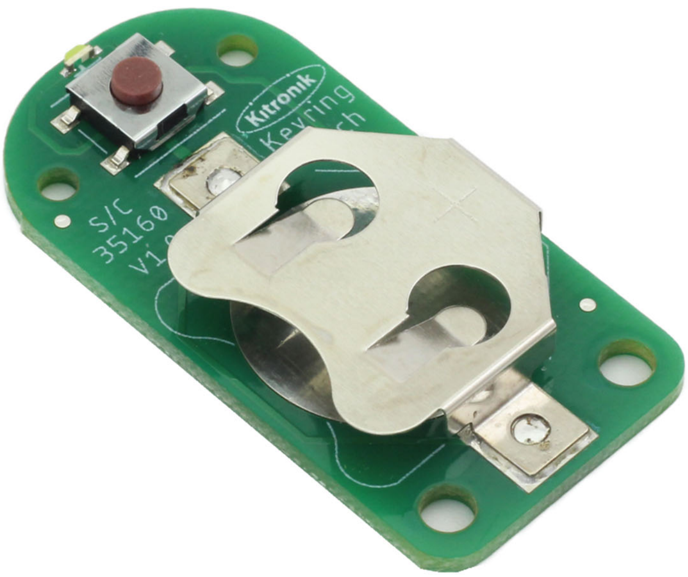
TEACHING RESOURCES

SCHEMES OF WORK
DEVELOPING A SPECIFICATION
COMPONENT FACTSHEETS
SURFACE MOUNT PACKAGES

LEARN ABOUT SIMPLE LIGHTING CIRCUITS WITH THIS

WHITE LED KEYRING TORCH



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 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 +44 (0) 115 970 4243.

Schemes of Work

A scheme of work is included in this pack; a complete project including the design & manufacture of an enclosure for the kit (below). Equally, feel free to use the material as you see fit to develop your own schemes.

Before starting we would advise that you familiarise yourself with the torch and build an example enclosure which can be used for demonstrations.

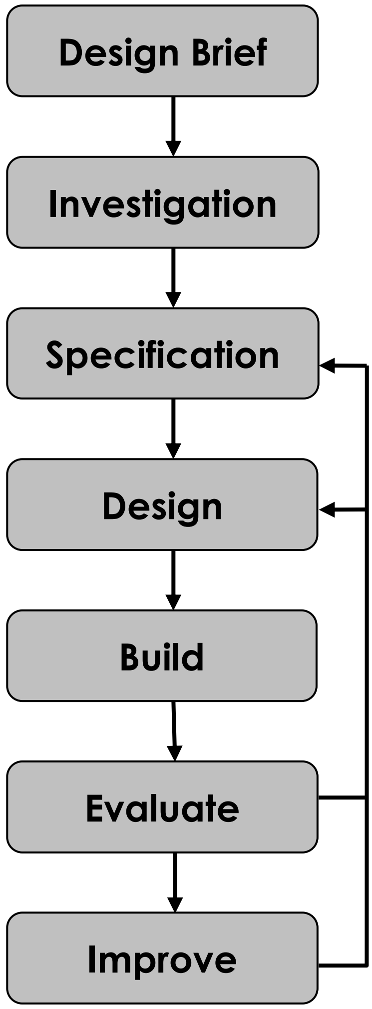
Complete product design project including electronics and enclosure

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 lighting product including some torches. 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 torches. 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 or other modelling materials, 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	Build the enclosure.
Hour 7	Build the enclosure.
Hour 8	Build the enclosure.
Hour 9	Using the 'Evaluation' and 'Improvement' sheet, get the students to evaluate their final product and state where improvements can be made.

Additional Work
Retail Package design for those who complete ahead of others.

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.

