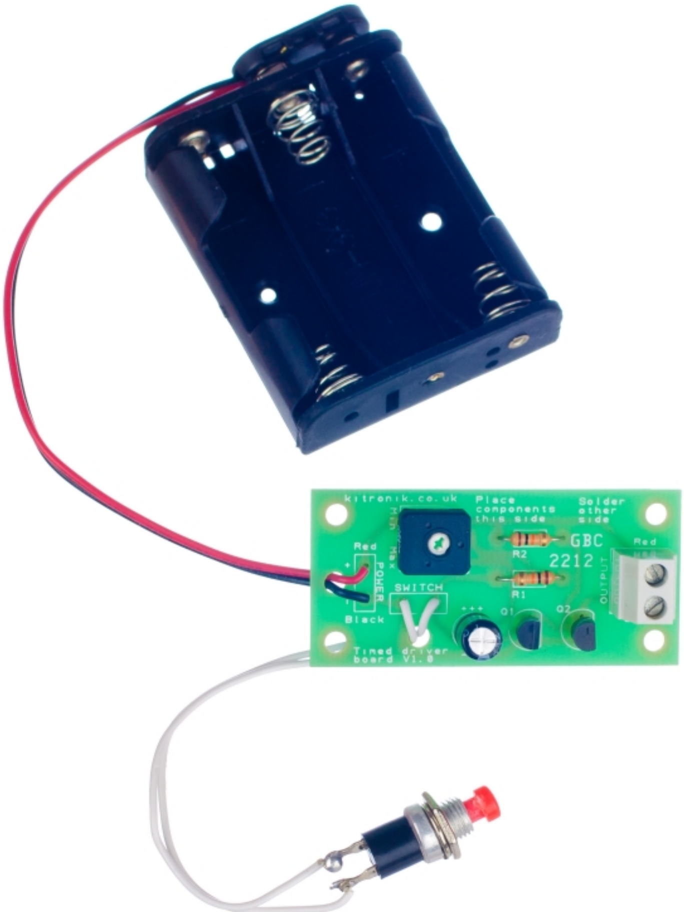
TEACHING RESOURCES

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

MAKE A DISPLAY OF YOUR MOST TREASURED PHOTOGRAPH WITH THIS

LED PICTURE FRAME KIT



Version 2.0

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 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 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. Homework: Collect examples of picture frames. 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 (picture frames). 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 Frame' sheet. Develop a product design using the 'Design' sheet. Homework: Complete design.
Hour 4	Split the students into groups and get them to perform a group design review using the 'Design Review' sheet.
Hour 5	Using the 'Soldering in Ten Steps' sheet, demonstrate and get students to practice soldering. Start the 'Resistor Value' worksheet. Homework: Complete any of the remaining resistor tasks.
Hour 6	Build the electronic kit using the 'Build Instructions'. Homework: Read the sheet on 'Field Effect Transistors (FETs)'.
Hour 7	Complete the build of the electronic kit. Check the completed PCB and fault find if required using the 'Checking Your LED Picture Frame PCB' section and the fault finding information. Homework: Read 'How the LED Picture Frame Works' sheet.
Hour 8	Build the picture frame.
Hour 9	Build the picture frame.
Hour 10	Build the picture frame.
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 Ten 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 LED Picture Frame PCB' and fault finding information.

Answers

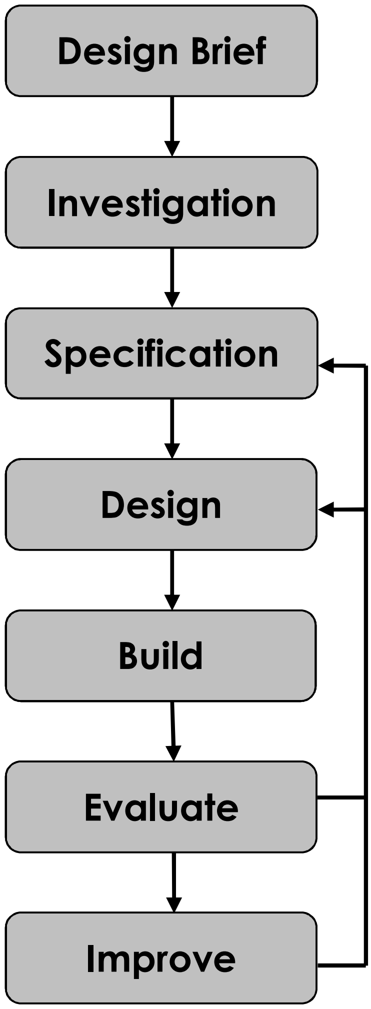
Resistor questions

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.

