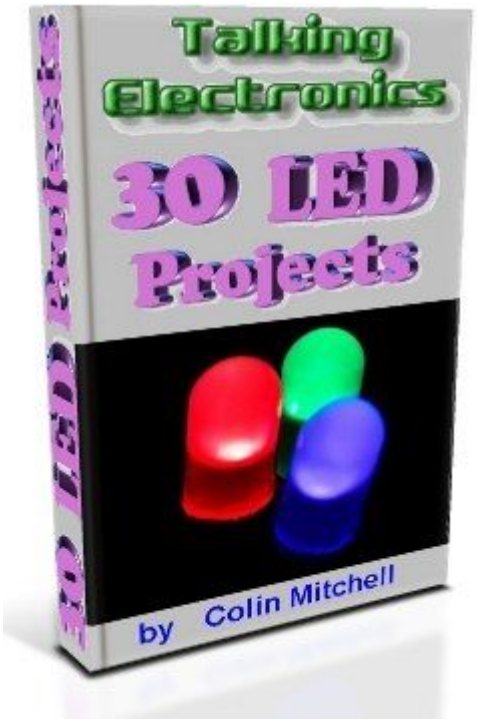


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**1 - 100 Transistor Circuits** **and:** **101 - 200 Transistor Circuits** **100 IC Circuits**

For a list of every electronic symbol, see: Circuit Symbols.

For more articles and projects for the hobbyist: **see TALKING ELECTRONICS WEBSITE**

email Colin Mitchell: talking@tpg.com.au

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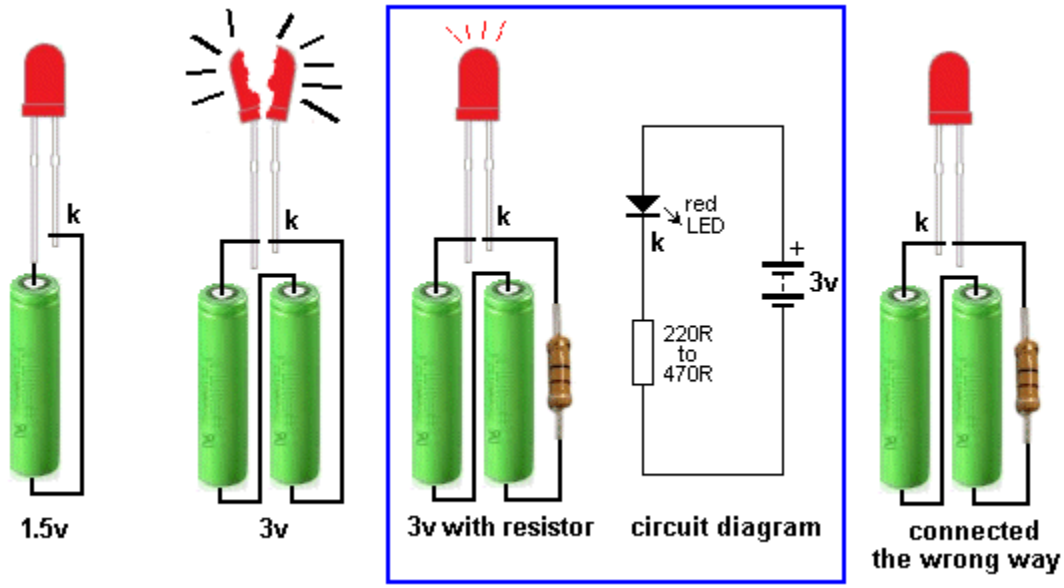
# INTRODUCTION

This e-book covers the Light Emitting Diode.

The LED (Light Emitting Diode) is the modern-day equivalent to the light-globe.
It has changed from a dimly-glowing indicator to one that is too-bright to look at.
However it is entirely different to a "globe."
A globe is an electrical device consisting of a glowing wire while a LED is an electronic device.
A LED is more efficient, produces less heat and must be "driven" correctly to prevent it being damaged.
This eBook shows you how to connect a LED to a circuit plus a number of projects using LEDs.
It's simple to use a LED - once you know how.

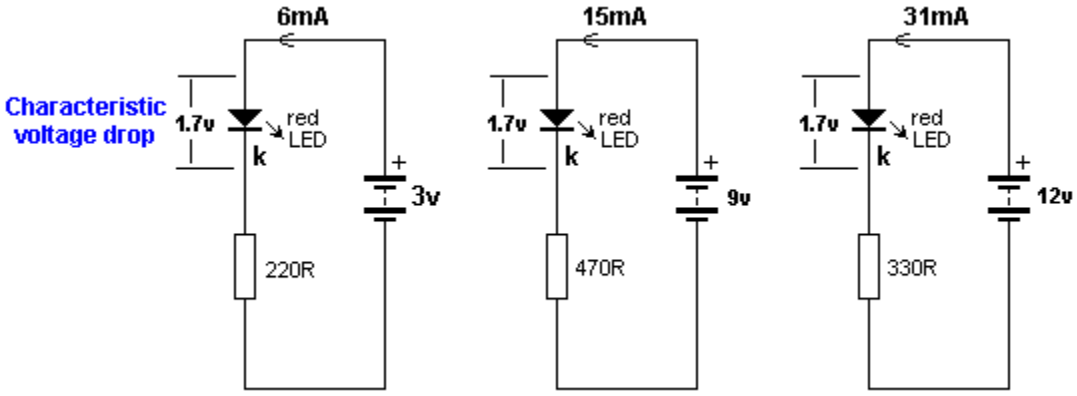
## CONNECTING A LED

A LED must be connected around the correct way in a circuit and it must have a resistor to limit the current. The LED in the first diagram does not illuminate because a red LED requires 1.7v and the cell only supplies 1.5v. The LED in the second diagram is damaged because it requires 1.7v and the two cells supply 3v. A resistor is needed to limit the current to about 25mA and also the voltage to 1.7v, as shown in the third diagram. The fourth diagram is the circuit for layout #3 showing the symbol for the LED, resistor and battery and how the three are connected. The LED in the fifth diagram does not work because it is around the wrong way.

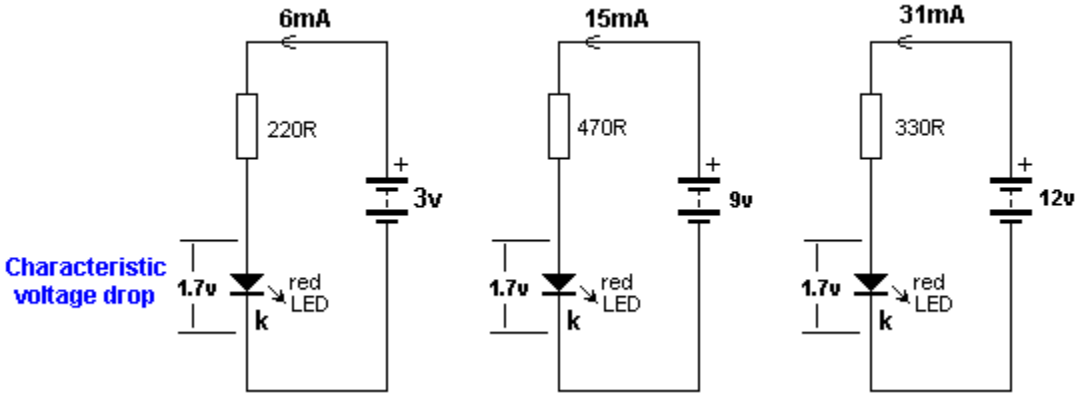



## CHARACTERISTIC VOLTAGE DROP

When a LED is connected around the correct way in a circuit it develops a voltage across it called the CHARACTERISTIC VOLTAGE DROP.
A LED must be supplied with a voltage that is higher than its "CHARACTERISTIC VOLTAGE" via a resistor - called a VOLTAGE DROPPING RESISTOR or CURRENT LIMITING RESISTOR - so the LED will operate correctly and provide at least 10,000 to 50,000 hours of illumination.
A LED works like this: A LED and resistor are placed in series and connected to a voltage.
As the voltage rises from 0v, nothing happens until the voltage reaches about 1.7v. At this voltage a red LED just starts to glow. As the voltage increases, the voltage across the LED remains at 1.7v but the current through the LED increases and it gets brighter.
We now turn our attention to the current though the LED. As the current increases to 5mA, 10mA, 15mA, 20mA the brightness will increase and at 25mA, it will be a maximum. Increasing the supply voltage will simply change the colour of the LED slightly but the crystal inside the LED will start to overheat and this will reduce the life considerably.
This is just a simple example as each LED has a different CHARACTERISTIC VOLTAGE DROP and a different maximum current.
In the diagram below we see a LED on a 3v supply, 9v supply and 12v supply. The current-limiting resistors are different and the first circuit takes 6mA, the second takes 15mA and the third takes 31mA. But the voltage across the red LED is the same in all cases. This is because the LED creates the CHARACTERISTIC VOLTAGE DROP and this does not change.

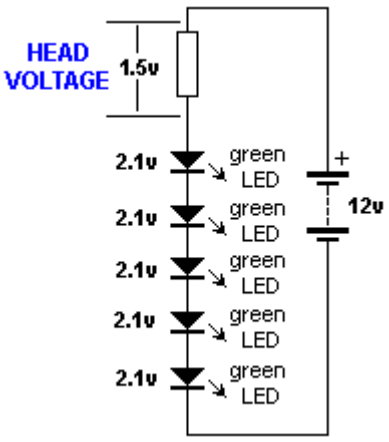



It does not matter if the resistor is connected above or below the LED. The circuits are the SAME in operation:




## HEAD VOLTAGE

Now we turn our attention to the resistor.
As the supply-voltage increases, the voltage across the LED will be constant at 1.7v (for a red LED) and the excess voltage will be dropped across the resistor. The supply can be any voltage from 2v to 12v or more.
In this case, the resistor will drop 0.3v to 10.3v.
This is called **HEAD VOLTAGE - or HEAD-ROOM**.
The following diagram shows **HEAD VOLTAGE:**

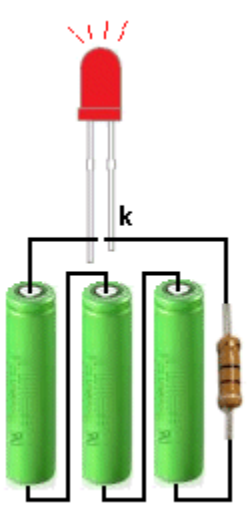



The voltage dropped across this resistor, combined with the current, constitutes wasted energy and should be kept to a minimum, but a small HEAD VOLTAGE is not advisable (such as 0.5v). The head voltage should be a minimum of 1.5v - and this only applies if the supply is fixed.
The head voltage depends on the supply voltage. If the supply is fixed and guaranteed not to increase or fall, the head voltage can be small (1.5v minimum).
But most supplies are derived from batteries and the voltage will drop as the cells are used.
Here is an example of a problem:
Supply voltage: 12v
7 red LEDs in series = 11.9v
Dropper resistor = 0.1v
As soon as the supply drops to 11.8v, no LEDs will be illuminated.
Example 2:

Supply voltage 12v
5 green LEDs in series @ 2.1v = 10.5v
Dropper resistor = 1.5v
The battery voltage can drop to 10.5v
But let's look at the situation more closely.
Suppose the current @ 12v = 25mA.
As the voltage drops, the current will drop.
At 11.5v, the current will be 17mA
At 11v, the current will be 9mA
At 10.5v, the current will be zero
You can see the workable supply drop is only about 1v.
Many batteries drop 1v and still have over 80% of their energy remaining. That's why you need to design your circuit to have a large **HEAD VOLTAGE.**

