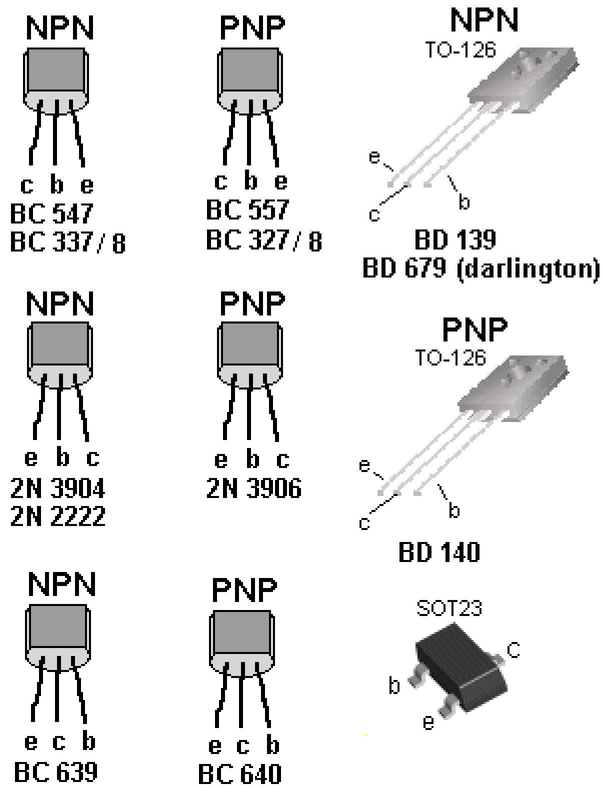
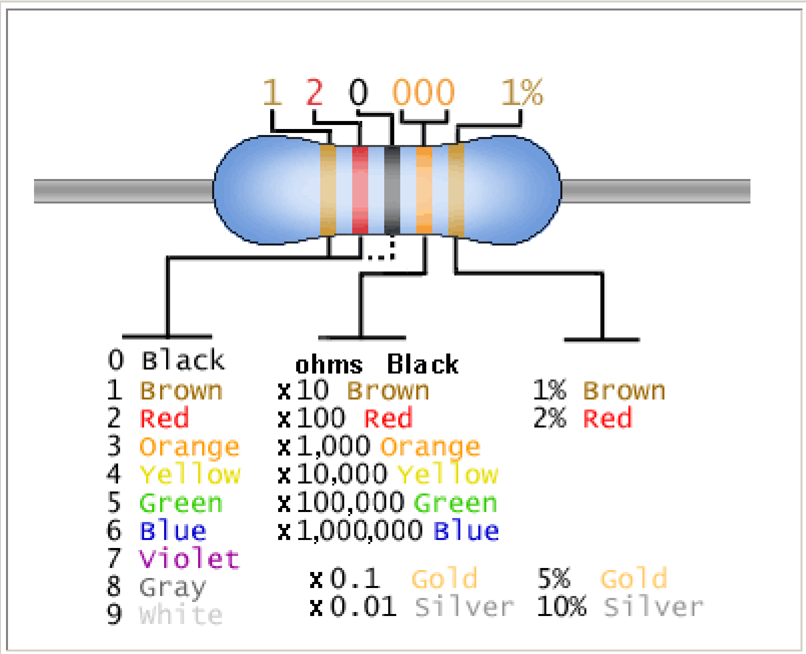
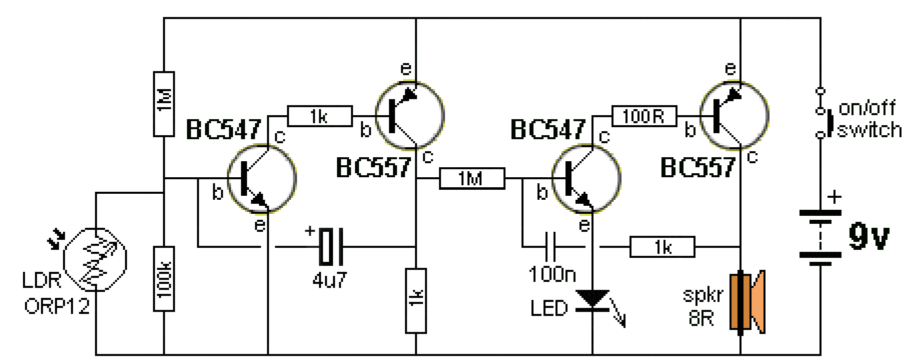

NPN
c b e
BC 547
BC 337 / 8
PNP
c b e
BC 557
BC 327 / 8
NPN
TO-126
e
c
b
BD 139
BD 679 (darlington)
NPN
e b c
2N 3904
2N 2222
PNP
e b c
2N 3906
PNP
TO-126
e
c
b
BD 140
NPN
e c b
BC 639
PNP
e c b
BC 640
SOT23
C
b
e

CONTENTS

RESISTOR COLOUR CODE



See resistors from 0.22ohm to 22M in full colour at end of book and another resistor table



DARK DETECTOR with beep-beep-beep Alarm

This circuit detects darkness and produces a beep-beep-beep alarm. The first two transistors form a high-gain amplifier with feedback via the 4u7 to produce a low-frequency oscillator. This provides voltage for the second oscillator (across the 1k resistor) to drive a speaker.

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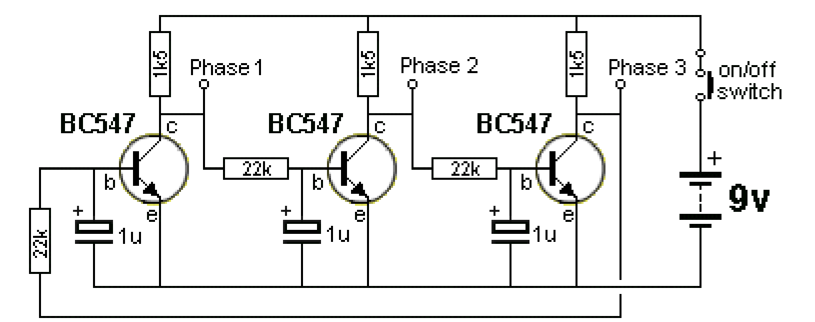

3-PHASE SINEWAVE GENERATOR

This circuit produces a sinewave and each phase can be tapped at the point shown.

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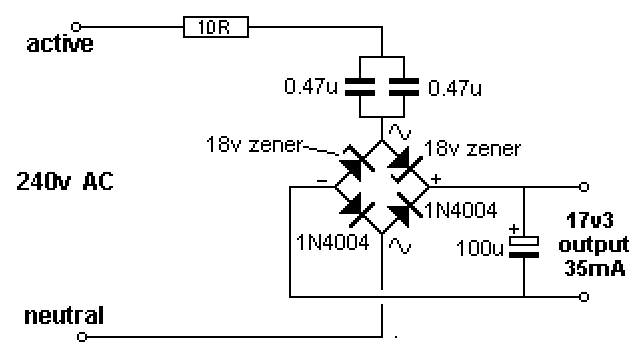

TRANSFORMERLESS POWER SUPPLY

This clever design uses 4 diodes in a bridge to produce a fixed voltage power supply capable of supplying 35mA.

All diodes (every type of diode) are zener diodes. They all break down at a particular voltage. The fact is, a power diode breaks down at 100v or 400v and its zener characteristic is not useful.

But if we put 2 zener diodes in a bridge with two ordinary power diodes, the bridge will break-down at the voltage of the zener. This is what we have done. If we use 18v zeners, the output will be 17v4.

When the incoming voltage is positive at the top, the left zener provides 18v limit (and the left power-diode produces a drop of 0.6v). This allows the right zener to pass current just like a normal diode but the voltage available to it is just 18v. The output of the right zener is 17v4. The same with the other half-cycle.

The current is limited by the value of the X2 capacitor and this is 7mA for each 100n when in full-wave (as per this circuit). We have 10 x 100n = 1u capacitance. Theoretically the circuit will supply 70mA but we found it will only deliver 35mA before the output drops. The capacitor should comply with X1 or X2 class. The 10R is a safety-fuse resistor.

The problem with this power supply is the "live" nature of the negative rail. When the power supply is connected as shown, the negative rail is 0.7v above neutral. If the mains is reversed, the negative rail is 340v (peak) above neutral and this will kill you as the current will flow through the diode and be lethal. You need to touch the negative rail (or the positive rail) and any earthed device such as a toaster to get killed. The only solution is the project being powered must be totally enclosed in a box with no outputs.

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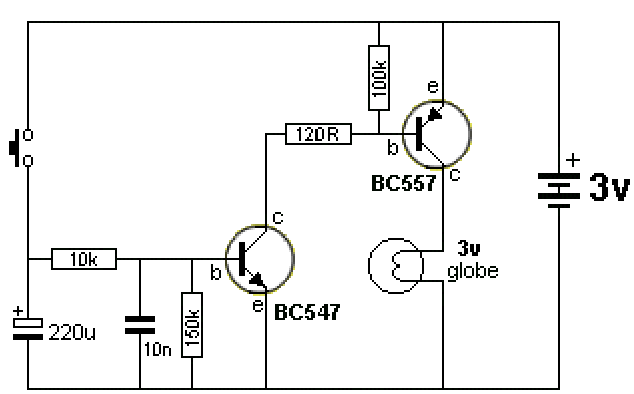
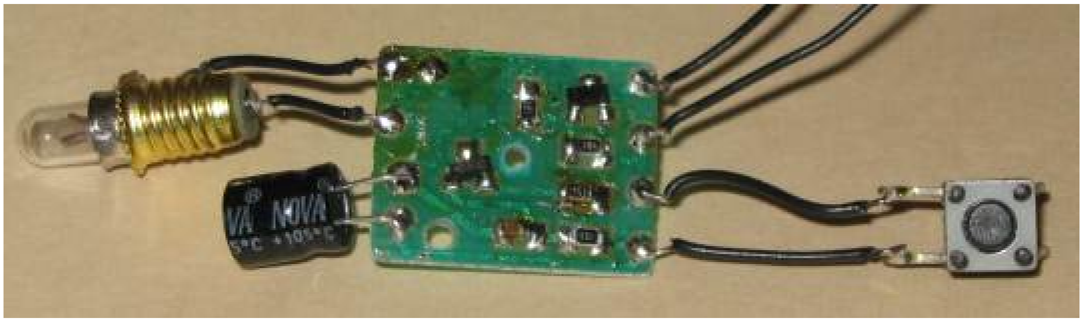


BOOK LIGHT

This circuit keeps the globe illuminated for a few seconds after the switch is pressed.

There is one minor fault in the circuit. The 10k should be increased to 100k to increase the "ON" time.

The photo shows the circuit built with surface-mount components:



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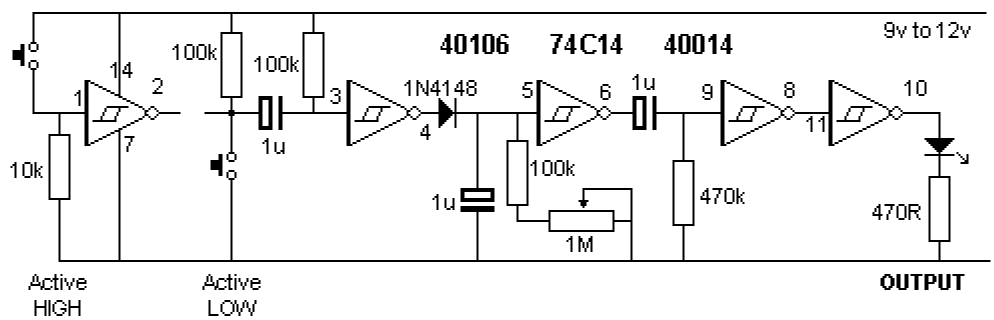

CAMERA ACTIVATOR

This circuit was designed for a customer who wanted to trigger a camera after a short delay.

The output goes HIGH about 2 seconds after the switch is pressed. The LED turns on for about 0.25 seconds.

The circuit will accept either active HIGH or LOW input and the switch can remain pressed and it will not upset the operation of the circuit. The timing can be changed by adjusting the 1M trim pot and/or altering the value of the 470k.

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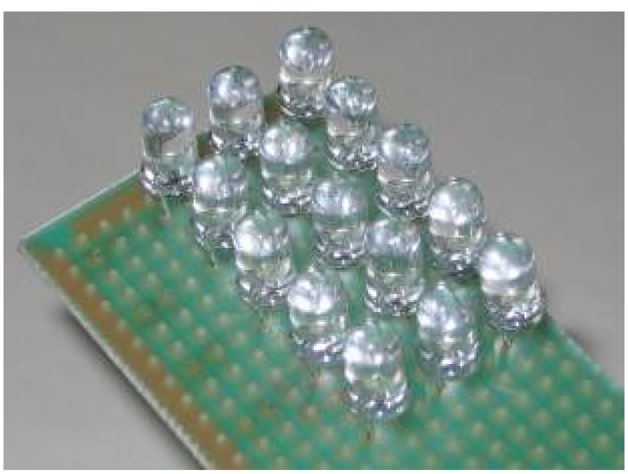
MAKE YOUR OWN:



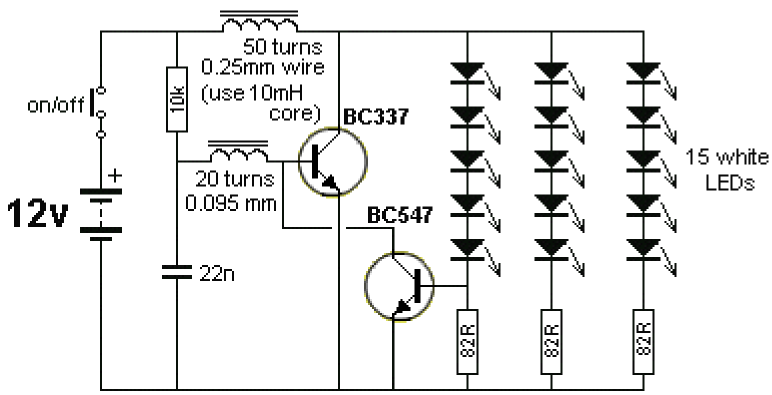
15 LEDs on Matrix board

The transformer consists of 50 turns 0.25mm wire connected to the pins. The feedback winding is 20 turns 0.095mm wire with "fly-leads."

1-WATT LED

This circuit drives 15 LEDs to produce the same brightness as a 1-watt LED. The circuit

consumes 750mW but the LEDs are driven with high-frequency, high-voltage spikes, and become more-efficient and produce a brighter output that if driven by pure-DC.
The LEDs are connected in 3 strings of 5 LEDs. Each LED has a characteristic voltage of 3.2v to 3.6v making each chain between 16v and 18v. By selecting the LEDs we have produced 3 chains of 17.5v Five LEDs (in a string) has been done to allow the circuit to be powered by a 12v battery and allow the battery to be charged while the LEDs are illuminating. If only 4 LEDs are in series, the characteristic voltage may be as low as 12.8v and they may be over-driven when the battery is charging. (Even-up the characteristic voltage across each chain by checking the total voltage across them with an 19v supply and 470R dropper resistor.) The transformer is shown above. It is wound on a 10mH choke with the original winding removed. This circuit is called a "**boost circuit**." It is not designed to drive a single 1-watt LED (a buck circuit is needed).
The LEDs in the circuit are 20,000mcd with a viewing angle of 30 degrees (many of the LED specifications use "half angle." You have to test a LED to make sure of the angle). This equates to approximately 4 lumens per LED. The 4-watt CREE LED claims 160 lumens (or 40 lumens per watt). Our design is between 50 - 60 lumens per watt and it is a much-cheaper design.



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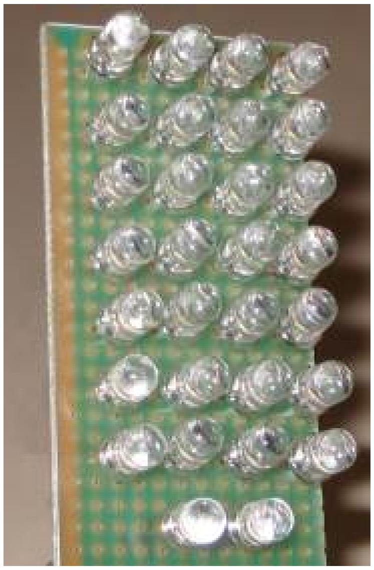
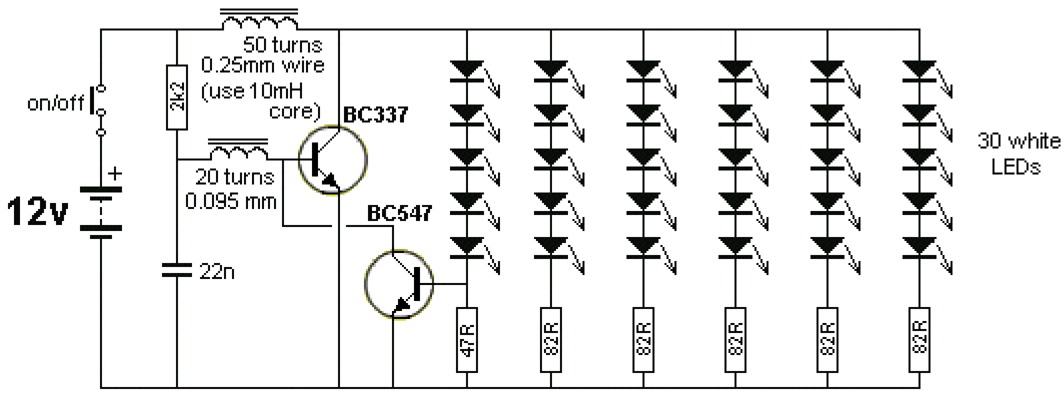


30 LEDs on Matrix board

1.5 WATT LED

The circuit below can be modified to drive up to 30 white LEDs.
The effectiveness of a LED array increases when they are spread out slightly and this makes them more efficient than a single 1 watt or 2 watt LED.
The two modifications to the circuit make the BC337 work harder and this is the limit of the inductor. The current consumption is about 95mA.
The winding details for the transformer are shown above.



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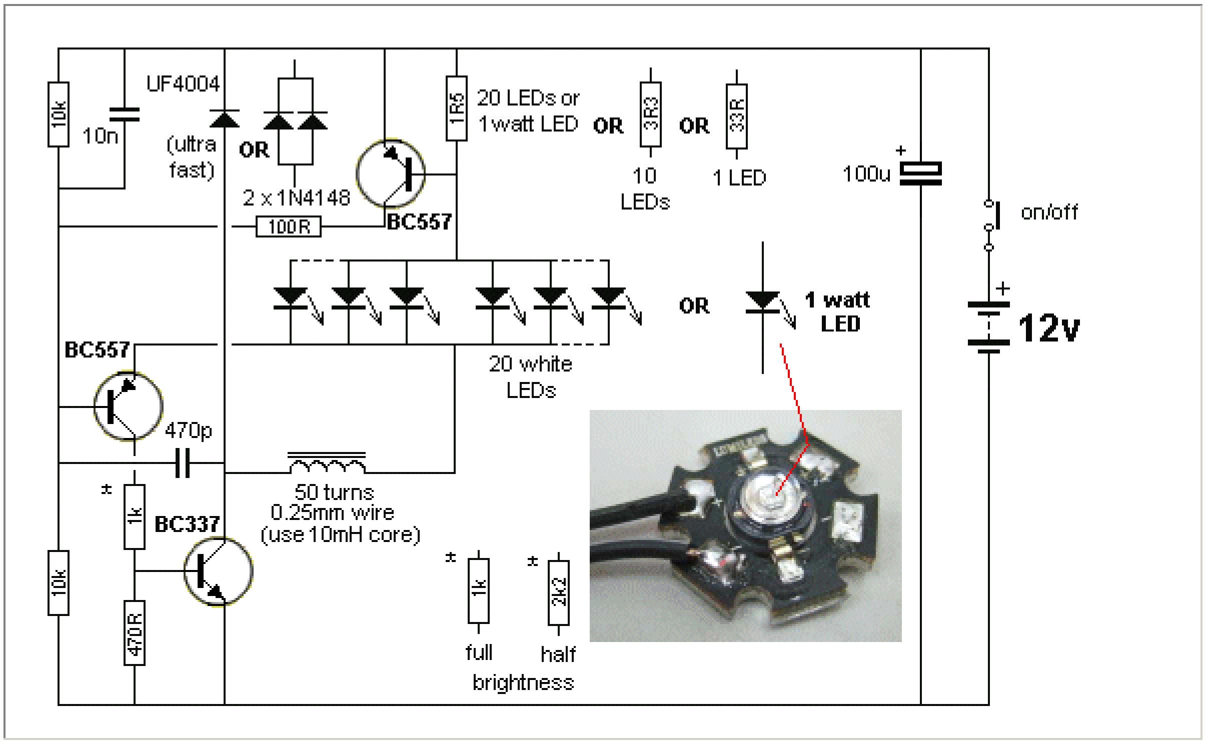
DRIVE 20 LEDs FROM 12v - approx 1watt circuit

This is another circuit that drives a number of LEDs or a single 1 watt LED. It is a "**Buck Circuit**" and drives the LEDs in parallel. They should be graded so that the characteristic voltage-drop across each of them is within 0.2v of all the other LEDs. The circuit will drive any number from 1 to 20 by changing the "sensor" resistor as shown on the circuit. The current consumption is about 95mA @ 12v and lower at 18v. The circuit can be put into dim mode by increasing the drive resistor to 2k2. The UF4004 is an ultra fast 1N4004 - similar to a high-speed diode. You can use 2 x 1N4148 signal diodes.

