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# INTRODUCTION

This e-book covers the Light Emitting Diode.

The LED (Light Emitting Diode) is the modern-day equivalent to the light-globe.

It has changed from a dimly-glowing indicator to one that is too-bright to look at.

However it is entirely different to a "globe."

A globe is an electrical device consisting of a glowing wire while a LED is an electronic device.

A LED is more efficient, produces less heat and must be "driven" correctly to prevent it being damaged.

This eBook shows you how to connect a LED to a circuit plus a number of projects using LEDs.

It's simple to use a LED - once you know how.

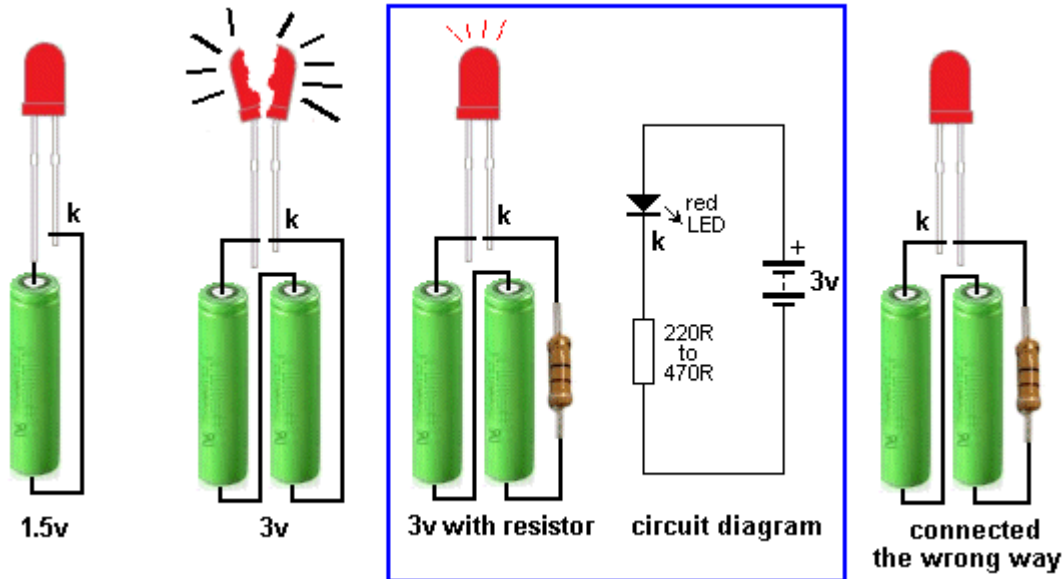
## CONNECTING A LED

A LED must be connected around the correct way in a circuit and it must have a resistor to limit the current.

The LED in the first diagram does not illuminate because a red LED requires 1.7v and the cell only supplies

1.5v. The LED in the second diagram is damaged because it requires 1.7v and the two cells supply 3v. A

resistor is needed to limit the current to about 25mA and also the voltage to 1.7v, as shown in the third diagram. The fourth diagram is the circuit for layout #3 showing the symbol for the LED, resistor and battery and how the three are connected. The LED in the fifth diagram does not work because it is around the wrong way.



## CHARACTERISTIC VOLTAGE DROP

When a LED is connected around the correct way in a circuit it develops a voltage across it called the CHARACTERISTIC VOLTAGE DROP.

A LED must be supplied with a voltage that is higher than its "CHARACTERISTIC VOLTAGE" via a resistor - called a VOLTAGE DROPPING RESISTOR or CURRENT LIMITING RESISTOR - so the LED will operate correctly and provide at least 10,000 to 50,000 hours of illumination.

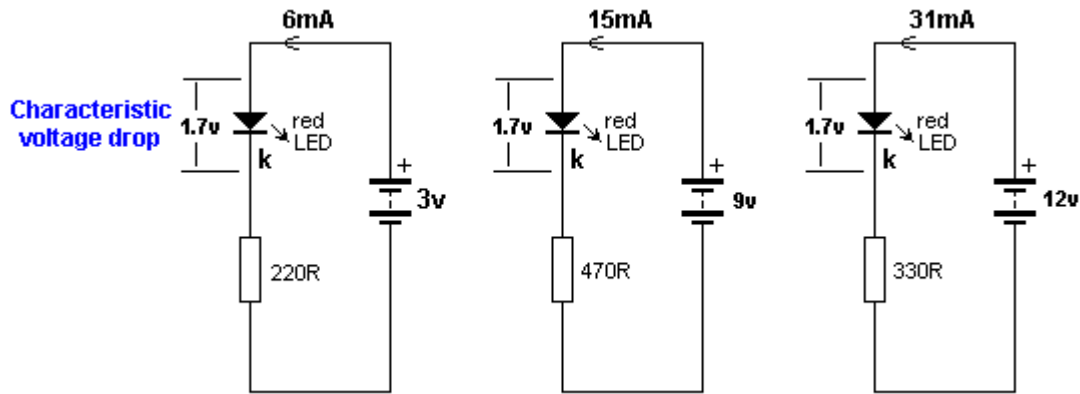
A LED works like this: A LED and resistor are placed in series and connected to a voltage.

As the voltage rises from 0v, nothing happens until the voltage reaches about 1.7v. At this voltage a red LED just starts to glow. As the voltage increases, the voltage across the LED remains at 1.7v but the current through the LED increases and it gets brighter.

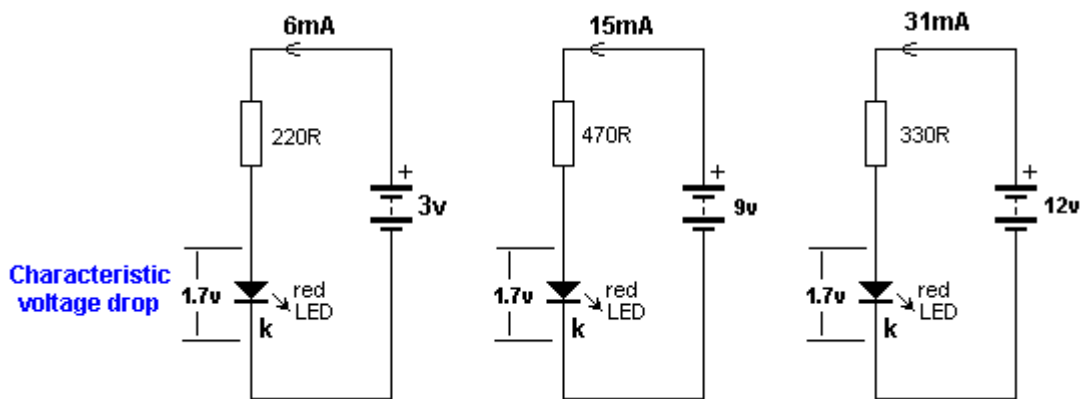
We now turn our attention to the current though the LED. As the current increases to 5mA, 10mA, 15mA, 20mA the brightness will increase and at 25mA, it will be a maximum. Increasing the supply voltage will simply change the colour of the LED slightly but the crystal inside the LED will start to overheat and this will reduce the life considerably.

This is just a simple example as each LED has a different CHARACTERISTIC VOLTAGE DROP and a different maximum current.

In the diagram below we see a LED on a 3v supply, 9v supply and 12v supply. The current-limiting resistors are different and the first circuit takes 6mA, the second takes 15mA and the third takes 31mA. But the voltage across the red LED is the same in all cases. This is because the LED creates the CHARACTERISTIC VOLTAGE DROP and this does not change.



It does not matter if the resistor is connected above or below the LED. The circuits are the SAME in operation:



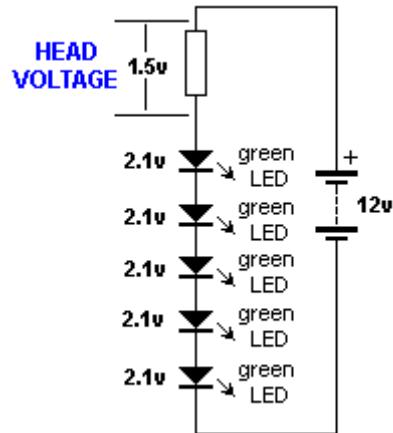
## HEAD VOLTAGE

Now we turn our attention to the resistor.

As the supply-voltage increases, the voltage across the LED will be constant at 1.7v (for a red LED) and the excess voltage will be dropped across the resistor. The supply can be any voltage from 2v to 12v or more. In this case, the resistor will drop 0.3v to 10.3v.

This is called **HEAD VOLTAGE** - or **HEAD-ROOM** or **OVERHEAD-VOLTAGE**. And the resistor is called the **CURRENT-LIMIT** resistor.

The following diagram shows **HEAD VOLTAGE**:



The voltage dropped across this resistor, combined with the current, constitutes wasted energy and should be kept to a minimum, but a small HEAD VOLTAGE is not advisable (such as 0.5v). The head voltage should be a minimum of 1.5v - and this only applies if the supply is fixed.

The head voltage depends on the supply voltage. If the supply is fixed and guaranteed not to increase or fall, the head voltage can be small (1.5v minimum).

But most supplies are derived from batteries and the voltage will drop as the cells are used.

Here is an example of a problem:

Supply voltage: 12v

7 red LEDs in series = 11.9v

Dropper resistor = 0.1v

As soon as the supply drops to 11.8v, no LEDs will be illuminated.

Example 2:

Supply voltage 12v

5 green LEDs in series @ 2.1v = 10.5v

Dropper resistor = 1.5v

The battery voltage can drop to 10.5v

But let's look at the situation more closely.

Suppose the current @ 12v = 25mA.

As the voltage drops, the current will drop.

At 11.5v, the current will be 17mA

At 11v, the current will be 9mA

At 10.5v, the current will be zero

You can see the workable supply drop is only about 1v.

Many batteries drop 1v and still have over 80% of their energy remaining. That's why you need to design your circuit to have a large **HEAD VOLTAGE**.

A large **Head Voltage** is also needed when a plug-pack (wall wart) is used. These devices consist of a transformer, set of diodes and an electrolytic. The voltage marked on the unit is the voltage it will deliver when fully loaded. It may be 200mA, 300mA or 500mA. When this current is delivered, the voltage will be 9v or 12v. But if the current is less than the rated current, the output voltage will be higher. It may be 1v, 2v or even 5v higher.

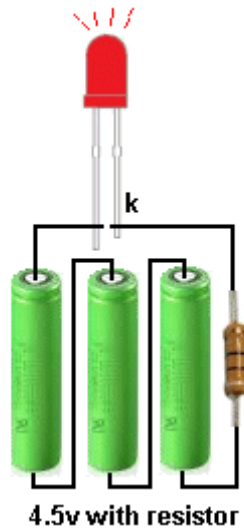
This is one of the characteristics of a cheap transformer. A cheap transformer has very poor regulation, so to deliver 12v @ 500mA, the transformer produces a higher voltage on no-load and the voltage drops as the current increases.

You need to allow for this extra voltage when using a plug-pack so the LEDs do not take more than 20mA to 25mA.

## TESTING A LED

If the cathode lead of a LED cannot be identified, place 3 cells in series with a 220R resistor and illuminate

the LED. 4.5v allows all types of LEDs to be tested as white LEDs require up to 3.6v. Do not use a multimeter as some only have one or two cells and this will not illuminate all types of LEDs. In addition, the negative lead of a multimeter is connected to the positive of the cells (inside the meter) for resistance measurements - so you will get an incorrect determination of the cathode lead.



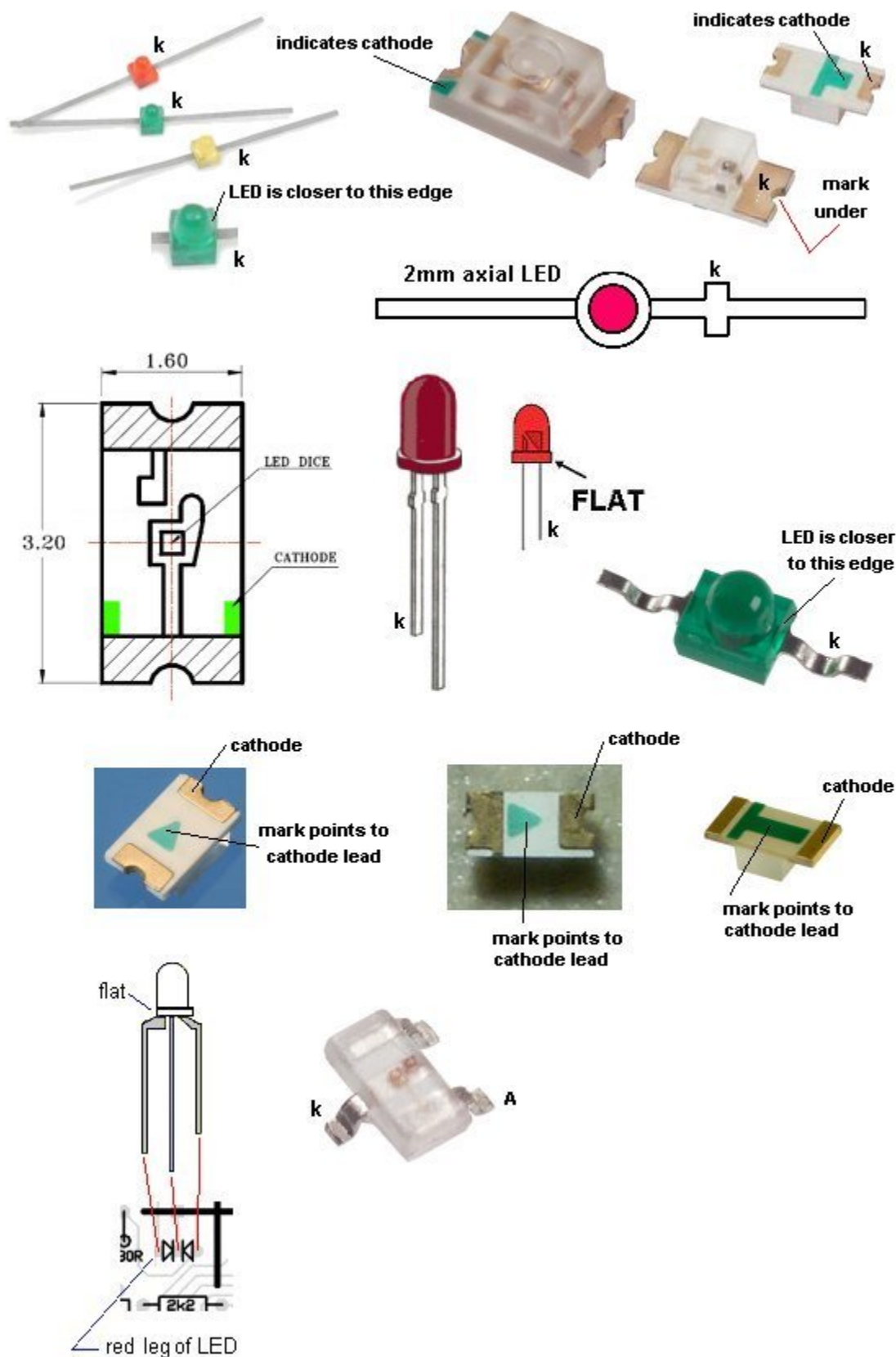
**CIRCUIT TO TEST ALL TYPES OF LEDs**

## IDENTIFYING A LED

A LED does not have a "Positive" or "Negative" lead. It has a lead identified as the "Cathode" or Kathode" or "k". This is identified by a flat on the side of the LED and/or by the shortest lead.