## 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.

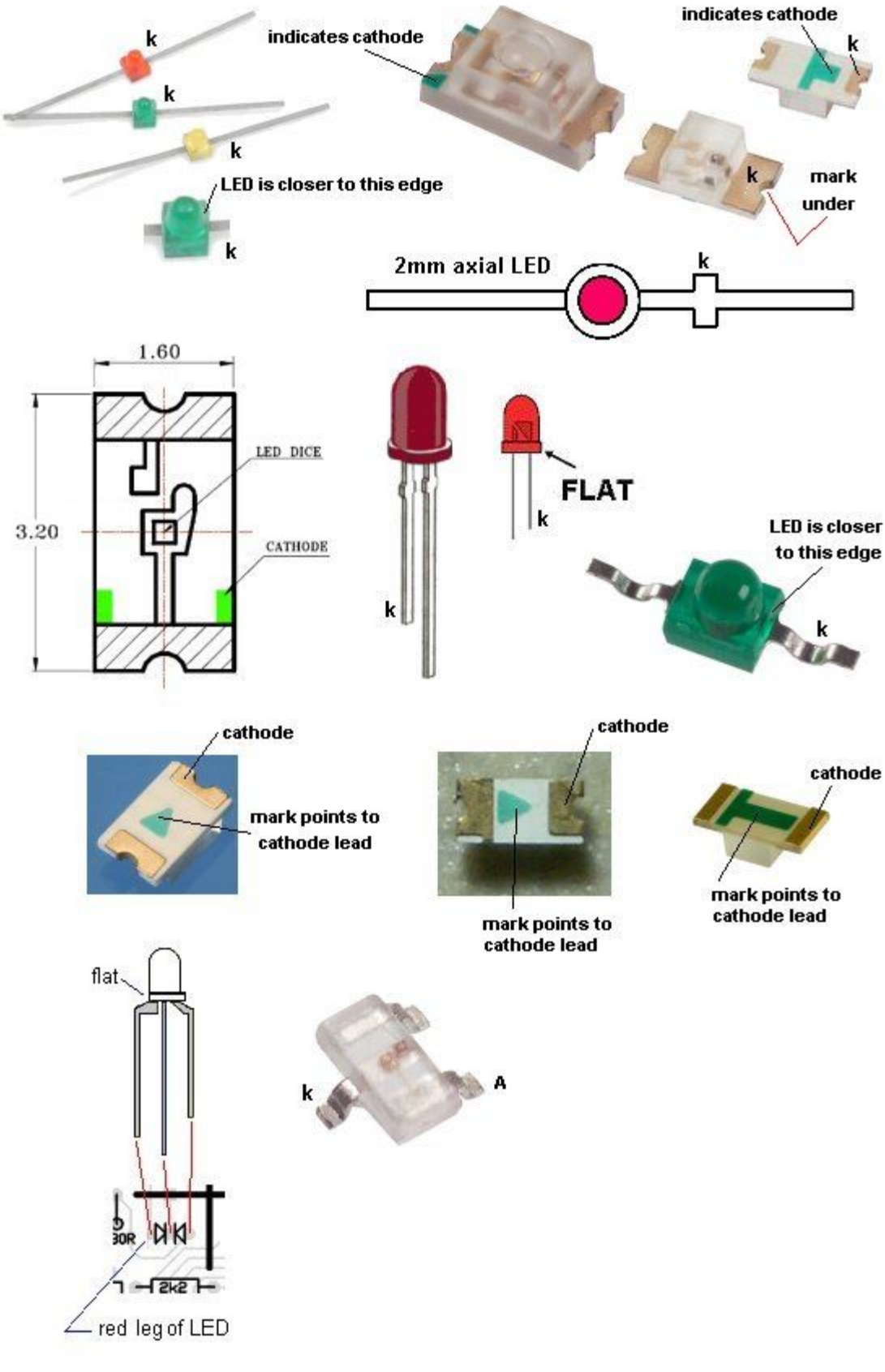


4.5v with resistor

**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

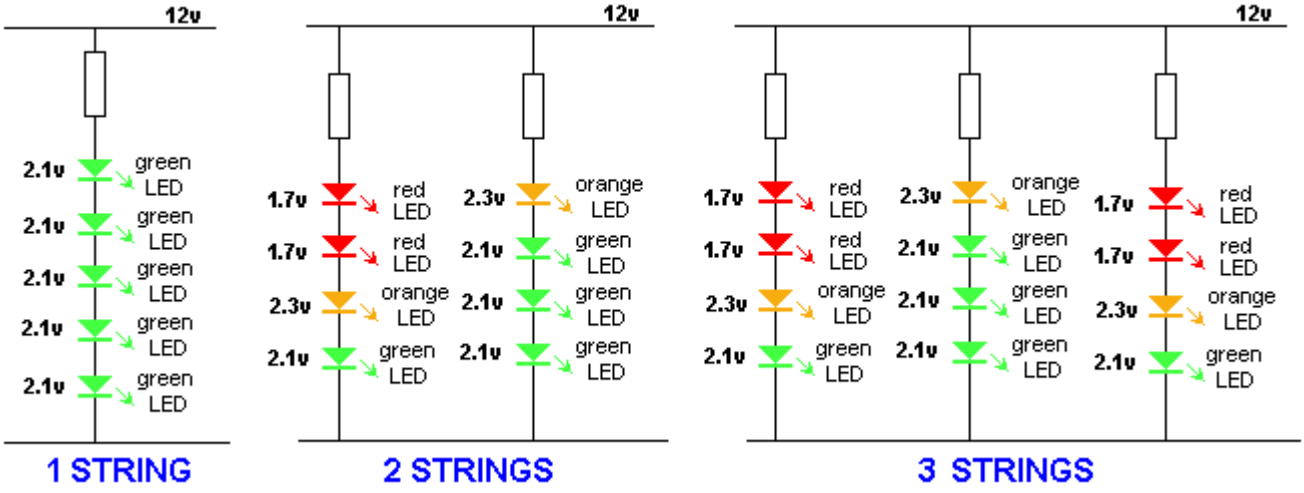
A LED is described as a CURRENT DRIVEN DEVICE. This means the illumination is determined by the amount of current flowing through it.
The brightness of a LED can be altered by increasing or decreasing the current. The effect will not be linear and it is best to experiment to determine the best current-flow for the amount of illumination you want. The life of many LEDs is determined at 17mA. This seems to be the best value for many types of LEDs.

## 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 rate.
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 this value.
The only LED with an internal resistor is a FLASHING LED. These LEDs can be placed on a supply from 5v to 12v and flash at approx 2Hz.
NEVER assume a LED has an internal resistor. Always add a series resistor.

## LEDs IN SERIES

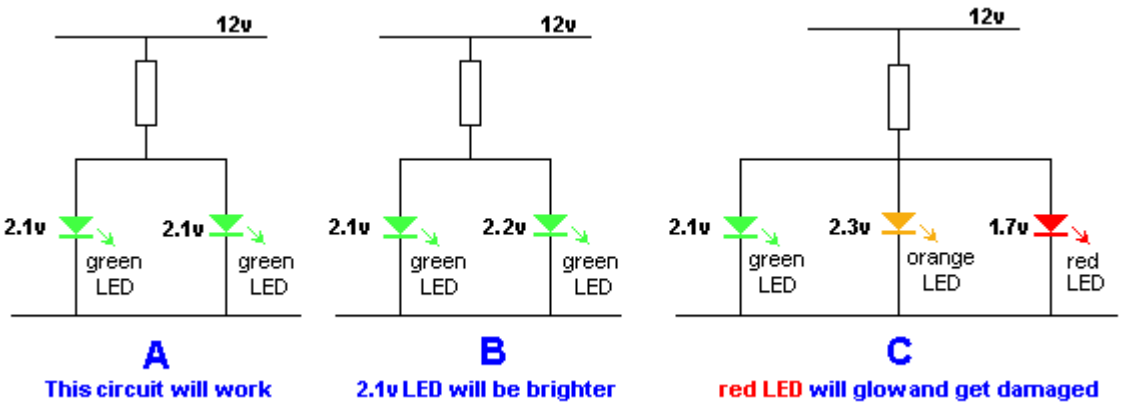
LEDs can be placed in series providing some features are taken into account.
A LED and resistor is called a string. A string can have 1, 2, 3 or more LEDs.
These three things must be observed:
1. Maximum current through each string = 25mA.
2. The CHARACTERISTIC VOLTAGE-DROP must be known so the correct 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 though 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.
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.

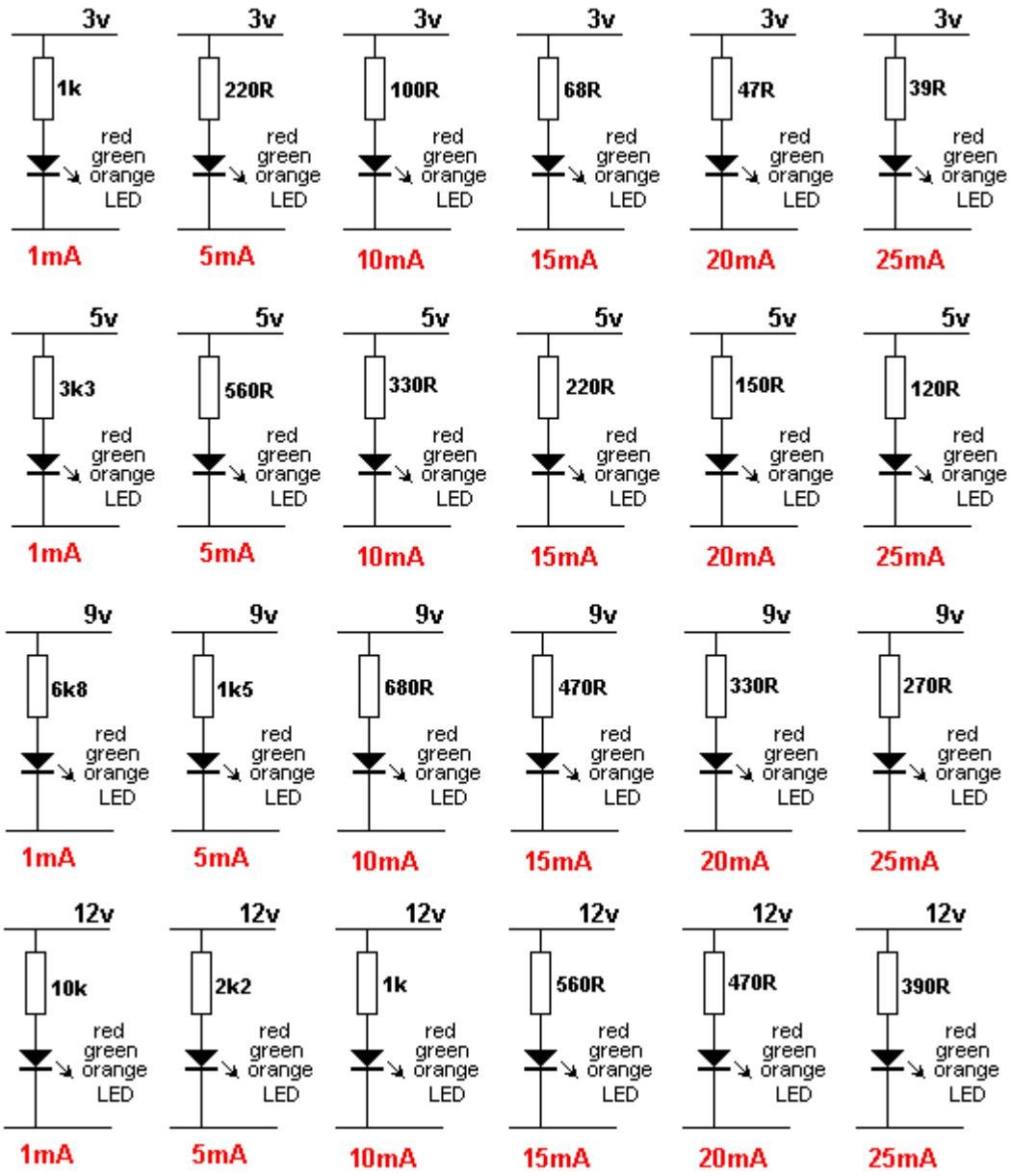
In diagram **B** the Characteristic Voltage Drop is slightly different for the second LED and the first green LED will glow brighter.
In diagram **C** the three LEDs have different Characteristic Voltage Drops and the red LED will glow very bright while the other two LEDs will not illuminate. All the 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.



