TEACHING RESOURCES

HOW TO SOLDER GUIDE
BUILD INSTRUCIONS
HOW THE KIT WORKS

DEVELOP YOUR SOLDERING SKILLS WITH THIS

LEARN TO SOLDER CLASS PACK

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.

This kit has been designed to give students soldering experience, with simple component placement.
Testing of a completed board is as simple as placing it on a PP3 battery and visually inspecting the solder joints.

This booklet contains a wealth of material to aid the teacher, both with teaching soldering, and with ongoing projects that may require attention to ensure a successful outcome for the student.

Using the booklet

The first page of this booklet contains 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.

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*

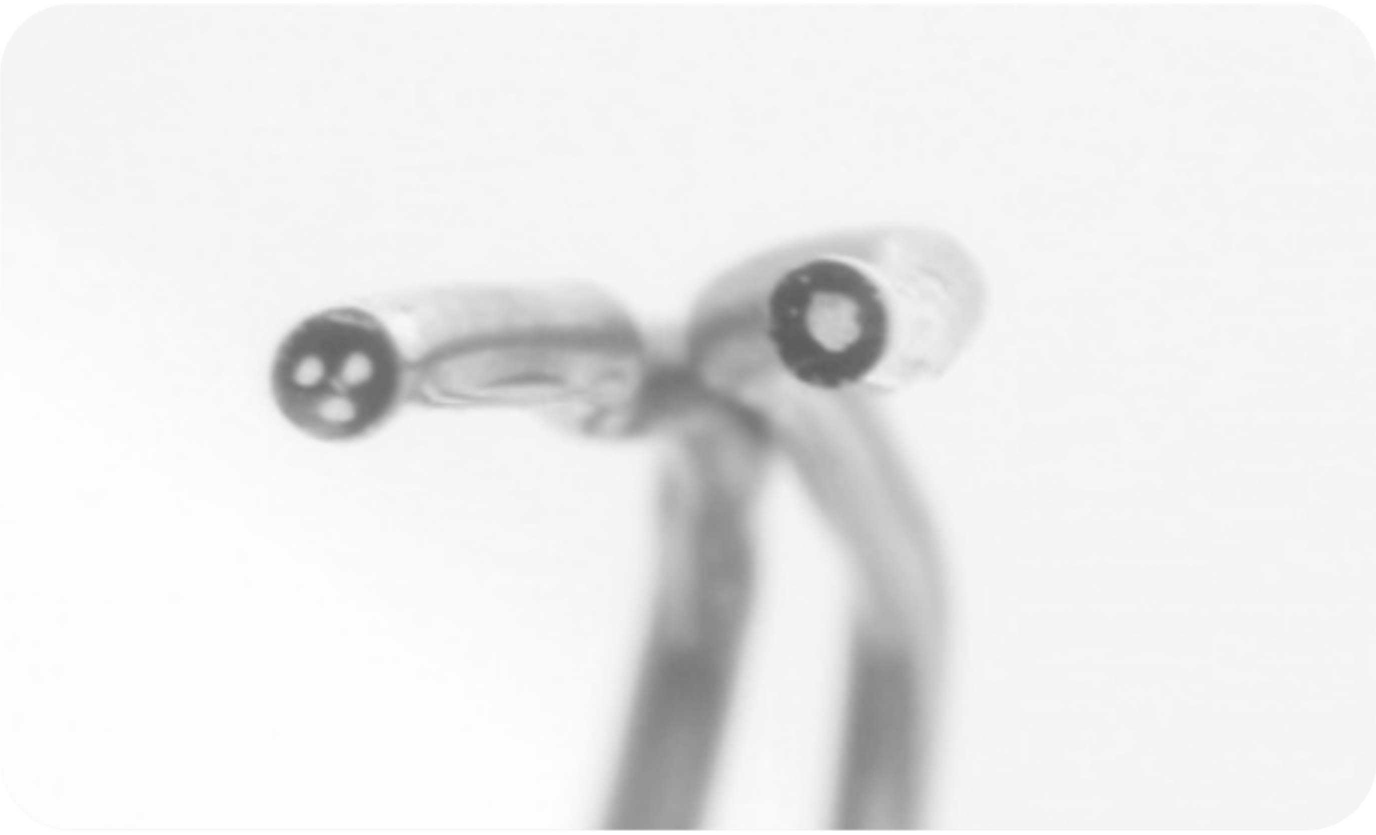
Value	1st Band	2nd Band	Multiplier x
180 Ω	Brown	Grey	*Brown*
3,900 Ω	Orange	White	*Red*
47,000 (47K) Ω	Yellow	Violet	*Orange*
1,000,000 (1M) Ω	Brown	Black	*Green*