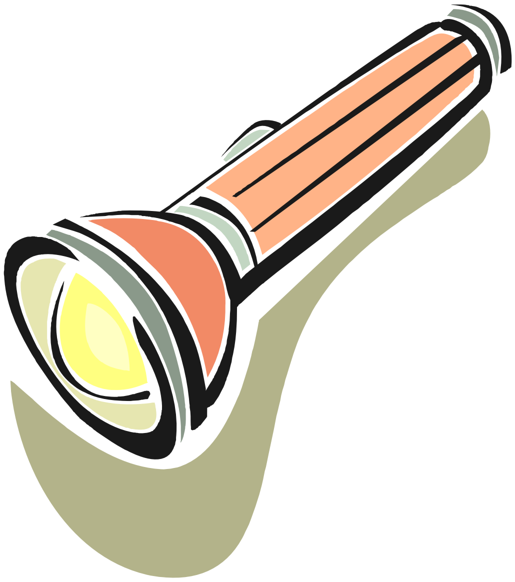
Evaluate

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.

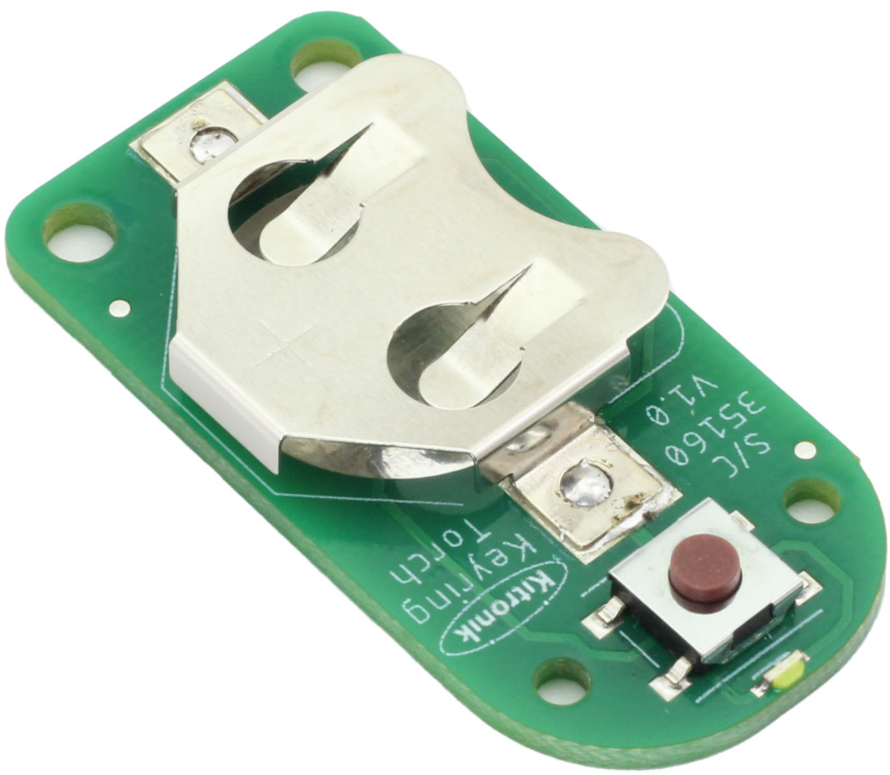
The Design Brief



A manufacturer has developed a simple circuit for producing a high brightness LED torch. 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 – a product to house the electronics.

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 allow access to the on / off switch.	Example: So that the torch can be turned on and off.

Design

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

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

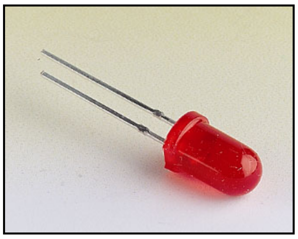
Design Review (group task)

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

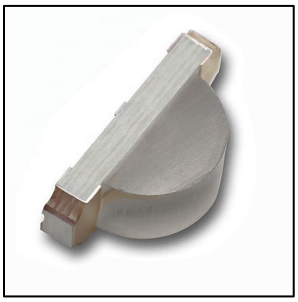
LEDs

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 usually use a current limit resistor. If we didn't, the LED would probably 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 (V_{LED}): typically, 1.8 volts for a standard red LED and around 3V for a white LED. There is also a maximum current the LED can safely draw (I_{LED}).

