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# Talking Electronics

See [TALKING ELECTRONICS WEBSITE](#)

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# INTRODUCTION

This eBook contains more than 200 transistor circuits.

Most of them can be made with components from your "junk box" and hopefully you can put them together in less than an hour.

The idea of this book is to get you into the fun of putting things together and there's nothing more rewarding than seeing something work.

It's amazing what you can do with a few transistors and some surrounding parts. And this is the place to start.

Most of the circuits are "stand-alone" and produce a result with as little as 5 components.

We have even provided a simple way to produce your own speaker transformer by winding turns on a piece of ferrite rod. The other components can be obtained from transistor radios, toys and other pieces of equipment you will find discarded all over the place.

To save space we have not provided lengthy explanations of how the circuits work. This has already been covered in TALKING ELECTRONICS Basic Electronics Course, and can be obtained on a [CD for \\$10.00](#) (posted to anywhere in the world) See Talking Electronics website for more details:

<http://www.talkingelectronics.com>

Transistor data is at the back of this book and a transistor tester circuit is also provided. There are lots of categories and I am sure many of the circuits will be new to you, because some of them have just been designed.

Basically there are two types of transistor: PNP and NPN.

All you have to do is identify the leads of an unknown device and you can build almost anything.

You have a choice of building a circuit "in the air," or using an experimenter board (solderless breadboard) or a matrix board or even a homemade printed circuit board. The choice is up to you but the idea is to keep the costs to a minimum - so don't buy anything expensive.

If you take parts from old equipment it will be best to solder them together "in the air" (as they will not be suitable for placing on a solderless breadboard as the leads will be bent and very short).

This way they can be re-used again and again.

No matter what you do, I know you will be keen to hear some of the "noise" circuits in operation.

All the circuits are in groups but before you start, the home-made **Speaker Transformer** project and Transistor Tester are the first things you should look at.

If you are starting in electronics, see the **World's Simplest Circuit**. It shows how a transistor works and three transistors in the **6 Million Gain** project will detect microscopic levels of static electricity!

## KIT OF PARTS

Talking Electronics supplies a kit of parts that can be used to build the majority of the circuits in this book.

The [kit costs \\$15.00](#) plus postage and contains the following components:

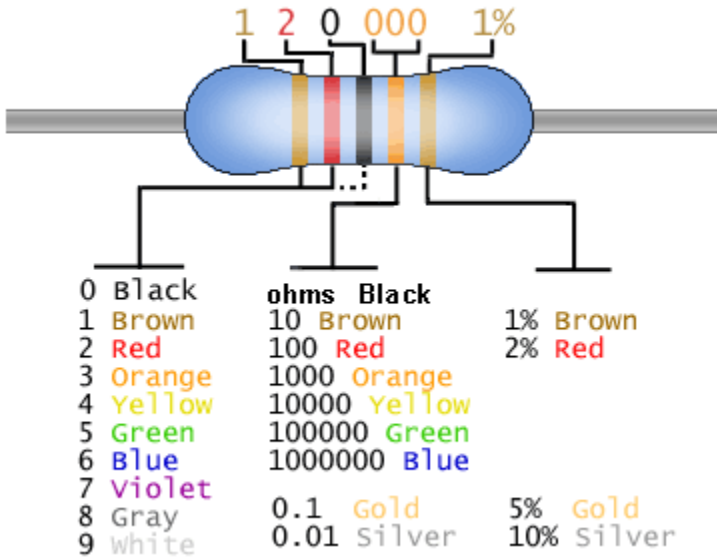
Before building a circuit, refer to the list and see if the project can be constructed using the parts in the kit.

In many cases, the value of a resistor or capacitor not in the kit, can be created by putting two resistors or capacitors in series or parallel or the next higher or lower value can be used.

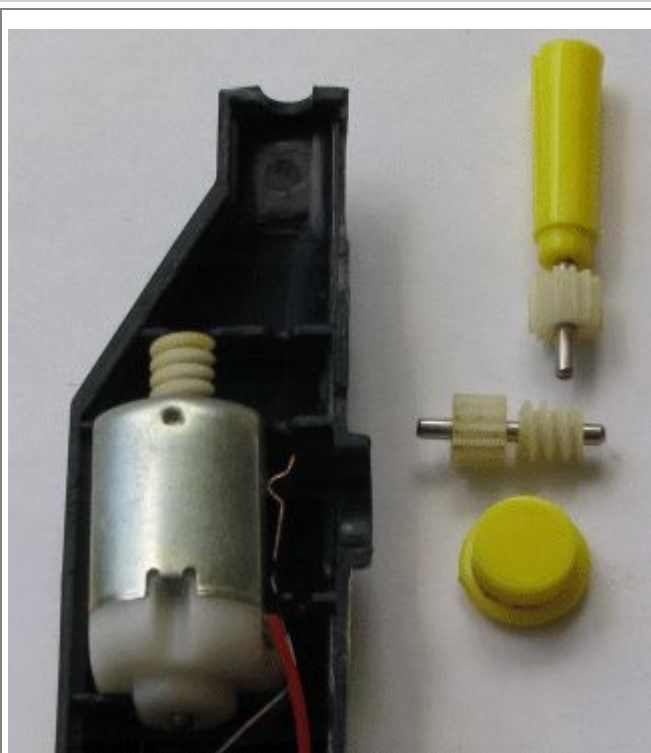
# CONTENTS

<p>Ammeter 0-1A          Automatic Light          Bench Power Supply          Boxes          Clock - Make Time Fly          Colpitts Oscillator          Constant Current Source          Dancing Flower          Door-Knob Alarm          Dynamic Microphone Amplifier          Electronic Drums          Fog Horn          Gold Detector          Guitar Fuzz          Hartley Oscillator          Heads or Tails          Hee Haw Siren          IC Radio          LED Detects Light          LED Flasher 1-Transistor          Lie Detector          Light Alarm-1          Light Alarm-2          Light Extender for Cars          Make Time Fly!          Making 0-1A Ammeter          Metal Detector          Microphone Pre-amplifier          Motor Speed Controller          Multimeter - V of Bench Supply</p>	<p>xx</p>	<p>On-Off via push Buttons          Phaser Gun          Phase-shift Oscillator          Resistor Colour Code          SCR with Transistors          Second Simplest Circuit          Signal Injector          Simple Logic Probe          Siren          Sound Triggered LED          Speaker Transformer          Strength Tester          Super Ear          Ticking Bomb          Touch Switch          Train Throttle          Transistor Tester-1          Transistor Tester-2          Trickle Charger 12v          Walkie Talkie          Worlds Simplest Circuit          White Line Follower          Zener Diode (making)          0-1A Ammeter          5 LED Chaser          5 Transistor Radio          6 Million Gain          12v Relay on 6v          12v Trickle Charger          20watt Fluoro Inverter          27MHz Transmitter          27MHz Transmitter - no Xtal          27MHz Transmitter-Sq Wave          27MHz Receiver          27MHz Receiver-2</p>	<p>xx</p>
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## RESISTOR COLOUR CODE



See resistors from 0.22ohm to 22M in full colour at end of book



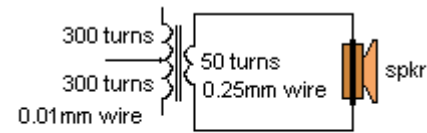
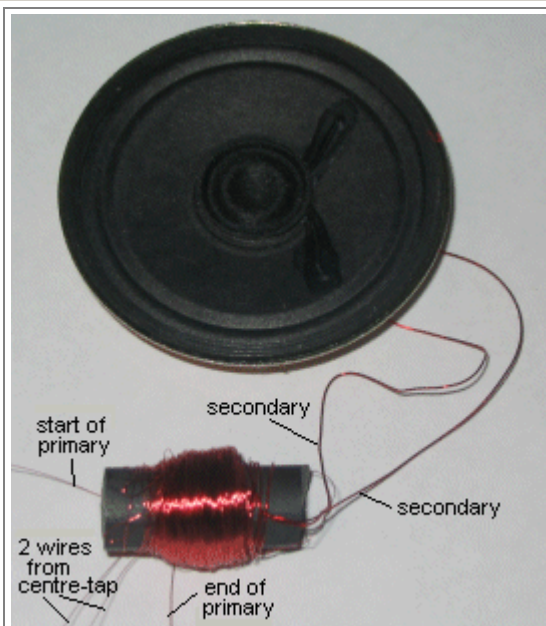
A two-worm reduction gearbox producing a reduction of 12:1 and 12:1 = 144:1 The gears are in the correct positions to produce the reduction.

## BOXES FOR PROJECTS

One of the most difficult things to find is a box for a project. Look in your local "junk" shop, \$2.00 shop, fishing shop, and toy shop. And in the medical section, for handy boxes. It's surprising where you will find an ideal box.

The photo shows a suitable box for a Logic Probe or other design. It is a toothbrush box. The egg shaped box holds "Tic Tac" mouth sweeteners and the two worm reduction twists a "Chuppa Chub." It cost less than \$4.00 and the equivalent reduction in a hobby shop costs up to \$16.00!

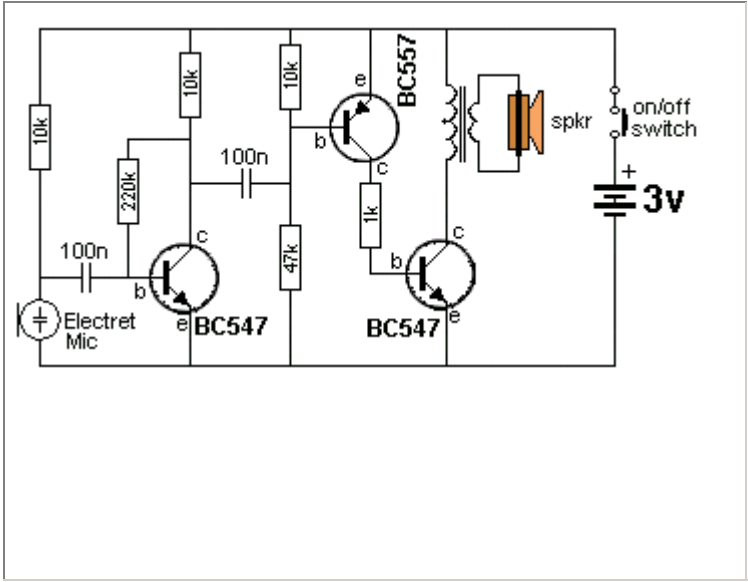




### HOME MADE SPEAKER TRANSFORMER

The **speaker transformer** is made by winding 50 turns of 0.25mm wire on a small length of 10mm dia ferrite rod. The size and length of the rod does not

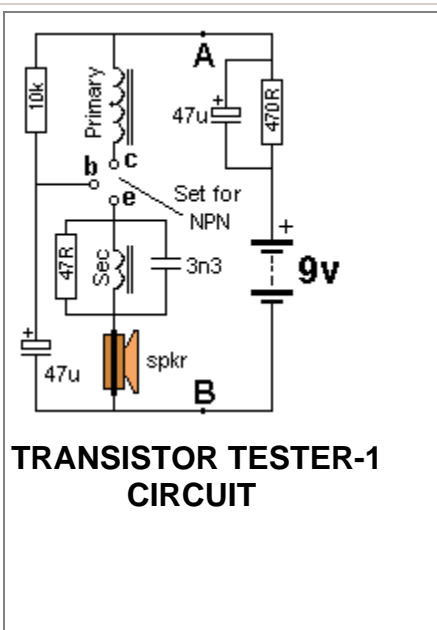
matter - it is just the number of turns that makes the transformer work. This is called the secondary winding. The primary winding is made by winding 300 turns of 0.01mm wire (this is very fine wire) over the secondary and ending with a loop of wire we call the centre tap. Wind another 300 turns and this completes the transformer. It does not matter which end of the secondary is connected to the top of the speaker. It does not matter which end of the primary is connected to the collector of the transistor in the circuits in this book.



### SUPER EAR

This circuit is a very sensitive 3-transistor amplifier using a speaker transformer. This can be wound on a short length of ferrite rod as show above or 150 turns on a 10mH choke. The biasing of the middle transistor is set for 3v supply. The second and third transistors are not turned on during idle conditions and the quiescent current is just 5mA. The project is ideal for listening to conversations or TV etc in another room with long leads connecting the microphone to the

amplifier.



### TRANSISTOR TESTER-1 CIRCUIT



The 10mH choke with 150 turns for the secondary

### TRANSISTOR TESTER - 1

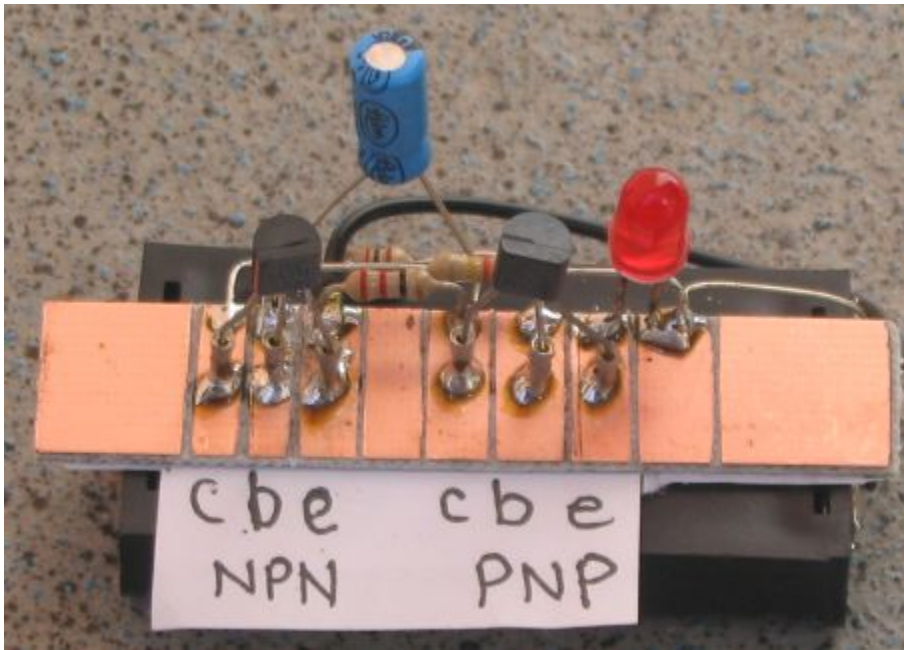
**Transistor Tester - 1** project will test all types of transistors including Darlington and power. The circuit is set to test NPN types. To test PNP types, connect the 9v battery around the other way at points A and B.

The transformer in the photo is a 10mH choke with 150 turns of 0.01mm wire wound over the 10mH winding. The two original pins (with the red and black leads) go to the primary winding and the fine wires are called the Sec.

Connect the transformer either way in the circuit and if it does not work, reverse either the primary or secondary (but not both).

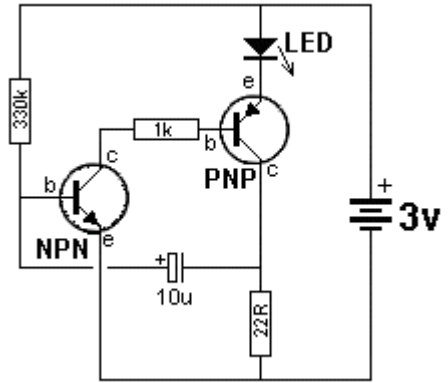
Almost any transformer will work and any speaker will be suitable.