The circuit will not drive two LEDs in series - it runs out of voltage (and current) when the voltage across the load is 7v. It oscillates at approx 200kHz. Build both the 20 LED and 1 watt LED version and compare the brightness and effectiveness.
The photo of the 1 watt LED on the left must be heatsinked to prevent the LED overheating. The photo on the circuit diagram shows the LED mounted on a heatsink and the connecting wires.

A 1-watt demo board showing the complex step-up circuitry.

This is a Boost circuit to illuminate the LED and is completely different to our design. It has been included to show the size of a 1 watt LED.
The reason for a Boost or Buck circuit to drive one or more LEDs is simple. The voltage across a LED is called a "characteristic voltage" and comes as a natural feature of the LED. We cannot alter it. To power the LED with exactly the correct amount of voltage (and current) you need a supply that is EXACTLY the same as the characteristic voltage. This is very difficult to do and so a resistor is normally added in series. But this resistor wastes a lot of energy. So, to keep the loses to a minimum, we pulse the LED with bursts of energy at a higher voltage and the LED absorbs them and produces light. With a Buck circuit, the transistor is turned on for a short period of time and illuminated the LEDs. At the same time, some of the energy is passed to the inductor so that the LEDs are not damaged. When the transistor is turned off, the energy from the inductor also gives a pulse of energy to the LEDs. When this has been delivered, the cycle starts again.



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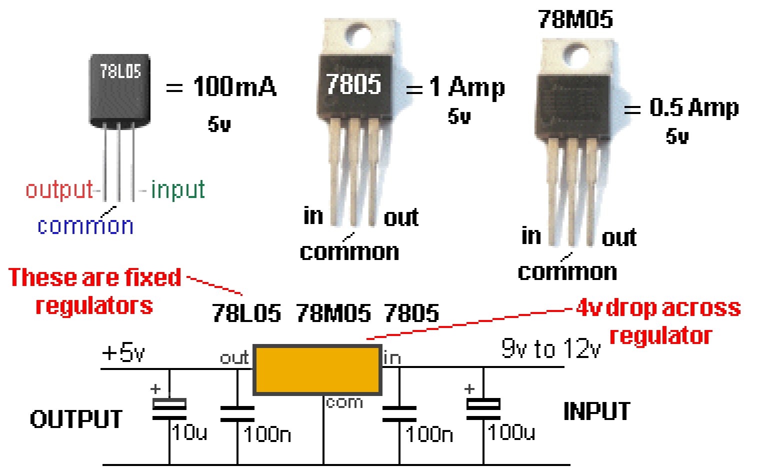
POWER SUPPLIES - FIXED:



A simple power supply can be made with a component called a "3-pin regulator or 3-terminal regulator" It will provide a very low ripple output (about 4mV to 10mV provided electrolytics are on the input and output.

The diagram above shows how to connect a regulator to create a power supply. The 7805 regulators can handle 100mA, 500mA and 1 amp, and produce an output of 5v, as shown.

These regulators are called **linear regulators** and drop about 4v across them - minimum. If the current flow is 1 amp, 4watts of heat must be dissipated via a large heatsink. If the output is 5v and input 12v, 7volts will be dropped across the regulator and 7watts must be dissipated.

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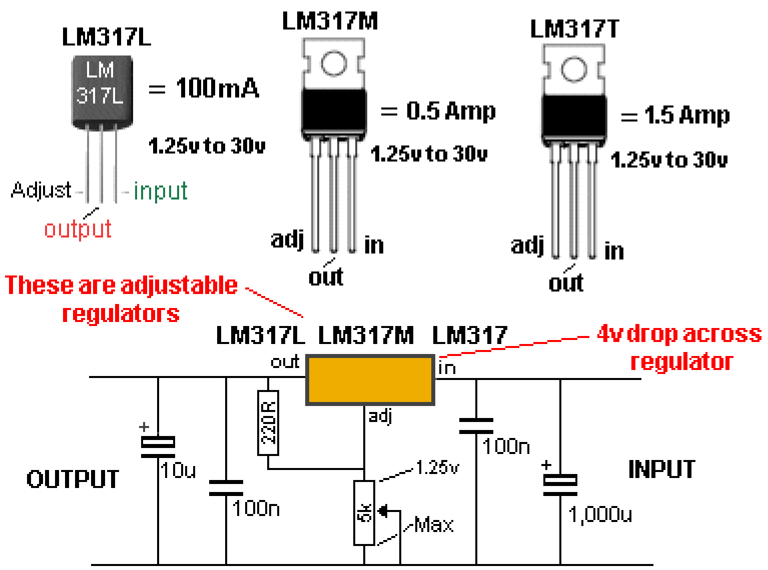
POWER SUPPLIES - ADJUSTABLE:



The LM317 regulators are adjustable and produce an output from 1.25 to about 35v. The LM317T regulator will deliver up to 1.5amp.

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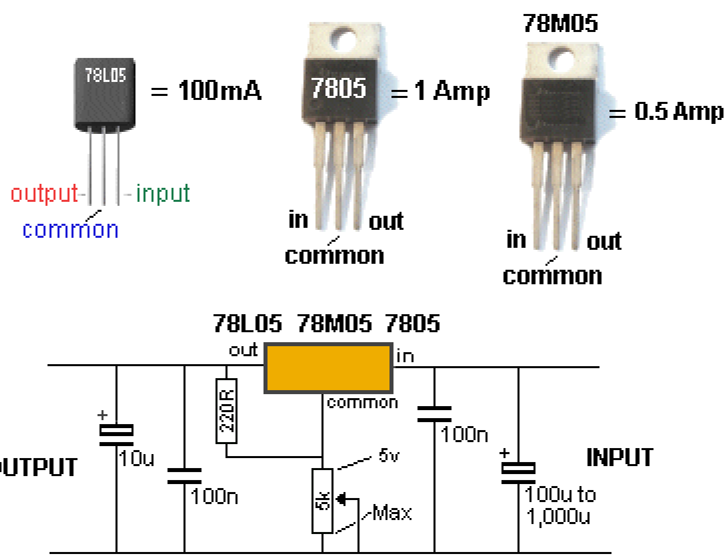
POWER SUPPLIES - ADJUSTABLE using 7805:



The 7805 range of regulators are called "fixed regulators" but they can be turned into adjustable regulators by "jacking-up" their output voltage. For a 5v regulator, the output can be 5v to 30v.

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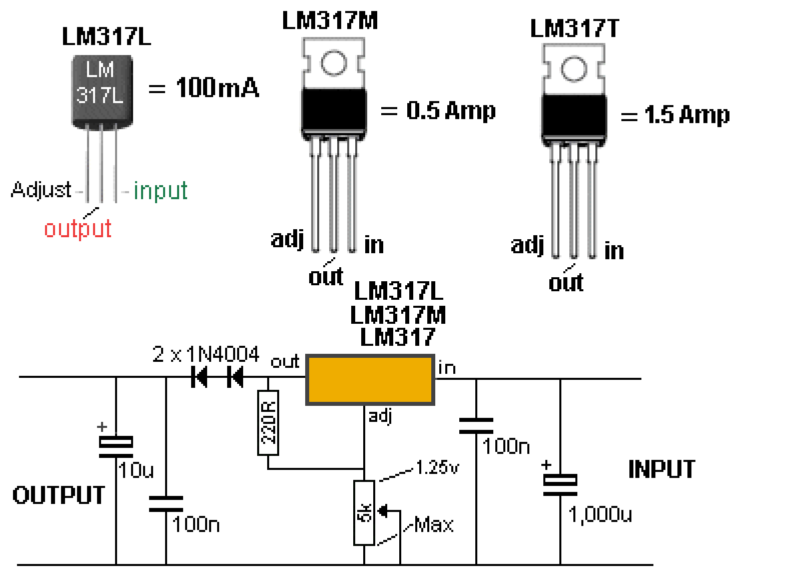
POWER SUPPLIES - ADJUSTABLE from 0v:



The LM317 regulator is adjustable from 1.25 to about 35v. To make the output 0v to 35v, two power diodes are placed as shown in the circuit. Approx 0.6v is dropped across each diode and this is where the 1.25v is "lost."

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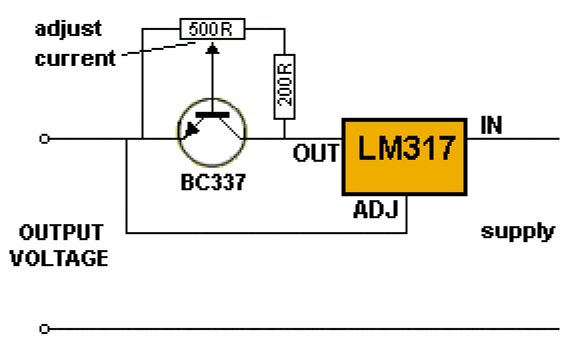

CONSTANT CURRENT

This constant current circuit can be adjusted to any value from a few milliamp to about 500mA - this is the limit of the BC337 transistor.
The circuit can also be called a current-limiting circuit and is ideal in a bench power supply to prevent the circuit you are testing from being damaged.
Approximately 4v is dropped across the regulator and 1.25v across the current-limiting section, so the input voltage (supply) has to be 5.25v above the required output voltage. Suppose you want to charge 4 Ni-Cad cells. Connect them to the output and adjust the 500R pot until the required charge-current is obtained.
The charger will now charge 1, 2, 3 or 4 cells at the same current. But you must remember to turn off the charger before the cells are fully charged as the circuit will not detect this and over-charge the cells.
The LM 317 3-terminal regulator will need to be heatsinked.

This circuit is designed for the LM series of regulator as they have a voltage differential of 1.25v between "adj" and "out" terminals.
7805 regulators can be used but the losses in the BC337 will be 4 times greater as the voltage across it will be 5v.

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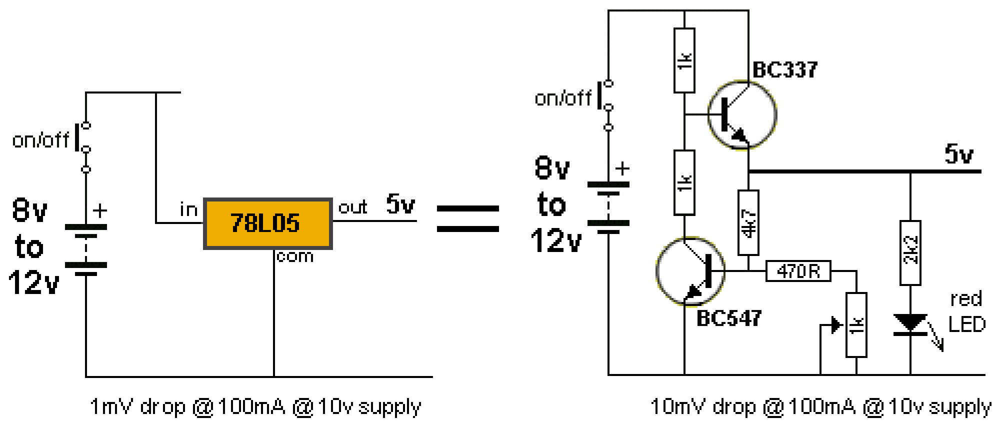
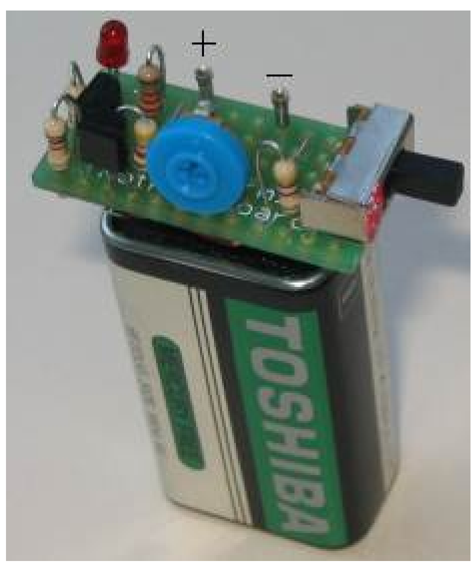
5v FROM OLD CELLS - circuit 1

This circuit takes the place of a 78L05 3-terminal regulator. It produces a constant 5v @ 100mA. You can use any old cells and get the last of their energy. Use an 8-cell holder. The voltage from 8 old cells will be about 10v and the circuit will operate down to about 7.5v. The regulation is very good at 10v, only dropping about 10mV for 100mA current flow (the 78L05 has 1mV drop). As the voltage drops, the output drops from 5v on no-load to 4.8v and 4.6v on 100mA current-flow. The pot can be adjusted to compensate for the voltage-drop. This type of circuit is called a LINEAR REGULATOR and is not very efficient (about 50% in this case). See circuit 2 below for BUCK REGULATOR circuit (about 85% efficient).



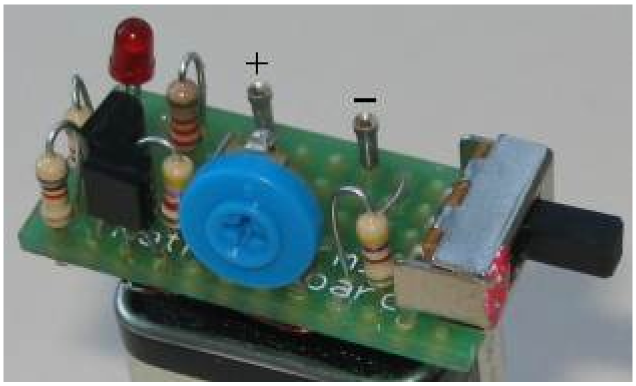
The regulator connected to a 12v battery pack



The regulator connected to a 9v battery

The battery snap plugs into the pins on the 5v regulator board with the red lead going to the negative output of the board as the battery snap is now DELIVERING voltage to the circuit you are powering.

A close-up of the regulator module



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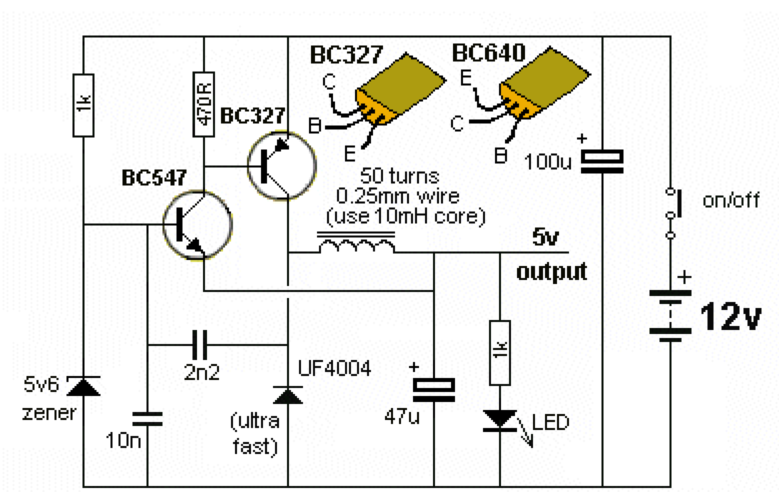
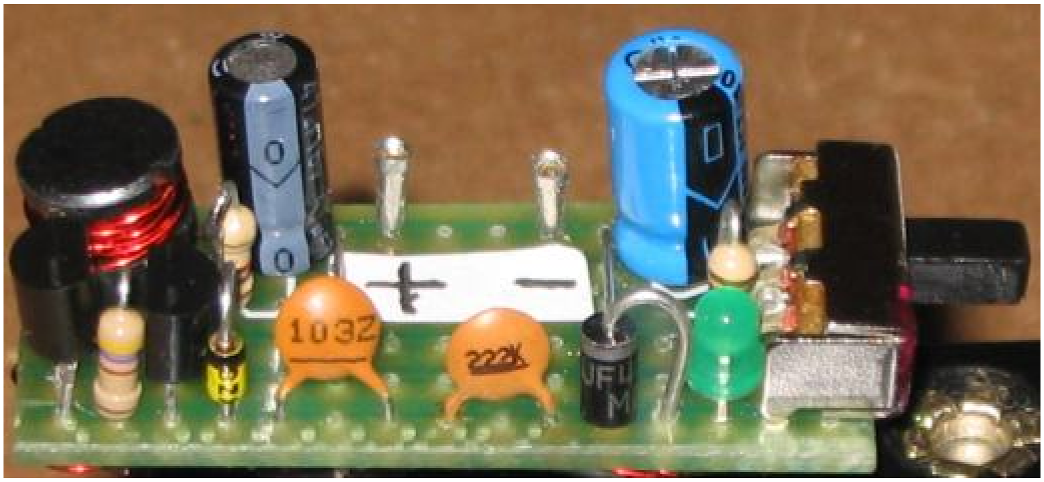
5v FROM OLD CELLS - circuit 2

This circuit is a BUCK REGULATOR. It can take the place of a 78L05 3-terminal regulator, but it is more efficient. It produces a constant 5v @ up to 200mA. You can use any old cells and get the last of their energy. Use an 8-cell holder. The voltage from 8 old cells will be about 10v and the circuit will operate down to about 7.5v. The regulation is very good at 10v, only dropping 10mV for up to 200mA output.





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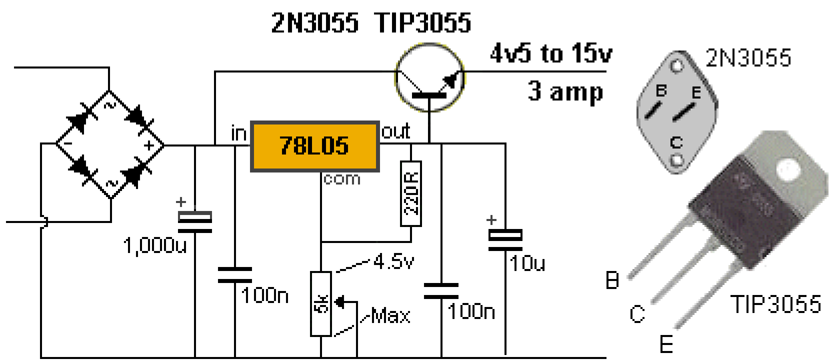

INCREASING THE OUTPUT CURRENT

The output current of all 3-terminal regulators can be increased by including a pass transistor. This transistor simply allows the current to flow through the collector-emitter leads.

The output voltage is maintained by the 3-terminal regulator but the current flows through the "pass transistor." This transistor is a power transistor and must be adequately heatsinked.

Normally a 2N3055 or TIP3055 is used for this application as it will handle up to 10 amps and creates a 10 amp power supply. The regulator can be 78L05 as all the current is delivered by the pass transistor.

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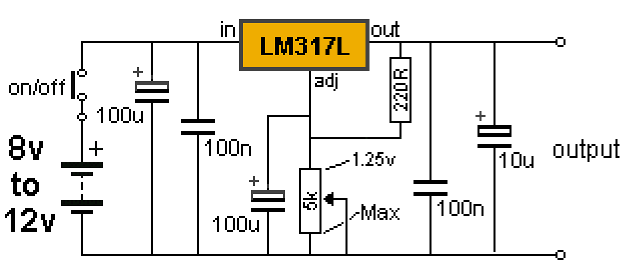

SOFT START

The output voltage of a 3-terminal regulator can be designed to rise slowly. This has very limited application as many circuits do not like this.

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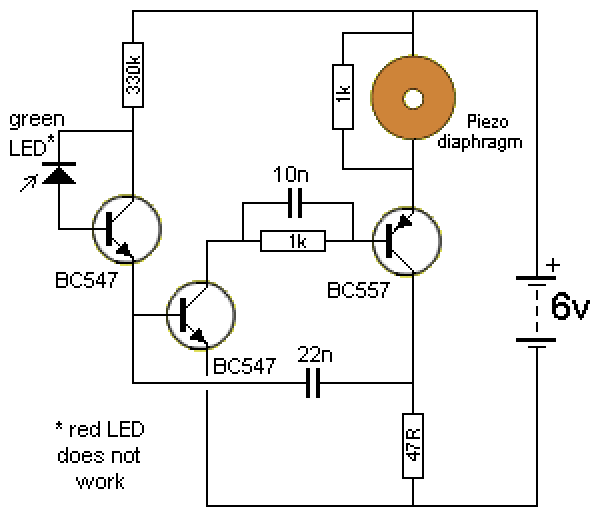

LED DETECTS LIGHT

The LED in this circuit will detect light to turn on the oscillator. Ordinary red LEDs do not work. But green LEDs, yellow LEDs and high-bright white LEDs and high-bright red LEDs work very well.
The output voltage of the LED is up to 600mV when detecting very bright illumination. When light is detected by the LED, its resistance decreases and a very small current flows into the base of the first transistor. The transistor amplifies this current about 200 times and the resistance between collector and emitter decreases. The 330k resistor on the collector is a current limiting resistor as the middle transistor only needs a very small current for the circuit to oscillate. If the current is too high, the circuit will "freeze."
The piezo diaphragm does not contain any active components and relies on the circuit to drive it to produce the tone. A different **LED Detects Light** circuit in eBook 1:
1 - 100 Transistor Circuits

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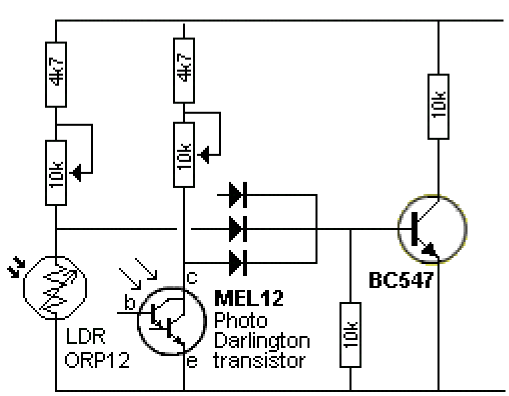

TRAIN DETECTORS

In response to a reader who wanted to parallel TRAIN DETECTORS, here is a diode OR-circuit.

