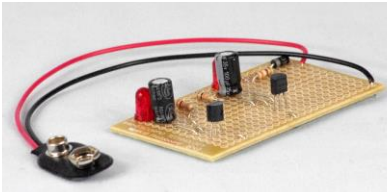
LED FLASHER – Protoboard Project

DESCRIPTION

The *LED FLASHER* project is a simple project based on a simple Astable Multivibrator circuit which is used to cause 2 LED's to flash on and off. By changing the resistor and/or electrolytic capacitor values you can see the effect on the circuit (that is - the length of time that the LEDs are "on and off.")



SECTION 1: PROJECT REQUIREMENTS

1.1 COMPONENTS REQUIRED

The following components are required and are available from Scorpio Technology (item codes in brackets). If you want to order the components for 10 of these, please use the code *FLASHY10-*– and if a Switch is required, also add SSWS.
Before starting we suggest that you check you have all the components using the checklist below – tick off each component as you identify it.

☐ 1 x Protoboard	(PCB-PROTO)
☐ 1 x Battery clip – 9V	(BCLIP)
☐ 2 x Capacitor – Electrolytic – 100uF	(CAP100uF)
☐ 1 x Diode – 1N4004	(DIO1N4004)
☐ 2 x Transistor – 9011	(TRAN9011)
☐ 2 x LED – 5mm Red	(LEDDLSR5)
☐ 1 x Resistor – 390 Ohm (RES390)	(O-W-Br-G)
☐ 2 x Resistor – 10k Ohm (RES10K)	(Br-Blk-O-G)
☐ 1 x Length of Tinned copper wire (for wire links)	(TCW)

1.2 ADDITIONAL REQUIREMENTS

The following material is to be supplied by the student / designer:

☐ Something to mount the PCB onto – refer "Section 2: Design".

1.3 TOOLS REQUIRED

The following tools are required. A number of these are available from Scorpio Technology, and can be ordered separately if required (item codes in brackets):

☐ Soldering Iron: a good quality soldering iron, with a fine tip (SOLDIRN) and Soldering Iron Stand (SOLDIRNSTD) or Soldering Station (SOLDSTN)
☐ Solder: the use of 0.71mm 60/40 solder is recommended (SOLD500)
☐ Assorted hand tools – depending on the choice of mounting for the PCB
☐ Drill and drill bits:
  - 3mm drill bit for wiring and the M3 bolts

SECTION 2: DESIGN

The designer has to decide if they plan to leave the unit "as is" or mount it, for example on or in an enclosure, as that is much neater, and hides the battery holder away.

HINT: If the battery holder will be hidden inside an enclosure, it is suggested that a small On-off switch is added to the circuit (Code: SSWS)
NOTE: If desired, Scorpio Technology have the following parts that are suitable for mounting the PCB:

- ☐ JIFCASELD – Jiffy case
- ☐ SPACER8 – PCB mounting spacers
- ☐ BOLT16 & NUTM3 – To attached the PCB and spacer to the Jiffy case

NOTE: if the PCB will be mounted, 3.5mm holes should be drilled through the PCB before starting to solder components to the Protoboard.

SECTION 3: ASSEMBLING THE PCB

3.1 SOLDERING THE COMPONENTS IN PLACE

NOTE: Check that all the components are in their correct positions: it pays to spend some time doing this before soldering components in place. It can prevent wasted time later on, trying to find out why the circuit is not working and unsoldering and replacing damaged or wrongly positioned components.

3.1.1. GENERAL PRINCIPLES

- ☐ Turn over the PCB and slightly bend the leads of the components outwards, to prevent them slipping out
- ☐ Apply the soldering iron's tip to the lead and track pad at the same time. Heat the joint for 2-3 seconds and then apply the solder to the heated lead and pad on the opposite side to the soldering iron tip. Melt the solder onto the hot pad and lead, not onto the soldering iron.
- ☐ Once all the components have been soldered, use a pair of side cutters to cut off the ends of the leads – as close as possible to the solder

