TEACHING RESOURCES

SCHEMES OF WORK
DEVELOPING A SPECIFICATION
COMPONENT FACTSHEETS
HOW TO SOLDER GUIDE

INVEST IN BIKE SAFTEY WITH THIS

REAR DELUXE BIKE LIGHT KIT

Version 1.1

Index of Sheets

Introduction

About the project kit

Both the project kit and the supporting material have been carefully designed for use in KS3 Design and Technology lessons. The project kit has been designed so that even teachers with a limited knowledge of electronics should have no trouble using it as a basis from which they can form a scheme of work.

The project kits can be used in two ways:

1. As part of a larger project involving all aspects of a product design, such as designing an enclosure for the electronics to fit into.
2. On their own as a way of introducing electronics and electronic construction to students over a number of lessons.

This booklet contains a wealth of material to aid the teacher in either case.

Using the booklet

The first few pages of this booklet contain information to aid the teacher in planning their lessons and also covers worksheet answers. The rest of the booklet is designed to be printed out as classroom handouts. In most cases all of the sheets will not be needed, hence there being no page numbers; teachers can pick and choose as they see fit.

Please feel free to print any pages of this booklet to use as student handouts in conjunction with Kitronik project kits.

Support and resources

You can also find additional resources at www.kitronik.co.uk. There are component fact sheets, information on calculating resistor and capacitor values, puzzles and much more.

Kitronik provide a next day response technical assistance service via e-mail. If you have any questions regarding this kit or even suggestions for improvements, please e-mail us at:

support@kitronik.co.uk

Alternatively, phone us on 0845 8380781.

Schemes of Work

Two schemes of work are included in this pack; the first is a complete project including the design & manufacture of an enclosure for the kit (below). The second is a much shorter focused practical task covering just the assembly of the kit (next page). Equally, feel free to use the material as you see fit to develop your own schemes.

Before starting we would advise that you build a kit yourself. This will allow you to become familiar with the project and will provide a unit to demonstrate.

Complete product design project including electronics and enclosure

Hour 1	Introduce the task using 'The Design Brief' sheet. Demonstrate a built unit. Take students through the design process using 'The Design Process' sheet. Homework: Collect examples of bike lights / safety lights or similar products. List the common features of these products on the 'Investigation / Research' sheet.
Hour 2	Develop a specification for the project using the 'Developing a Specification' sheet. Resource: Sample of products. Homework: Using the internet or other search method, find out what is meant by 'design for manufacture'. List five reasons why design for manufacture should be considered on any design project.
Hour 3	Read 'Designing the Enclosure' sheet. Develop a product design using the 'Design' sheet. Homework: Complete design.
Hour 4	Using cardboard, get the students to model their enclosure design. Allow them to make alterations to their design if the model shows any areas that need changing.
Hour 5	Split the students into groups and get them to perform a group design review using the 'Design Review' sheet.
Hour 6	Using the 'Soldering in Eight Steps' sheet, demonstrate and get students to practice soldering. Start the 'Resistor Value' and 'Capacitor Basics' worksheets. Homework: Complete any of the remaining resistor / capacitor tasks.
Hour 7	Build the electronic kit using the 'Build Instructions'.
Hour 8	Complete the build of the electronic kit. Check the completed PCB and fault find if required using the 'Checking Your PCB' section and the fault-finding flow chart. Homework: Read 'How the Square Wave Generator Works' sheet.
Hour 9	Build the enclosure.
Hour 10	Build the enclosure.
Hour 11	Build the enclosure.
Hour 12	Using the 'Evaluation' and 'Improvement' sheet, get the students to evaluate their final product and state where improvements can be made.

Additional Work

Package design for those who complete ahead of others.

Electronics only

Hour 1	Introduction to the kit demonstrating a built unit. Using the 'Soldering in Eight Steps' sheet, practice soldering.
Hour 2	Build the kit using the 'Build Instructions'.
Hour 3	Check the completed PCB and fault find if required using 'Checking Your PCB' and fault-finding flow chart.

Answers

Resistor questions

1st Band	2nd Band	Multiplier x	Value
Brown	**Black**	**Yellow**	***100,000 Ω***
Green	**Blue**	**Brown**	***560 Ω***
Brown	**Grey**	**Yellow**	***180,000Ω***
Orange	**White**	**Black**	***39Ω***

Value	1st Band	2nd Band	Multiplier x
180 Ω	**Brown**	**Grey**	***Brown***
3,900 Ω	**Orange**	**White**	***Red***
47,000 (47K) Ω	**Yellow**	**Violet**	***Orange***
1,000,000 (1M) Ω	**Brown**	**Black**	***Green***

Capacitor Ceramic Disc values

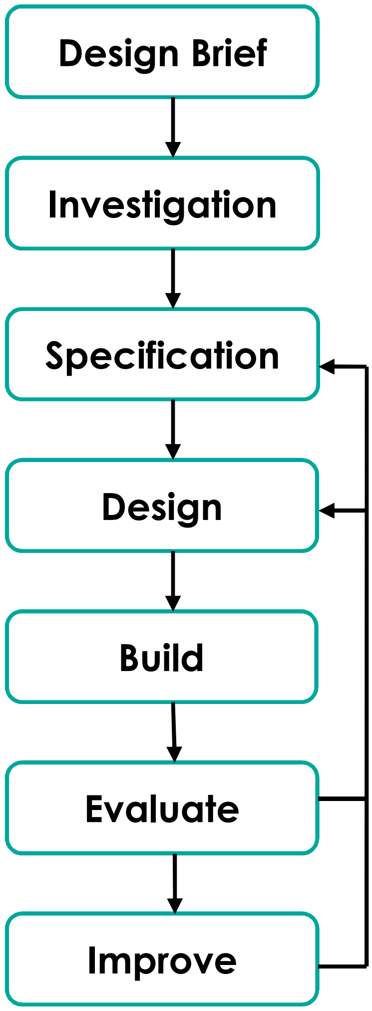
Printing on capacitor	Two digit start	Number of zero's	Value in pF
222	22	00	2200pF (2.2nF)
103	10	000	10000pF (10nF)
333	33	000	33000pF (33nF)
473	47	000	47000pF (47nF)

RC Time Constants

Resistor Value	Capacitor Value	RC Time Constant
2,000,000 (2MΩ)	**0.000,1 (100µF)**	200 Seconds
100,000 (100KΩ)	**0.000,1 (100µF)**	10 Seconds
100,000 (100KΩ)	**0.000,047 (47µF)**	4.7 Seconds

The Design Process

The design process can be short or long, but will always consist of a number of steps that are the same on every project. By splitting a project into these clearly defined steps, it becomes more structured and manageable. The steps allow clear focus on a specific task before moving to the next phase of the project. A typical design process is shown on the right.



Design Brief

What is the purpose or aim of the project? Why is it required and who is it for?

Investigation

Research the background of the project. What might the requirements be? Are there competitors and what are they doing? The more information found out about the problem at this stage, the better, as it may make a big difference later in the project.

Specification

This is a complete list of all the requirements that the project must fulfil - no matter how small. This will allow you to focus on specifics at the design stage and to evaluate your design. Missing a key point from a specification can result in a product that does not fulfil its required task.

Design

Develop your ideas and produce a design that meets the requirements listed in the specification. At this stage it is often normal to prototype some of your ideas to see which work and which do not.

Build

Build your design based upon the design that you have developed.

Evaluate

Does the product meet all points listed in the specification? If not, return to the design stage and make the required changes. Does it then meet all of the requirements of the design brief? If not, return to the specification stage and make improvements to the specification that will allow the product to meet these requirements and repeat from this point. It is normal to have such iterations in design projects, though you normally aim to keep these to a minimum.