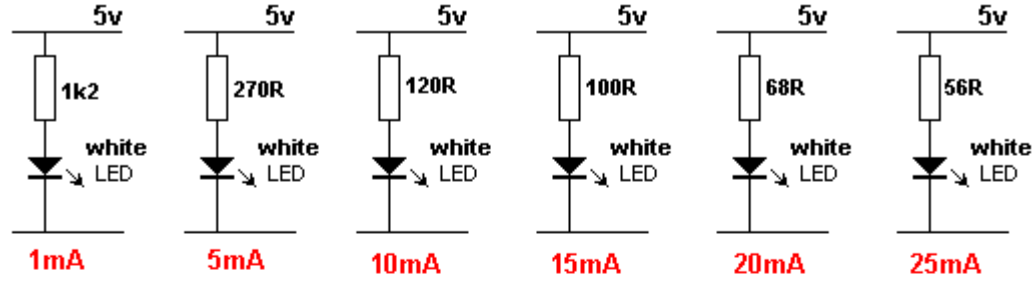

## THE RESISTOR

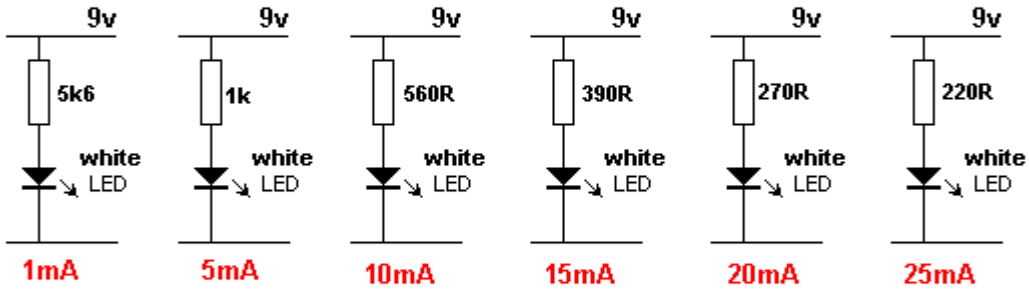
The value of the current limiting resistor can be worked out by Ohms Law.
Here are the 3 steps:
1. Add up the voltages of all the LEDs in a string. e.g: 2.1v + 2.3v + 2.3v + 1.7v = 8.4v
2. Subtract the LED voltages from the supply voltage. e.g: 12v - 8.4v = 3.6v
3. Divide the 3.6v (or your voltage) by 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.

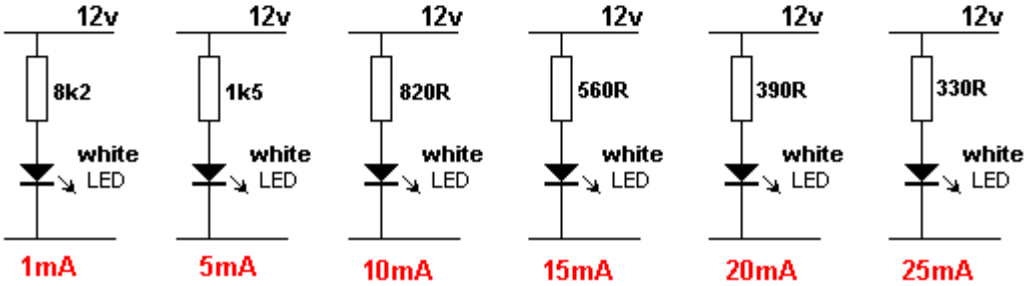
Here is a set of strings for a supply voltage of 3v to 12v and a single LED:



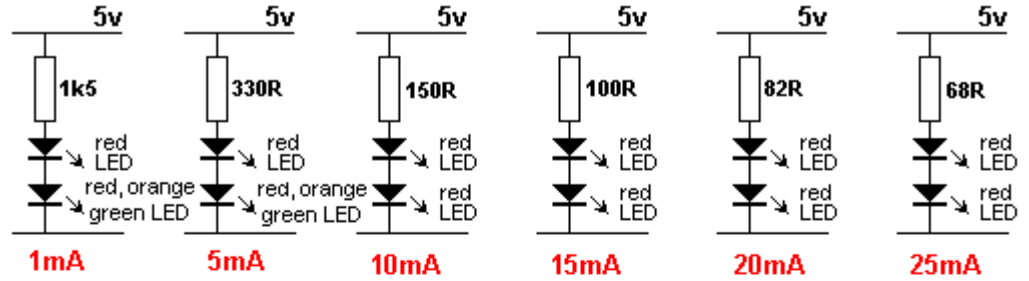
Here is a set of strings for a supply voltage of 5v to 12v and a white LED:

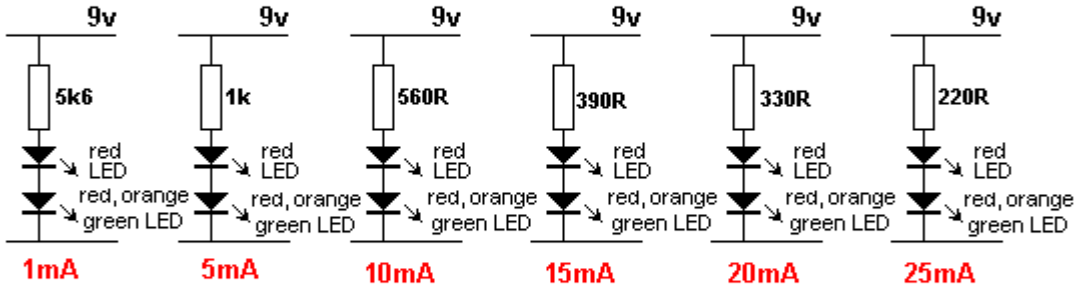


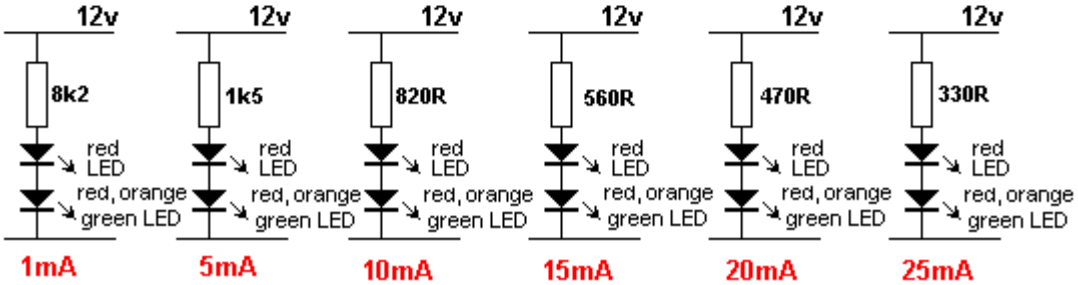




Here is a set of strings for a supply voltage of 5v to 12v and two LEDs:



# 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.

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

## 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 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 that can be clearly seen during daytime.
Some LEDs operate on a current as low as 1mA

## 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.

For photos of nearly every electronic component, see this website:
https://www.egr.msu.edu/eceshop/Parts_Inventory/totalinventory.php

## 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

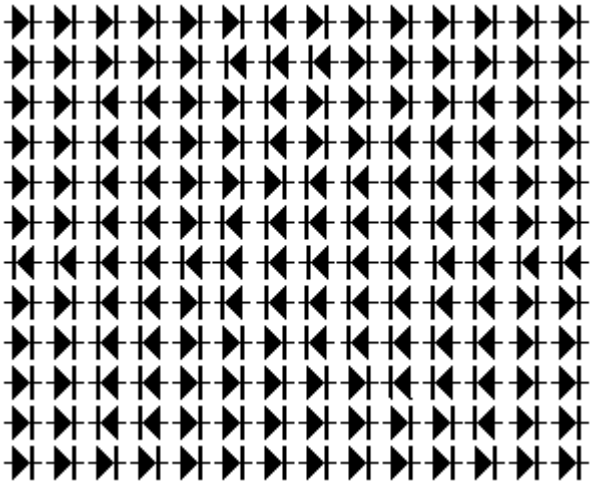
TALKING ELECTRONICS.
talking@tpg.com.au

## 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.
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)

How good is your power of observation?
Can you find the LED:



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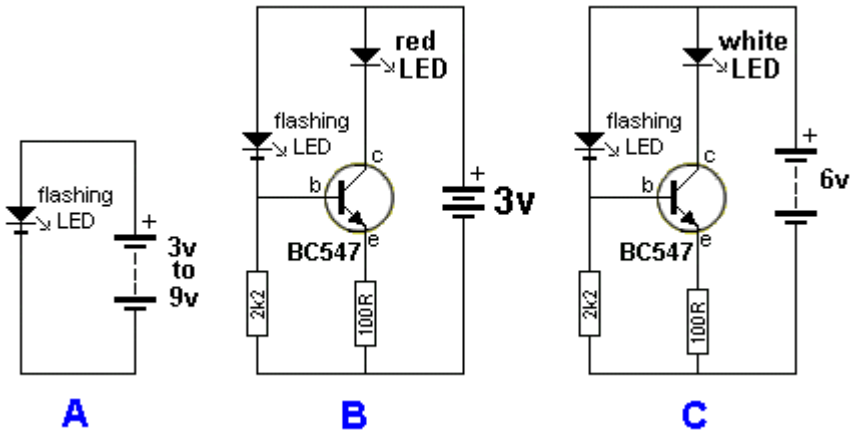
## POWERING A PROJECT

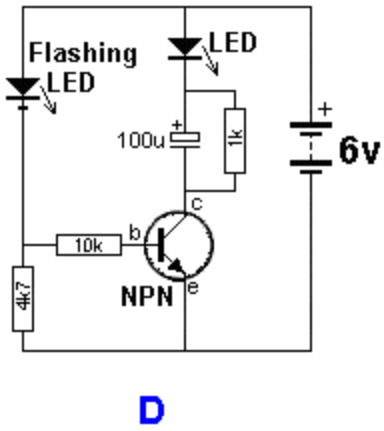
The safest way to power a project is with a battery. Each circuit requires a voltage from 3v to 12v. This can be supplied from a set of AA cells in a holder or you can also use a 9v battery for some projects.
If you want to power a circuit for a long period of time, you will need a "power supply." The safest power supply is a Plug Pack (wall-wort, wall wart, wall cube, power brick, plug-in adapter, adapter block, domestic mains adapter, power adapter, or AC adapter). Some plug packs have a switchable output voltage: 3v, 6v, 7.5v, 9v, 12v) DC with a current rating of 500mA. The black lead is negative and the other lead with a white stripe (or a grey lead with a black stripe) is the positive lead.
This is the safest way to power a project as the insulation (isolation) from the mains is provided inside the adapter and there is no possibility of getting a shock.
The rating "500mA" is the maximum the Plug Pack will deliver and if your circuit takes just 50mA, this is the current that will be supplied. Some pluck packs are rated at 300mA or 1A and some have a fixed output voltage. All these plug packs will be suitable.
Some Plug Packs are marked "12vAC." This type of plug pack is not suitable for these circuits as it does not have a set of diodes and electrolytic to convert the AC to DC. All the circuits in this eBook require DC.

