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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."

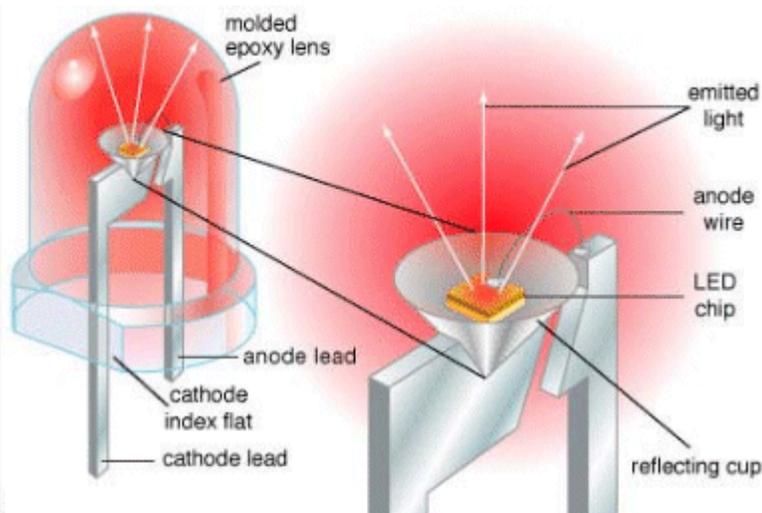
A globe is an electrical device consisting of a glowing wire while a LED is an electronic device.

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.

## INSIDE A LED:



| Color  | Material                           | Bandgap | $V_f$   |
|--------|------------------------------------|---------|---------|
| Blue   | SiC                                | 2.64 eV | 3.2–4.9 |
| Green  | GaP                                | 2.19 eV | 2.2–2.5 |
| Yellow | GaP <sub>85</sub> As <sub>15</sub> | 2.11 eV | 2.1–2.5 |
| Orange | GaP <sub>65</sub> As <sub>35</sub> | 2.03 eV | 1.9–2.2 |
| Red    | GaP <sub>4</sub> As <sub>6</sub>   | 1.91 eV | 1.7–2.7 |

| Color of LED  | Voltage Drop (Volt) |
|---|---------------------|
|  Red    | 1.63 ~ 2.03         |
|  Yellow | 2.10 ~ 2.18         |
|  Orange | 2.03 ~ 2.10         |
|  Blue   | 2.48 ~ 3.7          |
|  Green  | 1.9 ~ 4.0           |
|  Violet | 2.76 ~ 4.0          |
|  UV     | 3.1 ~ 4.4           |
|  White  | 3.2 to 3.6          |

A "Natural" or "Characteristic" voltage develops across a LED when it is correctly connected in a circuit with a current-limiting resistor to allow a current of between 1mA and 20mA. This voltage is shown in the table above and we normally use the lower value for each colour. However the table shows the voltage varies quite a lot and this depends on the actual crystalline construction of the crystal and the way it is manufactured. You cannot change this and that's why you need to measure the voltage across the LED when building some of the circuits.

## LED VOLTAGES

Here is another table showing LED Voltages. The voltage across a LED depends on the manufacturer, the intensity of the colour and the actual colour.

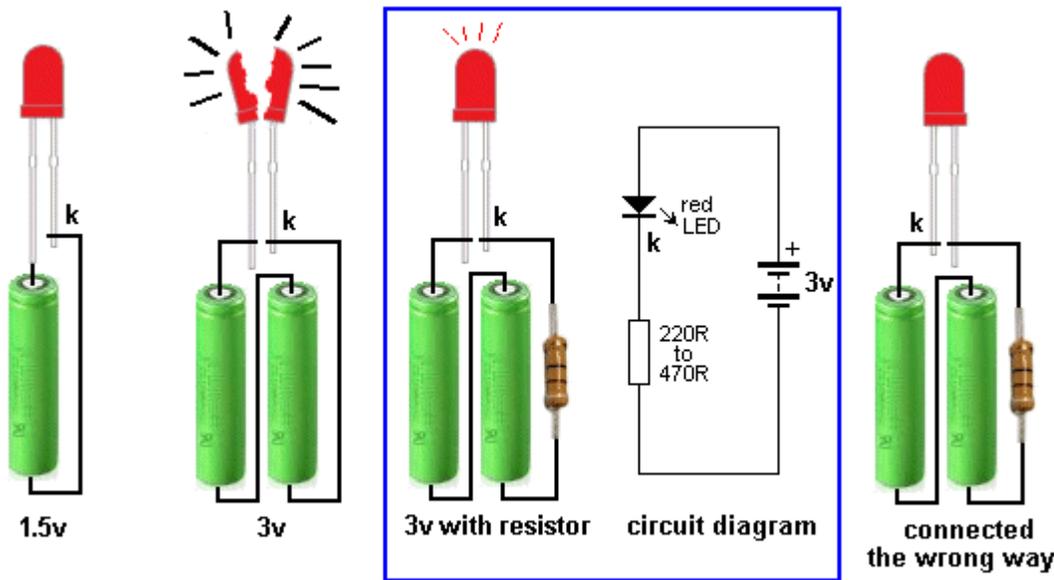
| Color     | Material | Wavelength (nm) | V-forward |
|-----------|----------|-----------------|-----------|
| Super Red | GaAlAs   | 660             | 1.8       |
| Green     | GaP      | 565             | 2         |
| Red       | GaAsP    | 635             | 2         |
| Red       | AlInGaP  | 636             | 2         |
| Orange    | AlInGaP  | 610             | 2         |
| Yellow    | AlInGaP  | 590             | 2         |
| Amber     | GaAsP    | 605             | 2.1       |
| Red       | GaP      | 700             | 2.1       |
| Green     | GaP      | 555             | 2.1       |
| Green     | AlInGaP  | 574             | 2.2       |
| Blue      | SiC      | 430             | 3.5       |
| Green     | InGaN    | 505             | 3.5       |
| Blue      | InGaN    | 470             | 3.5       |
| White     | InGaN    |                 | 3.5       |
| Green     | InGaN    | 525             | 3.7       |
| Green     | InGaN    | 525             | 4         |
| Blue      | SiC      | 430             | 4.5       |

**LED VOLTAGES** depend on many factors. You must test the LED(s) you are using.

The voltage across some LEDs increases by 500mV (0.5v) when the current increases from about 10mA to 25-30mA and if you have 6 LEDs in series, this is an increase of 3v. If you are using a 12v supply, you will need to remove one LED to get the brightness you require.

## 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.

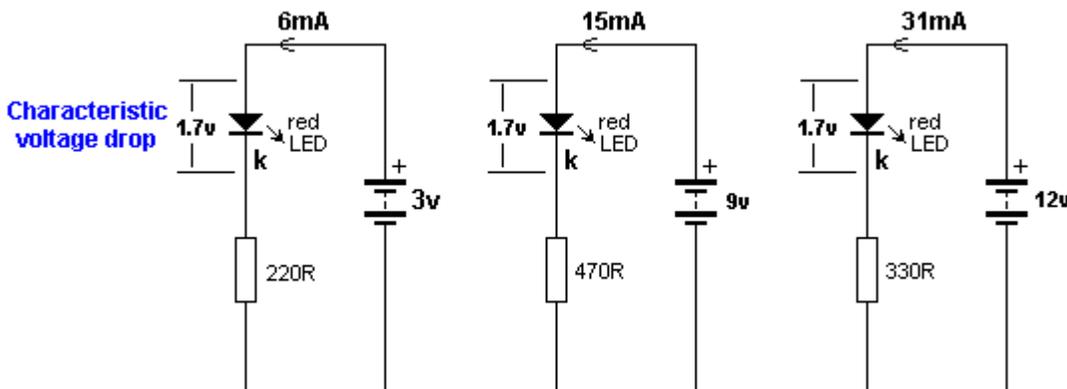
A LED works like this: A LED and resistor are placed in series and connected to a voltage.

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.

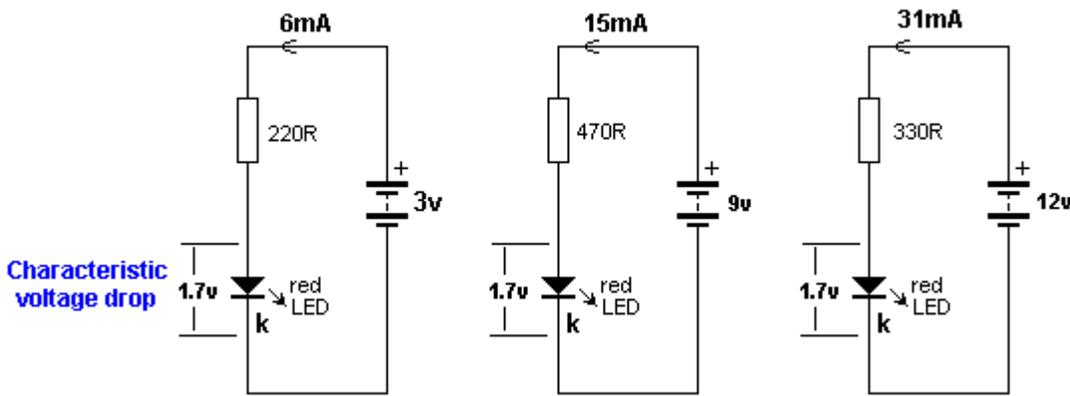
We now turn our attention to the current though the LED. As the current increases to 5mA, 10mA, 15mA, 20mA the brightness will increase and at 25mA, it will be a maximum. Increasing the supply voltage will simply change the colour of the LED slightly but the crystal inside the LED will start to overheat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



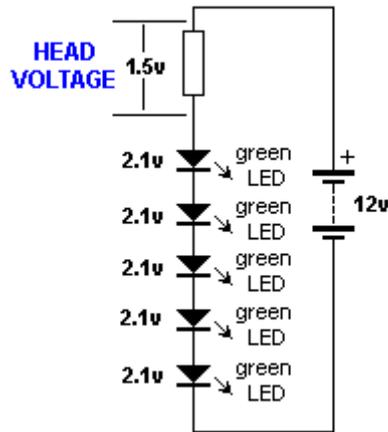
## HEAD VOLTAGE

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. (Sometimes the LEDs will illuminate because some LEDs will have a characteristic voltage that is slightly less than 1.7v and some will illuminate when the voltage is lower than 1.6v - but the brightness will reduce considerably.)

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.

Roger Mew contacted me asking for some suitable resistances for the HEAD VOLTAGE resistor. Here is a list:

**For 25mA current:**

**Use 56R for 1.5v drop.**

**Use 82R for 2v drop**

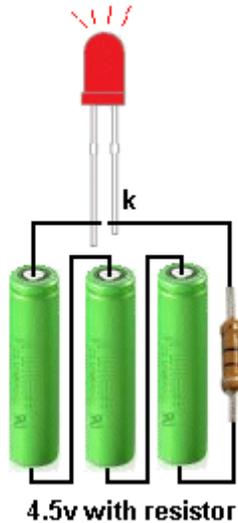
**Use 120R for 3v drop**

**Use 150R for 4v drop**

**Use 180R for about 5v drop**

## 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**

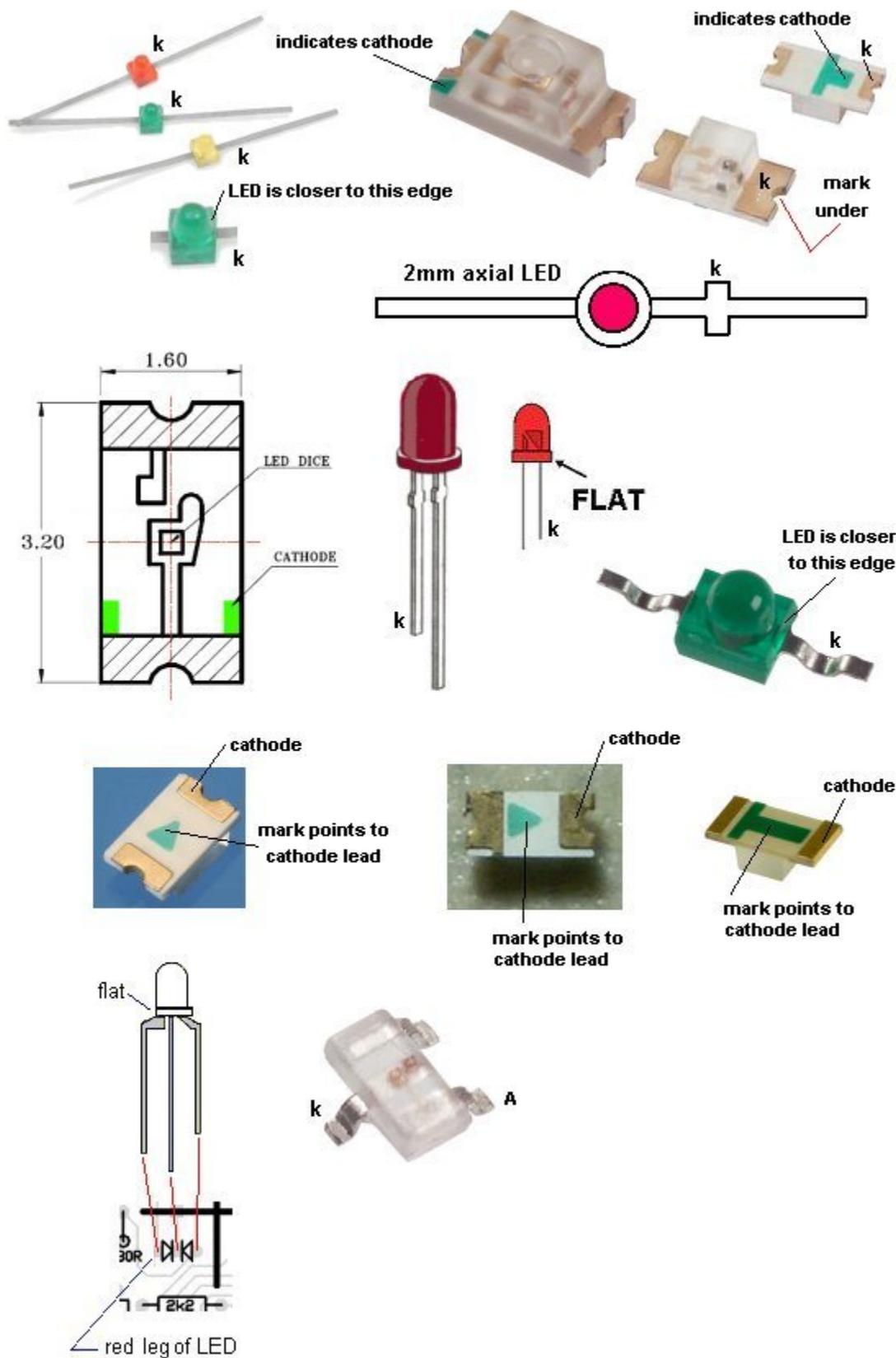
## IDENTIFYING A LED

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 of current flowing through it.

This is the way to see what we mean: Place a LED and 100R resistor in series and connect it to a variable power supply.

As the voltage is increased from 0v, to 1v, the LED will not produce any illumination, As the voltage from the

power-supply increases past 1v, the LED will start to produce illumination at about 1.6v to 1.7v (for a red LED). As the voltage is increased further, the illumination increases but the voltage across the LED does not increase. (It may increase 0.1v) but the brightness will increase enormously. That's why we say the LED is a CURRENT DRIVEN DEVICE.

The brightness of a LED can be altered by increasing or decreasing the current. The effect will not be linear and it is best to experiment to determine the best current-flow for the amount of illumination you want. High-bright LEDs and super-bright LEDs will illuminate at 1mA or less, so the quality of a LED has a lot to do with the brightness. The life of many LEDs is determined at 17mA. This seems to be the best value for many types of LEDs.

## 1mA to 5mA LEDs

Some LEDs will produce illumination at 1mA. These are "high Quality" or "High Brightness" LEDs and the only way to check this feature is to test them @1mA as shown below.

## THE 5v LED

Some suppliers and some websites talk about a 5v white or blue LED. Some LEDs have a small internal resistor and can be placed on a 5v supply. This is very rare.

Some websites suggest placing a white LED on a 5v supply. These LEDs have a characteristic voltage-drop of 3.6v and should not be placed directly on a voltage above 3.6v. If placed on a voltage below 3.6v, the LED will not glow very brightly. If you have a voltage EXACTLY 3.6v, you can connect the LED, but most voltages are higher than 3.6v and thus you need a resistor.

The only LED with an internal resistor is a FLASHING LED. These LEDs can be placed on a supply from 3.5v to 12v and flash at approx 2Hz. The LED is very weak on 3.5v but it flashing can be used to drive a powerful LED (see circuits section). It can also be used to produce a beep for a beeper FM transmitter.

NEVER assume a LED has an internal resistor. Always add a series resistor. Some high intensity LEDs are designed for 12v operation. These LEDs have a complete internal circuit to deliver the correct current to the LED. This type of device and circuitry is not covered in this eBook.

## LEDs IN SERIES

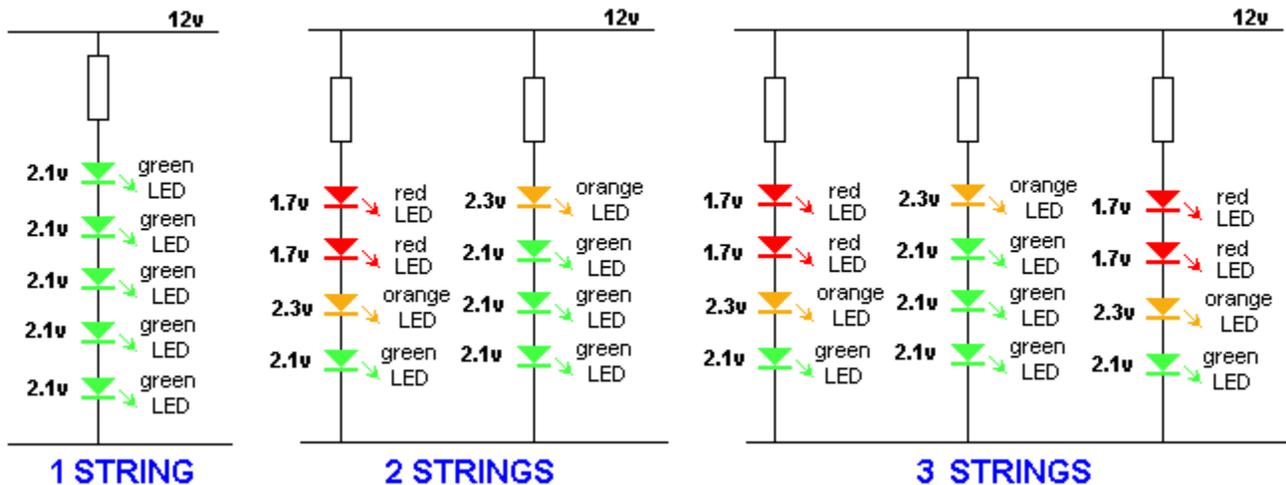
LEDs can be placed in series providing some features are taken into account. The main item to include is a current-limiting resistor.

A LED and resistor is called a string. A string can have 1, 2, 3 or more LEDs.

Three things must be observed:

1. MAXIMUM CURRENT through each string = 25mA.
2. The CHARACTERISTIC VOLTAGE-DROP must be known so the correct number of LEDs are used in any string.
3. A DROPPER RESISTOR must be included for each string.

The following diagrams show examples of 1-string, 2-strings and 3-strings:



## LEDs IN PARALLEL

LEDs **CANNOT** be placed in parallel - until you read this:

LEDs "generate" or "possess" or "create" a voltage across them called the CHARACTERISTIC VOLTAGE-DROP (when they are correctly placed in a circuit).

This voltage is generated by the type of crystal and is different for each colour as well as the "quality" of the LED (such as high-bright, ultra high-bright etc). This characteristic cannot be altered BUT it does change a very small amount from one LED to another in the same batch. And it does increase slightly as the current increases.

For instance, it will be different by as much as 0.2v for red LEDs and 0.4v for white LEDs from the same batch and will increase by as much as 0.5v when the current is increased from a minimum to maximum.

You can test 100 white LEDs @15mA and measure the CHARACTERISTIC VOLTAGE-DROP to see this range. If you get 2 LEDs with identical CHARACTERISTIC VOLTAGE-DROP, and place them in parallel, they will each take the same current. This means 30mA through the current-limiting resistor will be divided into 15mA for each LED.