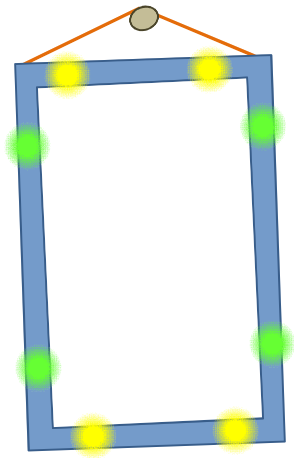
Evaluate

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



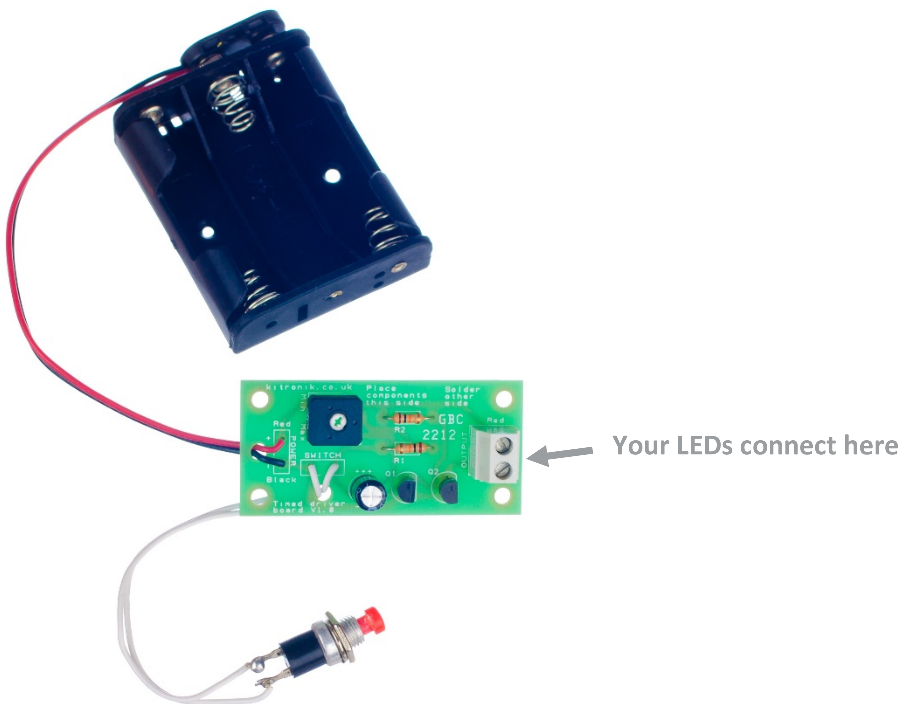
A manufacturer has developed a simple circuit for an LED picture frame. When a button is pressed, a number of LEDs are illuminated for a period of time. The circuit has been developed to the point where they have a working Printed Circuit Board (PCB).

The manufacturer would like ideas for how to design a frame that holds both the PCB and the batteries. They would also like you to consider what colour LEDs to use and where these should be positioned and, therefore, how the final product might look.

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: It should be easy to access the batteries.	Example: So that the batteries can easily be changed when they become flat.