The resistor values on each detector will need to be adjusted (changed) according to the voltage of the supply and the types of detector being used. Any number of detectors can be added. See Talking Electronics website for train circuits and kits including Air Horn, Capacitor Discharge Unit for operating point motors without overheating the windings, Signals, Pedestrian Crossing Lights and many more.

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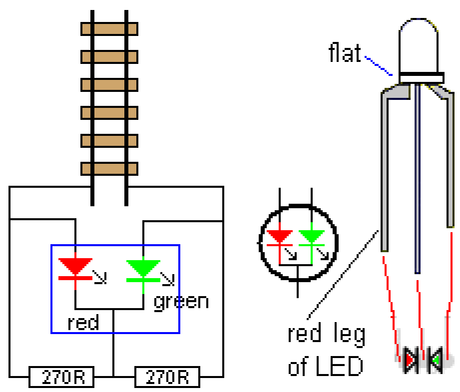

TRACK POLARITY

This circuit shows the polarity of a track via a 3-legged LED. The LED is called dual colour (or tri-colour) as it shows red in one direction and green in the other (orange when both LEDs are illuminated).

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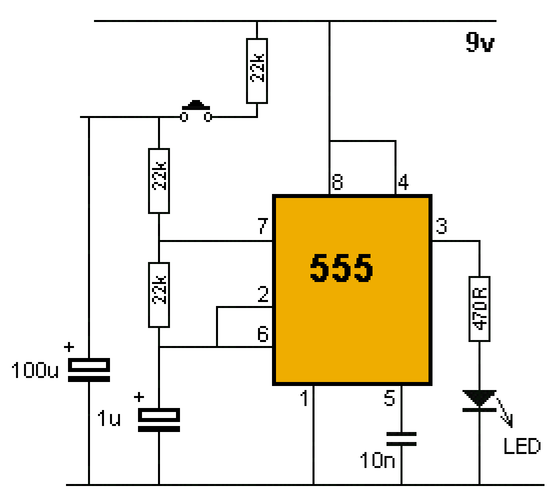

DECAYING FLASHER

In response to a reader who wanted a flashing LED circuit that slowed down when a button was released, the above circuit increases the flash rate to a maximum and when the button is released, the flash rate decreases to a minimum and halts.

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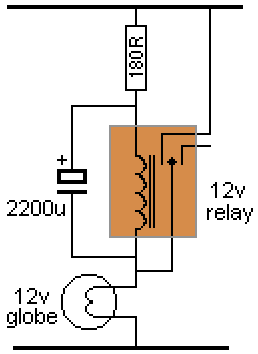
SIMPLE FLASHER



This simple circuit flashes a globe at a rate according to the value of the 180R and 2200u electrolytic.

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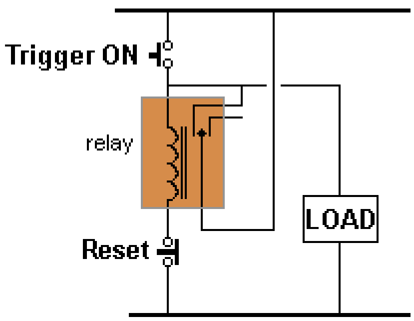
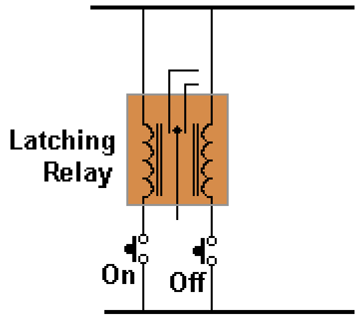
LATCHING RELAY

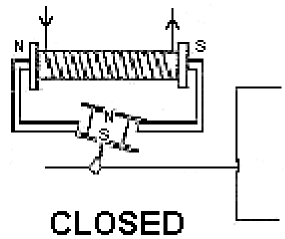
To reduce the current in battery operated equipment a relay called LATCHING RELAY can be used.
This is a relay that latches itself ON when it receives a pulse in one direction and unlatches itself when it receives a pulse in the other direction.
The following diagram shows how the coil makes the magnet click in the two directions.



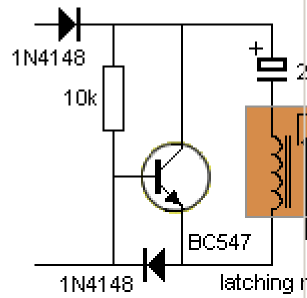
Latching an ordinary relay



A 2-coil Latching Relay



CLOSED

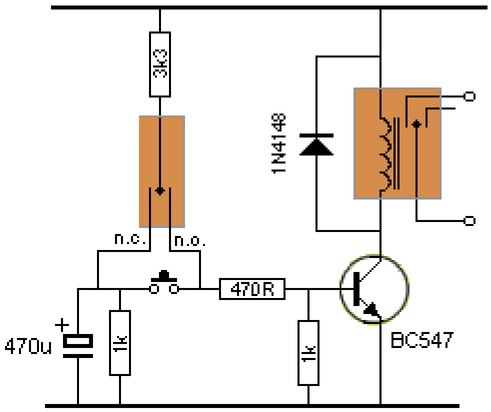


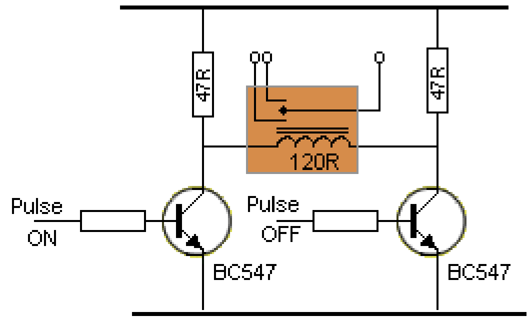
PULSE LATCHING RELAY C

To operate this type of relay, the voltage must be reversed to unlatch it. The circuit above produces a strong pulse to latch the relay ON and the input voltage must remain HIGH. The 220u gradually charges and the current falls to a very low level. When the input voltage is removed, the circuit produces a pulse in the opposite direction to unlatch the relay.

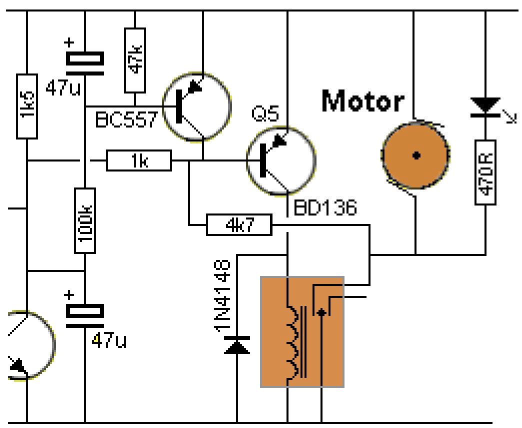
If you want to latch an ordinary relay so it remains ON after a pulse, the circuit at the left can be used. Power is needed all the time to keep the relay ON.

Latching Relays are expensive but a 5v Latching Relay is available from: Excess Electronics for $1.00 as a surplus item. It has 2 coils and requires the circuit at the left. A 5v Latching Relay can be use on 12v as it is activated for a very short period of time.





A double-pole (ordinary) relay and transistor can be connected to provide a toggle action.
The circuit comes on with the relay de-activated and the contacts connected so that the 470u charges via the 3k3. Allow the 470u to charge. By pressing the button, the BC547 will activate the relay and the contacts will change so that the 3k3 is now keeping the transistor ON.
The 470u will discharge via the 1k. After a few seconds the electro will be discharged. If the press-button is now pushed for a short period of time, the transistor will turn off due to the electro being discharged.



A single-coil latching relay normally needs a reverse-voltage to unlatch but the circuit at the left provides forward and reverse voltage by using 2 transistors in a very clever H-design.
The pulse-ON and pulse-OFF can be provided from two lines of the microcontroller.

A normal relay can be activated by a short tone and de-activated by a long tone as shown via the circuit on the left. This circuit can be found in "**27MHz Links**" Page 2.

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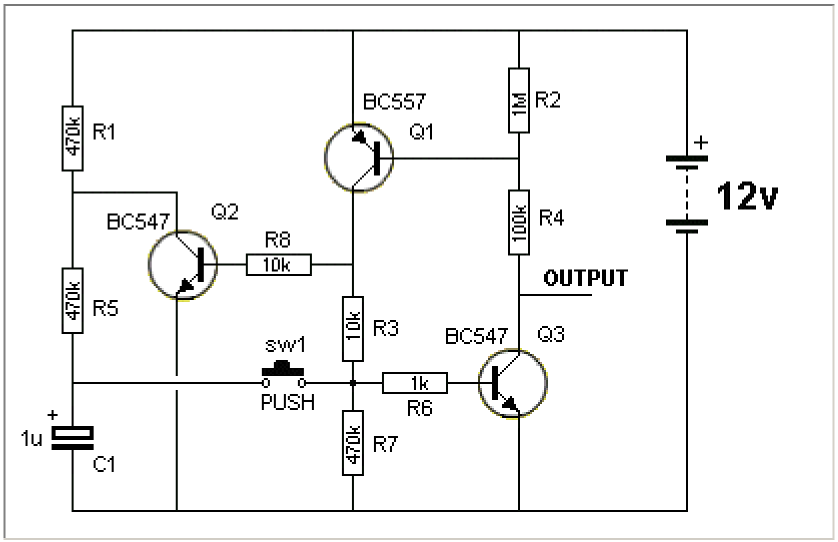
LATCHING A PUSH BUTTON

When the circuit is turned on, capacitor C1 charges via the two 470k resistors. When the switch is pressed, the voltage on C1 is passed to Q3 to turn it on. This turns on Q1 and the voltage developed across R7 will keep Q1 turned on when the button is released.
Q2 is also turned on during this time and it discharges the capacitor. When the switch is pressed again, the capacitor is in a discharged state and this zero voltage will be passed to Q3 turn it off. This turns off Q1 and Q2 and the capacitor begins to charge again to repeat the cycle.



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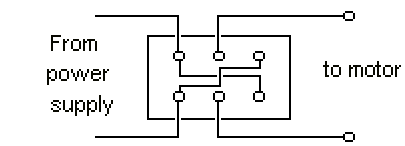
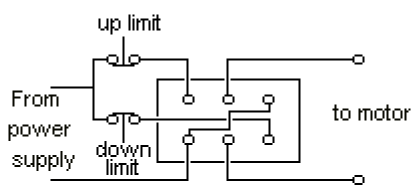
REVERSING A MOTOR-1

There are a number of ways to reverse a motor. The following diagrams show how to connect a double-pole double throw relay or switch and a set of 4 push buttons. The two buttons must be pushed at the same time or two double pole push-switches can be used.
See H-Bridge below for more ways to reverse a motor.

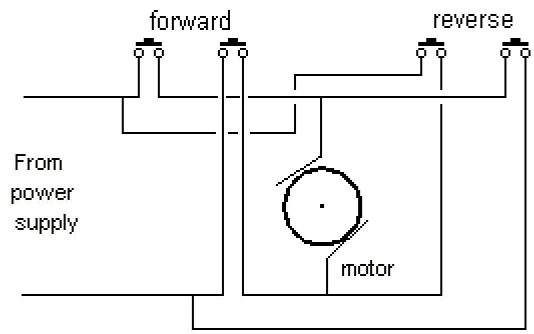


double-pole double-throw relay

Adding limit switches:



double-pole double-throw relay



The way the dpdt relay circuit (above) works is this:
The relay is powered by say 12v, via a MAIN SWITCH. When the relay is activated, the motor travels in the forward direction and hits the "up limit" switch. The motor stops. When the MAIN SWITCH is turned off, the relay is de-activated and reverses the motor until it reaches the "down-limit" switch and stops. The MAIN SWITCH must be used to send the motor to the "up limit" switch.

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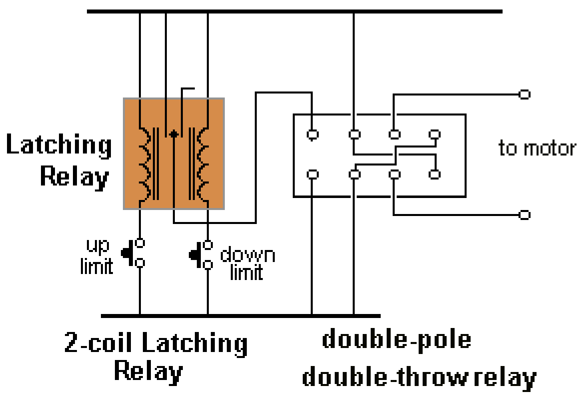
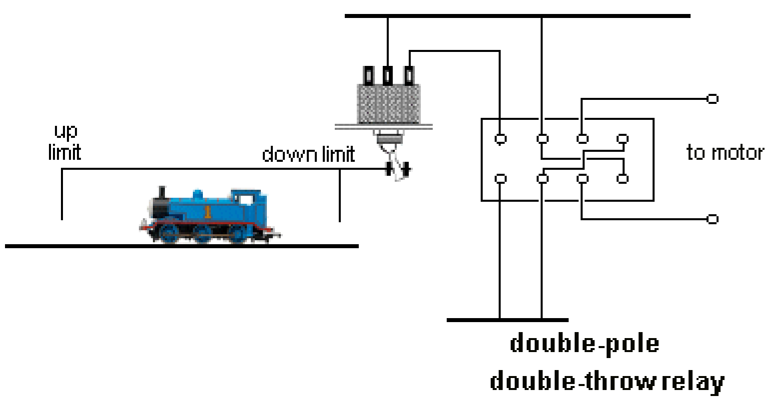
REVERSING A MOTOR-2

AUTOMATIC FORWARD-REVERSE

The following circuit allows a motor (such as a train) to travel in the forward direction until it hits the "up limit" switch. This sends a pulse to the latching relay to reverse the motor (and ends the short pulse). The train travels to the "down limit" switch and reverses.



If the motor can be used to click a switch or move a slide switch, the following circuit can be used:



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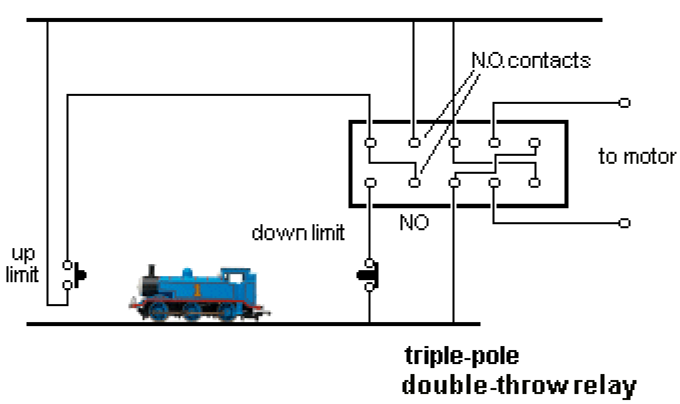
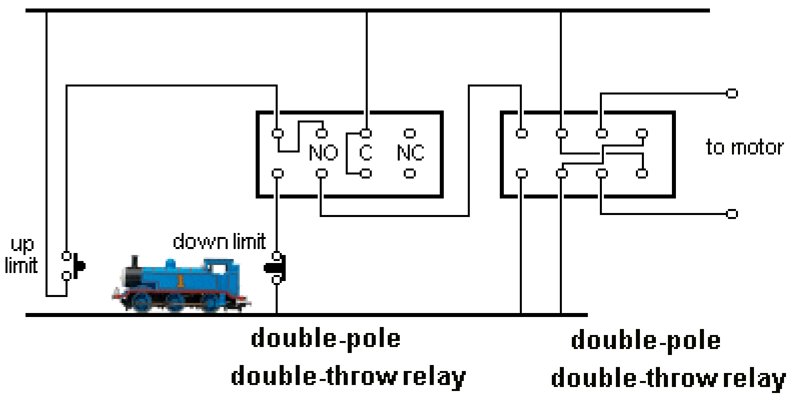
REVERSING A MOTOR-3

If the train cannot physically click the slide switch in both directions, via a linkage, the following circuit should be used:



When power is applied, the relay is not energised and the train **must**

travel towards the "up limit." The switch is pressed and the relay is energised. The Normally Open contacts of the relay will close and this will keep the relay energised and reverse the train. When the down limit is pressed, the relay is de-energised.
If you cannot get a triple-pole change-over relay, use the following circuit:



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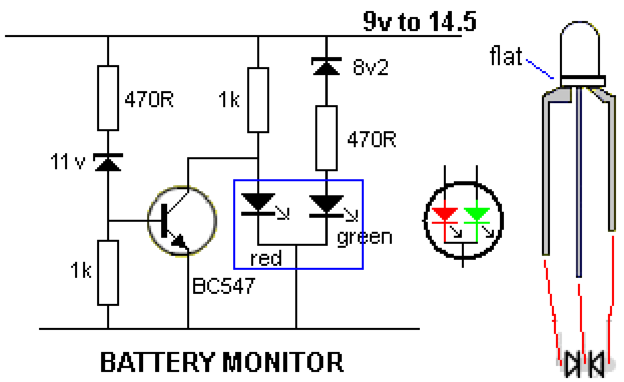
BATTERY MONITOR MkI

A very simple battery monitor can be made with a dual-colour LED and a few surrounding components. The LED produces orange when the red and green LEDs are illuminated.
The following circuit turns on the red LED below 10.5v
The orange LED illuminates between 10.5v and 11.6v.
The green LED illuminates above 11.6v



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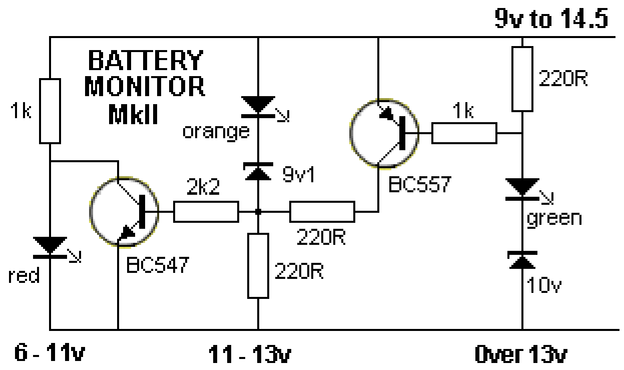
BATTERY MONITOR MkII

This battery monitor circuit uses 3 separate LEDs.
The red LED turns on from 6v to below 11v.
It turns off above 11v and
The orange LED illuminates between 11v and 13v.
It turns off above 13v and
The green LED illuminates above 13v



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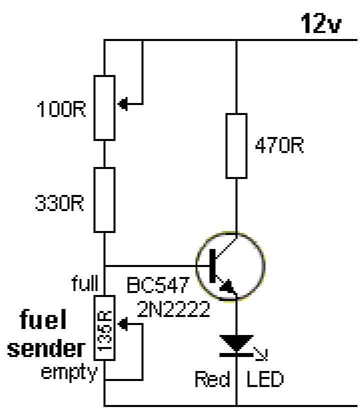
LOW FUEL INDICATOR

This circuit has been designed from a request by a reader. He wanted a low fuel indicator for his motorbike. The LED illuminates when the fuel gauge is 90 ohms. The tank is empty at 135 ohms and full at zero ohms. To adapt the circuit for an 80 ohm fuel sender, simply reduce the 330R to 150R. (The first thing you have to do is measure the resistance of the sender when the tank is amply.)



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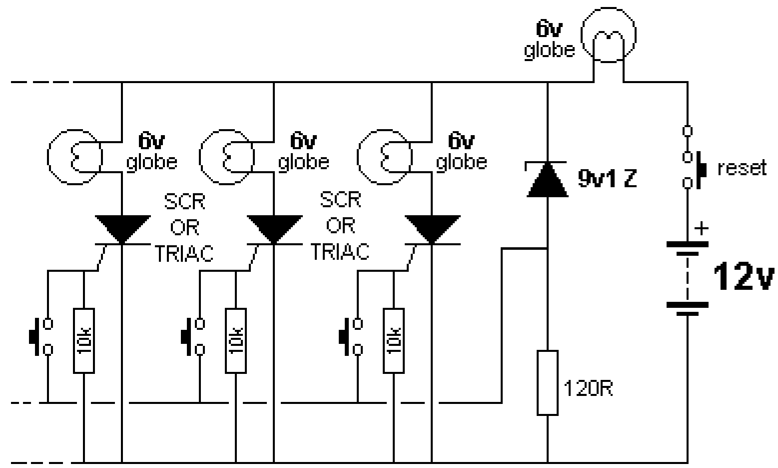
QUIZ TIMER

This circuit can be used to indicate: "fastest finger first." It has a globe for each contestant and one for the Quiz Master.



When a button is pressed the corresponding globe is illuminated. The Quiz Master globe is also illuminated and the cathode of the 9v1 zener sees approx mid-rail voltage. The zener comes out of conduction and no voltage appears across the 120R resistor. No other globes can be lit until the circuit is reset.

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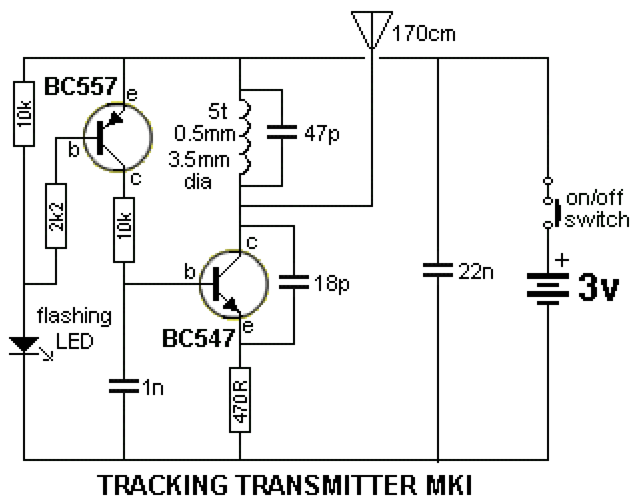
TRACKING TRANSMITTER

This circuit can be used to track lots of items.