However if one LED has a higher CHARACTERISTIC VOLTAGE-DROP, it will take less current and the other LED will take considerably more. Thus you have no way to determine the "current-sharing" in a string of parallel LEDs. If you put 3 or more LEDs in parallel, one LED will start to take more current and will over-heat and you will get very-rapid LED failure. As one LED fails, the others will take more current and the rest of the LEDs will start to self-destruct. The reason why they take more current is this: the current-limit resistor will have been designed so that say 60mA will flow when 3 LEDs are in parallel. When one LED fails, the remaining LEDs will take 30mA each.

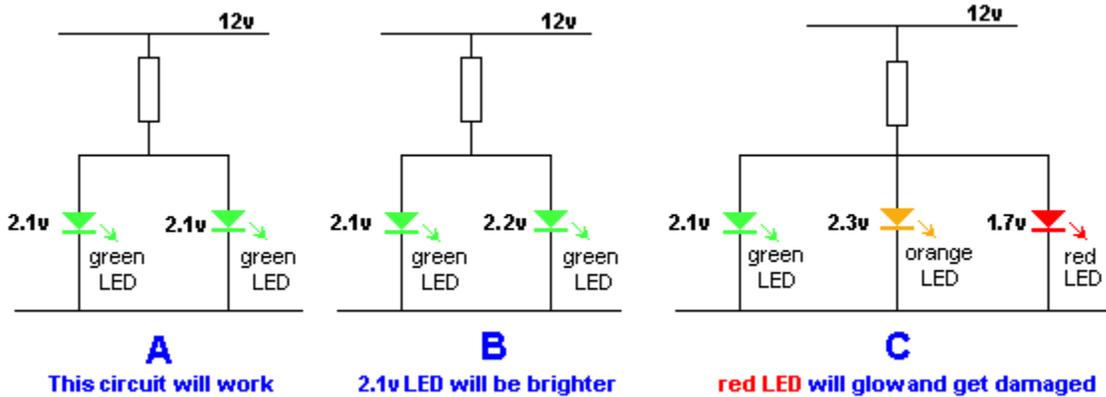
Thus LEDs in PARALLEL should be avoided.

Diagram A below shows two green LEDs in parallel. This will work provided the Characteristic Voltage Drop across each LED is the same.

In diagram B the Characteristic Voltage Drop is slightly different for the second LED and the first green LED will glow brighter.

In diagram C the three LEDs have different Characteristic Voltage Drops and the red LED will glow very bright while the other two LEDs will not illuminate. All the current will pass through the red LED and it will be damaged.

The reason why the red LED will glow very bright is this: It has the lowest Characteristic Voltage Drop and it will create a 1.7v for the three LEDs. The green and orange LEDs will not illuminate at this voltage and thus all the current from the dropper resistor will flow in the red LED and it will be destroyed.



## THE RESISTOR

The value of the current limiting resistor can be worked out by Ohms Law.

Here are the 3 steps:

1. Add up the voltages of all the LEDs in a string. e.g:  $2.1v + 2.3v + 2.3v + 1.7v = 8.4v$
2. Subtract the LED voltages from the supply voltage. e.g:  $12v - 8.4v = 3.6v$
3. Divide the 3.6v (or your voltage) by the current through the string.

for 25mA:  $3.6/.025 = 144$  ohms

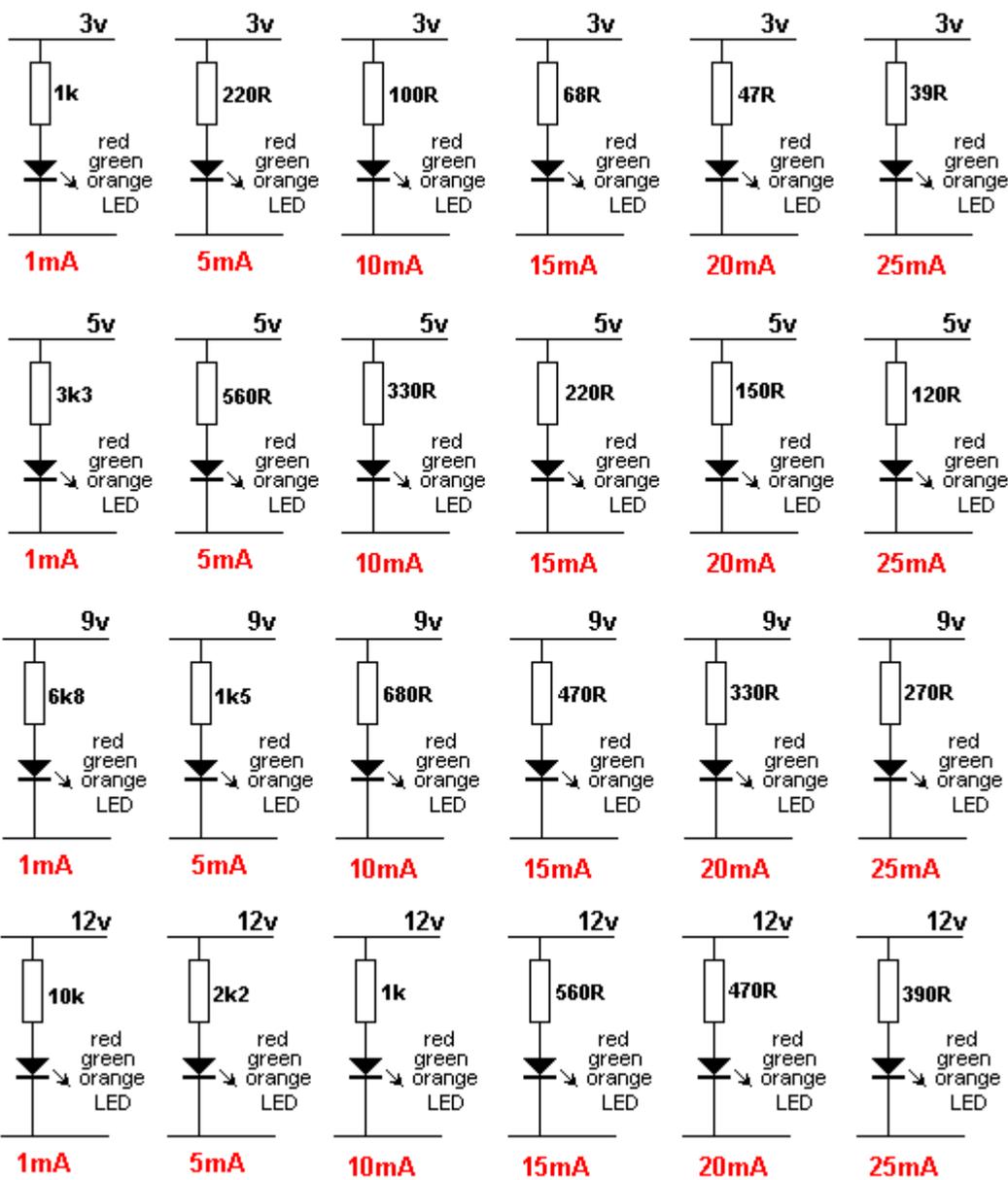
for 20mA:  $3.6/.02 = 180$  ohms

for 15mA:  $3.6/.015 = 250$  ohms

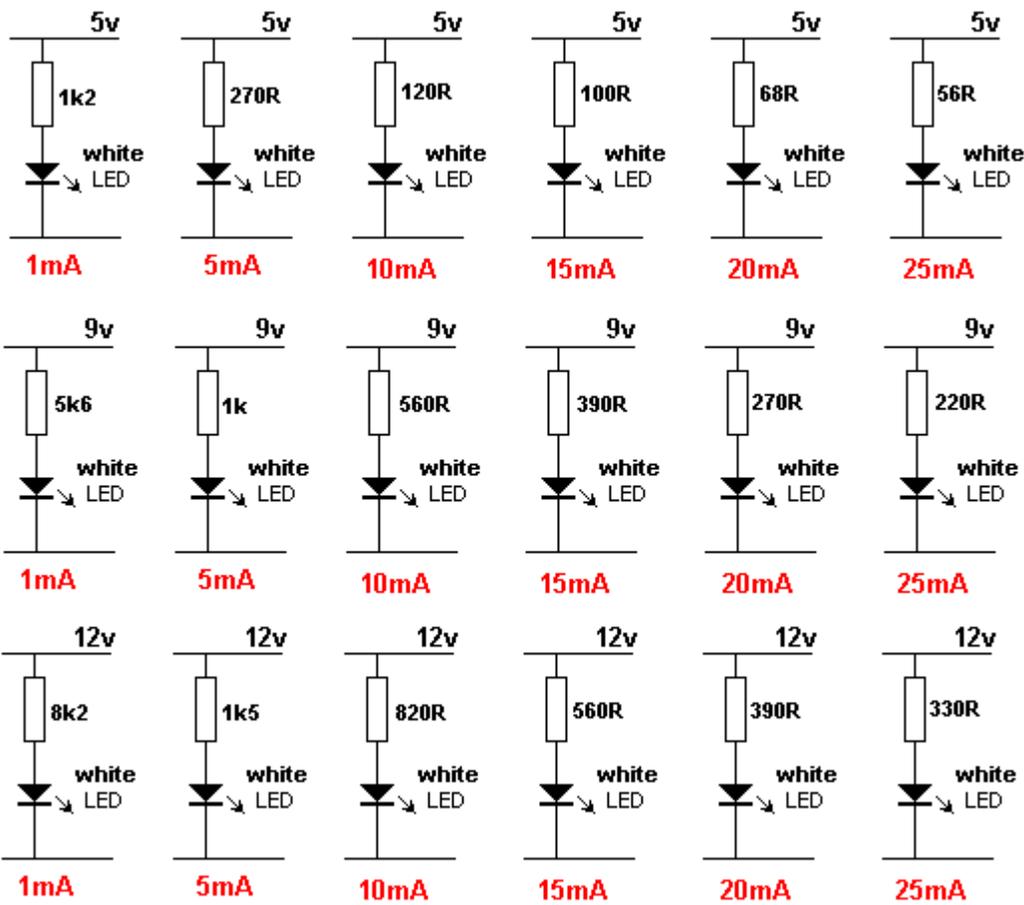
for 10mA:  $3.6/.01 = 360$  ohms

This is the value of the current-limiting resistor.

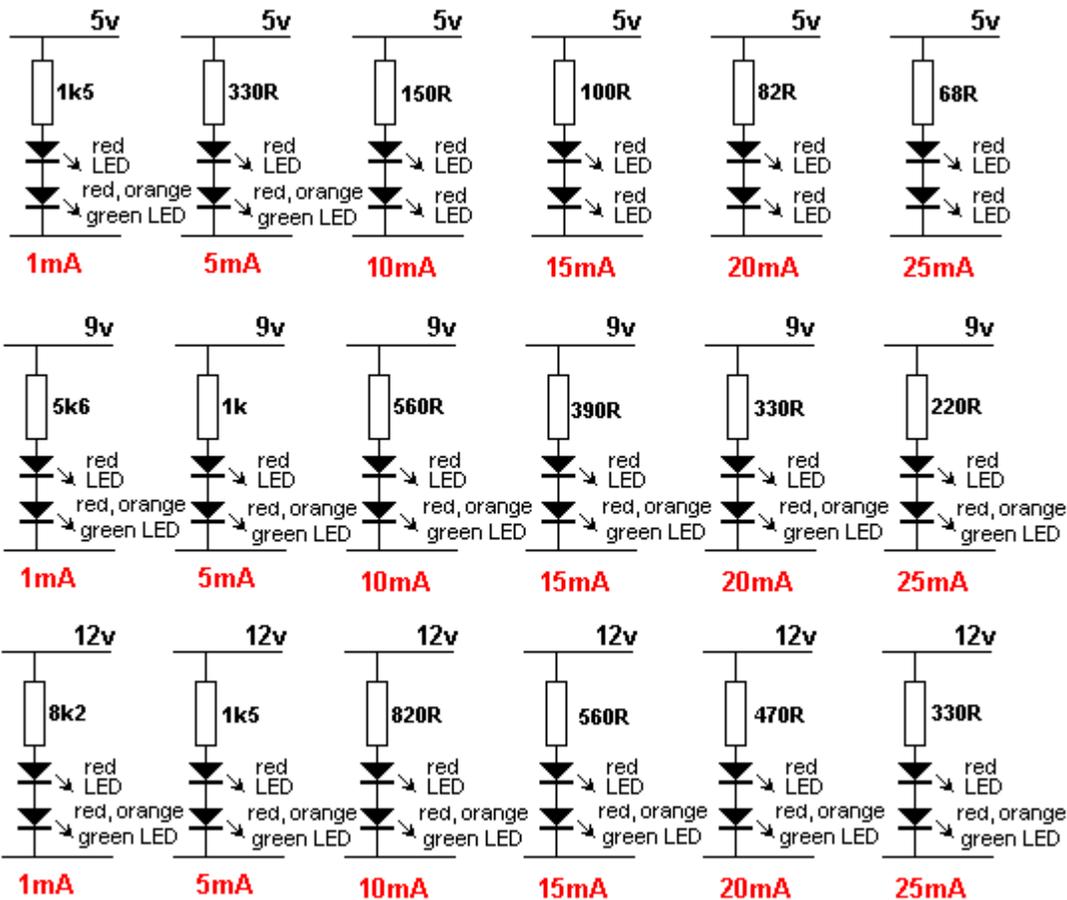
Here is a set of strings for a supply voltage of 3v to 12v and a single LED:



Here is a set of strings for a supply voltage of 5v to 12v and a white LED:



Here is a set of strings for a supply voltage of 5v to 12v and two LEDs:



## LEDS ON 12v - for cars and trucks

When connecting LEDs to cars and trucks, you have to allow for an increase in voltage during the time when the battery is being charged. Normally the battery sits at 12.6v, but when charging, it can rise to 13.5v or slightly higher.

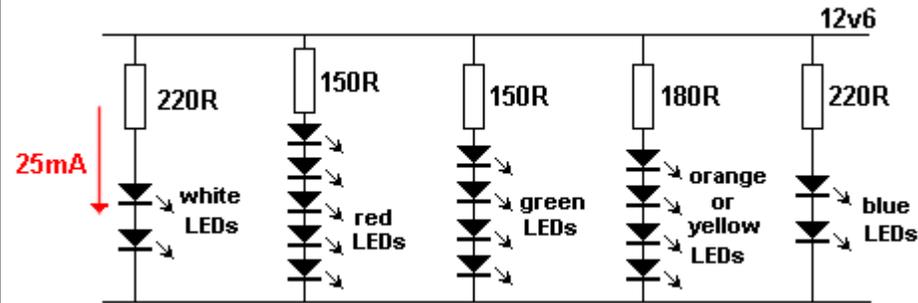
If you put 3 white LEDs in series, the "head" voltage will be about 1.8v when the battery is 12.6v, but increase to 2.7v when it is charging.

This will increase the current through the LEDs by about 50% and will be noticeable as the brightness will increase considerably. The extra current may also damage the LEDs.

To keep an even brightness, we suggest using strings of LEDs with just two white LEDs and 220R 0.25watt resistors as shown in the following diagram.

Red, green, orange, yellow and blue LEDs have a different characteristic voltage across them when illuminated and so you can have more LEDs in a single string, with a suitable current-limiting resistor.

Here is the answer for each colour:



25mA is the MAXIMUM for 3mm and 5mm ordinary, high-bright or Super-bright LEDs.

## LED series/parallel array wizard

The LED series/parallel array wizard below, is a calculator that will help you design large arrays of single-colour LEDs.

This calculator has been designed by Rob Arnold and you will be taken to his site:

<http://led.linear1.org/led.wiz> when you click: **Design my array**

The wizard determines the current limiting resistor value for each string of the array and the power consumed. All you need to know are the specs of your LED and how many you'd like to use. The calculator only allows one LED colour to be used. For mixed colours, you will have to use the 3 steps explained above. The result is not always correct. Read the discussion below: **"THE DANGERS OF USING A "LED WIZARD"** to understand the word "HEAD VOLTAGE." The HEAD VOLTAGE should be as high as possible to allow for the differences in Characteristic Voltage and the variations in power supply voltage.

Source voltage

diode forward voltage

diode forward current (mA)

number of LEDs in your array

View output as:  ASCII  schematic  wiring diagram

help with resistor colour codes

Design my array

## Resistor Calculator

Use this JavaScript resistor calculator to work out the value of the current-limiting resistor:

|                                      |   |                                   |
|--------------------------------------|---|-----------------------------------|
| Source voltage                       | = | <input type="text" value="12.6"/> |
| LED forward voltage drop             | = | <input type="text" value="3.6"/>  |
| LED current in milliamps             | = | <input type="text" value="25"/>   |
| Current-limiting resistance in Ohms  | = | <input type="text"/>              |
| Closest 5% Resistor                  | = | <input type="text"/>              |
| Resistor wattage                     | = | <input type="text"/>              |
| Actual current                       | = | <input type="text"/>              |
| Power dissipated by LED (watts)      | = | <input type="text"/>              |
| Power dissipated by resistor (watts) | = | <input type="text"/>              |

## LED VOLTAGE AND CURRENT

LED characteristics are very broad and you have absolutely no idea of any value until you test the LED. However here are some of the generally accepted characteristics:

| Lens Color      | Forward Voltage |           | Forward Current |          |
|-----------------|-----------------|-----------|-----------------|----------|
|                 | Typical         | Maximum   | Typical         | Maximum  |
| RED             | 1.6 Volts       | 2.0 Volts | .010 Amp        | .020 Amp |
| GREEN           | 2.2 Volts       | 3.0 Volts | .010 Amp        | .020 Amp |
| YELLOW          | 2.2 Volts       | 3.0 Volts | .010 Amp        | .020 Amp |
| * Blue * (Note) | 3.8 Volts       | 4.5 Volts | .020 Amp        | .020 Amp |
| WHITE           | 3.2 – 3.6 Volts | 3.8 Volts | .010 Amp        | .020 Amp |

**NOTE 1:** The above Voltage and Current ratings are based on several everyday generic LEDs in the 3 mm and 5 mm size ranges.

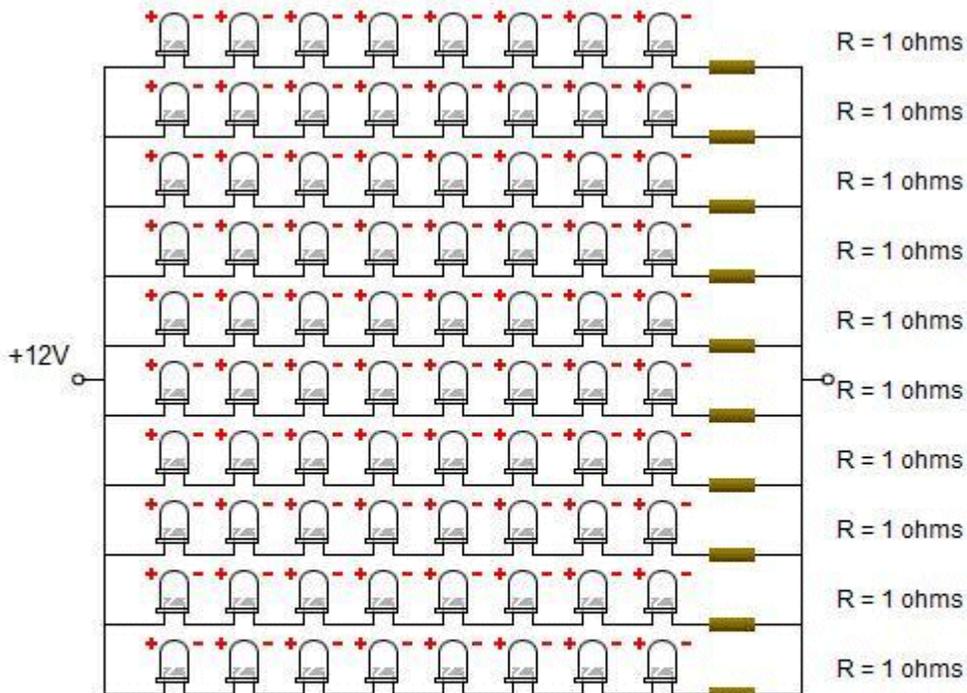
**NOTE 2:** Blue color LEDs may typically have forward working voltages exceeding those used in the above example. Forward working voltages for some Blue color LEDs may also fall in the 4.9 to 5.5 Volt range.

## THE DANGERS OF USING A "LED WIZARD"

You can find a LED WIZARD on the web that gives you a circuit to combine LEDs in series and/or parallel for all types of arrays.

Here is an example, provided by a reader. Can you see the major fault?

### Solution 0: 8 x 10 array uses 80 LEDs exactly



The wizard says: In solution 0:

- each 1 ohm resistor dissipates 0.4 mW
- the wizard thinks 1/4W resistors are fine for your application
- together, all resistors dissipate 4 mW
- together, the diodes dissipate 2400 mW
- total power dissipated by the array is 2404 mW
- the array draws current of 200 mA from the source.