If you use the speaker transformer described in the **Home Made Speaker Transformer** article, use one-side of the primary.



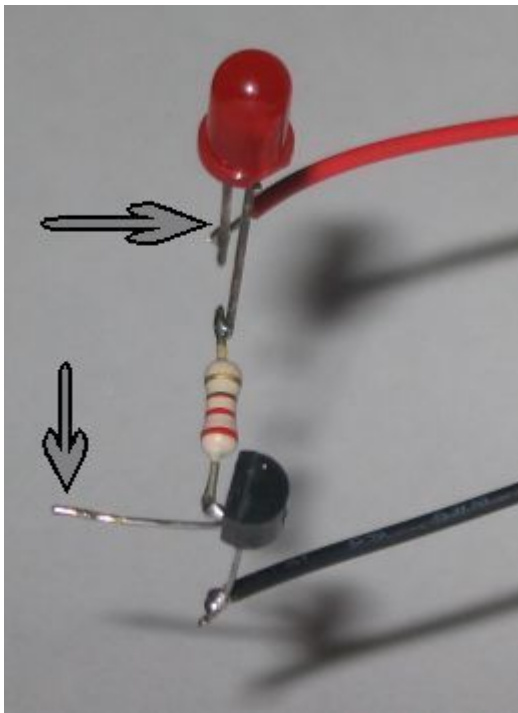
## TRANSISTOR TESTER - 2

Here is another transistor tester.



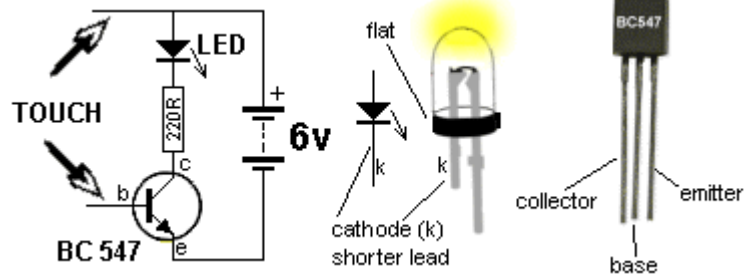
This is basically a high gain amplifier with feedback that causes the LED to flash at a rate determined by the 10u and 330k resistor.

Remove one of the transistors and insert the unknown transistor. When it is NPN with the pins as shown in the photo, the LED will flash. To turn the unit off, remove one of the transistors.



## WORLDS SIMPLEST CIRCUIT

This is the simplest circuit you can get. Any NPN transistor can be used.



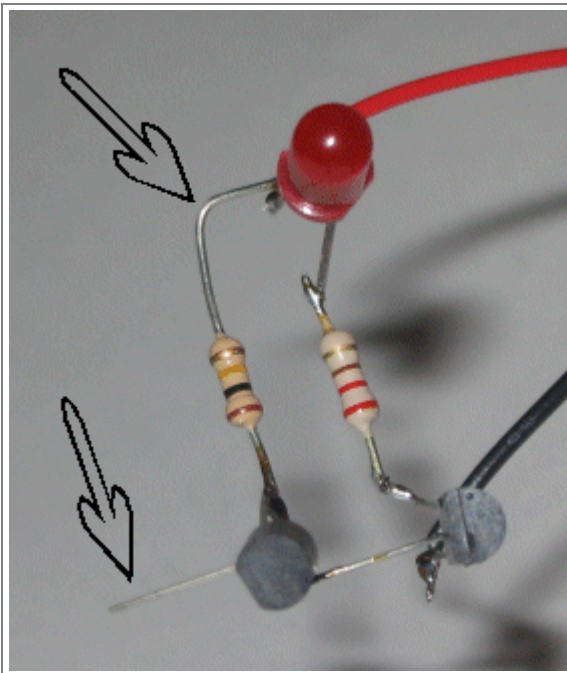
Connect the LED, 220 ohm resistor and transistor as shown in the photo.

Touch the top point with two fingers of one hand and the lower point with

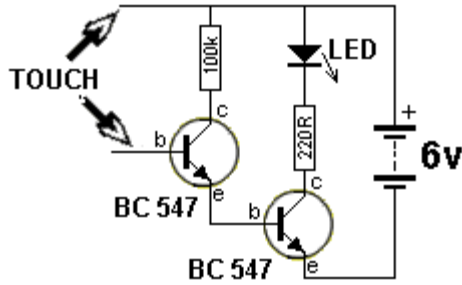
fingers of the other hand and squeeze.

The LED will turn on brighter when you squeeze harder.

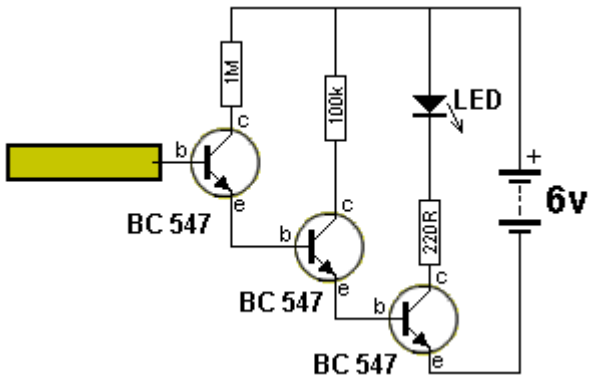
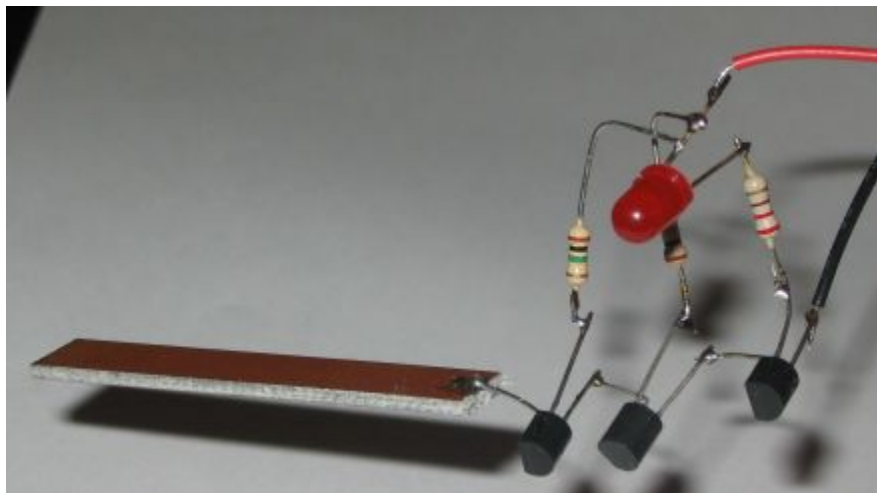
Your body has resistance and when a voltage is present, current will flow through your body (fingers). The transistor is amplifying the current through your fingers about 200 times and this is enough to illuminate the LED.



## SECOND SIMPLEST CIRCUIT



This is the second simplest circuit in the world. A second transistor has been added in place of your fingers. This transistor has a gain of about 200 and when you touch the points shown on the diagram, the LED will illuminate with the slightest touch. The transistor has amplified the current (through your fingers) about 200 times.

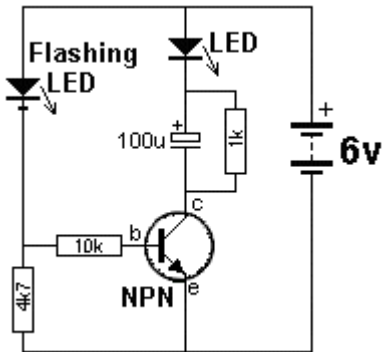


## 6 MILLION GAIN!

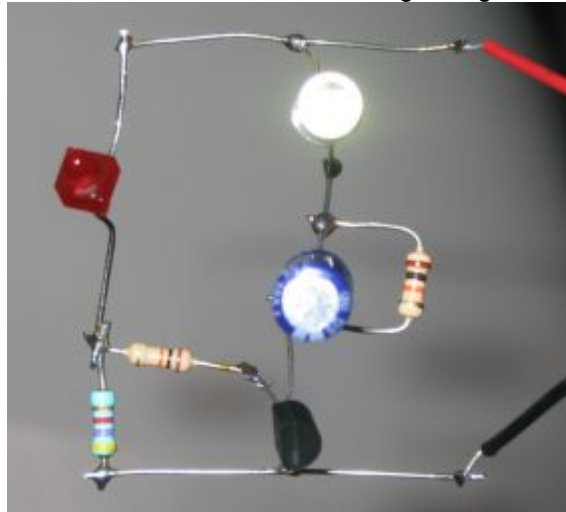
This circuit is so sensitive it will detect "mains hum." Simply move it across any wall and it will detect where the mains cable is located. It has a gain of about  $200 \times 200 \times 200 = 6,000,000$  and will also detect static electricity and the presence of your hand without any direct contact. You will be amazed what it detects! There is static electricity EVERYWHERE! The input of this circuit is classified as very high impedance.

## LED FLASHER WITH ONE TRANSISTOR!

This is a novel flasher circuit using a single driver transistor that takes its flash-rate from a flashing LED. The flasher in the photo is 3mm.



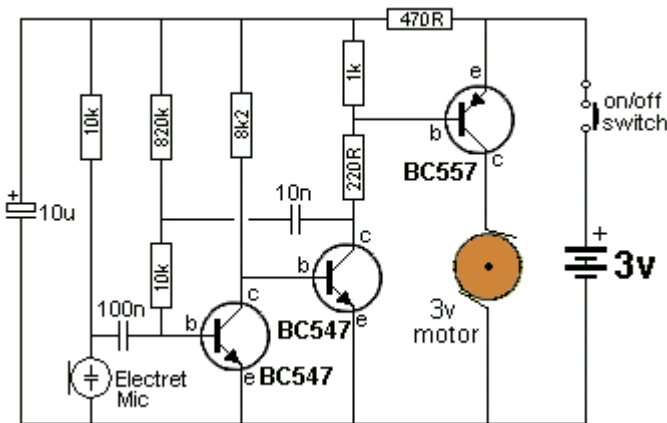
The circuit uses a flashing LED to flash a super-bright 20,000mcd white LED



An ordinary LED will not work.

The flash rate cannot be altered by the brightness of the high-bright white LED. The flash rate can be adjusted by altering the 1k resistor across the 100u electrolytic to 4k7 or 10k. The 1k resistor discharges the 100u so that when the transistor turns on, the charging current into the 100u illuminates the white LED.

If a 10k discharge resistor is used, the 100u is not fully discharged and the LED does not flash as bright. All the parts in the photo are in the same places as in the circuit diagram to make it easy to see how the parts are connected.

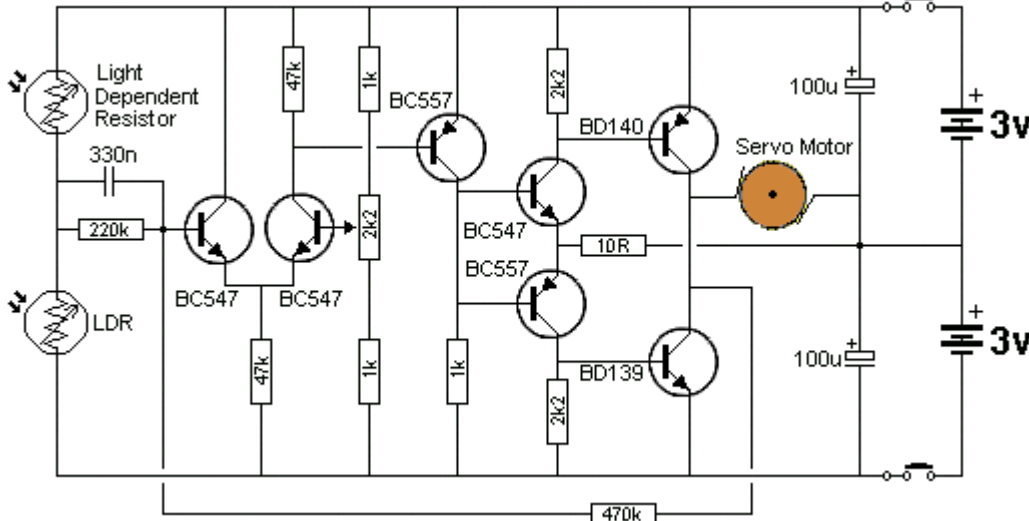


## DANCING FLOWER

This circuit was taken from a dancing flower.

A motor at the base of the flower had a shaft up the stem and when the microphone detected music, the bent shaft made the flower wiggle and move.

The circuit will respond to a whistle, music or noise.



## WHITE LINE FOLLOWER

This circuit can be used for a toy car to follow a white line. The motor is either a 3v type with gearing to steer the car or a rotary actuator or a servo motor.

When equal light is detected by the photo resistors the voltage on the base of the first transistor will be mid rail and the circuit is adjusted via the 2k2 pot so the motor does not receive any voltage. When one of the LDR's receives more (or less) light, the motor is activated. And the same thing happens when the other LDR receives less or more light.

## LED DETECTS LIGHT

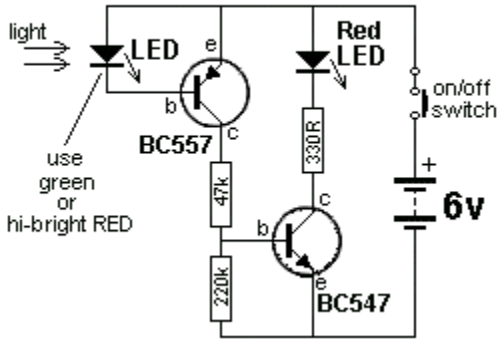
All LEDs give off light of a particular colour but some LEDs are also able to detect light. Obviously they are not as good as a device that has been specially made to detect light; such as solar cell, photocell, photo resistor, light dependent resistor, photo transistor, photo diode and other photo sensitive devices.

A green LED will detect light and a high-bright red LED will respond about 100 times better than a green LED, but the LED in this position in the circuit is classified as very high impedance and it requires a considerable amount of amplification to turn the detection into a worthwhile current-source.

All other LEDs respond very poorly and are not worth trying.

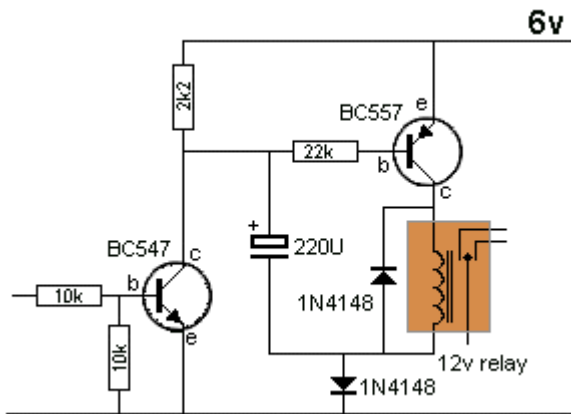
The accompanying circuit amplifies the output of the LED and enables it to be used for a number of applications.

The LED only responds when the light enters the end of the LED and this makes it ideal for solar trackers and any time there is a large difference between the dark and light conditions. It will not detect the light in a room unless the lamp is very close.



## 12v RELAY ON 6V SUPPLY

This circuit allows a 12v relay to operate on a 6v or 9v supply. Most 12v relays need about 12v to "pull-in" but will "hold" on about 6v. The 220u charges via the 2k2 and bottom diode. When an input above 1.5v is applied to the input of the circuit, both transistors are turned ON and the 5v across the electrolytic causes the negative end of the electro to go below the 0v rail by about 4.5v and this puts about 10v across the relay.