It has a range of 200 - 400 metres depending on the terrain and the flashing LED turns the circuit ON when it flashes. The circuit consumes 5mA when producing a carrier (silence) and less than 1mA when off (background snow is detected).

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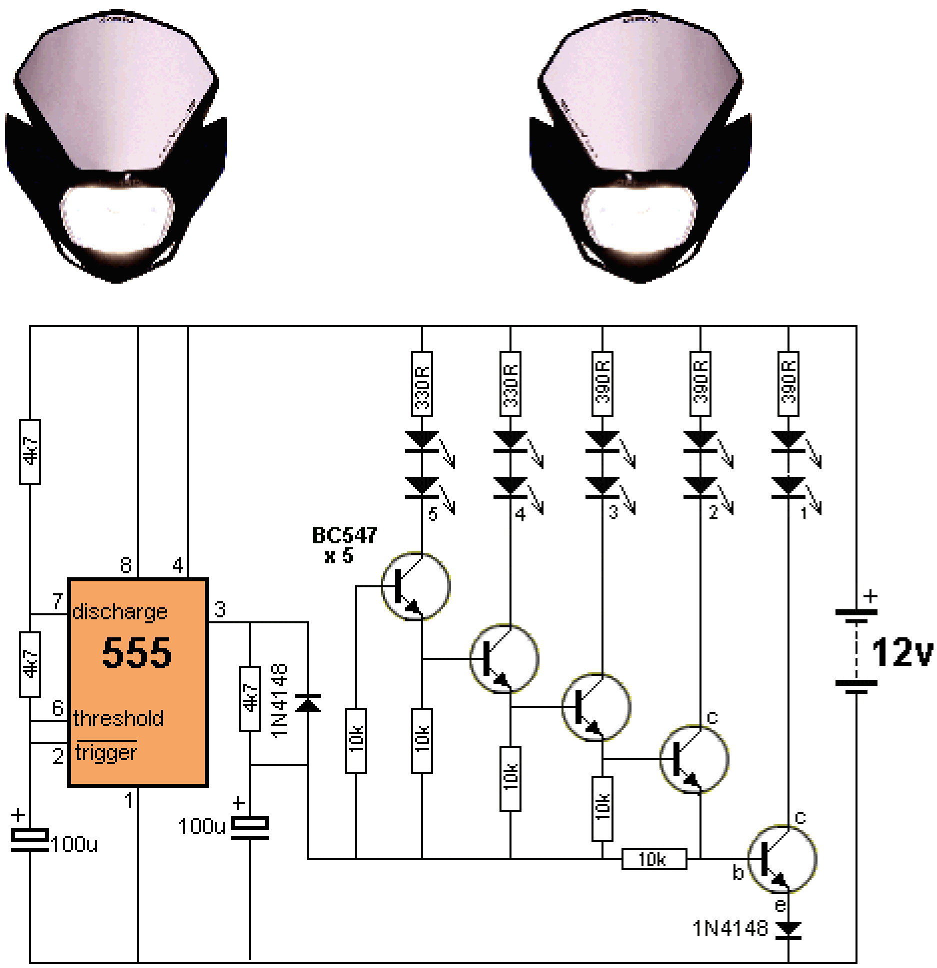
BIKE TURNING SIGNAL

This circuit can be used to indicate left and right turn on a motor-bike. Two identical circuits will be needed, one for left and one for right.



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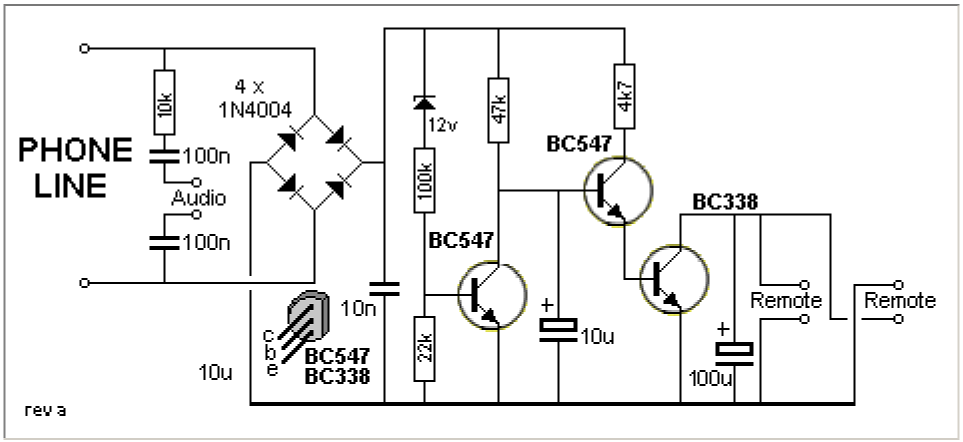
PHONE TAPE-3

This circuit can be used to turn on a tape recorder when the phone line voltage is less than 15v. This is the approximate voltage when the handset is picked up. See Phone Tape-1 and Phone Tape-2 in **200 Transistor Circuits eBook (circuits 1 - 100).** When the line voltage is above 25v, the BC547 is turned on and this robs the base of the second BC547 of the 1.2v it needs to turn on. When the line voltage drops, the first BC547 turns off and the 10u charges via the 47k and gradually the second BC547 is turned on. This action turns on the BC338 and the resistance between its collector-emitter leads reduces. Two leads are taken from the BC338 to the "rem" (remote) socket on a tape recorder. When the lead is plugged into a tape recorder, the motor will stop. If the motor does not stop, a second remote lead has been included with the wires connected the opposite way. This lead will work. The audio for the tape recorder is also shown on the diagram. This circuit has the advantage that it does not need a battery. It will work on a 30v phone line as well as a 50v phone line.



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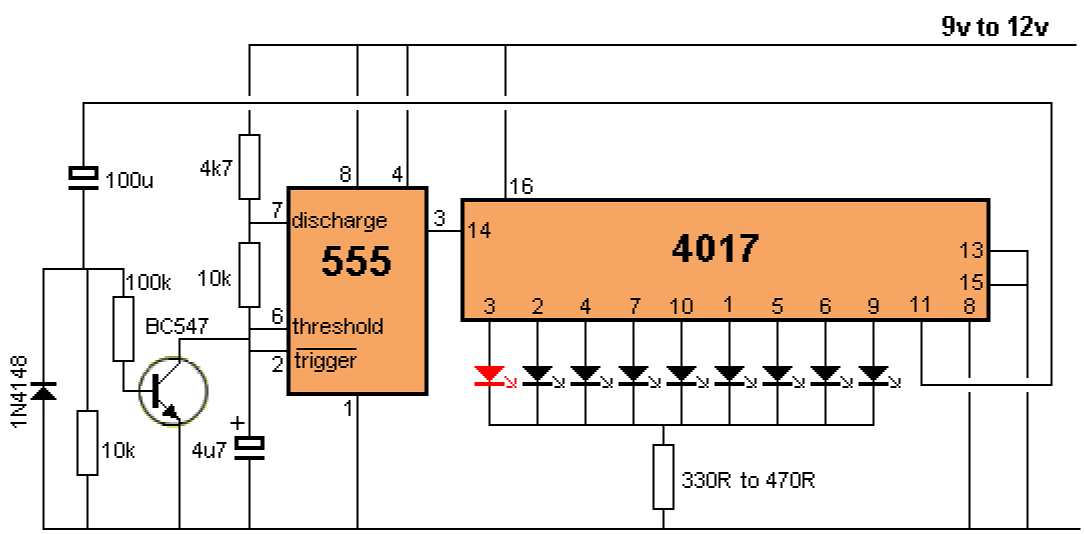
SEQUENCER

This circuit has been requested by a reader. He wanted to have a display on his jacket that ran 9 LEDs then stopped for 3 seconds.
The animated circuit shows this sequence:



SEQUENCER WITH 3 SECOND INTERVAL

Note the delay produced by the 100u and 10k produces 3 seconds by the transistor inhibiting the 555 (taking pin 6 LOW). Learn more about the 555 - see the article: **"The 555"** on Talking Electronics website by clicking the title on the left index. See the article on CD 4017. See **"Chip Data eBook"** on TE website in the left index.

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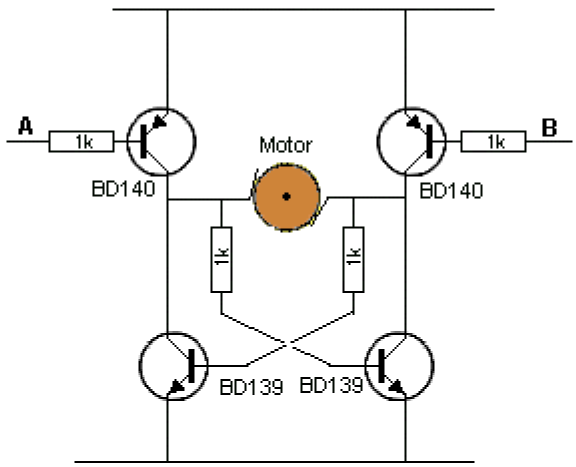
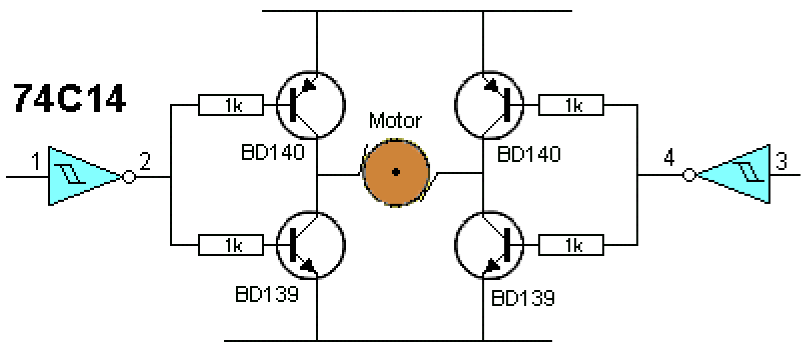
H-BRIDGE

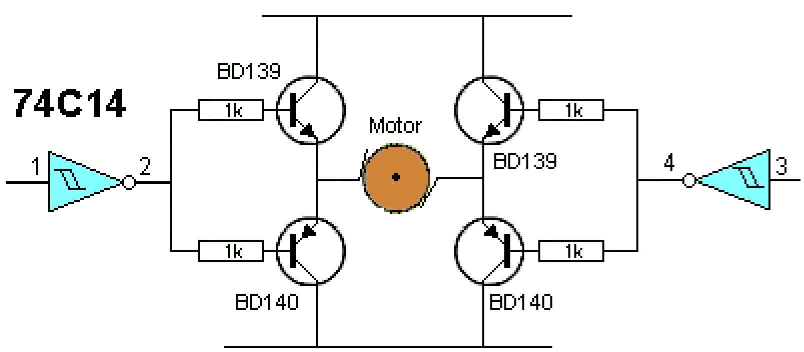
These circuits reverse a motor via two input lines. Both inputs must not be LOW with the first H-bridge circuit. If both inputs go LOW at the same time, the transistors will "short-out" the supply. This means you need to control the timing of the inputs. In addition, the current capability of some H-bridges is limited by the transistor types.



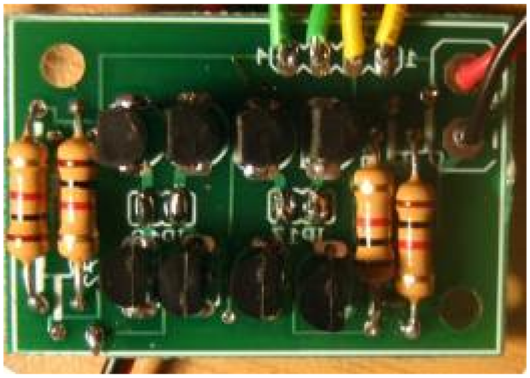
A and B must NEVER both be low



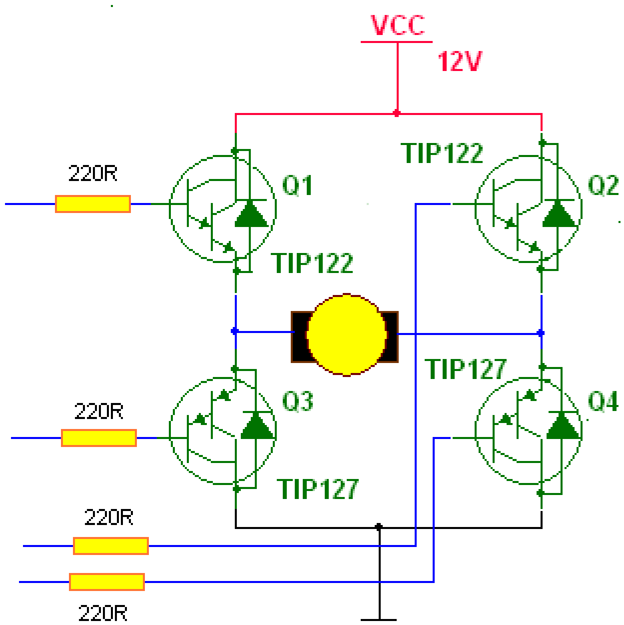
When A and B are equal, motor does not run



The driver transistors are in "emitter follower" mode in this circuit.



Two H-Bridges on a PC board



H-Bridge using Darlington transistors

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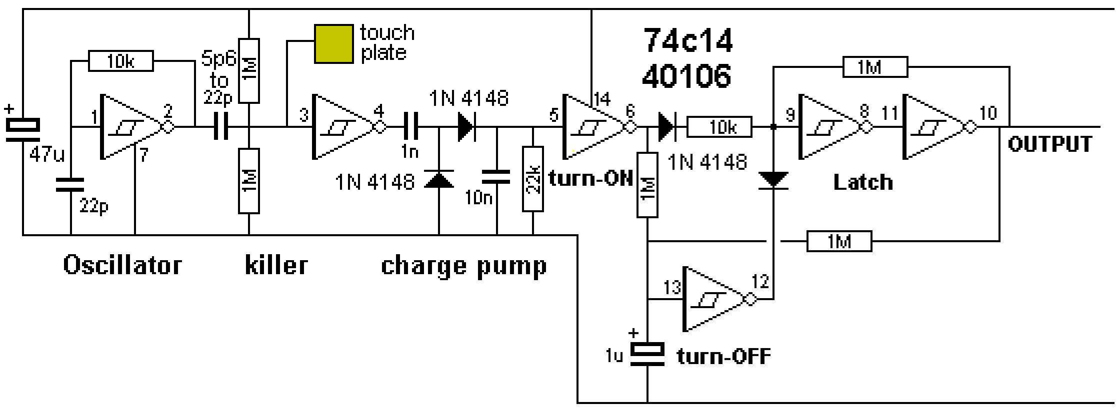
TOUCH-ON TOUCH-OFF SWITCH

This circuit will create a HIGH on the output when the Touch Plate is touched briefly and produce a low when the plate is touched again for a slightly longer period of time. Most touch switches rely on 50Hz mains hum and do not work when the hum is not present. This circuit does not rely on "hum."



TOUCH-ON TOUCH-OFF SWITCH

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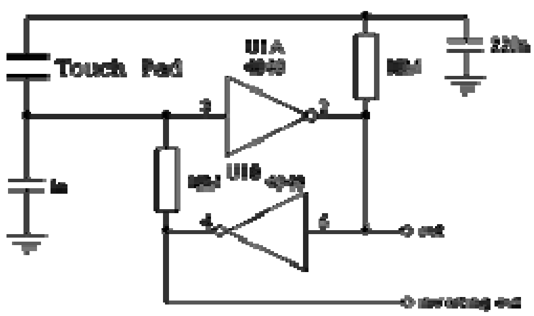
SIMPLE TOUCH-ON TOUCH-OFF SWITCH

This circuit will create a HIGH on the output when the Touch Plate is touched briefly and produce a low when the plate is touched again.



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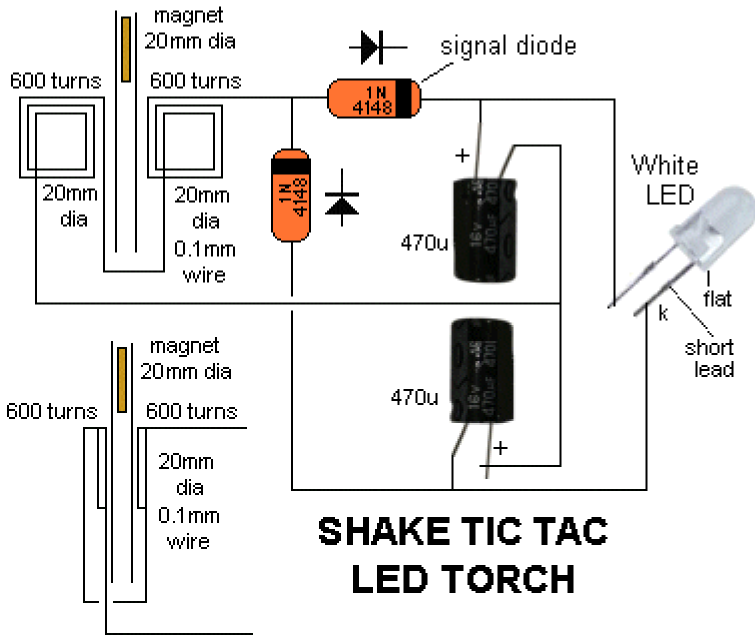
SHAKE TIC TAC LED TORCH



In the diagram, it looks like the coils sit on the "table" while the magnet has its edge on the table. This is just a diagram to show how the parts are connected. The coils actually sit flat against the slide (against the side of the magnet) as shown in the diagram: The output voltage depends on how quickly the magnet passes from one end of the slide to the other. That's why a rapid shaking produces a higher voltage. You must get the end of the magnet to fully pass though the coil so the voltage will be a maximum. That's why the slide extends past the coils at the top and bottom of the diagram.

The circuit consists of two 600-turn coils in series, driving a voltage doubler. Each coil produces a positive and negative pulse, each time the magnet passes from one end of the slide to the other.
The positive pulse charges the top electrolytic via the top diode and the negative pulse charges the lower electrolytic, via the lower diode.
The voltage across each electrolytic is combined to produce a voltage for the white LED. When the combined voltage is greater than 3.2v, the LED illuminates. The electrolytics help to keep the LED illuminated while the magnet starts to make another pass.

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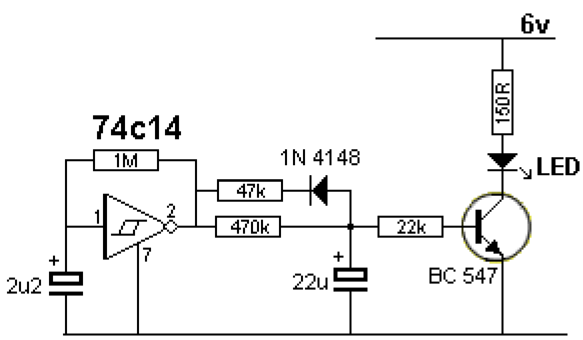
FADING LED

The circuit fades the LED ON and OFF at an equal rate. The 470k charging and 47k discharging resistors have been chosen to create equal on and off times.



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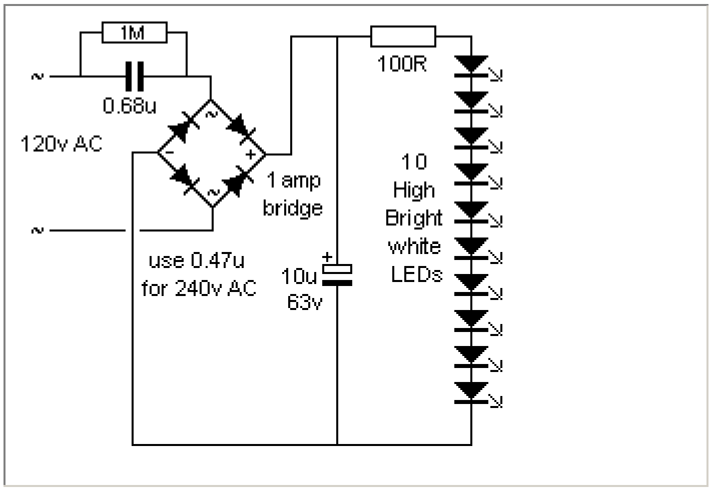
MAINS NIGHT LIGHT

The circuit illuminates a column of 10 white LEDs. The 10u prevents flicker and the 100R also reduces flicker.