The characteristic voltage (the colour of the LED) is not important in this discussion. Obviously white LEDs will not work as they require 3.4v to 3.6v to operate.

The main fault is the dropper resistor.

Read our article on [LEDs](#).

The most important component is the DROPPER RESISTOR.

It must allow for the difference between the maximum and minimum supply voltage and ALSO the maximum and minimum CHARACTERISTIC VOLTAGE of the string of LEDs.

When we say a red LED has a CHARACTERISTIC VOLTAGE of 1.7v, we need to measure the exact maximum and minimum value for the LEDs we are installing.

Some high-bright and super-high-bright LEDs have a Characteristic Voltage of 1.6v to 1.8v and this will make a big difference when you have 8 LEDs in series.

Secondly, the 12v supply may rise to 13.6v when the battery is being charged and fall to 10.8v at the end of its life.

Thirdly, you need to know the current required by the LEDs.

The normal value is 17mA for long life.

This can rise to 20mA but must not go higher than 25mA

You should also look at the minimum current. Many high-bright LEDs will perform perfectly on 5-10mA and become TOO BRIGHT on 20mA.

As you can see, it is much more complex than a WIZARD can handle.

That's why it produced the absurd result above.

The maximum characteristic voltage for 8 red LEDs is  $8 \times 1.8v = 14.4v$

This means you can only put 6 LEDs in series. = 10.8v

The LEDs will totally die when the battery reaches 10.8v

The value of the dropper resistor for 6 LEDs and a supply of 12v @20mA = 60 ohms. When the battery voltage rises to 13.6v during charging, the current will be: 46mA. This is too high.

The CURRENT LIMITING resistor is too low.

We need to have a higher-value CURRENT LIMITING resistor and fewer LEDs.

Use 5 LEDs:

The characteristic voltage for 5 LEDs will be:  $5 \times 1.7v = 8.5v$

Allow a current of 20mA when the supply is 12.6v Dropper resistor = 200 ohms.

Current at 10.8v will be 11mA. And current at 13.6v will be 25mA

Now you can see why the value of the CURRENT LIMITING RESISTOR has to be so high.

## SOLDERING LEDs

LEDs are the most heat-sensitive device of all the components.

When soldering surface-mount LEDs, you should hold the LED with tweezers and "tack" one end. Then wait for the LED to cool down and solder the other end very quickly. Then wait a few seconds and completely solder the first end. Check the glow of each LED with 3 cells in series and a 220R resistor. If you have overheated the LED, its output will be dim, or a slightly different colour, or it may not work at all. They are extremely sensitive to heat - mainly because the crystal is so close to the soldering iron.

## HIGH-BRIGHT LEDs

LEDs have become more efficient over the past 25 years.

Originally a red LED emitted 17mcd @20mA. These LEDs now emit 1,000mcd to 20,000mcd @20mA.

This means you can lower the current and still produce illumination. Some LEDs operate on a current as low as 1mA.

Some high-bright white LEDs are TOO BRIGHT to look at and will hurt your eyes.

It is impossible to give any information on the output required for any particular application.

Old LEDs require 15mA to produce a dull illumination that does not emit out of the opaque red/green/orange LED and is just a waste of 15mA.

You can get a high-bright LED to produce a higher brightness at 1mA to 5mA and save a lot of battery energy.

Design all your projects using high-bright LEDs with a current of 1mA to 10mA.

## LEDs as LIGHT DETECTORS

LEDs can also be used to detect light.

Green LEDs are the best, however all LEDs will detect light and produce a voltage equal to the CHARACTERISTIC VOLTAGE-DROP, providing they receive sufficient light. The current they produce is miniscule however high-bright and super-bright LEDs produce a higher output due to the fact that their crystal is more efficient at converting light into electricity.

The [Solar Tracker](#) project uses this characteristic to track the sun's movement across the sky.

## BI-COLOUR, TRI-COLOUR, FLASHING LEDS and 7-colour LEDs

LEDs can also be obtained in a range of novelty effects as well as a red and green LED inside a clear or

opaque lens. You can also get red, blue, white, green or any combination inside a LED with 2 leads.

Simply connect these LEDs to a 6v supply and 330R series dropper resistor to see the effects they produce.

Some LEDs have 3 leads and the third lead needs to be pulsed to change the pattern.

Some LEDs can be reversed to produce a different colour. These LEDs contain red and green and by reversing the voltage, one or the other colour will illuminate.

When the voltage is reversed rapidly, the LED produces orange.

Sometimes it is not convenient to reverse the voltage to produce orange.

In this case three leaded LEDs are available to produce red, green and orange.

## FLASHING LEDs

Flashing LEDs contain a chip and inbuilt current-limiting resistor. They operate from 3.5v to 12v. The flash-rate will alter slightly on different supply voltage. You can get 3mm and 5mm versions as well as high-bright types and surface-mount.

## NOVELTY LEDs

Novelty LEDs can have 2 or three leads. They contain a microcontroller chip, inbuilt current-limiting resistor and two or three colours.

The two leaded LEDs cycle through a range of colours, including flashing and fading.

The three leaded LEDs have up to 16 different patterns and the control lead must be taken from 0v to rail volts to activate the next pattern.

## LEDs LEDs LEDs

There are hundreds of circuits that use a LED or drive a LED or flash a LED and nearly all the circuits in this eBook are different.

Some flash a LED on a 1.5v supply, some use very little current, some flash the LED very brightly and others use a flashing LED to create the flash-rate.

You will learn something from every circuit. Some are interesting and some are amazing. Some consist of components called a "building Block" and they can be added to other circuits to create a larger, more complex, circuit.

This is what this eBook is all about.

It teaches you how to build and design circuits that are fun to see working, yet practical.

You will learn a lot . . . even from these simple circuits.

Colin Mitchell  
TALKING ELECTRONICS.  
[talking@tpg.com.au](mailto:talking@tpg.com.au)

## SI NOTATION

All the schematics in this eBook have components that are labelled using the **System International (SI)** notation system. The SI system is an easy way to show values without the need for a decimal point. Sometimes the decimal point is difficult to see and the SI system overcomes this problem and offers a clear advantage.

Resistor values are in ohms (R), and the multipliers are: k for kilo, M for Mega. Capacitance is measured in farads (F) and the sub-multiples are u for micro, n for nano, and p for pico. Inductors are measured in Henrys (H) and the sub-multiples are mH for milliHenry and uH for microHenry.

A 10 ohm resistor would be written as 10R and a 0.001u capacitor as 1n.

Some countries use the letter "E" to represent Ohm, such as 100E = 100 ohms = 100R.

The markings on components are written slightly differently to the way they are shown on a circuit diagram (such as 100p on a circuit and 101 on the capacitor or 10 on a capacitor and 10p on a diagram) and you will have to look on the internet under **Basic Electronics** to learn about these differences.

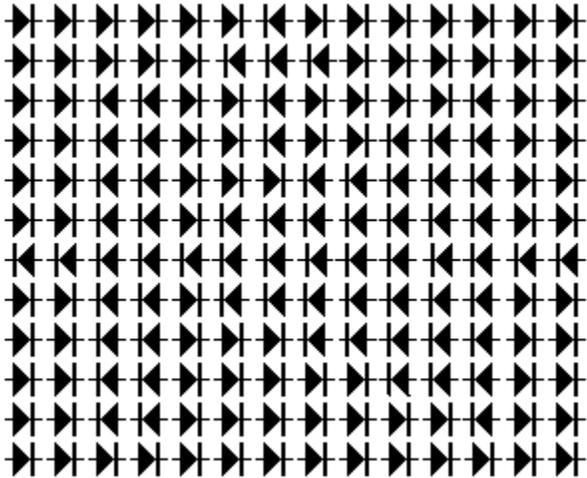
We have not provided lengthy explanations of how any of the circuits work. This has already been covered in TALKING ELECTRONICS Basic Electronics Course, and can be obtained on a [CD for \\$10.00](#) (posted to anywhere in the world)

For photos of nearly every electronic component, see this website:

[https://www.egr.msu.edu/eceshop/Parts\\_Inventory/totalinventory.php](https://www.egr.msu.edu/eceshop/Parts_Inventory/totalinventory.php)

How good is your power of observation?

Can you find the LED:



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## INFRARED LED

Infrared LEDs are just like ordinary LEDs but the light output cannot be seen. To view an infrared LEDs, turn it on with the appropriate battery and dropper resistor and view it with a camera. You will see the illumination on the screen.

Infrared LEDs are sometimes clear and sometimes black. They operate just like a red LED with the same characteristic voltage-drop of about 1.7v.

Sometimes an infrared LED is pulsed with a high current for a very short period of time but the thing to remember is the wattage-dissipation of a 5mm LED is about 70mW.

This means the constant-current should be no more than 40mA.

Infrared LEDs are also called TRANSMITTING LEDs as they emit light. These are given the term **Tx** (for transmitting). An infrared LED can be connected to a 5v supply via a 220R current-limiting resistor for 15mA current.

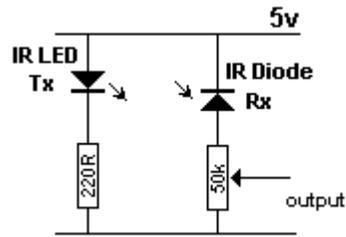
**Infrared receivers (Rx)** can look exactly like infrared LEDs, but they do not emit IR light. They detect Infrared illumination and must be connected the correct way in a

circuit.

They have a very high resistance when no receiving IR illumination and the resistance decreases as the illumination increases.

This means they are connected to a 5v supply via a resistor and when the resistance of the infrared receiver decreases, current will flow through it and the resistor. This will produce a voltage across the resistor and this voltage is fed to the rest of the circuit.

Here is a circuit to show how to connect an infrared LED and Infrared (diode) receiver:



You cannot use an IR LED as a receiver or an Infrared diode as an illuminator. They are constructed differently. An infrared LED has a characteristic voltage drop of 1.7v. An Infrared receiver does not have a characteristic voltage-drop. It has a high resistance when not illuminated and a low resistance when it receives illumination.

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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.

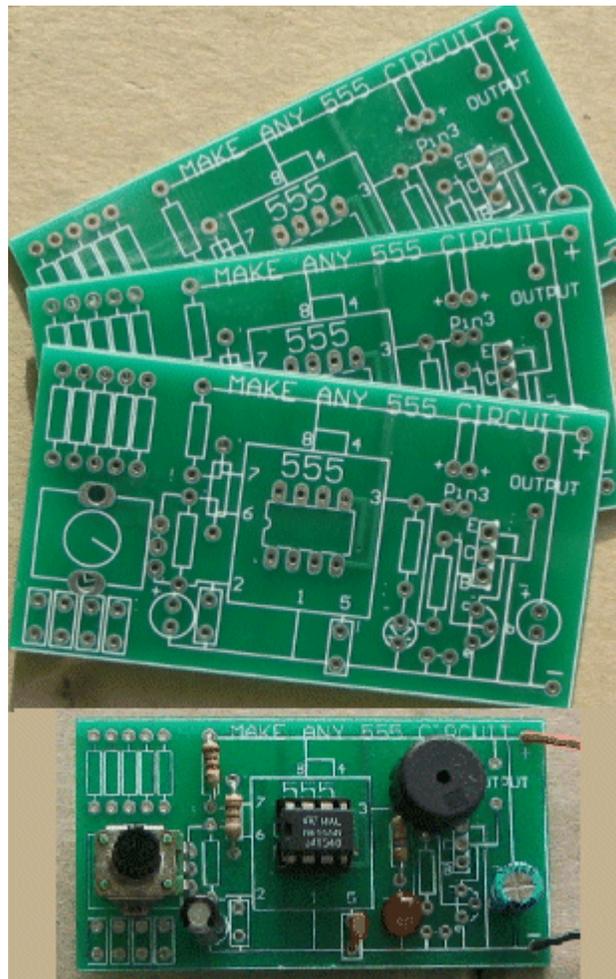
**BUY NOW**

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email Colin Mitchell: [talking@tpg.com.au](mailto:talking@tpg.com.au)

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A set of components for **MAKE ANY 555 PROJECT** is just \$5.00 extra

The parts include:

- 2 - 220R
- 2 - 1k
- 2 - 4k7
- 2 - 10k
- 2 - 33k
- 2 - 47k
- 2- 100k
- 2 - 1M
- 1 - 10k mini pot
- 1 - 100k mini pot
- 2 - 10n
- 2 - 100n
- 1 - 10u electrolytic
- 2- 100u electrolytic
- 1 - 1N4148 signal diodes
- 3 - BC547 transistors
- 3 - 555 timer chips
- 3 - 8 pin IC sockets
- 1 - red LED
- 1 - green LED
- 1 - orange LED
- 3 - mini piezos
- 1 - LDR (Light Dependent Resistor)
- 3 - slim tactile push buttons

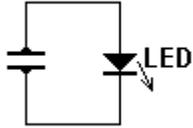
**3 x Make any 555 Project PCB boards plus components: \$15.00 (post FREE)**

# PROJECTS

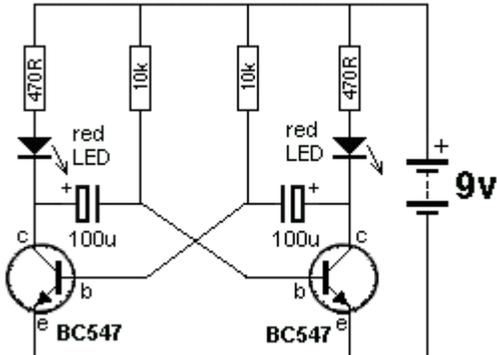
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## Simplest LED Circuit

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.



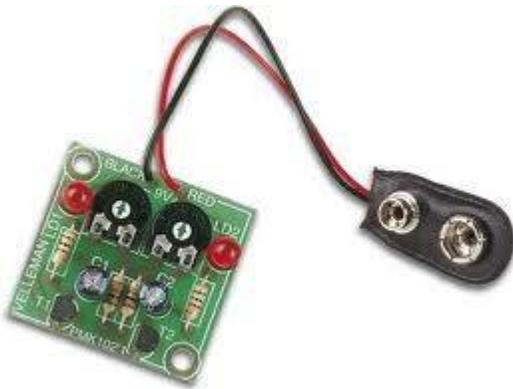
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## ROBOT MAN

This multivibrator circuit will flash the Robot Man's eyes as shown in the photo. The kit of components is available from Talking Electronics for \$8.50 plus postage. Send an email to find out the cost of postage: [talking@tpg.com.au](mailto:talking@tpg.com.au)

Here is the circuit from **Velleman Kits**. The two 10k resistors are replaced with a **resistor and pot** so the "flip flop" can be altered.



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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.

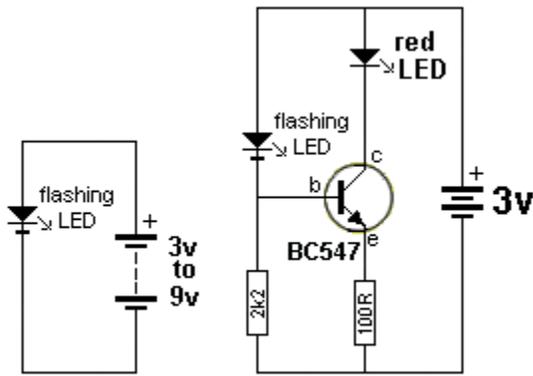
Figure **D** produces a very bright flash for a very short period of time - for a red, green, orange or white

LED.

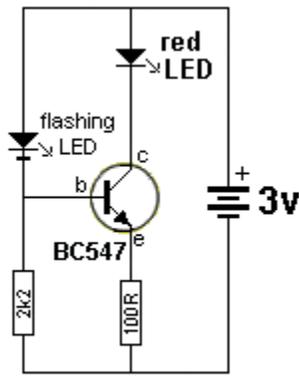
Figure E uses 2 transistors to produce a brief flash - for a red, green, orange or white LED.

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

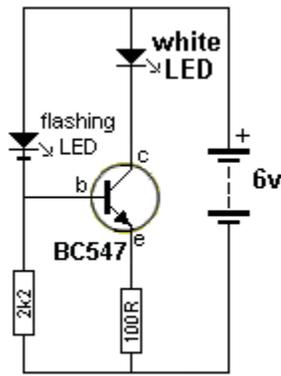
Figure G flashes a white LED on a 3v supply.



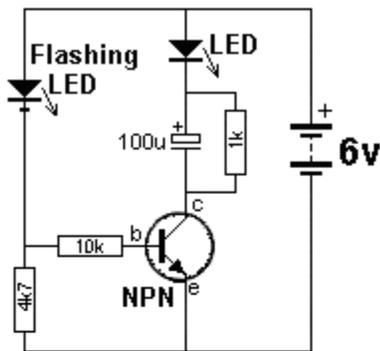
**A**



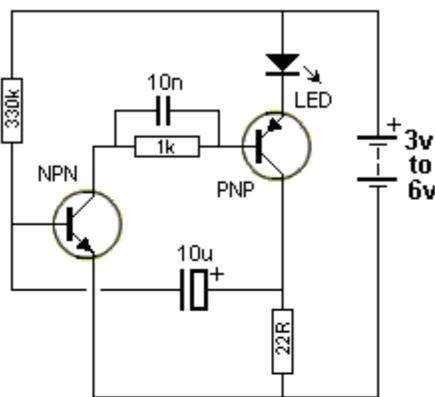
**B**



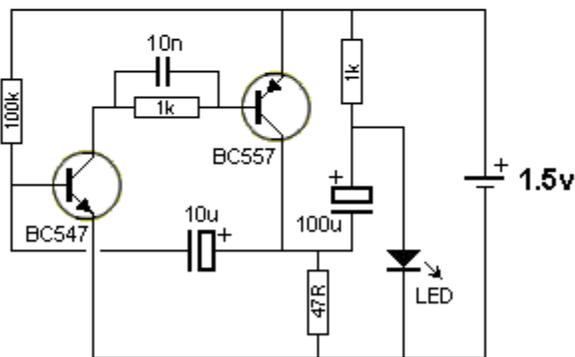
**C**



**D**

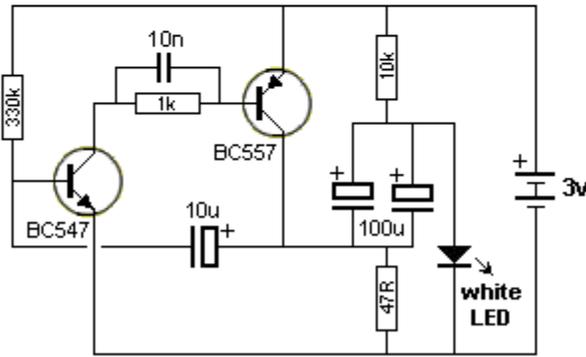


**E**



**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.

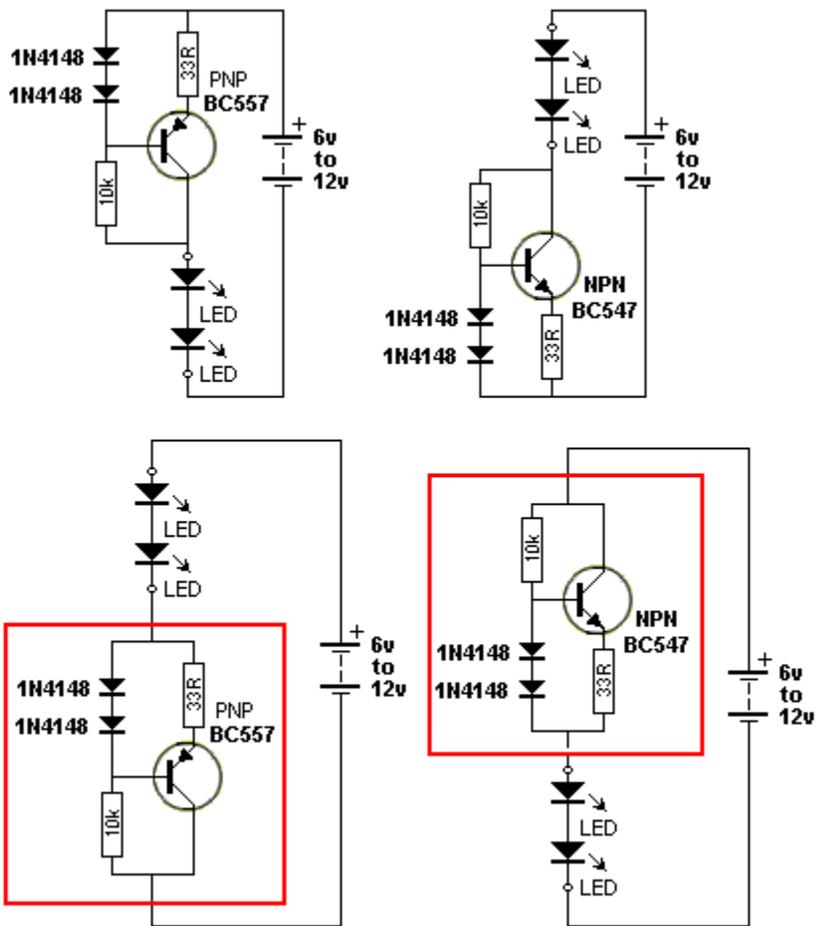
You can connect:

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:

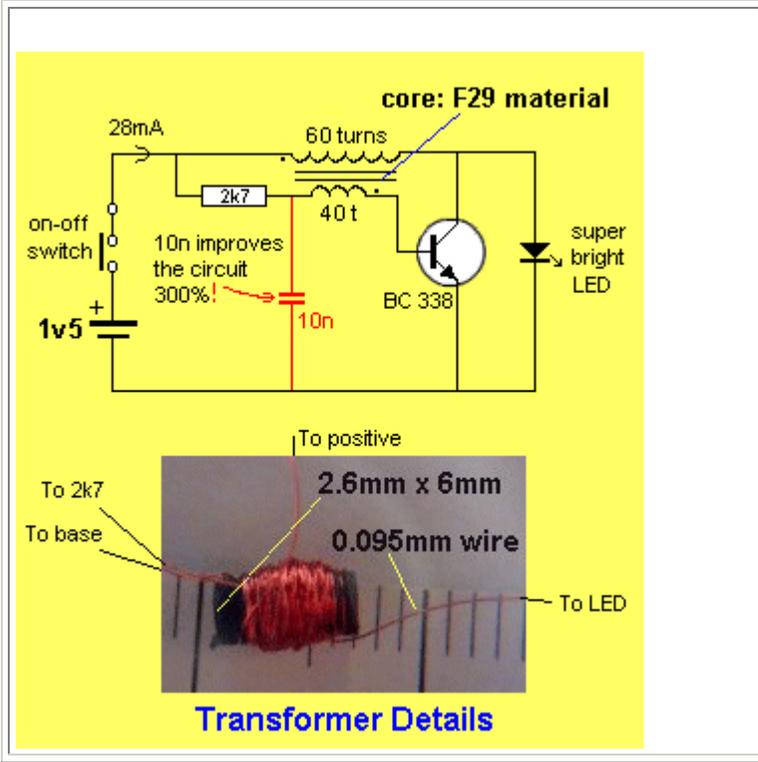


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## WHITE LED on 1.5v SUPPLY

This circuit will illuminate a white LED using a single cell.