This lead goes to the 0v rail of the circuit or near the 0v rail (if the LED is connected to other components). Many LEDs have a "flat" on one side and this identifies the cathode. Some surface-mount LEDs have a dot or shape to identify the cathode lead and some have a cut-out on one end.

Here are some of the identification marks:



## LEDs ARE CURRENT DRIVEN DEVICES

A LED is described as a CURRENT DRIVEN DEVICE. This means the illumination is determined by the amount

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## POWERING A PROJECT

The safest way to power a project is with a battery. Each circuit requires a voltage from 3v to 12v. This can be supplied from a set of AA cells in a holder or you can also use a 9v battery for some projects.

If you want to power a circuit for a long period of time, you will need a "power supply."

The safest power supply is a Plug Pack (wall-wort, wall wart, wall cube, power brick, plug-in adapter, adapter block, domestic mains adapter, power adapter, or AC adapter). Some plug packs have a switchable output voltage: 3v, 6v, 7.5v, 9v, 12v) DC with a current rating of 500mA. The black lead is negative and the other lead with a white stripe (or a grey lead with a black stripe) is the positive lead.

This is the safest way to power a project as the insulation (isolation) from the mains is provided inside the adapter and there is no possibility of getting a shock.

The rating "500mA" is the maximum the Plug Pack will deliver and if your circuit takes just 50mA, this is the current that will be supplied. Some pluck packs are rated at 300mA or 1A and some have a fixed output voltage. All these plug packs will be suitable.

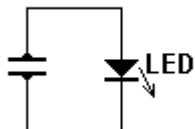
Some Plug Packs are marked "12vAC." This type of plug pack is not suitable for these circuits as it does not have a set of diodes and electrolytic to convert the AC to DC. All the circuits in this eBook require DC.

# PROJECTS

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## Simplest LED Circuit

Connect a LED to a piezo diaphragm and tap the piezo with a screwdriver at the centre of the disc and the LED will flash very briefly.



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## FLASHING A LED

These 7 circuits flash a LED using a supply from 1.5v to 12v.

They all have a different value of efficiency and current consumption. You will find at least one to suit your requirements.

The simplest way to flash a LED is to buy a FLASHING LED as shown in figure A. It will work on 3v to 9v



but it is not very bright - mainly because the LED is not high-efficiency.

A Flashing LED can be used to flash a super-bright red LED, as shown in figure **B**.

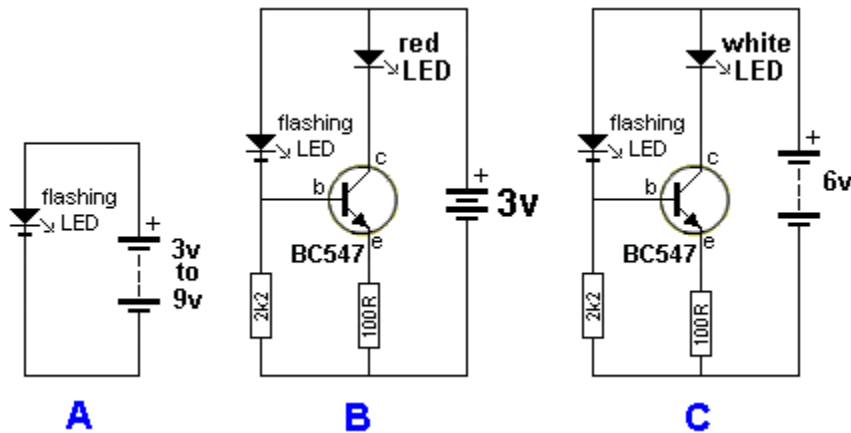
Figure **C** shows a flashing LED driving a buffer transistor to flash a white LED. The circuit needs 4.5v - 6v.

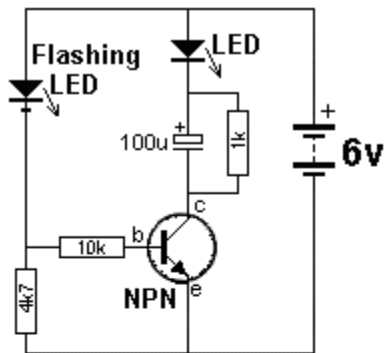
Figure **D** produces a very bright flash for a very short period of time - for a red, green, orange or white LED.

Figure **E** uses 2 transistors to produce a brief flash - for a red, green, orange or white LED.

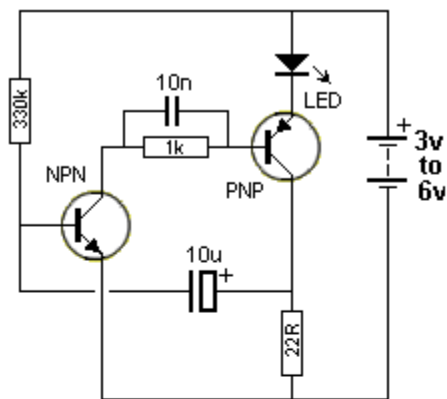
Figure **F** uses a single cell and a voltage multiplying arrangement to flash a red or green LED.

Figure **G** flashes a white LED on a 3v supply.

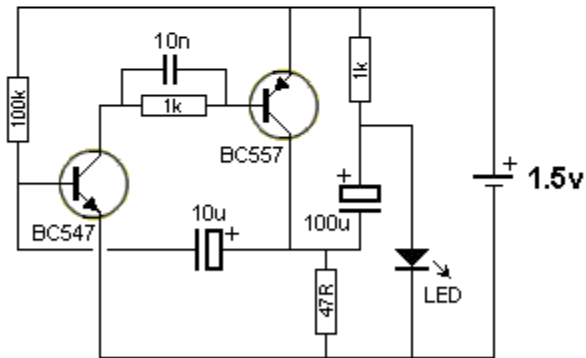




**D**

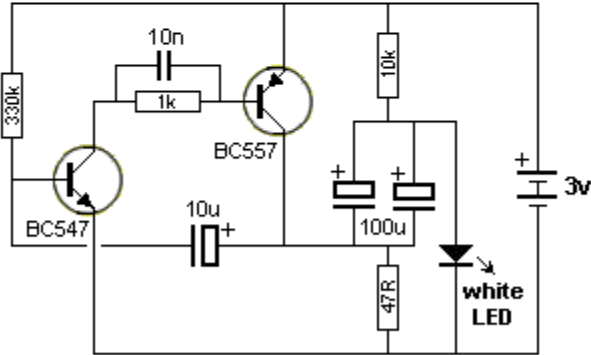


**E**



**1.5v LED FLASHER**

**F**



**WHITE LED FLASHER**

**G**

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## CONSTANT CURRENT

These four circuits delivers a constant 12mA to any number of LEDs connected in series (to the terminals shown) in the following arrangements.

The circuits can be connected to 6v, 9v or 12v and the brightness of the LEDs does not alter.

You can connect:

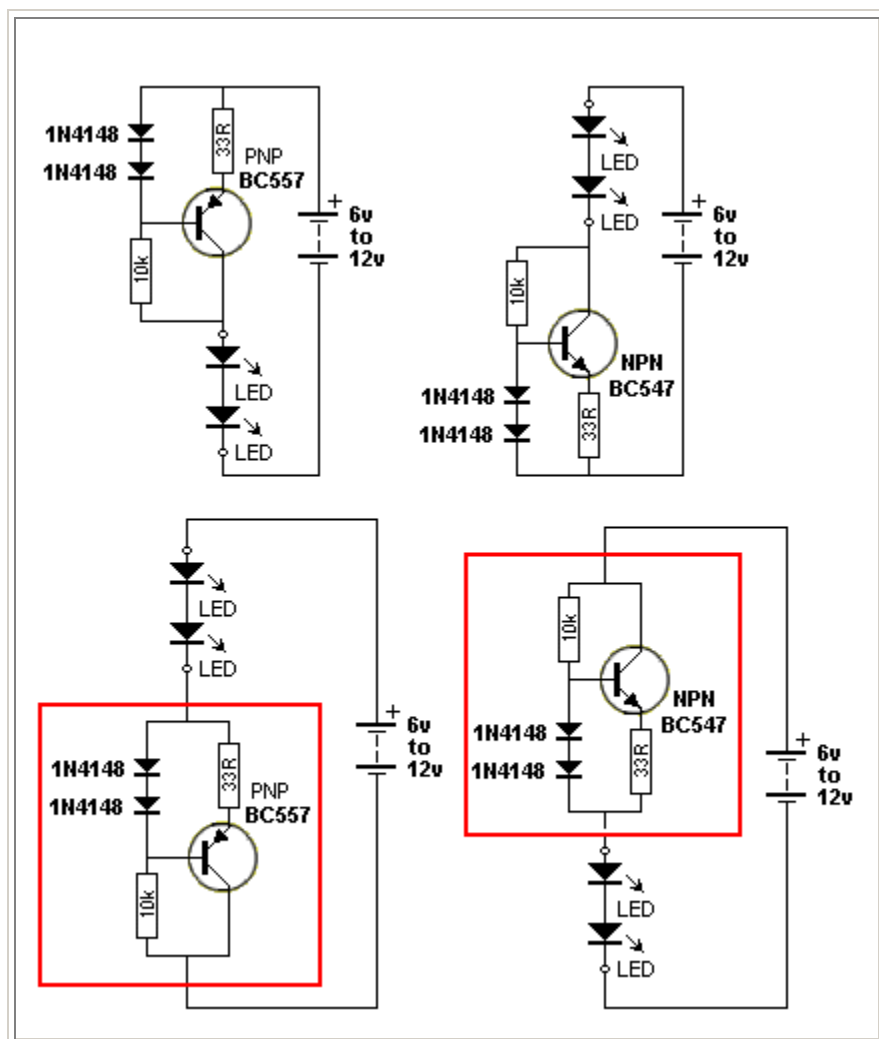
1 or 2 LEDs to 6v,

1, 2 or 3 LEDs to 9v or

1, 2, 3 or 4 LEDs to 12v.

The LEDs can be any colour.

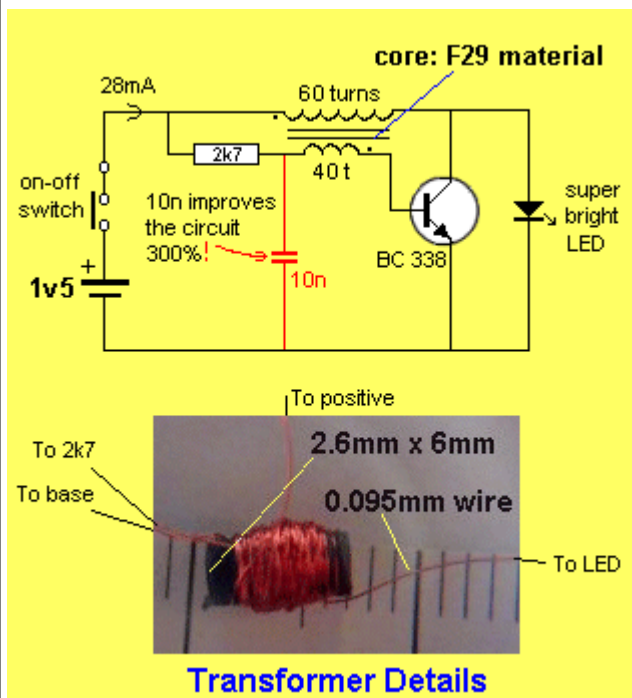
The constant-current section can be considered as a MODULE and can be placed above or below the load:



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## WHITE LED on 1.5v SUPPLY

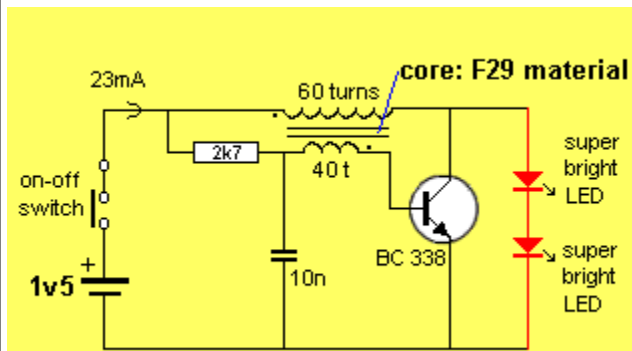
This circuit will illuminate a white LED using a single cell.  
See [LED Torch Circuits](#) article for more details.



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## 2 WHITE LEDs on 1.5v SUPPLY

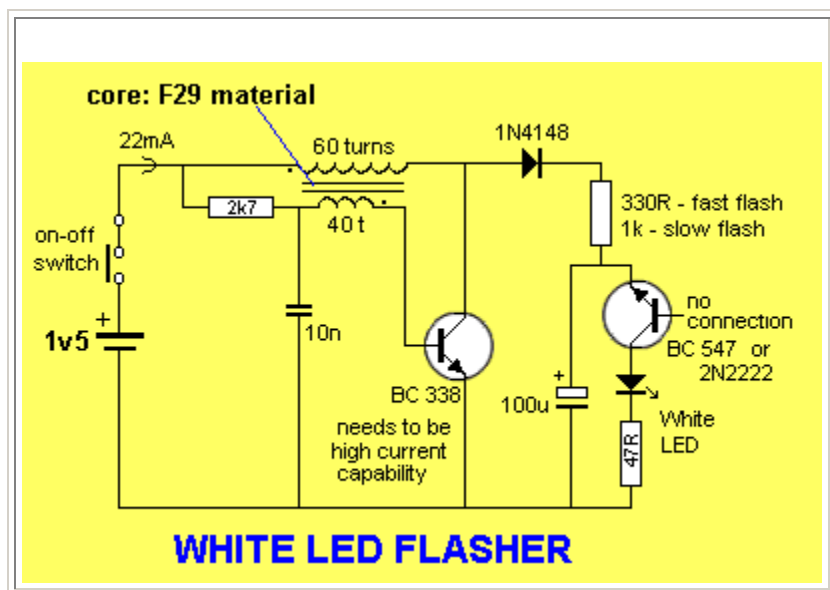
This circuit will illuminate two white LEDs using a single cell. See [LED Torch Circuits](#) article for more details.



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## WHITE LED FLASHER

This circuit will flash a white LEDs using a single cell. See [LED Torch Circuits](#) article for more details.