Design

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

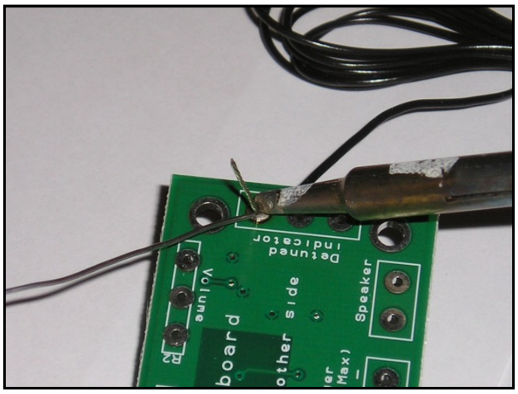
Name…………………………………………… Class……………………………

Design Review (group task)

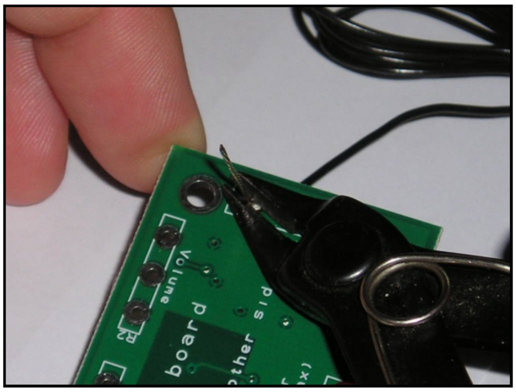
Split into groups of three or four. Take it in turns to review each person's design against the requirements of their specification. Also look to see if you can spot any additional aspects of each design that may cause problems with the final product. This will allow you to ensure that you have a good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

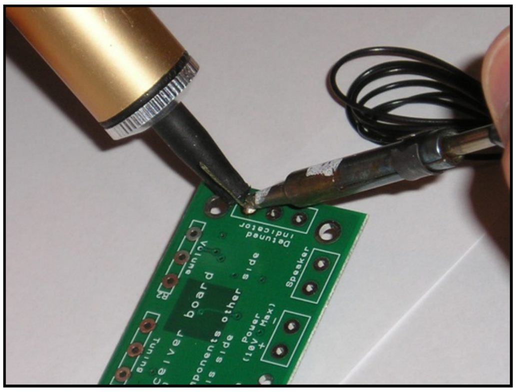
Comment	Reason for comment	Accept or Reject

Soldering in Ten Steps

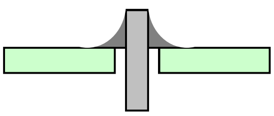


1. Start with the smallest components working up to the taller components, soldering any interconnecting wires last.
2. Place the component into the board, making sure that it goes in the right way around and the part sits flush against the board.
3. Bend the leads slightly to secure the part.
4. Make sure that the soldering iron has warmed up and if necessary, use the damp sponge to clean the tip.
5. Place the soldering iron on the pad.
6. Using your free hand, feed the end of the solder onto the pad (top picture).
7. Remove the solder, then the soldering iron.
8. Leave the joint to cool for a few seconds.
9. Using a pair of cutters, trim the excess component lead (middle picture).
10. If you make a mistake heat up the joint with the soldering iron, whilst the solder is molten, place the tip of your solder extractor by the solder and push the button (bottom picture).