Improve

Do you feel the product could be improved in any way? These improvements can be added to the design.

The Design Brief

A bicycle manufacturer has developed a simple circuit for producing a warning light for a bicycle. The circuit flashes two out of four Ultra Bright LEDs alternately to produce a highly visible warning. The circuit has been developed to the point where they have a working Printed Circuit Board (PCB).

The manufacturer would like ideas for an enclosure for the PCB that will allow it to be attached securely to the back of a bicycle. The manufacturer has asked you to do this for them. It is important that you make sure that the final design meets all of the requirements that you identify for such a product.

Complete Circuit

Investigation / Research

Using a number of different search methods, find examples of similar products that are already on the market. Use additional pages if required.

Name………………………………………………… Class……………………………

Developing a Specification

Using your research into the target market for the product, identify the key requirements for the product and explain why each of these is important.

Name………………………………………………………… Class………………………………

Requirement	Reason
Example: The enclosure should have holes in it.	Example: So that the LED's can be seen.

Design

Develop your ideas to produce a design that meets the requirements listed in the specification.

Name…………………………………………………… Class……………………………….

Design Review (group task)

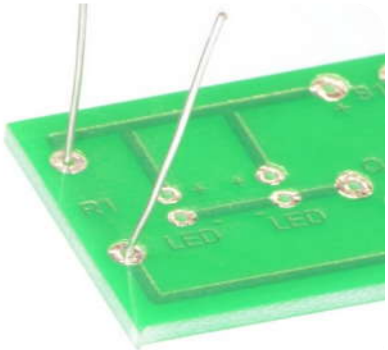
Split into groups of three or four. Take it in turns to review each person’s design against the requirements of their specification. Also look to see if you can spot any additional aspects of each design that may cause problems with the final product. This will allow you to ensure that you have a good design and catch any faults early in the design process. Note each point that is made and the reason behind it. Decide if you are going to accept or reject the comment made. Use these points to make improvements to your initial design.

Comment	Reason for comment	Accept or Reject

Soldering in 8 Steps

1 INSERT COMPONENT

Place the component into the board, making sure that it goes in the correct way around, and the part sits closely against the board. Bend the legs slightly to secure the part. Place the board so you can access the pads with a soldering iron.

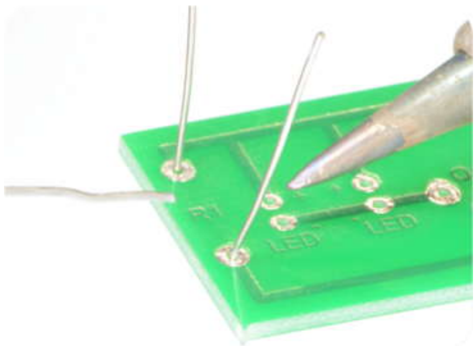


2 CLEAN SOLDERING IRON

Make sure the soldering iron has warmed up. If necessary use a brass soldering iron cleaner or damp sponge to clean the tip.

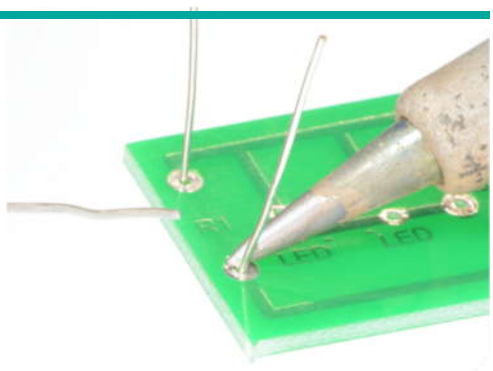
3 PICKUP IRON AND SOLDER

Pick up the Soldering Iron in one hand, and the solder in the other hand.



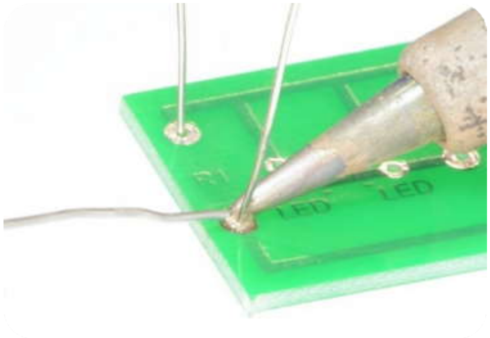
4 HEAT PAD

Place soldering iron tip on the pad.



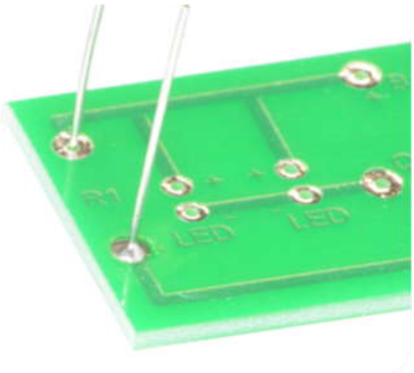
5 APPLY SOLDER

Feed a small amount of solder into the joint. The solder should melt on the pad and flow around the component leg.



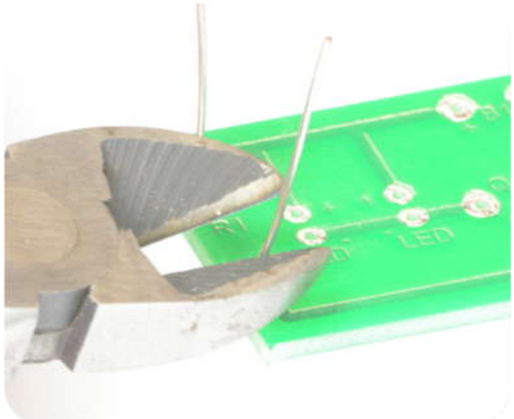
6 STOP SOLDERING

Remove the solder, and then remove the soldering iron.



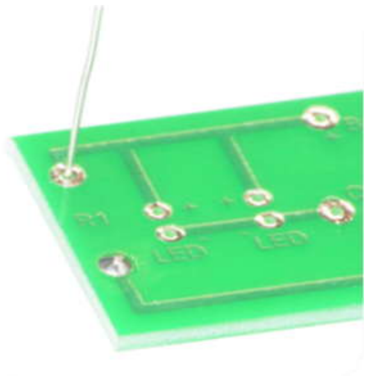
7 TRIM EXCESS

Leave the joint to cool for a few seconds, then using a pair of cutters trim the excess component lead.



8 REPEAT

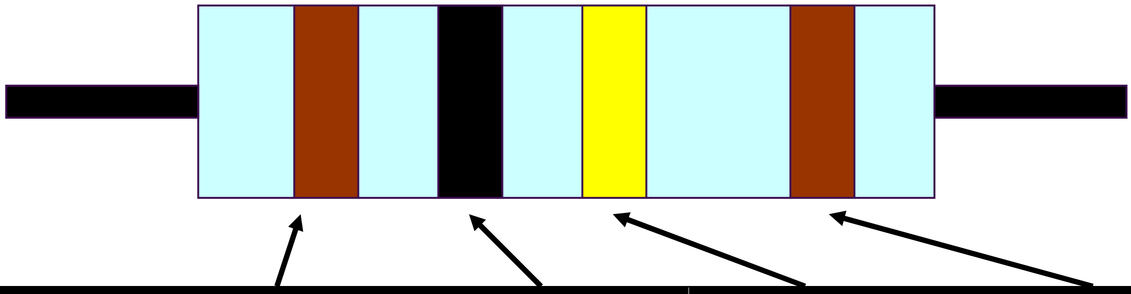
Repeat this process for each solder joint required.



Resistor Values

A resistor is a device that opposes the flow of electrical current. The bigger the value of a resistor, the more it opposes the current flow. The value of a resistor is given in Ω (ohms) and is often referred to as its 'resistance'.