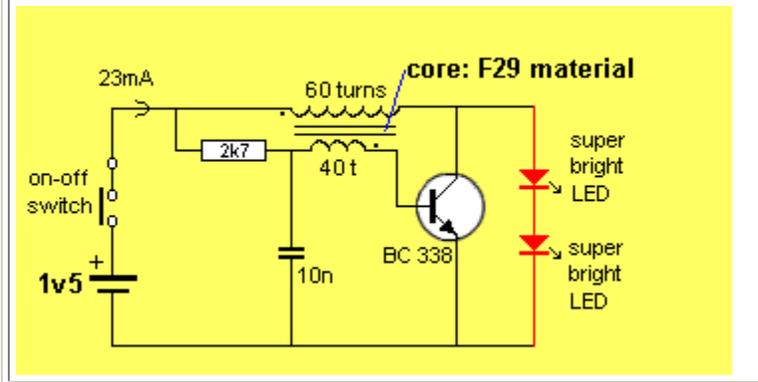
See [LED Torch Circuits](#) article for more details.



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## 2 WHITE LEDs on 1.5v SUPPLY

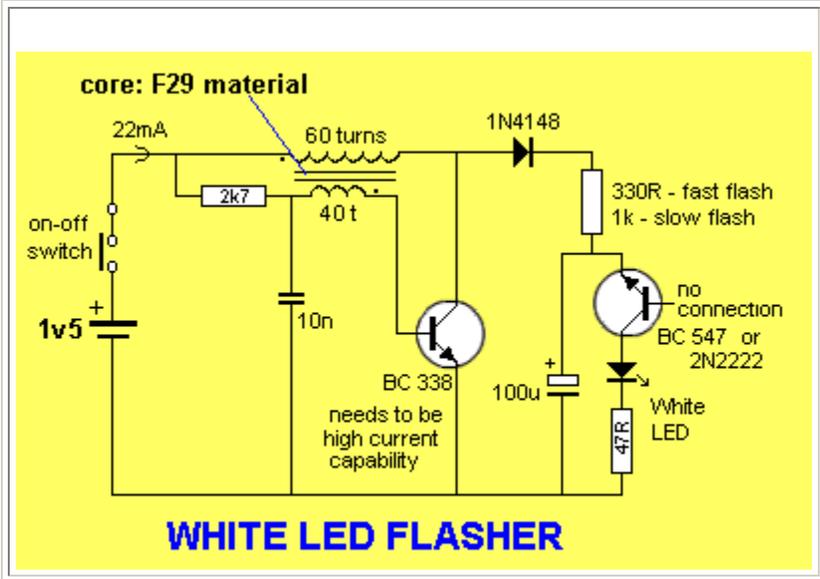
This circuit will illuminate two white LEDs using a single cell. See [LED Torch Circuits](#) article for more details.



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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.



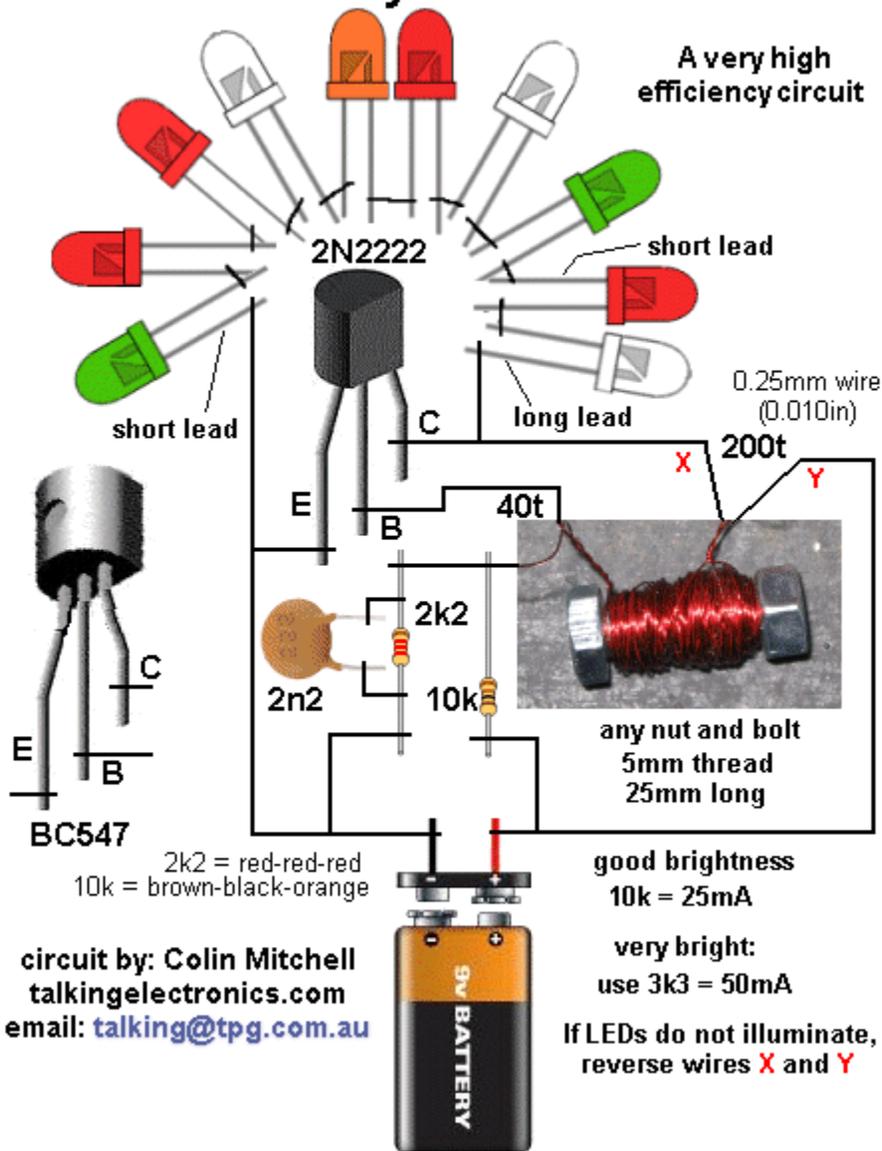
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## 10 LEDs on a 9v BATTERY

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

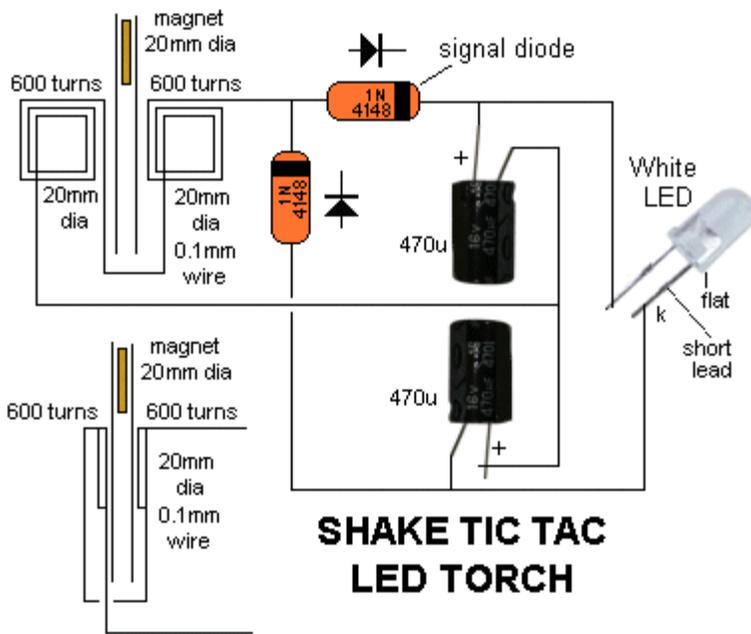
# 10 LEDs - any colour !!!!!!!

A very high efficiency circuit



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## SHAKE TIC TAC LED TORCH



### 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 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 FLASHLIGHT

Here is a request from one of our readers:

**I want to build a solar powered flashlight. It will contain 3-AAAs nickel hydride batteries of 1.2v each. I want many ultrabright white LEDs @ 25mA. I also need a voltage regulator circuit so the batteries won't overcharge. The batteries are 800 mAh capacity. I need a high-low beam too. Do you have a schematic for this?**

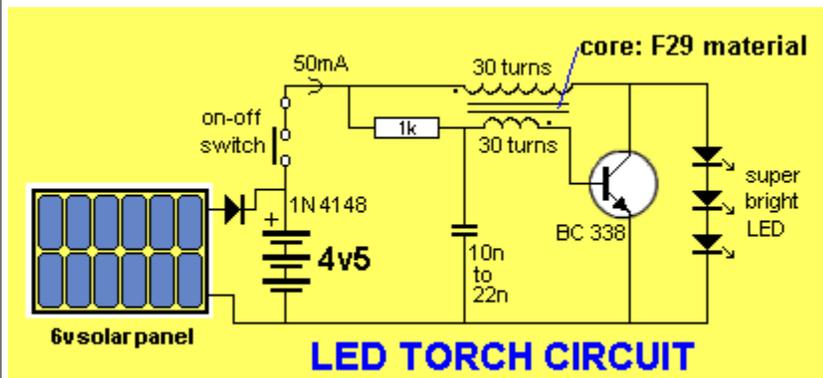
Here is a very simple circuit.

The circuit produces a voltage higher than 3.6v, from a supply of 4.5v to 6v to illuminate 3 super-bright LEDs in series.

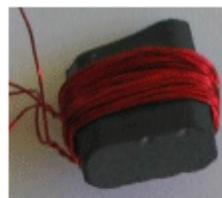
The flyback transformer consists of 30 turns and 30 turns wound on an old ferrite antenna slab.

Reverse the feedback winding if the LEDs do not illuminate.

Some solar panels will drain a small current from the battery when not illuminated, so a "protection diode" can be added.



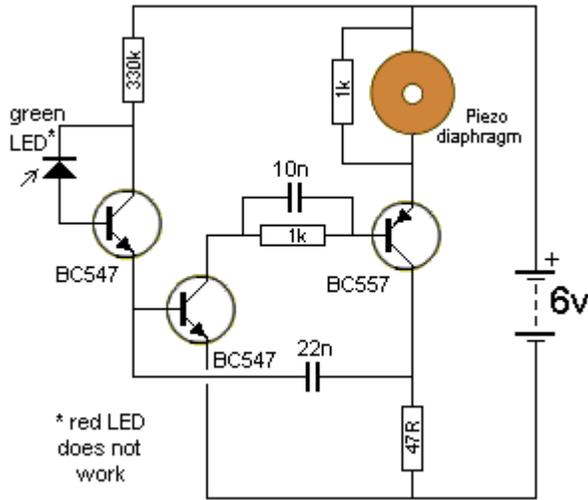
### LED TORCH CIRCUIT



The fly-back transformer 30turns & 30 turns on any ferrite core

You can also use a single 3.7v Li-Ion cell.

These are available on eBay for \$2.00 post free. Solar panels are also available on eBay.

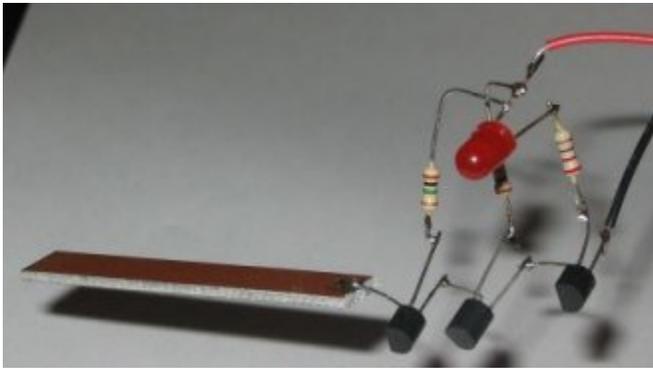


## LED DETECTS LIGHT

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.

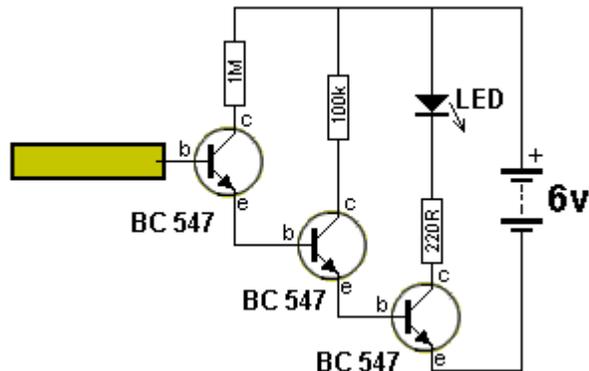
The output voltage of the LED is up to 600mV when detecting very bright illumination. When light is detected by the LED, its resistance decreases and a very small current flows into the base of the first transistor. The transistor amplifies this current about 200 times and the resistance between collector 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.

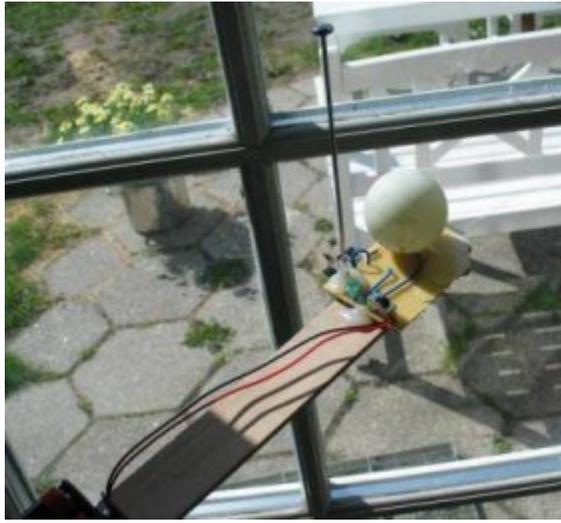


## 8 MILLION GAIN!

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.

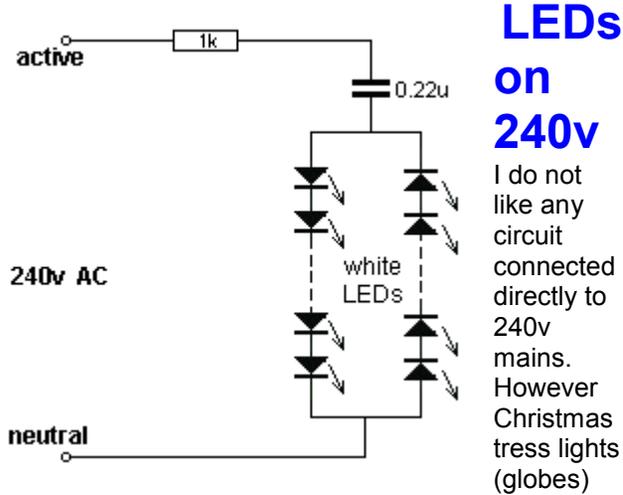
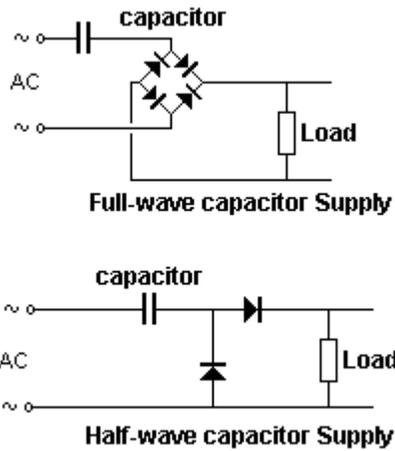


Here is a photo of the circuit, produced by a



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 x 1,000 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.

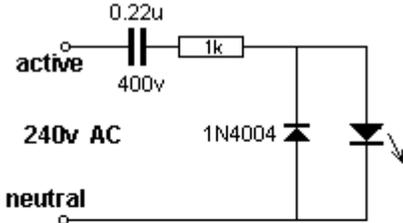
This means each 100n of capacitance will deliver 7mA RMS (10mA peak on each half-cycle).

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.

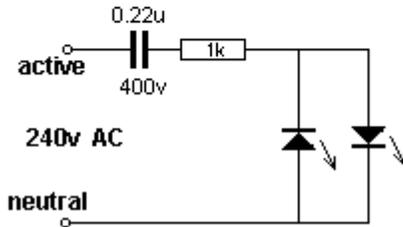
You can use any LEDs and try to keep the total voltage-drop in each string equal. Each string is actually working on DC. It's not constant DC but varying DC. In fact is it zero current for 1/2 cycle then nothing until the voltage rises above the total characteristic voltage of all the LEDs, then a gradual 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

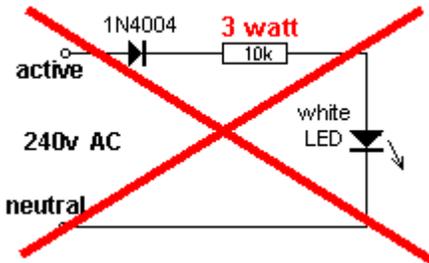
A single LED can be illuminated by using a 100n or 220n capacitor with a rating of 400v. These capacitors are called "X2" and are designed to be connected to the mains.



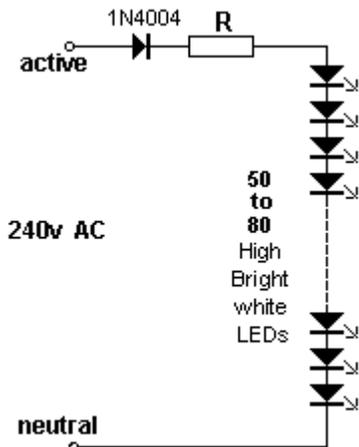
The LED will be 240v above earth if the active and neutral are swapped and this represents a shock of over 340v if anything is exposed. The power diode in the first diagram is designed to discharge the 0.22u during one half of the cycle so that the capacitor will charge during the other half-cycle and 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.



