# TEACHING RESOURCES

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

DESIGN AN EDGE LIT DISPLAY PIECE WITH THIS

# 5V LED Strip Kit


Version 1.0

# 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 contains 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 0115 970 4243.

# 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 to 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.<br>Homework: Collect examples of lighting products including mood lighting and display lights. 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.<br>Resource: Sample of lamps and lighting products.<br>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.<br>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' work sheet and the information on 'LEDs & Current Limit Resistors'.<br>Homework: Complete any of the remaining resistor 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 5V LED Strip PCB' section. Homework: Read 'How the 5V LED Strip Works' sheet in conjunction with the LED 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.

# 5V LED Strip Kit Teaching Resources

www.kitronik.co.uk/2176

### *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 5V USB Strip PCB'. |

## Answers

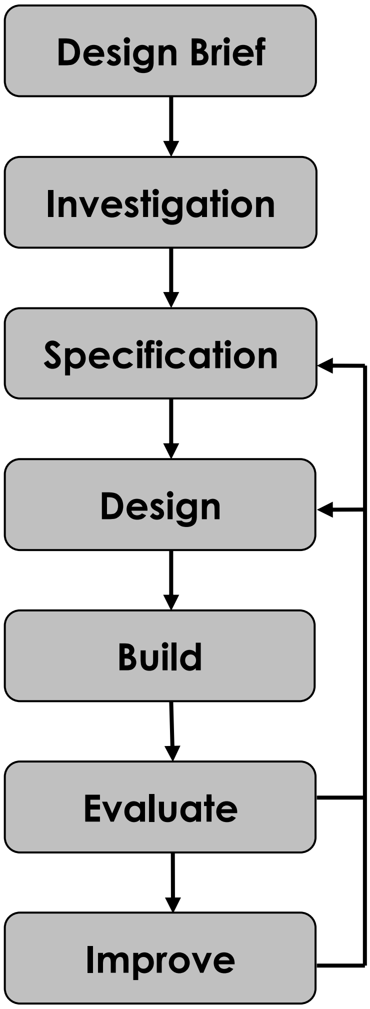
### *Resistor questions*

| 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* |

# 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 manufacturer has developed a simple circuit for producing a mood lamp or lighting display that is powered by a 5V USB power supply. The circuit has been developed to the point where they have a working Printed Circuit Board (PCB).

The manufacturer would like ideas for a product that can be created by designing an enclosure for this PCB. For example the lamp could be used for lighting a picture or the lamp could also be used to create some form of mood lighting.

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*

A fully built circuit is shown below.

# 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 a square opening. | Example: So that the LEDs can point out of the enclosure. |

# Design

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

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

# Design Review (group task)

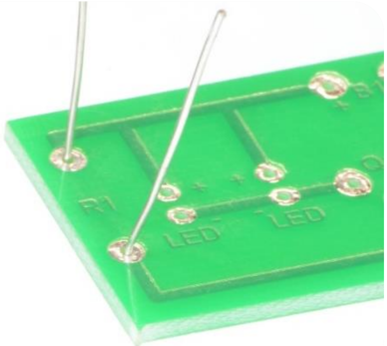
Split into groups of three or four. Take it in turns to review each person's design against the requirements of their specification. Also look to see if you can spot any additional aspects of each design that may cause problems with the final product. This will allow you to ensure that you have a good 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.