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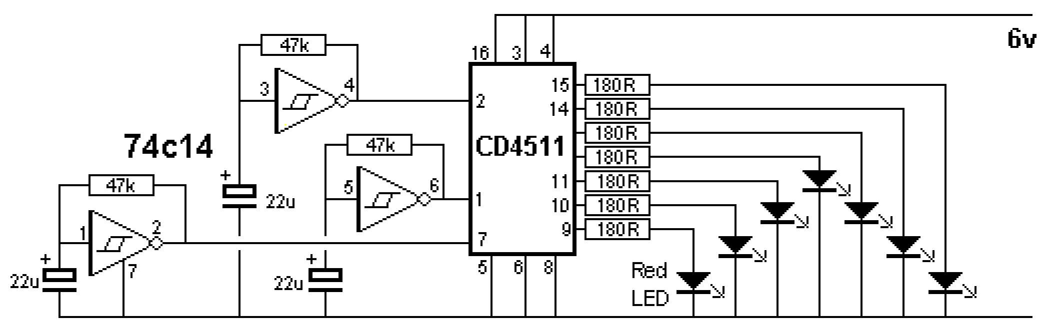
RANDOM BLINKING LEDS

This circuit blinks a set of LEDs in a random pattern according to the slight differences in the three Schmitt Trigger oscillators. The CD4511 is BCD to 7-segment Driver



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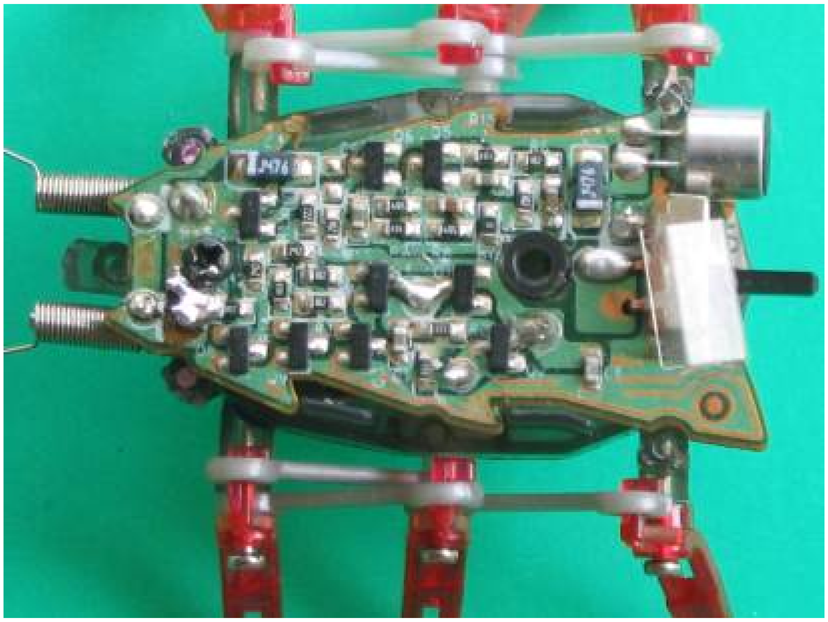
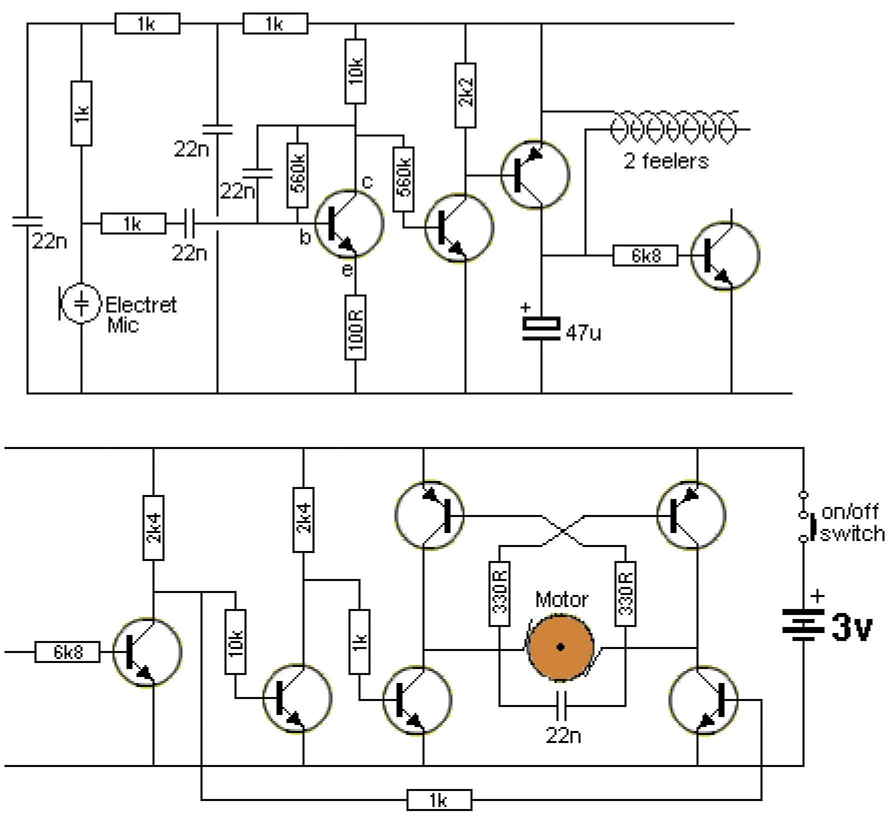
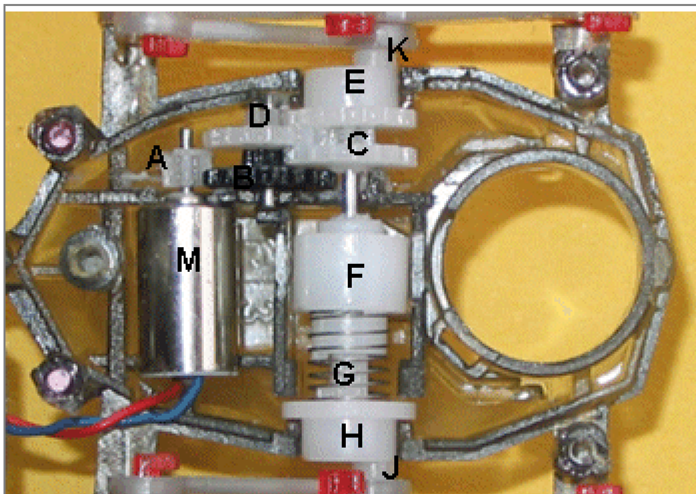
HEX BUG

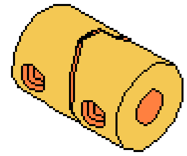
This is the circuit from a HEX BUG. It is a surface-mount bug with 6 legs. The pager motor is driven by an H-Bridge and "walks" to a wall where a feeler (consisting of a spring with a stiff wire down the middle) causes the motor to reverse.
In the forward direction, both sets of legs are driven by the compound gearbox but when the motor is reversed, the left legs do not operate as they are connected by a clutch consisting of a spring-loaded inclined plane that does not operate in reverse.
This causes the bug to turn around slightly.
The circuit also responds to a loud clap. The photo shows the 9 transistors and accompanying components:





HEX BUG CIRCUIT





Inclined Dog Clutch

HEX BUG

GEARBOX

Hex Bug gearbox consists of a compound gearbox with output "K" (eccentric pin) driving the legs. You will need to see the project to understand how the legs operate.
When the motor is reversed, the clutch "F" is a housing that is spring-loaded to "H" and drives "H via a square shaft "G". Gearwheel "C" is an idler and the centre of "F" is connected to "E" via the shaft. When "E" reverses, the centre of "F" consists of a driving inclined plane and pushes "F" towards "H" in a clicking motion. Thus only the right legs reverse and the bug makes a turn. When "E" is driven in the normal direction, the centre of "F" drives the outer casing "F" via an action called an "Inclined Dog Clutch" and "F" drives "G" via a square shaft and "G" drives "H" and "J" is an eccentric pin to drive the legs.
The drawing of an Inclined Dog Clutch shows how the clutch drives in only one direction. In the reverse direction it rides up on the ramp and "clicks" once per revolution. The spring "G" in the photo keeps the two halves together.

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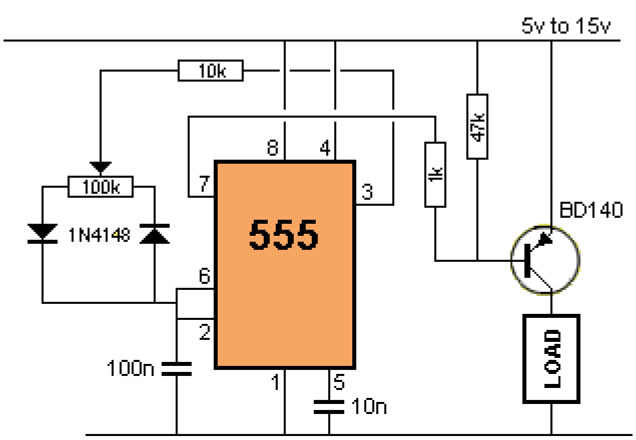
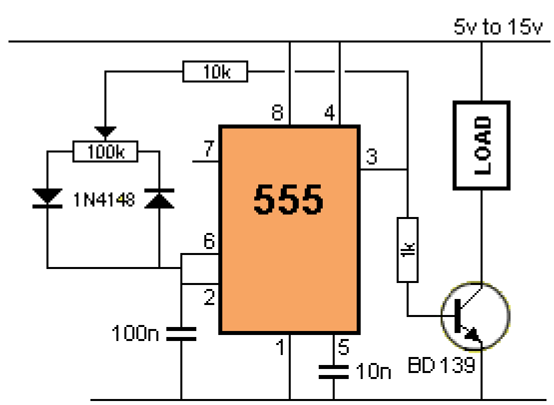
PWM CONTROLLER

This 555 based PWM controller features almost 0% to 100% pulse width regulation using the 100k variable resistor, while keeping the oscillator frequency relatively stable. The frequency is dependent on the 100k pot and 100n to give a frequency range from about 170Hz to 200Hz.





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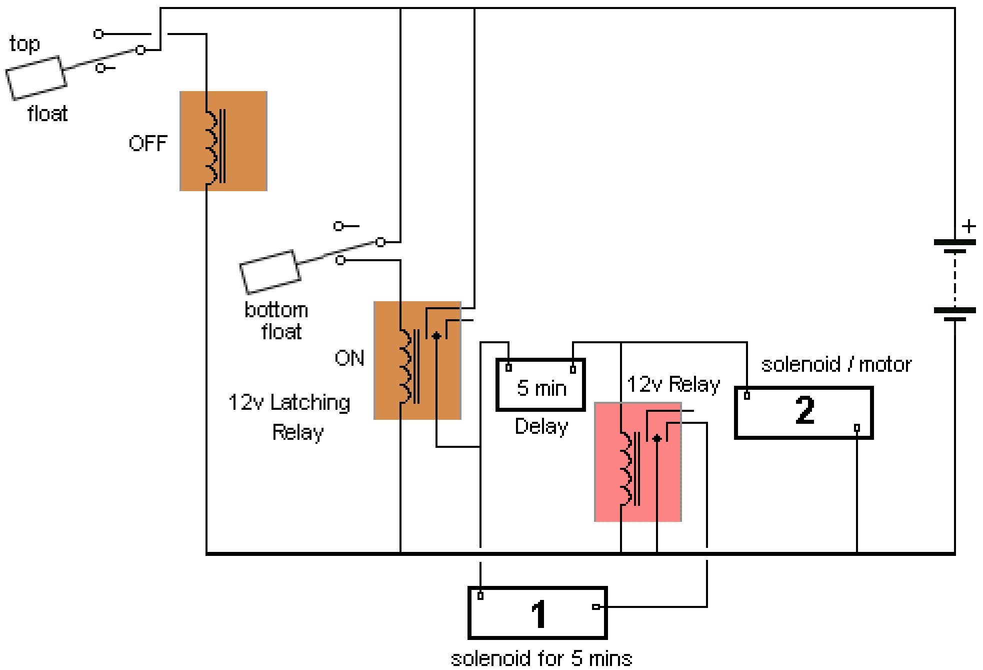
LIMIT SWITCHES

This circuit detects when the water level is low and activates solenoid (or pump) 1 for 5 minutes (adjustable) to allow dirty water to be diverted, before filling the tank via solenoid 2.



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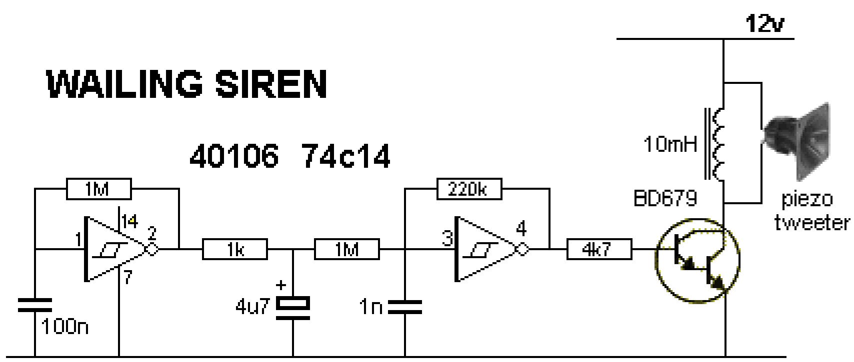
WAILING SIREN

This circuit produces a penetrating (deafening) up/down siren sound.



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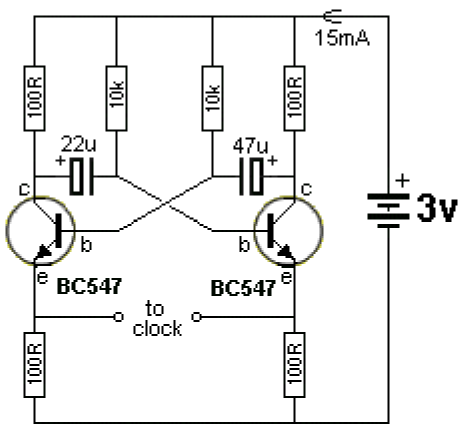
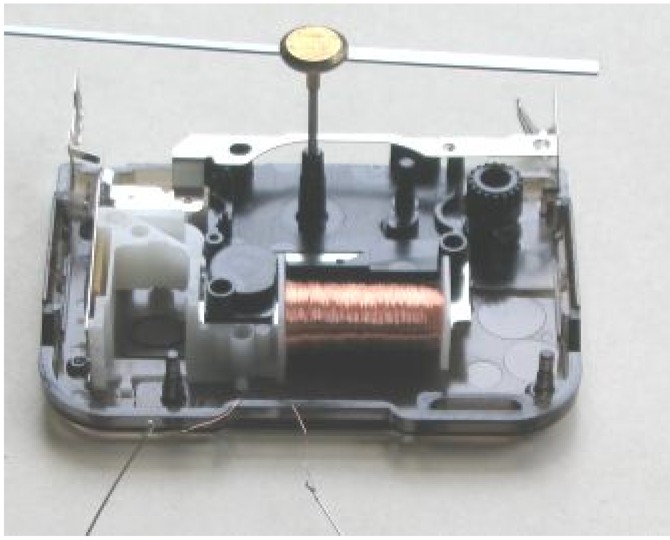
MODEL RAILWAY TIME

Here is a simpler circuit than MAKE TIME FLY from our first book of 100 transistor circuits.
For those who enjoy model railways, the ultimate is to have a fast clock to match the scale of the layout. This circuit will appear to "make time fly" by revolving the seconds hand once every 6 seconds.

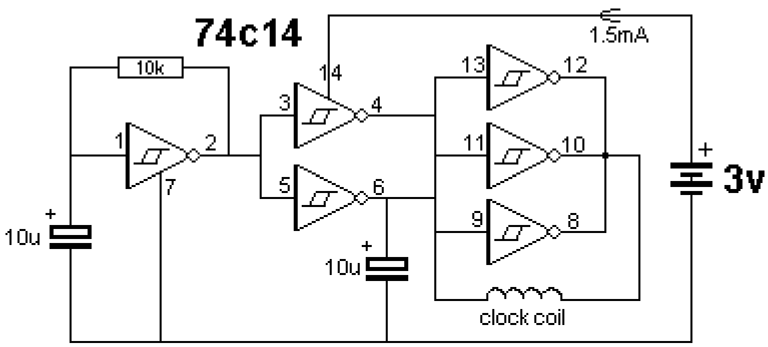
The timing can be adjusted by the electrolytics in the circuit. The electronics in the clock is disconnected from the coil and the circuit drives the coil directly. The circuit takes a lot more current than the original clock (1,000 times more) but this is the only way to do the job without a sophisticated chip.





Model Railway Time Circuit **Connecting the circuit to the clock coil**

For those who want the circuit to take less current, here is a version using a Hex Schmitt Trigger chip:



Model Railway Time Circuit using a 74c14 Hex Schmitt Chip

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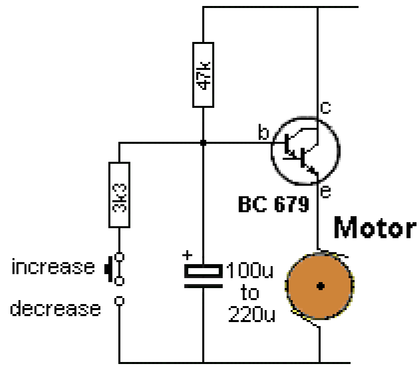
SLOW START-STOP
To make a motor start slowly and slow down slowly, this circuit can be used. The slide switch controls the action. The Darlington transistor will need a heatsink if the motor is loaded.



Slow Start-Stop Circuit

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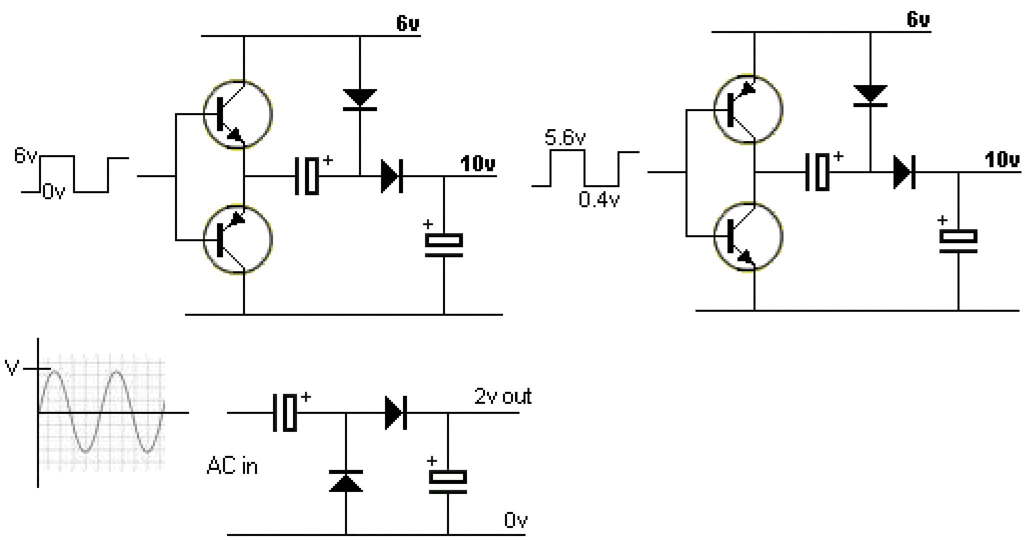
VOLTAGE MULTIPLIERS

The first circuit takes a square wave (any amplitude) and doubles it - minus about 2v losses in the diodes and base-emitter of the transistors.
The second circuit must rise to at least 5.6v and fall to nearly 0.4v for the circuit to work. Also the rise and fall times must be very fast to prevent both transistors coming on at the same time and short-circuiting.
The third circuit doubles an AC voltage. The AC voltage rises "V" volts above the 0v rail and "V" volts below the 0v rail.



VOLTAGE DOUBLER CIRCUITS

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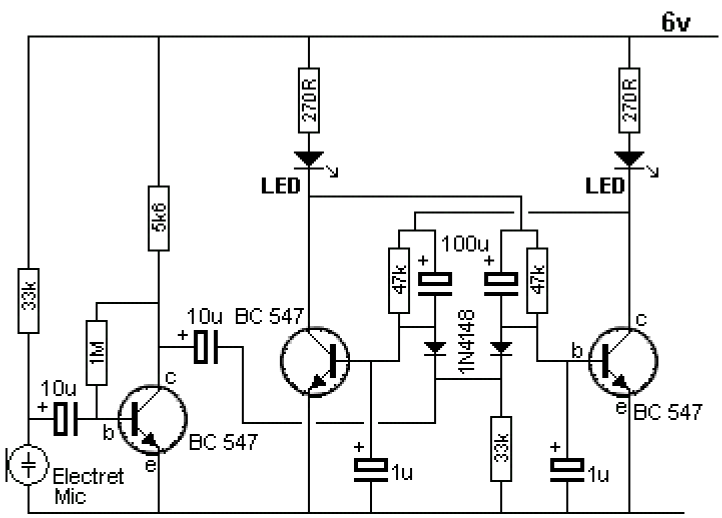
CLAP SWITCH

This circuit toggles the LEDs each time it detects a clap or tap or short whistle.
The second 10u is charged via the 5k6 and 33k and when a sound is detected, the negative excursion of the waveform takes the positive end of the 10u towards the 0v rail. The negative end of the 10u will actually go below 0v and this will pull the two 1N4148 diodes so the anode ends will have near to zero volts on them.
As the voltage drops, the transistor in the bi-stable circuit that is turned on, will have 0.6v on the base while the transistor that is turned off, will have zero volts on the base.

As the anodes of the two signal diode are brought lower, the transistor that is turned on, will begin to turn off and the other transistor will begin to turn on via its 100u and 47k. As it begins to turn on, the transistor that was originally turned on will get less "turn-on" from its 100u and 47k and thus the two switch over very quickly. The collector of the third transistor can be taken to a buffer transistor to operate a relay or other device.