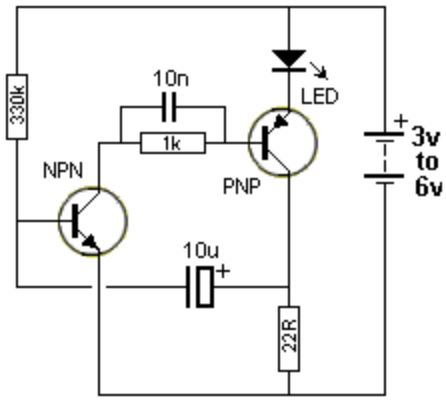
# PROJECTS

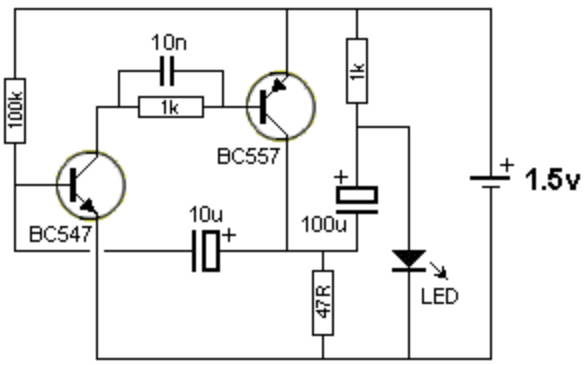
## FLASHING A LED

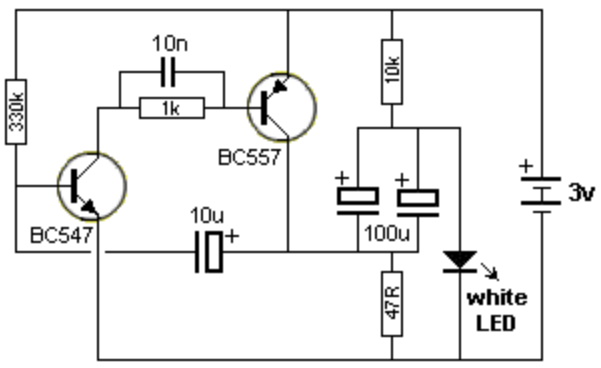
These 7 circuits flash a LED using a supply from 1.5v to 12v.
They all have a different value of efficiency and current consumption. You will find at least one to suit your requirements.
The simplest way to flash a LED is to buy a FLASHING LED as shown in figure **A**. It will work on 3v to 9v but it 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.
Figure **E** uses 2 transistors to produce a brief flash.
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.



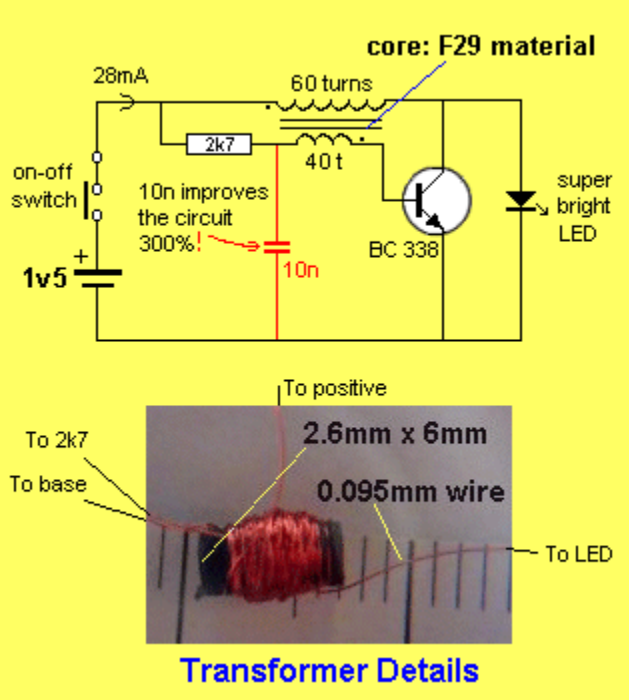



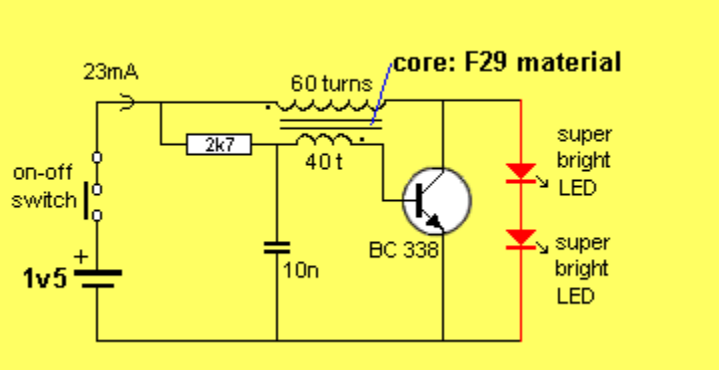
# WHITE LED on 1.5v SUPPLY

This circuit will illuminate a white LED using a single cell.
See LED Torch Circuits article for more details.



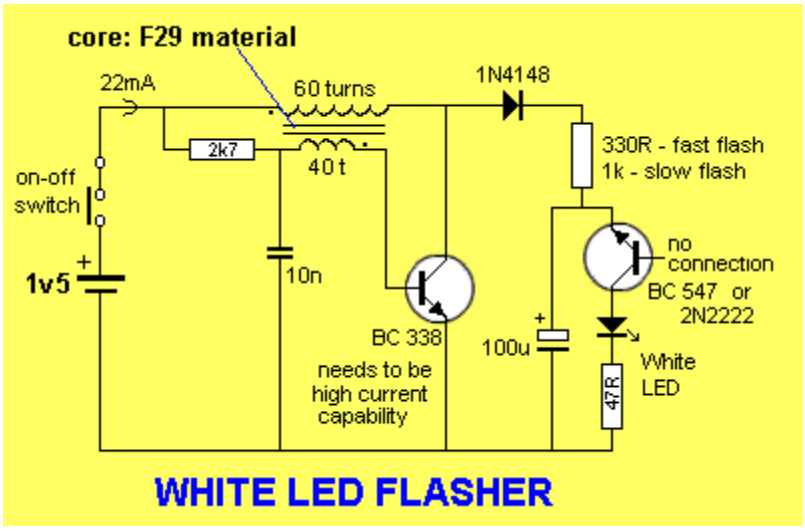

# 2 WHITE LEDs on 1.5v SUPPLY

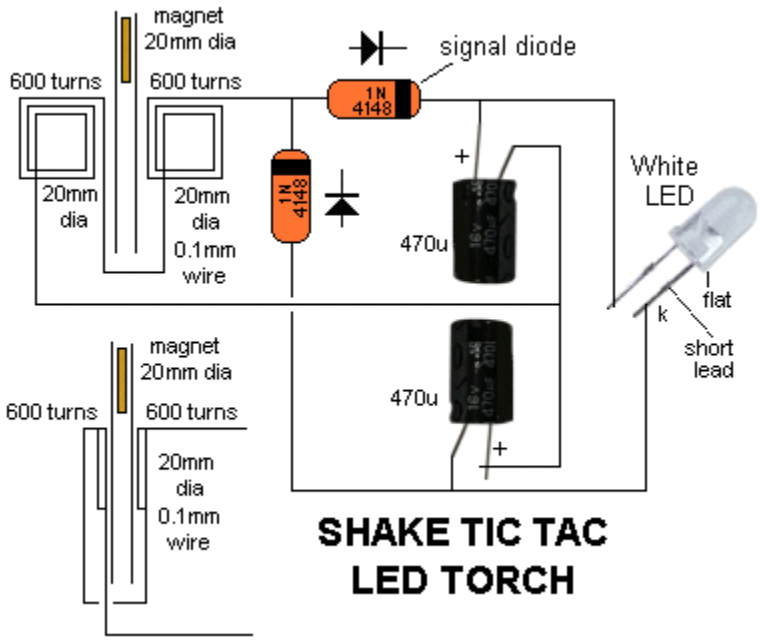
This circuit will illuminate two white LEDs using a single cell.
See LED Torch Circuits article for more details.



# WHITE LED FLASHER

This circuit will flash a white LEDs using a single cell.
See LED Torch Circuits article for more details.

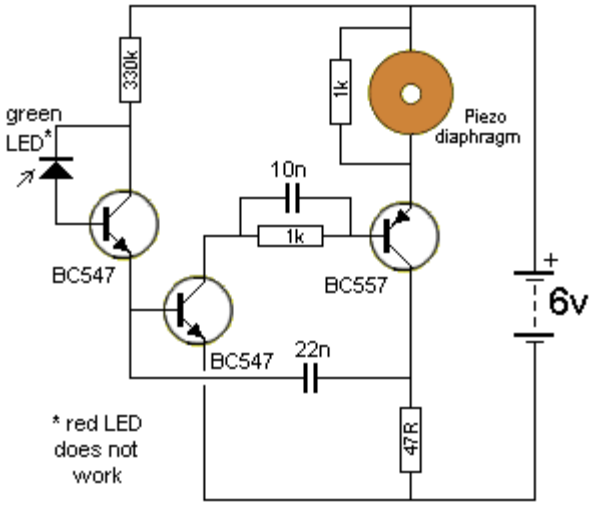



# SHAKE TIC TAC LED TORCH

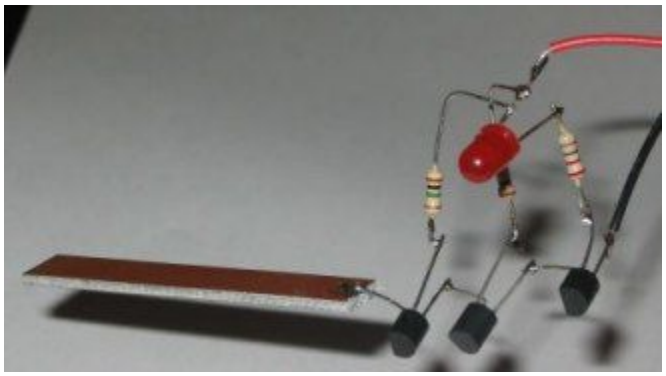
In the diagram, it looks like the coils sit on the “table” while the magnet has its edge on the table. This is just a diagram to show how the parts are connected. The coils actually sit flat against the slide (against the side of the magnet) as shown in the diagram: The output voltage depends on how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

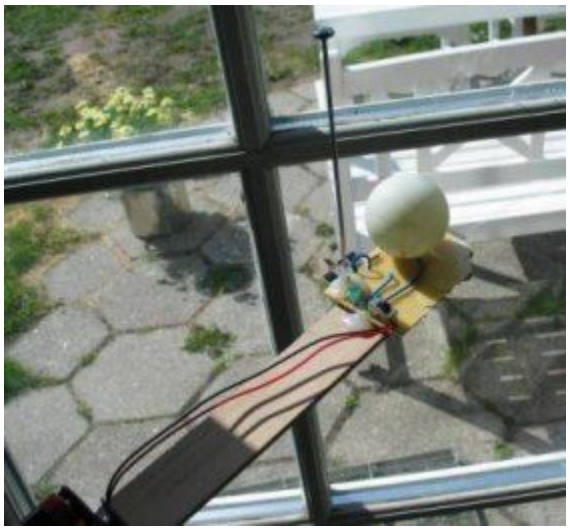
The circuit consists of two 600-turn coils in series, driving a voltage doubler. Each coil produces a positive and negative pulse, each time the magnet passes from one end of the slide to the other.
The positive pulse charges the top electrolytic via the top diode and the negative pulse charges the lower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




# LED DETECTS LIGHT

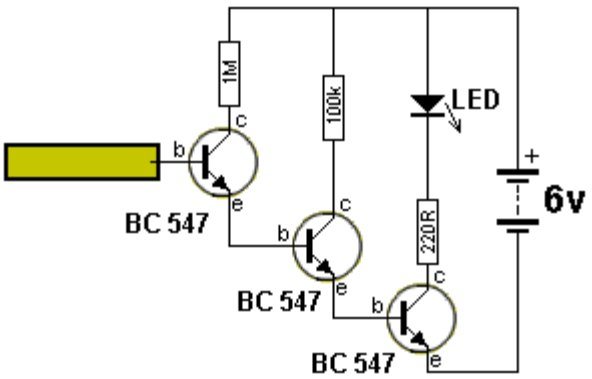
The LED in this circuit will detect light to turn on the oscillator. Ordinary red LEDs do not work. But green LEDs, yellow LEDs and high-bright white LEDs and high-bright red LEDs work very well.
The output voltage of the LED is up to 600mV when detecting very bright illumination. When light is detected 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.