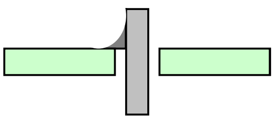




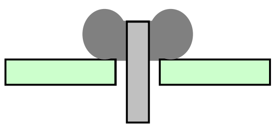
Solder joints



Good solder joint



Too little solder

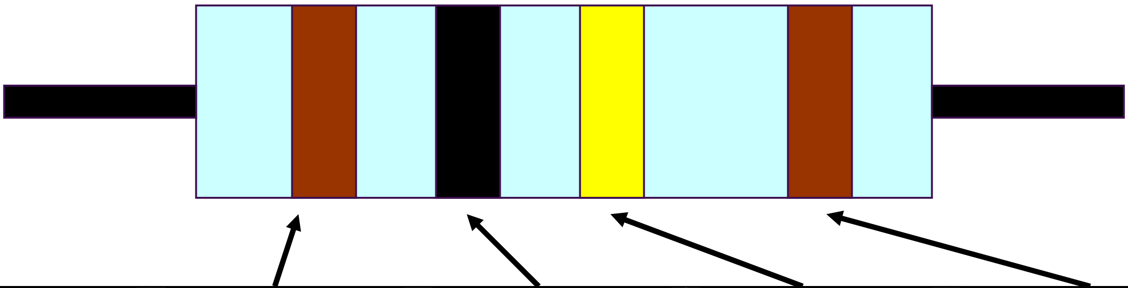


Too much solder

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

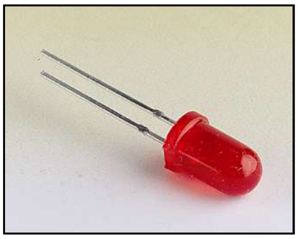
There are a number of different ranges of values for resistors. Two of the most popular are the E12 and E24. They take into account the manufacturing tolerance and are chosen such that there is a minimum overlap between the upper possible value of the first value in the series and the lowest possible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

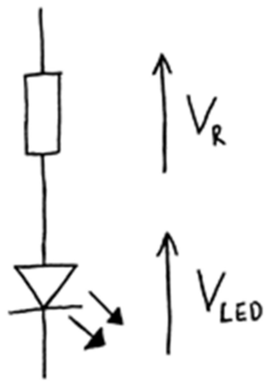
For an LED to light properly, the amount of current that flows through it needs to be controlled. To do this we use a current limit resistor. If we didn't use a current limit resistor the LED would be very bright for a short amount of time, before being permanently destroyed.

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 high brightness LED used in the 'white light' version of the lamp drops 3.5 volts.



The USB lamp runs off the 5V supply provided by the USB connection so there must be a total of 5 volts dropped across the LED (V_{LED}) and the resistor (V_R). As the LED manufacturer's datasheet tells us that there is 3.5 volts dropped across the LED, there must be 1.5 volts dropped across the resistor. ($V_{LED} + V_R = 3.5 + 1.5 = 5V$).

LEDs normally need about 10mA to operate at a good brightness. Since we know that the voltage across the current limit resistor is 1.5 volts and we know that the current flowing through it is 0.01 Amps, the resistor can be calculated.

Using Ohms Law in a slightly rearranged format:

$$R = \frac{V}{I} = \frac{1.5}{0.01} = 150\Omega$$

Hence we need a 150Ω current limit resistor.

LEDs Continued

The Colour Changing LEDs used in the ‘colour’ version of the lamp has the current limit resistor built into the LED itself. Therefore no current limit resistor is required. Because of this, a ‘zero Ω’ resistor is used to connect the voltage supply of 5V directly to the Colour Changing LED.

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 break 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.

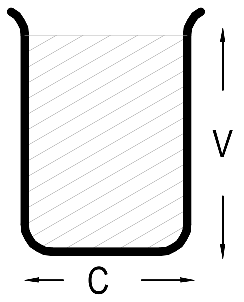
Typical LED applications

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

Capacitor Basics

What is a capacitor?

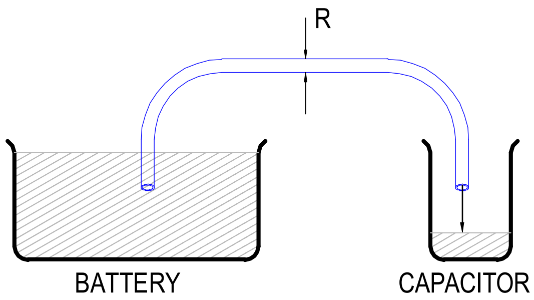


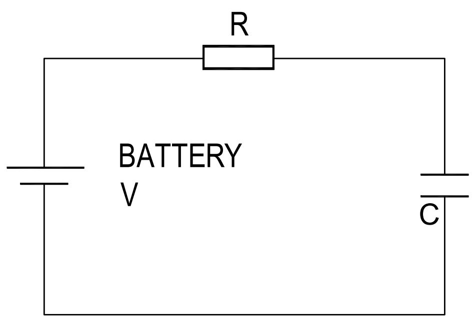
A capacitor is a component that can store electrical charge (electricity). In many ways, it is like a rechargeable battery.