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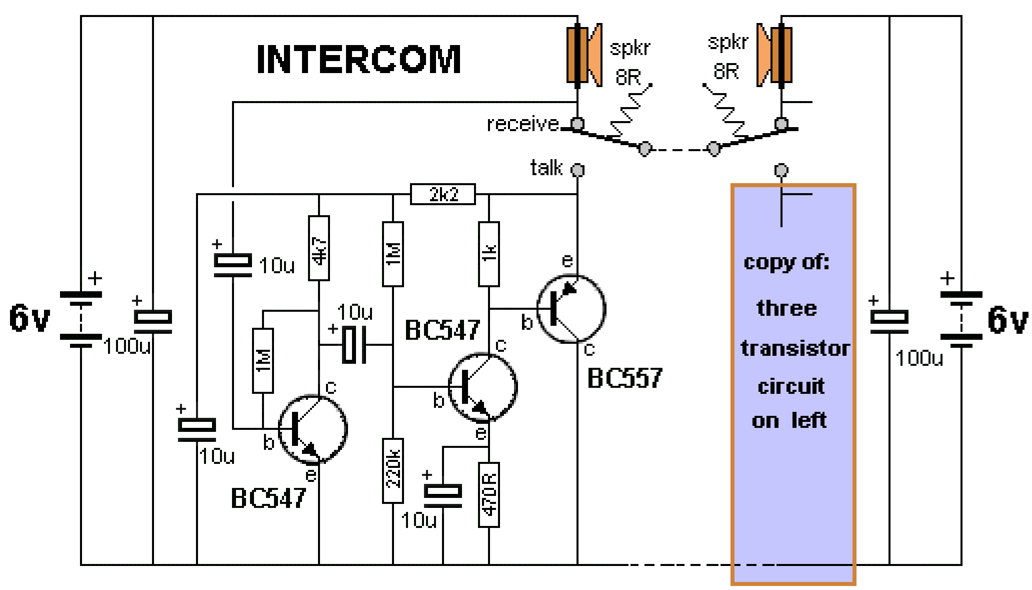
INTERCOM

Here is a 2-station intercom using common 8R mini speakers. The "press-to-talk" switches should have a spring-return so the intercom can never be left ON. The secret to preventing instability (motor-boating) with a high gain circuit like this is to power the speaker from a separate power supply! You can connect an extra station (or two extra stations) to this design.



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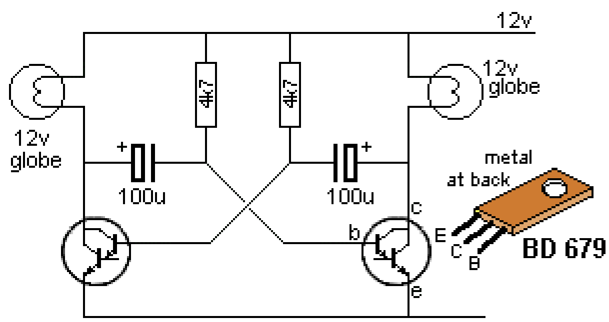
WARNING BEACON



Here is a 12v Warning Beacon suitable for a car or truck break- down on the side of the road. The key to the operation of the circuit is the high gain of the Darlington transistors. The circuit must be kept "tight" (thick wires) to be sure it will oscillate.
A complete kits of parts and PC board costs $5.00 plus postage from: Talking Electronics. Email **HERE** for details.

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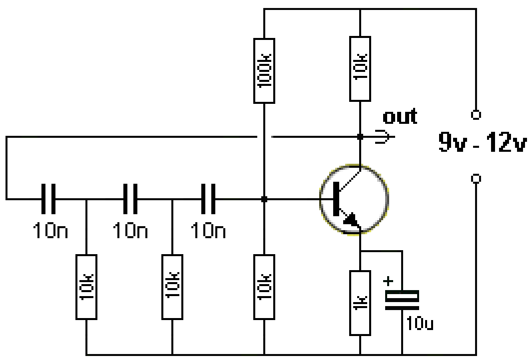
PHASE-SHIFT OSCILLATOR also called SINEWAVE OSCILLATOR



This circuit produces a sinewave very nearly equal to rail voltage.
The important feature is the need for the emitter resistor and 10u bypass electrolytic. It is a most-important feature of the circuit. It provides reliable start-up and guaranteed operation. For 6v operation, the 100k is reduced to 47k.
The three 10n capacitors and two 10k resistors (actually 3) determine the frequency of operation (700Hz).
The 100k and 10k base-bias resistors can be replaced with 2M2 between base and collector.
This type of circuit can be designed to operate from about 10Hz to about 200kHz.

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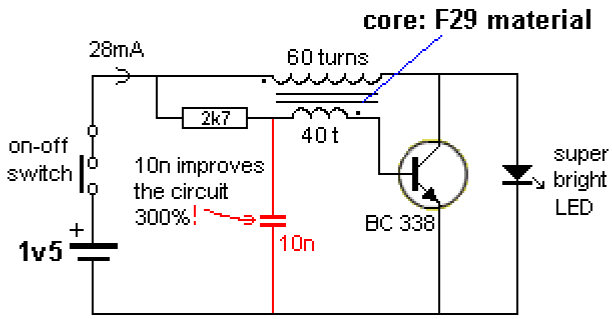
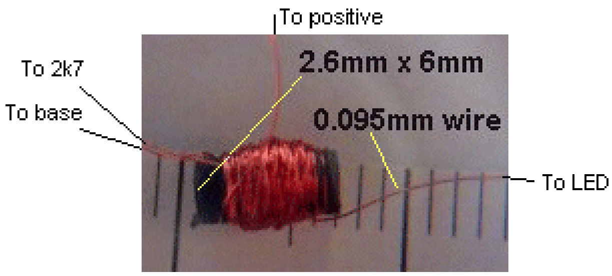
BLOCKING OSCILLATOR also called FLYBACK OSCILLATOR



LED TORCH CIRCUIT



Transformer Details

The circuit produces high voltage pulses (spikes) of about 40v p-p (when the LED is not connected), at a frequency of 200kHz. The super-bright LED on the output absorbs the pulses and uses the energy to produce illumination. The voltage across the LED will be about 3.6v
The winding to the base is connected so that it turns the transistor ON harder until it is saturated. At this point the flux cannot increase any more and the transistor starts to turn off. The collapsing magnetic field in the transformer produces a very high voltage and that's why we say the transformer operates in FLYBACK mode.
This type of circuit will operate from 10kHz to a few MHz.

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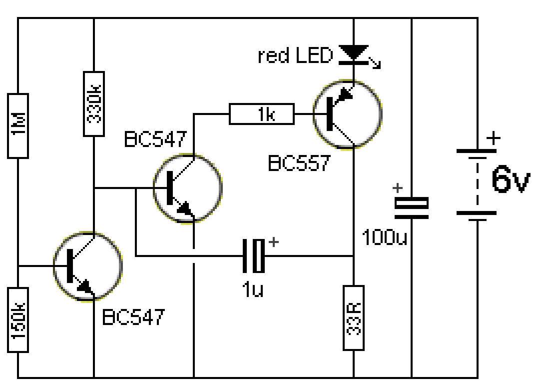
LOW VOLTAGE FLASHER



This circuit flashes when the voltage drops to 4v. The voltage "set-point" can be adjusted by changing the 150k on the base of the first transistor.

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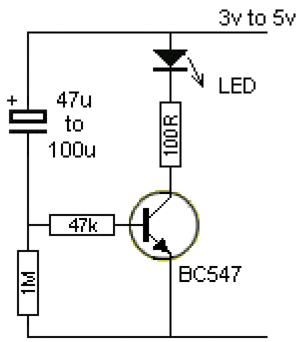
POWER ON



This LED illuminates for a few seconds when the power is turned on. The circuit relies on the 47u discharging into the rest of the circuit so that it is uncharged when the circuit is turned on again.

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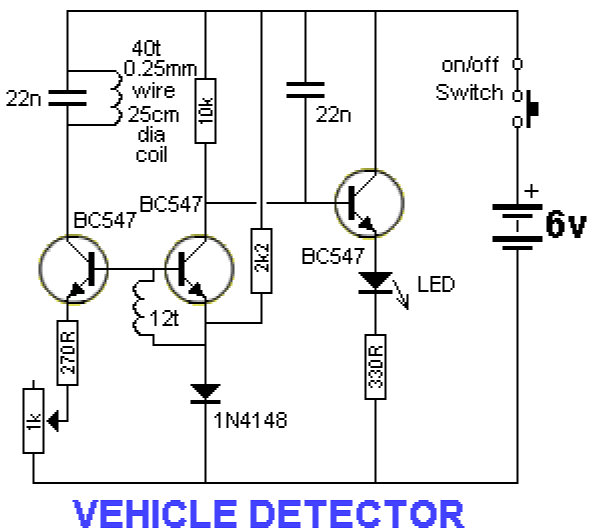
CAR LOOP DETECTOR



A 25cm dia coil (consisting of 40 turns and 12 turns) is placed in the centre of a driveway (between two sheets of plastic). When a vehicle is driven over the coil, it responds by the waveform collapsing. This occurs because the tank circuit made up of the 40 turns is receiving just enough feedback signal from the 12 turns to keep it oscillating. When metal is placed near the coil, it absorbs some of the electromagnetic waves and the amplitude decreases. This reduces the amplitude in the 12 turns and the oscillations collapses. The second transistor turns off and the 10k pulls the base of the third transistor (an emitter-follower) to the 6v rail and turns on the LED.

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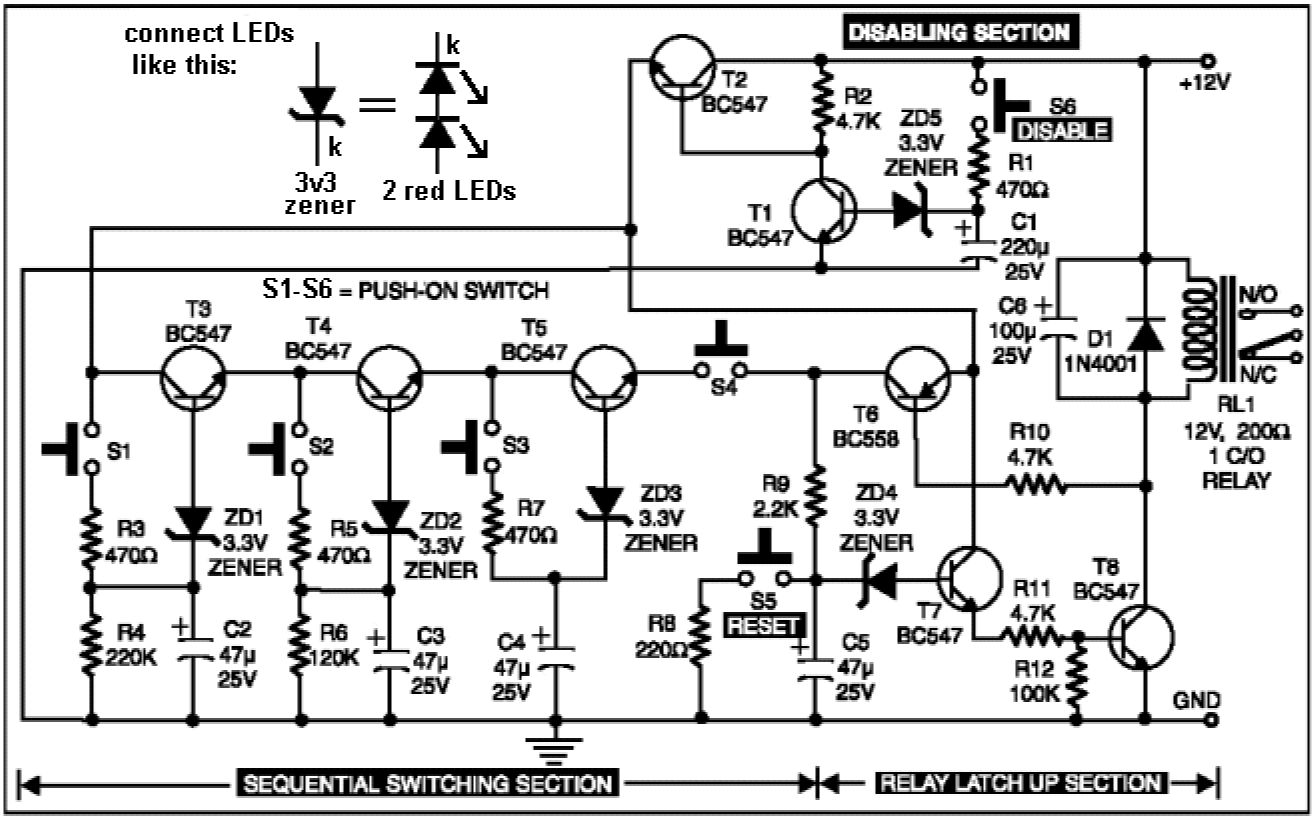
ALARM USING 4-BUTTONS



To open the lock, buttons S1, S2, S3, and S4 must be pressed in this order. They must be pressed for more than 0.7 seconds and less than 1.3 seconds.
Reset button S5 and disable button S6 are also included with the other buttons and if the disable button is pressed, the circuit will not accept any code for 60 seconds. Each of the 3v3 zeners can be replaced with two red LEDs and this will show how you are progressing through the code. Make sure the LEDs are not visible to other users.

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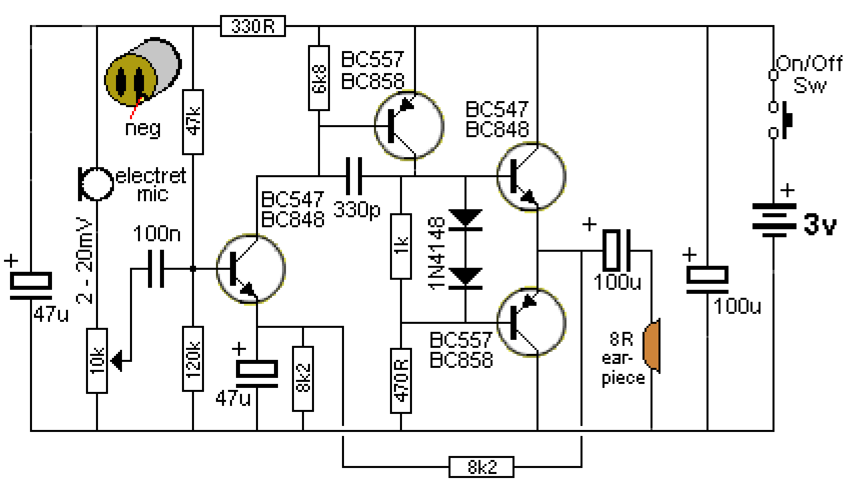

AUDIO AMPLIFIER (mini)

This project is called "mini" because its size is small and the output is small.
It uses surface mount technology.

HOW THE CIRCUIT WORKS

The output is push-pull and consumes less than 3mA (with no signal) but drives the earpiece to a very loud level when audio is detected.
The whole circuit is DC coupled and this makes it extremely difficult to set up. Basically you don't know where to start with the biasing. The two most critical components are 8k2 between the emitter of the first transistor and 0v rail and the 470R resistor.
The 8k2 across the 47u sets the emitter voltage on the BC 547 and this turns it on. The collector is directly connected to the base of a BC 557, called the driver transistor. Both these transistors are now turned on and the

output of the BC 557 causes current to flow through the 1k and 470R resistors so that the voltage developed across each resistor turns on the two output transistors. The end result is mid-rail voltage on the join of the two emitters.
The 8k2 feedback resistor provides major negative feedback while the 330p prevents high-frequency oscillations occurring.

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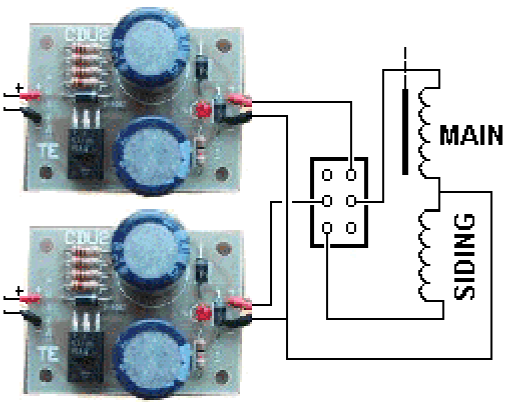
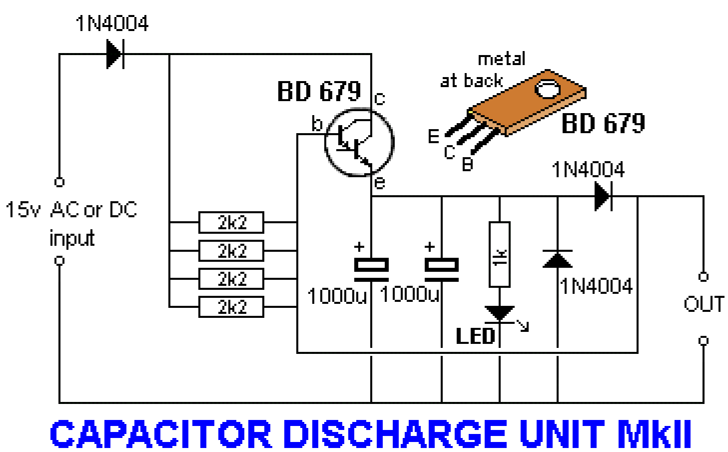
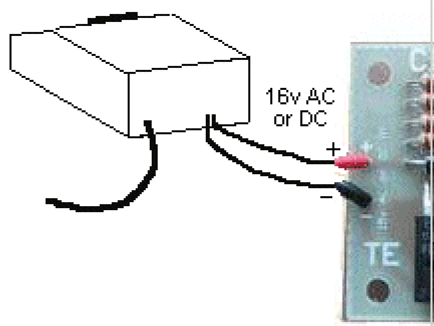


CAPACITOR DISCHARGE UNIT MkII (CDU2)

This project is available as a kit for $10.80 plus $6.50 post. email Talking Electronics for details.

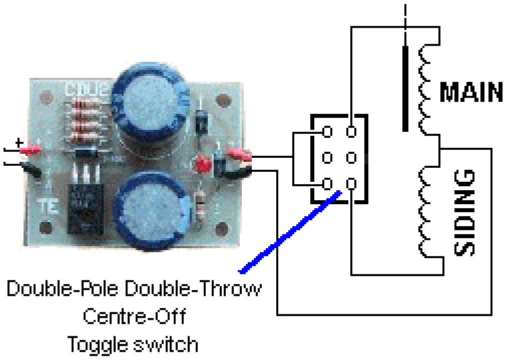




This circuit will operate a two-solenoid point-motor and prevent it overheating and causing any damage. The circuit produces energy to change the points and ceases to provide any more current. This is carried out by the switching arrangement within the circuit, by sampling the output voltage.
If you want to control the points with a DPDT toggle switch or slide switch, you will need two CDU2 units.

HOW THE CIRCUIT WORKS

The circuit is supplied by 16v AC or DC and the diode on the input is used to rectify the voltage if AC is supplied. If nothing is connected to the output, the base of the BD679 is pulled high and the



emitter follows. This is called an emitter-follower stage. The two 1,000u electrolytics charge and the indicator LED turns on. The circuit is now ready. When the Main or Siding switch is pressed, the energy from the electrolytics is passed to the point motor and the points change. As the output voltage drops, the emitter-follower transistor is turned off and when the switch is released, the electrolytics start to charge again.

The point-motor can be operated via a Double-Pole Double-Throw Centre-Off toggle switch, providing the switch is returned to the centre position after a few seconds so that the CDU unit can charge-up.

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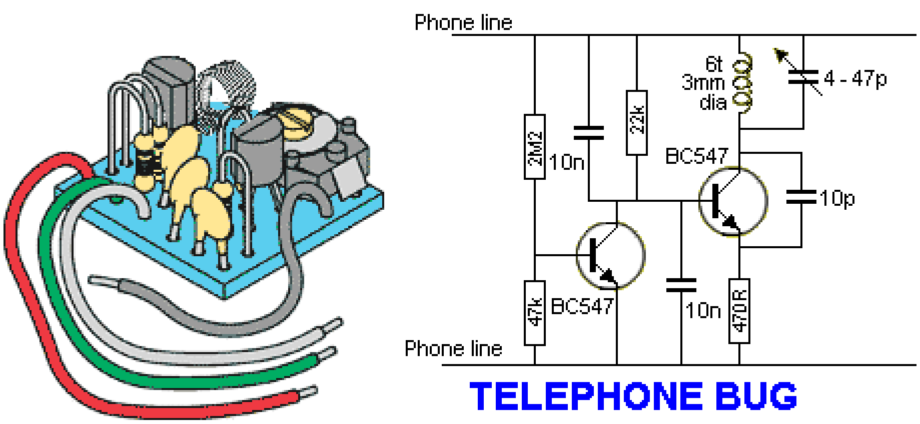
PHONE BUG

This circuit connects to a normal phone line and when the voltage drops to less than 15v, the first transistor is turned off and enables the second transistor to oscillate at approx 100MHz and transmit the phone conversation to a nearby FM radio.



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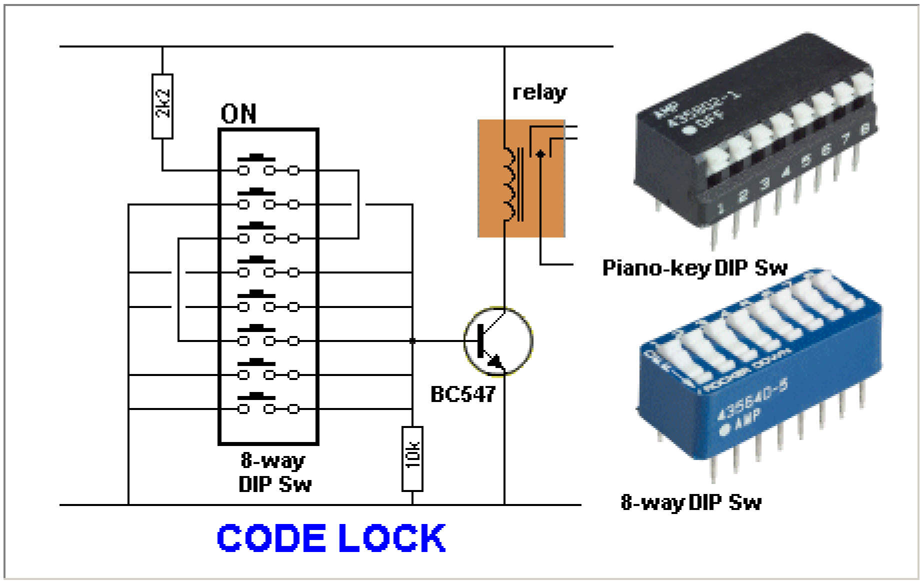
CODE LOCK

This circuit turns on a relay when the correct code is entered on the 8-way DIP switches. Two different types of DIP switches are shown.
Keep the top switch off and no current will be drawn by the circuit.
There are 256 different combinations and because the combination is in binary, it would be very difficult for a burglar to keep up with the settings of the switches.