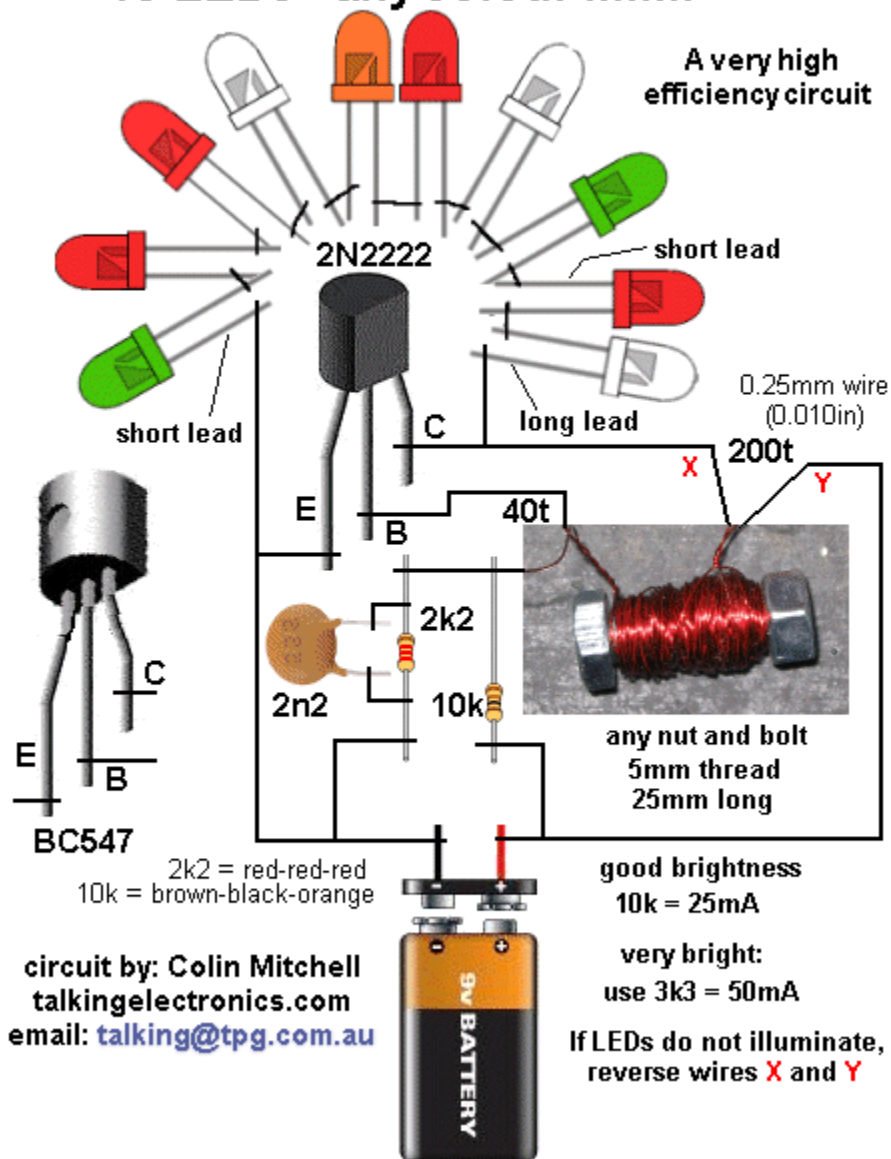
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## 10 LEDs on a 9v BATTERY

This circuit will illuminate 10 LEDs on a 9v battery.  
It was designed in response to a readers request:

**10 LEDs - any colour !!!!!!!**

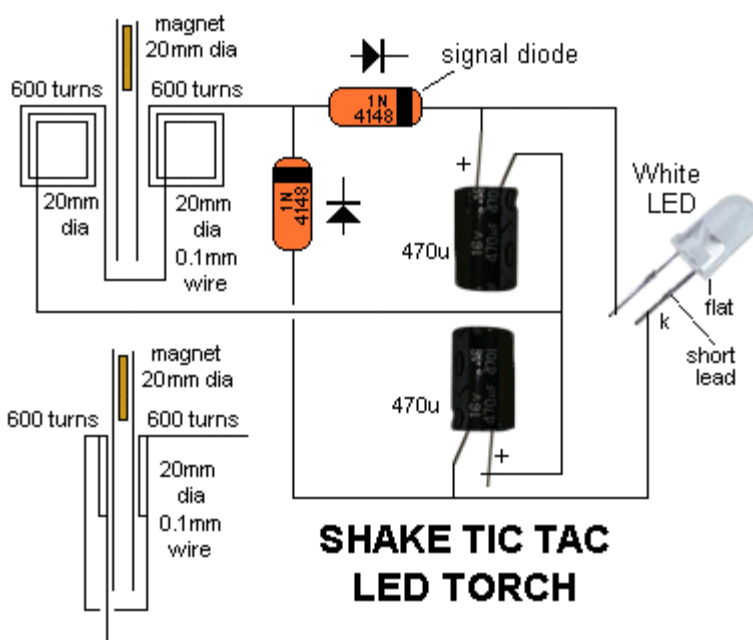
A very high efficiency circuit



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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



## SHAKE TIC TAC LED TORCH

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 through 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.

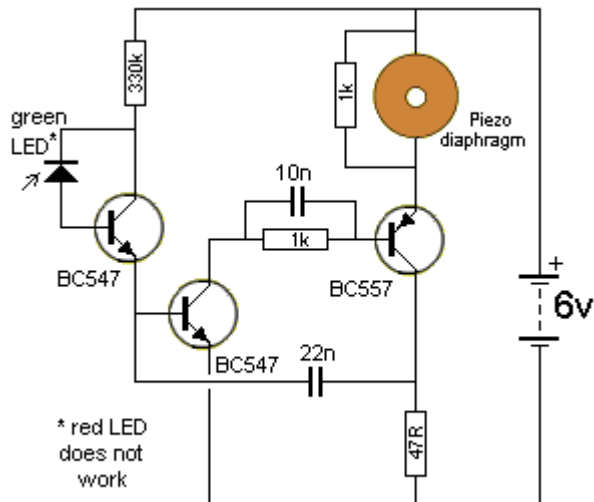
The circuit consists of two 600-turn coils in series, driving a voltage doubler. Each coil produces a positive and negative pulse, each time the magnet passes from one end of the slide to the other.

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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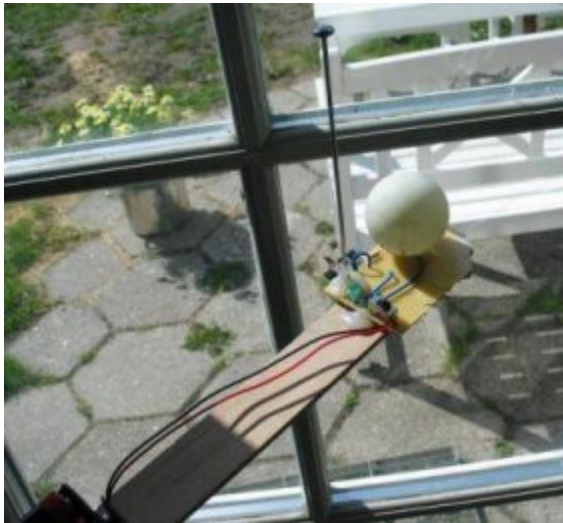
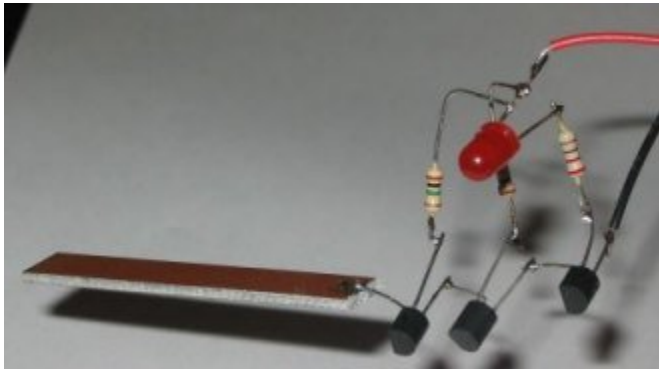
## LED DETECTS LIGHT

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.

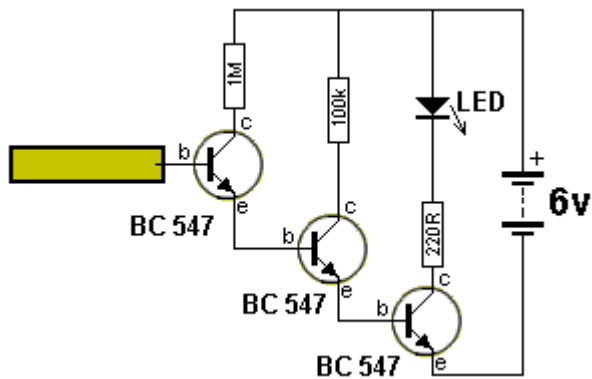
When light is detected by the LED, its resistance decreases and a very small current flows into the base of the first transistor. The transistor amplifies this current about 200 times and the resistance between collector and emitter decreases. The 330k resistor on the collector is a current limiting 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.

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## 8 MILLION GAIN!

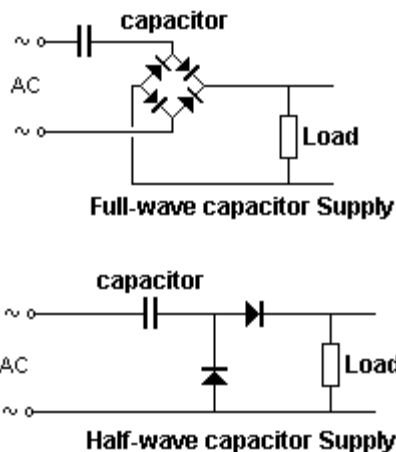
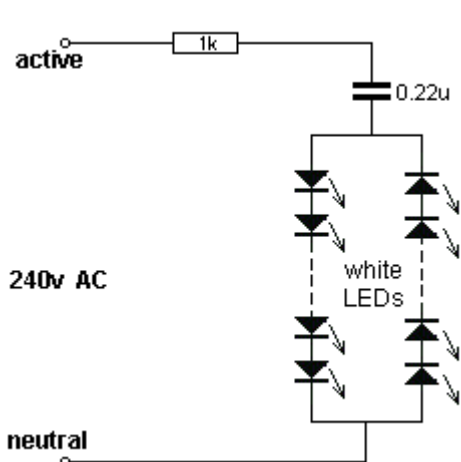
This circuit is so sensitive it will detect "mains hum." Simply move it across any wall and it will detect where the mains cable is located. It has a gain of about  $200 \times 200 \times 200 = 8,000,000$  and will also detect static electricity and the presence of your hand without any direct contact. You will be amazed what it detects! There is static electricity EVERYWHERE! The input of this circuit is classified as very high impedance.



Here is a photo of the circuit, produced by a constructor.

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## LEDs on 240v

I do not like any circuit connected directly to 240v mains. However Christmas tress lights (globes)

have been connected directly to the mains for 30 years without any major problems. Insulation must be provided and the lights (LEDs) must be away from prying fingers.

You need at least 50 LEDs in each string to prevent them being damaged via a surge through the 1k resistor - if the circuit is turned on at the peak of the waveform. As you add more LEDs to each string, the current will drop a very small amount until eventually, when you have 90 LEDs in each string, the current will be zero.

For 50 LEDs in each string, the total characteristic voltage will be 180v so that the peak voltage will be  $330v - 180v = 150v$ . Each LED will see less than 7mA peak during the half-cycle they are illuminated (because the voltage across the 0.22u is 150v and this voltage determines the current-flow). The 1k resistor will drop 7v - since the RMS current is 7mA ( $7mA \times 1,000 \text{ ohms} = 7v$ ). No rectifier diodes are needed. The LEDs are the "rectifiers." Very clever. You must have LEDs in both directions to charge and discharge the capacitor. The resistor is provided to take a heavy surge current through one of the strings of LEDs if the circuit is switched on when the mains is at a peak. This can be as high as 330mA if only 1 LED is used, so the value of this resistor must be adjusted if a small number of LEDs are used. The LEDs above detect peak current. The LEDs are turned on and off 50 times per second and this may create "flickering" or "strobing." To prevent this flicker, see the DC circuit below:

**A 100n cap will deliver 7mA RMS or 10mA peak in full wave or 3.5mA RMS (10mA peak for half a cycle) in half-wave.** (when only 1 LED is in each string).

The current-capability of a capacitor needs more explanation. In the diagram on the left we see a capacitor feeding a full-wave power supply. This is exactly the same as the **LEDs on 240v** circuit above. Imagine the LOAD resistor is removed. Two of the diodes will face down and two will face up. This is exactly the same as the LEDs facing up and facing down in the circuit above. The only difference is the mid-point is joined. Since the voltage on the mid-point of one string is the same as the voltage at the mid-point of the other string, the link can be removed and the circuit will operate the same.

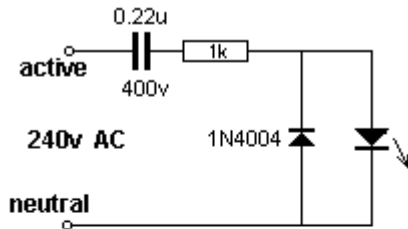
This means each 100n of capacitance will deliver 7mA RMS (10mA peak on each half-cycle).

In the half-wave supply, the capacitor delivers 3.5mA RMS (10mA peak on each half-cycle, but one half-cycle is lost in the diode) for each 100n to the load, and during the other half-cycle the 10mA peak is lost in the diode that discharges the capacitor.

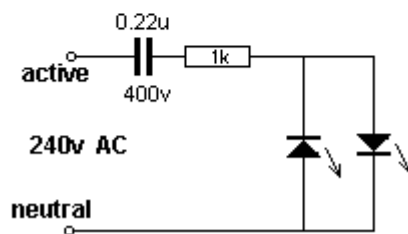
You can use any LEDs and try to keep the total voltage-drop in each string equal. Each string is actually working on DC. It's not constant DC but varying DC. In fact it is zero current for 1/2 cycle then nothing until the voltage rises above the total characteristic voltage of all the LEDs, then a gradual increase in current over the remainder of the cycle, then a gradual decrease to zero over the falling portion of the cycle, then nothing for 1/2 cycle. Because the LEDs turn on and off, you may observe some flickering and that's why the two strings should be placed together.

## SINGLE LED on 240v

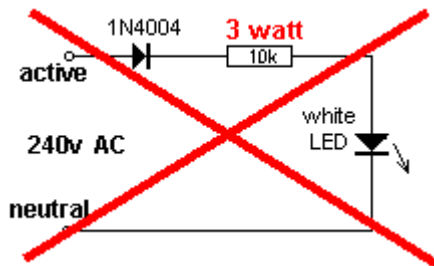
A single LED can be illuminated by using a 100n or 220n capacitor with a rating of 400v. These capacitors are called "X2" and are designed to be connected to the mains.



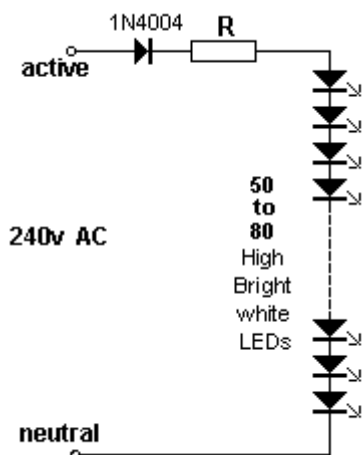
The LED will be 240v above earth if the active and neutral are swapped and this represents a shock of over 340v if anything is exposed. The power diode in the first diagram is designed to discharge the 0.22u during one half of the cycle so that the capacitor will charge during the other half-cycle and deliver energy to the LED. The 1k resistor limits the peak in-rush current when the circuit is first turned on and the mains happens to be at a peak.



Two LEDs can be driven from the same circuit as one LED will be illuminated during the first half cycle and the other LED will be driven during the second half of the cycle.