# 6 MILLION GAIN!

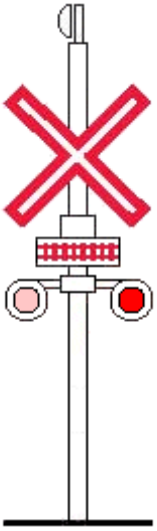
This circuit is so sensitive it will detect "mains hum." Simply move it across any wall and it will detect where the mains cable is located. It has a gain of about 200 x 200 x 200 = 6,000,000 and will also detect static electricity and the presence of your hand without any direct contact. You will be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



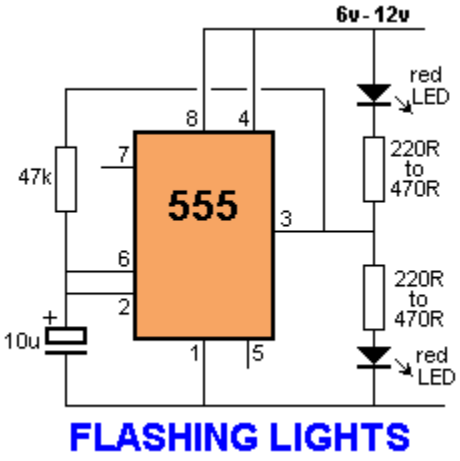

Here is a photo of the circuit, produced by a constructor.

# FLASHING RAILROAD LIGHTS

This circuit flashes two red LEDs for a model railway

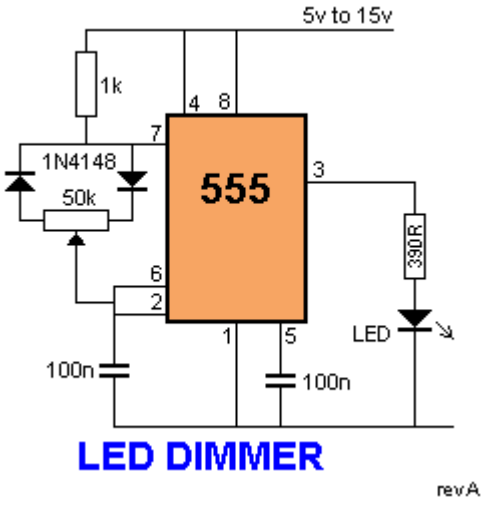


crossing.



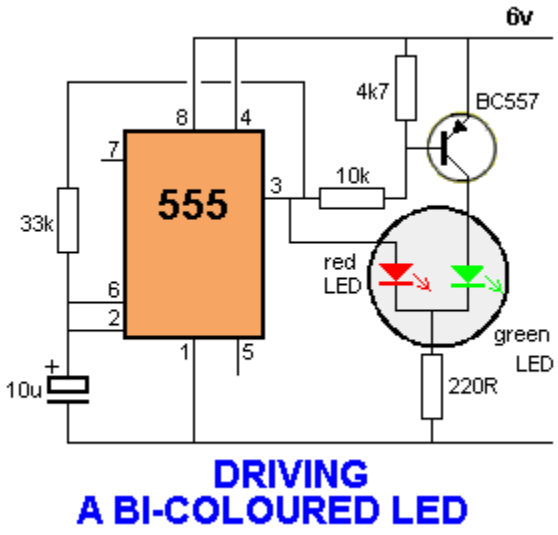

# LED DIMMER

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



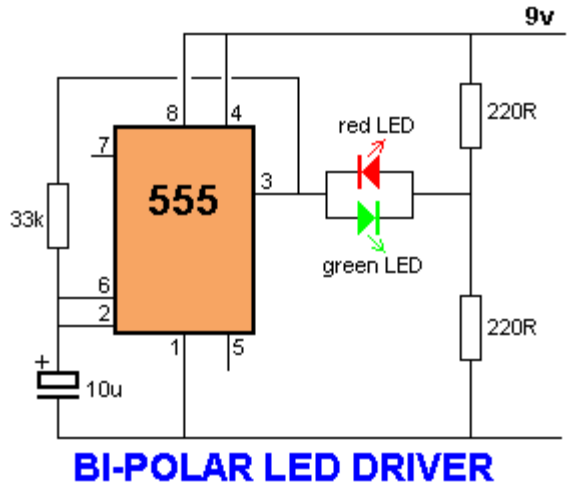
# DRIVING A BI-COLOUR LED

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




# 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:



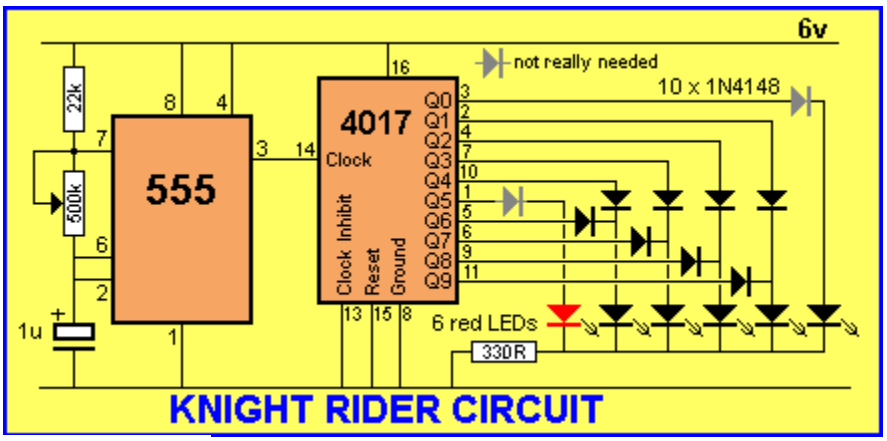

# KNIGHT RIDER

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

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

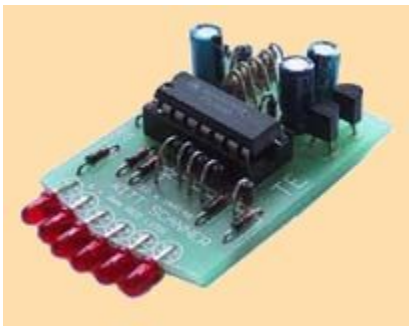
The first 6 outputs of the chip are connected directly to the 6 LEDs and these "move" across the display. The next 4 outputs move the effect in the opposite direction and the cycle repeats. The animation above shows how the effect appears on the display.

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

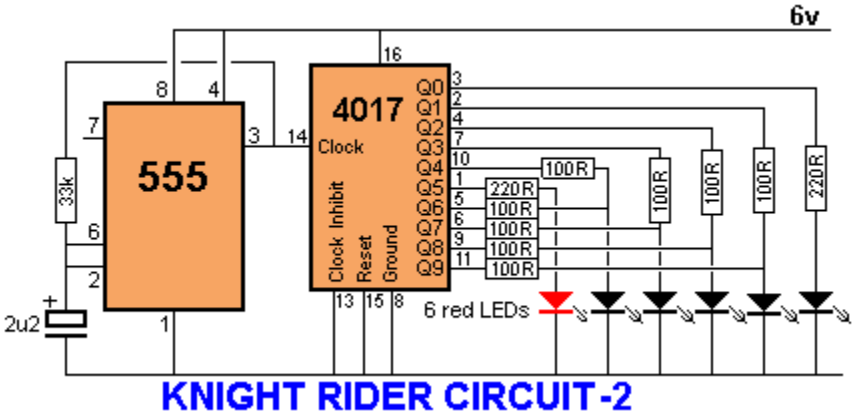



BUY NOW

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

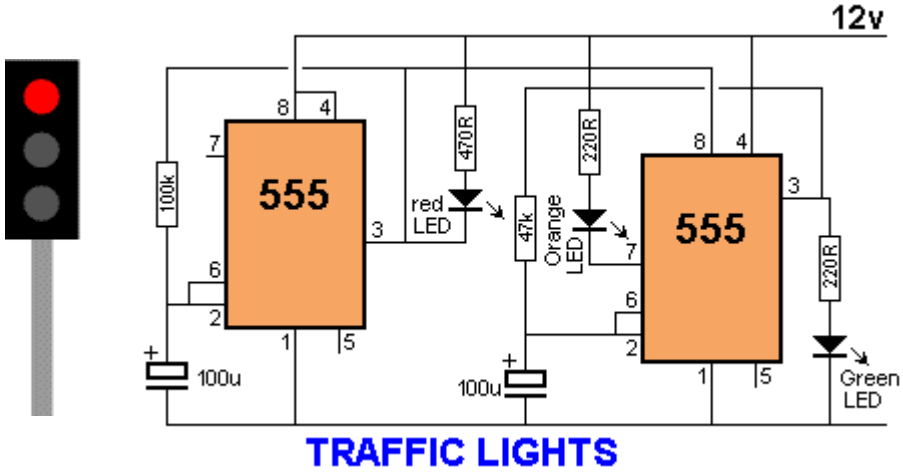


Here is a simple Knight Rider circuit using resistors to drive the LEDs. This circuit consumes 22mA while only delivering 7mA to each LED. The outputs are "fighting" each other via the 100R resistors (except outputs Q0 and Q5).



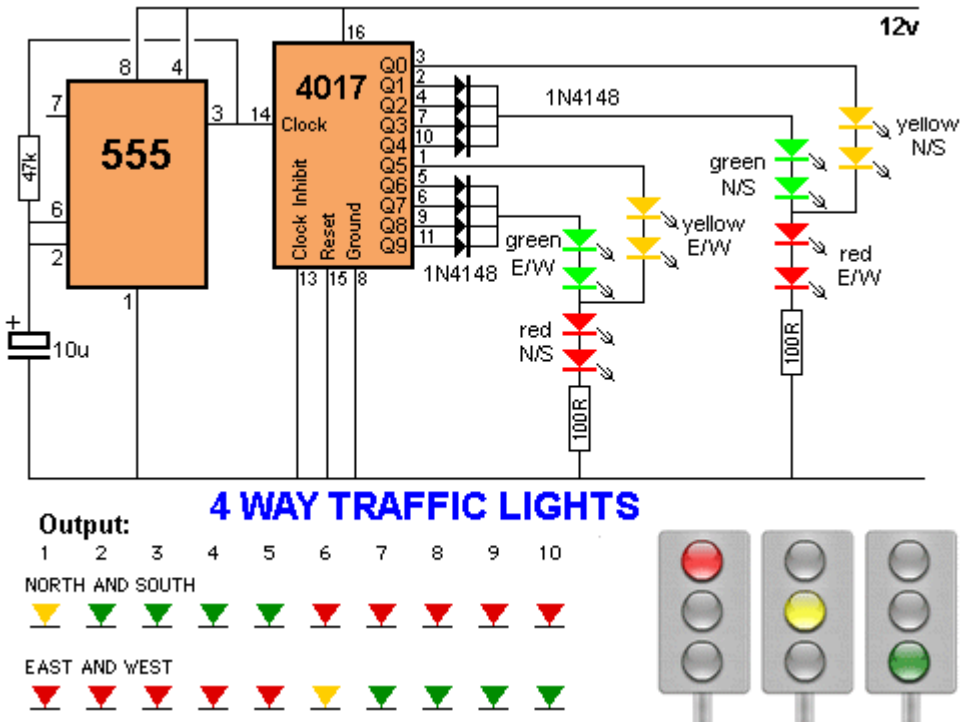
# TRAFFIC LIGHTS

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.