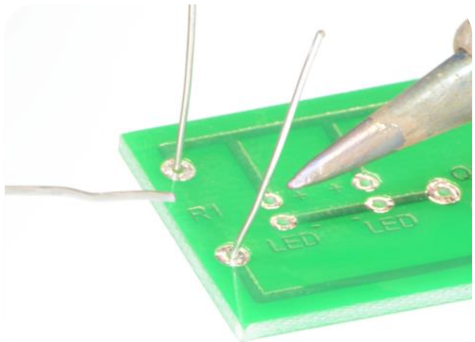


## 2 CLEAN SOLDERING IRON

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

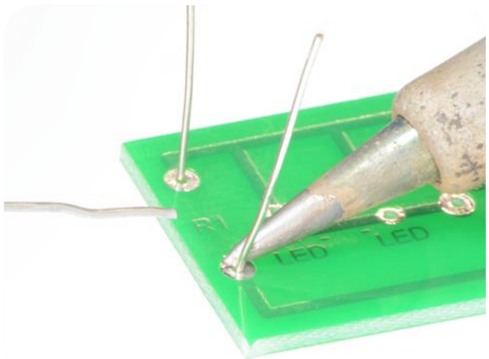
## 3 PICKUP IRON AND SOLDER

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



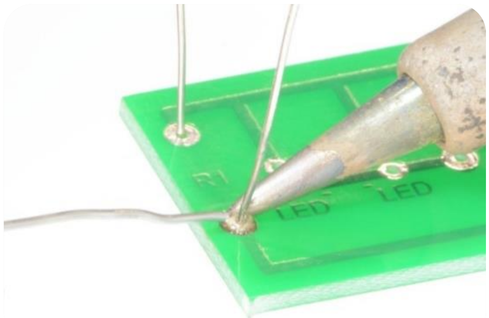
## 4 HEAT PAD

Place soldering iron tip on the pad.



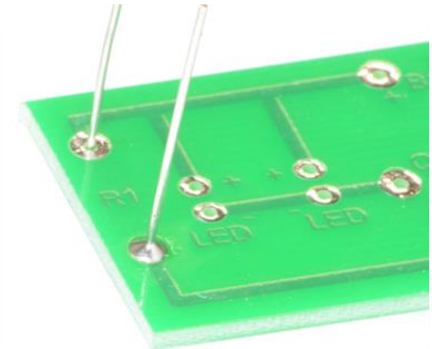
## 5 APPLY SOLDER

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



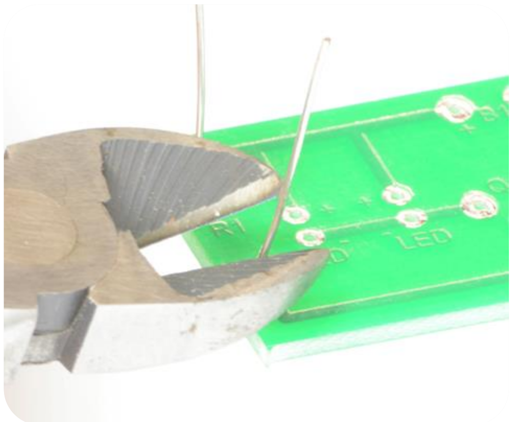
## 6 STOP SOLDERING

Remove the solder, then remove the soldering iron.



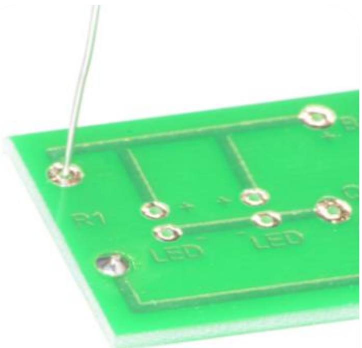
## 7 TRIM EXCESS

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.



## De-Soldering in Five Steps

### 1 USE A SOLDER EXTRACTOR

To de-solder a joint, for instance if the wrong component has been placed in the PCB, use a solder extractor, also known as a solder sucker

### 2 PRIME EXTRACTOR

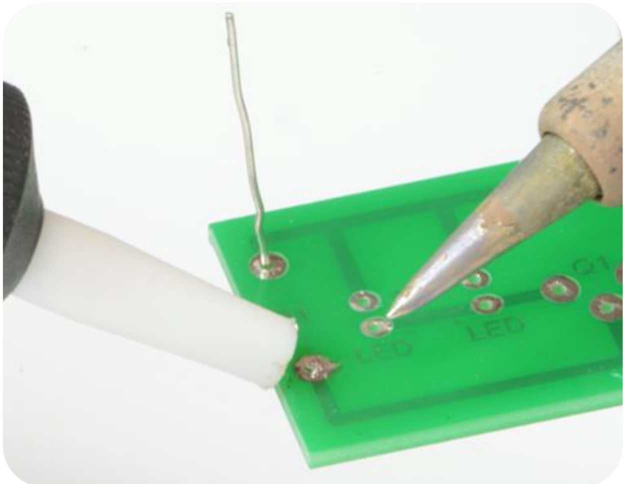
Prime the solder sucker by pushing the plunger down against the spring. Pick up the soldering iron in one hand and the solder sucker in the other