Identifying resistor values



Band Colour	1st Band	2nd Band	Multiplier x	Tolerance
Silver			÷ 100	10%
Gold			÷ 10	5%
Black	0	0	1	
Brown	1	1	10	1%
Red	2	2	100	2%
Orange	3	3	1000	
Yellow	4	4	10,000	
Green	5	5	100,000	
Blue	6	6	1,000,000	
Violet	7	7		
Grey	8	8		
White	9	9		

Example: Band 1 = Red, Band 2 = Violet, Band 3 = Orange, Band 4 = Gold

The value of this resistor would be:
2 (Red) **7** (Violet) x **1,000** (Orange) = 27 x 1,000
= **27,000** with a 5% tolerance (gold)
= **27KΩ**

Too many zeros?

Kilo ohms and mega ohms can be used:

1,000Ω = 1K

1,000K = 1M

Resistor identification task

Calculate the resistor values given by the bands shown below. The tolerance band has been ignored.

1st Band	2nd Band	Multiplier x	Value
Brown	Black	Yellow	
Green	Blue	Brown	
Brown	Grey	Yellow	
Orange	White	Black	

Calculating resistor markings

Calculate what the colour bands would be for the following resistor values.

Value	1st Band	2nd Band	Multiplier x
180 Ω			
3,900 Ω			
47,000 (47K) Ω			
1,000,000 (1M) Ω			

What does tolerance mean?

Resistors always have a tolerance but what does this mean? It refers to the accuracy to which it has been manufactured. For example, if you were to measure the resistance of a gold tolerance resistor you can guarantee that the value measured will be within 5% of its stated value. Tolerances are important if the accuracy of a resistors value is critical to a design's performance.

Preferred values

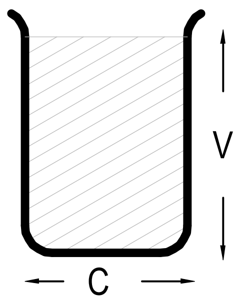
There are a number of different ranges of values for resistors. Two of the most popular are the E12 and E24. They take into account the manufacturing tolerance and are chosen such that there is a minimum overlap between the upper possible value of the first value in the series and the lowest possible value of the next. Hence there are fewer values in the 10% tolerance range.

E-12 resistance tolerance (± 10%)											
10	12	15	18	22	27	33	39	47	56	68	82

E-24 resistance tolerance (± 5 %)											
10	11	12	13	15	16	18	20	22	24	27	30
33	36	39	43	47	51	56	62	68	75	82	91

Capacitor Basics

What is a capacitor?

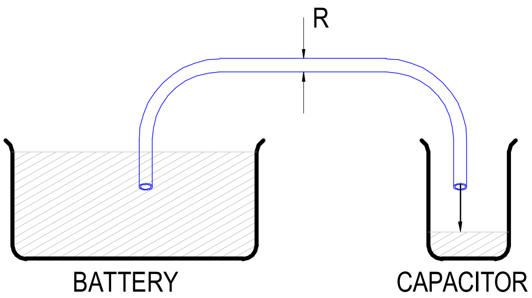


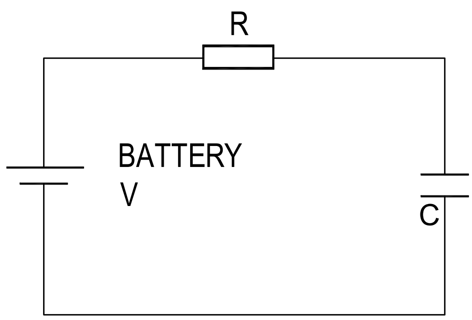
A capacitor is a component that can store electrical charge (electricity). In many ways, it is like a rechargeable battery.

A good way to imagine a capacitor is as a bucket, where the size of the base of the bucket is equivalent to the capacitance (C) of the capacitor and the height of the bucket is equal to its voltage rating (V).

The amount that the bucket can hold is equal to the size of its base multiplied by its height, as shown by the shaded area.

Filling a capacitor with charge

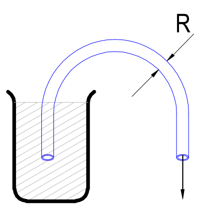




When a capacitor is connected to an item such as a battery, charge will flow from the battery into it. Therefore, the capacitor will begin to fill up. The flow of water in the picture above left is the equivalent of how the electrical charge will flow in the circuit shown on the right.

The speed at which any given capacitor will fill depends on the resistance (R) through which the charge will have to flow to get to the capacitor. You can imagine this resistance as the size of the pipe through which the charge has to flow. The larger the resistance, the smaller the pipe and the longer it will take for the capacitor to fill.

Emptying (discharging) a capacitor

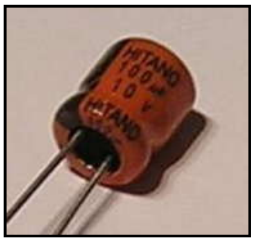


Once a capacitor has been filled with an amount of charge, it will retain this charge until it is connected to something into which this charge can flow.

The speed at which any given capacitor will lose its charge will, like when charging, depend on the resistance (R) of the item to which it is connected. The larger the resistance, the smaller the pipe and the longer it will take for the capacitor to empty.

Maximum working voltage

Capacitors also have a maximum working voltage that should not be exceeded. This will be printed on the capacitor or can be found in the catalogue the part came from. You can see that the capacitor on the right is printed with a 10V maximum working voltage.



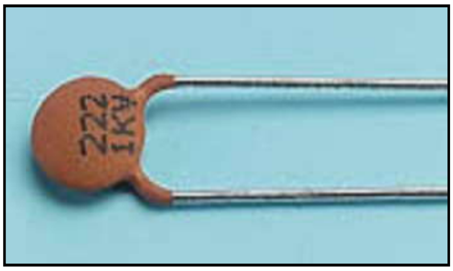
Ceramic Disc Capacitors

Values

1F	= 1,000mF
1F	= 1,000,000μF
1F	= 1,000,000,000nF
1F	= 1,000,000,000,000pF

The value of a capacitor is measured in Farads, though a 1 Farad capacitor would be very big. Therefore, we tend to use milli Farads (mF), micro Farads (μF), nano Farads (nF) and pico Farads (pF). A μF is a millionth of a Farad, 1μF = 1000 nF and 1nF = 1000 pF.

The larger electrolytic capacitors tend to have the value printed on the side of them along with a black band showing the negative lead of the capacitor.



Other capacitors, such as the ceramic disc capacitor shown on the right, use a code. They are often smaller and may not have enough space to print the value in full, hence the use of the 3-digit code. The first 2 digits are the first part of the number and the third digit gives the number of zeros to give its value in pF.

Example: 104 = 10 + 0000 (4 zero's) = **100,000 pF** (which is also 0.1 μF)

Work out what value the four capacitors are in the table below.

Printing on capacitor	Two digit start	Number of zero's	Value in pF
222			
103			
333			
473			

RC Time Constants

The amount of time taken to charge (fill) or discharge (empty) the capacitor to a given voltage depends upon how quickly charge is allowed to flow into the capacitor. If a capacitor is connected across a battery without a resistor, it will charge to the same voltage as the battery almost instantly as the flow of charge is not opposed. If, however, a current limiting resistor is placed in series with the capacitor, the charge is opposed and the capacitor charges at a slower rate. When a resistor and capacitor are used together, an RC timing circuit is produced. The RC timing circuit can be used to produce delays; the amount of time taken to get to 70% of the final voltage is given by the resistance times the capacitance.