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

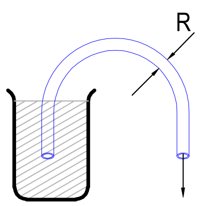




When a capacitor is connected to an item such as a battery, charge will flow from the battery into it. Therefore the capacitor will begin to fill up. The flow of water in the picture above left is the equivalent of how the electrical charge will flow in the circuit shown on the right.

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

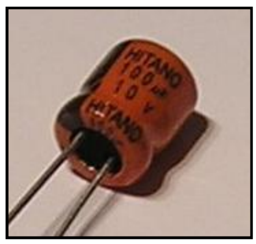


Once a capacitor has been filled with an amount of charge, it will retain this charge until it is connected to something into which this charge can flow.

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.



Field Effect Transistors (FETs)

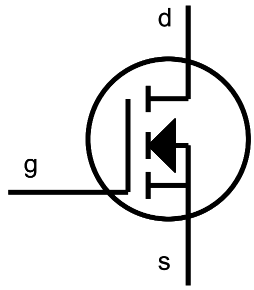
Functionality

An FET is a type of transistor and, like regular transistors, a small amount of power on input of the FET can be used to switch a large amount of power on the output. There are two types of FET: an N-channel and a P-channel. This sheet only examines the N-channel FET.

An FET has three legs: the gate, drain and source. When a voltage is present on the gate (relative to the source), the FET switches on and current flows from the drain to the source. The amount of current that flows into the gate is so small that it isn't worth considering. However the FET will be able to switch anything from a few hundred milliamps to tens of amps depending upon the case that it is packaged in.

Schematic symbol

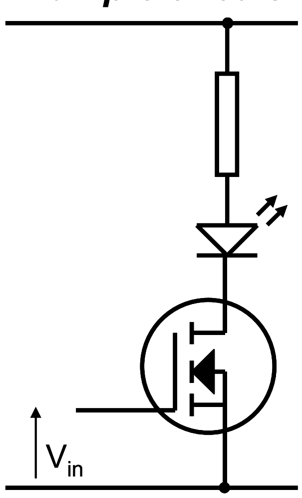
The symbol for an N-channel FET is shown to the right along with the labelled pins.



Current rating

FETs are available in different current ratings; the style of the package changes as the current rating goes up. Low current FETs come in a 'D' shaped plastic package, whilst the higher current FETs are produced in metal cans that can be bolted onto heat sinks so that they don't over heat. The 'D' shape or a tag on the metal can is used to work out which pin does what. All FETs are wired differently so they have to be looked up in a catalogue to find out which pin connects where.

Example circuit



In this circuit an FET is connected to an LED, however it could be used to drive any load including higher power loads. When V_{in} is at zero volts the gate of the FET has no voltage on it, and no current flows through the LED. When V_{in} is high the FET turns on and current flows through the FET from the drain to the source and the LED lights.

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

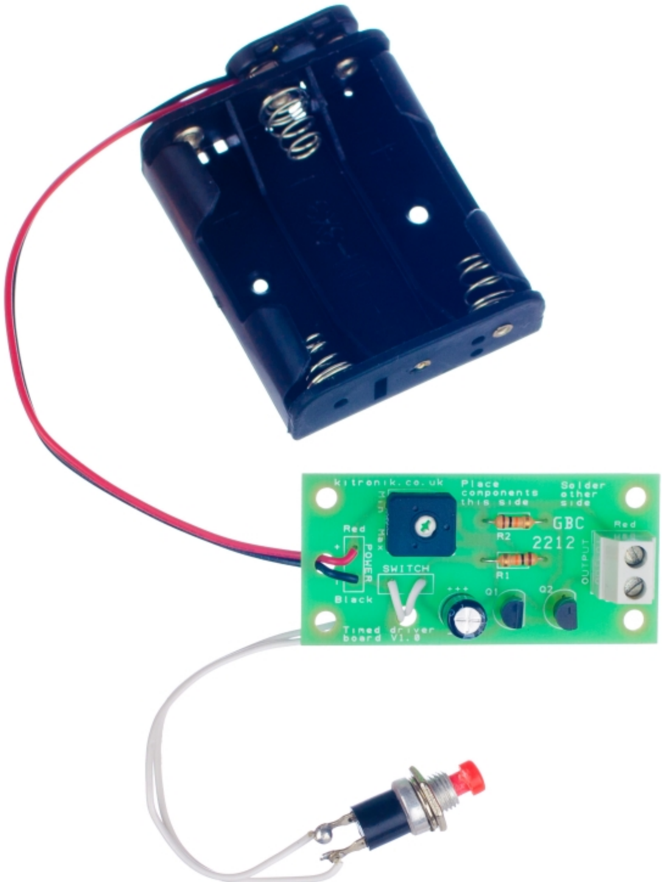
Develop a packaging design for your product that meets these requirements. Use additional pages if required.