A Little About Solder

Soldering is a process for joining metals. In soldering the metals to be joined are ‘glued’ together by melting another metal, whose melting point is lower than the metals to be joined.
Other similar metal joining processes include welding and brazing.
Brazing is a stronger, higher temperature version of soldering.
The Welding Institute defines the difference between soldering and brazing as the temperature at which the filler metal melts. Below 450 °C the process is soldering, above 450 °C it is brazing.

Solder is available in several different alloys. Before the Restriction on Hazardous Substances (RoHS) legislation electronic solder was typically made from an alloy containing 60% Tin and 40% Lead. This melts at 183 °C
RoHS legislation restricts the use of lead, and other metals, in electronic assemblies. This has led to the development, and widespread use, of lead free solders.
Typical lead free solders contain mostly tin, with small amounts of copper, and silver. The melting point varies with the alloy, but is typically 220 °C to 240°C.

Heating metal in the air causes oxidisation. This is a cause of poor joints. To prevent this solder needs to have a flux.
Solders used for hand assembly of electronics usually include the flux as part of the solder. The manufacturer has selected the most appropriate flux and incorporated it in tiny holes that run the length of the wire.
The photograph shows 2 different solders, one has 3 cores of flux, and the other has a single flux core. The flux core is visible as the white areas in the end of the wire.



Tools and Equipment

To solder electronic kits the following tools and equipment are usually required:

Soldering Iron and Stand

This provides the heat to melt the solder. There are many different types of Soldering iron, but they all have a handle to hold, and a tip that gets hot. It is usually held like a large pencil.

Because the soldering iron gets hot it is essential to have a safe place to put it down. A soldering iron stand provides this. It usually has a spring like surround to guard the hot tip, and a place to put a sponge, or brass shavings to clean the tip prior to use.

Soldering Irons often have interchangeable tips. This allows the best tip to be used for different jobs. For instance, soldering a thick cable requires a larger tip, with a greater heat capacity. Soldering a fine pitched integrated circuit needs a very fine tip to be able to get at the individual legs.

De-soldering Tool

Occasionally it is useful to be able to unmake a soldered joint. To do this a de-soldering tool is used in conjunction with the soldering iron.

The de-soldering tool has a spring-loaded plunger, and a heat resistant nozzle. When the plunger is released it creates a short burst of suction that is used to suck up the molten solder away from the joint. Because of this the tool is often known as a solder sucker.

Wire cutters

Once the components have been soldered it is usual to trim off the excess leads. To do this a pair of wire cutters are used.

Helping Hands

Holding the soldering iron, the solder, and the things to be soldered is tricky. Helping Hands are a pair of crocodile clips attached to some flexible mounts that have a heavy base for stability. They can be used to hold PCBs and wires for soldering, leaving actual hands free to manouver the soldering iron and solder.

Care of Soldering Irons

Soldering Iron tips are hot. As a result, they are subject to the same sort of oxidisation that can affect the solder. They also suffer from being repeatedly heated and cooled.

Although the tip is robust it does require a small amount of maintenance.

Before starting to solder examine the tip. It should be clean and shiny. Wipe off any accumulation of carbon, old solder and similar debris on the sponge or brass shavings.

This tip shows a build-up of deposits:

If after cleaning on the sponge / brass shavings the tip is still not shiny then melt a small amount of solder onto it and clean again. The flux in the solder will help to clean the tip.