Example of calculating RC constants for a 1MΩ resistor and a 100µF capacitor:

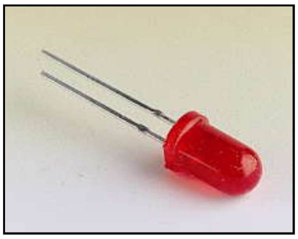
T = R x C
T = 1,000,000 (1M) x 0.000,1 (100µF)
T = 100 Seconds

So an RC of 1 second could be produced with a 10K resistor and 100µF capacitor.

Resistor Value	Capacitor Value	RC Time Constant
2,000,000 (2MΩ)	**0.000,1 (100µF)**	
100,000 (100KΩ)	**0.000,1 (100µF)**	
100,000 (100KΩ)	**0.000,047 (47µF)**	

LEDs & Current Limit Resistors

Before we look at LEDs, we first need to start with diodes. Diodes are used to control the direction of flow of electricity. In one direction they allow the current to flow through the diode, in the other direction the current is blocked.



An LED is a special diode. LED stands for Light Emitting Diode. LEDs are like normal diodes, in that they only allow current to flow in one direction, however, when the current is flowing, the LED lights up.

The symbol for an LED is the same as the diode but with the addition of two arrows to show that there is light coming from the diode. As the LED only allows current to flow in one direction, it's important that we can work out which way the electricity will flow. This is indicated by a flat edge on the LED.

For an LED to light properly, the amount of current that flows through it needs to be controlled. To do this we use a current limit resistor. If we didn't use a current limit resistor the LED would be very bright for a short amount of time, before being permanently destroyed.

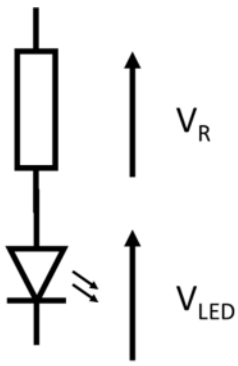
To work out the best resistor value we need to use Ohm's Law. This connects the voltage across a device and the current flowing through it to its resistance.

Ohm's Law tells us that the flow of current (I) in a circuit is given by the voltage (V) across the circuit divided by the resistance (R) of the circuit.

$$I = \frac{V}{R}$$

Like diodes, LEDs drop some voltage across them: typically a high brightness white LED will have 3.2 volts drop and a high brightness red LED will have 2.2 volts drop.
Each of these LEDs will require a different value for the current limit resistor. The Deluxe Bike Light runs off 3 AAA batteries typically giving 4.5V supply, so across the LED (V_{LED}) and the resistor (V_R) must be 4.5 volts.
For a high brightness red LED, there must be a voltage drop of 2.2 volts across the LED leaving 2.3V ($V_{LED} + V_R = 2.2 + 2.3 = 4.5V$).

LEDs normally need about 30mA to operate at full brightness. Since we know that the voltage across the current limit resistor is 2.3 volts and we know that the current flowing through it is 0.03 Amps, the resistor value can be calculated.



Using Ohm's Law in a slightly rearranged format:

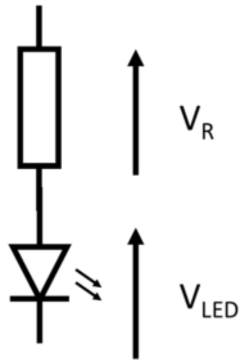
$$R = \frac{V}{I} = \frac{2.3}{0.03} = 76$$

Hence, we need a 82Ω current limit resistor (it being the nearest value above the calculated value).

LEDs Continued

For a high brightness white LED, there must be a voltage drop of 3.2 volts across the LED leaving 1.3V ($V_{LED} + V_R = 3.2 + 1.3 = 4.5V$).

Taking the current of 30mA for the LEDs to operate at full brightness. We also know that the voltage across the current limit resistor is 2.8 volts and we know that the current flowing through it is 0.03 Amps, the resistor value can be calculated.



Using Ohms Law in a slightly rearranged format:

$$R = \frac{V}{I} = \frac{1.3}{0.03} = 43$$

Hence, we need a 47Ω current limit resistor (it being the nearest value above the calculated value).

Packages

LEDs are available in many shapes and sizes. The 5mm round LED is the most common. The colour of the plastic lens is often the same as the actual colour of light emitted – but not always with high brightness LEDs.

Advantages of using LEDs over bulbs

Some of the advantages of using an LED over a traditional bulb are:

Power efficiency	LEDs use less power to produce the same amount of light, which means that they are more efficient. This makes them ideal for battery power applications.
Long life	LEDs have a very long life when compared to normal light bulbs. They also fail by gradually dimming over time instead of a sharp burn out.
Low temperature	Due to the higher efficiency of LEDs, they can run much cooler than a bulb.
Hard to break	LEDs are much more resistant to mechanical shock, making them more difficult to break than a bulb.
Small	LEDs can be made very small. This allows them to be used in many applications, which would not be possible with a bulb.
Fast turn on	LEDs can light up faster than normal light bulbs, making them ideal for use in car brake lights.

Disadvantages of using LEDs

Some of the disadvantages of using an LED over a traditional bulb are:

Cost	LEDs currently cost more for the same light output than traditional bulbs. However, this needs to be balanced against the lower running cost of LEDs due to their greater efficiency.
Drive circuit	To work in the desired manner, an LED must be supplied with the correct current. This could take the form of a series resistor or a regulated power supply.
Directional	LEDs normally produce a light that is focused in one direction, which is not ideal for some applications.

Typical LED applications

Some applications that use LEDs are:

- Bicycle lights
- Car lights (brake and headlights)
- Traffic lights
- Indicator lights on consumer electronics
- Torches
- Backlights on flat screen TVs and displays
- Road signs
- Information displays
- Household lights
- Clocks

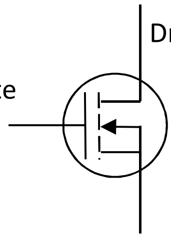
Using a FET as a Switch

Overview

A FET (Field-effect transistor) in its simplest form is an electronic switch. There are two basic types of FETs: N channel and P channel. The letters relate to what type of material is used to make the main body of the FET. N channels will have a negative material to make the main body; P channels will have a positive material to make the main body. Both types are available in different power ratings, from signal FET through to power FET. The N channel FET is the more common of the two and the one examined in this resource.

Schematic symbol

The symbol for an N channel FET is shown to the right along with the labelled pins.



Operation

An N channel FET has three legs: the gate, the source and the drain. The source is usually connected to 0V and the drain is connected to the electronics that are to be switched on. An example of this can be seen in Fig A. Typically a resistor is normally placed between the gate and the source output of the Integrated Circuit (IC) and the Gate of the FET to limit the current drawn through the IC output pin. This limiting of current in is to help protect the IC from being damaged.

The voltage between the gate and source (V_{GS}) of the FET is used to switch the FET on and off. In order to turn a FET on, there is a required level of voltage on the gate before the device conducts. This voltage is known as the threshold voltage (V_{TH}). When the voltage between these two legs is less than the threshold voltage, the FET is turned off or the switch is open (Fig B). Inside the FET, the material between the drain and source can be thought of as a very large value resistor.

When the gate-source voltage is greater than the threshold voltage (turning the FET on or like closing a switch (Fig C)), the resistance between the drain and source lowers and allows current to flow through. If the gate-source voltage increases more, the resistance will decrease, and more current will flow through. It could be compared to a voltage controlled variable resistor.