ESSENTIAL INFORMATION

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

MAKE A DISPLAY OF YOUR MOST TREASURED PHOTOGRAPH WITH THIS

LED PICTURE FRAME KIT



Version 2.0

LED Picture Frame Essentials

www.kitronik.co.uk/2146

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 two resistors:
The text on the PCB shows where R1 and R2 go.
Ensure that you put the resistors in the right place.

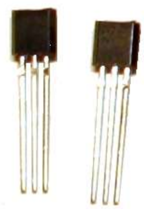
PCB Ref	Value	Colour Bands
R1	10K	Brown, black, orange
R2	10K	Brown, black, orange

2 SOLDER THE VARIABLE RESISTORS

Solder the variable resistor into R3. It will only fit in the holes in the board when it is the correct way around.

3 SOLDER THE FETs

The two FETs should be placed into Q1 & Q2. Both are the same type but it is important that they are inserted in the correct orientation. Ensure that the shape of the device matches the outline printed on the PCB. Once you are happy, solder the devices into place.



4 SOLDER THE ELECTROLYTIC CAPACITOR

The capacitor C1 is an electrolytic capacitor and needs to be put into the board the correct way around. The capacitor has a '-' sign marked on it, which should match the same sign on the PCB. Now solder the capacitor.

5 SOLDER THE 2-WAY TERMINAL BLOCK

Solder the 2-way terminal block into the 'OUTPUT' connection. The terminal connections should face the edge of the board.

6 ATTACH THE BATTERY CLIP

Now you must attach the battery clip. It needs to be connected to the terminals marked 'POWER'. First feed the pair of wires up through the hole next to the power connection. The red lead should be soldered to the '+' terminal, which is also marked 'red', and the black lead should be soldered to the '-' terminal which is also marked 'black'.

7 SOLDER THE SWITCH

To attach the start switch, first cut and strip two short lengths of the wire supplied. Solder one to each of the two terminals on the switch. Now take the other end of the wires and feed them through the strain relief next to the connection marked 'SWITCH'. Solder the wires to the 'SWITCH' pads. It does not matter which way around the two wires go.

Checking Your LED Picture Frame PCB

Carefully check the following before you insert the batteries:

Check the bottom of the board to ensure that:

- All holes (except the 4 large (3mm) holes in the corners) are filled with the lead of a component.
- All these leads are soldered.
- Pins next to each other are not soldered together.

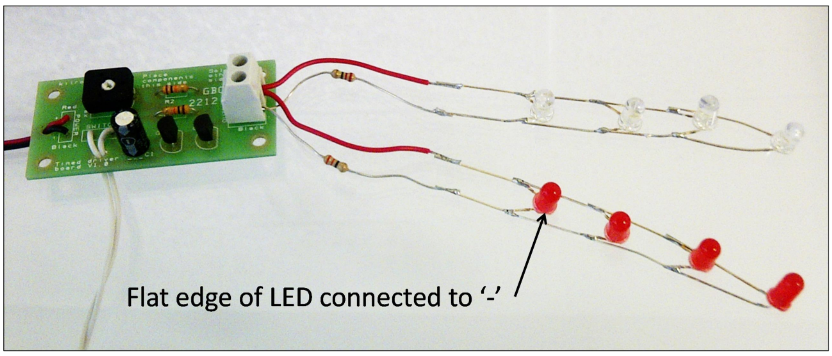
Check the top of the board to ensure that:

- The red and black wires on the battery clip match the red and black text on the PCB.
- The '-' on the capacitor match the same marks on the PCB.
- The 'D' shape of Q1 & Q2 match the outline on the PCB.