### 3 HEAT JOINT

Heat the joint to be de-soldered with the soldering iron. Keep the tip of the solder sucker close to the joint, ready to use

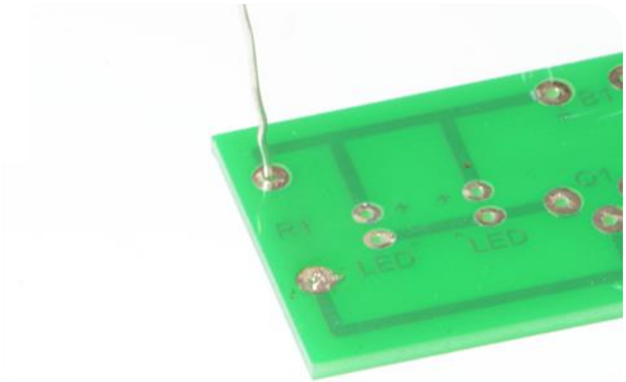
## 4 ACTIVATE EXTRACTOR

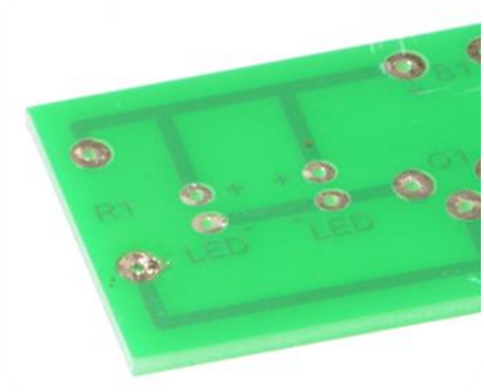
When the solder melts press the button on the solder sucker to suck up the molten solder.
Sometimes it is useful to remove the soldering iron to allow better access with the solder sucker to the joint.



## 5 REPEAT (OPTIONAL)

If all the solder is not removed then repeat the process of heating and sucking. Allow the board to cool for a little while, then remove the de-soldered component.

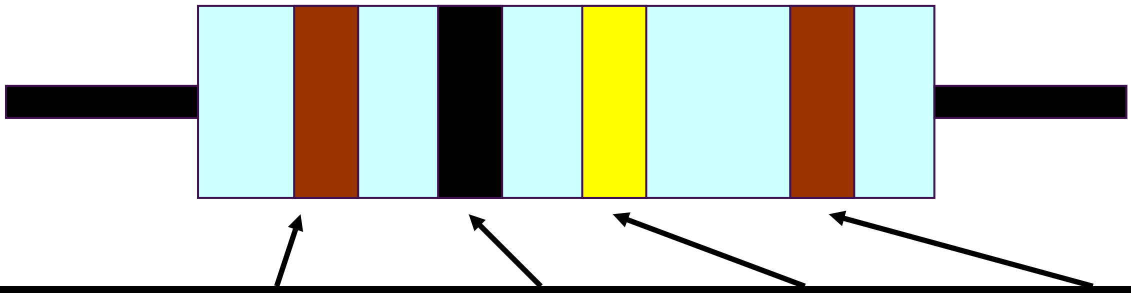




Resistor Values

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*

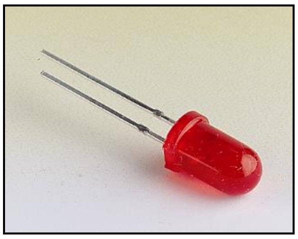
There are a number of different ranges of values for resistors. Two of the most popular are the E12 and E24. They take into account the manufacturing tolerance and are chosen such that there is a minimum overlap between the upper possible value of the first value in the series and the lowest possible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

# 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.

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 Ohms Law. This connects the voltage across a device and the current flowing through it to its resistance.