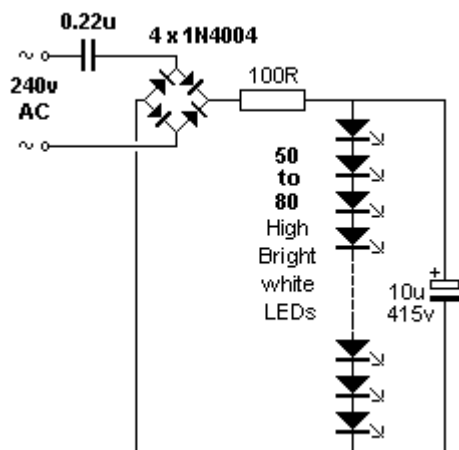
LEDs can also be connected to the mains via a power diode and current-limiting resistor. But the wattage lost (dropped) in the resistor is about 2.5 watts and a 3 watt resistor will be needed to illuminate a 70mW white LED. This is an enormous waste of energy and a capacitor-fed supply shown above is the best solution.



When 50 to 80 white LEDs are connected in series, a resistor can be used. For 50 white LEDs, use a 4k7 2watt resistor to provide 10mA average current.

For 100 white LEDs, use a 2k2 1watt resistor to provide 10mA average current.

The circuit will not work with more than 95 LEDs as the characteristic voltage-drop across the combination will be more than the peak of the supply (340v).



## DC CONNECTION

To prevent "flickering" or "strobing," the LEDs must be driven with DC. This requires a BRIDGE.

The 0.22u will deliver 15mA when one LED is connected to the output. As additional LEDs are connected, the current gradually reduces to zero with 100 LEDs.

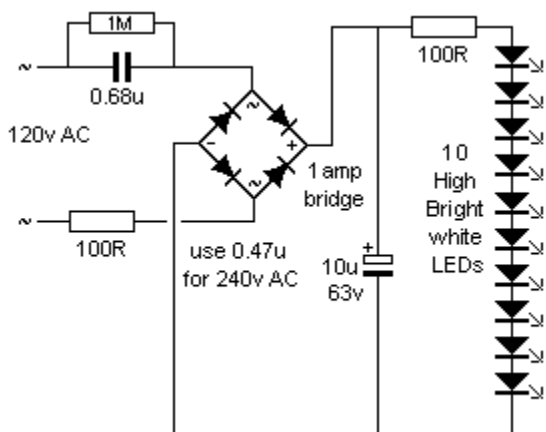
40 LEDs will be provided with:

$$345 - 145 = 200v = 200/345 \times 15 = 8.6mA$$

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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.



This circuit is classified as a CONSTANT CURRENT GENERATOR or CONSTANT CURRENT CIRCUIT.

This means any component placed on the output of the circuit will pass 7mA if the capacitor is 100n on a 240v supply or  $4.7 \times 7mA = 33mA$  if the capacitor is 470n.

This also applies to a short-circuit on the output.

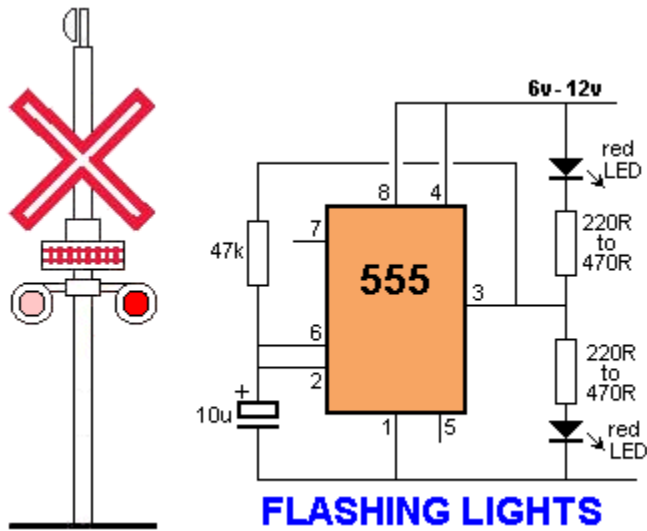
If no load is connected, the output voltage will be  $230v \times 1.4 = 320v$  and if the voltage across the load is 100v, the output will be reduced to about 20mA. If the output voltage is 200v, the current will be 10mA and if the output voltage is 300v, the current will be 0mA. In our case the output voltage will be about 35v and the current will be 30mA.

This means you cannot add LEDs endlessly. A time will come when they will simply not illuminate.

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## FLASHING RAILROAD LIGHTS

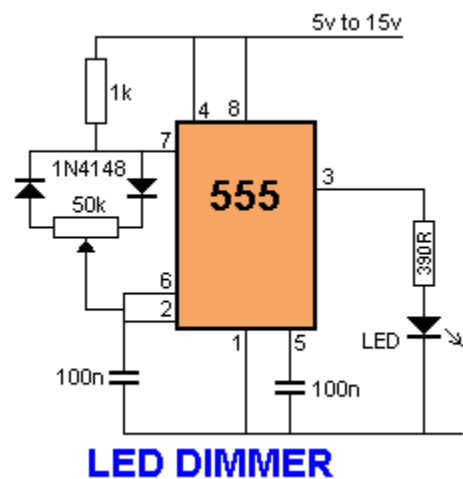
This circuit flashes two red LEDs for a model railway crossing.



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## LED DIMMER

This circuit will adjust the brightness of one or more LEDs from 5% to 95%.

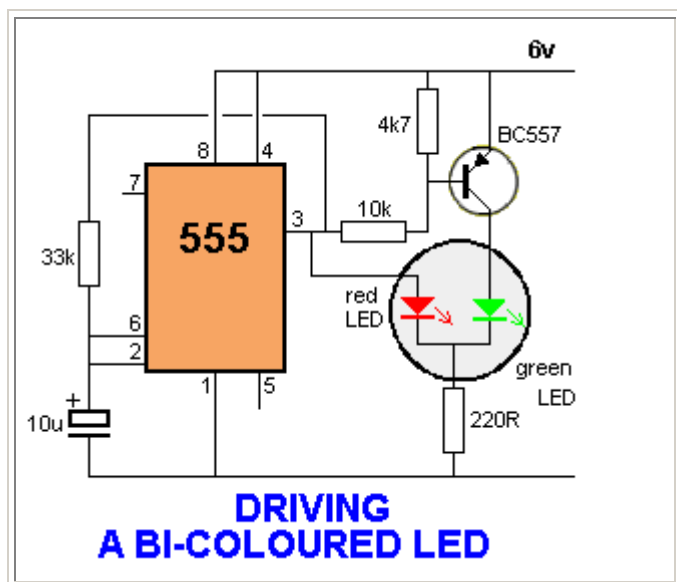


rev A

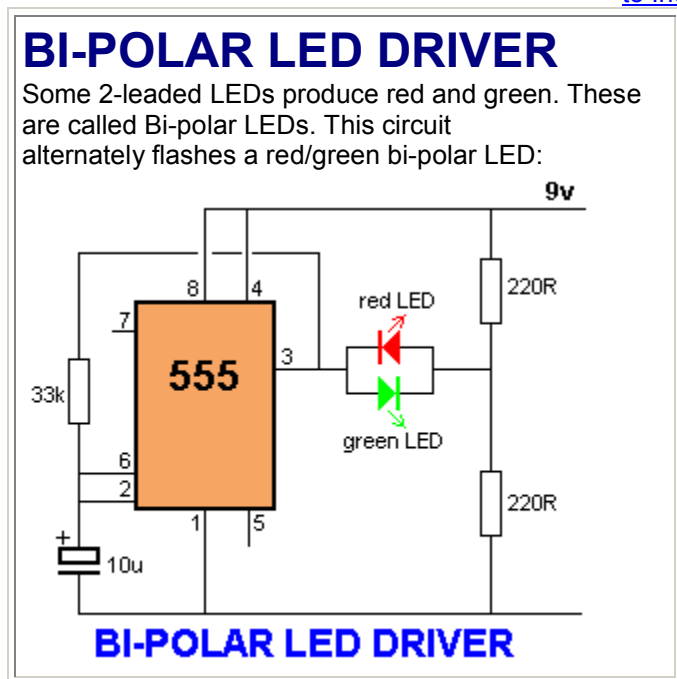
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## DRIVING A BI-COLOUR LED

Some 3-leaded LEDs produce red and green. This circuit alternately flashes a red/green bi-coloured LED:

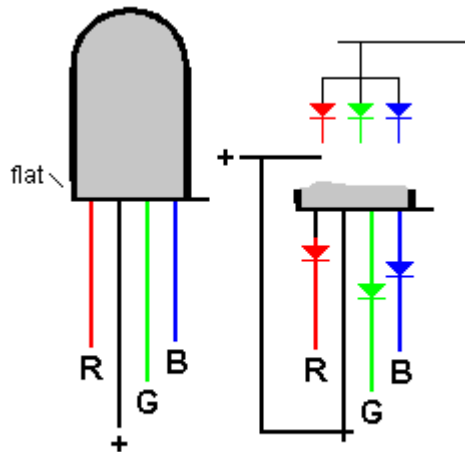


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## RGB LED DRIVER

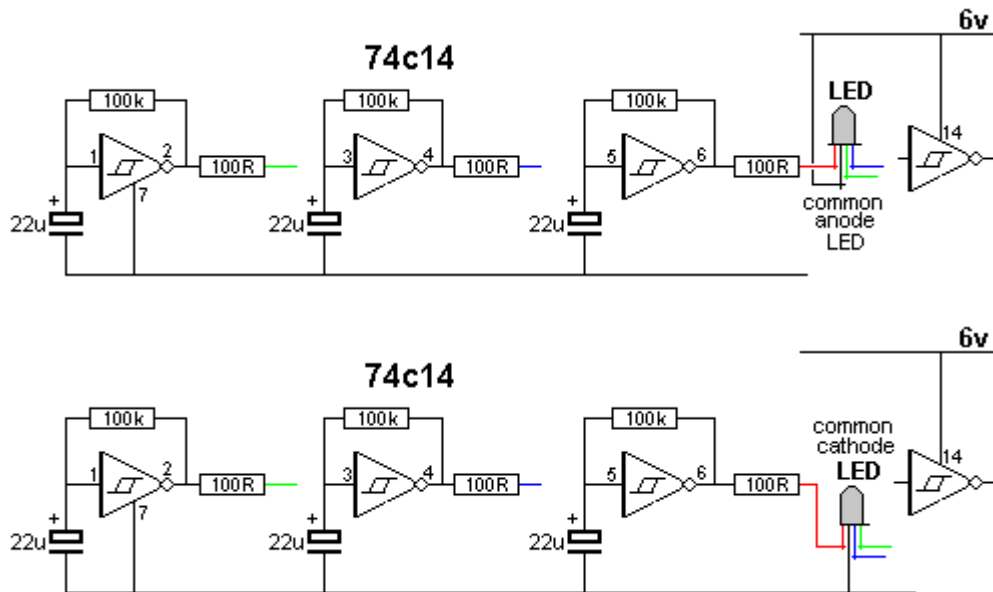


**COMMON ANODE RGB LED**

This is a simple driver circuit that drives the 3 LEDs in an RGB LED to produce a number of interesting colours. Even though the component values are identical in the three oscillators, the slight difference in tolerances will create a random display of colours and it will take a while for the pattern to repeat.

The colours change abruptly from one colour to another as the circuit does not use Pulse Width Modulation to produce a gradual fading from one colour to another.

This LED is called COMMON ANODE. This has been done so it can be connected to transistors or other devices that "SINK." The second circuit a common cathode LED. Note the different pinout.



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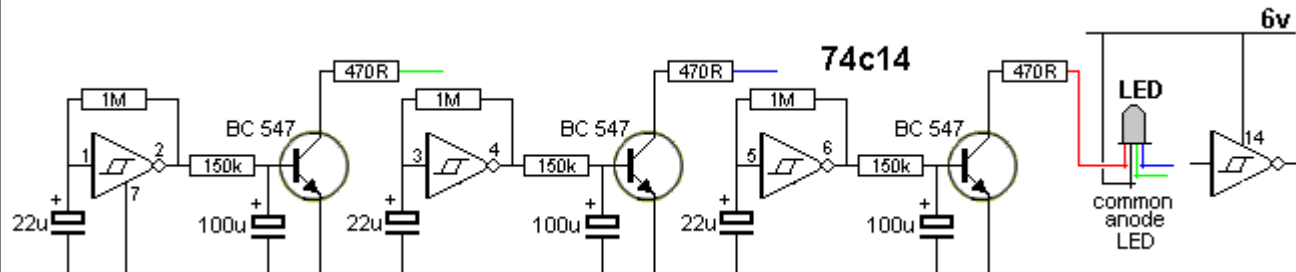
## RGB LED FLASHER

This LED flashes at a fast rate then a slow rate. It only requires a current-limiting resistor of 100R for 4.5v to 6v supply or 470R for 7v to 12v supply.

This LED is available from: <http://alan-parekh.vstore.ca/flashing-5000mcd-p-88.html> for 80 cents plus postage.

There are two different types of RGB LEDs. The **RGB LED Driver** circuit above uses an RGB LED with 4 leads and has 3 coloured chips inside and NOTHING ELSE.

The LED described in the video has 2 leads and requires a dropper resistor so that about 20mA flows. The LED also contains a microcontroller producing PWM signals. If you cannot get the 2-leaded LED, you can use a 4-leaded LED plus the circuit below. It is an analogue version of the circuit inside the self-flashing LED, for the slow-rate:



As with everything Chinese, the self-flashing LED is too gimmicky.

It is better to produce your own colour-change via the circuit above. You can alter the rate by changing the value of the components and/or remove one or more of the 100u's. The circuit for a common cathode RGB LED is shown in the RGB LED Driver above.

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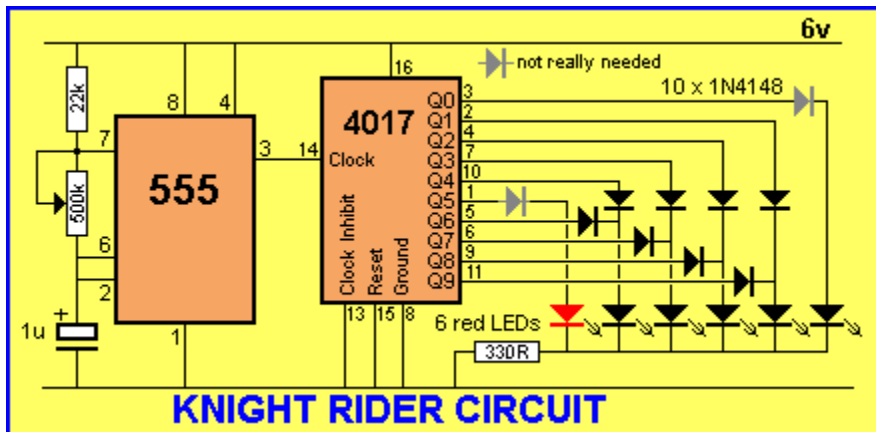
## KNIGHT RIDER

In the **Knight Rider** circuit, the 555 is wired as an oscillator. It can be adjusted to give the desired speed for the display. The output of the 555 is directly connected to the input of a Johnson Counter (CD 4017). The input of the counter is called the CLOCK line.