Connecting LEDs to the Board

The output terminals have about 4.5 Volts on them when the button is pressed, most LEDs require a lower voltage than this. This means that a current limit resistor will be required. In theory, every LED should have its own current limit resistor. In practice, if the LEDs that are being used are from the same batch and the LEDs aren't high power LEDs, then it is possible to share one current limit resistor between a number of LEDs. When this is done the resistor value will be smaller than the resistor that is used with a single LED. When different types of LEDs are used, a separate resistor is required for each type of LED.

Suppose a red LED and a white LED is going to be positioned in each corner of a picture frame, then the four red LEDs would be connected in parallel and the four white LEDs in parallel. Each then shares a current limit resistor. The picture below shows these connections. This example is connected to make it easy to see how to do the connections; in reality longer wires would be needed.



Current limit resistor for **four** LEDS

3504 Standard red	33Ω
3505 Standard green	33Ω
3506 Standard yellow	33Ω
3542 Standard white	22Ω
3543 Standard blue	22Ω
3507 Ultra bright red	33Ω
3524 Ultra bright white	68Ω
3537 Ultra bright blue	68Ω

Testing the Board

Connect the PP3 clip to the 3x AA battery cage. **Do not use with 9V**.
To test the board, turn the trimmer potentiometer to ‘Min’ and then turn it back slightly. When the button is pressed the LEDs should turn on for a few seconds. The required duration can now be set with the potentiometer.

Fault Finding Information

There are only a few things that can happen if there is a mistake on the board. Generally nothing will happen, however the LED may function incorrectly. Find the description that best describes what fault is present and then check the items listed below the heading.

Nothing happens
Check the following:

- The batteries are good and in the holder the right way around.
- The LEDs are connected to the board the right way around.
- The power connection is the right way around and have dry joints.
- Check the switch for dry joints (on the switch & PCB).
- Check capacitor C1 for a solder short.
- A short or dry joint on the centre pin on Q1.
- Q1 is in the right way around.
- Check Q2 for a short or dry joint.
- Check R2 for dry joints.

The LED is on before the switch is pressed and stays on
Check:

- Q1 for a short.
- Q1 for dry joints on the edge two pins.
- Q2 for a short (if the LEDs go off when the button is pressed, this will be the fault).
- Q2 is the right way around (if the LEDs get brighter when the button is pressed, this will be the fault).

The LEDs are on only whilst the button is pressed
There is a dry joint on the capacitor C1.

The LEDs go on when the button is pressed but then never turns off
There is a dry joint on R1 or R3.

The LEDs flicker on power up
There is a solder short on Q1.