Fig A. Typical FET circuit

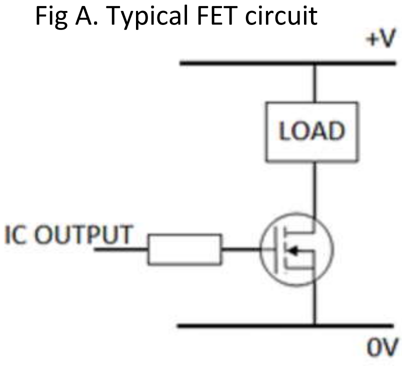


Fig B. FET turned off

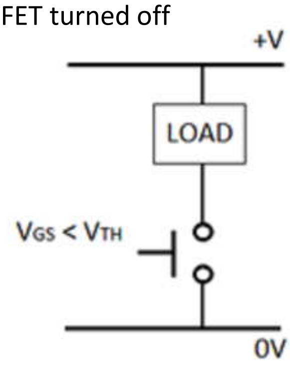
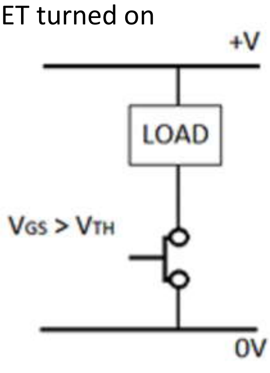


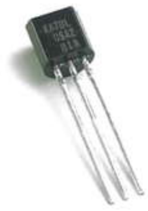
Fig C. FET turned on



Current & Voltage ratings

FETs are great for current flow, but will only allow a certain amount to flow through the drain pin. Most datasheets will refer this current flow as Drain Current.
FETs will also only allow a max voltage between the drain and source due to the type of material used to form the main body of the component; this is referred to as Drain Source Voltage. If this voltage is exceeded it can damage the FET and preventing it from switching on.
All these ratings change from device to device and it is worth checking for the required needs of a circuit.

Component Packages



FETs come in different styles of packages. Devices that require higher ratings in power, voltage or current will have a metal can/heatsink which can then enable more heatsinks to be attached if they are required.

Lower rated FETs will come in a ‘D’ shaped plastic package, as they do not require any additional protection for heat.

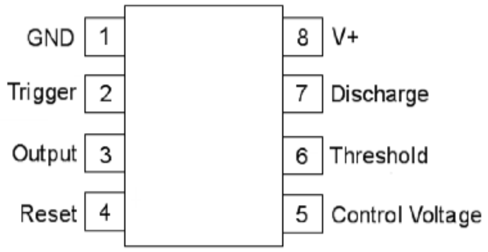
With different packages, the pinouts for the gate, source and drain will be wired differently, so it is always a good idea to check the datasheet to find out which pin connects where.

555 Timers

Overview

The 555 integrated circuit is a highly accurate timing circuit which is capable of producing both time delays or oscillation.

Pin Outs



Pin Descriptions

V+	=	(Pin 8) Supply voltage.
GND	=	(Pin 1) GND (0V) connection for supply voltage.
Threshold	=	(Pin 2) Active high input pin that is used to monitor the charging of the timing capacitor.
Control Voltage	=	(Pin 5) Used to adjust the threshold voltage if required. This should be left disconnected if the function is not required. A 0.01uF capacitor to GND can be used in electrically noisy circuits.
Trigger	=	(Pin 2) Active low trigger input that starts the timer.
Discharge	=	(Pin 7) Output pin that is used to discharge the timing capacitor.
Out	=	(Pin 3) Timer output pin.
Reset	=	(Pin 4) Active low reset pin. Normally connected to +V if the reset function is not required.

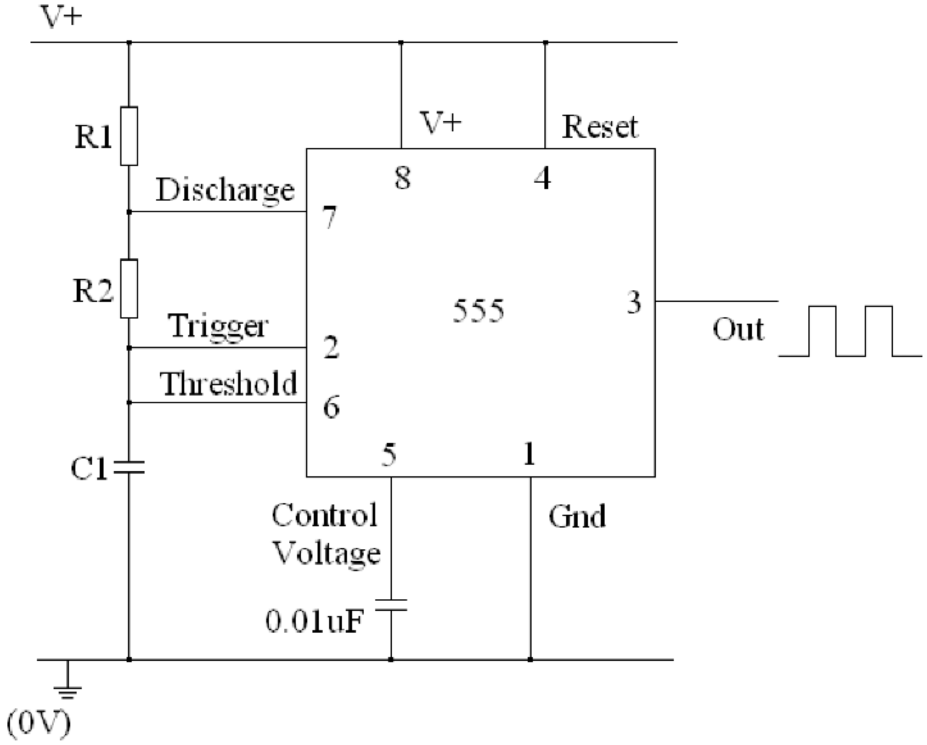
Operating Overview

The 555 timer is a simple circuit. Inside, there is a latch that can be set and reset from the trigger pin. By taking the trigger signal from high to low the latch is set. This causes the output to go high and the discharge pin to be released from GND (0V). The releasing of the discharge pin from GND causes an external capacitor to begin charging.

When the capacitor is charged, the voltage across it increases. This results in the voltage on the threshold pin increasing. When this is high enough it will result in the threshold pin causing the latch to reset.

This causes the output to go low and the discharge pin is also taken back to GND. This discharges the external capacitor ready for the next time the device is triggered.

How the Square Wave Generator Works



The 555 Timer needs to be configured as an astable timer (like the circuit above) where the output is continuously alternating between high and low. In this configuration the 555 Timer re-triggers itself after each cycle, which results in the continuous alternating signal.

The frequency of the output is determined by the time taken to charge the capacitor C1. This capacitor charges through the resistors R1 and R2. When the output of the circuit (pin 3) goes high, C1 begins to charge until the voltage across it is high enough to activate the threshold input. This causes the output to go low and the capacitor now starts to discharge through R2. This continues until the voltage across C1 is low enough to activate the (active low) trigger input. The output now goes high and the process is repeated.

The time the output is 'High' compared to the time the output is 'Low' is known as the duty cycle. The duty cycle is determined by the ratio of these resistors. If the value of the two resistors is the same the duty cycle will be 50% and the output will be a square wave.

The 'High' output time is given by: $t1=0.693\times(R1+R2)\times C1$

The 'Low' output time is given by: $t2=0.693\times R2\times C1$

Therefore, the total period is given by: $T= t1+t2=0.693\times(R1+(2\times R2))\times C1$

The frequency of oscillation is given by:

$$f=\frac{1}{T}=\frac{1.44}{(R1+R2)\times C1}$$

Evaluation

It is always important to evaluate your design once it is complete. This will ensure that it has met all of the requirements defined in the specification. In turn, this should ensure that the design fulfils the design brief.

Check that your design meets all of the points listed in your specification.

Show your product to another person (in real life this person should be the kind of person at which the product is aimed). Get them to identify aspects of the design, which parts they like and aspects that they feel could be improved.