3.2 MOUNTING COMPONENTS TO THE PCB

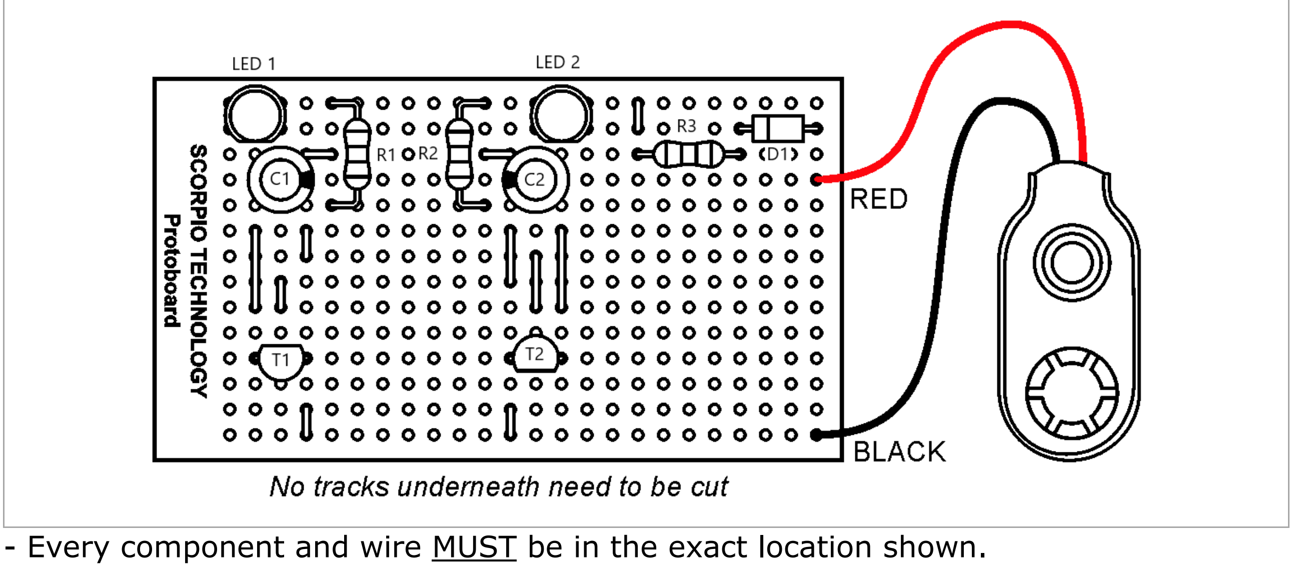
Begin with the components that sit lowest on the PCB.

3.3 MOUNTING LOCATIONS FOR COMPONENTS AND LINKS.

Use the following picture to help you correctly locate the component leads and wire links.

Protoboard Layout

Carefully follow the layout of the picture below:



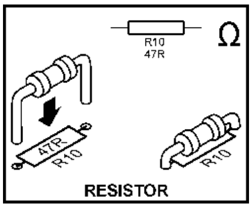
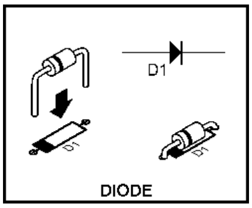
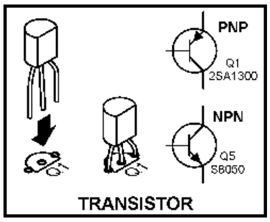
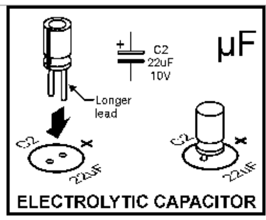
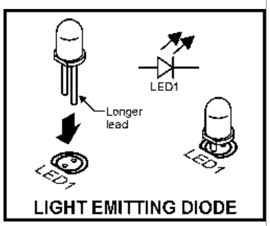
- Every component and wire MUST be in the exact location shown.
- Any variations will prevent the circuit from working.

If your circuit does not work make sure the components and wires are connected as shown. The LED’s, Transistors, Capacitors and Diode MUST face in the direction shown or the circuit will not work. The LED’s, Transistors, Capacitors and Diode must face in the direction shown or the circuit will not work.

NOTES:
The voltage connected to this circuit is 9 volts.
- The diode is used protect the circuit as it will not allow current to flow through it, if battery is accidentally connected the wrong way round.
- Without the diode it is possible to permanently damage the transistors preventing the circuit from ever working again. Make sure it is facing in the correct direction before soldering.
- The 390 ohm resistor is used to limit the maximum current that can be drawn from the battery to a safe level for the LED’s and transistors to operate.