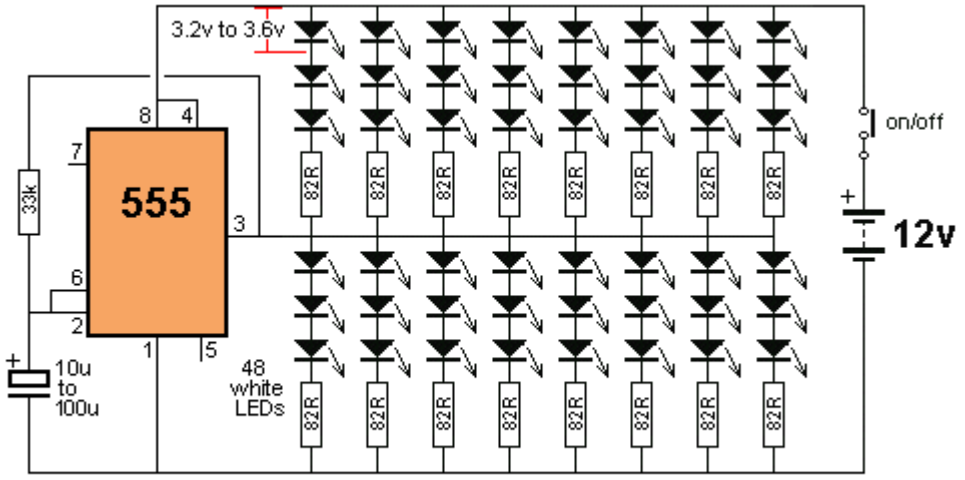

# 4 WAY TRAFFIC LIGHTS

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



# DRIVING MANY LEDS

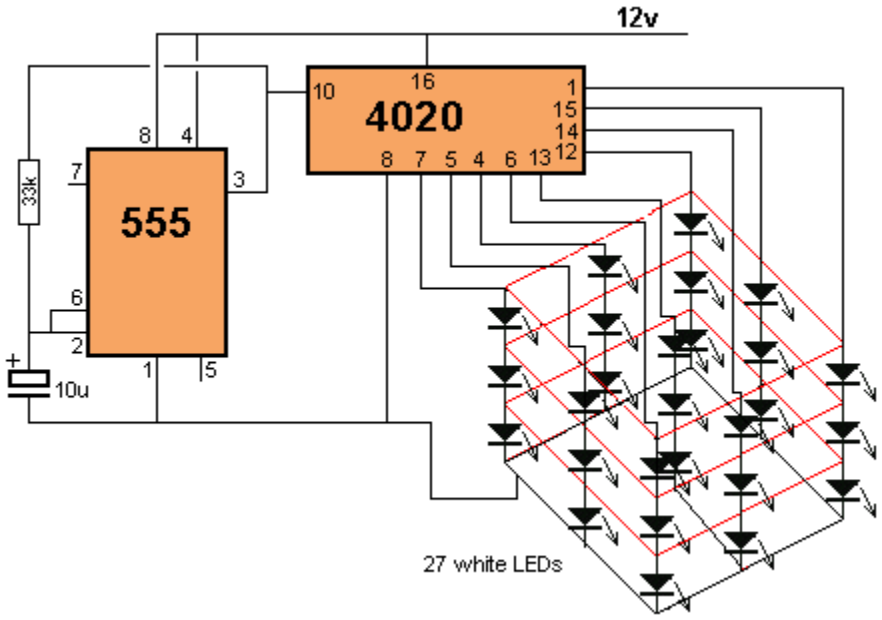
The 555 is capable of sinking and sourcing up to 200mA, but it gets very hot when doing this on a 12v supply.
The following circuit shows the maximum number of white LEDs that can be realistically driven from a 555 and we have limited the total current to about 130mA as each LED is designed to pass about 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.

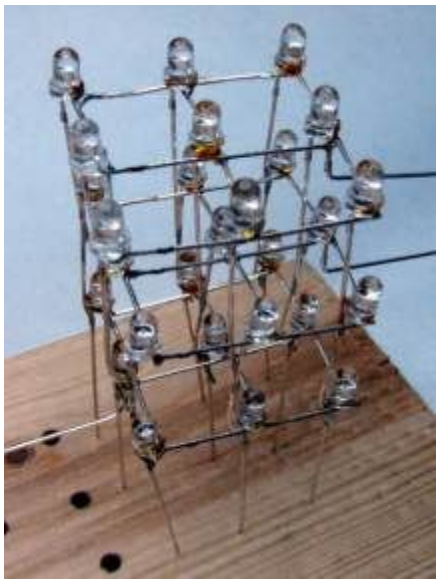



DRIVING WHITE LEDS (FLASHING)

# 3x3x3 CUBE

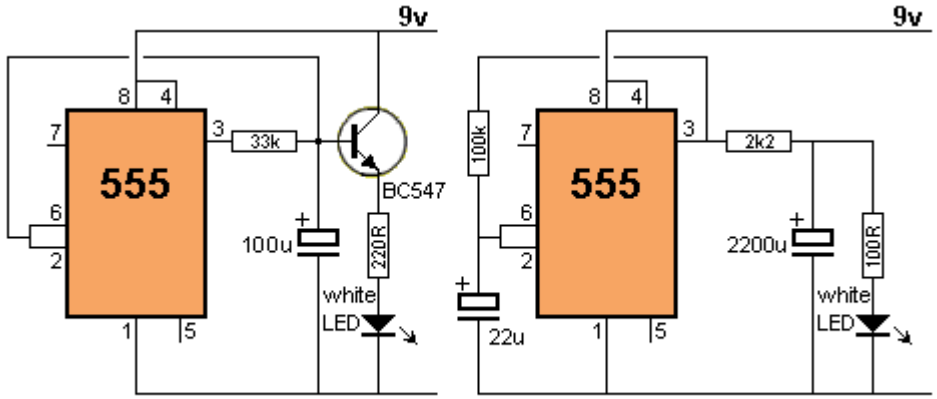
This circuit drives a 3x3x3 cube consisting of 27 white LEDs. The 4020 IC is a 14 stage binary counter and we have used 9 outputs. Each output drives 3 white LEDs in series and we have omitted a dropper resistor as the chip can only deliver a maximum of 15mA per output. The 4020 produces 512 different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



# UP/DOWN FADING LED

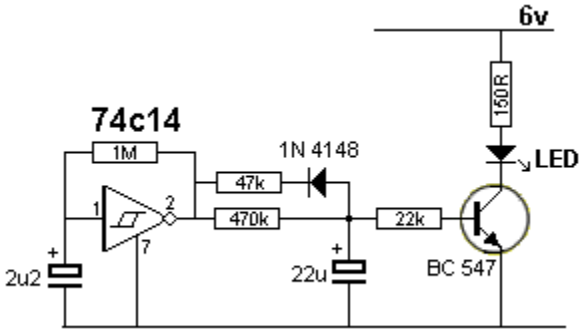
These two circuits make a LED fade on and off. The first circuit charges a 100u and the transistor amplifies the current entering the 100u and delivers 100 times this value to the LED via the collector-emitter pins. The circuit needs 9v for operation since pin 2 of the 555 detects 2/3Vcc before changing 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

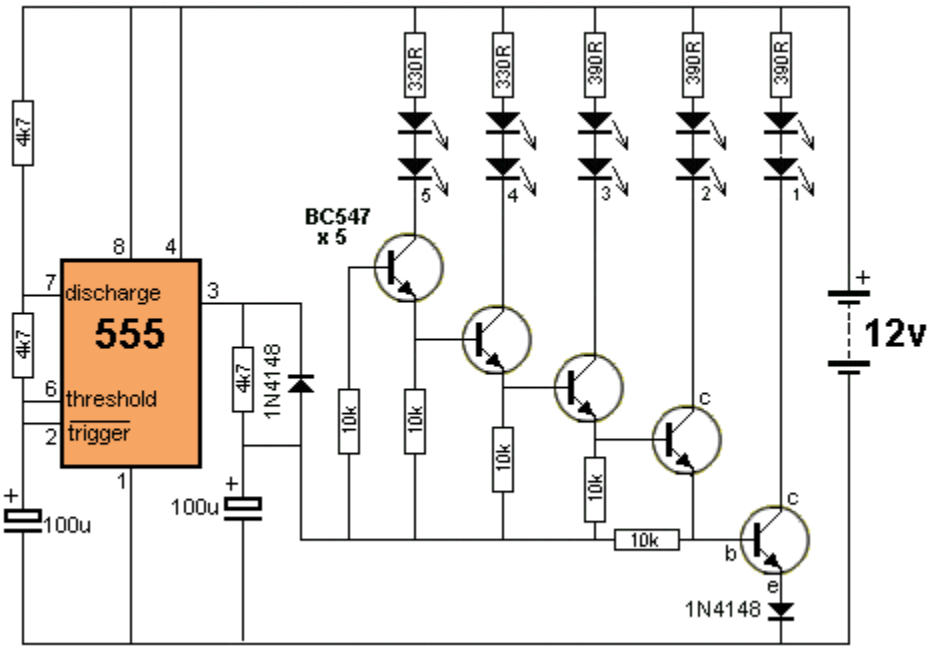
# UP/DOWN FADING LED-2

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.



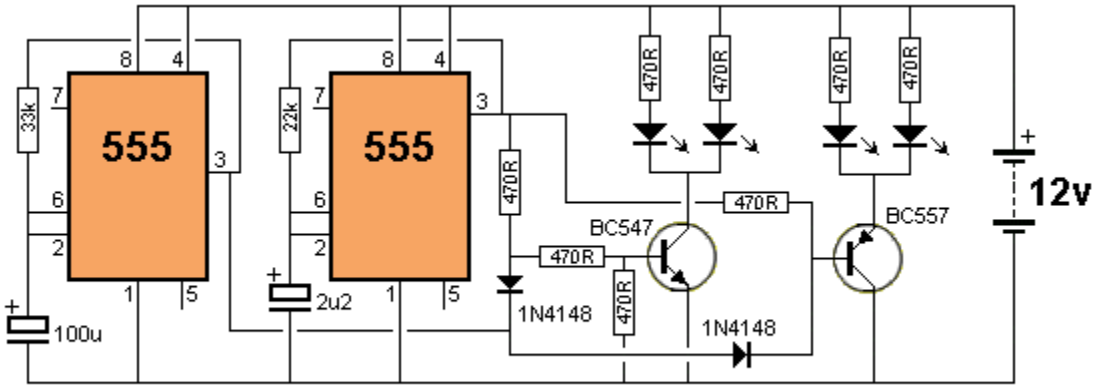
# BIKE TURNING SIGNAL

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.