## MAKE TIME FLY!

Connect this circuit to an old electronic clock mechanism and speed up the motor 100 times!

The "motor" is a simple "stepper-motor" that performs a half-rotation each time the electromagnet is energised. It normally takes 2 seconds for one revolution. But our circuit is connected directly to the winding and the frequency can be adjusted via the pot.

Take the mechanism apart, remove the 32kHz crystal and cut one track to the electromagnet. Connect the circuit below via wires and re-assemble the clock.

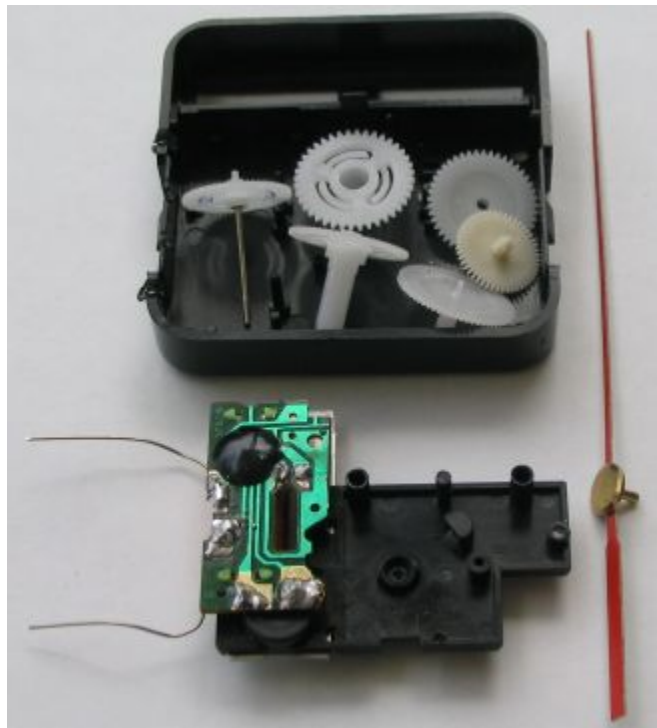
As you adjust the pot, the "seconds hand" will move clockwise or anticlockwise and you can watch the hours "fly by" or make "time go backwards."

The multivibrator section needs strong buffering to drive the 2,800 ohm inductive winding of the motor and that's why push-pull outputs have been used. The flip-flop circuit cannot drive the highly inductive load directly (it upsets the waveform enormously).

From a 6v supply, the motor only gets about 4v due to the voltage drops across the transistors. Consumption is about 5mA.

## HOW THE MOTOR WORKS

The rotor is a magnet with the north pole shown with the



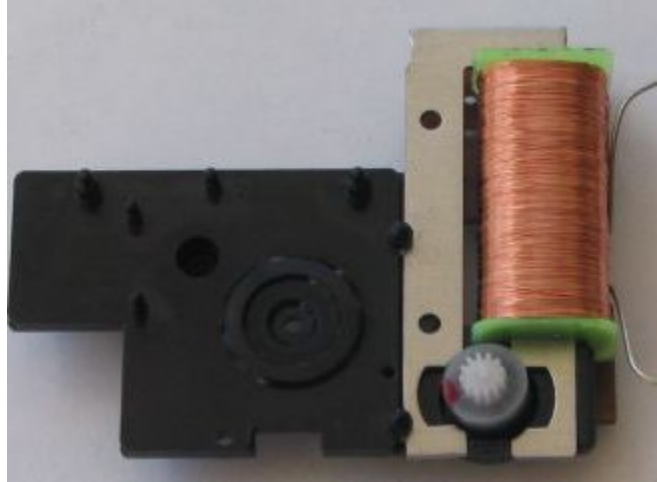
The crystal removed and a "cut track" to the coil.

red mark and the south pole opposite. The electromagnet actually produces poles. A strong North near the end of the electromagnet, and a weak North at the bottom. A strong South at the top left and weak South at bottom left. The rotor rests with its poles being attracted to the 4 pole-pieces equally.



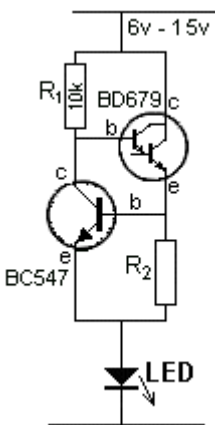
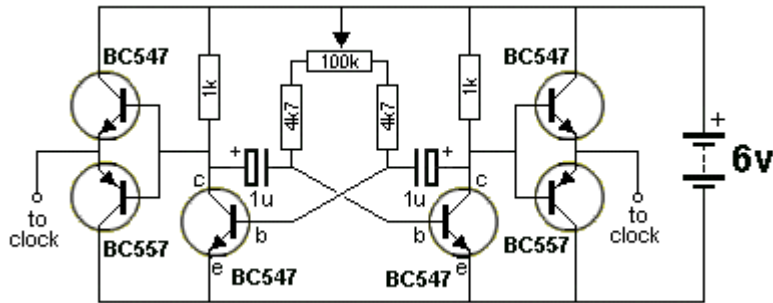
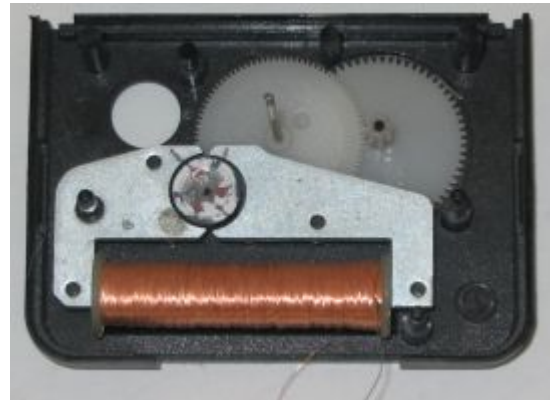
Voltage must be applied to the electromagnet around the correct way so that repulsion occurs. Since the rotor is sitting equally between the North poles, for example, it will see a strong pushing force from the pole near the electromagnet and this is how the motor direction is determined. A reversal of voltage will revolve the rotor in the same direction as before. The design of the motor is much more complex than you think!!

**The 6 gears must be re-fitted for the hands to work.**



**A close-up of the clock motor**

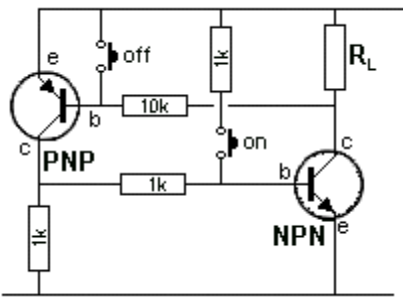
Another clock motor is shown below. Note the pole faces spiral closer to the rotor to make it revolve in one direction. What a clever design!!



### CONSTANT CURRENT SOURCE

This circuit provides a constant current to the LED. The LED can be replaced by any other component and the current through it will depend on the value of R2. Suppose R2 is 560R. When 1mA flows through R2, 0.56v will develop across this resistor and begin to turn on the BC547. This will rob the base of BD 679 with turn-on voltage and the transistor turns off slightly. If the supply voltage increases, this will try to increase the current through the circuit. If the current tries to increase, the voltage across R2 increases and the BD 679 turns off more and the additional voltage appears across the BD 679. If R2 is 56R, the current through the circuit will be 10mA. If R2 is 5R6, the current through the circuit will be 100mA - although you cannot pass 100mA through a LED without damaging it.

## ON - OFF VIA MOMENTARY PUSH-BUTTONS

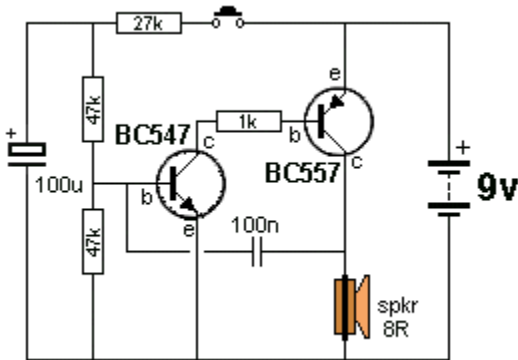


This circuit will supply current to the load  $R_L$ . The maximum current will depend on the second transistor. The circuit is turned on via the "ON" push button and this action puts a current through the load and thus a voltage develops across the load. This voltage is passed to the PNP transistor and it turns ON. The collector of the PNP keeps the power transistor ON. To turn the circuit OFF, the "OFF" button is pressed momentarily. The 1k between base and emitter of the power transistor prevents the base floating or receiving any slight current from the PNP transistor that would keep the circuit latched ON.

The circuit was originally designed by a Professor of Engineering at Penn State University. It had 4 mistakes. So much for testing a circuit!!!! It has been corrected in the circuit on the left.

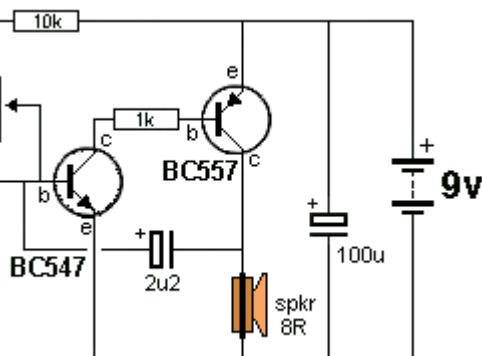
## SIREN

This circuit produces a wailing or siren sound that gradually increases and decreases in frequency as the 100uF capacitor charges and discharges when the push-button is pressed and released. In other words, the circuit is not automatic. You need to press the button and release it to produce the up/down sound.



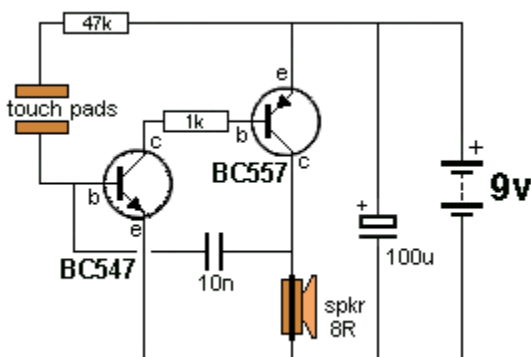
## TICKING BOMB

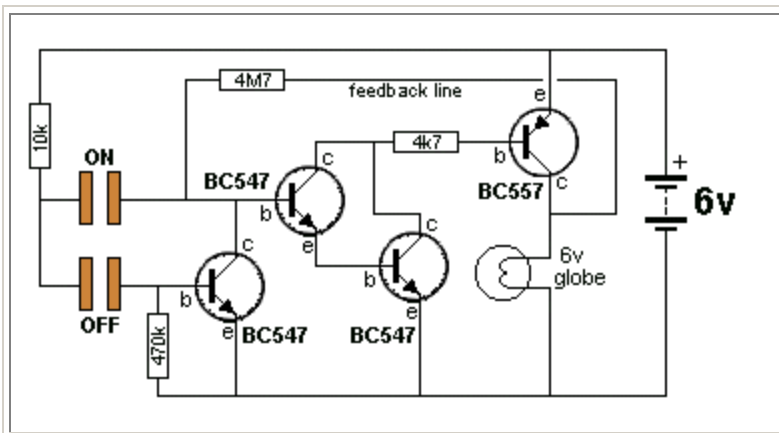
This circuit produces a sound similar to a loud clicking clock. The frequency of the tick is adjusted by the 220k pot. The circuit starts by charging the 2u2 and when 0.65v is on the base of the NPN transistor, it starts to turn on. This turns on the BC 557 and the voltage on the collector rises. This pushes the small charge on the 2u2 into the base of the BC547 to turn it on more. This continues when the negative end of the 2u2 is above 0.65v and now the electro starts to charge in the opposite direction until both transistors are fully turned on. The BC 547 receives less current into the base and it starts to turn off. Both transistors turn off very quickly and the cycle starts again.



## LIE DETECTOR

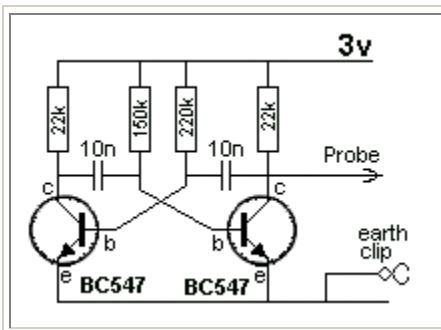
This circuit detects the resistance between your fingers to produce an oscillation. The detection-points will detect resistances as high as 300k and as the resistance decreases, the frequency increases. Separate the two touch pads and attach them to the back of each hand. As the subject feels nervous, he will sweat and change the frequency of the circuit.





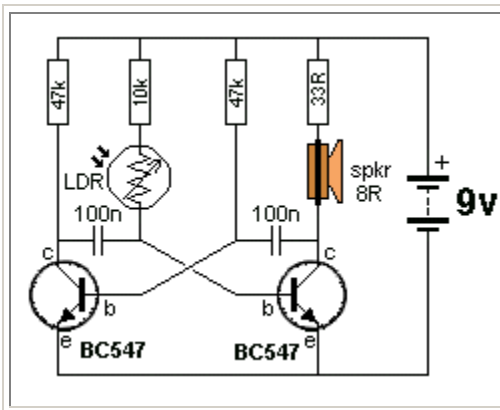
### TOUCH SWITCH

This circuit detects the skin resistance of a finger to deliver a very small current to the super-alpha pair of transistors to turn the circuit ON. The output of the "super transistor" turns on the BC 557 transistor. The voltage on the top of the globe is passed to the front of the circuit via the 4M7 to take the place of your finger and the circuit remains ON. To turn the circuit OFF, a finger on the OFF pads will activate the first transistor and this will rob the "super transistor" of voltage and the circuit will turn OFF.



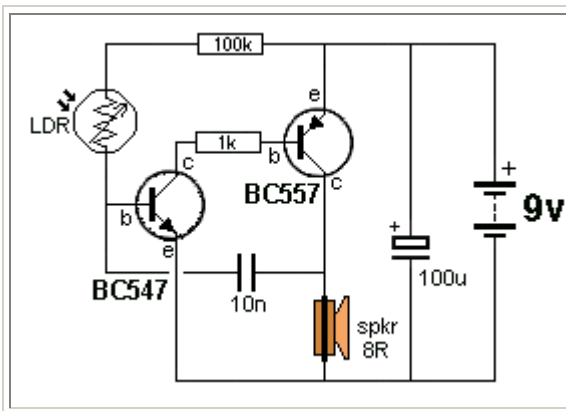
### SIGNAL INJECTOR

This circuit is rich in harmonics and is ideal for testing amplifier circuits. To find a fault in an amplifier, connect the earth clip to the 0v rail and move through each stage, starting at the speaker. An increase in volume should be heard at each preceding stage. This injects will also go through the IF stages of radios and FM sound sections in TV's.



