing to do with reading the value. I just wanted you to be aware of them so that you don't confuse them with the tolerance.

Wrapup

As usual, if you find any errors, however small, in this article or if you feel there's some information that needs to be added, please don't hesitate to contact me at: **dhuster at semo dot net** (don't forget to use "@" for "at" and "." for "dot"). If everyone wants to see tempco information here, then I'll go ahead and add it.

Footnotes

Note 1: While scientific notation takes the form, $n.nnnnn \times 10^p$ where you have only one digit to the left of the decimal point and an appropriate power of 10 so that the number in scientific notation will be numerically equal to the original number in decimal form, engineering notation takes one of the three following forms, $n.nnnnn \times 10^{3p}$, $nn.nnnn \times 10^{3p}$, $nnn.nnn \times 10^{3p}$, where there are either one, two or three digits to the left of the decimal point to achieve a power of ten that is an integer multiple of three, the final number being numerically equal to the original number in decimal form or scientific notation form. So, the only powers of 10 allowed in engineering notation are powers such as 15, 12, 9, 6, 3, 0, -3, -6, -9, -12, -15, etc. Engineering notation is handy in that it directly translates into the metric prefix form, which also uses powers of ten that are integer multiples of three. Some models of Casio scientific calculators are capable of displaying their results in engineering notation while some even have the capability of displaying in metric prefix form.

The metric prefix form follows the engineering form exactly with two common exceptions. The "bel", the unit of measure for a ratio of sound or signal amplitude levels, is too large to be practical.

One-tenth of a bel, or a decibel, is the normal unit used, abbreviated "dB", a term you have probably seen often. "Deci" is the same as " $\times 10^{-1}$ ".

Another exception is the centimeter, often used in the metric system where we would use inches in the English or SAE system. A centimeter is 1/100 of a meter, abbreviated "cm". "Centi" is the same as " $\times 10^{-2}$ ".

Note 2: "giga" is technically pronounced "jigga" beginning with a soft "g" as in the word "giant" with a hard "g" as in "gallup" the second time, and as is done by the character of Dr. Emmett Brown in the motion picture "Back to the Future" when he refers to "one point twenty-one gigawatts of power." However, you'll find that nearly everyone involved in electronics pronounces it beginning with a hard "g" as they would the "g" in the word "go".

Note 3: Other units of measure had similar doubling up. For instance, fast oscilloscope risetimes were noted as 3mfs or "3 millimicro seconds" which is the same as today's 3ns. At the other end of the spectrum, so to speak, microwave signal generators were marked as having frequencies of 1.5KMC or "1.5 kilomega cycles (per second)" which is 1.5GHz in today's vernacular. In addition, "cycles per second" as the unit of measure of frequency, which was usually shortened to the erroneous "cycles", was changed to Hertz, abbreviated Hz, in the 1960s.

Thanks Dean Huster for your contribution, much appreciated!



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"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!

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"Capacitor Nomenclature", by Dean Huster. Contributing author/editor for our leading electronic magazines. Thanks Dean. It's an honor adding your explanation to my tutorial!

Suggested Reading:

"The Radio Amateur Handbook" from the **A**merican **R**adio **R**elay **L**eaque (ARRL). Good resource.

"The Capacitor Book". by Cletus J. Kaiser., C.J. Publishing. ISBN: 0-9628525-3-8

"Williamson Labs". Website about bypassing, decoupling, shielding, layout, etc.: <http://williamson-labs.com>

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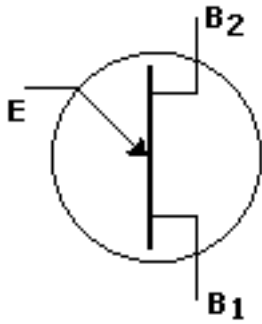
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Testing a UJT

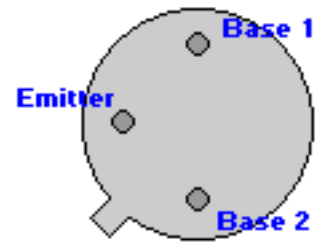
Uni Junction Transistor

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).



'Bottom' view

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.

4) Remember that the 'B1' pin should always be connected to the load and not B2.

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.

The UJT's main application is (and was) to work with and connect to SCR's. It was especially designed for this purpose. But with only a couple external components it can produce an oscillator. As previously stated, only the UJT's B1 connection was designed to work with a load. The 'load' is connected between the '0' volt rail and B1. The standard and more common UJT for many decades was the 2N2646. These days trying to find one can be difficult and expensive.

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