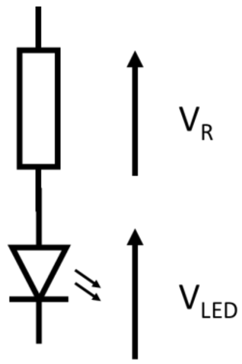
Ohms Law tells us that the flow of current (I) in a circuit is given by the voltage (V) across the circuit divided by the resistance (R) of the circuit.

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

Like diodes, LEDs drop some voltage across them: typically 1.8 volts for a standard LED. However the white LEDs used in the LED Strip drop 3.1 volts. There are 4 LEDs, but they are connected in parallel, so the voltage drop across them is the same. Because there are 4 LEDs the current through the resistor is 4x what it would be for a single LED.

The LED strip runs off a 5V USB supply so there must be a total of 5 volts dropped across the LEDs ($V_{LED}$) and the resistor ($V_R$). As the LED manufacturer's datasheet tells us that there is 3.1 volts dropped across the LED, there must be 1.9 volts dropped across the resistor. ($V_{LED} + V_R = 3.5 + 1.9 = 5V$).

To give a good brightness white LEDs normally need 20 - 25mA flowing through them. Since we know that the voltage across the current limit resistor is 1.9 volts and we know that the current flowing through each LED is 0.025 Amps, the resistor can be calculated. Because there are 4 LEDs and only 1 resistor the current flowing through the resistor is 4x25= 100mA
Using Ohms Law in a slightly rearranged format:




$$R = \frac{V}{I} = \frac{1.9}{0.1} = 19\Omega$$

The next nearest preferred value is 22Ω, which results in an actual current of 21.5 mA per LED, which is in the right range (20-25mA).

## LEDs Continued

## 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 can 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

# Instruction Manual

Your lamp is going to be supplied with some instructions. Identify four points that must be included in the instructions and give a reason why.

Point to include:

Reason:

Point to include:

Reason:

Point to include:

Reason:

Point to include:

Reason:

# 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

DESIGN AN EDGE LIT DISPLAY PIECE WITH THIS

# 5V LED Strip Kit

Version 1.0

# 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 THE SWITCH

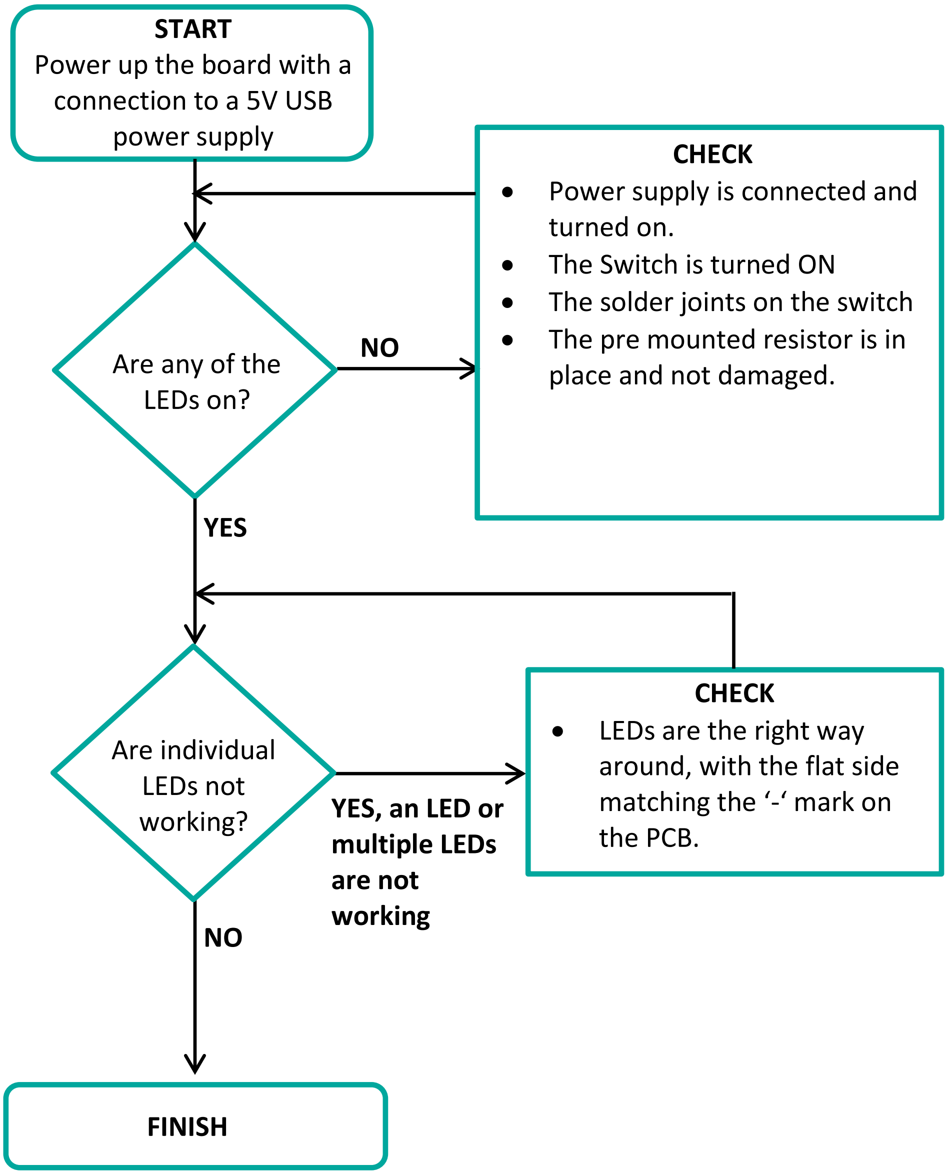
Place the switch into the three holes at the end. Make sure the switch actuator sticks out from the end of the PCB.
Solder the switch and trim the legs.

## 2 PLACE THE LEDs

Place the 4 LEDs.
Make sure they are the correct way round. The PCB silk screen indicates the shape – line up the flat side as shown.  Additionally, the longer leg goes in the hole marked with the +.
Solder the LEDs and trim the legs.

# Checking Your 5V LED Strip PCB

- Have you soldered all the components in? There should be no unused component holes. Only the mounting hols should be empty.
- Is the LED orientation correct? (Does the outline of the LED match the markings on the PCB?)