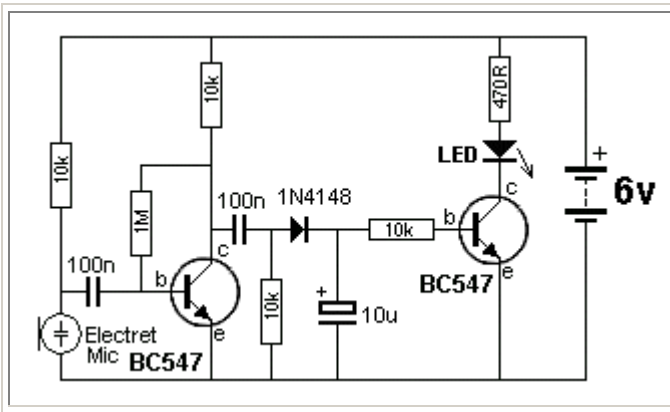
### LIGHT ALARM - 1

This circuit operates when the Light Dependent Resistor receives light. When no light falls on the LDR, its resistance is high and the transistor driving the speaker is not turned on. When light falls on the LDR its resistance decreases and the collector of the second transistor falls. This turns off the first transistor slightly via the second 100n and the first 100n puts an additional spike into the base of the second transistor. This continues until the second transistor is turned on as hard as it can go. The first 100n is now nearly charged and it cannot keep the second transistor turned on. The second transistor starts to turn off and both transistors swap conditions to produce the second half of the cycle.



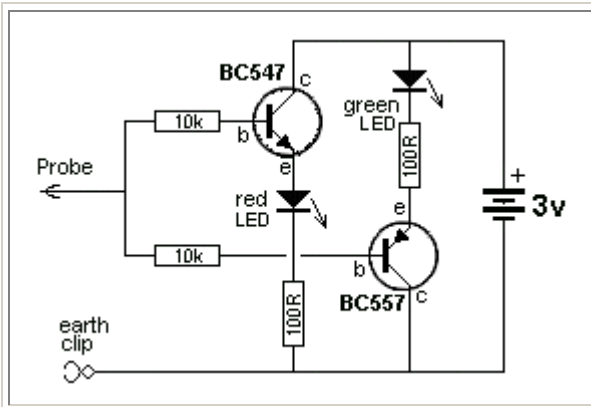
### LIGHT ALARM - 2

This circuit is similar to Light Alarm -1 but produces a louder output due to the speaker being connected directly to the circuit. The circuit is basically a high-gain amplifier that is turned on initially by the LDR and then the 10n keeps the circuit turning on until it can turn on no more. The circuit then starts to turn off and eventually turns off completely. The current through the LDR starts the cycle again.



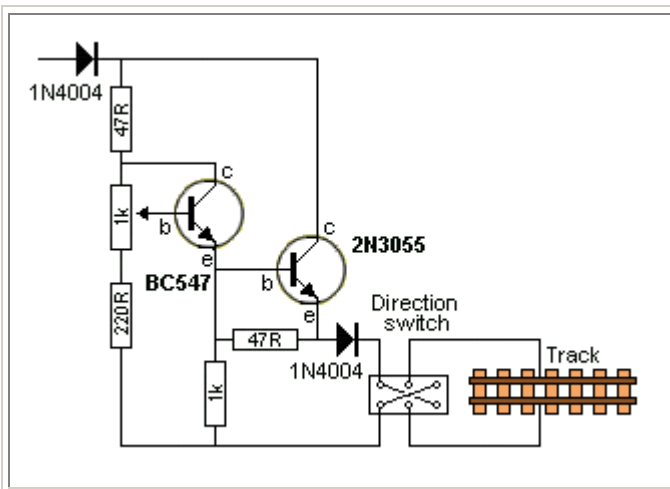
### SOUND TRIGGERED LED

This circuit turns on a LED when the microphone detects a loud sound. The "charge-pump" section consists of the 100n, 10k, signal diode and 10u electrolytic. A signal on the collector of the first transistor is passed to the 10u via the diode and this turns on the second transistor, to illuminate the LED.



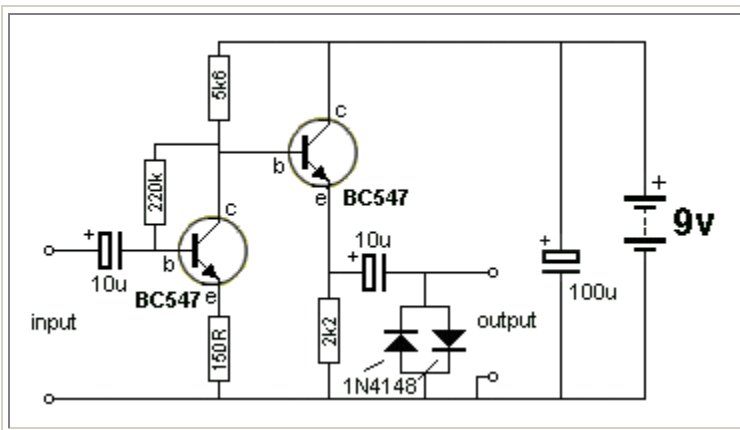
### SIMPLE LOGIC PROBE

This circuit consumes no current when the probe is not touching any circuitry. The reason is the voltage across the green LED, the base-emitter junction of the BC557, plus the voltage across the red LED and base-emitter junction of the BC547 is approx:  $2.1v + 0.6v + 1.7v + 0.6v = 5v$  and this is greater than the supply voltage. When the circuit detects a LOW, the BC557 is turned on and the green LED illuminates. When a HIGH (above 2.3v) is detected, the red LED is illuminated.



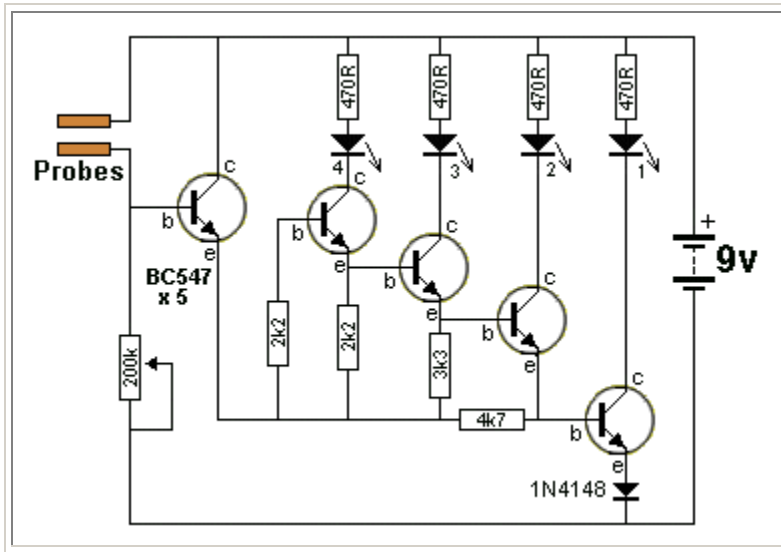
### TRAIN THROTTLE

This circuit is for model train enthusiasts. By adding this circuit to your speed controller box, you will be able to simulate a train starting slowly from rest. Remove the wire-wound rheostat and replace it with a 1k pot. This controls the base of the BC547 and the 2N3055 output is controlled by the BC547. The diodes protect the transistors from reverse polarity from the input and spikes from the rails.



### GUITAR FUZZ

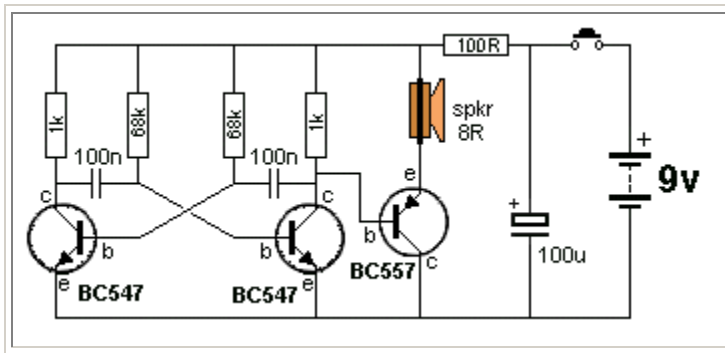
The output of a guitar is connected to the input of the Fuzz circuit. The output of this circuit is connected to the input of your amplifier. With the guitar at full volume, this circuit is overdriven and distorts. The distorted signal is then clipped by the diodes and your power amp amplifies the Fuzz effect.



### STRENGTH TESTER

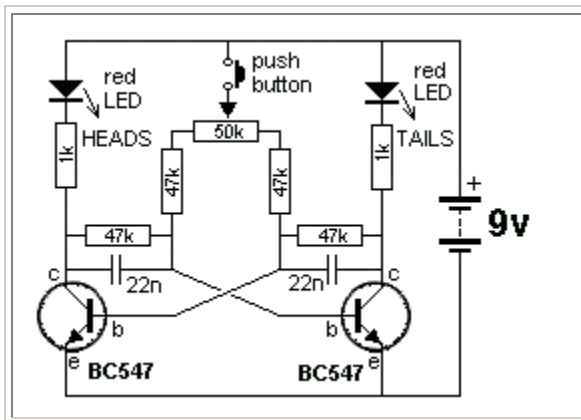
This is a simple "staircase" circuit in which the LEDs come on as the resistance between the probes decreases.

When the voltage on the base of the first transistor sees  $0.6v + 0.6v + 0.6v = 1.8v$ , LED1 comes on. LEDs 1&2 will come on when the voltage rises a further  $0.6v$ . The amount of pressure needed on the probes to produce a result, depends on the setting of the 200k pot.



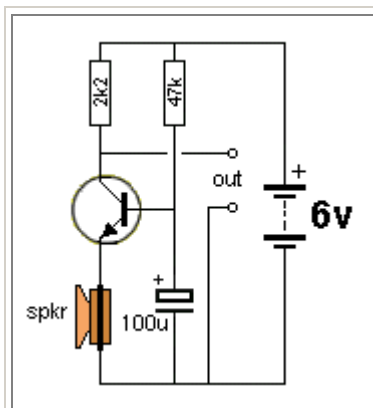
### FOG HORN

When the push-button is pressed, the 100u will take time to charge and this will provide the rising pitch and volume. When the push-button is released, the level and pitch will die away. This is the characteristic sound of a ship's fog horn.



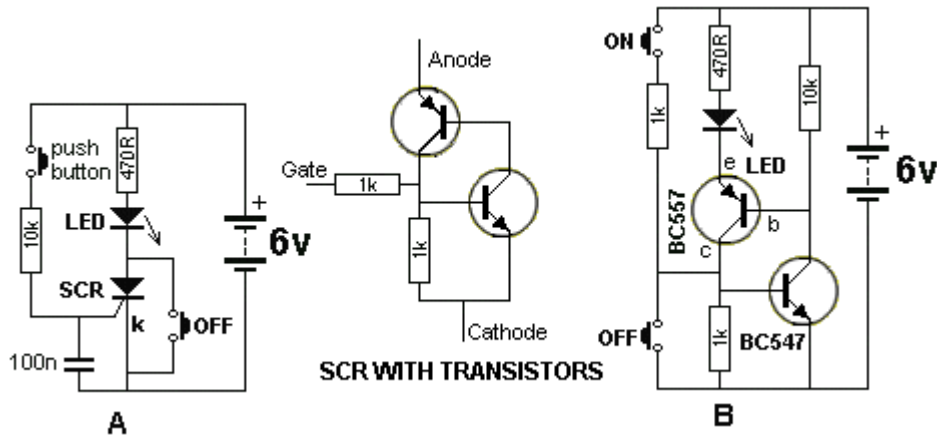
### HEADS OR TAILS

When the push-button is pressed, the circuit will oscillate at a high rate and both LEDs will illuminate. When the push button is released, one of the LEDs will remain illuminated. The 50k is designed to equalise the slightly different values on each half of the circuit and prevent a "bias."



### DYNAMIC MICROPHONE AMPLIFIER

This circuit takes the place of an electret microphone. It turns an ordinary mini speaker into a very sensitive microphone. Any NPN transistors such as BC 547 can be used. The circuit will work from 3v to 9v. It is a common-base amplifier and accepts the low impedance of the speaker to produce a gain of more than 100.

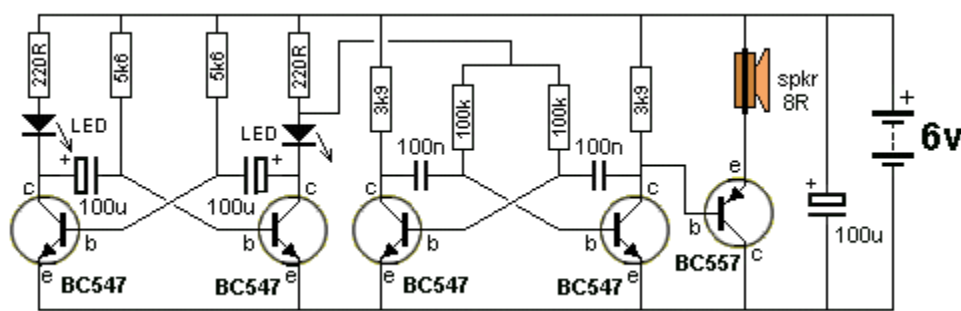


### SCR WITH TRANSISTORS

The SCR in circuit A produces a 'LATCH.' When the button is pressed, the LED remains illuminated.

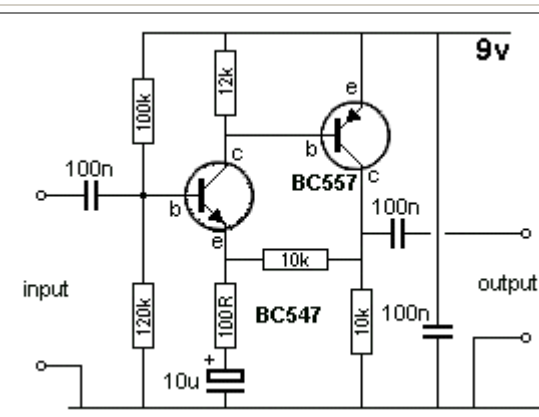
The SCR can be replaced with two transistors as shown in circuit B.

To turn off circuit A, the current through the SCR is reduced to zero by the action of the OFF button. In circuit B the OFF button removes the voltage on the base of the BC547. The OFF button could be placed across the two transistors and the circuit will turn off.



### HEE HAW SIREN

The circuit consists of two multivibrators. The first multi-vibrator operates at a low frequency and this provides the speed of the change from Hee to Haw. It modifies the voltage to the tone multivibrator, by firstly allowing full voltage to appear at the bottom of the 220R and then a slightly lower voltage when the LED is illuminated.



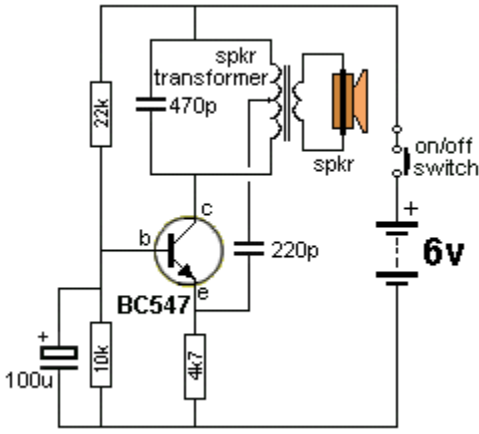
### MICROPHONE PRE-AMPLIFIER

This circuit consists of two directly coupled transistors operating as common-emitter amplifiers.

The ratio of the 10k resistor to the 100R sets the gain of the circuit at 100.