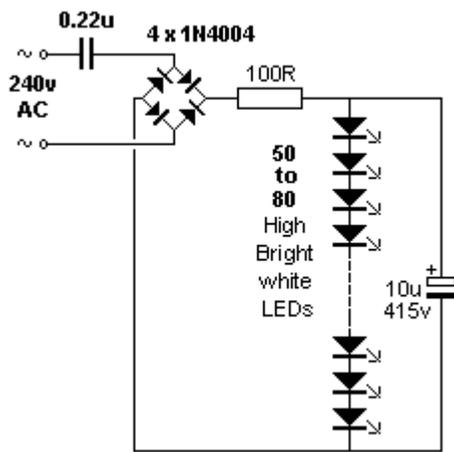
LEDs can also be connected to the mains via a power diode and current-limiting resistor. But the wattage lost (dropped) in the resistor is about 2.5 watts and a 3 watt resistor will be needed to illuminate a 70mW white LED. This is an enormous waste of energy and a capacitor-fed supply shown above is 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. (A bridge is used in this circuit however the secret to prevent flickering is the addition of the electrolytic and the circuit can be driven by a single diode in half-wave.) 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:  
 $345 - 145 = 200v = 200/345 \times 15 = 8.6mA$

## LEDs on 120v

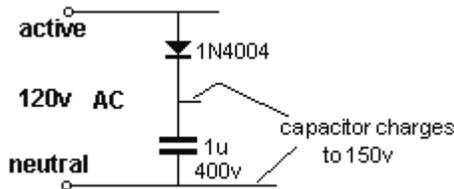
Here is a very clever CONSTANT-CURRENT voltage-doubling design. It produces up to 300v on a 120v supply and the current is 30mA. (see below for the reason why the current is 30mA for about 40 LEDs)

The amazing thing is, you can put any number of LEDs on the output, up to 80 white LEDs. When 80 LEDs are added, the current will reduce to only a few milliamps.

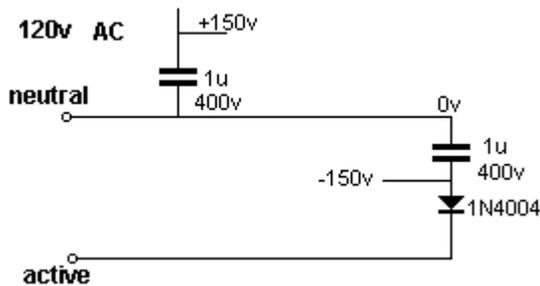
How does the circuit work?

We will explain how the circuit works in 3 steps.

Step 1: The 1u charges to the peak voltage of 150v when the active line is 150v higher than the neutral:



Step 2: When the active line is 150v LOWER than the neutral, the second capacitor charges as shown in the following diagram:



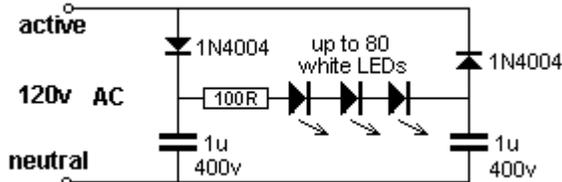
Step 3: The LEDs are connected to these capacitors and the resulting voltage is about 300v. The characteristic voltage of about 3.6v for a white LED will reduce the voltage and that's why the 300v is only a theoretical maximum.

On each half-cycle, the energy from a 1u is fed to the string of LEDs and it will deliver an average of about 70mA when only 1 LED is in the chain.

This makes it a FULL WAVE capacitor-fed supply and because it is a capacitor-fed supply, it is a constant-current supply. The current will gradually decrease as the number of LEDs increase because the current through the capacitor depends on the voltage on each side of the capacitor. As the number of LEDs increase, the voltage on the LED-side of the capacitor increases, reducing the actual voltage across the capacitor.

The current will decrease by about 1mA for each added LED.

## HOW TO VIEW THE "MAINS"

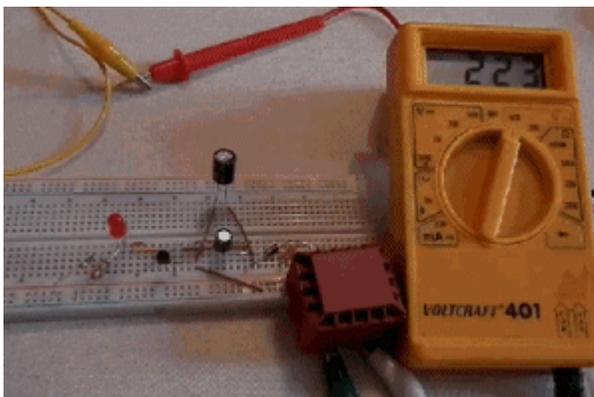
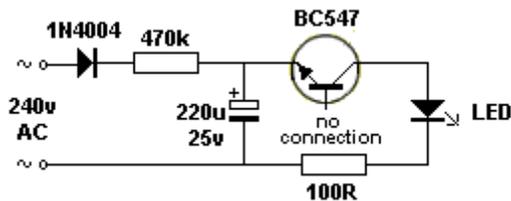


The mains is changing direction 50 or 60 times per second and this is called AC (Alternating Current). Instead of seeing the mains as "changing direction," it is more convenient to consider the Neutral as always at EARTH POTENTIAL and the Active is 150v higher than "earth" then 150v lower than earth.

Now you can understand the diagrams above.

## FLASHING LED on 240v by Franz Bachler

This circuit flashes a single LED on 240v. The circuit will also work on 120v by reducing the 470k to 220k. The base of the transistor is **not** connected.



Flashing LED on 240v

## HOW THE CIRCUIT WORKS

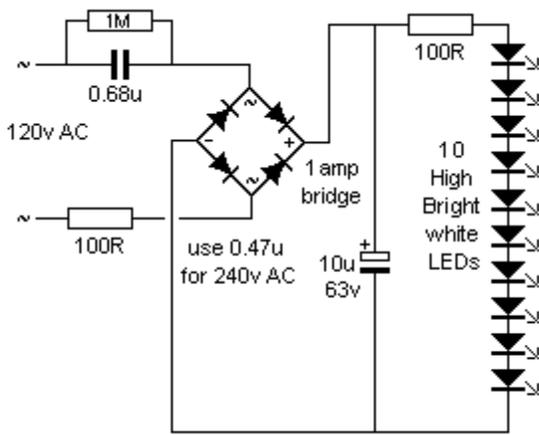
The NPN transistor is wired the wrong way round in the circuit, with a positive voltage on the emitter, and the base lead is left open. The voltage on the capacitor gradually rises to approximately 9v. At this point the transistor suddenly starts conducting and discharges the capacitor to deliver energy to the LED and produce a single flash. Each transistor behaves differently and it's worth trying a variety of transistors in this circuit.

When operated with an **inverted voltage** between the emitter and the collector, the transistor has a characteristic curve with a negative slope. The base-emitter junction exhibits an avalanche breakdown effect at approximately 9v. At this voltage the high electric field strength in the thin reverse-biased junction region causes the charge carriers to move so fast that they dislodge other charge-carriers from the crystal lattice. As a result the number of charge-carriers rises very quickly. This is the same as what happens in a 9v zener diode, but a zener diode has a positive internal resistance. There's another factor involved with an inverted transistor. Here the emitter and collector switch roles, but due to the essentially symmetrical structure, the transistor also operates in this inverted condition.

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## MAINS NIGHT LIGHT

The circuit illuminates a column of 10 white LEDs. The 10uF prevents flicker and the 100R also reduces flicker (it allows the 10uF to charge to a slightly higher value and this extra energy is delivered to the LEDs during each of the low portions of the AC cycle.)



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  $4.7 \times 7\text{mA} = 33\text{mA}$  if the capacitor is 470n.

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

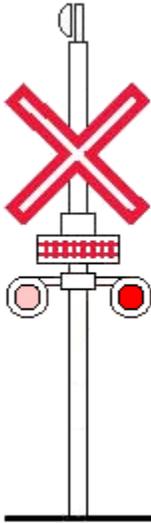
If no load is connected, the output voltage will be  $230\text{v} \times 1.4 = 320\text{v}$  and if the voltage across the load is 100v, the output will be reduced to about 20mA. If the output voltage is 200v, the current will be 10mA and if the output voltage is 300v, the current will be 0mA. In our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

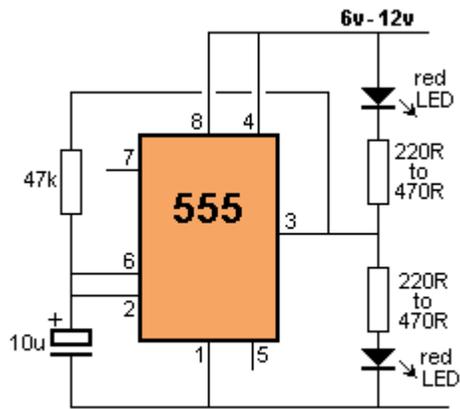
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## FLASHING RAILROAD LIGHTS

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



This project can be constructed on our [MAKE ANY 555 PROJECT](#) printed circuit board.

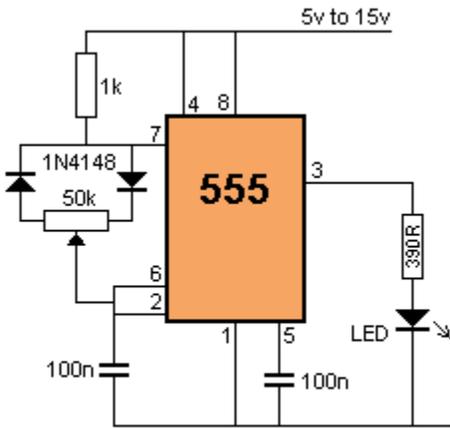


**FLASHING LIGHTS**

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## LED DIMMER

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



**LED DIMMER**

rev.A

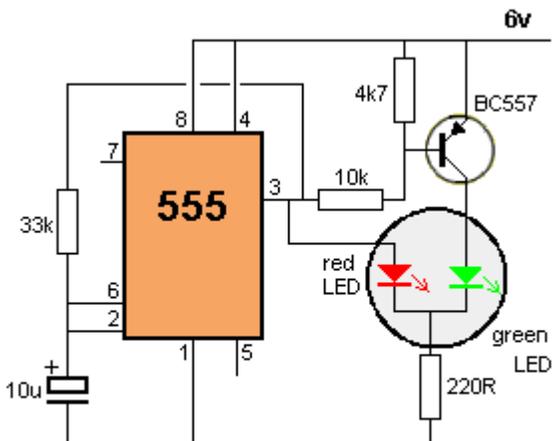


This project can be constructed on our [MAKE ANY 555 PROJECT](#) printed circuit board.

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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:

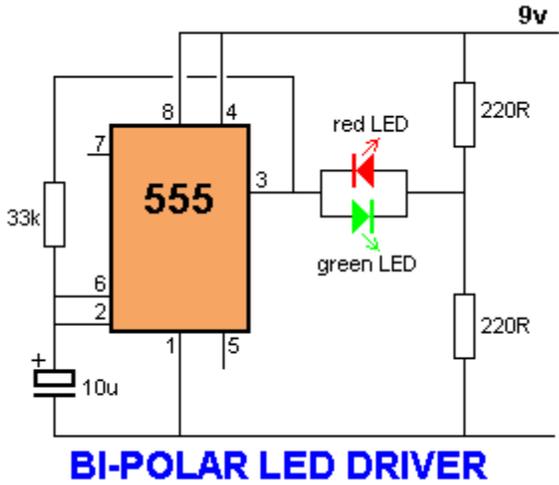


**DRIVING A BI-COLOUR LED**

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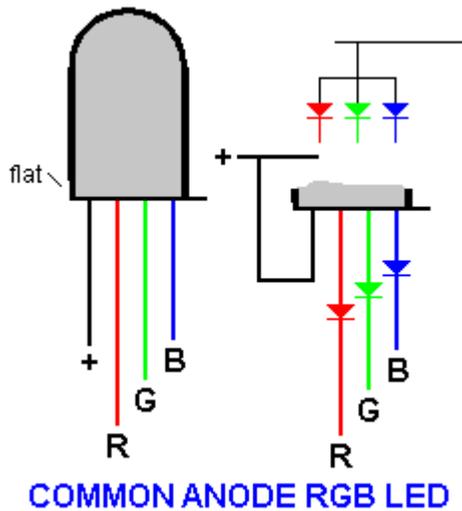
## BI-POLAR LED DRIVER

Some 2-leaded LEDs produce red and green. These are called Bi-polar LEDs. This circuit alternately flashes a red/green bi-polar LED:



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## RGB LED DRIVER

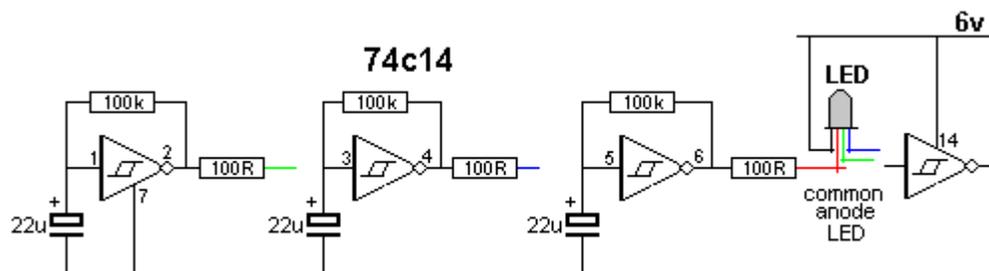


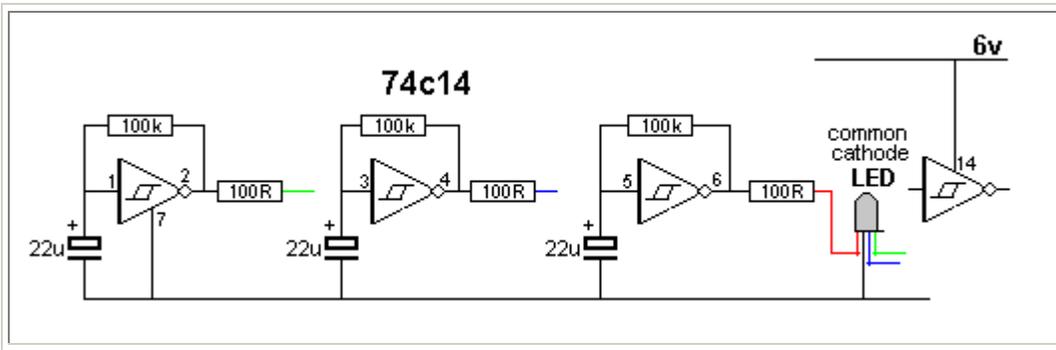
This is a simple driver circuit that drives the 3 LEDs in an RGB LED to produce a number of interesting colours. Even though the component values are identical in the three oscillators, the slight difference in tolerances will create a random display of colours and it will take a while for the pattern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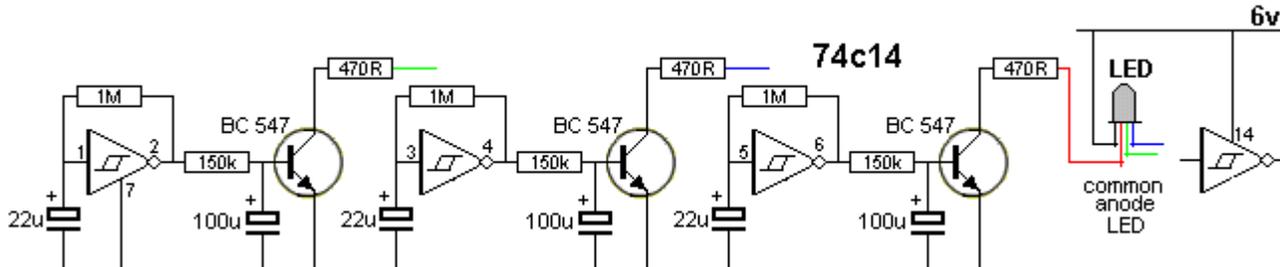
## RGB LED FLASHER

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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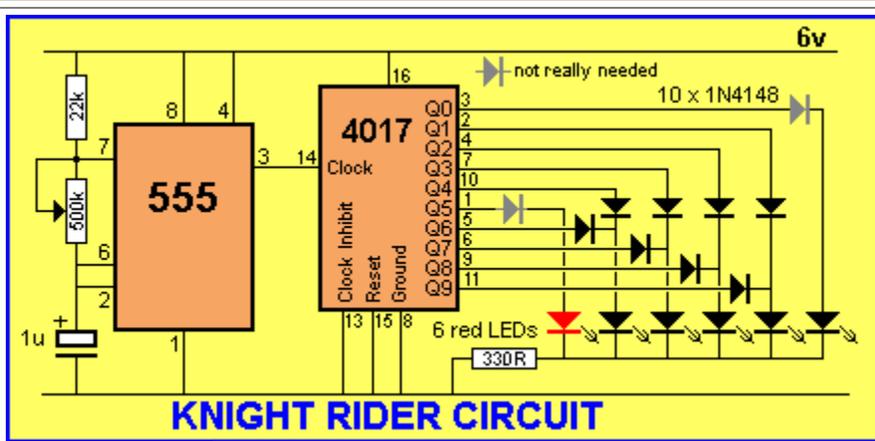
## KNIGHT RIDER

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).

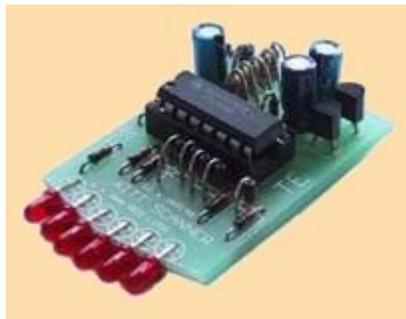
The first 6 outputs of the chip are connected directly to the 6 LEDs and these "move" across the display. The next 4 outputs move the effect in the opposite direction and the cycle repeats. The animation above shows how the effect appears on the display.

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.

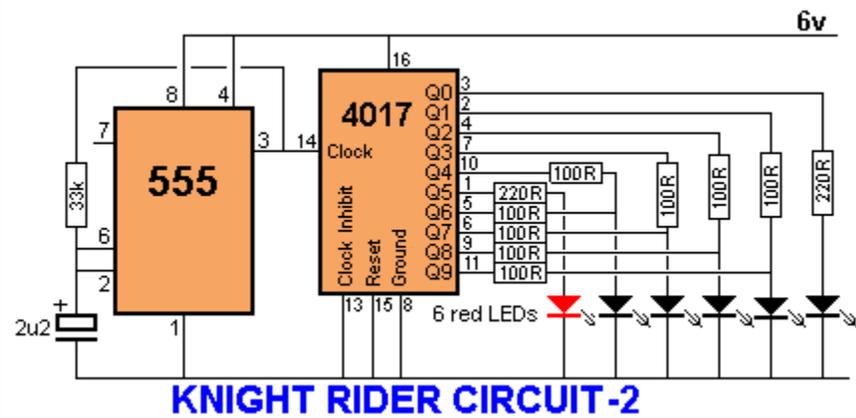


**BUY NOW**

The **Knigh 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).