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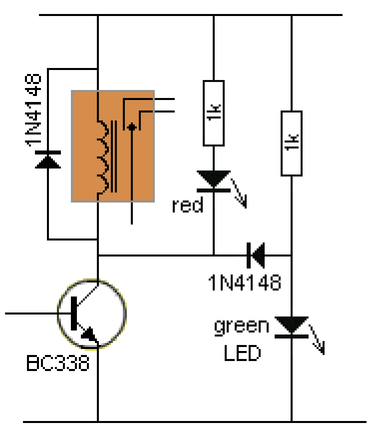
LEDS SHOW RELAY STATE

The green LED indicates the relay is not energised and the red LED shows the relay is energised.



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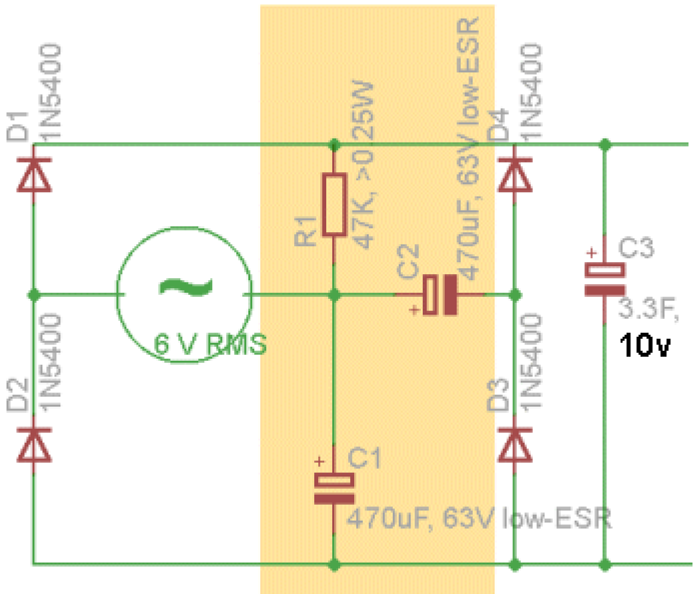
VOLTAGE DOUBLER



This is a voltage doubler circuit from a bicycle dynamo design found on the web. The dynamo produces 6v AC and charges a 3.3FARAD super cap via 2 diodes and an electrolytic. As you will see, C2, D3 and D4 are not needed and can be removed.
This is how the circuit works.
The voltage at the mid point of diodes D1 and D2 can fall to -0.6v and rise to rail voltage plus 0.6v without any current being supplied from the dynamo.
When the voltage rises more than 0.6v above rail voltage, the dynamo needs to deliver current and this will allow the rail voltage to increase. We start with the dynamo producing negative from the left side and positive on the right side.
The left side will fall to -0.6v below the 0v rail and the right side will charge C1 and C2 will simply rise in exactly the same manner as we described the left side of the dynamo being able to rise.
Suppose C1 charges to about 7v (which it will be able to do after a few cycles). The voltage from the dynamo now reverses and the left side is positive and the right side is negative. The right side is already sitting at a potential of 7v (via C1) and as the left side increases, it raises the rail voltage higher by an amount that could be as high as 7v minus 0.6v.
The actual rail voltage will not be as high as this as the 3.3 Farad capacitor will be charging, but if energy is not taken from the circuit it will rise to nearly 14v or even higher according to the peak voltage delivered by the dynamo.
When the dynamo is delivering energy to the positive rail, it is "pushing down" on the C1 and some of its stored energy is also delivered. This means it will have a lower voltage across it when the next cycle comes around. C2, D3 and D4 are not needed and can be removed. In fact, C1 will always have rail voltage on it due to the 47 resistor, so the voltage doubling will start as soon as the dynamo operates.

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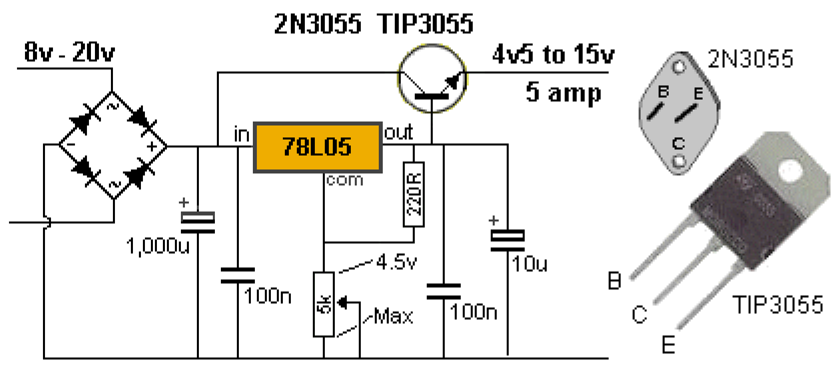
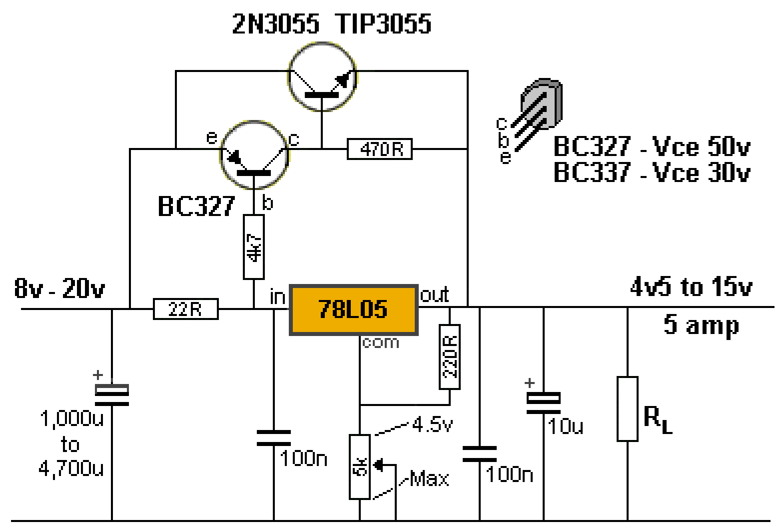
Adjustable High Current Regulated Power Supply

There are two ways to add a 2N3055 (TIP3055) as the pass transistor for a high current power supply. This is handy as most hobbyists will have one of these in their parts box.





RL must be low enough to guarantee at least a 30mA. It can be a separate resistor or part of the actual load.

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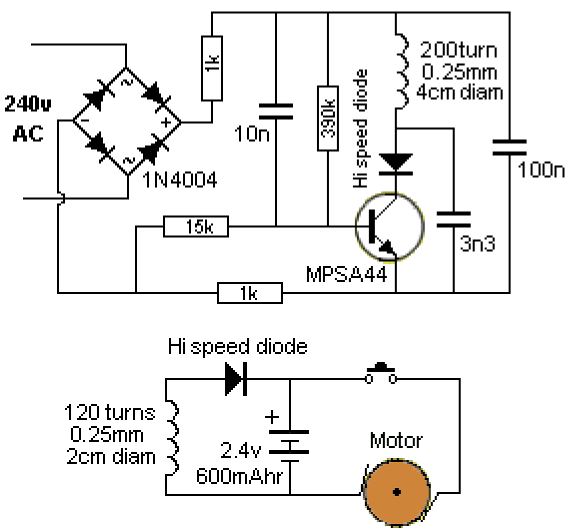
INDUCTIVELY COUPLED POWER SUPPLY

This circuit is from an Interplak Model PB-12 electric toothbrush.
A coil in the charging base (always plugged in and on) couples to a mating coil in the hand unit to form a step down transformer. The MPSA44 transistor is used as an oscillator at about 60 kHz which results in much more efficient energy transfer via the air core coupling than if the system were run at 50 or 60Hz. The amplitude of the oscillations varies with the full wave rectified 100Hz or 120Hz unfiltered DC.



The battery charger is nothing more than a diode to rectify the signal from the 120 turn coil in the charging base. Thus the battery is in constant trickle charge as long as the hand unit is in the base. The battery pack is a pair of 600mAhr AA NiCd cells.

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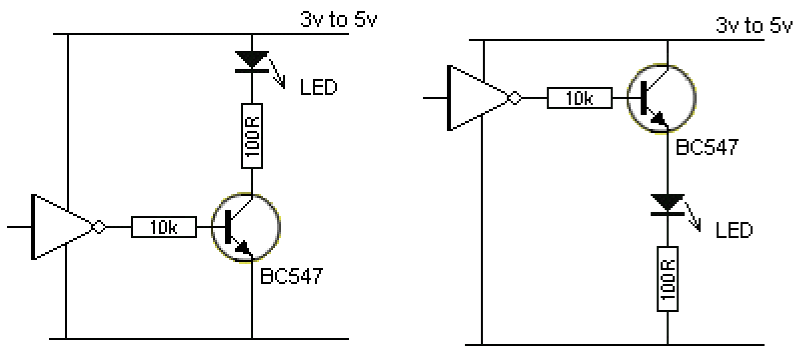
POWERING A LED

Sometimes the output of a gate does not have sufficient current to illuminate a LED to full brightness.
Here are two circuits. The circuits illuminate the LED when the output signal is HIGH. Both circuits operate the same and have the same effect on loading the output of the gate.



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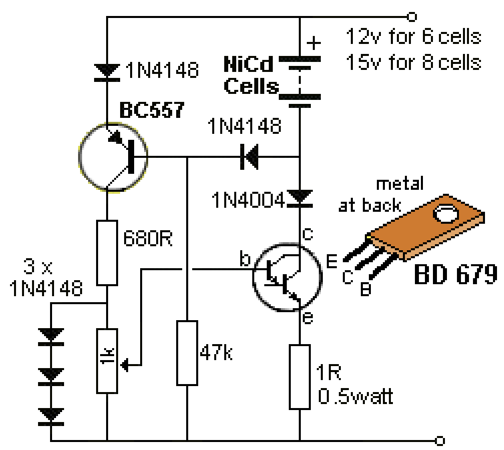
NiCd BATTERY CHARGER

This NiCd battery charger can charge up to 8 NiCd cells connected in series. This number can be increased if the power supply is increased by 1.65v for each additional cell. If the BD679 is mounted on a good heatsink, the input voltage can be increased to a maximum of 25v. The circuit does not discharge the battery if the charger is disconnected from the power supply.
Usually NiCd cells must be charged at the 14 hour rate. This is a charging current of 10% of the capacity of the cell for 14 hours. This applies to a nearly flat cell. For

example, a 600 mAh cell is charged at 60mA for 14 hours. If the charging current is too high it will damage the cell. The level of charging current is controlled by the 1k pot from 0mA to 600mA. The BC557 is turned on when NiCd cells are connected with the right polarity. If you cannot obtain a BD679, replace it with any NPN medium power Darlington transistor having a minimum voltage of 30v and a current capability of 2A. By lowering the value of the 1 ohm resistor to 0.5 ohm, the maximum output current can be increased to 1A.



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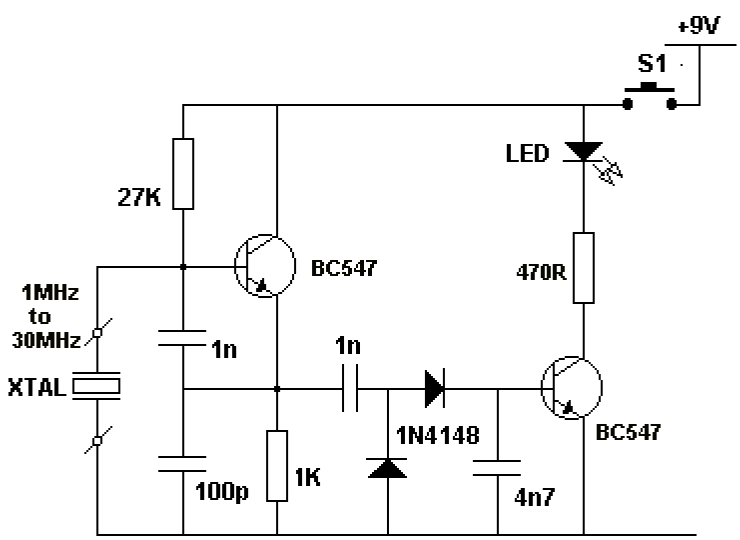
CRYSTAL TESTER

This circuit will test crystals from 1MHz to 30MHz. When the crystal oscillates, the output will pass through the 1n capacitor to the two diodes. These will charge the 4n7 and turn on the second transistor. This will cause the LED to illuminate.



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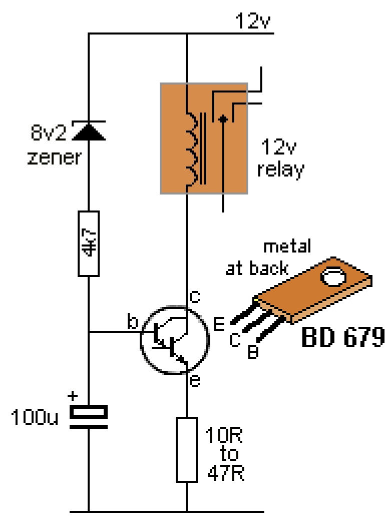
LOW VOLTAGE CUT-OUT

This circuit will detect when the voltage of a 12v battery reaches a low level. This is to prevent deep-discharge or maybe to prevent a vehicle battery becoming

discharged to a point where it will not start a vehicle. This circuit is different to anything previously presented. It has HYSTERESIS. Hysteresis is a feature where the upper and lower detection-points are separated by a gap.
Normally, the circuit will deactivate the relay when the voltage is 10v and when the load is removed. The battery voltage will rise slightly by as little as 50mV and turn the circuit ON again. This is called "Hunting." The off/on timing has been reduced by adding the 100u. But to prevent this totally from occurring, a 10R to 47R is placed in the emitter lead. The circuit will turn off at 10v but will not turn back on until 10.6v when a 33R is in the emitter.
The value of this resistor and the turn-on and turn-off voltages will also depend on the resistance of the relay.



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Circuit Symbols

The list below covers almost every symbol you will find on an electronic circuit diagram. It allows you to identify a symbol and also draw circuits. It is a handy reference and has some symbols that have never had a symbol before, such as a Flashing LED and electroluminescence panel.
Once you have identified a symbol on a diagram you will need to refer to specification sheets to identify each lead on the actual component.
The symbol does not identify the actual pins on the device. It only shows the component in the circuit and how it is wired to the other components, such as input line, output, drive lines etc. You cannot relate the shape or size of the symbol with the component you have in your hand or on the circuit-board.
Sometimes a component is drawn with each pin in the same place as on the chip etc. But this is rarely the case.
Most often there is no relationship between the position of the lines on the circuit and the pins on the component.

That’s what makes reading a circuit so difficult.

This is very important to remember with transistors, voltage regulators, chips and so many other components as the position of the pins on the symbol are not in the same places as the pins or leads on the component and sometimes the pins have different functions according to the manufacturer. Sometimes the pin numbering is different according to the component, such as positive and negative regulators.
These are all things you have to be aware of.

You must to refer to the manufacturer’s specification sheet to identify each pin, to be sure you have identified them correctly.

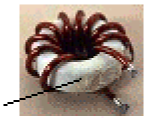
Colin Mitchell

CIRCUIT SYMBOLS

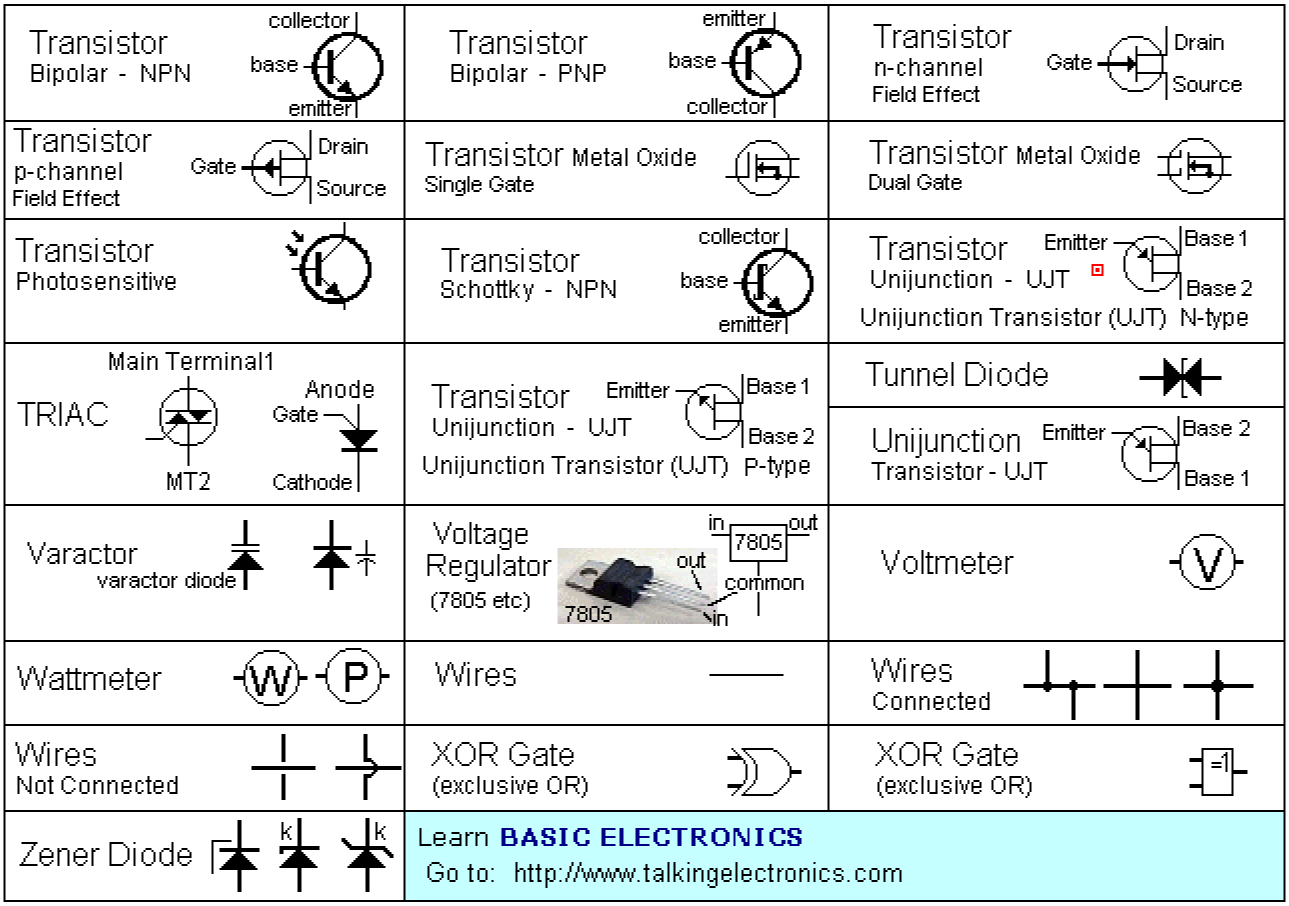
Some additional symbols have been added to the following list. See **Circuit Symbols** on the index of Talking Electronics.com

CIRCUIT SYMBOLS by TALKING ELECTRONICS

AC current: voltage:	ALTERNISTOR TRIAC A TRIAC and 33 - 43v DIAC Main Terminal1 Gate Main Terminal 2	Ammeter (amp meter)
AND Gate	AND Gate	Antenna balanced
Antenna Loop, Shielded	Antenna Loop, Unshielded	Antenna unbalanced
Attenuator, fixed (see Resistor)	Attenuator, variable (see Resistor)	Battery
Bilateral Switch (DIAC)	Bridge Rectifier (Diode Bridge)	BUFFER (Amplifier Gate)
BUFFER (Amplifier Gate)	Buzzer	Capacitor feedthrough
Capacitor non-polarised	Capacitor polarised (see electrolytic)	Capacitor Variable
Cavity Resonator	Cell	Circuit Breaker
Coaxial Cable	CRO – Cathode Ray Oscilloscope	Crystal Microphone (Piezoelectric)
Connectors Plug (male) Jack (female) connected Plug (male) (female)	Crystal Piezoelectric	DC current: voltage:
	Darlington Transistor collector base emitter	Delay Line
	DIAC (Bilateral Switch)	Diode
Diode - Gunn	Diode - Light Emitting (LED)	Diode Photo Sensitive
Diode Photovoltaic	Diode Bridge (Bridge Rectifier)	Diode - Pin
Diode - Varactor	Diode - Zener	Earth Ground
Earpiece (earphone, crystal earpiece)	Electroluminescence el	Electret Microphone (Condenser mic)
Electrolytic (Polarised Capacitor) alternate symbols: (positive on top)	Electrolytic - Tanatalum positive end black band or chamfer 10u tantalum	Exclusive-OR Gate (XOR Gate) Exclusive-OR Gate (XOR Gate)
Field Effect Transistor Gate Drain	Field Effect Transistor Drain	Flashing LED