Good aspects of the design	Areas that could be improved

Improvements

Every product on the market is constantly subject to redesign and improvement. What aspects of your design do you feel you could improve? List the aspects that could be improved and where possible, draw a sketch showing the changes that you would make.

Packaging Design

If your product was to be sold in a high street electrical retailer, what requirements would the packaging have? List these giving the reason for the requirement.

Requirement	Reason

Develop a packaging design for your product that meets these requirements. Use additional pages if required.

ESSENTIAL INFORMATION

BUILD INSTRUCTIONS
CHECKING YOUR PCB & FAULT-FINDING
MECHANICAL DETAILS
HOW THE KIT WORKS

INVEST IN BIKE SAFTEY WITH THIS

REAR DELUXE BIKE LIGHT KIT

Version 1.1

Rear Deluxe Bike Light Essentials

www.kitronik.co.uk/2167

Build Instructions

Before you start, take a look at the Printed Circuit Board (PCB). The components go in the side with the writing on and the solder goes on the side with the tracks and silver pads.

1 PLACE RESISTORS

Start with the resistors. The text on the PCB shows where R1, R2 etc go.
Ensure that you put the resistors in the right place.

PCB Ref	Value	Colour Bands
R1, R2, R3, R4	100Ω	Brown, Black, Brown
R5, R7	1kΩ	Brown, Black, Red
R6	220kΩ	Red, Red, Yellow

2 SOLDER THE CAPACITORS

Place the 1uF capacitor into the board where it is labelled C1. Make sure the negative leg is placed in the negative side. With the legs of the capacitor in the holes, bend the capacitor to match the outline on the PCB. Once the component is bent over, solder both legs of the capacitor.

Place the 10nF capacitor into the board where it is labelled C2. It does not matter which way around this component is fitted.

3 SOLDER THE FET

Place the 2N7000 FET into the board where it is labelled TR1. Make sure that the device is the correct way around. The shape of the device should match the outline on the PCB.

4 SOLDER THE DIODE

Place the BAT41 diode into the board where labelled D1. Make sure that the band on the component matches the outline on the PCB.

5 SOLDER THE IC HOLDER

Solder the Integrated Circuit (IC) holder into U1. When putting it into the board, be sure to get it the right way around. The notch on the IC holder should line up with the notch on the lines marked on the PCB.

6 SOLDER THE LED

Place LEDs in to LED1, LED2, LED3 and LED4 making sure that the LED matches the outline on the PCB. The short leg (or flat section of the LED rim) will be on the switch edge.

7 SOLDER THE SWITCH

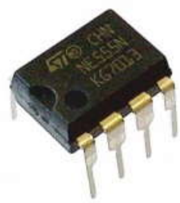
Place switch into outline of SW1. Making sure component is flat on the PCB, solder all pins of the switch.

8 ATTACH THE BATTERY CLIP

Now you must attach the battery clip. Start by feeding the leads through the strain relief hole on the right hand side.
The leads should be connected to the 'Power' terminals.
The red lead should be soldered to the '+' terminal (also marked with text 'red') and the black lead should be soldered to the '-' terminal (also marked with the text 'black').

9 INSERT THE IC INTO HOLDER

The 555 IC can now be put into the holder, ensuring that the notch on the chip lines up with the notch on the holder.



Checking Your PCB

Check the following before you power up the unit:

Check the bottom of the board to ensure that:

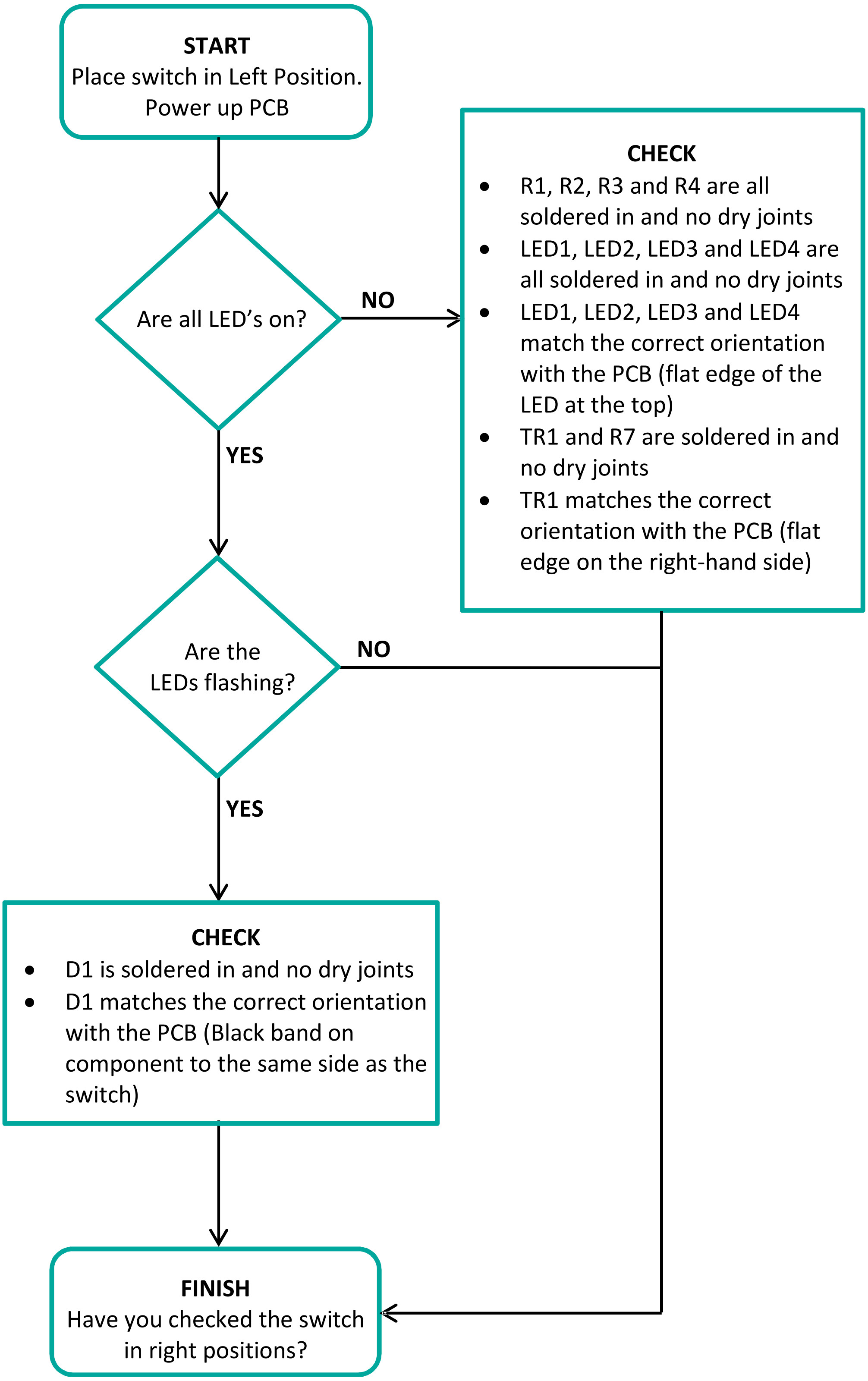
- All holes (except the large mounting holes) are filled with the lead of a component.
- All these leads are soldered.
- Pins next to each other are not soldered together.

Check the top of the board to ensure that:

- The notch on the 555 IC matches the outline on the PCB.
- The shape of the FET matches the outline on the PCB.
- C1 matches the outline on the PCB.
- The resistor bands on R1,R2,R3,R4 are Brown, Black, Brown
- The resistor bands on R5 and R7 are Brown, Black, Red
- The resistor bands on R6 are Red, Red, Yellow
- All flat edge of the LEDs match the outline on the PCB
- All the connecting leads are connected to the right part and that the power connection is the right way around.