The 10 outputs  $Q_0$  to  $Q_9$  become active, one at a time, on the rising edge of the waveform from the 555. Each output can deliver about 20mA but a LED should not be connected to the output without a current-limiting resistor (330R in the circuit above).

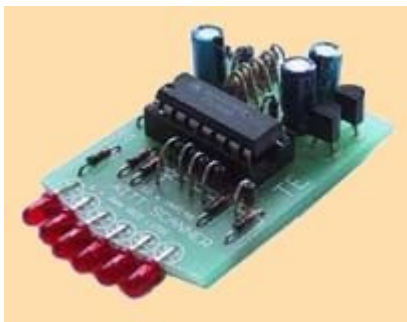
The first 6 outputs of the chip are connected directly to the 6 LEDs and these "move" across the display. The next 4 outputs move the effect in the opposite direction and the cycle repeats. The animation above shows how the effect appears on the display.

Using six 3mm LEDs, the display can be placed in the front of a model car to give a very realistic effect. The same outputs can be taken to driver transistors to produce a larger version of the display.

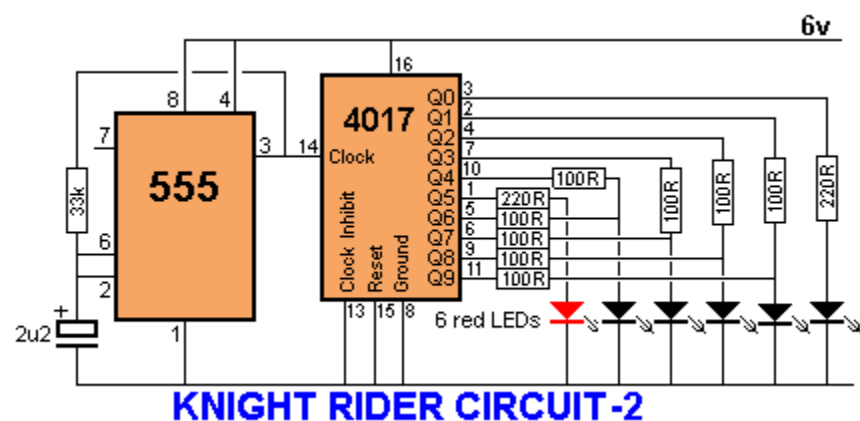


**BUY NOW**

The **Knight Rider** circuit is available as a kit for less than \$15.00 plus postage as **Kitt Scanner**.



Here is a simple Knight Rider circuit using resistors to drive the LEDs. This circuit consumes 22mA while only delivering 7mA to each LED. The outputs are "fighting" each other via the 100R resistors (except outputs Q0 and Q5).



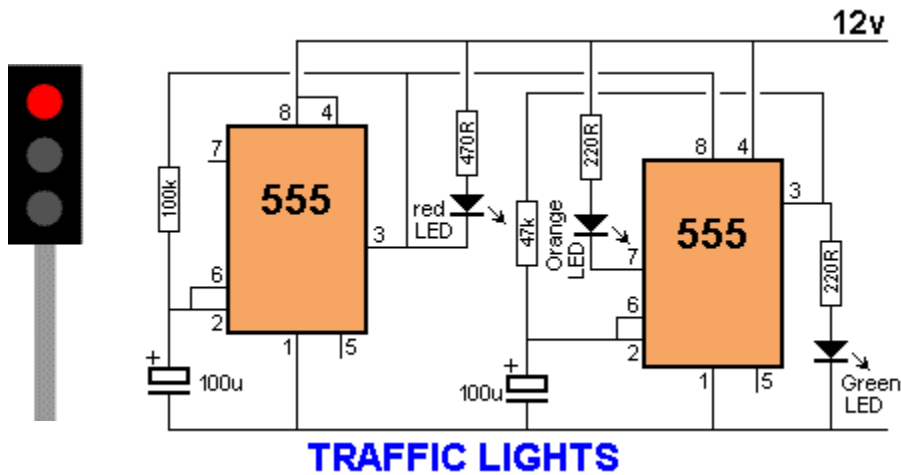
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## TRAFFIC LIGHTS

Here's a clever circuit using two 555's to produce a set of traffic lights for a model layout.



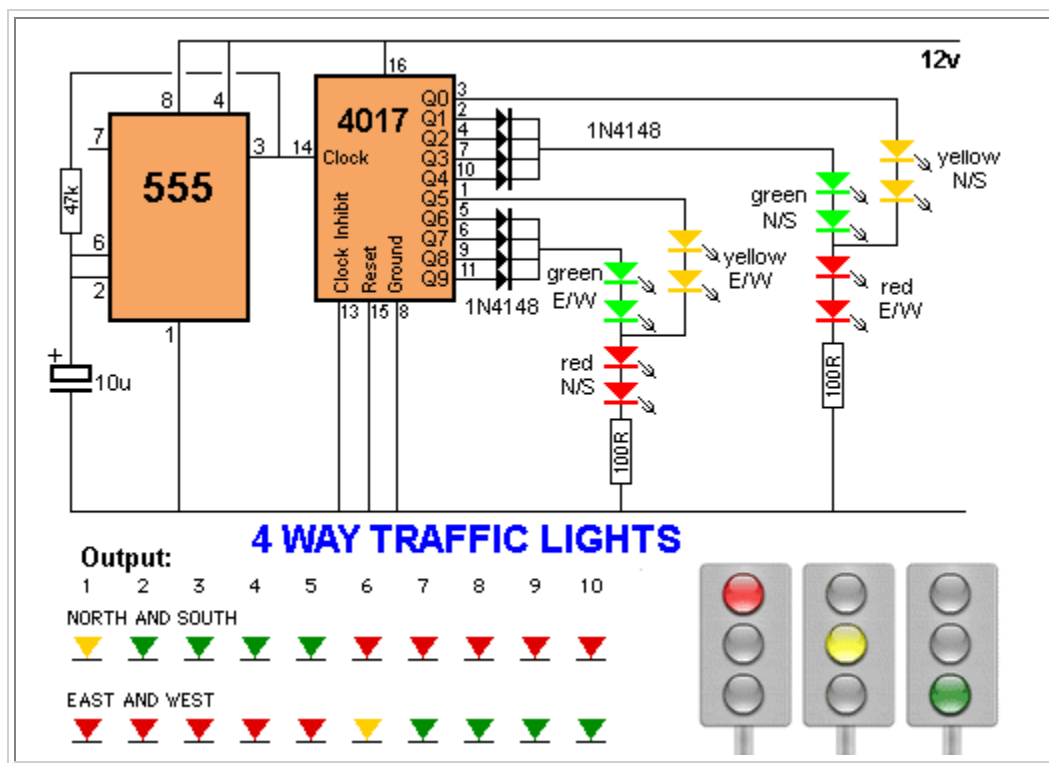
The animation shows the lighting sequence and this follows the Australian-standard. The red LED has an equal on-off period and when it is off, the first 555 delivers power to the second 555. This illuminates the Green LED and then the second 555 changes state to turn off the Green LED and turn on the Orange LED for a short period of time before the first 555 changes state to turn off the second 555 and turn on the red LED. A supply voltage of 9v to 12v is needed because the second 555 receives a supply of about 2v less than rail. This circuit also shows how to connect LEDs high and low to a 555 and also turn off the 555 by controlling the supply to pin 8. Connecting the LEDs high and low to pin 3 will not work and since pin 7 is in phase with pin 3, it can be used to advantage in this design.



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## 4 WAY TRAFFIC LIGHTS

This circuit produces traffic lights for a "4-way" intersection. The seemingly complex wiring to illuminate the lights is shown to be very simple.

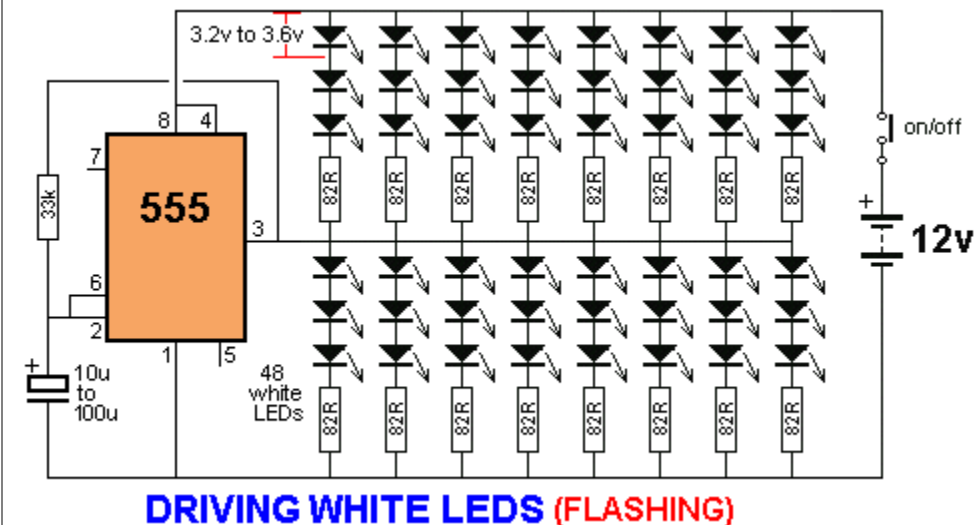


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## DRIVING MANY LEDs

The 555 is capable of sinking and sourcing up to 200mA, but it gets very hot when doing this on a 12v supply.

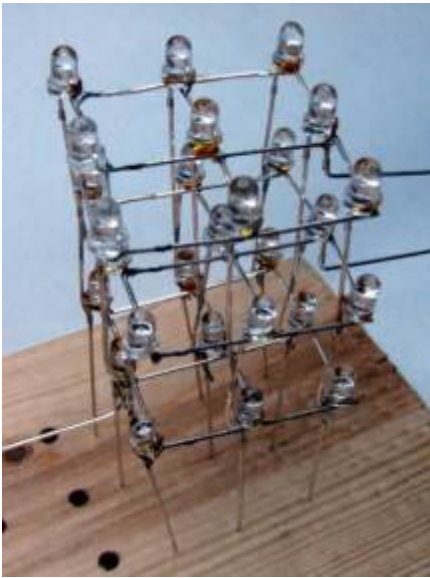
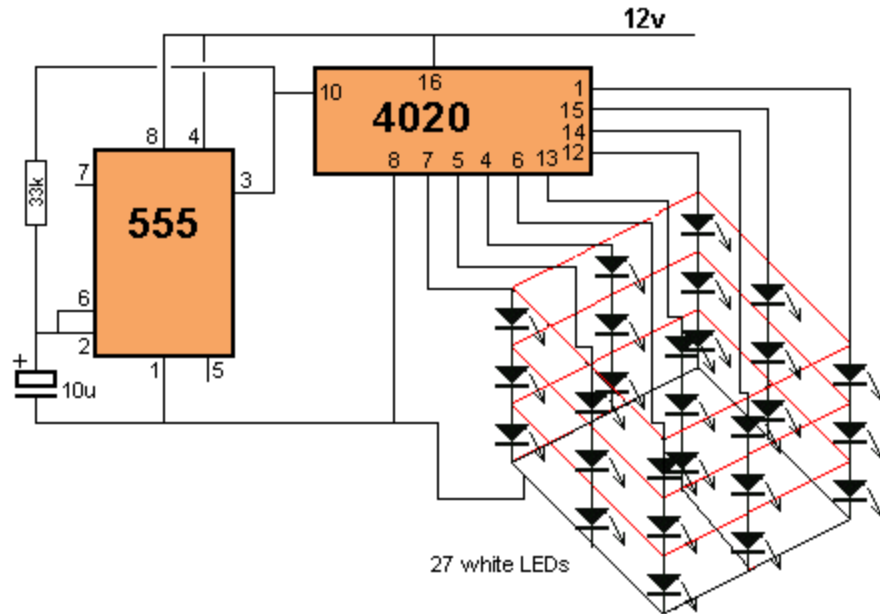
The following circuit shows the maximum number of white LEDs that can be realistically driven from a 555 and we have limited the total current to about 130mA as each LED is designed to pass about 17mA to 22mA maximum. A white LED drops a characteristic 3.2v to 3.6v and this means only 3 LEDs can be placed in series.



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## 3x3x3 CUBE

This circuit drives a 3x3x3 cube consisting of 27 white LEDs. The 4020 IC is a 14 stage binary counter and we have used 9 outputs. Each output drives 3 white LEDs in series and we have omitted a dropper resistor as the chip can only deliver a maximum of 15mA per output. The 4020 produces 512 different patterns before the sequence repeats and you have to build the project to see the effects it produces on the 3D cube.

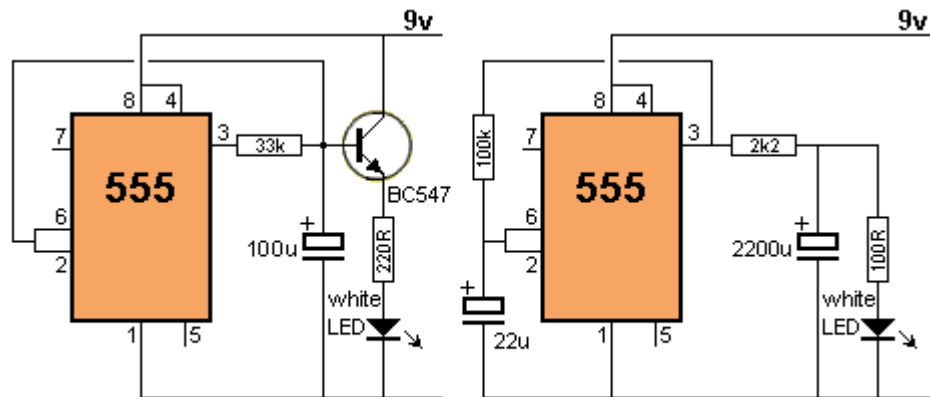


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## UP/DOWN FADING LED

These two circuits make a LED fade on and off. The first circuit charges a 100u and the transistor amplifies the current entering the 100u and delivers 100 times this value to the LED via the collector-emitter pins. The circuit needs 9v for

operation since pin 2 of the 555 detects  $2/3V_{cc}$  before changing the state of the output so we only have a maximum of 5.5v via a 220R resistor to illuminate the LED. The second circuit requires a very high value electrolytic to produce the same effect.