Rearranging the Ohms Law equation allows the required resistance to be calculated:

$$R = \frac{V_{supply} - V_{LED}}{I_{LED}}$$

The torch runs from the supply provided by the coin cell battery which is 3V (V_{supply}), so there must be a total of 3V dropped across the LED (V_{LED}) and any resistor (V_R). The LED manufacturer's datasheet tells us that there is 3V dropped across the LED and a maximum current draw of 25mA (I_{LED}).

Entering these values into the rearranged equation we can see that in this instance there is no need for a current limiting resistor as the supply voltage and the LED voltage are the same – the LED will only draw the required current and will not exceed its safe maximum.

LEDs Continued

Packages

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

Surface mount LEDs come in a range of shapes and sizes. The most common is known as an 0805 package. Surface mount LEDs have a lens over the top of the LED, often these lenses are clear. The LED doesn't always have to shine 'up', it could be from the side (like this keyring torch) or even 'down' through a hole in the PCB. Instead of wire legs, surface mount LEDs have two (sometimes more) plates on each end for soldering to the PCB.

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

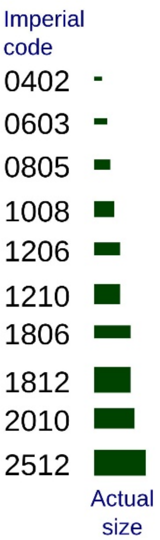
Surface Mount Packages

As circuit boards have developed so has the technology used to manufacture them. Previously electronics would have been manufactured using though hole components, placed by hand into the holes. Because of the need for a wire through the hole, components take up a lot of area for circuits. To help minimise the size of circuit boards and to increase manufacturing speeds, surface mount packages which can be placed by automatic machines were developed.

Having the component fit on the surface of the circuit board meant that machines could be used to place components with increased speed and at high accuracy. Designs of circuit boards could therefore become smaller with decreased size of components.

Surface mount components come in a range of packages. The two most common formats are:

- Packages described with a numeric format, usually used with capacitors, resistors, and LEDs.
- A more complex format, based on letter abbreviations and numbers, is used mainly for Integrated Circuits (ICs).



The package for LED used on this PCB is described using a four-digit code. This code refers to the physical size of the component in Inches (imperial measurements). The use of imperial measurements in electronics is common as many of the standards were written at a time when these measures were still in widespread use in America, which was then at the forefront of electronic development.

The first two numbers indicate the length measurement, the last two numbers indicate the width measurement.

The LED package is 0805. The physical size of an 0805 package = 0.08” x 0.05”, or about 2mm x 1.3mm.

See the picture (left) to compare the typical different size of components.

The more complex format consists of letter and numbers that describe the part. A typical example would be a SOT23 component. This code indicates that it is a Small Outline Transistor (SOT) with a certain size. The numbers in this format do not indicate directly the size of the part.

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

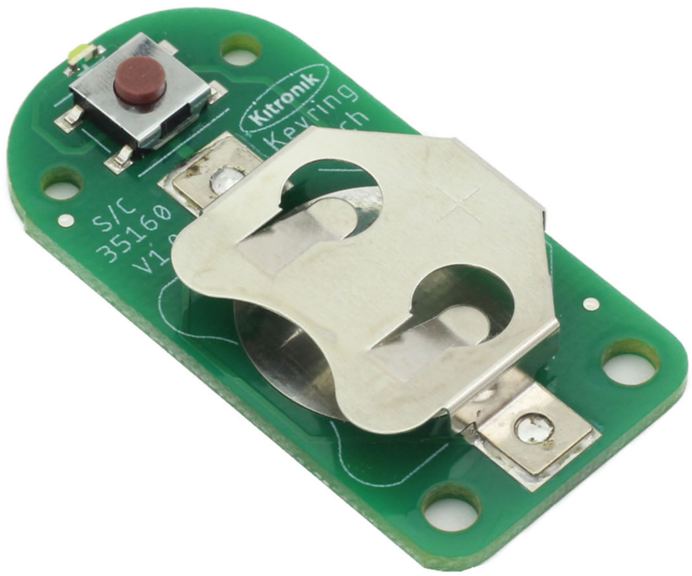
Develop a packaging design for your product that meets these requirements. Use additional pages if required.