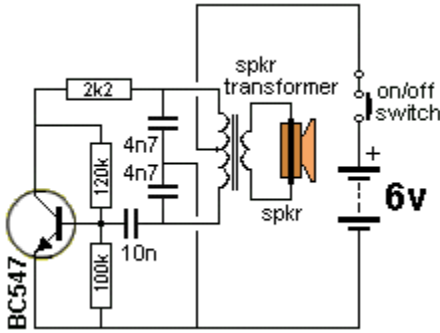
### HARTLEY OSCILLATOR

The Hartley Oscillator is characterised by an LC circuit in its collector. The base of the transistor is held steady and a small amount of signal is taken from a tapping on the inductor and fed to the emitter to keep the transistor in oscillation. The transformer can be any speaker transformer with centre-tapped primary. The frequency is adjusted by changing the 470p.



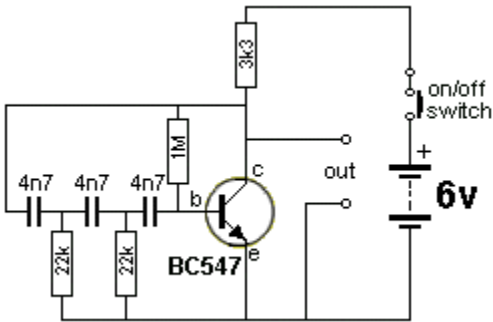
### COLPITTS OSCILLATOR

The Colpitts Oscillator is characterised by tapping the mid-point of the capacitive side of the oscillator section. The inductor can be the primary side of a speaker transformer. The feedback comes via the inductor.



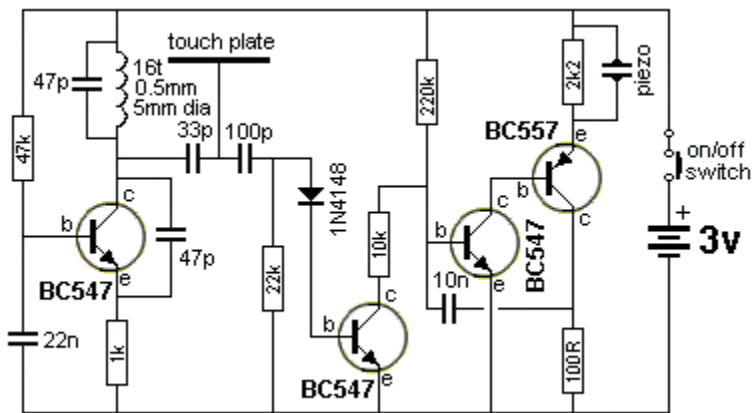
### PHASESHIFT OSCILLATOR

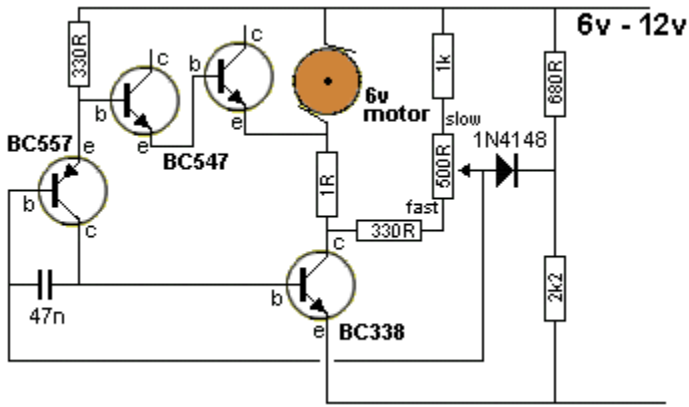
The Phaseshift Oscillator is characterised by 3 high-pass filters, creating a 180° phase shift. The output is a sinewave. Take care not to load the output - this will prevent reliable start-up and may stop the circuit from oscillating. The 3k3 load resistor must be reduced in value if the load prevents the circuit oscillating.



### DOOR-KNOB ALARM

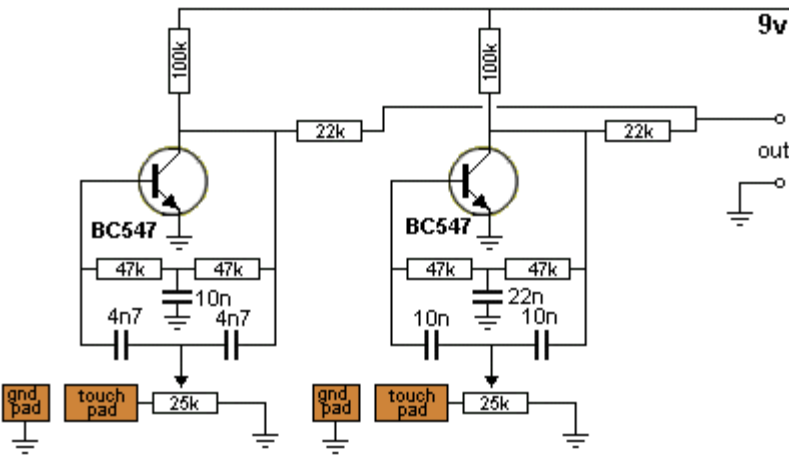
This circuit can be used to detect when someone touches the handle of a door. A loop of bare wire is connected to the point "touch plate" and the project is hung on the door-knob. Anyone touching the metal door-knob will kill the pulses going to the second transistor and it will turn off. This will activate the "high-gain" amplifier/oscillator. The circuit will also work as a "Touch Plate" as it does not rely on main hum, as many other circuits do.





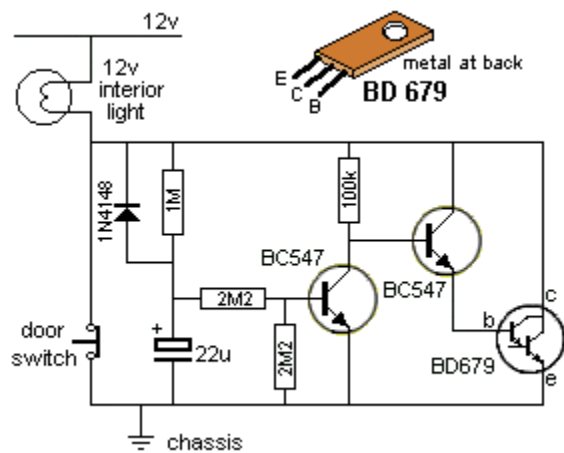
### MOTOR SPEED CONTROLLER

Most simple motor speed controllers simply reduce the voltage to a motor by introducing a series resistance. This reduces the motor's torque and if the motor is stopped, it will not start again. This circuit detects the pulses of noise produced by the motor to turn the circuit off slightly. If the motor becomes loaded, the amplitude of the pulses decreases and the circuit turns on more to deliver a higher current.



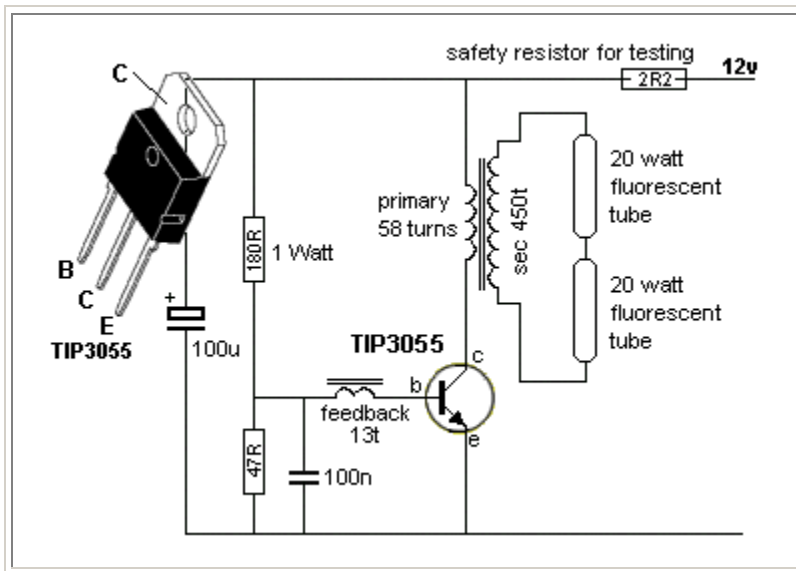
### ELECTRONIC DRUMS

The circuit consists of two "twin-T" oscillators set to a point below oscillation. Touching a Touch Pad will set the circuit into oscillation. Different effects are produced by touching the pads in different ways and a whole range of effects are available. The two 25k pots are adjusted to a point just before oscillation. A "drum roll" can be produced by shifting a finger rapidly across adjacent ground and drum pads.



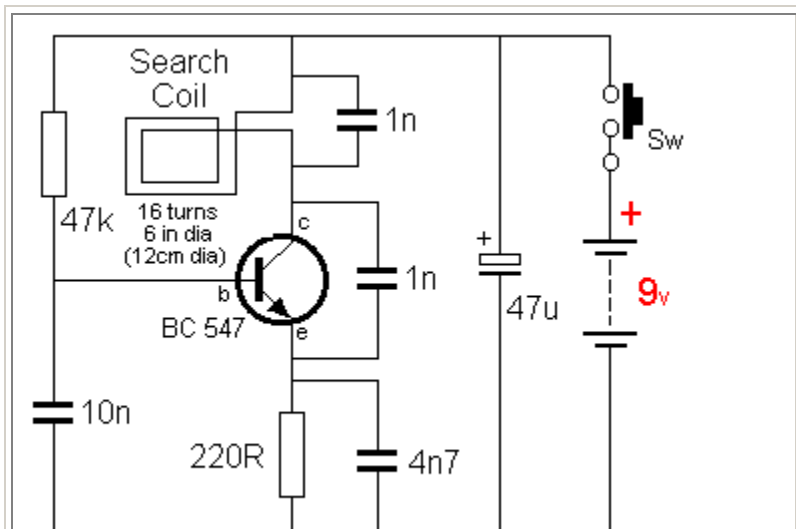
### LIGHT EXTENDER

This circuit is a Courtesy Light Extender for cars. It extends the "ON" time when a door is closed in a car, so the passenger can see where he/she is sitting. When the door switch is opened, the light normally goes off immediately, but the circuit takes over and allows current to flow because the 22u is not charged and the first BC 547 transistor is not turned ON. This turns on the second BC547 via the 100k and the BD679 is also turned on to illuminate the interior light. The 22u gradually charges via the 1M and the first BC547 turns on, robbing the second BC547 of "turn-on" voltage and it starts to turn off the BD679. The 1N4148 discharges the 22u when the door is opened.



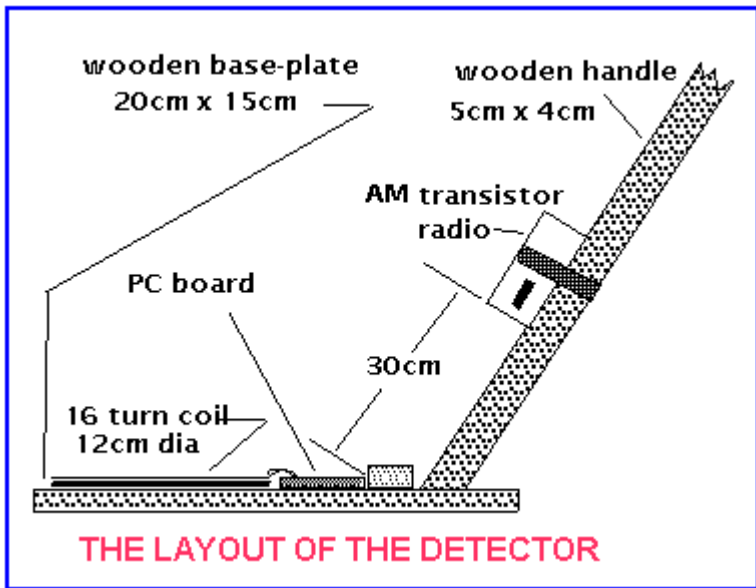
### 20 WATT FLUORO INVERTER

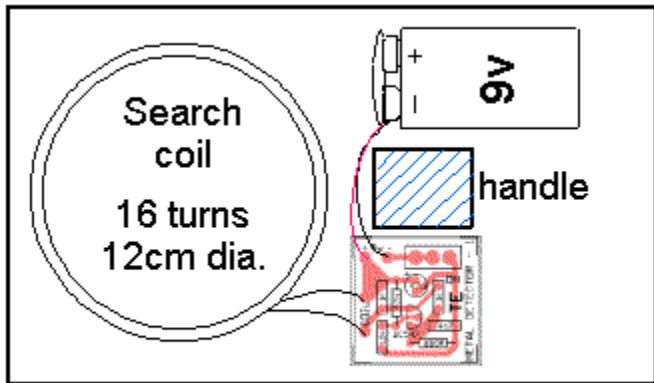
This circuit will drive a 40 watt fluoro or two 20-watt tubes in series. The transformer is wound on a ferrite rod 10mm dia and 8cm long. The wire diameters are not critical but our prototype used 0.61mm wire for the primary and 0.28mm wire for the secondary and feedback winding. Do not remove the tube when the circuit is operating as the spikes produced by the transformer will damage the transistor. The circuit will take approx 1.5amp on 12v, making it more efficient than running the tubes from the mains. A normal fluoro takes 20 watts for the tube and about 15 watts for the ballast.



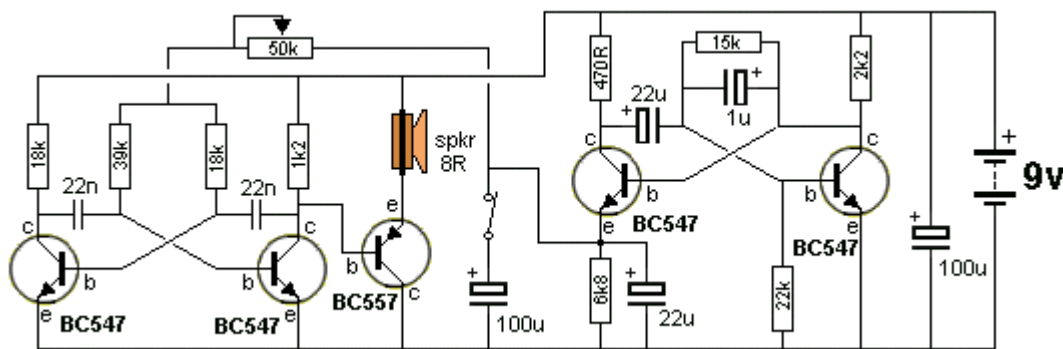
### GOLD DETECTOR

This very simple circuit will detect gold or metal or coins at a distance of approx 20cm - depending on the size of the object. The circuit oscillates at approx 140kHz and a harmonic of this frequency is detected by an AM radio. Simply tune the radio until a squeal is detected. When the search coil is placed near a metal object, the frequency of the circuit will change and this will be heard from the speaker. The layout of the circuit is shown and the placement of the radio.