SECTION 4: THE ELECTRONIC COMPONENTS

The components required are:

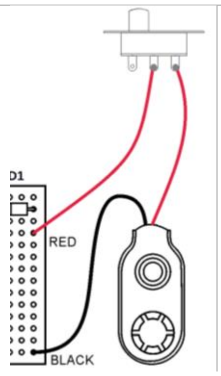
Mount the Resistors (R1 to R3) in place. ☐ Resistor – 10k Ohm (Brown-Black-Orange-Gold) R1, R2 ☐ Resistor – 390 Ohm (Orange-White-Brown-Gold) R3 *Resistors are non-polarised components and do not need to be placed in any particular direction. However, the convention is that horizontal resistors are mounted with the tolerance band to the right or to the bottom of the board*	
Mount the Diode (D1). ☐ Diode – 1N4004 (DIO1N4004) *When mounting diodes ensure that the negative end, with the band, is facing in the correct direction as shown on the PCB.* *WARNING: if diodes are inserted in the wrong direction the microcontroller will NOT work.*	
Insert the Transistors T1, T2 ☐ Transistors – 9011 (TRANS9011) *It is very important to ensure that this is mounted in the correct direction (as shown on the layout drawing). The flat side of the Transistor MUST face the same direction as shown.* *The transistors have 3 leads (legs): the Emitter (E), Base (B) and the Collector (C).*	
☐ **Insert the 100 uF Electrolytic Capacitors C1 & C2** *This capacitor has a cylindrical body with a stripe down one side. The stripe indicates the negative lead and is next to the short lead. The longer lead is positive - these must be connected correctly or the capacitor will be damaged.*	
☐ **Insert the LEDs – LED1, LED2.** *LEDs are polarised components and must be mounted correctly. The negative lead can be identified in different ways:* *1. The flag (the larger connection inside the body) identifies the negative lead. This is visible when the LED is held up to the light* *2. The short leg is negative* *3. A flat on the ridge, around the base of the LED is on the negative side.*	

SECTION 5: WIRING

Once the PCB has been assembled, it needs to be mounted in place.

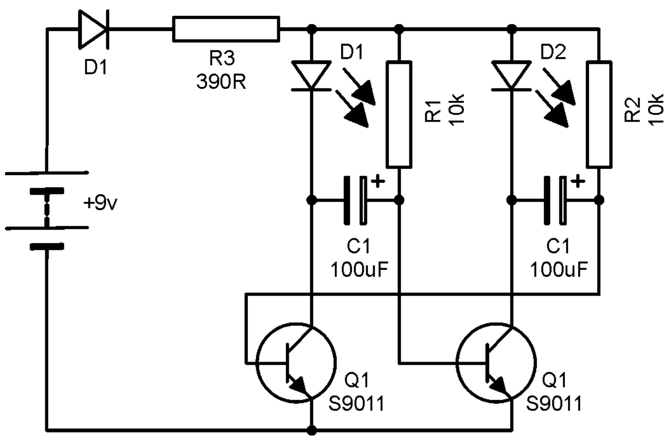
When the PCB has been mounted, the last thing to do is to mount and solder in the battery clip.

If a switch is to added to the circuit, it should be wired as shown on the right.



SECTION 6: THEORY - HOW THE CIRCUIT WORKS

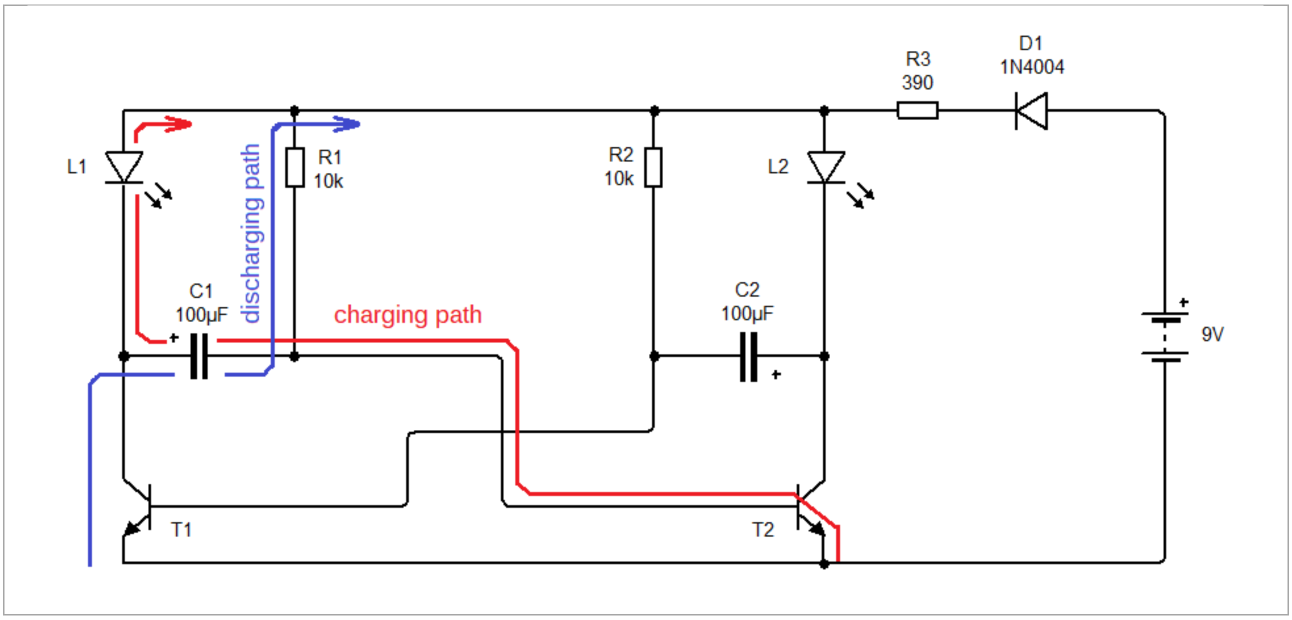
This type of circuit is called and Astable Multivibrator. When you turn on this circuit both capacitors will begin to charge (only one path is shown). The time this takes will depend upon the value of the capacitor and the resistance of the LED. A transistor requires about 0.7 volt applied to its base to turn it on. This voltage is only an approximation and the voltage might be slightly higher or lower than 0.7 volt.