Rear Deluxe Bike Light Essentials

www.kitronik.co.uk/2167



Rear Deluxe Bike Light Essentials

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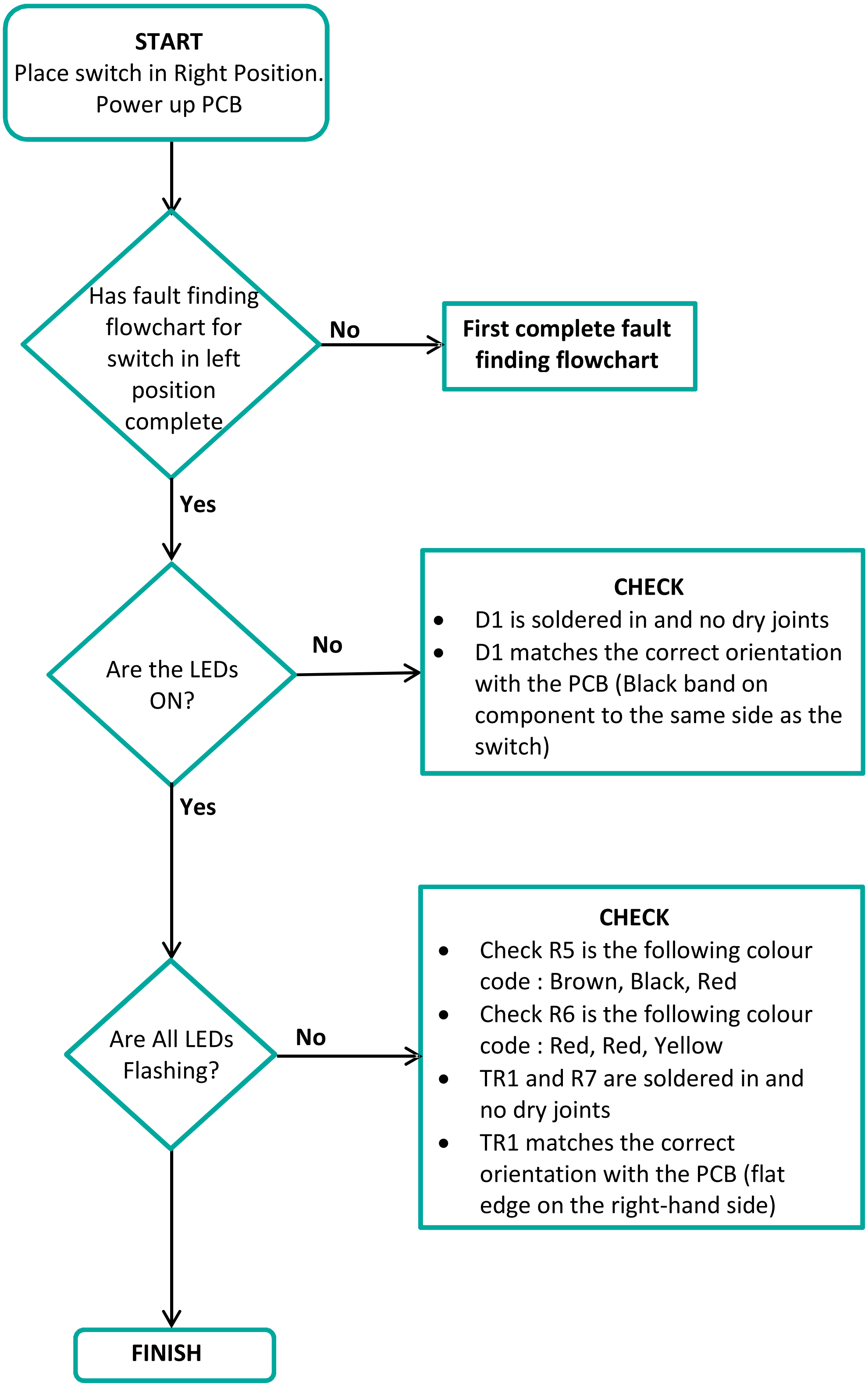

555 Timers

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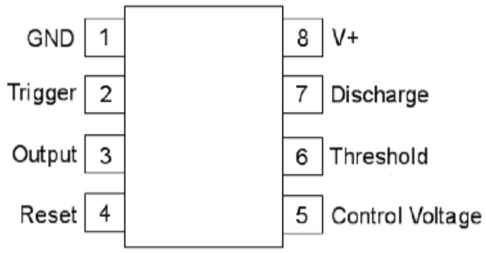
Pin Outs



Pin Descriptions

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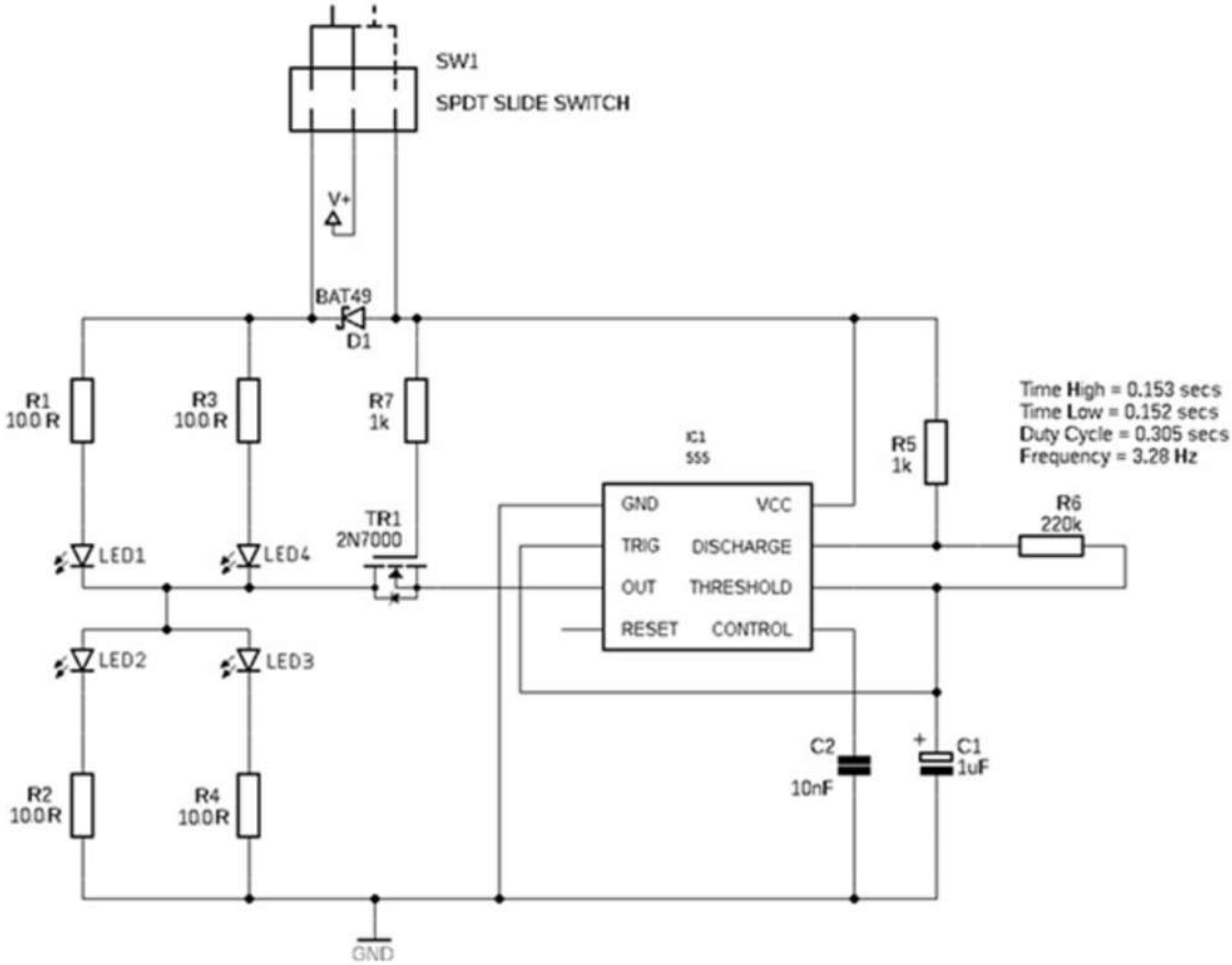
Operating Overview