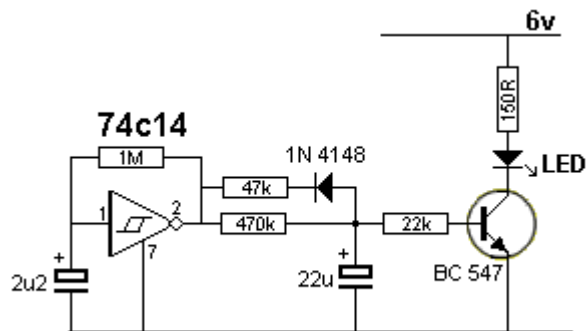


**UP/ DOWN FADING LED**

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## UP/DOWN FADING LED-2

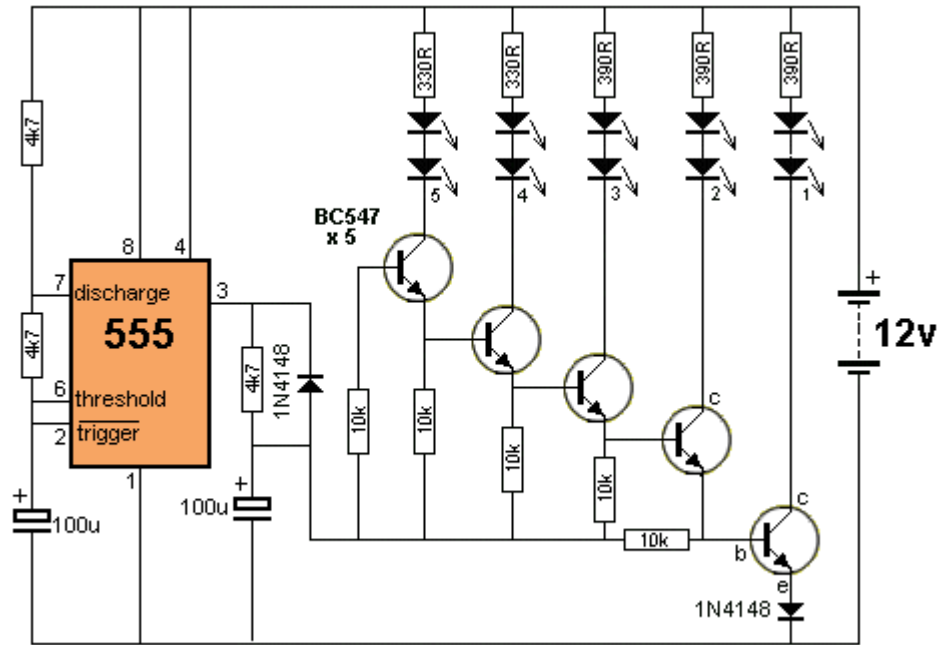
The circuit fades the LED ON and OFF at an equal rate. The 470k charging and 47k discharging resistors have been chosen to create equal on and off times.



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## BIKE TURNING SIGNAL

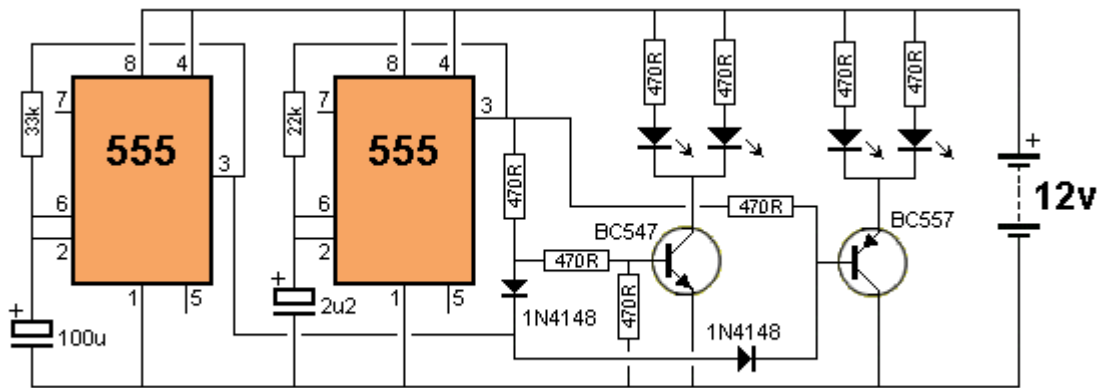
This circuit can be used to indicate left and right turn on a motor-bike. Two identical circuits will be needed, one for left and one for right.



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## POLICE LIGHTS

These three circuits flash the left LEDs 3 times then the right LEDs 3 times, then repeats. The only difference is the choice of chips.



**POLICE LIGHTS**



## LED DICE with Slow Down

This circuit produces a random number from 1 to 6 on LEDs that are similar to the pips on the side of a dice. When the two TOUCH WIRES are touched with a finger, the LEDs flash very quickly and when the finger is removed, they gradually slow down and come to a stop. **LED Dice with Slow Down kit** is available from Talking Electronics.

The circuit diagram illustrates the internal components of the LED Dice with Slow Down kit. It features a 555 timer (IC 555) and a CD 4017 counter (IC CD 4017). The 555 timer is configured as a monostable multivibrator, triggered by a touch wire sensor. The output of the 555 timer is connected to the clock input (pin 14) of the CD 4017 counter. The CD 4017 counter has ten outputs (pins 1-10) that are connected to seven LEDs (pins 1-7) via BC547 transistors. The output sequence of the dice is 5, 2, 3, 4, 6, 1. A 9V battery powers the circuit. A legend shows the output sequence of the dice: 5, 2, 3, 4, 6, 1.

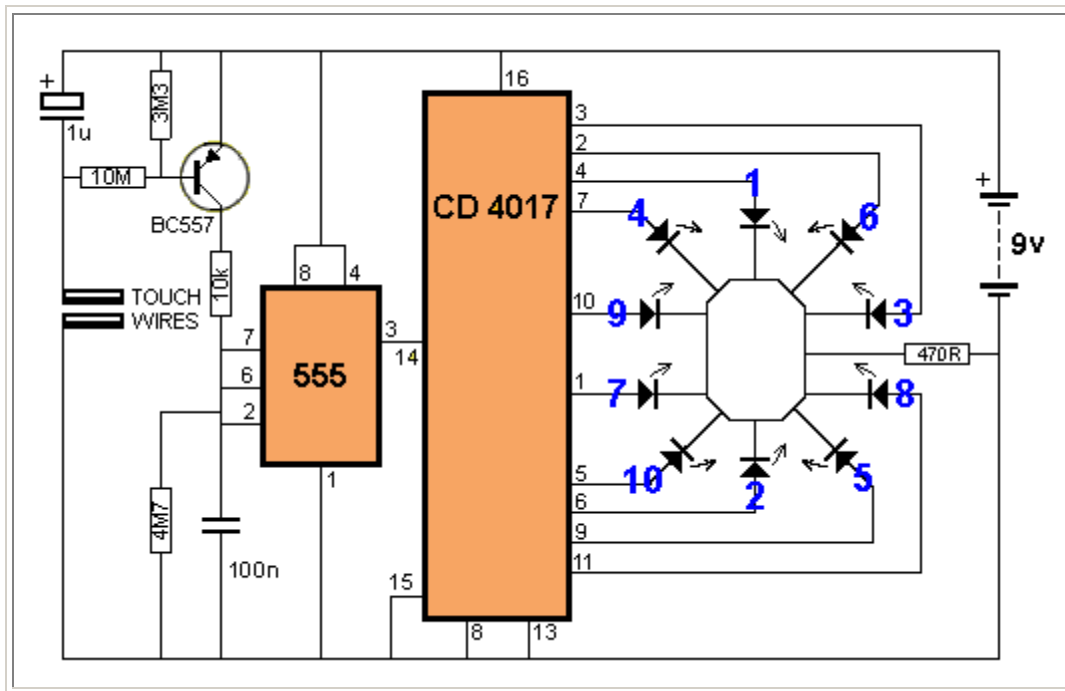
**BUY NOW**

The **LED Dice with Slow Down** kit is available for \$16.00 plus \$6.50 postage. The kit includes the parts and PC board.

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## ROULETTE

This circuit creates a rotating LED that starts very fast when a finger touches the TOUCH WIRES. When the finger is removed, the rotation slows down and finally stops.



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## DICE TE555-4



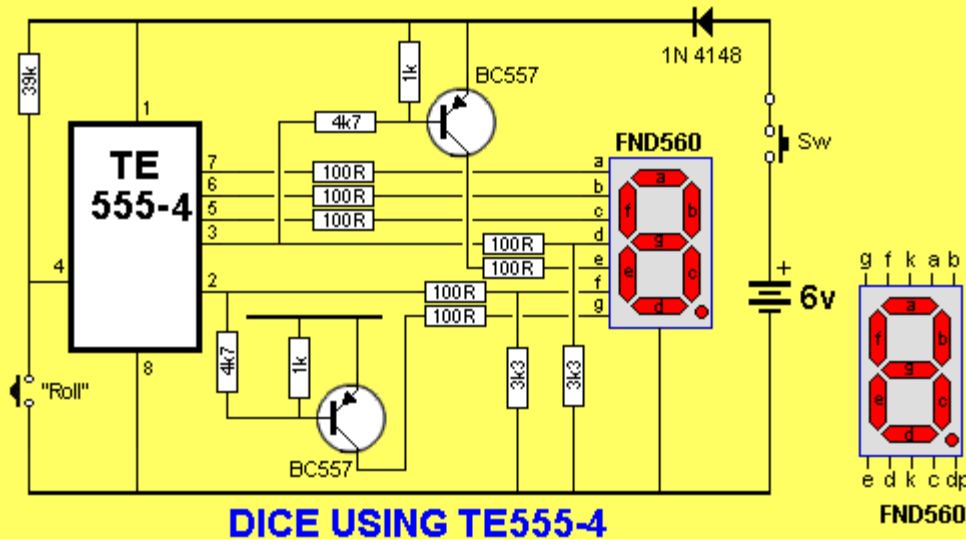
**TE 555-4**  
just  
**\$2.50**

[CLICK TO BUY](#)



This circuit uses the latest [TE555-4 DICE](#) chip from Talking Electronics. This 8-pin chip is available for \$2.50 and drives a 7-Segment display. The circuit can be assembled on proto-type board. For more help on the list of components, email Colin Mitchell: [talking@tpg.com.au](mailto:talking@tpg.com.au)



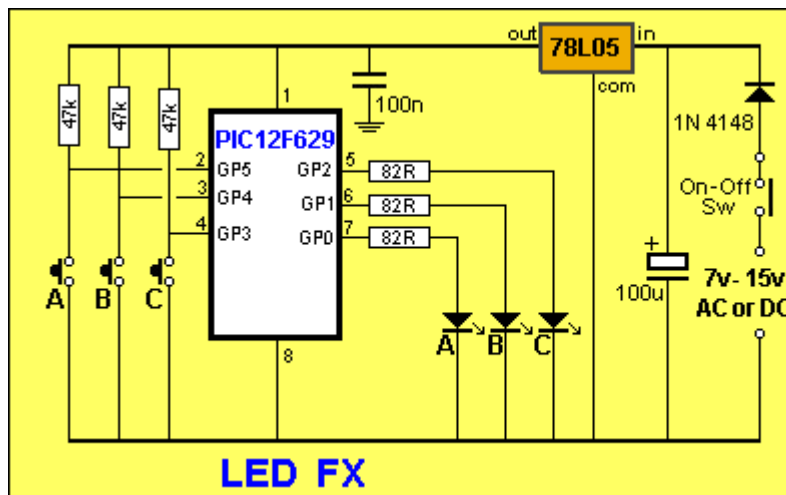


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## LED FX TE555-5



This circuit uses the latest [TE555-5 LED FX](#) chip from Talking Electronics. This 8-pin chip is available for \$2.50 and drives 3 LEDs. The circuit can be assembled on matrix board. The circuit produces 12 different sequences including flashing, chasing, police lights and flicker. It also has a feature where you can create your own sequence and it will show each time the chip is turned on. The kit of components and matrix board can be purchased for \$15.00 plus postage. Email Colin Mitchell: [talking@tpg.com.au](mailto:talking@tpg.com.au) for more details.



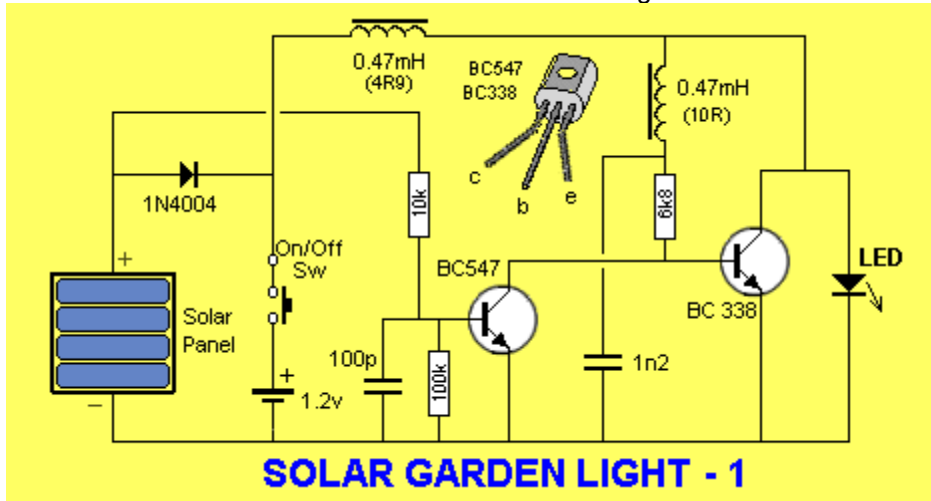


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# SOLAR GARDEN LIGHT

This is the circuit in a \$2.00 Solar Garden Light.

The circuit illuminates a white LED from a 1.2v rechargeable cell.

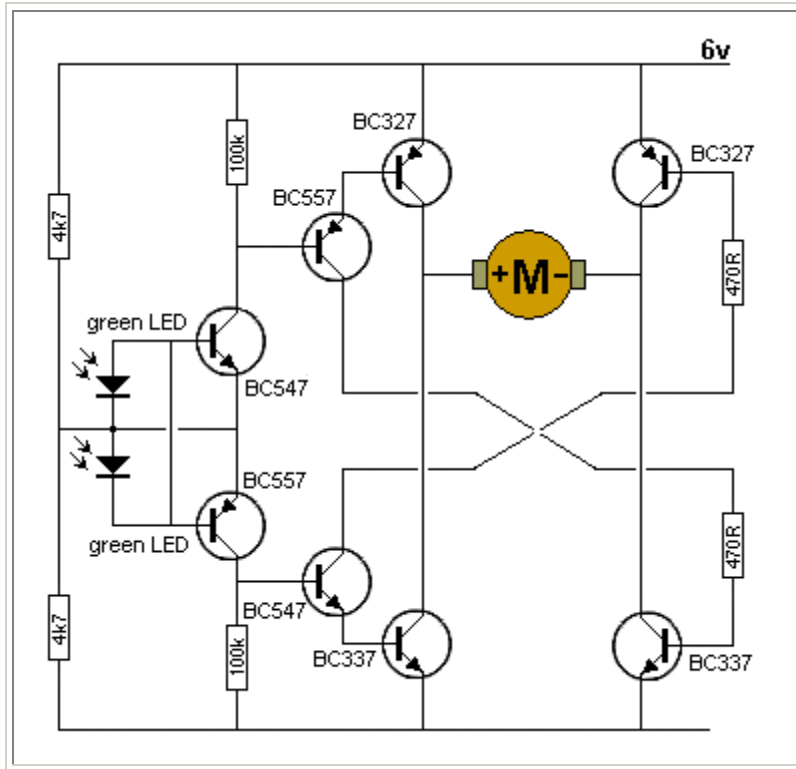
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# SOLAR TRACKER

This circuit is a SOLAR TRACKER. It uses green LEDs to detect the sun and an H-Bridge to drive the motor. A green LED produces nearly 1v but only a fraction of a milliamp when sunlight is detected by the crystal inside the LED and this creates an imbalance in the circuit to drive the motor either clockwise or anticlockwise. The circuit will deliver about 300mA to the motor.