ESSENTIAL INFORMATION

DESIGNING THE ENCLOSURE
MECHANICAL DETAILS
HOW THE KIT WORKS
EXAMPLE ENCLOSURE

LEARN ABOUT SIMPLE LIGHTING CIRCUITS WITH THIS

WHITE LED KEYRING TORCH



Version 1.0

White LED Torch Essentials

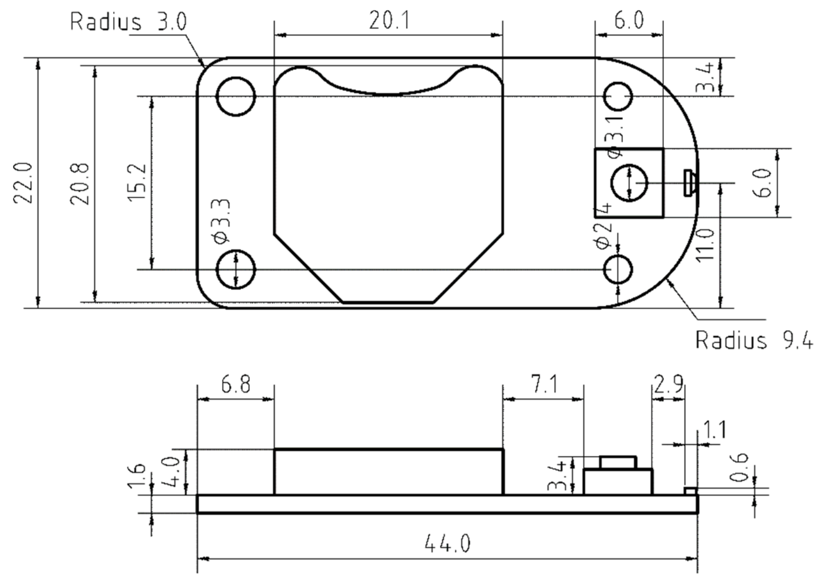
www.kitronik.co.uk/35160

Designing the Enclosure

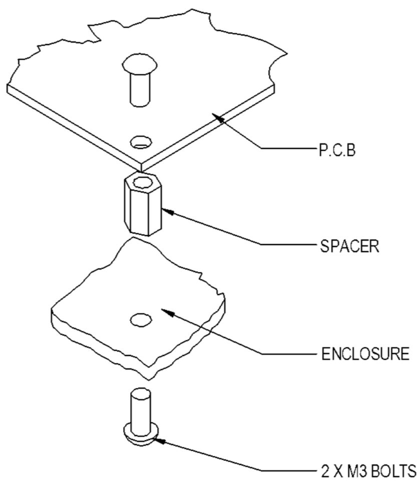
When you design the enclosure, you will need to consider:

- The size of the PCB.
- Where the LED is mounted.
- Where the power button is mounted.
- There are two 3.3mm (M3) holes at the back of the torch and two 2.4mm (M2) holes at the front which can be used to secure the PCB to your enclosure.
- Depending on your design, you could attach the torch to a keyring – using one of the 3.3mm holes or an external hole on the enclosure.

This technical drawing of the torch PCB should help you to design your enclosure.



All dimensions in mm.