The 555 timer is a simple circuit. Inside there is a latch that can be set and reset from the trigger pin. By taking the trigger signal from high to low the latch is set. This causes the output to go high and the discharge pin to be released from GND (0V). The releasing of the discharge pin from GND causes an external capacitor to begin charging.
When the capacitor is charged, the voltage across it increases. This results in the voltage on the threshold pin increasing. When this is high enough it will result in the threshold pin causing the latch to reset.

This causes the output to go low and the discharge pin is also taken back to GND. This discharges the external capacitor ready for the next time the device is triggered.

How the Circuit Works



The circuit has two operating modes. Flashing LED and constant illumination LED. This is determined by the position of the switch.

With the switch in the left position. The diode (D1) blocks the supply to the timing circuit and the FET (TR1) does not allow the 555 to sink the common rail of the LED's down to ground due to the high impedance of the FET (the 555 has low impedance). The voltage flows through to the current limiting resistors R1, R2, R3, R4 and LED1, LED2, LED3, LED4. The circuit is a simple LED circuit.

With the switch in the right position. The supply goes to the 555 timer circuit and to the FET, as well as voltage to pass through the diode to give a voltage supply to the LEDs.

The 555 Timer is configured as an astable timer (like the circuit above) where the output is continuously alternating between high and low. In this configuration the 555 Timer re-triggers itself after each cycle, which results in the continuous alternating signal.

The frequency of the output is determined by the time taken to charge the capacitor C1. This capacitor charges through the resistors R1 and R2. When the output of the circuit (pin 3) goes high, C1 begins to charge until the voltage across it is high enough to activate the threshold input. This causes the output to go low and the capacitor now starts to discharge through R2. This continues until the voltage across C1 is low enough to activate the (active low) trigger input. The output now goes high and the process is repeated.

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The frequency of oscillation is given by:
$f= 1/T=1.44/((R1+R2)\times C1)$

The output from the 555 goes to the FET. With the voltage supply always going to the gate of the FET (when the switch is in the right position), this acts like a switch is on and makes the connection between the 555 and the common track between the LEDs. This results in the common track of the LEDs matching that of the 555.

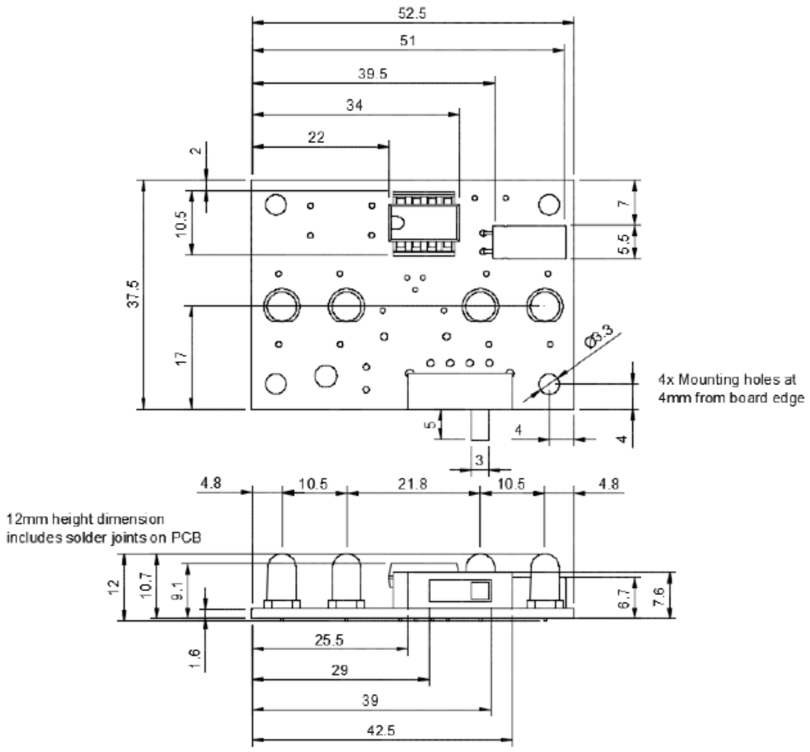
When the output of the 555 is High then LED 1 and 4 have no voltage across them, and so do not illuminate. At the same time LED 2 and 3 are driven by the 555 and illuminate. The 555 can drive 200mA, which is enough for this pair of LEDs.
When the output is low then there is no voltage across LEDs 2 and 3, and so they do not illuminate. LEDs 1 and 4 are now referenced to ground through the 555 and illuminate.
This cycle continues, and so the pairs of LEDs flash in sequence.

Designing the Enclosure

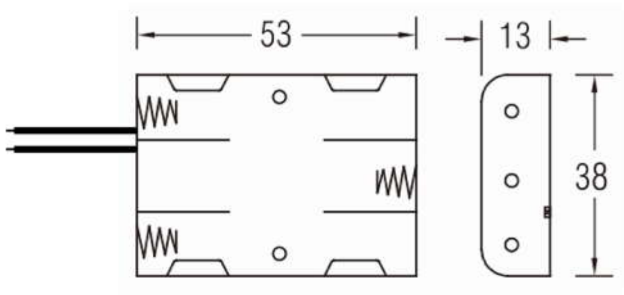
When you design the enclosure, you will need to consider:

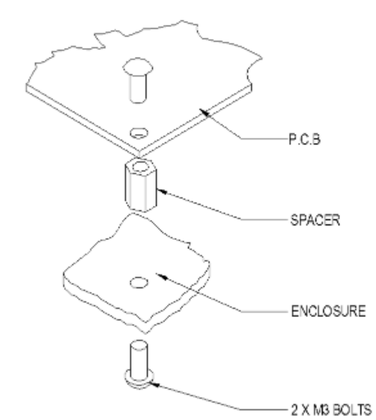
- The size of the PCB (below left).
- Where the batteries will be housed.
- Where the switch will be mounted.
- Height of the components.

This technical drawing of the PCB and other components should help you to design your enclosure.



All dimensions are in mm. The PCB has four mounting holes 3.3mm in diameter. These holes are 4mm from the board edge





Mounting the PCB to the enclosure

The drawing to the left shows how a hex spacer can be used with two bolts to fix the PCB to the enclosure.

Your PCB has four mounting holes designed to take M3 bolts.

Online Information

Two sets of information can be downloaded from the product page where the kit can also be reordered from. The 'Essential Information' contains all of the information that you need to get started with the kit and the 'Teaching Resources' contains more information on soldering, components used in the kit, educational schemes of work and so on and also includes the essentials. Download from:

www.kitronik.co.uk/2167

This kit is designed and manufactured in the UK by Kitronik

Telephone: +44 (0) 845 8380781

Sales email: sales@kitronik.co.uk

Tech support email: support@kitronik.co.uk

Web: www.kitronik.co.uk

www.kitronik.co.uk/twitter

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