Ferrite Bead	Fuse	Galvanometer
Globe	Ground Chassis	Ground Earth
Heater (immersion heater) (cooker etc)	IC Integrated Circuit power ground	Inductor Air Core
Headphone		Inductor Iron Core or ferrite core 
Inductor Tapped	Inductor Variable	Integrated Circuit 
Inverter (NOT Gate)	INVERTER (NOT Gate)	
Jack Co-axial	Jack Phone (Phone Jack)	Jack Phone (Switched)
Jack Phone (3 conductor)	Key Telegraph (Morse Key)	Lamp Incandescent
Lamp - Neon	LASCR (Light Activated Silicon Controlled Rectifier)	LDR (Light Dependent Resistor)
LASER diode laser diode photo diode	Light Emitting Diode (LED) 	Light Emitting Diode (LED - flashing) (Indicates chip inside LED)
Mercury Switch	Micro-amp meter (micro-ammeter)	Microphone (see Electret Mic) 
Microphone (Crystal - piezoelectric)	Milliamp meter (milli-ammeter)	Motor
NAND Gate	NAND Gate	Nitinol wire "Muscle wire"
Negative Voltage Connection	NOR Gate	NOR Gate
NOT Gate Inverter	NOT Gate Inverter	Ohm meter
Operational Amplifier (Op Amp)	Optocoupler (Transistor output)	Opto Coupler (Opto-isolator) a c k e Photo-transistor output
Optocoupler (Darlington output)	Opto Coupler (Opto-isolator) a c k e TRIAC output	OR Gate
OR Gate	Oscilloscope see CRO	Outlet (Power Outlet)
Piezo Diaphragm	Photo Cell (photo sensitive resistor)	Photo Diode
Photo Darlington Transistor	Photo FET Gate Drain Source (Field Effect Transistor)	Photo Transistor

Photovoltaic Cell (Solar Cell) + λ +	Piezo Tweeter (Piezo Speaker)	Positive Voltage Connection +
Potentiometer (variable resistor)	Programmable Unijunction Transistor PUT gate anode cathode	Rectifier Silicon Controlled (SCR) Anode Gate Cathode
Rectifier Semiconductor k	Reed Switch N	Relay - spst
Relay - spdt	Relay - dpst	Relay - dpdt
Resistor Fixed	Resistor Non Inductive	Resistor preset
Resistor variable	Resonator 3-pin	RFC Radio Frequency Choke
Rheostat (Variable Resistor)	Saturable Reactor	Schmitt Trigger (Inverter Gate)
Schottky Diode k k (also Shottky) Low forward voltage 0.3v Fast switching also called Schottky Barrier Diode	Shielding Signal Generator	Shockley Diode k 4-layer PNPN device Remains off until forward current reaches the forward break-over voltage.
Silicon Bilateral Switch (SBS) T_2 Terminal Gate T_1 Terminal e.g: BS08D T_2 G T_1	Silicon Unilateral Switch (SUS) Anode Gate Cathode(k) A G k	Silicon Controlled Rectifier (SCR) Anode Gate Cathode Solar Cell + λ +
Surface Mount c SOT-23 b e b c e b c e k k k A no connection & LED	Switch - spst Switch - spdt Switch - dpst Switch - dpdt Switch - mercury tilt switch Spark Gap	Switch - process activated normally open: normally closed: Flow Level Pressure Temperature Speaker 8R
Switch - push (Push Button)	Switch - push off (used in alarms etc)	Switch - Rotary
Test Point Thermal Probe NTC t° = ? NTC: as temp rises, resistance decreases	Thyristors: Main Terminal1 Bilateral Switch Anode Gate Cathode MT2 Anode Gate Cathode DIAC SCR TRIAC TRIAC	Thermocouple Tilt switch mercury Touch Sensor
Transformer	Transformer	Transformer



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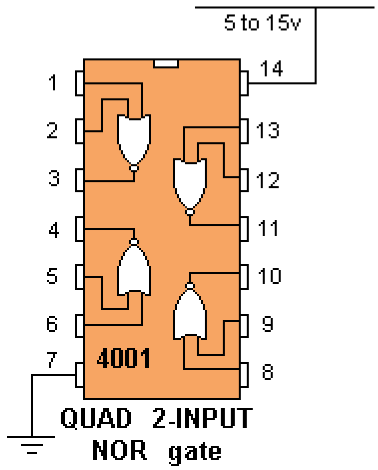
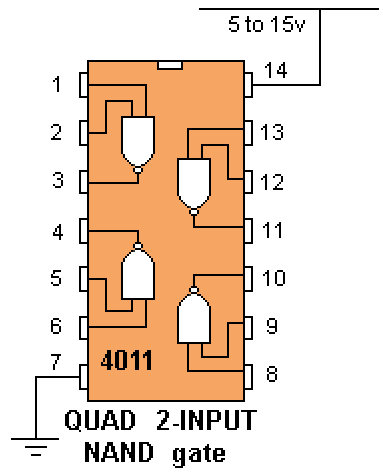
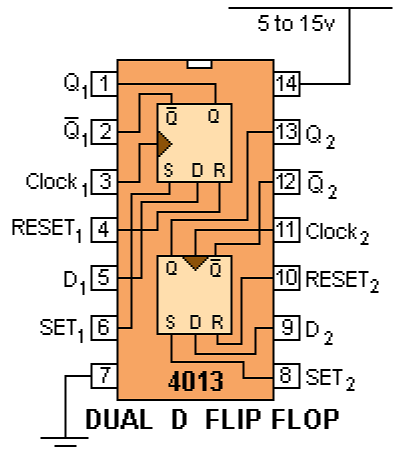
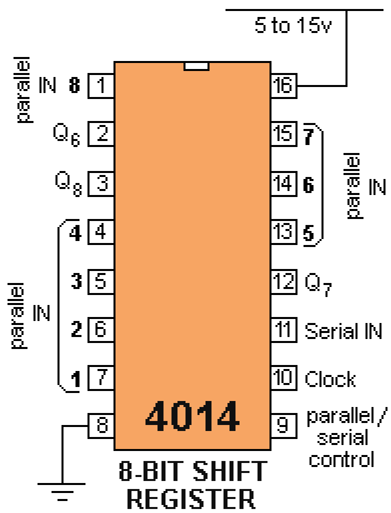
IC PINOUTS

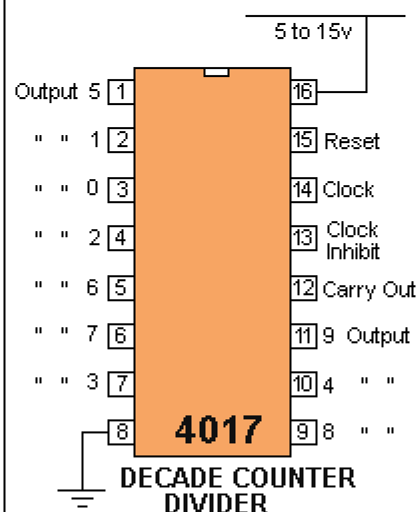
The following list covers just a few of the IC's on the market and these are the "simple" or "basic" or "digital" or "op-amp" IC's suitable for experimenting.
When designing a circuit around an IC, you have to remember two things:
1. Is the IC still available? and
2. Can the circuit be designed around a microcontroller?
Sometimes a circuit using say 3 or 4 IC's can be re-designed around an 8-pin or 16-pin microcontroller and the program can be be kept from prying eyes due to a feature called "code protection." A microcontroller project is more up-to-date, can be cheaper and can be re-programmed to alter the features.
This will be covered in the next eBook. It is worth remembering - as it is the way of the future.

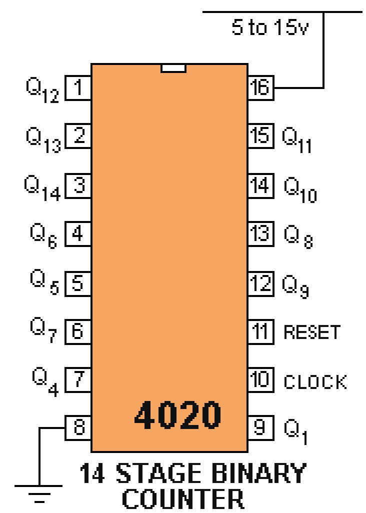

5 to 15v
1
2
3
4
5
6
7
14
13
12
11
10
9
8
4001
QUAD 2-INPUT
NOR gate

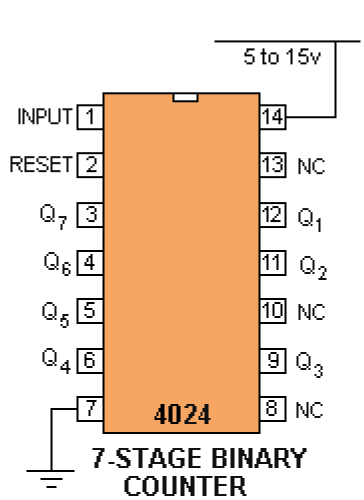

5 to 15v
1
2
3
4
5
6
7
14
13
12
11
10
9
8
4011
QUAD 2-INPUT
NAND gate

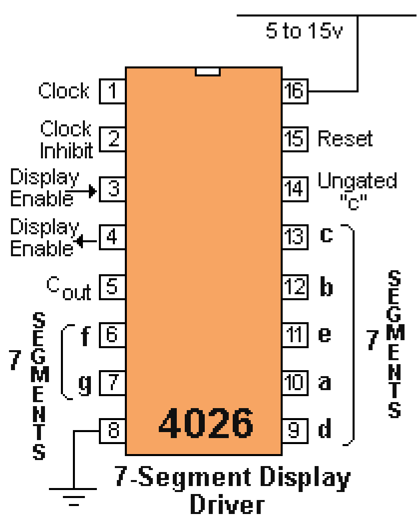

5 to 15v
Q_1 1
$\bar{Q}_1$ 2
Clock$_1$ 3
RESET$_1$ 4
D_1 5
SET$_1$ 6
7
14
13 Q_2
12 $\bar{Q}_2$
11 Clock$_2$
10 RESET$_2$
9 D_2
8 SET$_2$
$\bar{Q}$ Q
S D R
Q $\bar{Q}$
S D R
4013
DUAL D FLIP FLOP

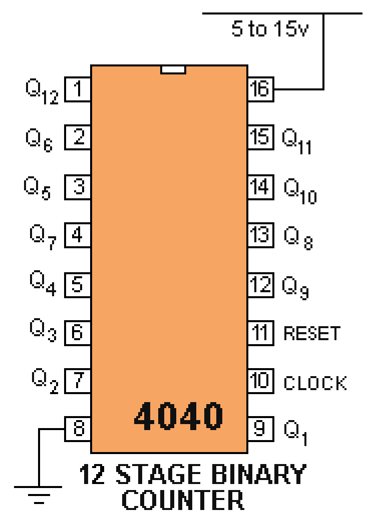

5 to 15v
parallel IN 8 1
Q_6 2
Q_8 3
4 4
3 5
2 6
1 7
parallel IN
8
16
15 7
14 6
13 5
parallel IN
12 Q_7
11 Serial IN
10 Clock
9 parallel / serial control
4014
8-BIT SHIFT
REGISTER

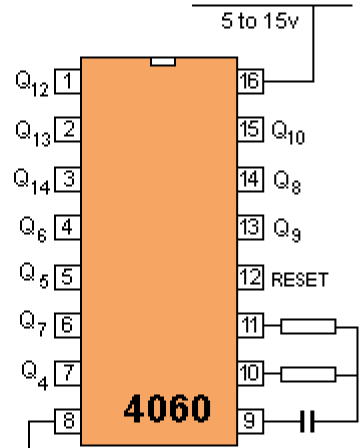

5 to 15v
Output 5 1
" " 1 2
" " 0 3
" " 2 4
" " 6 5
" " 7 6
" " 3 7
8
16
15 Reset
14 Clock
13 Clock Inhibit
12 Carry Out
11 9 Output
10 4 " "
9 8 " "
4017
DECADE COUNTER
DIVIDER


5 to 15v
Q_{12} 1
Q_{13} 2
Q_{14} 3
Q_6 4
Q_5 5
Q_7 6
Q_4 7
8
16
15 Q_{11}
14 Q_{10}
13 Q_8
12 Q_9
11 RESET
10 CLOCK
9 Q_1
4020
14 STAGE BINARY
COUNTER

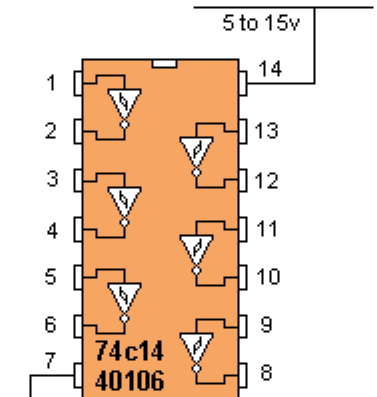

5 to 15v
INPUT 1
RESET 2
Q_7 3
Q_6 4
Q_5 5
Q_4 6
7
14
13 NC
12 Q_1
11 Q_2
10 NC
9 Q_3
8 NC
4024
7-STAGE BINARY
COUNTER


5 to 15v
Clock 1
Clock Inhibit 2
Display Enable 3
Display Enable 4
C_{out} 5
f 6
g 7
7 SEGMENTS
8
16
15 Reset
14 Ungated "c"
13 c
12 b
11 e
10 a
9 d
7 SEGMENTS
4026
7-Segment Display
Driver

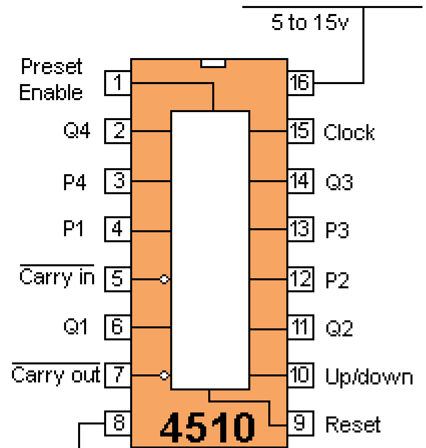

5 to 15v
Q_{12} 1
Q_6 2
Q_5 3
Q_7 4
Q_4 5
Q_3 6
Q_2 7
8
16
15 Q_{11}
14 Q_{10}
13 Q_8
12 Q_9
11 RESET
10 CLOCK
9 Q_1
4040
12 STAGE BINARY
COUNTER



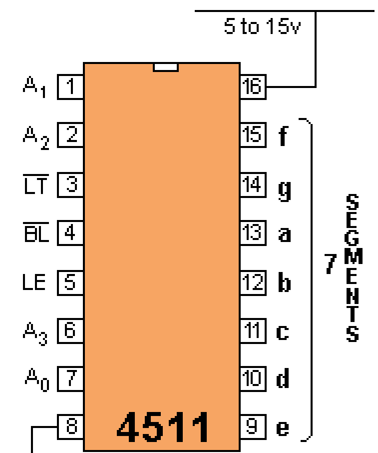
14 STAGE BINARY COUNTER with OSC



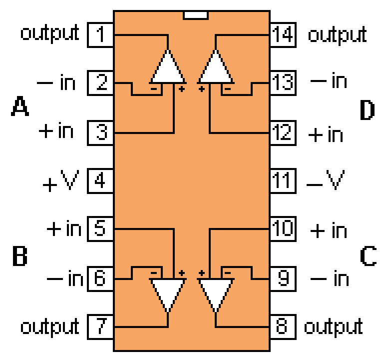
HEX Schmitt Trigger Inverter



BCD UP/DOWN COUNTER

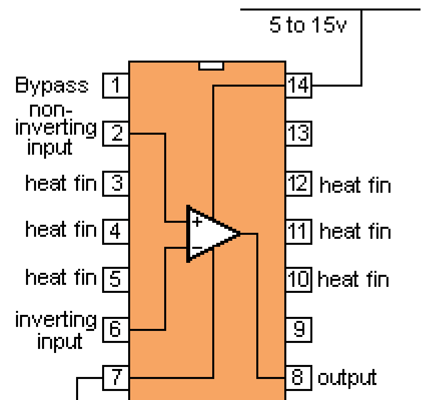


BCD to 7-Segment Display Driver



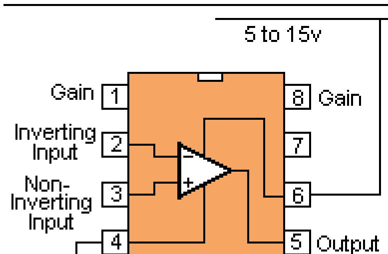
LM 324

QUAD OP-AMP

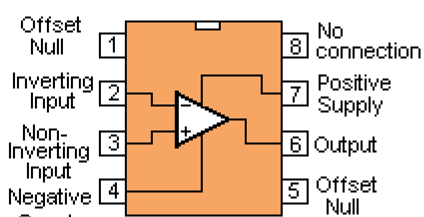


LM 380

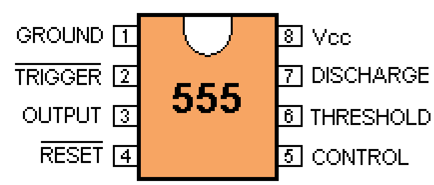
4-watt audio amp



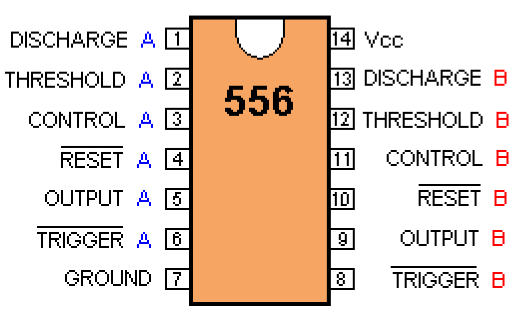
LM 386



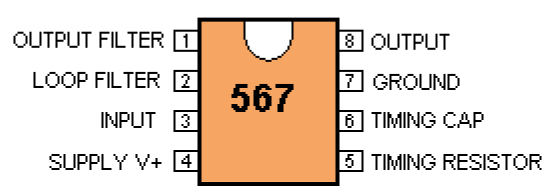
LM 741



555



556



567 Tone Decoder

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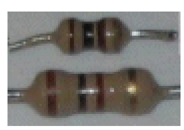
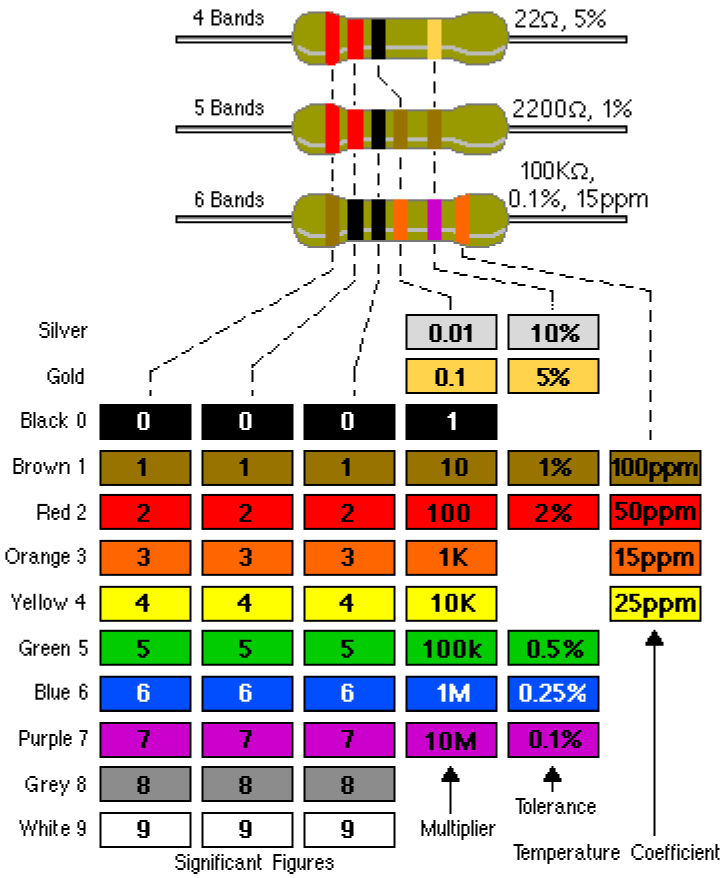
All the resistor colours:

This is called the "normal" or "3 colour-band" (5%) range. If you want the 4 colour-band (1%) series, refer to Talking Electronics website and click: **Resistors 1%** on the left index. Or you can use the table below.

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	0R1
22k	220k	2M2	R22
27k	270k	2M7	0R0 zero ohm (link)
33k	330k	3M3	
39k	390k	3M9	
47k	470k	4M7	
56k	560k	5M6	1/10th watt and 0.25 watt
68k	680k	6M8	
82k	820k	8M2	



Resistor Color Code System

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MAKE ANY RESISTOR VALUE:

If you don't have the exact resistor value for a project, don't worry. Most circuits will work with a value slightly higher or lower.
But if you want a particular value and it is not available, here is a chart.
Use 2 resistors in series or parallel as shown:

Required Value	R1	Series/ Parallel	R2	Actual value:
10	4R7	S	4R7	9R4
12	10	S	2R2	12R2
15	22	P	47	14R9
18	22	P	100	18R
22	10	S	12	22
27	22	S	4R7	26R7
33	22	S	10	32R

47	22	S	27	49
56	47	S	10	57
68	33	S	33	66
82	27	S	56	83

There are other ways to combine 2 resistors in parallel or series to get a particular value. The examples above are just one way.

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MAKE ANY CAPACITOR VALUE:

If you don't have the exact capacitor value for a project, don't worry. Most circuits will work with a value slightly higher or lower.
But if you want a particular value and it is not available, here is a chart.
Use 2 capacitors in series or parallel as shown. "p" is "puff" but can be "n" (nano) or "u" (microfarad).

Required Value	C1	Series/ Parallel	C2	Actual value:
10	4p7	P	4p7	9p4
12	10	P	2p2	12p2
15	22	S	47	14p9
18	22	S	100	18p
22	10	P	12	22
27	22	P	4p7	26p7
33	22	P	10	32p
39	220	S	47	38p7
47	22	P	27	49
56	47	P	10	57
68	33	P	33	66
82	27	P	56	83

There are other ways to combine 2 capacitors in parallel or series to get a particular value. The examples above are just one way. 4p7 = 4.7p