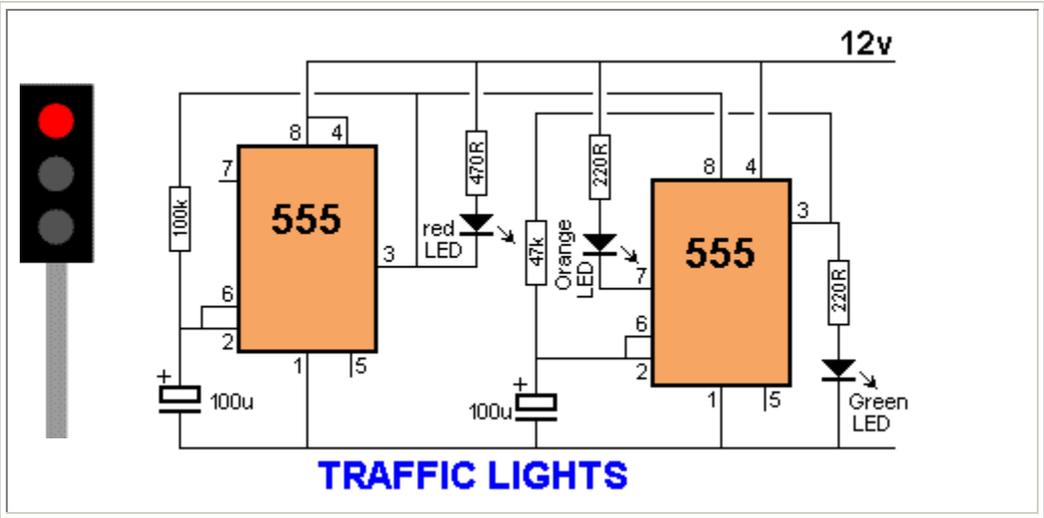


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## TRAFFIC LIGHTS

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

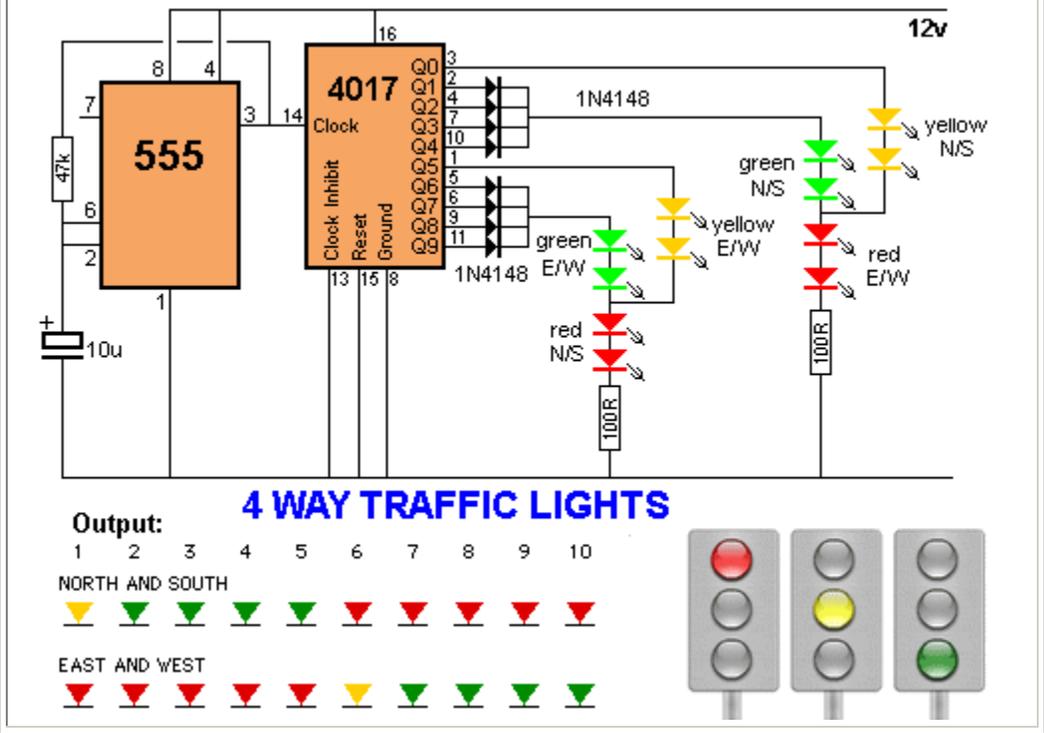
The animation shows the lighting sequence and this follows the Australian-standard. The red LED has an equal on-off period and when it is off, the first 555 delivers power to the second 555. This illuminates the Green LED and then the second 555 changes state to turn off the Green LED and turn on the 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.

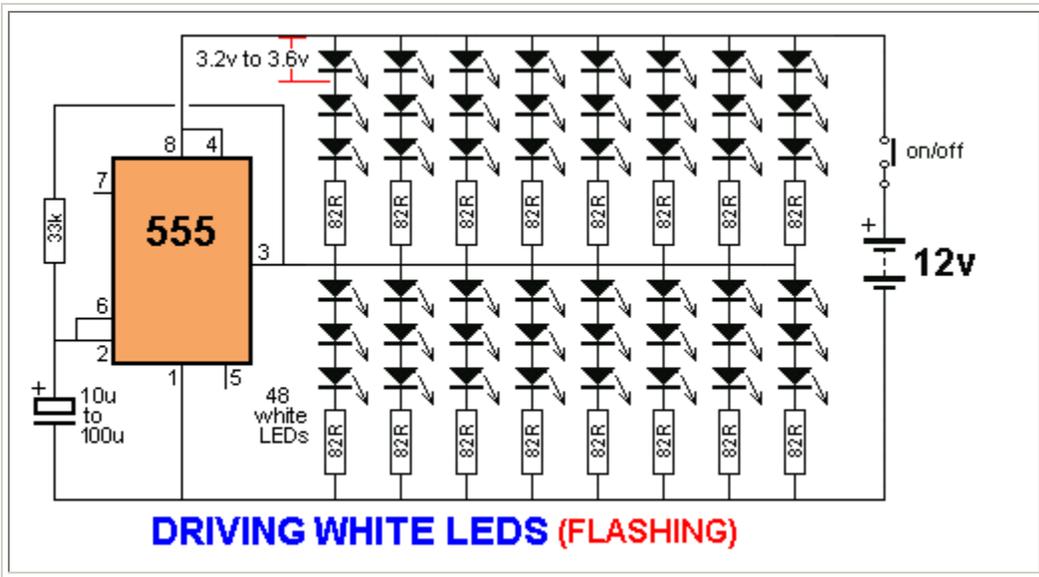


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## DRIVING MANY LEDs

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

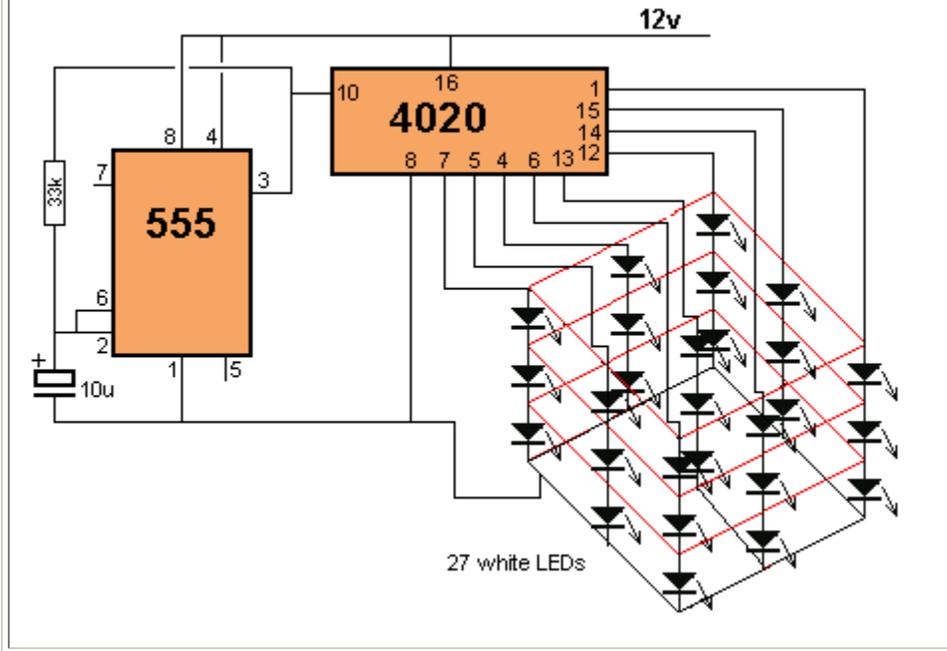
The following circuit shows the maximum number of white LEDs that can be realistically driven from a 555 and we have limited the total current to about 130mA as each LED is designed to pass about 17mA to 22mA maximum. A white LED drops a characteristic 3.2v to 3.6v and this means only 3 LEDs can be placed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

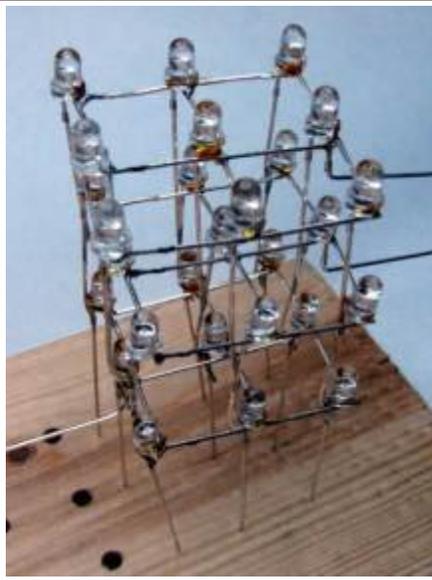


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## 3x3x3 CUBE

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.

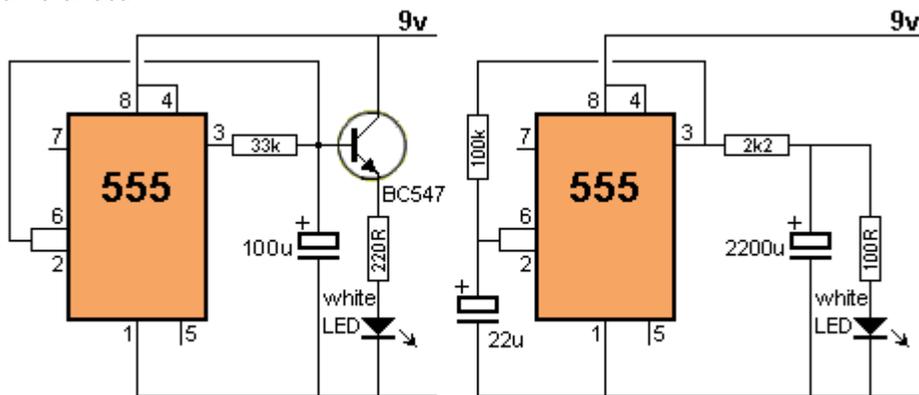




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## UP/DOWN FADING LED

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.

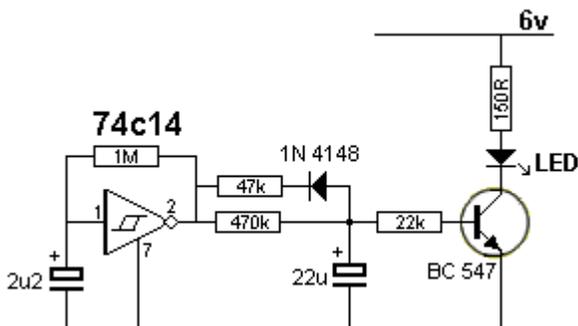


## UP/ DOWN FADING LED

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## UP/DOWN FADING LED-2

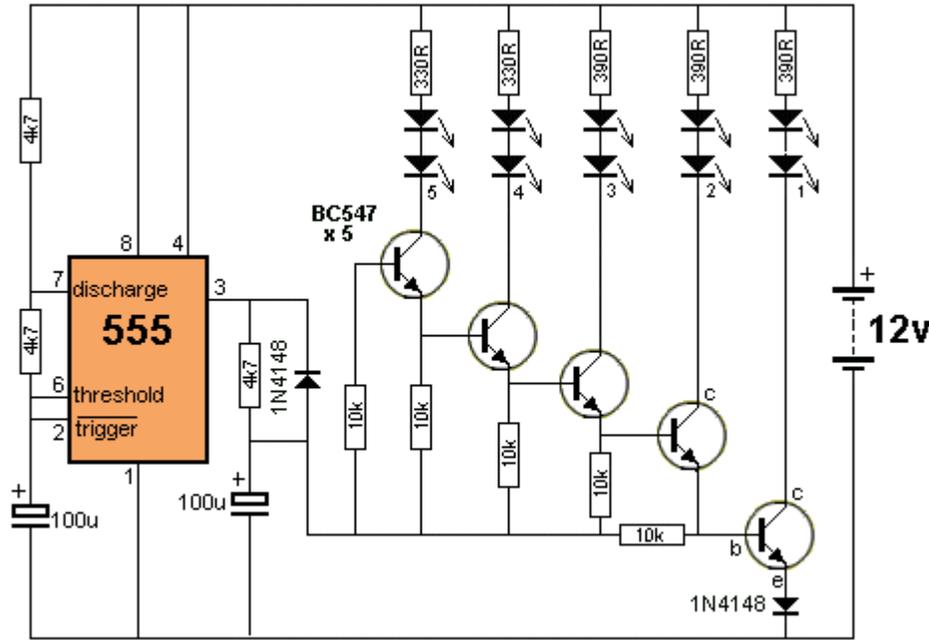
The circuit fades the LED ON and OFF at an equal rate. The 470k charging and 47k discharging resistors have been chosen to create equal on and off times.



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# BIKE TURNING SIGNAL

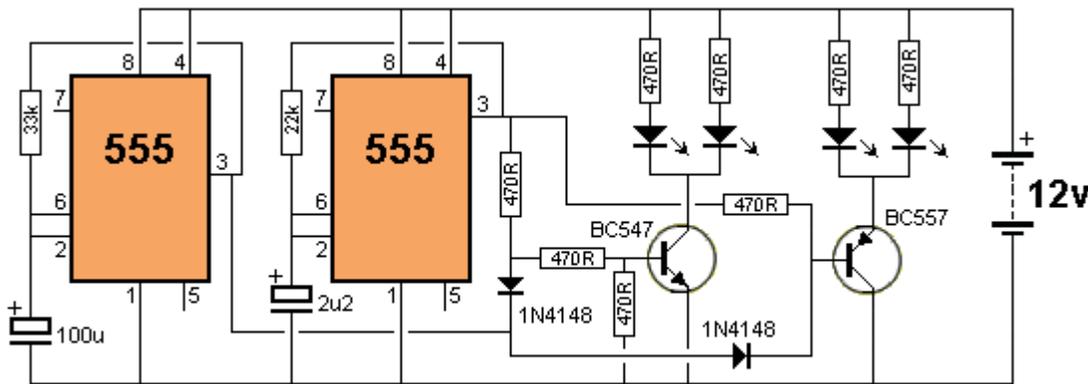
This circuit can be used to indicate left and right turn on a motor-bike. Two identical circuits will be needed, one for left and one for right.



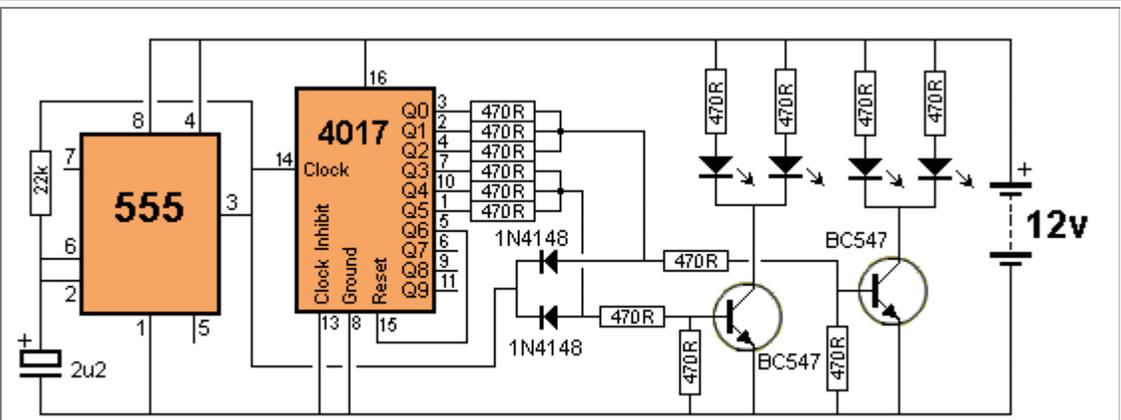
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# POLICE LIGHTS

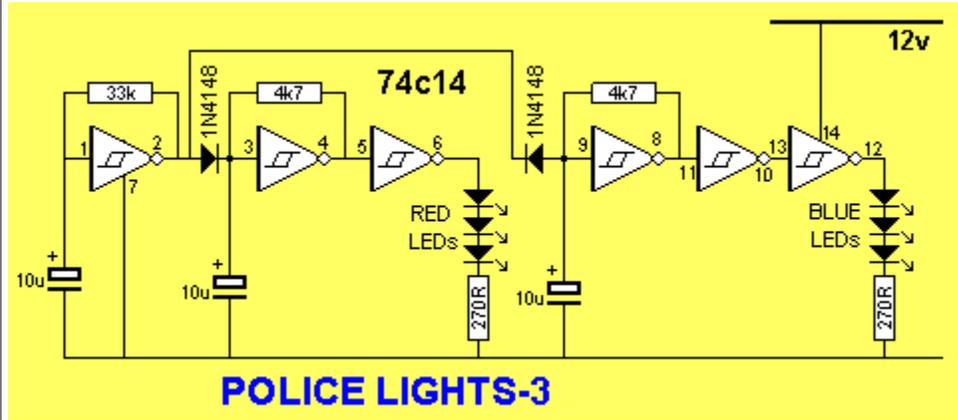
These three circuits flash the left LEDs 3 times then the right LEDs 3 times, then repeats. The only difference is the choice of chips.



**POLICE LIGHTS**



**POLICE LIGHTS-2**

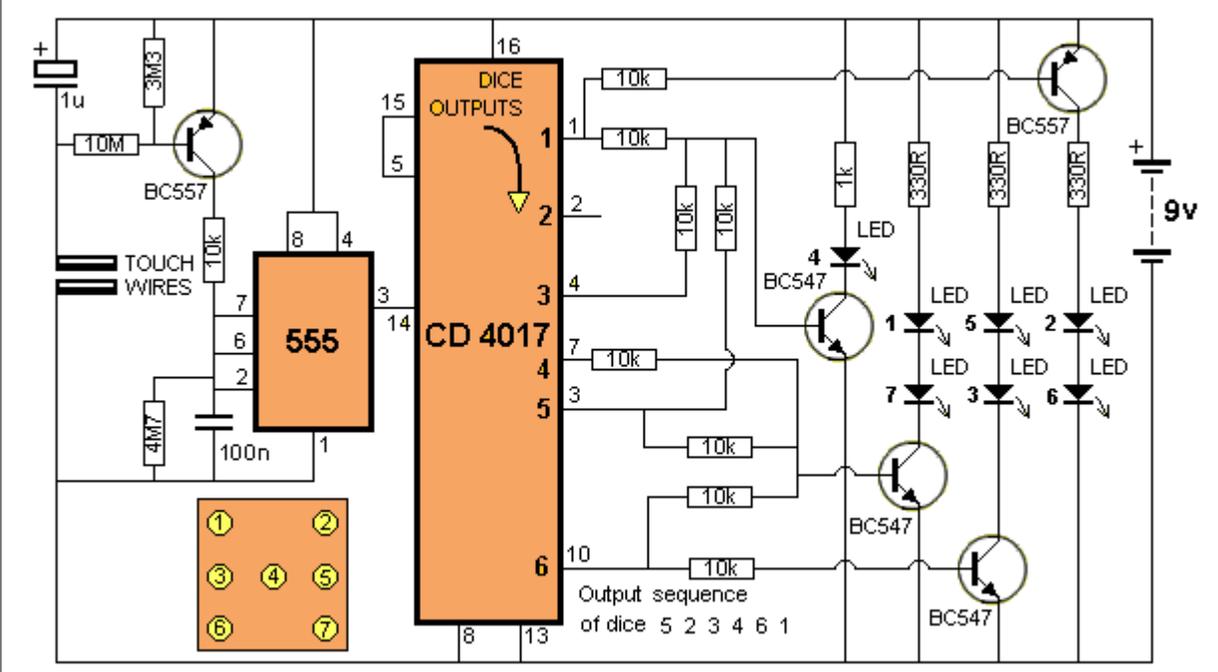


**POLICE LIGHTS-3**

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## 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.



**BUY NOW**



**BUY NOW**

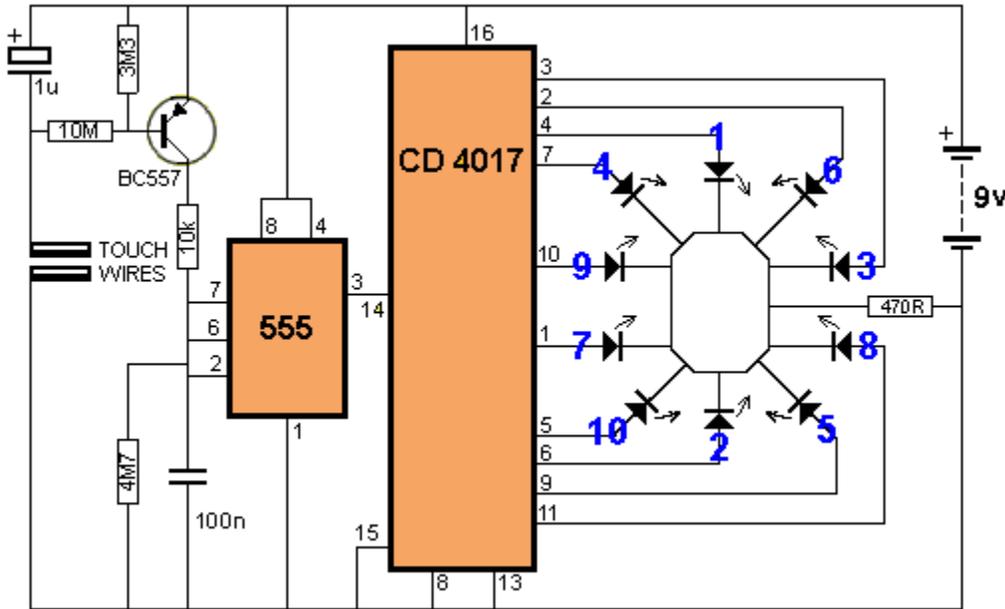
The LED Dice with Slow Down kit is available for \$16.00 plus \$6.50 postage.