The circuit was designed by RedRok and kits for the **Solar Tracker** are available from:

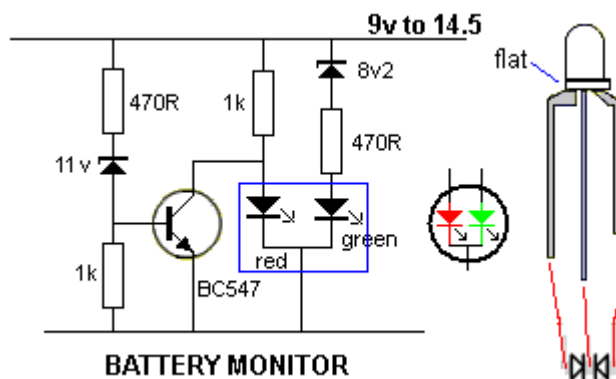
<http://www.redrok.com/electron.htm#tracker> This design is called: **LED5S5V Simplified LED low power tracker.**



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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.

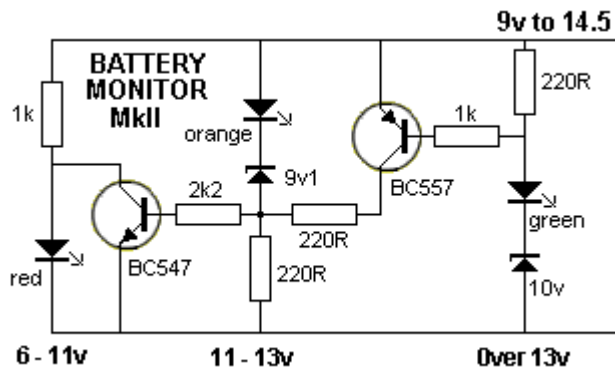


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### BATTERY MONITOR MkII

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.

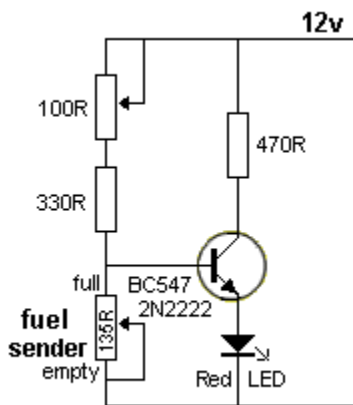
It turns off above 13v and  
The green LED illuminates above 13v



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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 empty.)



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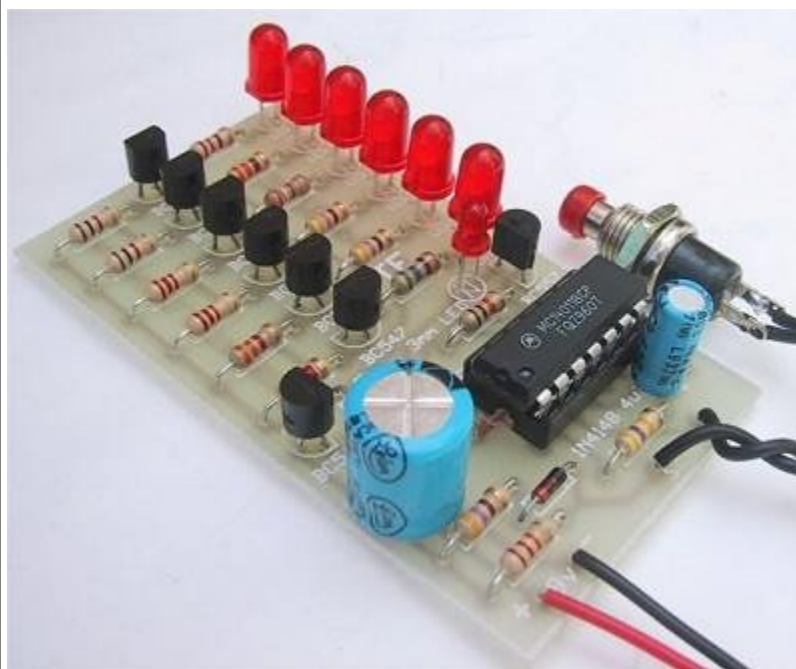
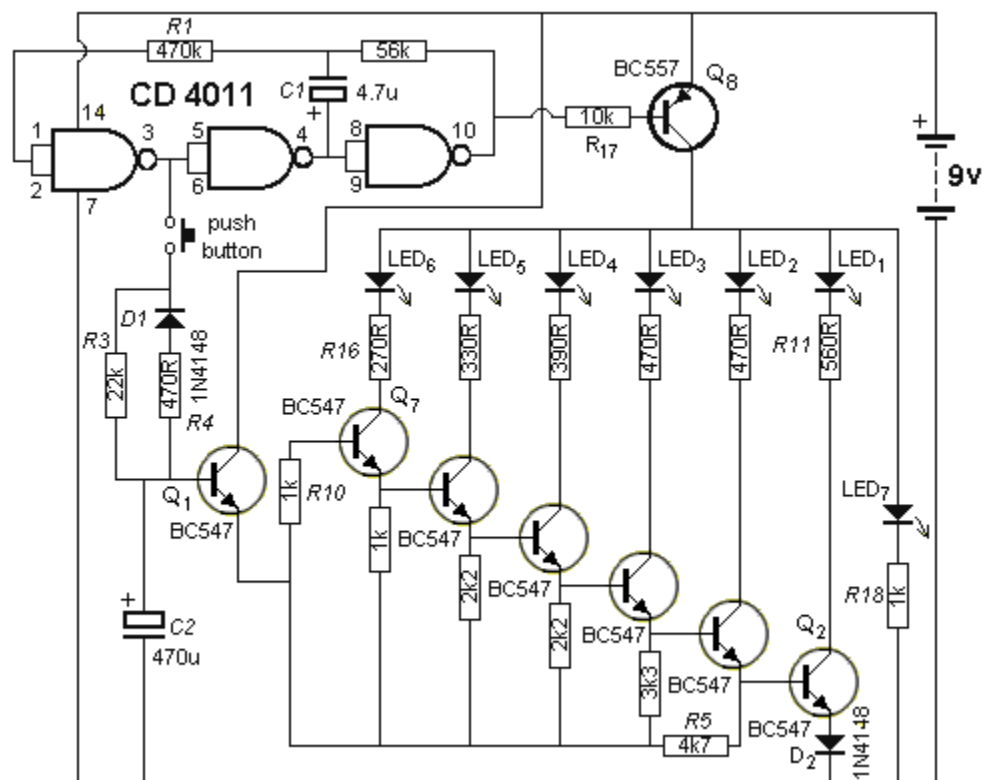
## LED ZEPPELIN

This circuit is a game of skill. See full article: [LED Zeppelin](#). The kit is available from talking electronics for \$15.50 plus postage. Email [HERE](#) for details.

The game consists of six LEDs and an indicator LED that flashes at a rate of about 2 cycles per second. A push button is the "Operations Control" and by carefully pushing the button in synchronisation with the flashing LED, the row of LEDs will gradually light up.

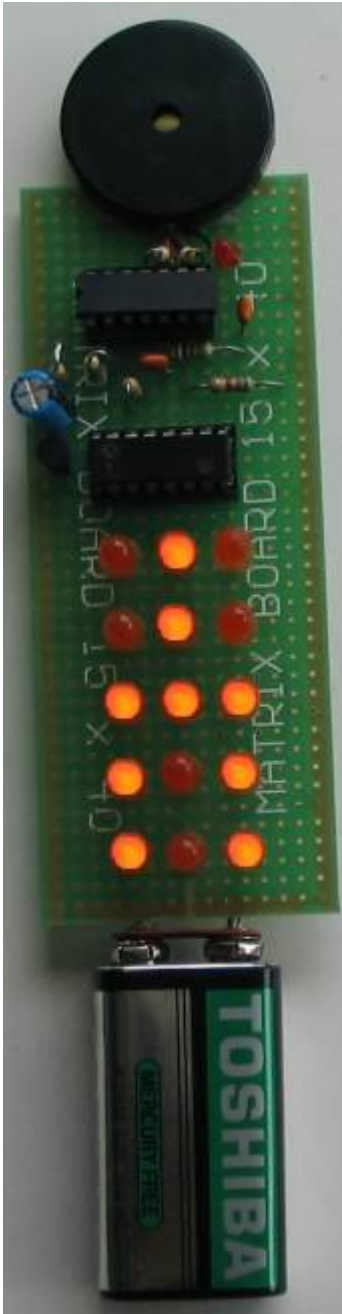
But the slightest mistake will immediately extinguish one, two or three LEDs. The aim of the game is to illuminate the 6 LEDs with the least number of pushes.

We have sold thousands of these kits. It's a great challenge.



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## THE DOMINO EFFECT



Here's a project with an interesting name. The original design was bought over 40 years ago, before the introduction of the electret microphone. They used a crystal earpiece.

We have substituted it with a piezo diaphragm and used a quad op-amp to produce two building blocks. The first is a high-gain amplifier to take the few millivolts output of the piezo and amplify it sufficiently to drive the input of a counter chip. This requires a waveform of at least 6V for a 9V supply and we need a gain of about 600.

The other building block is simply a buffer that takes the high-amplitude waveform and delivers the negative excursions to a reservoir capacitor (100u electrolytic). The charge on this capacitor turns on a BC557 transistor and this effectively takes the power pin of the counter-chip to the positive rail via the collector lead.

The chip has internal current limiting and some of the outputs are taken to sets of three LEDs.

The chip is actually a counter or divider and the frequency picked up by the piezo is divided by 128 and delivered to one output and divided by over 8,000 by the highest-division output to three more LEDs. The other lines have lower divisions.

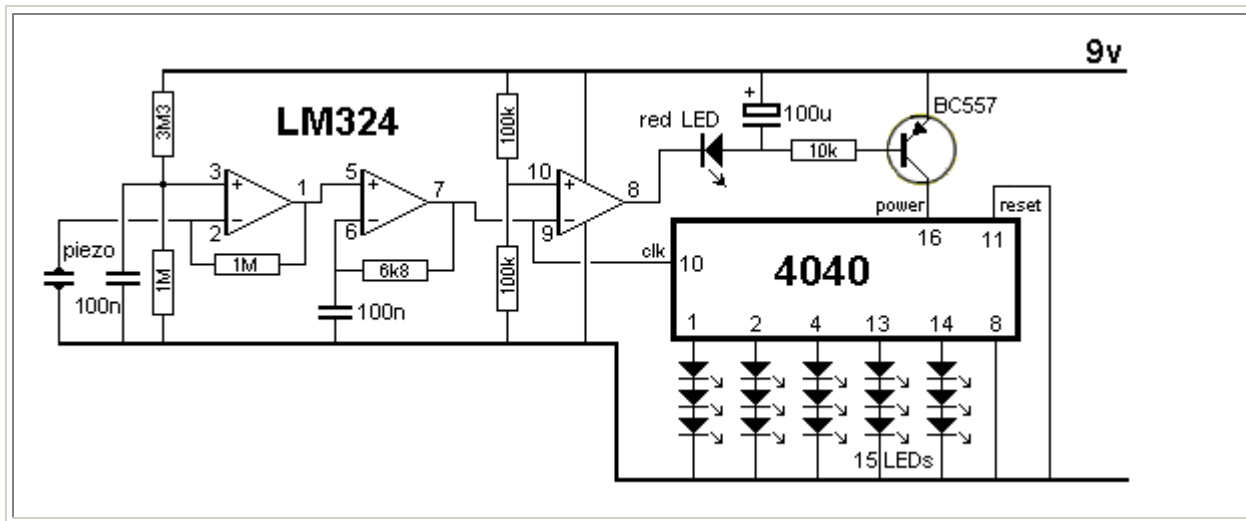
This creates a very impressive effect as the LEDs are connected to produce a balanced display that changes according to the beat of the music.

The voltage on the three amplifiers is determined by the 3M3 and 1M voltage-divider on the first op-amp. It produces about 2V. This makes the output go HIGH and it takes pin 2 with it until this pin sees a few millivolts above pin 3. At this point the output stops rising. Any waveform (voltage) produced by the piezo that is lower than the voltage on pin 3 will make the output go HIGH and this is how we get a large waveform.

This signal is passed to the second op-amp and because the voltage on pin 6 is delayed slightly by the 100nF capacitor, it also produces a gain.

When no signal is picked up by the piezo, pin 7 is approx 2V and pin 10 is about 4.5V. Because pin 9 is lower than pin 10, the output pin 8 is about 7.7V (1.3V below the supply rail) as this is as high as the output will go - it does not go full rail-to-rail.

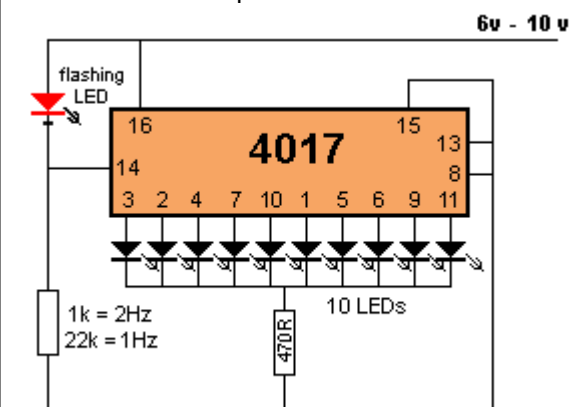
The LED connected to the output removes 1.7V, plus 0.6V between base and emitter and this means the transistor is not turned on. Any colour LEDs can be used and a mixture will give a different effect.



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### 10 LED CHASER

Here's an interesting circuit that creates a clock pulse for a 4017 from a flashing LED. The flashing LED takes almost no current between flashes and thus the clock line is low via the 1k to 22k resistor. When the LED flashes, the voltage on the clock line is about 2v -3v below the rail voltage (depending on the value of the resistor) and this is sufficient for the chip to see a HIGH.



(circuit designed on 9-10-2010)

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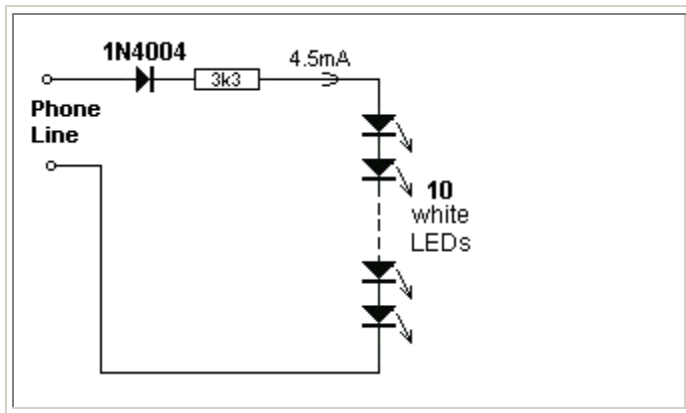
### Emergency PHONE-LINE LIGHT

Here's a project that uses the phone line to illuminate a set of white LEDs.

The circuit delivers a current of 4.5mA as any current above 10mA will be detected by the exchange as the hand-set off the hook.

Be warned: This type of circuit is not allowed as it uses the energy from the phone line (called "leeching") and may prevent the phone from working.