The voltage required turn on one transistor will NEVER be exactly the same as the voltage required to turn on another transistor. The other factor that needs to be taken into account that effects the length of time the capacitor takes to charge and discharge is the values of the capacitor and resistor involved.

The larger the values of these components the longer the capacitor will take to charge or discharge. The tolerance of the component values is another factor. Even though their value is marked, their actual value will be different because of their tolerance. Tolerance is a measurement of how accurately the component has been manufactured. The typical tolerance value of an Electrolytic Capacitor is +80% and –20%. What this means is the manufacturer guarantees that for a 100uF Electrolytic Capacitor its actual value will be somewhere between 180uF and 80uF.

The resistors used in this circuit are 5% values. Their resistance can be either 5% higher or 5% lower than the value marked on the resistor. The 10K (10,000 ohm) resistor used will have a value somewhere between 10,500 and 9,500 ohms.



As the capacitors charge one of them will charge slightly faster and reach the voltage needed (0.7 volts) at the base of one of the transistors to turn it on.

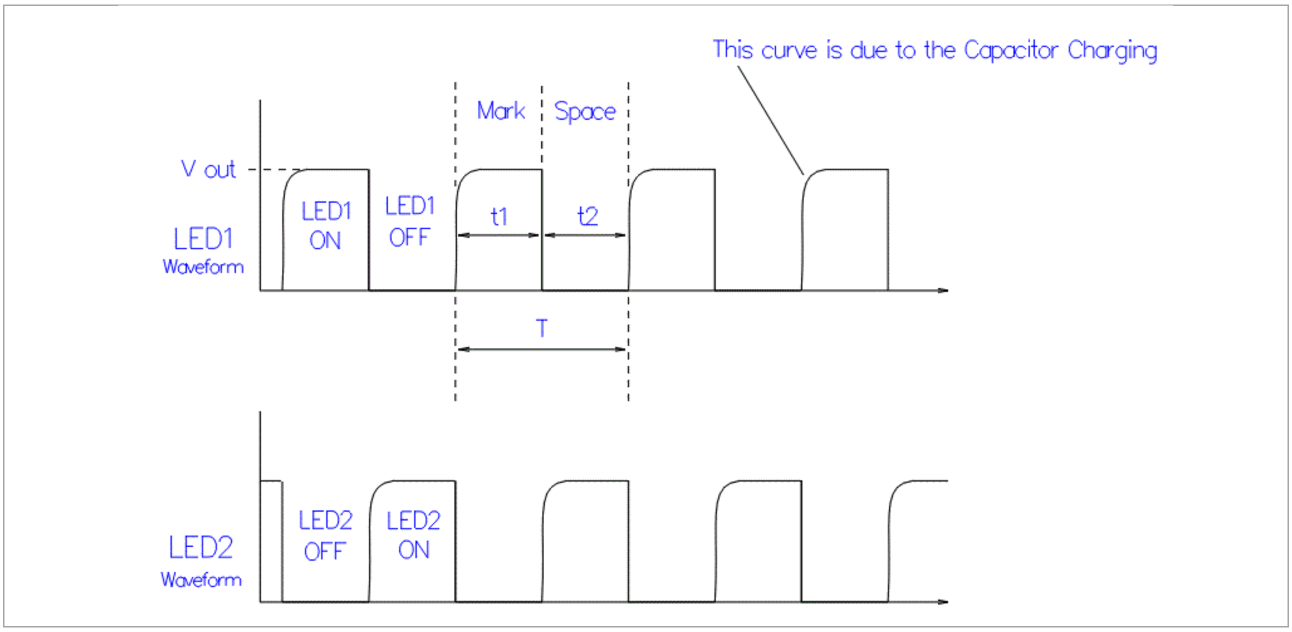
- When the transistor turns on the LED connected to it will now light.