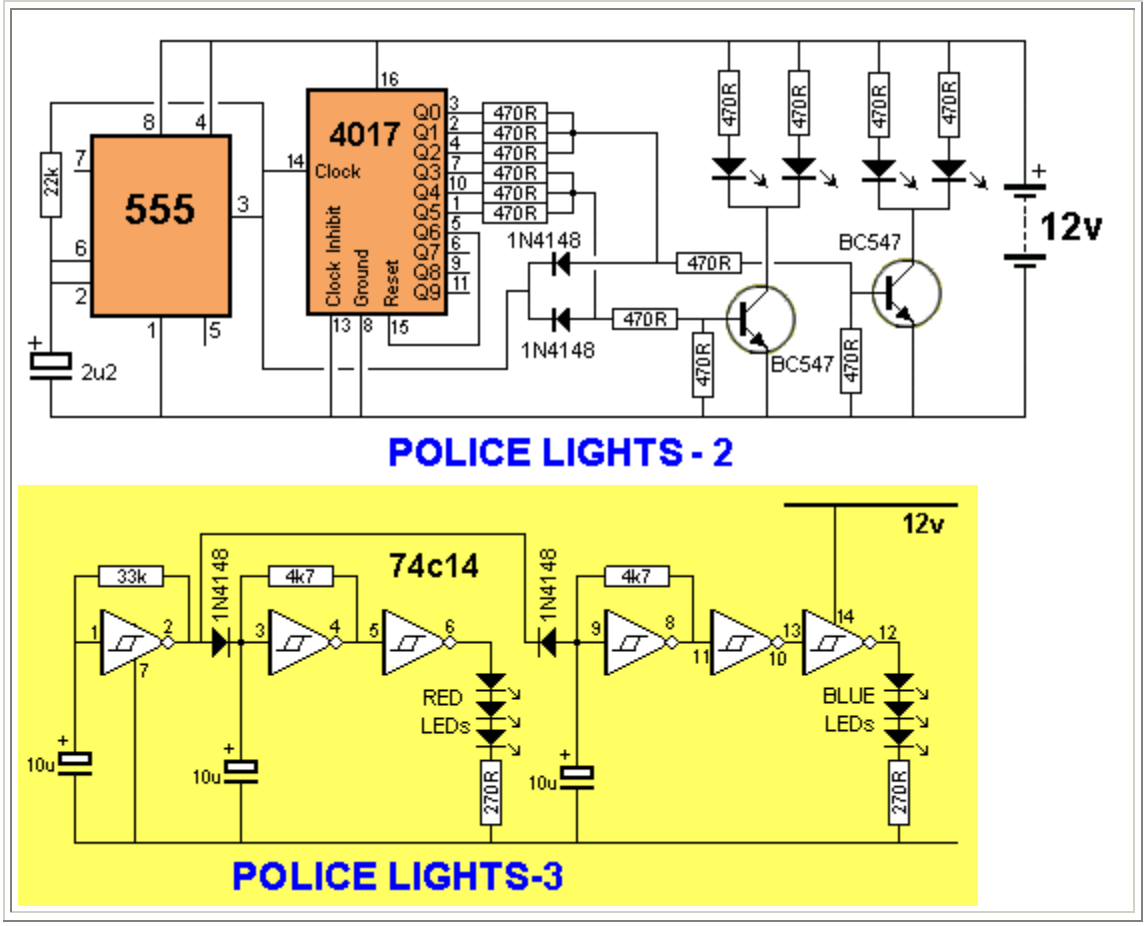



# POLICE LIGHTS

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

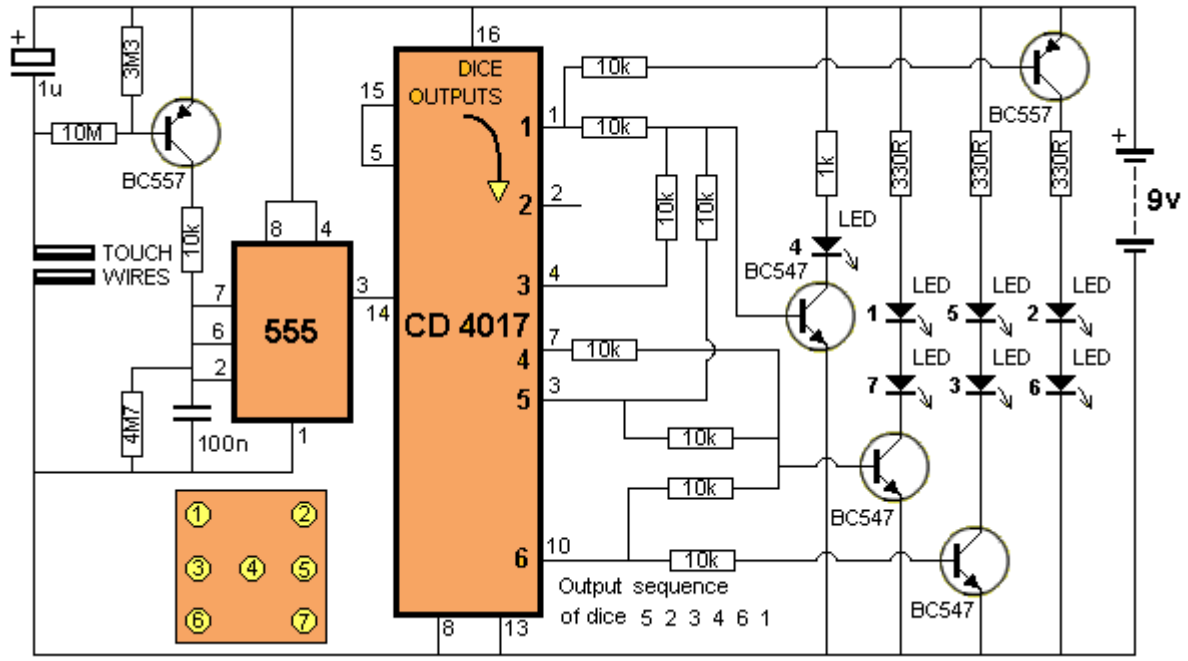



POLICE LIGHTS




# LED DICE with Slow Down

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

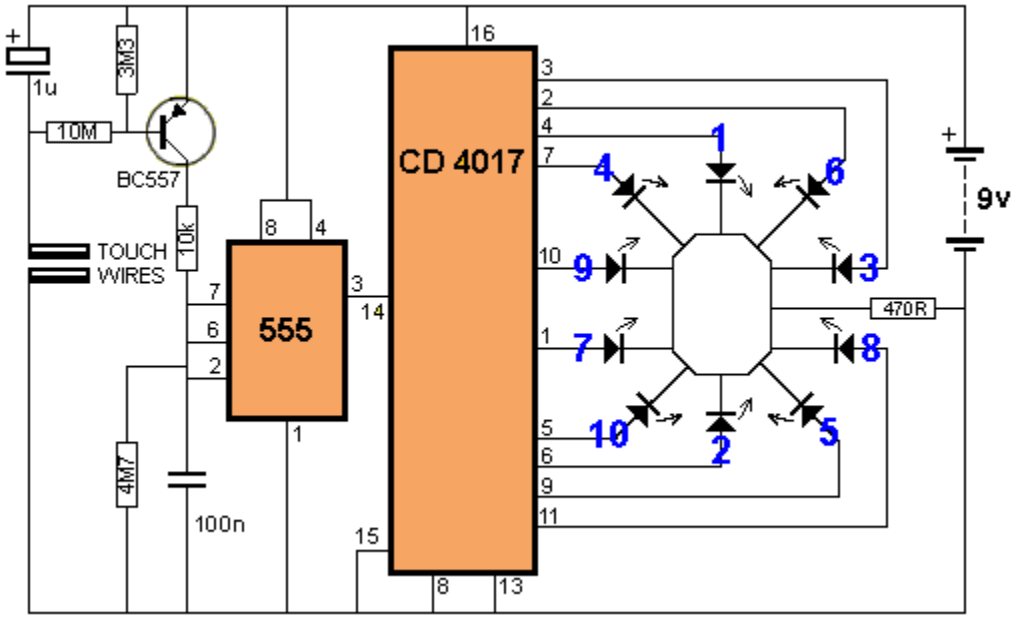


BUY NOW

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

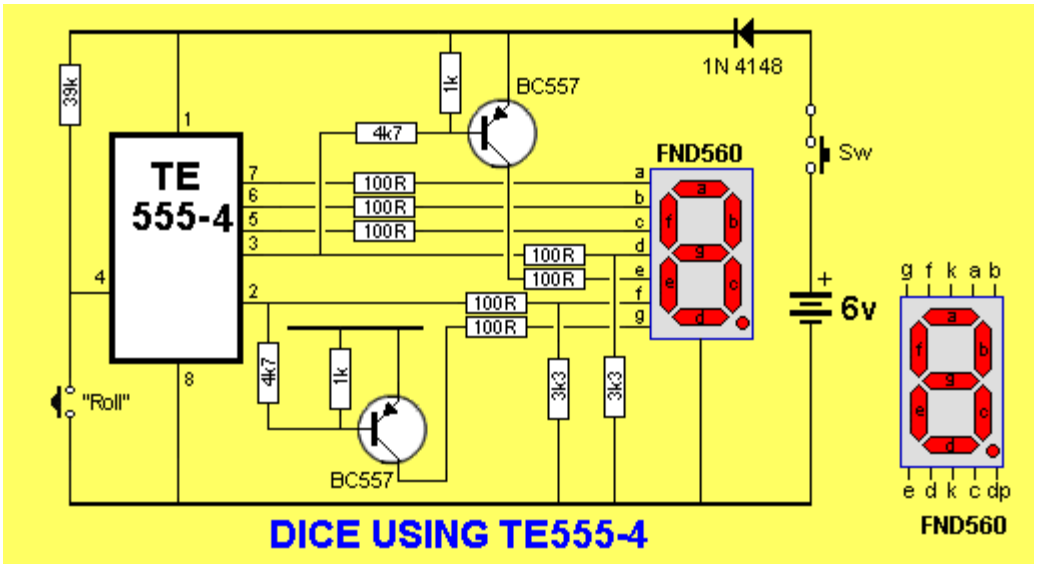
# ROULETTE

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.



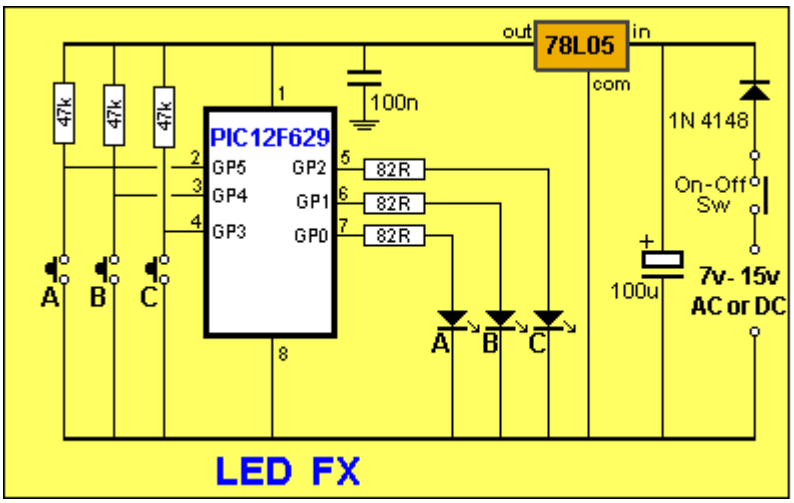

# DICE TE555-4

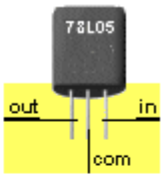
This circuit uses the latest TE555-4 **DICE** chip from Talking Electronics. This 8-pin chip is available for $2.50 and drives a 7-Segment display. The circuit can be assembled on proto-type board. For more help on the list of components, email Colin Mitchell: talking@tpg.com.au