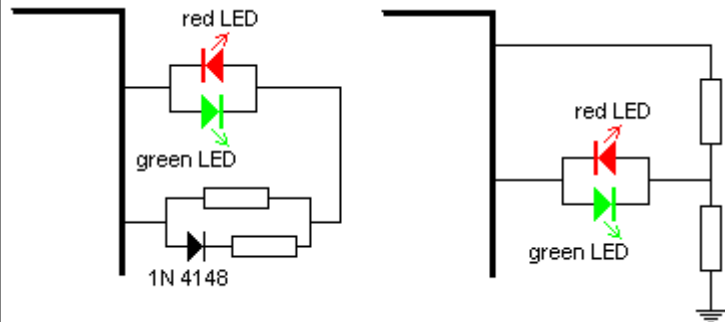




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### EQUAL BRIGHTNESS

A 2-leaded dual colour LED can be connected to the outputs of a microcontroller and the brightness can be equalized by using the circuits shown.



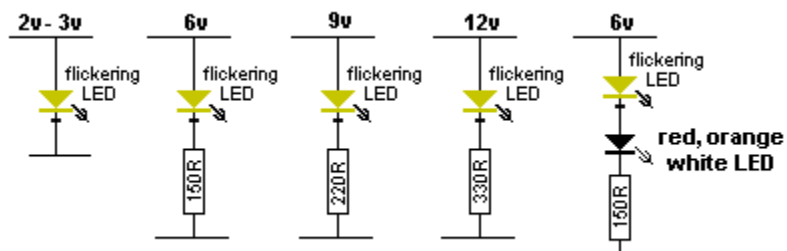
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### FLICKERING LED

A Flickering LED is available from eBay and some electronics shops.

It can be connected to a supply from 2v to 6v and needs an external resistor when the supply is above 3v. The LED has an internal circuit to create the flickering effect and limit the current. We suggest adding a 150R resistor when the supply is above 3v and up to 6v. Above 6v, the current-limit resistor should be increased to 220R for 9v and 330R for 12v.

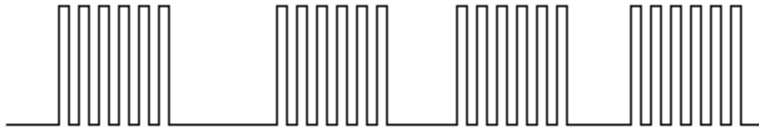
You can connect the flickering LED to an ordinary LED and both will flicker. Here are some arrangements:



The Pulse-Width Modulation to activate the flickering can be observed on an oscilloscope by connecting the probe across the

LED. It is a very complex waveform. It is approx 1v in amplitude and approx 15 x 1kHz pulses to create each portion of the on-time, something like this:

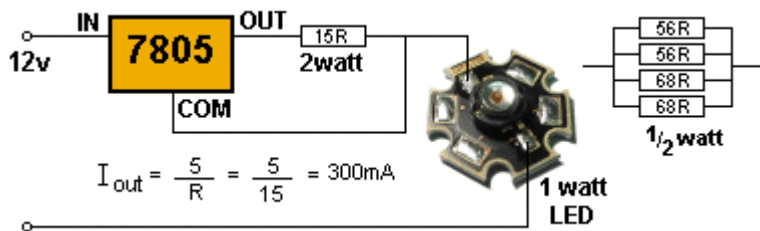
The pulses vary in width to create a brighter illumination.



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### CONSTANT-CURRENT 7805 DRIVES 1 WATT LED

The circuit can be reduced to 2 components:



The 7805 can be converted into a content-current device by connecting a resistor as shown above.

We will take the operation of the circuit in slow-motion to see how it works.

As the 12v rises from 0v, the 7805 starts to work and when the input voltage is 4v, the output is 1v as a minimum of 3v is lost across the 7805. The voltage rises further and when the output is 5v, current flows through the 15R resistor and illuminates the LED. The LED starts to illuminate at 3.4v and the voltage across

the 15R at the moment is 1.6v and the output current will be 100mA. The input voltage keeps rising and now the output voltage is 7v. The current through the LED increases and now the voltage across the LED is 3.5v. The voltage across the 15R is 3.5v and the current is 230mA.

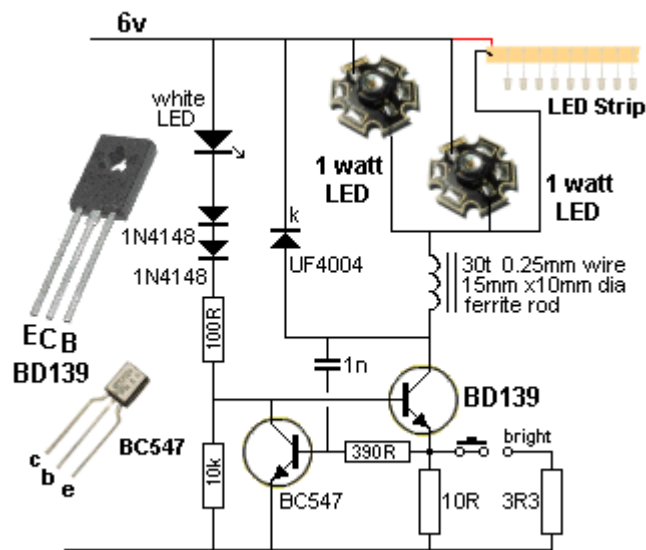
The input voltage keeps rising and the output voltage is now 8.6v. The current through the LED increases and the voltage across the LED is now 3.6v. The voltage across the 15R is 5v and the current is 330mA. The input voltage keeps rising but a detector inside the 7805 detects the output voltage is exactly 5v above the common and the output voltage does not rise any more. The input voltage can rise above 13v, 14v . . . . 25v or more but the output voltage will not rise.

If the output voltage rises, more current will be delivered to the LED and the voltage across the 15R will increase. The 7805 will not allow this to happen.

The LED will have 3.6v across it. The 15R will have 5v across it and the output will be 8.6v. The input voltage will have to be at least 12.6v for the 7805 to operate.

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## 1-WATT LED - very good design



**Circuit takes 70mA on LOW brightness  
and 120mA on HIGH Brightness**

This circuit has been specially designed for a 6v rechargeable battery or 5 x 1.2v NiCad cells. **Do not use any other voltage.**

It has many features:

The pulse-operation to the two 1-watt LEDs delivers a high current for a short period of time and this improves the brightness.

The circuit can drive two 1-watt LEDs with extremely good brightness and this makes it more efficient than any other design.

The circuit is a two-transistor high-frequency oscillator and it works like this:

The BD139 is turned ON via the base, through the white LED and two signal diodes and it amplifies this current to appear through the collector-emitter circuit. This current flows through the 1-watt LED to turn it ON and also through the 30-turn winding of the inductor. At the same time the current through the 10R creates a voltage-drop and when this voltage rises to 0.65v, the BC547 transistor starts to turn ON. This robs the base of the BD139 of "turn-on voltage" and the current through the inductor ceases to be expanding flux, but stationary flux.

The 1n capacitor was initially pushing against the voltage-rise on the base of the BC547 but it now has a reverse-effect of allowing the BC547 to turn ON.

This turns off the BD139 a little more and the current through the inductor reduces.

This creates a collapsing flux that produces a voltage across the coil in the opposite direction. This voltage passes via the 1n to turn the BC547 ON and the BD139 is fully turned OFF.

The inductor effectively becomes a miniature battery with negative on the lower LED and positive at the anode of the Ultra Fast diode. The voltage produced by the inductor flows through the UF diode and both 1-watt LEDs to give them a spike of high current. The circuit operates at approx 500kHz and this will depend on the inductance of the inductor.

The circuit has about 85% efficiency due to the absence of a current-limiting resistor, and shuts off at 4v, thus preventing deep-discharge of the rechargeable cells or 6v battery. The clever part of the circuit is the white LED and two diodes. These form a zener reference to turn the circuit off at 4v. The 10k resistor helps too. The circuit takes 70mA on low brightness and 120mA on HIGH brightness via the brightness-switch. The LEDs actually get 200mA pulses of current and this produces the high brightness.

### The Inductor

The coil or inductor is not critical. You can use a broken antenna rod from an AM radio (or a flat antenna slab) or an inductor from a computer power supply. Look for an inductor with a few turns of thick wire (at least 30) and you won't have to re-wind it.

Here are two inductors from surplus outlets:

<http://www.goldmine-elec-products.com/prodinfo.asp?number=G16521B>

- 50 cents

<http://www.allelectronics.com/make-a-store/item/CR-345/345-UH-TOROIDAL-INDUCTOR/1.html> - 40cents

Here are the surplus inductors:



The cost of surplus is from 10 cents to 50 cents, but you are sure to find something from a computer power supply.

Pick an inductor that is about 6mm to 10mm diameter and 10mm to 15mm high. Larger inductor will not do any damage. They simply have more ferrite material to store the energy and will not be saturated. It is the circuit that delivers the energy to the inductor and then the inductor releases it to the LEDs via the high speed diode.

### IMPROVEMENT

By using the following idea, the current reduces to 90mA and 70mA and the illumination over a workbench is much better than a single high-power LED. It is much brighter and much nicer to work under.

Connect fifteen 5mm LEDs in parallel (I used 20,000mcd LEDs) by soldering them to a double-sided strip of PC board, 10mm wide and 300mm long. Space them at about 20mm. I know you shouldn't connect LEDs in parallel, but the concept works very well in this case. If some of the LEDs have a characteristic high voltage and do not illuminate very brightly, simply replace them and use them later for another strip.

You can replace one or both the 1-watt LEDs with a LED Strip, as shown below:



## No current-limit resistor. . . why isn't the LED damaged?

Here's why the LED isn't damaged:

When the BD139 transistor turns ON, current flows through the LEDs and the inductor. This current gradually increases due to the gradual turning-on of the transistor and it is also increasing through the inductor. The inductor also has an effect of slowing-down the "in-rush" of current due to the expanding flux cutting the turns of the coil, so there is a "double-effect" on avoiding a high initial current. That's why there is little chance of damaging the LEDs.

When it reaches 65mA, it produces a voltage of  $.065 \times 10 = 650\text{mV}$  across the 10R resistor, but the 1n is pushing against this increase and it may have to rise to 150mA to turn on the BC547. LEDs can withstand 4 times the normal current for very short periods of time and that's what happens in this case. The BD139 is then turned off by the voltage produced by the inductor due to the collapsing magnetic flux and a spike of high current is passed to the LEDs via the high speed diode. During each cycle, the LEDs receive two pulses of high current and this produces a very high brightness with the least amount of energy from the supply. All the components run "cold" and even the 1-watt LEDs are hardly warm.

## Charging and Discharging

This project is designed to use all your old NiCad cells and mobile phone batteries.

It doesn't matter if you mix up sizes and type as the circuit takes a low current and shuts off when the voltage is approx 4v for a 6v pack.

If you mix up 600mA-Hr cells with 1650mA-Hr, 2,000mA-Hr and 2,400mA-Hr, the lowest capacity cell will determine the operating time.

The capacity of a cells is called "C."

Normally, a cell is charged at the 14 hour-rate.

The charging current is 10% of the capacity. For a 600mA-Hr cell, this is 60mA. In 10 hours it will be fully charged, but charging is not 100% efficient and so we allow another 2 to 4 hours.

For a 2,400mA-Hr cell, it is 240mA. If you charge them faster than 14-hr rate, they will get HOT and if they get very hot, they may leak or even explode. But this project is designed to be charged via a solar panel using 100mA to 200mA cells, so nothing will be damaged.

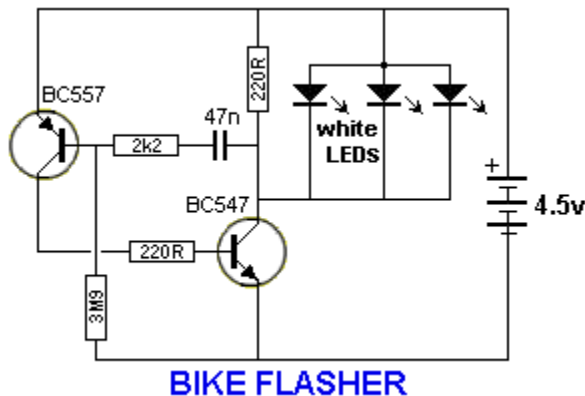
Ideally a battery is discharged at C/10 rate. This means the battery will last 10 hours and for a 600mA-Hr cell, this is 60mA. If you discharge it at the "C-rate," it will theoretically last 1 hour and the current will be 600mA. But at 600mA, the cells may only last 45 minutes. If you discharge is at C/5 rate, it will last 5 hours.

Our project takes 120mA so no cell will be too-stressed. A 600mA-Hr cell will last about 4-5 hours, while the other cells will last up to 24 hours. Try to keep the capacity of each cell in a "battery-pack" equal.

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## BIKE FLASHER

This circuit will flash a white LED (or 2,3 4 LEDs in parallel) at 2.7Hz, suitable for the rear light on a bike.



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1R0 10R

gold 5% gold 5%

If 3rd band is gold, Divide by 10  
If 3rd band is silver, Divide by 100  
(to get 0.22ohms etc)

ROW	SILVER	GOLD	BLACK	BROWN	RED	ORANGE	YELLOW	GREEN
1-	R10	1R0	10R	100R	1K0	10K	100K	1M0
2-	R11	1R1	11R	110R	1K1	11K	110K	1M1
3-	R12	1R2	12R	120R	1K2	12K	120K	1M2
4-	R13	1R3	13R	130R	1K3	13K	130K	1M3
5-	R15	1R5	15R	150R	1K5	15K	150K	1M5
6-	R16	1R6	16R	160R	1K6	16K	160K	1M6
7-	R18	1R8	18R	180R	1K8	18K	180K	1M8
8-	R20	2R0	20R	200R	2K0	20K	200K	2M0
9-	R22	2R2	22R	220R	2K2	22K	220K	2M2
10-	R24	2R4	24R	240R	2K4	24K	240K	2M4
11-	R27	2R7	27R	270R	2K7	27K	270K	2M7
12-	R30	3R0	30R	300R	3K0	30K	300K	3M0
13-	R33	3R3	33R	330R	3K3	33K	330K	3M3
14-	R36	3R6	36R	360R	3K6	36K	360K	3M6
15-	R39	3R9	39R	390R	3K9	39K	390K	3M9
16-	R43	4R3	43R	430R	4K3	43K	430K	4M3
17-	R47	4R7	47R	470R	4K7	47K	470K	4M7
18-	R51	5R1	51R	510R	5K1	51K	510K	5M1
19-	R56	5R6	56R	560R	5K6	56K	560K	5M6
20-	R62	6R2	62R	620R	6K2	62K	620K	6M2
21-	R68	6R8	68R	680R	6K8	68K	680K	6M8
22-	R75	7R5	75R	750R	7K5	75K	750K	7M5
23-	R82	8R2	82R	820R	8K2	82K	820K	8M2
24-	R91	9R1	91R	910R	9K1	91K	910K	9M1
								10M
								BLUE

**COLOR CODES FOR THE WHOLE E12/E24 RANGE OF RESISTORS**

The twelve odd rows - 1, 3, 5... - represent values available in the E12 range only, plus 10M

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