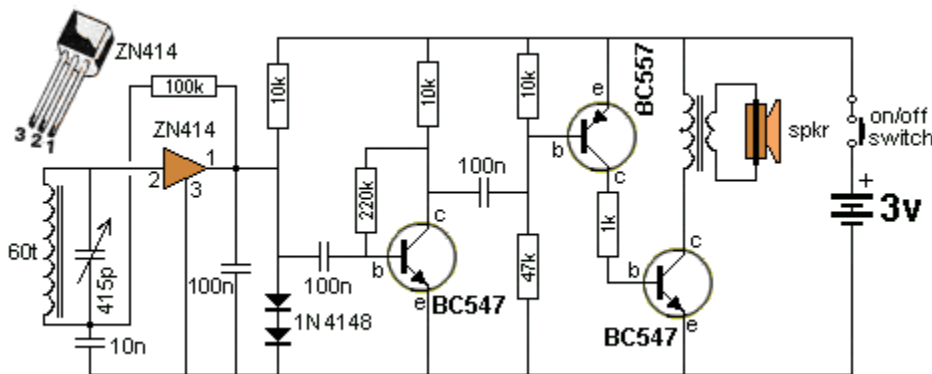


**The Layout of Metal Detector -1**



### PHASER GUN

This is a very effective circuit. The sound is amazing. You have to build it to appreciate the range of effects it produces. The 50k pot provides the frequency of the sound while the switch provides fast or slow speed.



### IC RADIO

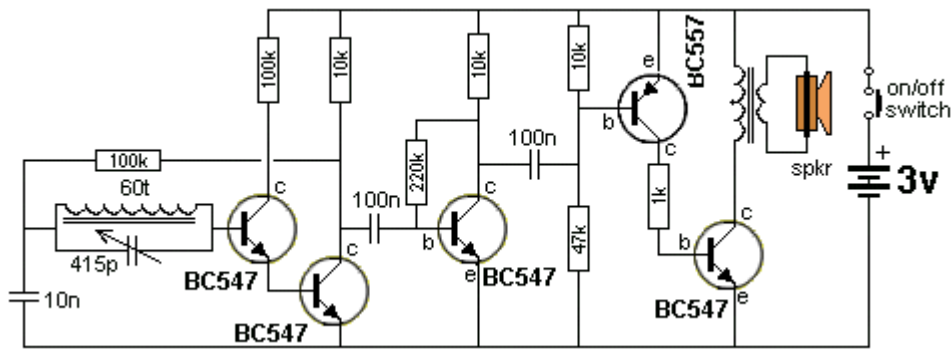
This circuit contains an IC but it looks like a 3-leaded transistor and that's why we have included it here.

The IC is called a "Radio in a Chip" and it contains 10 transistors to produce a TRF (tuned Radio Frequency) front end for our project.

The 3-transistor amplifier is taken from our SUPER EAR project with the electret microphone removed.

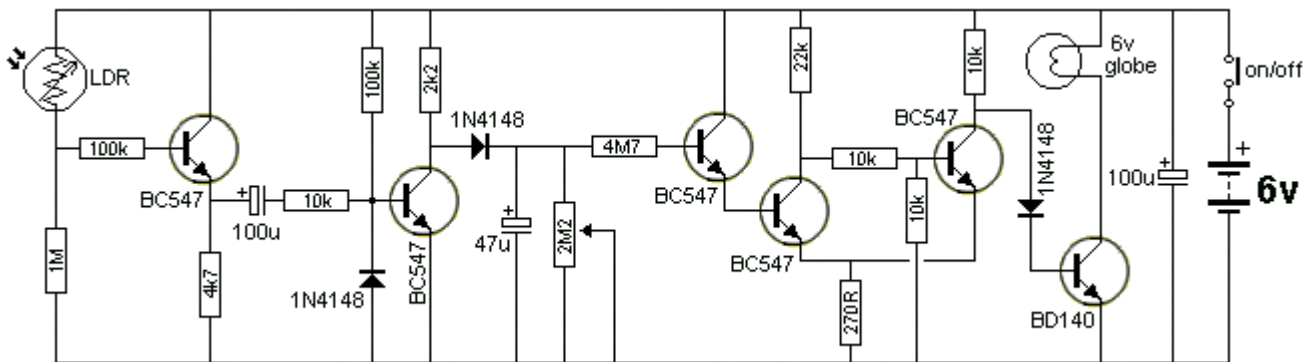
The two 1N 4148 diodes produce a constant voltage of 1.3v for the chip as it is designed for a maximum of 1.5v.

The "antenna coil" is 60t of 0.25mm wire wound on a 10mm ferrite rod. The tuning capacitor can be any value up to 450p.



### 5-TRANSISTOR RADIO

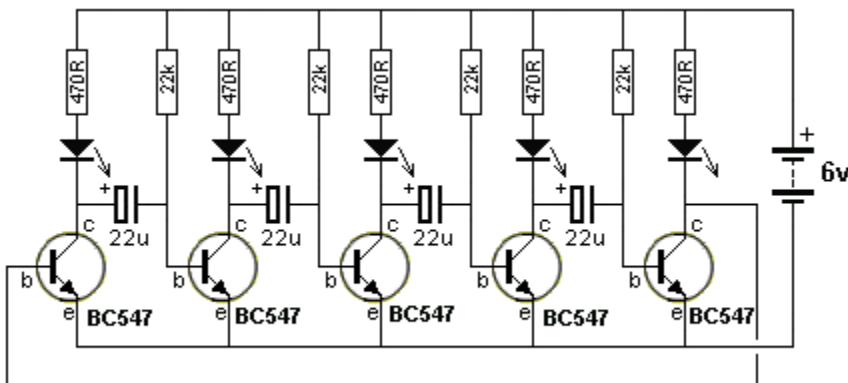
If you are not able to get the ZN414 IC, this circuit uses two transistors to take the place of the chip.



### AUTOMATIC LIGHT

This circuit automatically turns on a light when illumination is removed from the LDR. It remains ON for the delay period set by the 2M2 pot.

The important feature of this circuit is the building blocks it contains - a delay circuit and Schmitt Trigger. These can be used when designing other circuits.



### 5-LED CHASER

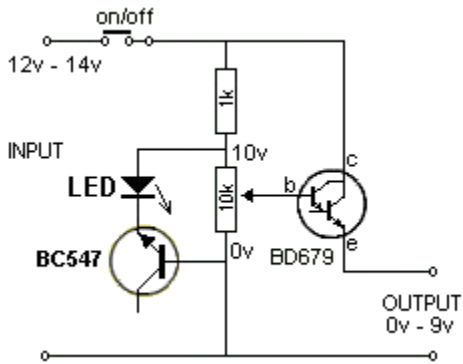
The LEDs in this circuit produce a casing pattern similar the running LEDs display in video shops.

All transistors will try to come on at the same time when the power is applied, but some will be faster due to their internal characteristics and some will get a different turn-on current due to the exact value of the 22u electrolytics.

Only 3 of the LEDs will be on at any one-time as the display has to be ON-OFF-ON-OFF-ON.

The circuit can be extended to any number of odd stages.

## BENCH POWER SUPPLY



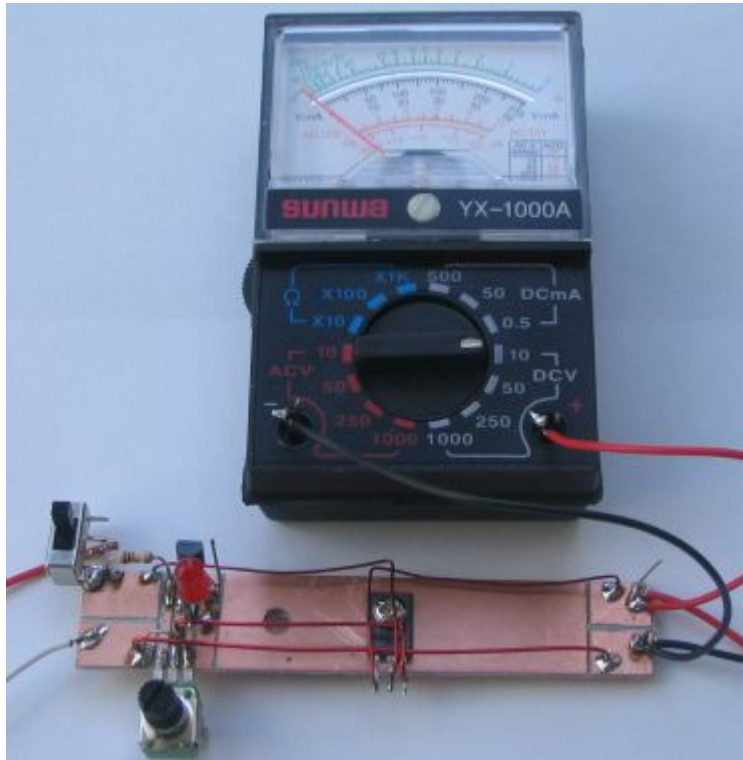
This power supply can be built in less than an hour on a piece of copper-laminate. The board acts as a heat-sink and the other components can be mounted as shown in the photo, by cutting strips to suit their placement.

The components are connected with enamelled wire and the transistor is bolted to the board to keep it cool.

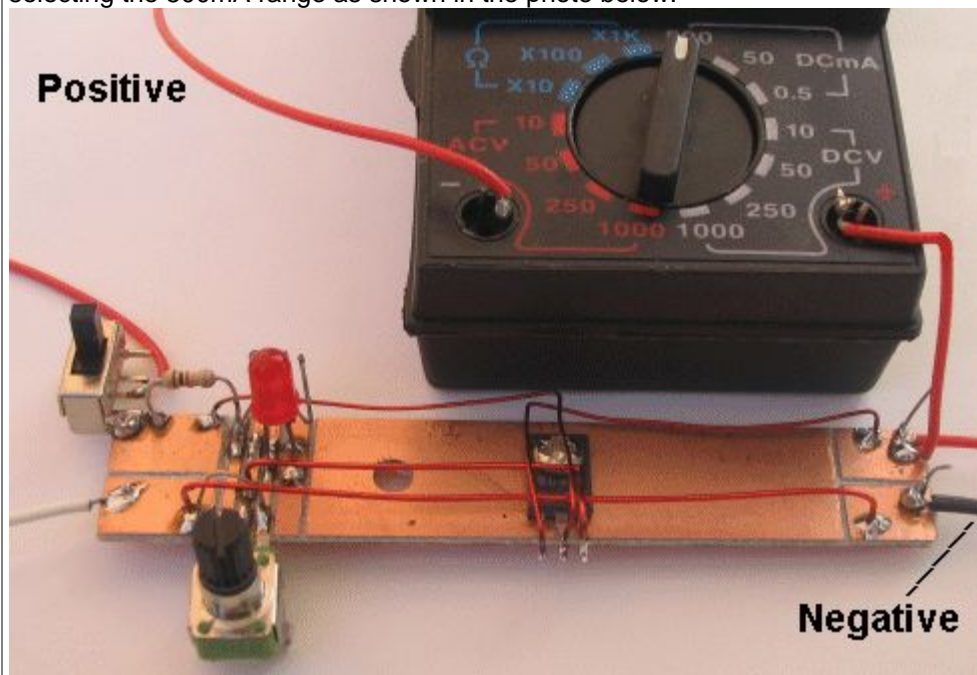
The Bench Power Supply was designed to use old "C," "D" and lantern batteries, that's why there are no diodes or electrolytics. Collect all your old batteries and cells and connect them together to get at least 12v -14v.

The output of this power supply is regulated by a 10v zener made up of the characteristic zener voltage of 8.2v between the base-emitter leads of a BC547 transistor (in reverse bias) and approx 1.7v across a red LED. The circuit will deliver 0v - 9v at 500mA (depending on the life left in the cells your are using). The 10k pot adjusts the output voltage and the LED indicates the circuit is ON. It's a very good circuit to get the last of the energy from old cells.

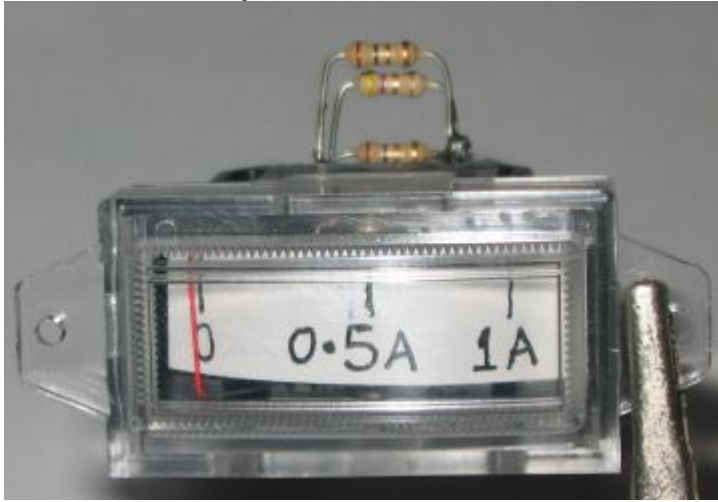
## ADDING A VOLT-METER TO THE BENCH POWER SUPPLY



A voltmeter can be added to the Bench Power Supply by using a very low cost multimeter. For less than \$10.00 you can get a mini multimeter with 14 ranges, including a 10v range. The multimeter can **also** be used to monitor current by removing the negative lead and making a new RED lead, fitting it to the "-" of the multimeter and selecting the 500mA range as shown in the photo below:



## MAKING 0-1Amp meter for the BENCH POWER SUPPLY



The item in the photo is called a "Movement." A movement is a moving coil with a pointer and no resistors connected to the leads.

Any Movement can be converted to an ammeter without any mathematics.

Simply solder two 1R resistors (in parallel) across the terminals of any movement and connect it in series with an ammeter on the output of the Bench Power Supply. The second ammeter provides a reference so you can calibrate the movement. Connect a globe and increase the voltage.

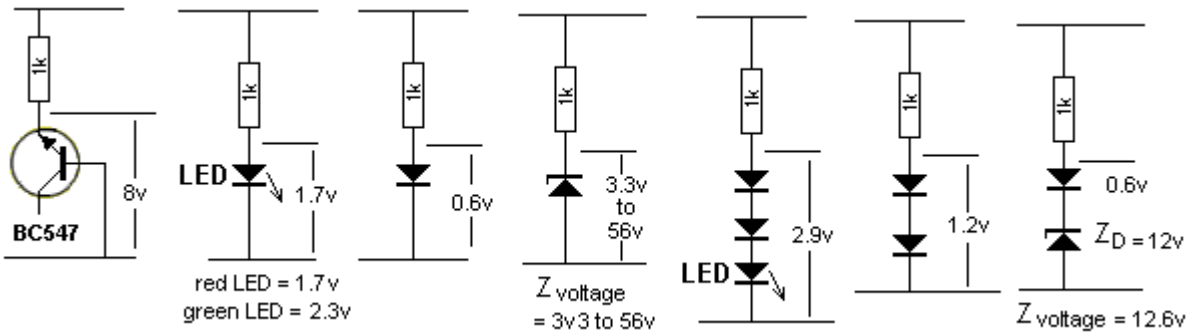
At 500mA, if the pointer is "up scale" (reading too high) add a trim-resistor. In our case it was 4R7.

The three shunt resistors can be clearly seen in the photo. Two 1R and the trim resistor is 4R7.