When the circuit is first connected to power (the battery), the capacitors begin to charge. Current flows from the negative terminal of the battery through the emitter and base of the transistor (T1 and T2), through the capacitor (C1 and C2) and through the LED (L1 and L2).(1)

- Let's say capacitor C1 charges the quickest and the voltage at the base T2 reaches 0.7 volt.

This voltage will cause transistor T2 to turn on.

- This will cause current to flow through LED 2 and make it light up.
- At the same time C2 is charging through L2 and T1.
- When the voltage at the base of T1 reaches 0.7 volt it turns transistor T1 to turn on.
- This now causes C1 to discharge through T1 and R1 and the voltage at the base of T2 drops below 0.7 volt and transistor T2 turns off this prevents any current flowing through LED2 and it turns off.
- C1 begins to charge again and the process begins again.



The circuit alternates between one state in which transistor T1 is "OFF" and transistor T2 is "ON", and a second state where T1 is "ON" and T2 is "OFF".

The speed that this happens can be calculated using the following formula.

T = t1 + t2

t1 = 0.7C1xLED1's Resistance

t2 = 0.7C1xR1

NOTE: **C** is in Farads, **R** is in Ohms and **T** is in Seconds.

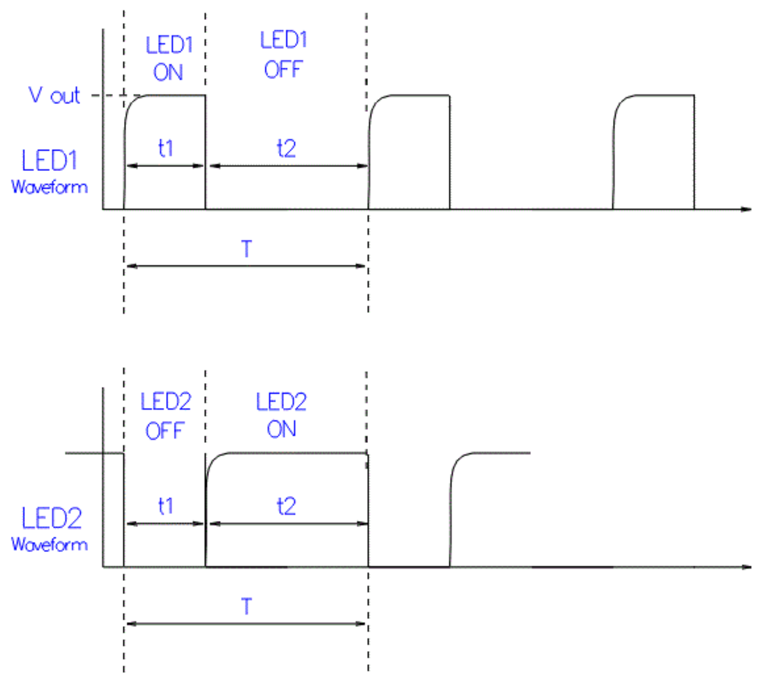
The frequency that this takes can be calculated as follows:

$$F = \frac{1}{T}$$

F is in Hertz, **T** is in seconds

Increasing either the size of the Capacitor or Resistor will increase these times.

- If you are wiring up a breadboard you easily change the change them and observe how the circuit operation changes.
- In the circuit shown, because C1 and C2 and R1 and R2 are the same values, then both t1 and t2 will be the same.
- If C1 and R1 remain the same value and you increase the value of either C2 or R2 will increase the length of time that LED2 stays on.
- Conversely if C2 and R2 remain the same value and you increase the value of either C1 or R1 will increase the length of time that LED1 stays on.



Try changing the capacitor and resistor values of C1, C2 and R1, R2 to see what happens.

Only change one value at a time, so you can see its effect on the operation of the circuit.