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



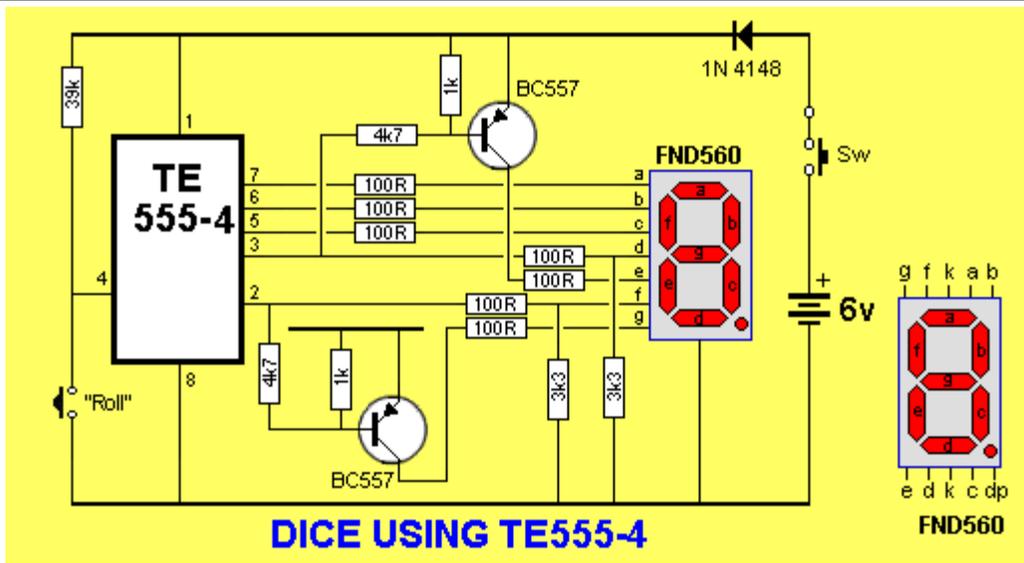
**TE 555-4**

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)

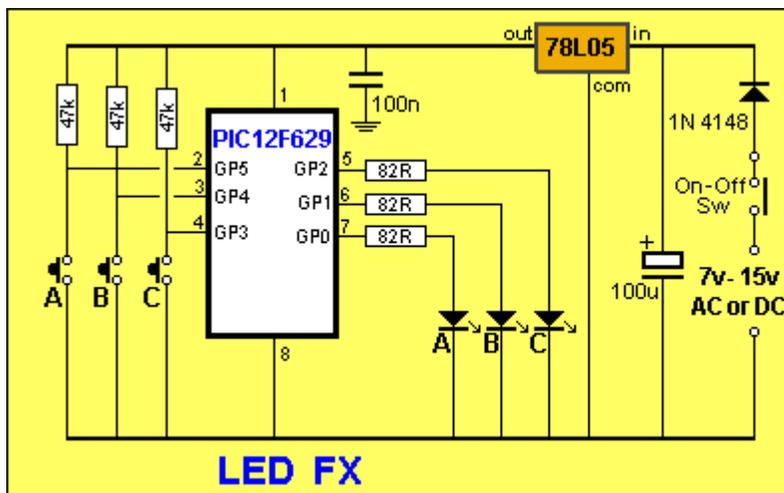


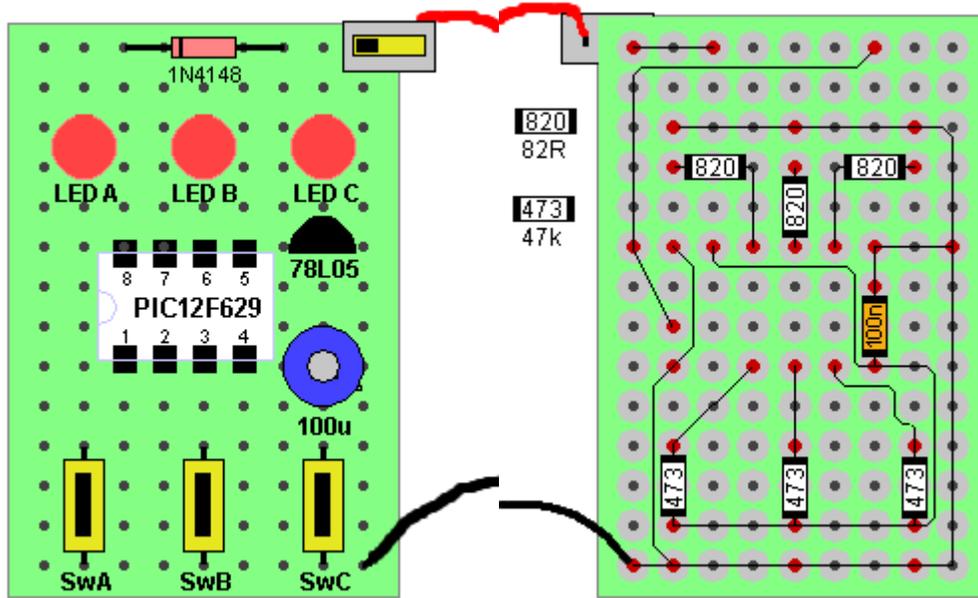
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## LED FX TE555-5

**NEW** **TE 555-5**  
 just **\$2.50**  
[CLICK TO BUY](#)

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.

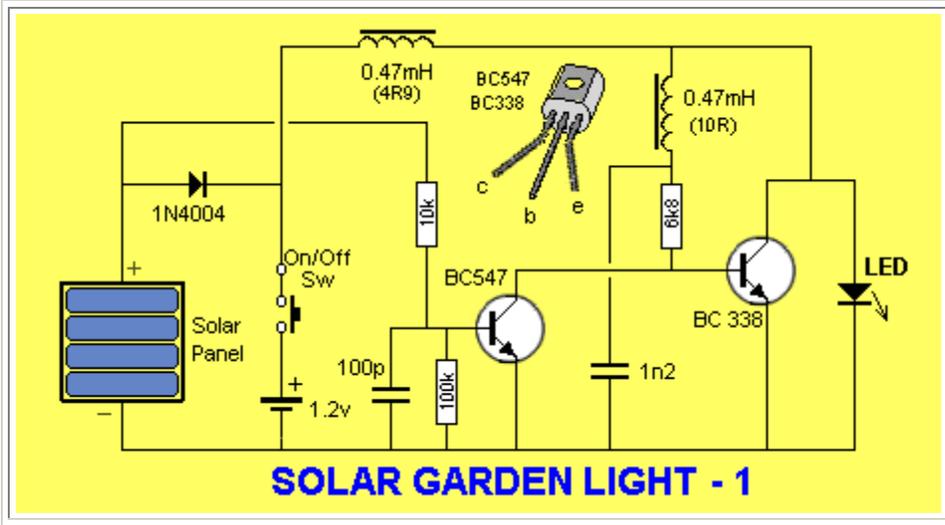




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## SOLAR GARDEN LIGHT

This is the circuit in a \$2.00 Solar Garden Light.  
The circuit illuminates a white LED from a 1.2v rechargeable cell.

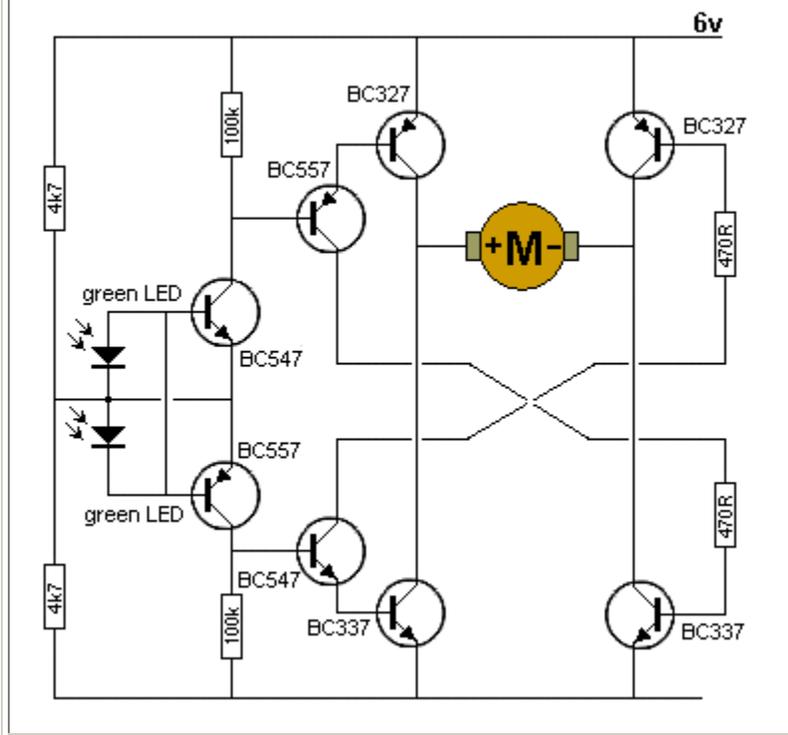


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## SOLAR TRACKER

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:

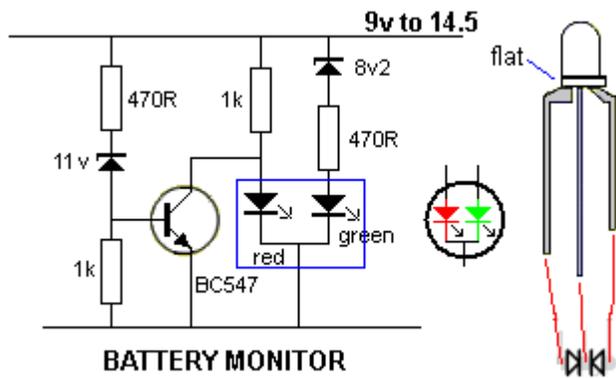
<http://www.redrok.com/electron.htm#tracker> This design is called: **LED5S5V Simplified LED low power tracker.**



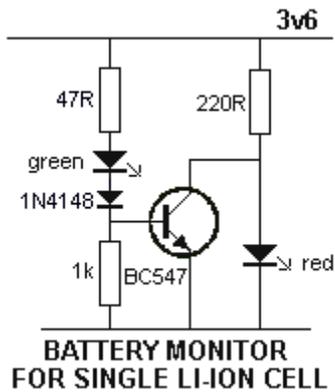
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## BATTERY MONITOR MkI

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



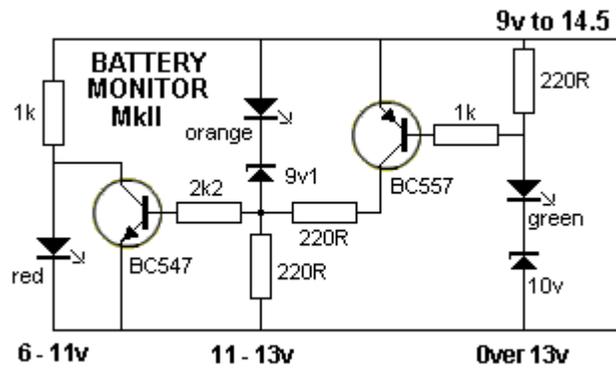
The following circuit monitors a single Li-ION cell. The green LED illuminates when the voltage is above 3.5v and the goes out when the voltage falls below 3.4v. The red LED then illuminates.



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### BATTERY MONITOR MkII

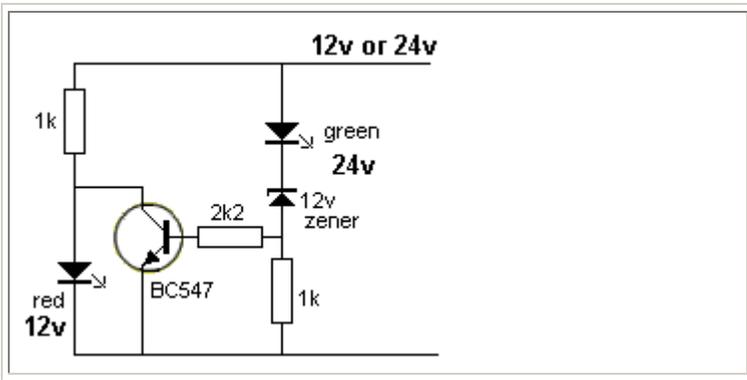
This battery monitor circuit uses 3 separate LEDs.  
 The red LED turns on from 6v to below 11v.  
 It turns off above 11v and  
 The orange LED illuminates between 11v and 13v.  
 It turns off above 13v and  
 The green LED illuminates above 13v



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### 12v or 24v

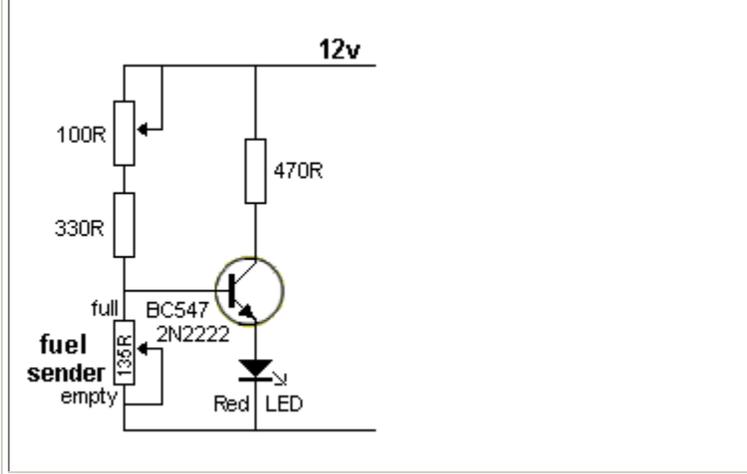
This circuit turns on a red LED when 12v is present or the green LED when 24v is present:



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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

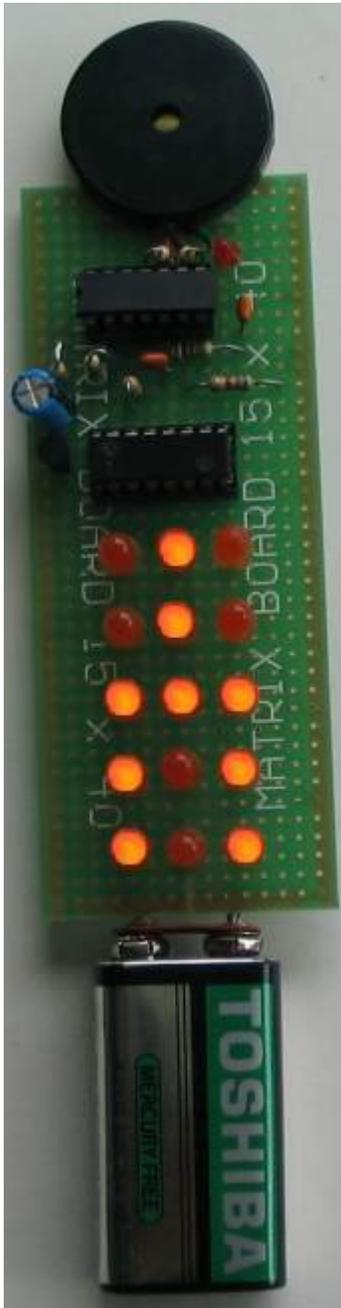
This circuit is a game of skill. See full article: [LED Zeppelin](#). The kit is available from talking electronics for \$15.50 plus postage. Email [HERE](#) for details.

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.





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.

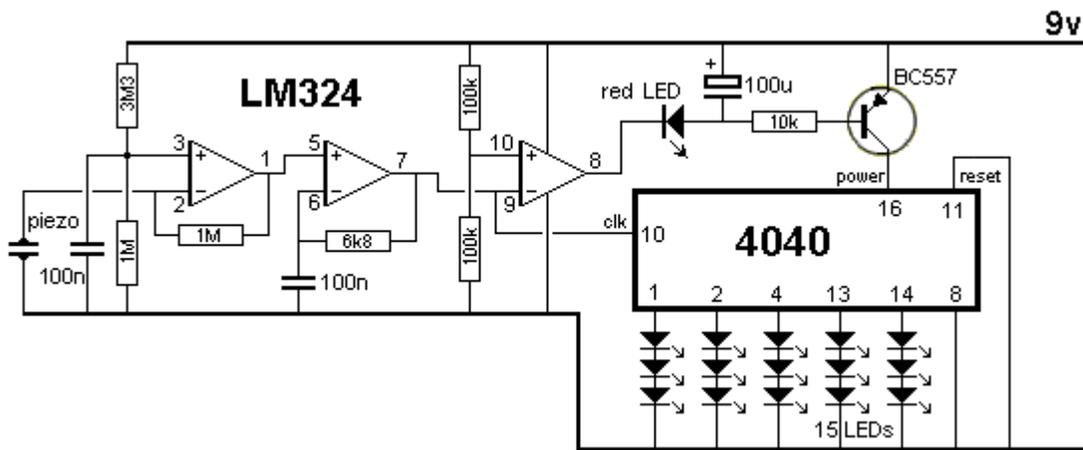
This creates a very impressive effect as the LEDs are connected to produce a balanced display that changes according to the beat of the music.

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 see a few millivolts above pin3. 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 100n capacitor, is 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.

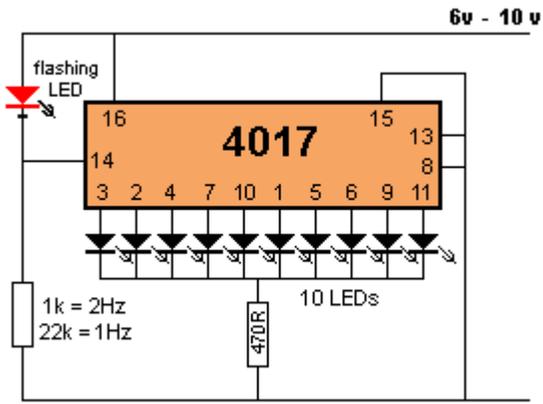


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### 10 LED CHASER

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)

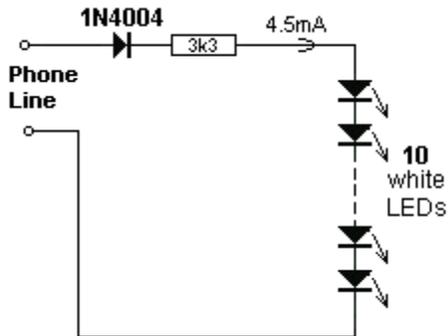
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### Emergency PHONE-LINE LIGHT

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.

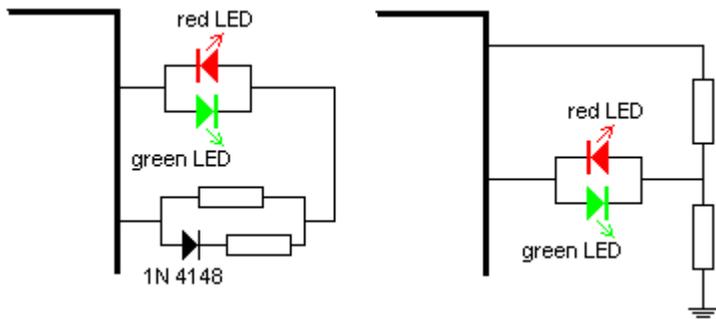
Be warned: This type of circuit is not allowed as it uses the energy from the phone line (called "leeching") and may prevent the phone from working.



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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.



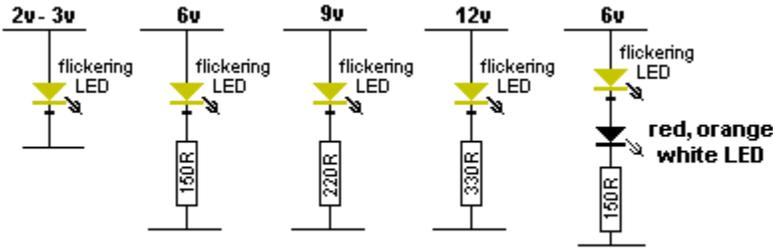
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### FLICKERING LED

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

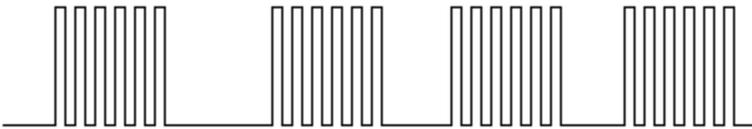
It can be connected to a supply from 2v to 6v and needs an external resistor when the supply is above 3v. The LED has an internal circuit to create the flickering effect and limit the current. We suggest adding a 150R resistor when the supply is above 3v and up to 6v. Above 6v, the current-limit resistor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

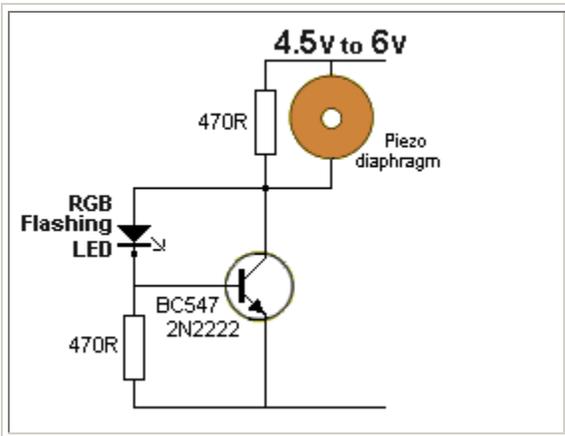
The pulses vary in width to create a brighter illumination.