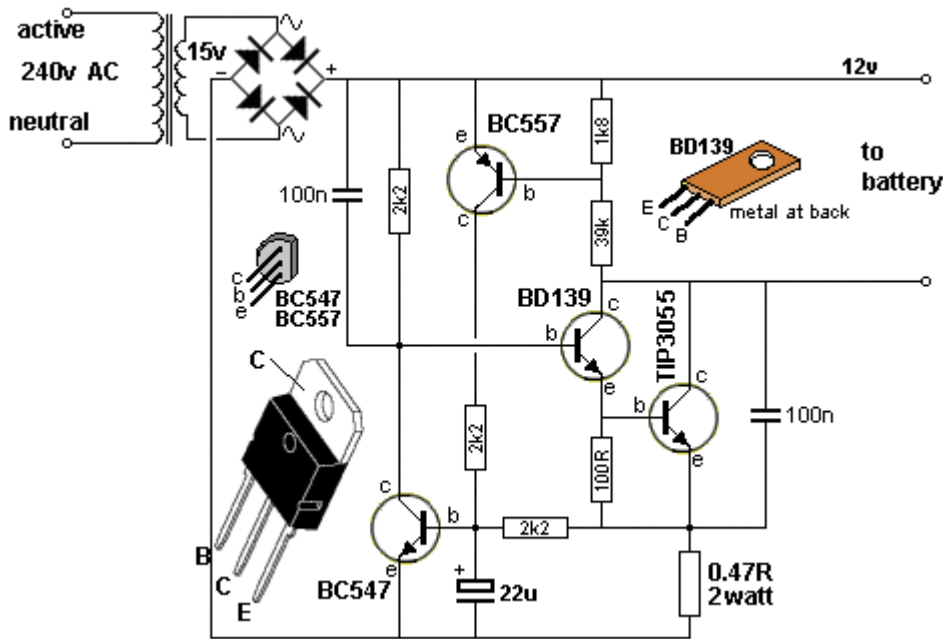
You can get a movement from an old multimeter or they are available in electronics shops as a separate item. The sensitivity does not matter. It can be 20uA or 50uA FSD or any sensitivity.

## MAKING A ZENER DIODE

Sometimes a zener diode of the required voltage is not available. Here are a number of components that produce a characteristic voltage across them. Since they all have different voltages, they can be placed in series to produce the voltage you need. A reference voltage as low as 0.65v is available and you need at least 1 to 3mA through the device(s) to put them in a state of conduction (breakdown).



## 12v TRICKLE CHARGER



The 12v Trickle Charger circuit uses a TIP3055 power transistor to limit the current to the battery by turning off when the battery voltage reaches approx 14v or if the current rises above 2 amp. The signal to turn off this transistor comes from two other transistors - the BC557 and BC 547.

Firstly, the circuit turns on fully via the BD139 and TIP3055. The BC557 and BC 547 do not come into operation at the moment. The current through the 0.47R creates a voltage across it to charge the 22u and this puts a voltage between the base and emitter of the BC547. The transistors turn on slightly and remove some of the turn-on voltage to the BD139 and this turns off the TIP3055 slightly.

This is how the 2 amp max is created.

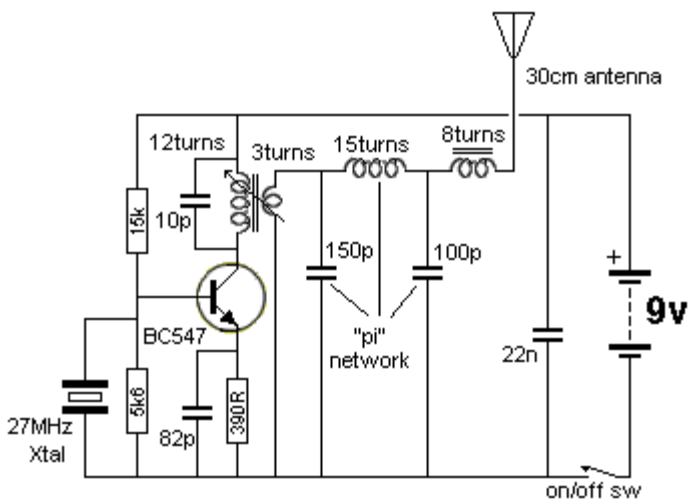
As the battery voltage rises, the voltage divider made up of the 1k8 and 39k creates a 0.65v between base and emitter of the BC557 and it starts to turn on at approx 14v. This turns on the BC 547 and it robs the BD136 of "turn-on" voltage and the TIP3055 is nearly fully turned off.

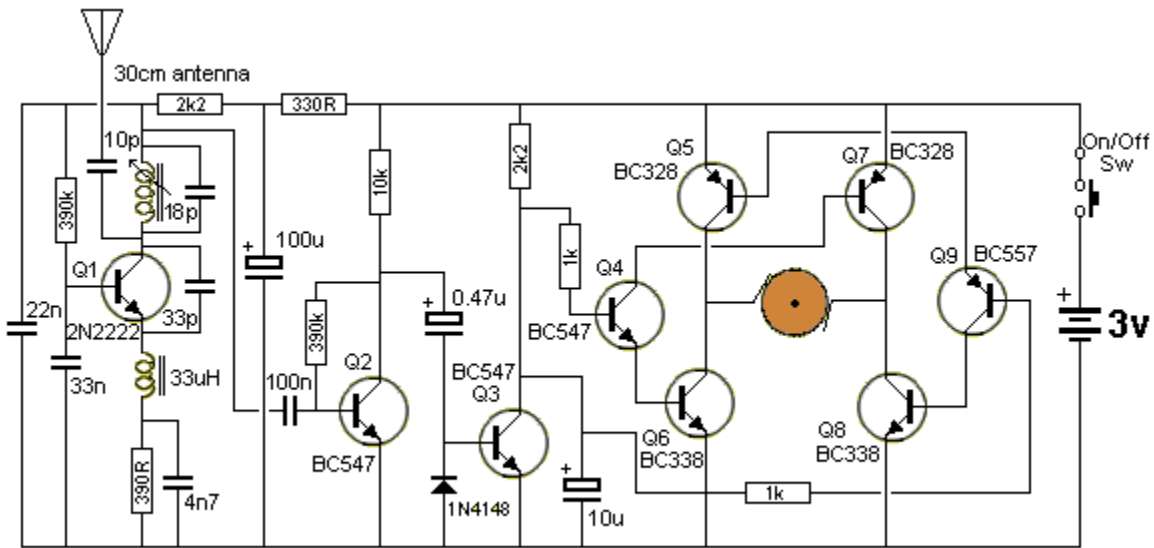
All battery chargers in Australia must be earthed. The negative of the output is taken to the earth pin.

## 27MHz TRANSMITTER

The transmitter is a very simple crystal oscillator. The heart of the circuit is the tuned circuit consisting of the primary of the transformer and a 10p capacitor. The frequency is adjusted by a ferrite slug in the centre of the coil until it is exactly the same as the crystal. The transistor is configured as a common emitter amplifier. It has a 390R on the emitter for biasing purposes and prevents a high current passing through the transistor as the resistance of the transformer is very low.

The "pi" network matches the antenna to the output of the circuit. See full description in [27MHz Links](#) article.

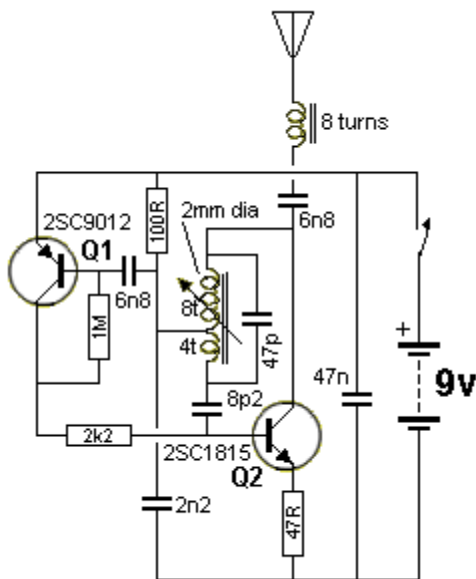




## 27MHz RECEIVER

The 27MHz receiver is really a transmitter. It's a very weak transmitter and delivers a low level signal to the surroundings via the antenna. When another signal (from the transmitter) comes in contact with the transmission from the receiver it creates an interference pattern that reflects down the antenna and into the first stage of the receiver.

The receiver is a super-regenerative design. It is self-oscillating (or already oscillating) and makes it very sensitive to nearby signals. See full description in [27MHz Links](#) article.

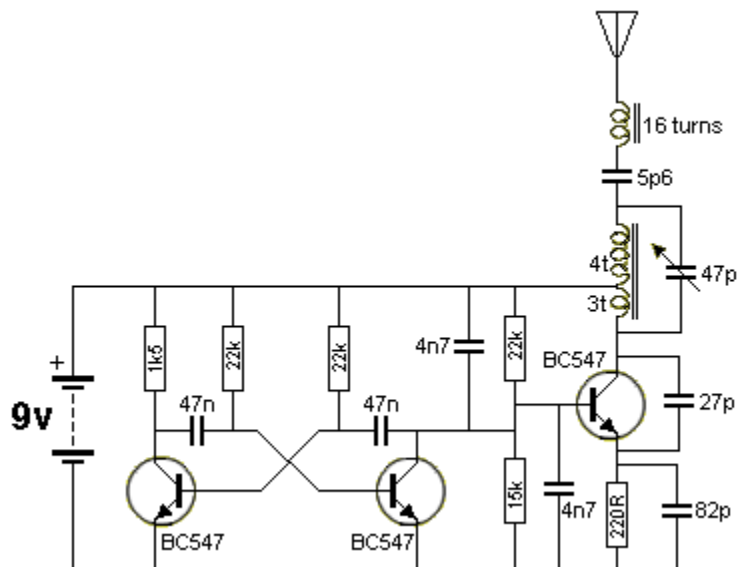


## 27MHz TRANSMITTER WITHOUT A CRYSTAL

Circuit shows a 27MHz transmitter circuit without a crystal. When a circuit does not have a crystal, the oscillator is said to be "voltage dependent" or "voltage controlled" and when the supply voltage drops, the frequency changes.

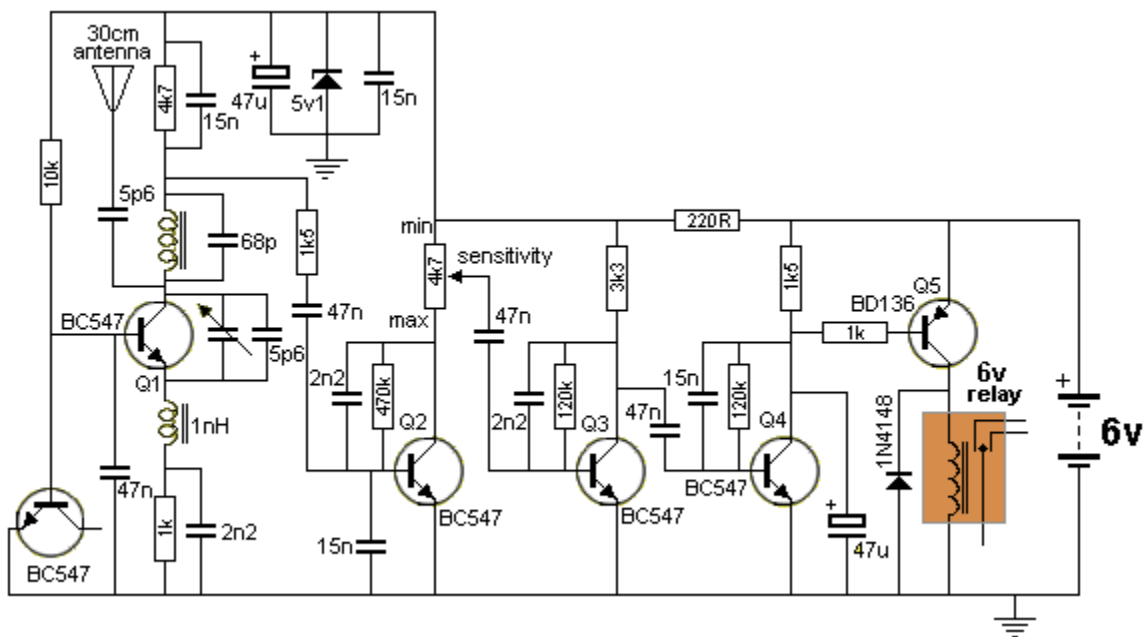
If the frequency drifts too much, the receiver will not pick up the signal. For this reason, a simple circuit as shown is not recommended. We have only included it as a concept to show how the 27MHz frequency is generated. It produces a tone and this is detected by a receiver.

See full description in [27MHz Links](#) article.



### 27MHz TRANSMITTER WITH SQUARE-WAVE OSCILLATOR

The circuit consists of two blocks. Block 1 is a multivibrator and this has an equal mark/space ratio to turn the RF stage on and off. Block 2 is an RF oscillator. The feedback to keep the stage operating is provided by the 27p capacitor. The frequency-producing items are the coil (made up of the full 7 turns) and the 47p air trimmer. These two items are called a parallel tuned circuit. They are also called a TANK CIRCUIT as they store energy just like a TANK of water and pass it to the antenna. The frequency of the circuit is adjusted by the 47p air trimmer. See full description in [27MHz Links](#) article.



### 27MHz RECEIVER-2

This circuit matches with the 27MHz Transmitter with Square-wave Oscillator. See full description in [27MHz Links](#) article.



# BIPOLAR TRANSISTORS

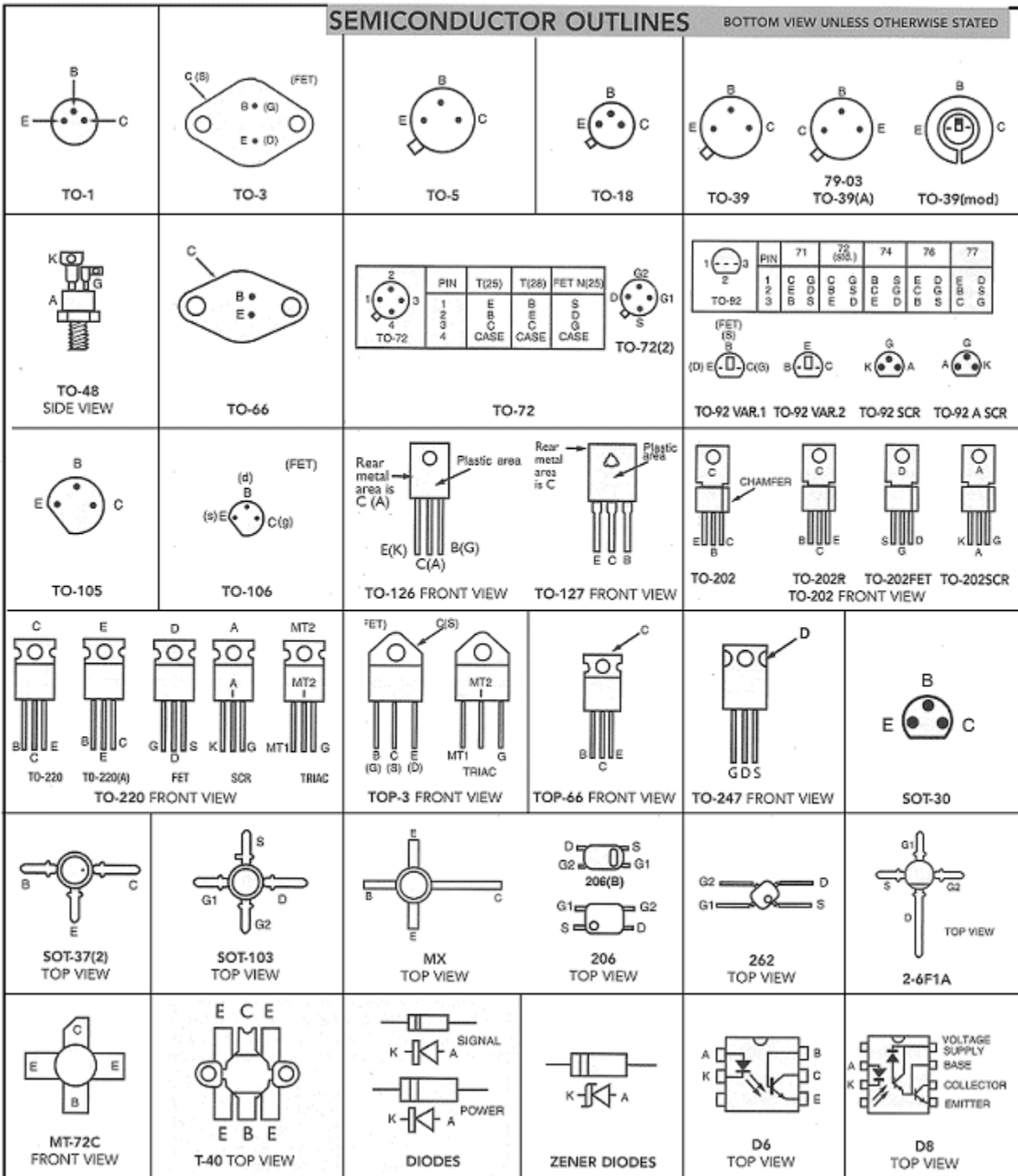
Some small signal transistors may have a TO-92 case and a "PN" prefix. The electrical specifications are the same, only the case is changed.