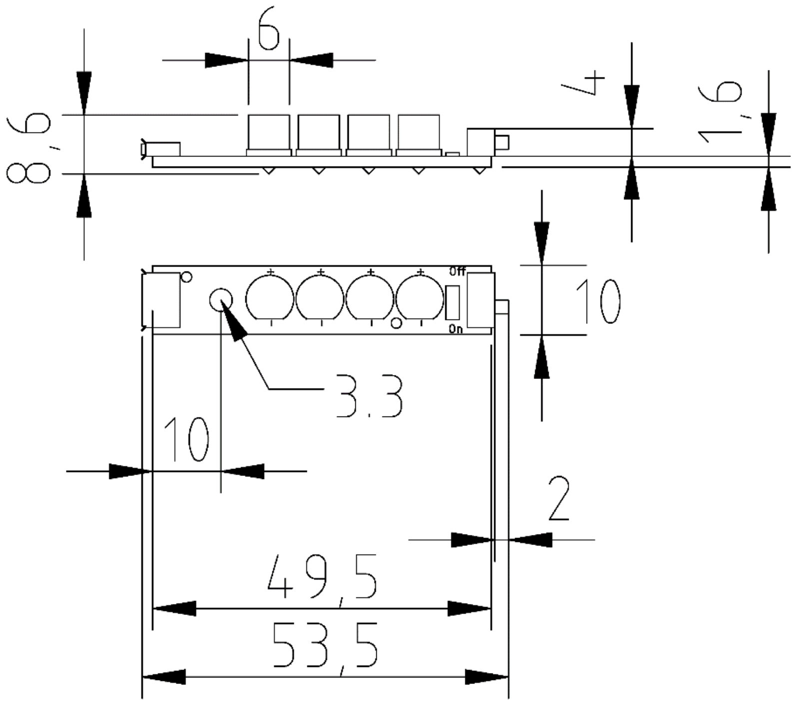


## Designing the Enclosure

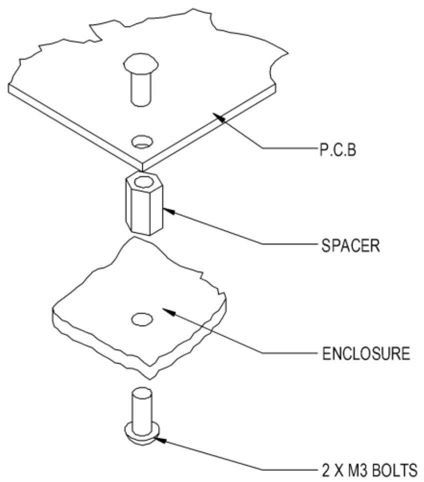
When you design the enclosure, you will need to consider:

- The size of the PCB (below).
- Where the power cable comes out.
- Where the power switch is
- There is a single 3.2mm hole in the PCB to secure the PCB in the enclosure.

This technical drawing of the built 5V LED Desk Lamp PCB should help you to design your enclosure.
The total height of the assembled unit is approximately 9mm.




(Dimensions in mm)

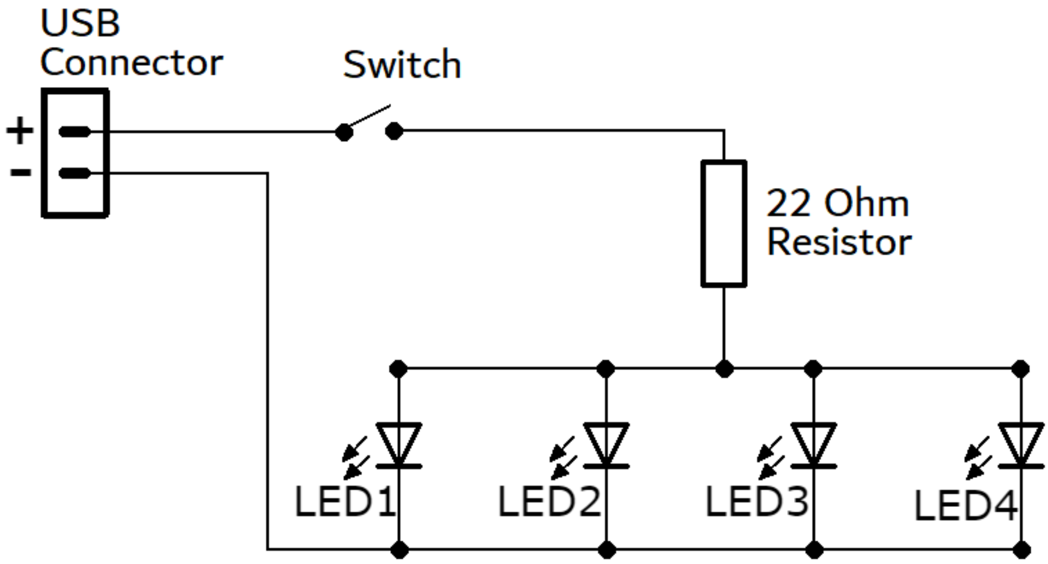



**Mounting the PCB to the enclosure**

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 one mounting hole designed to take M3 bolts.*

## How the 5V LED Strip Works




The circuit diagram for the 5V LED Desk Lamp is shown above. It is a very simple circuit. The board contains four LEDs, sharing a current limit resistor.

LEDs can be damaged if too much current goes through them, so a 22 Ohm resistor is used. This allows around 21mA to each LED, or 84mA overall. To save space on the PCB the kit comes with a surface mount resistor already soldered in place.

# 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/2176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