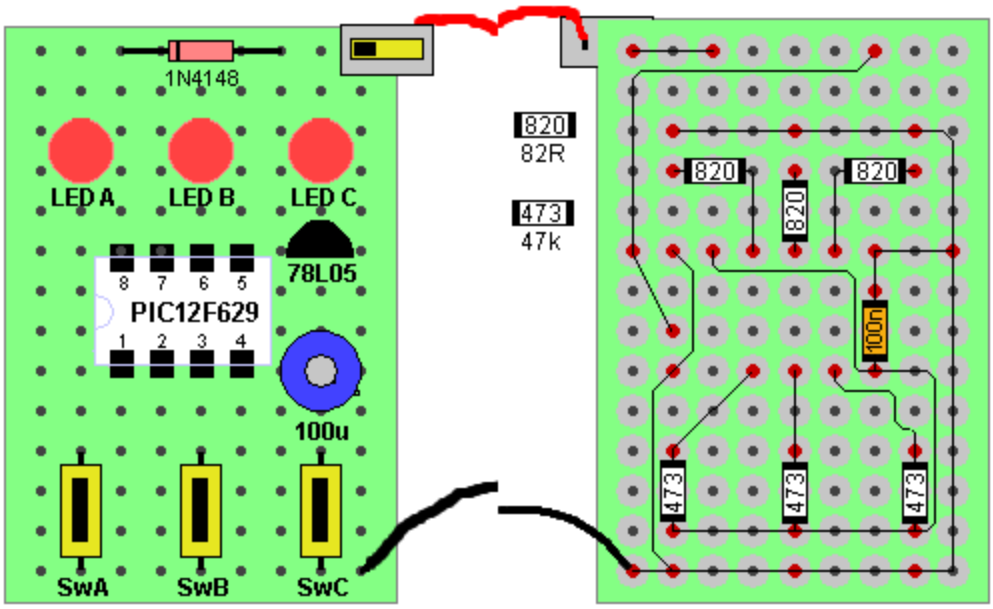



# LED FX TE555-5

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

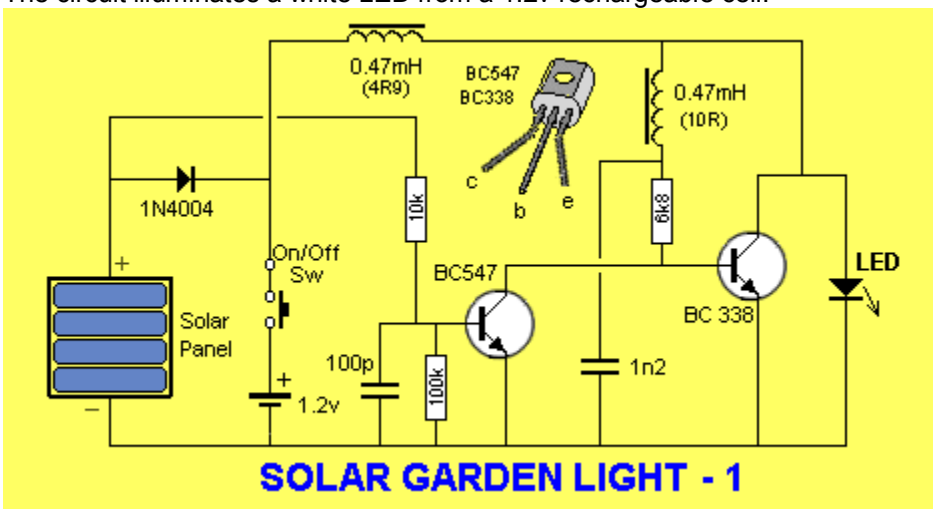



1N4148
LED A
LED B
LED C
78L05
8 7 6 5
PIC12F629
1 2 3 4
100u
SwA
SwB
SwC
820
82R
473
47k
820
820
820
100n
473
473
473

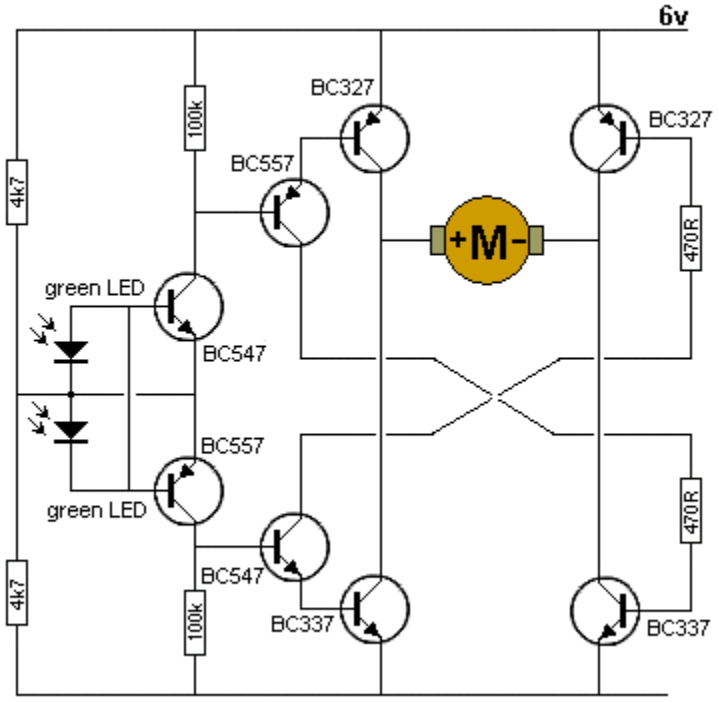
# SOLAR GARDEN LIGHT

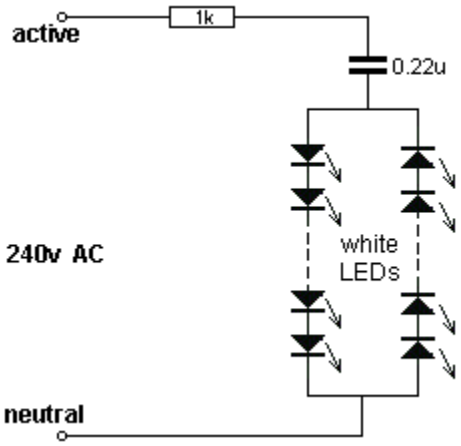
This is the circuit in a $2.00 Solar Garden Light.
The circuit illuminates a white LED from a 1.2v rechargeable cell.

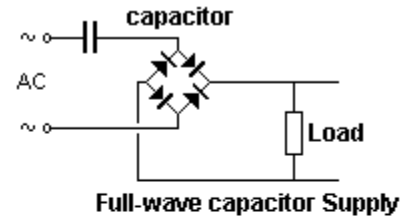


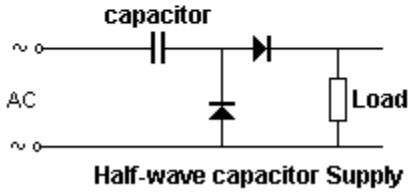

# SOLAR TRACKER

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.**






# LEDs on 240v

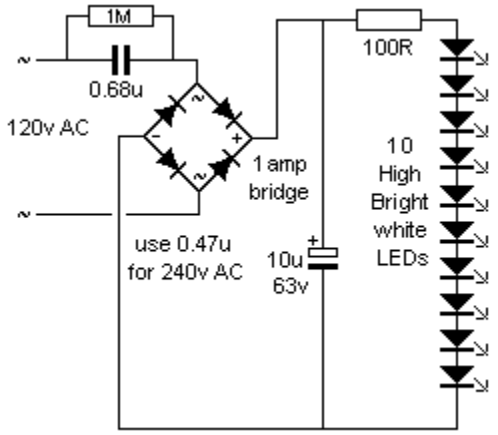
I do not like any circuit connected directly to 240v mains. However Christmas tress lights have been connected directly to the mains for 30 years without any major problems.
Insulation must be provided and the lights (LEDs) must be away from prying fingers.
Read the article above for the type of capacitor and add an equal number of LEDs in each string so the reverse voltage is equal across each LED.
It does not matter how many LEDs you add to each string as the brightness will be the same. As you add each pair, the current will drop a very small amount until eventually, when you have 100 LEDs in each string, the current will be zero.
For the circuit shown, each LED will see 20mA peak during the half-cycle they are illuminated. The 1k resistor will drop 15v - since the RMS current is 15mA (15mA x 1,000 ohms = 15v). 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.
**A 100n cap will deliver 7mA RMS or 10mA peak in full wave or 3.5mA RMS (5mA peak) in half-wave.** The LEDs above detect peak current.

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 3.5mA RMS or 5mA peak on each half-cycle.
In the half-wave supply, the capacitor delivers 3.5mA RMS or 5mA peak for each 100n to the load and during the other half-cycle the 3.5mA RMS 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 DC for 1/2 cycle then a gradual increase to full characteristic voltage-drop for each LED over a 1/4 cycle, then a gradual decrease to zero over another 1/4 cycle, then 0v 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.

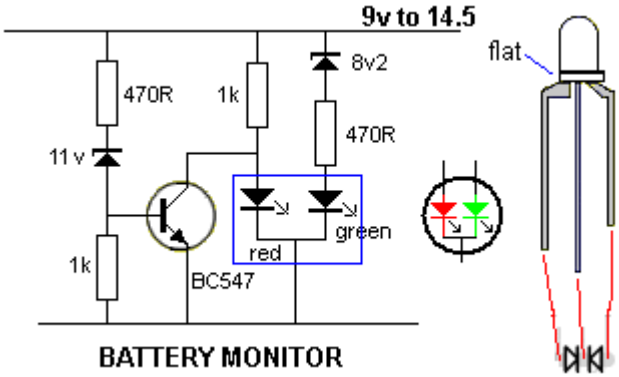
# MAINS NIGHT LIGHT

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



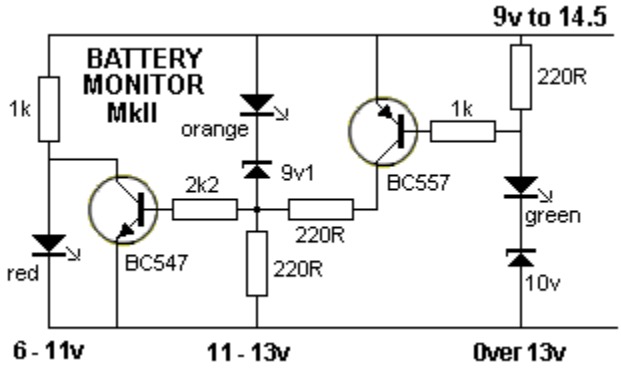

## BATTERY MONITOR MkI

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



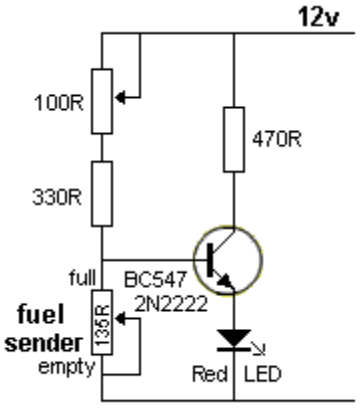

## BATTERY MONITOR MkII

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

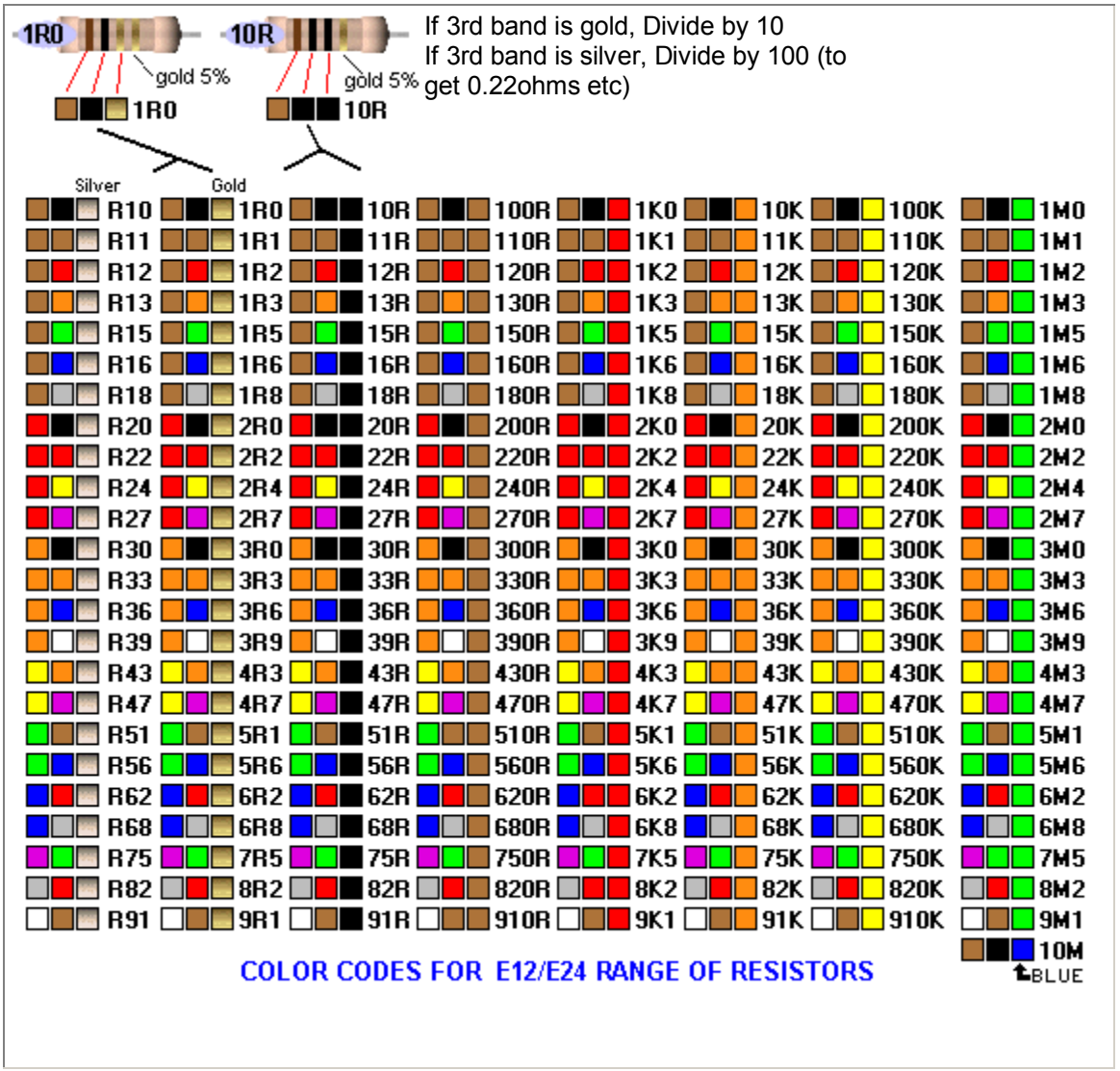


## LOW FUEL INDICATOR

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




to Index

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