Type	CASE		V <sub>CE</sub>	V <sub>CE(s)</sub>	I <sub>C</sub>	V <sub>CE(s)</sub>	@ I <sub>C</sub>	h <sub>FE</sub>	@ I <sub>C</sub>	FT	@ I <sub>C</sub>	P <sub>TOPT</sub>	USE	COMPARABLE TYPES
	Polarity	mA												
BC107	TO-18	NS	45	50	100	0.2	10	110-450	2	300	10	300	G.P. S.S. amp.	BC 207, BC147, BC182
BC108	TO-18	NS	20	30	100	0.2	10	110-800	2	300	10	300	G.P. S.S. amp.	BC 208, BC148, BC13
BC109	TO-18	NS	20	30	100	0.25	10	200-800	2	300	10	300	Low noise S.S. amp	BC 209, BC149, BC184
BC109C	TO-18	NS	20	30	100	0.25	10	420-800	2	300	10	300	Low noise high gain	BC209C BC149C
BC177	TO-18	PS	45	50	100	0.3	10	75-260	2	150	10	300	G.P. S.S. amp.	BC157, BC307, BC212
BC178	TO-18	PS	25	30	100	0.3	10	75-500	2	150	10	300	G.P. S.S. amp.	BC158, BC308, BC213
BC179	TO-18	PS	20	25	100	0.3	10	125-500	2	150	10	300	G.P. S.S. amp.	BC159, BC309, BC214
BC327	TO-92VAR1	PS	45	50	500	0.7	500	100-600	100	100	10	625	Output	2N3638
BC328	TO-92VAR1	PS	25	30	500	0.7	500	100-600	100	100	10	625	Output	BC 327
BC337	TO-92VAR1	NS	45	50	500	0.7	500	100-600	100	100	10	625	Output	2N3642
BC338	TO-92VAR1	NS	25	30	500	0.7	500	100-600	100	100	10	625	Output	BC337
BC546	TO-92VAR1	NS	65	80	100	0.6	100	110-450	2	300	10	500	G.P. S.S. amp.	
BC547	TO-92VAR1	NS	45	50	100	0.6	100	110-800	2	300	10	500	G.P. S.S. amp.	BC107, BC207, BC147
BC548	TO-92VAR1	NS	30	30		0.6	100	110-800	2	300	10	500	G.P. S.S. amp.	BC108, BC208, BC148
BC549	TO-92VAR1	NS	30	30	100	0.6	100	200-800	2	300	10	500	Low noise S.S. amp.	BC109, BC209, BC149
BC549C	TO-92VAR1	NS	30	30	100	0.6	100	420-800	2	300	10	500	Low noise high gain	BC109C, BC149C
BC556	TO-92VAR1	PS	65	80	100	0.65	100	75-475	2	200	10	500	G.P. S.S. amp.	
BC557	TO-92VAR1	PS	45	50	100	0.65	100	75-800	2	200	10	500	G.P. S.S. amp.	BC157
BC558	TO-92VAR1	PS	30	30	100	0.65	100	75-800	2	200	10	500	G.P. S.S. amp.	BC158
BC559	TO-92VAR1	PS	30	30	100	0.65	100	125-800	2	200	10	500	G.P. S.S. amp.	BC159
BC639	TO-92(74)	NS	80	100	1A	0.5	500	40-250	150	130		1W	Audio O/P	MU9610, TT801
BC640	TO-92(74)	PS	80	100	1A	0.5	500	40-250	150	50		1V	Audio O/P	MU9660, TT800
BD139	TO-126	NS	80	10	1.5A	0.5	500	40-250	150	250	50	8W	G.P. O/P	40409
BD140	TO-126	PS	80	10	1.5A	0.5	500	40-250	150	75	50	8W	G.P. O/P	40410
BD262	TO-126	PS	60	60	4A	2.5	1.5A	750	1.5A	7	1.5A	36W	High gain Darl. O/P	BD 266
BD263	TO-126	NS	60	80	4A	2.5	1.5A	750	1.5A	7	1.5A	36W	High gain Darl. O/P	BD267
BD266A	TO-220	PS	80	80	8A	2	3A	750	3A	7		60W	High gain Darl. O/P	
BD267A	TO-220	NS	80	10	8A	2	3A	750	3A	7		60W	High gain Darl. O/P	
BD681	TO-126	NS	100	10	4A	2.5	1.5A	750	1.5A	1		40W	Darlington O/P	BD 263
BD682	TO-126	PS	100	100	4A	2.5	1.5A	750	1.5A	1		40W	Darlington O/P	BD 262
BF173	TO-72(28)	NS	25	40	25			40-100	7	550	5	230	T.V. I.F. amp.	
BF199	TO-92VAR2	NS	25	40	25			37	7	550		500	H.F. amp.	BF180
BF463	TO-202	PS	250	25	500			40-180	30	20		2W	H.V. med. power.	
BF469	TO-126	NS	250	25	50			50	25	60	10	1.8W	G.P. high-V. amp.	
BF470	TO-126	PS	250	25	50			50	25	60	10	1.8W	G.P. high-V. amp.	
BFR90	SOT-37(2)	NS	15	20	25			25-250	14	5GHz	14	180	Wideband amp..	
BFR91	SOT-37(2)	NS	12	15	35	0.3	30	25-250	30	5GHz	30	180	Wideband amp.	
BFY90	TO-72(25)	NS	15	30	25			25-125	2	1GHz	2	200	Wideband amp.	
BUX80	TO-3	NS	400	80	10A	1.5	5A	30	1.2A	8		100W	Def'n, high current	
MJ802	TO-3	NS	90	10	30A	0.8	7.5A	25-100	7.5A	2	1A	200W	High power output	
MJ2955	TO-3	PS	60	70	15A	1.1	4A	20-70	4A	2.5	500	115W	G.P. power	
MJ4502	TO-3	PS	90	10	30A	0.8	7.5A	25-100	7.5A	2	1A	200W	High power output	
MJ10012	TO-3	NS	400	60	10A	2	6A	100-2K	6A			175W	Power Darlington	
MJ15003	TO-3	NS	140	14	20A	1	5A	25-150	5A	2	500	250W	High power output	
MJ15004	TO-3	PS	140	140	20A	1	5A	25-150	5A	2	500	250W	High power output	
MJE340	TO-126	NS	300		500	0.75	100	30-240	50			20W	G.P. H.V. power	

Type	CASE	V <sub>CE</sub>	V <sub>CE</sub>	I <sub>c</sub>	V <sub>CEC</sub>	@ I <sub>c</sub>	h <sub>FE</sub>	@ I <sub>c</sub>	FT	@ I <sub>c</sub>	P <sub>TOT</sub>	USE	COMPARABLE TYPES
	Polarity	mA				mA		MHz		mW			
MJE350T	TO-126 PS	300	500	0.77	100	30-240	50				20W	G.P. H.V. power	
MJE2955	TO-220 PS	60	70	10A	1.1	4A	20-100	4A	2	500	75W	G.P. power	TIP 2955
MJE3055T	TO-220 NS	60	70	10A	1.1	4A	20-100	4A	2	500	75W	G.P. power	TIP 3055
MPSA14	TO-92(72) NS	30	30	500	1.5	100	20000	100	125	10	625	G.R. Darlington	
MPSA65	TO-92(72) PS	30	30	500	1.5	100	20000	100	100	10	625	G.P. Darlington	
MRF629	TO-39A NS	16	36	400			20-200	100			9W	UHF power	
MRF660	TO-220A NS	16	36	2.4A			20-160	250			29W	UHF power	
PN100	TO-92(72) NS	35	60	500	0.5	100	60-240	150	350	50	600	G.P. amp/switch	PN2222, 2N3643
PN2907	TO-92(72) PS	40	60	600	0.4	150	100-300	150	200	50	625	High S. switch	
PN200	TO-92(72) PS	35	60	500	0.5	150	50-400	150	200	50	600	G.P. amp/switch	2N3638, BC214
TIP 31B	TOP-66 NS	80	80	3A	1.2	3A	25	1A	3	500	40W	Power output	
TIP 32B	TOP-66 PS	80	80	3A	1.2	3A	25	1A	3	500	40W	Power output	
TIP 142	TOP-3 NS	100	100	10A	2	5A	>1000	5A			125W	Audio output	TIP 140, TIP 141
TIP 147	TOP-3 PS	100	100	10A	2	5A	>1000	5A			125W	Audio output	TIP 145, TIP 146
TIP 2955	TOP-3 PS	70	100	15A	1.1	4A	20	4A	3	500	90W	Power output	MJE 2955
TIP 3055	TOP-3 NS	70	100	15A	1.1	4A	20	4A	3	500	90W	Power output	MJE 3055
2N2222A	TO-18 NS	40	75	800	1.6	500	00-300	150	300	20	500	High S. switch	
2N3019	TO-39 NS	80	140	1A	0.5	500	50-100	500	100	50	800	H.F. amp	
2N3053	TO-39 NS	40	60	700	1.4	150	50-250	150	100	50	2.86W	G.R. switch	BD137
2N3054	TO-66 NS	60	90	4A	0.1	200	25-100	500	0.8	200	29W	Audio output	TIP 31B
2N3055	TO-3 NS	60	70	15A	1.1	4A	20-70	4A	2.5	500	115W	G.P. power	BDY20
2N3563	TO-106 NS	15	30	50			0-200	8	600	8	200	RF-IF amp	BF173
2N3564	TO-106 NS	15	30	100	0.3	20	20-500	15	400	15	200	RF-IF amp	BF167
2N3565	TO-106 NS	25	30	50	0.35	1	150-600	1	400	1	200	Lowlevel amp	BC108, BC208
2N3566	TO-105 NS	30	40	200	1	100	50-600	10	40	30	300	G.R. amp & switch	BC183
2N3567	TO-105 NS	40	80	500	0.25	150	40-120	150	60	50	300	G.P. amp & switch	BC337
2N3568	TO-105 NS	60	80	500	0.25	150	40-120	150	60	50	300	G.P. amp & switch	
2N3569	TO-105 NS	40	80	500	0.25	150	00-300	150	60	50	300	G.P. amp & switch	
2N3638A	TO-105 PS	25	25	500	0.25	50	100	50	150	50	300	G.P. amp & switch	BC328
2N3641	TO-105 NS	30	60	500	0.22	150	40-120		250	50	350	G.P. amp & switch	BC337
2N3642	TO-105 NS	45	60	500	0.22	150	40-120		250	50	350	G.R. amp & switch	BC337
2N3643	TO-105 NS	30	60	500	0.22	150	100-300	150	250	50	350	G.P. amp & switch	BC337
2N3644	TO-105 PS	45	45	500	1	300	100-300	150	200	20	300	G.P. amp & switch	BC327
2N3645	TO-105 PS	60	60	500	1	300	100-300	150	200	20	300	G.P. amp & switch	
2N3771	TO-3 NS	40	50	30A	2	15A	15-60	15A	0.2	1A	150W	Power output	
2N3866	TO-39 NS	30	55	400			0-200	50	500	50	1W	VHF amp	
2N3904	TO-92(72) NS	40	60	200	0.2	10	00-300	10	300	10	310	Lowlevel amp	BC167A, BF194
2N3905	TO-92(72) PS	40	40	200	0.4	50	50-200	10	200	20	310	G.P. amp & switch	
2N3948	TO-39 NS	20	36	400			15	50	700	50	1W	VHF amp	
2N4030	TO-39 PS	60	60	1A	0.5	500	25	500	260	100	800	G.P. amp & switch	
2N4250	TO-106 PS	40	40	100	0.25	10	50-700	0.1	50		200	Lowlevel amp	BC559
2N4258	TO-106 PS	12	12	50	0.5	50	30-120	10	700	10	200	Saturated switch	
2N4427	TO-39 NS	20	40	400	0.4	100	10-200	100	500	50	1W	VHF/UHF driver	2N3866
2N5401	TO-92(72) PS	150	160	6000	0.5	50	60-250	10	100	10	625	H.V. switch	MP SL51
2N6557	TO-202 NS	250	250	500			> 40	50	45		2W	H.V. med power	
2SC710	TO-92/76 NS	25	30	30			90		100		200	G.P. RF amp	BFS18
2SC1306	TOP-66 NS	65	65	3A			0-200	500	300		12W	H.F. output	2SC2166
2SC1307	TOP-66 NS	70	70	8A			0-150	2A	150		29W	H.F. output	2SC1969
2SC1674	TO-92(74) NS	20	30	20	0.3	10	40-180	1	600	1	250	VHF amp	
2SC1969	TOP-66 NS	30	60	6A			0-180	10	150		20W	H.F. output	2SC1307
2SC2166	TOP-66 NS	75	75	4A			5-180	100					
2SC2694	T40 NS	17	35	20A			0-180	1A	800		140W	VHF output	MRF 247
2SC3355	TO-92(74) NS	12	20	100			0-300	20	6.5GHz	20	600	UHFSS	MRF 573
2SC3358	MX NS	12	20	100			0-300	20	7GHz	20	250	UHFSS	MRF 573

# SEMICONDUCTOR OUTLINES

BOTTOM VIEW UNLESS OTHERWISE STATED



## All the resistor colours:

1R0	10R	100R	1k0
1R2	12R	120R	1k2
1R5	15R	150R	1k5
1R8	18R	180R	1k8
2R2	22R	220R	2k2
2R7	27R	270R	2k7
3R3	33R	330R	3k3
3R9	39R	390R	3k9
4R7	47R	470R	4k7
5R6	56R	560R	5k6
6R8	68R	680R	6k8
8R2	82R	820R	8k2
10k	100k	1M0	10M
12k	120k	1M2	22M
15k	150k	1M5	
18k	180k	1M8	
22k	220k	2M2	0R1
27k	270k	2M7	R22
33k	330k	3M3	0R0
39k	390k	3M9	zero ohm (link)
47k	470k	4M7	
56k	560k	5M6	
68k	680k	6M8	
82k	820k	8M2	