LED Picture Frame Essentials

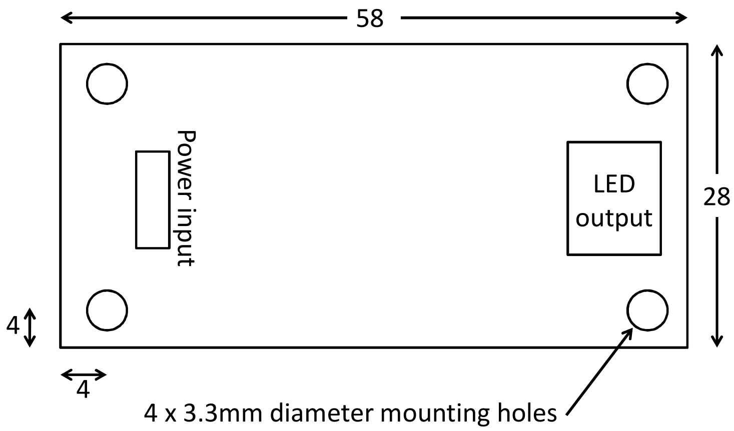
www.kitronik.co.uk/2146

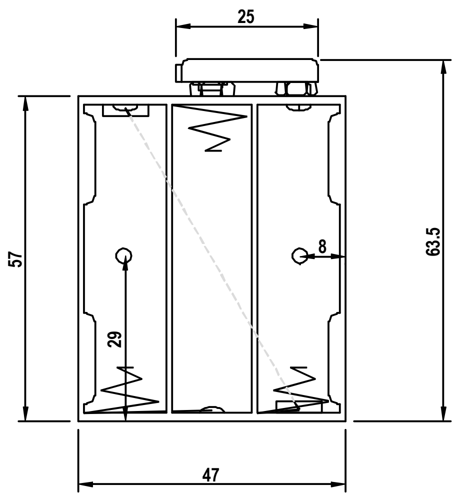
Designing the Frame

When you design the picture frame, you will need to consider:

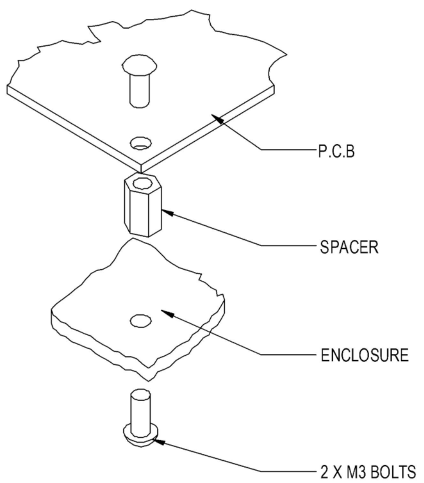
- The size of the PCB (below left, height including components = 15mm).
- How big the batteries are (below right, height = 16mm).
- Where on the picture frame you want the LEDs positioning.

The technical drawings of the PCB & battery case should help you to plan this.





All dimensions in mm

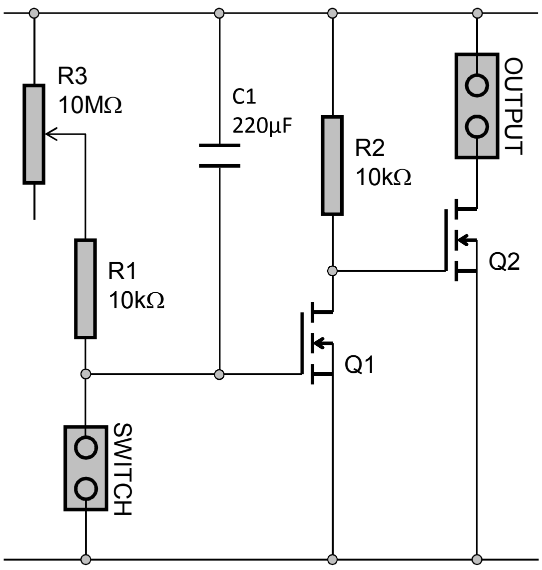


Mounting the PCB to the enclosure

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 four mounting holes designed to take M3 bolts.

How the LED Picture Frame Works



The circuit is triggered when the switch is pressed. At this point, current flows through the switch and charges the capacitor C1. When the switch is released the capacitor will still be full of charge and starts to discharge through R1 / R3. As the capacitor discharges there is less and less voltage across it, as this happens the voltage on the gate of the FET (Q1) gets closer to the positive voltage of the circuit.

The FET operates like a switch: when voltage is present on the gate, current can flow thought the FET. So in this circuit, when the capacitor is charged there is no voltage on the gate but as it discharges, the voltage at the gate increases. When this gets to approximately 2 Volts the FET switches on.

When the capacitor is charged and Q1 is off, the gate of Q2 is held high by the pull up resistor R2. Since a voltage is present on the gate of Q2, the output will be on and the LEDs that are connected to it will be on. As the capacitor discharges and a voltage becomes present on the gate of Q1, the FET Q1 turns on taking the gate of Q2 low and the LEDs turn off.

Although the switching point on FETs is a lot sharper than on a transistor, when there is a gradual change in voltage on the gate input the output gradually turns off. This is noticeable when different LEDs are used that have a different forward voltage as they can be seen turning off at different times. By adding the second FET, the circuit output goes from on (having full Volts on it) to off (no Volts) instantly.

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/2146

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

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