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### RGB FLASHING LED

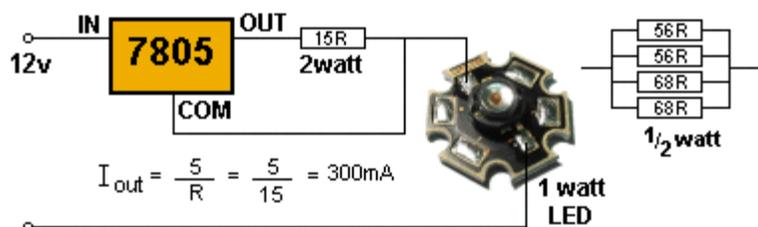
There are many different flickering and flashing LEDs on the market via eBay. They contain a microscopic microcontroller chip and current limiting resistor. Many of them work on a voltage from 3v to 6v and you can hear the oscillator turning ON and OFF to produce the different effects by building the following circuit:



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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 constant-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.

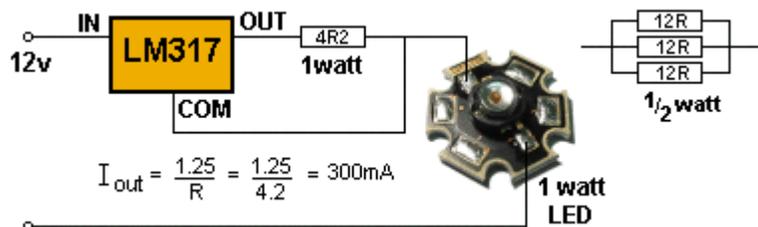
As the 12v rises from 0v, the 7805 starts to work and when the input voltage is 4v, the output is 1v as a minimum of 3v is lost across the 7805. The voltage rises further and when the output is 5v, current flows through the 15R resistor and illuminates the LED. The LED starts to illuminate at 3.4v and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

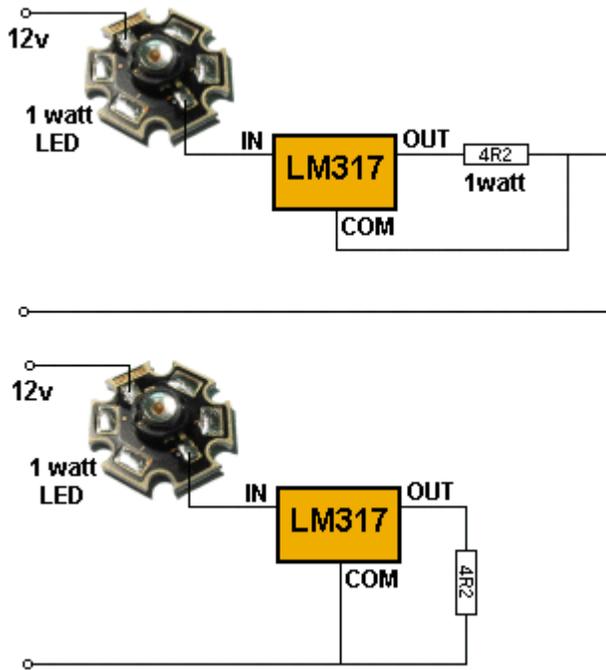
The LED will have 3.6v across it. The 15R will have 5v across it and the output will be 8.6v. The input voltage will have to be at least 12.6v for the 7805 to operate.

## USING LM317

The 3-Terminal Regulator can be LM317. This is similar to 7805 except the voltage between the COM and OUT is 1.25v instead of 5v. When using an LM317 regulator, less wattage will be lost in the resistor and more heat will be generated via the regulator, when compared with a 7805 however the total wattage lost will be the same in both cases.



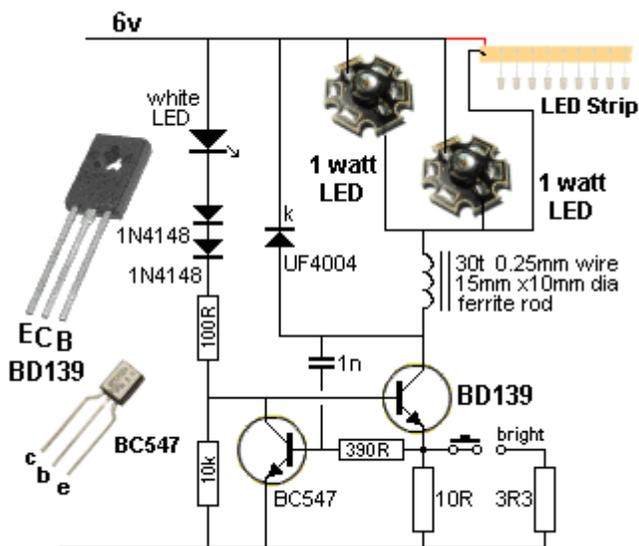
Since the LED and regulator are in series, the LED can be placed before the regulator:



Driving a single 1-watt LED from 12v is very inefficient. The voltage across the LED will be about 3.6v. The remaining 8.4v must be dropped across the LM317 and 4R2 resistor. The 4R2 must have 1.25v across it for the LM317 to operate and the LM317 has 7.15v across it. The minimum voltage across a LM317 is about 3v and this voltage is required to operate the circuitry inside the regulator. This means two 1-watt LEDs can be placed on a 12v supply and the regulator will run cooler while the circuit will produce twice the light-output for no additional current.

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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 though the collector-emitter circuit. This current flows though 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.

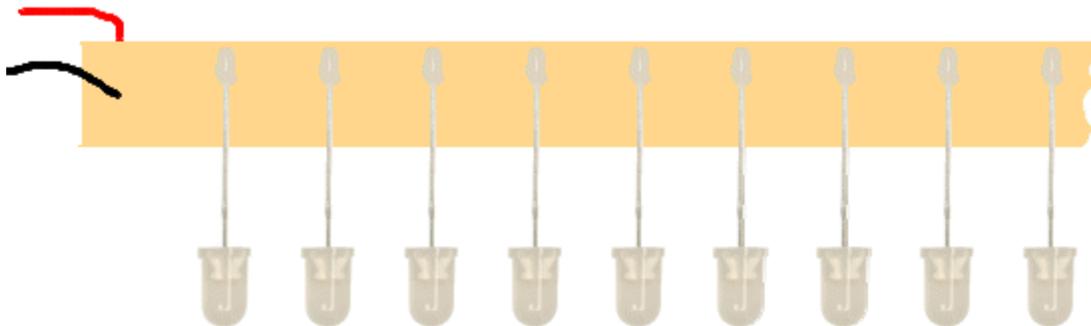
Pick an inductor that is about 6mm to 10mm diameter and 10mm to 15mm high. Larger inductor will not do any damage. They simply have more ferrite material to store the energy and will not be saturated. It is the circuit that delivers the energy to the inductor and then the inductor releases it to the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

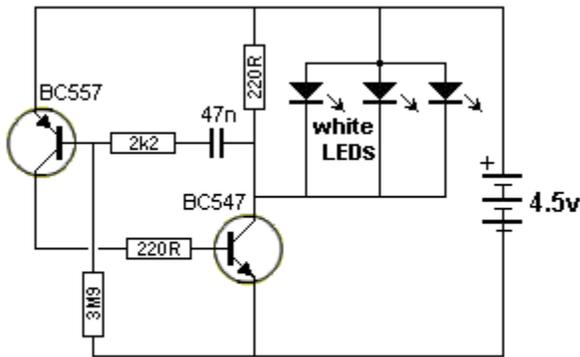
Ideally a battery is discharged at C/10 rate. This means the battery will last 10 hours and for a 600mA-Hr cell, this is 60mA. If you discharge it at the "C-rate," it will theoretically last 1 hour and the current will be 600mA. But at 600mA, the cells may only last 45 minutes. If you discharge is at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



BIKE FLASHER

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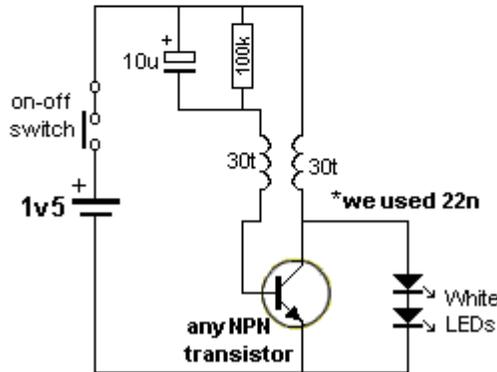
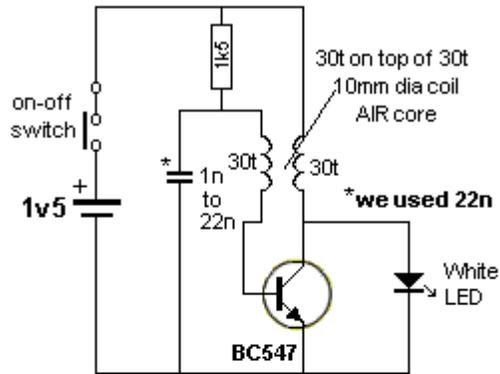
## BIKE FLASHER - Amazing!

This bike flasher uses a single transistor to flash two white LEDs from a single cell. And it has **no core** for the transformer - just AIR!

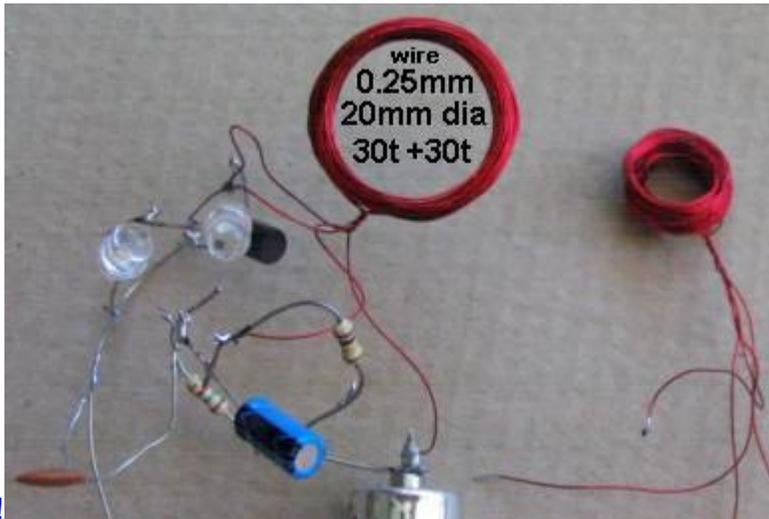
All **Joule Thief** circuits you have seen, use a ferrite rod or toroid (doughnut) core and the turns are wound on the ferrite material. But this circuit proves the collapsing magnetic flux produces an increased voltage, even when the core is AIR. The fact is this: When a magnetic field collapses quickly, it produces a higher voltage in the opposite direction and in this case the magnetic field surrounding the coil is sufficient to produce the energy we need.

Wind 30 turns on 10mm (1/2" dia) pen or screwdriver and then another 30 turns on top. Build the first circuit and connect the wires. You can use 1 or two LEDs. If the circuit does not work, swap the wires going to the base.

Now add the 10u electrolytic and 100k resistor (remove the 1k5). The circuit will now flash. You must use 2 LEDs for the flashing circuit.



### BIKE FLASHER -



AMAZING!

### THE IMPROVED BIKE FLASHER CIRCUIT

The original 30 turns + 30 turns coil is shown on the right. The circuit took 20mA to illuminate two LEDs.

The secret to getting the maximum energy from the coil (to flash the LEDs) is the maximum amount of air in the centre of the coil. Air cannot transfer a high magnetic flux so we provide a large area (volume) of low flux to provide the energy. The larger (20mm) coil reduced the current from 20mA to 11mA for the same brightness. This could be improved further but the coil gets too big. The two 30-turn windings must be kept together because the flux from the main winding must cut the feedback winding to turn ON the transistor **HARD**.

When the transistor starts to turn on via the 100k, it creates magnetic flux in the main winding that cuts the feedback winding and a positive voltage comes out the end connected to the base and a negative voltage comes out the end connected to the 100k and 10u. This turns the transistor ON more and it continues to turn ON until fully turned ON. At this point the magnetic flux is not expanding and the voltage does not appear in the feedback winding.

During this time the 10u has charged and the voltage on the negative lead has dropped to a lower voltage than before. This effectively turns off the transistor and the current in the main

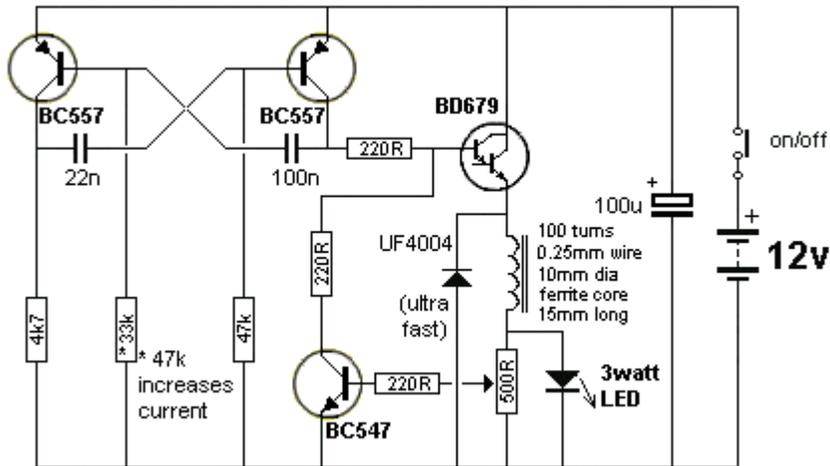
winding ceases abruptly. The magnetic flux collapses and produces a voltage in the opposite direction that is higher than the supply and this is why the two LEDs illuminate. This also puts a voltage through the feedback winding that keeps the transistor OFF. When the magnetic flux has collapsed, the voltage on the negative lead of the 10u is so low that the transistor does not turn on. The 100k discharges the 10u and the voltage on the base rises to start the next cycle.

You can see the 100k and 1k5 resistors and all the other parts in a "birds nest" to allow easy experimenting.

**Note:** Changing the turns to 40t for the main winding and 20t for the feedback (keeping the turns tightly wound together by winding wire around them) reduced the current to 8-9mA.

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## BUCK CONVERTER for 3watt LED



This circuit drives a 3watt LED. You have to be careful not to damage the LED when setting up the circuit. Add a 10R to the supply rail and hold it in your fingers. Make sure it does not get too hot and monitor the voltage across the resistor. Each 1v represents 100mA. The circuit will work and nothing will be damaged. If the resistor "burns your fingers" you have a short circuit.

The BC557 multivibrator has a "mark-to-space ratio" determined by the 22n and 33k, compared to the 100n and 47k, producing about 3:1. The BC679 is turned ON for about 30% of the time. This produces a very bright output, and takes about 170mA for 30% of the time. You cannot measure this current with a meter as it reads the peak value and the reading will be totally false. The only way to view the waveform is on a CRO, and calculate the current.

The 100-turn inductor allows the BC679 turn ON fully and "separates" the voltage on the emitter of the BC679 from the voltage on the top of the 3watt LED.

When the BC679 turns ON, the emitter rises to about 10v. But the top of the LED **NEVER** rises above 3.6v. The inductor "buffers" or "separates" these two voltages by producing a voltage across the winding equal to 6.4v and that's why the LED is not damaged.

When the transistor turns off (for 60% of the time), the magnetic flux produced by the current in the inductor collapses and produces a voltage in the opposite direction. This means the inductor now becomes a miniature battery and for a very short period of time it produces energy to illuminate the LED. The top of the inductor becomes negative and the bottom is positive. The current flows through the LED and through the Ultra High-Speed 1N4004 diode to complete the circuit. Thus the circuit takes advantage of the energy in the inductor.

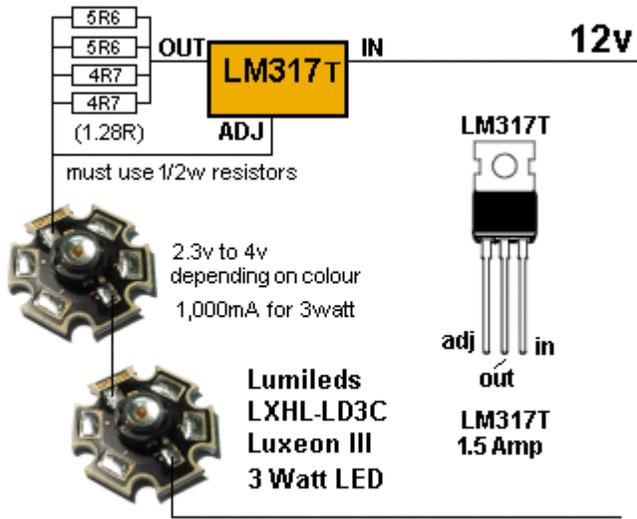
A 500R pot is placed across the LED and a voltage is picked off the pot to turn on a BC547 transistor. This transistor "robs" some of the "turn-on" for the BC679 transistor to reduce the brightness of the LED.

Because the circuit is driving the LED with pulses, very high brightness is obtained with a low current.

Our eyes detect peak brightness and you can compare the performance of this circuit with a DC driven LED.

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## CONSTANT CURRENT DRIVES TWO 3WATT LEDs



The value of the current-limiting resistor:

$$\text{Resistor(Ohms)} = 1.25(\text{V}) / \text{current(A)}$$

<http://www.reuk.co.uk/LM317-Current-Calculator.htm>

This constant current circuit is designed to drive two 3-watt Luxeon LEDs. The LEDs require 1,000mA (1Amp) and have a characteristic voltage-drop across them of about 3.8v. Approximately 4v is dropped across the LM317T regulator and 1.25v across the current-limiting resistors, so the input voltage (supply) has to be 12.85v. A 12v battery generally delivers 12.6v. The LM 317T 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.

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## DIMMING A 10WATT LED

The following circuit is a request from a reader. He wanted to dim a 10 watt LED from a 4.2v Lithium Ion cell.

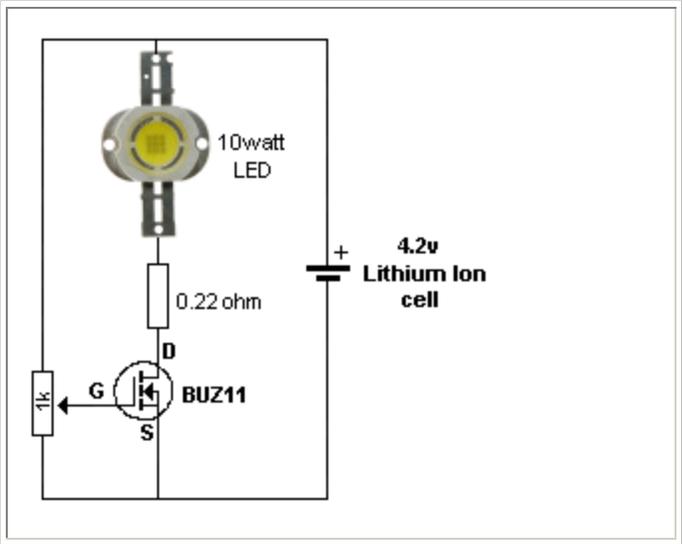
The current will be about 3 amps and a power MOSFET is needed to deliver this current.

The characteristic voltage across the LED is about 3.3v to 3.6v and this leaves very little voltage for the control circuit. The resistance of the MOSFET is about 0.05 ohms and very little voltage is lost here.

The 0.22 ohm (1 watt) resistor will drop about 650millivolts.

The LED will not be overloaded or damaged by this circuit. When the pot is adjusted from full brightness, the MOSFET will dissipate a lot of energy and will get very hot if not properly heatsinked.

You can buy two 3200mAh Li-ion cells for \$4.00 (posted) on [eBay](#). Some suppliers want \$15.00 per cell. You will need 4 cells in parallel to keep the current from each cell below 1 amp and this will allow the circuit to operate for about 2 hours.



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**FL**  
The

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| 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