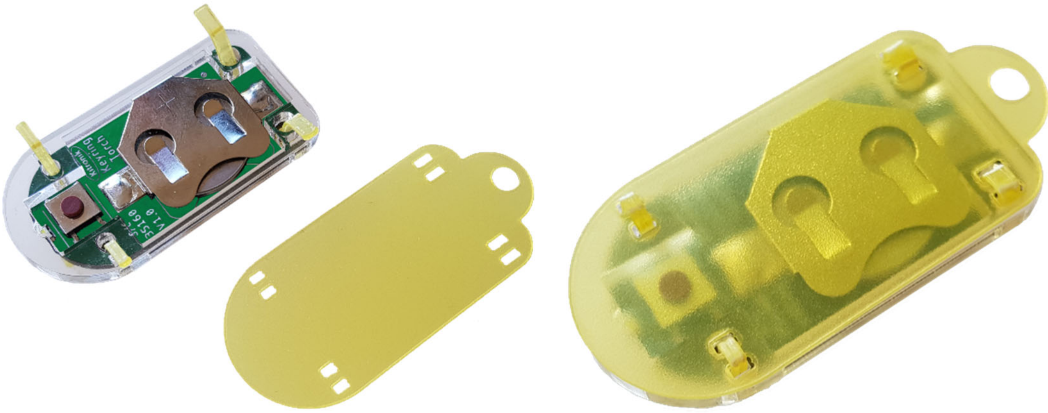


Mounting the PCB to the enclosure

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 two mounting holes designed to take M3 bolts, and two for M2.

Example Enclosures



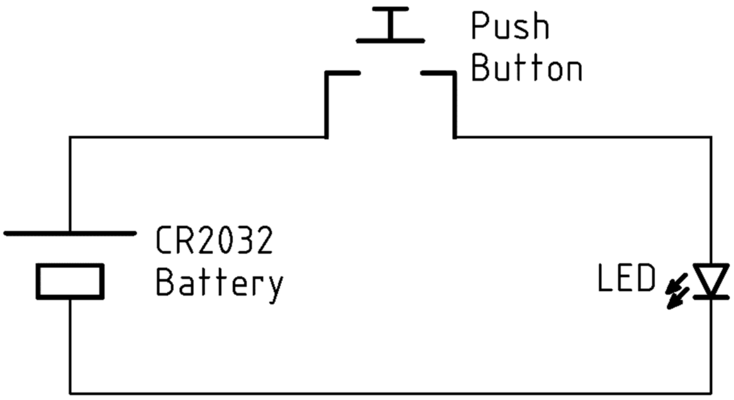
The images above show an example enclose for the torch. A combination of polypropylene and acrylic have been used to form a layered case around the torch PCB – the thinner polypropylene top and bottom and the 3mm acrylic in the centre. The acrylic layer has cut-outs to fit around the components and completely surrounds the torch to make sure everything is protected. The flexibility of the polypropylene means that it can be pressed through the activate the push button. Simple tabs through the PCB mounting holes keep the layers held together. The tab at the rear of the case with the large hole allows the torch to be attached to a keyring.

In the second example, the case uses laser cut rubber to create a complete shell around the torch, with a slot at one end to allow the LED light to shine out. The case is made up of segments which are glued together and then slotted over the torch PCB.

Due to the different cross-sectional shape of the torch at different points along its length, the cut-out section in the middle of each rubber segment needs to be carefully matched to its position in the case (the central cut-out section can be seen in the right-hand image). The segments are formed into two larger sections to allow the torch to be removed from the case, thereby meaning the battery can be changed. In the area above the push button a depression has been cut into the rubber to make it easier for a user's finger to find and press the button to turn the torch on. At the rear of the case, an extra wide segment has been included with a large hole which means the torch could be attached to a keyring.

The design files for both example cases can be found here:
www.kitronik.co.uk/35160

How the Torch Works



The circuit diagram for the torch is shown above. It is a very simple circuit, powered by a CR2032 coin cell battery.

LEDs often need to have the current supplied to them limited, however, as this circuit uses a 3V coin cell (which only provides a low current) and the forward voltage of the LED is around 3V, the LED will only draw a max of 22mA, which is below its limit of 25mA. This also means that the LED will be nice and bright.

Finally, the push button allows the circuit to be opened, when the LED will be off, or completed, when the LED will be on.

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/35160

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