If the tip is still not clean and shiny then use a tip cleaner. This is a mixture of a more aggressive flux than usually found in solder, and powdered solder. The flux in tip cleaner removes the oxidisation and build up from the soldering iron tip, and then the solder re tins the tip ready for use. Soldering Iron tips do not last forever. Eventually they wear out. Common signs that the tip needs replacing are: a hollow forming in the end of the tip, cleaning and re-tinning has no effect, or needs frequent repeating.

Some new soldering iron tips require tinning before their first use. To do this apply a little solder, or tip tinner / cleaner as the iron warms up. This will give the tip its initial clean shiny appearance.

How to use the Tip tinner/cleaner

1 HEAT IRON

Heat the soldering iron as normal.

2 DIP INTO CLEANER

Dip the hot tip into the tin of tinner/ cleaner.

3 TWIST IRON

Twist the tip in the tinner/cleaner. This will coat the iron in a mixture of flux and solder.

4 WIPE EXCESS

Wipe the iron on a damp sponge to remove the excess.

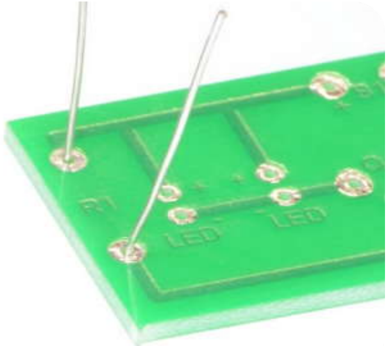
5 REPEAT (OPTIONAL)

This should lead to a clean shiny tip, ready for use.

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.

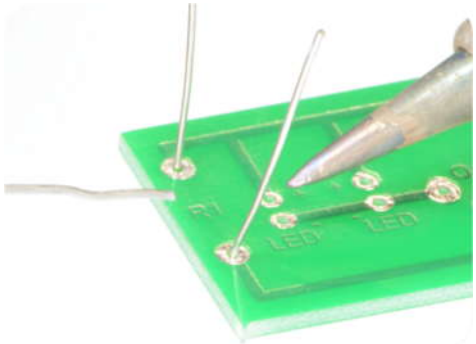


2 CLEAN SOLDERING IRON

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

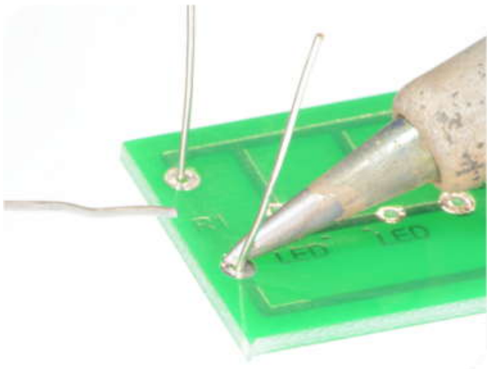
3 PICKUP IRON AND SOLDER

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



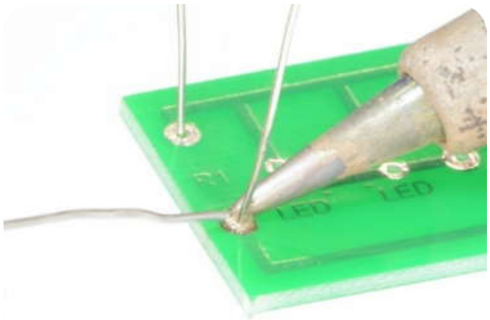
4 HEAT PAD

Place soldering iron tip on the pad.



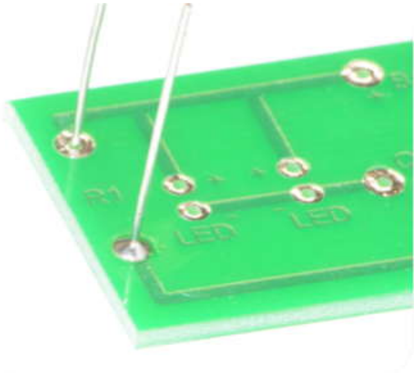
5 APPLY SOLDER

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



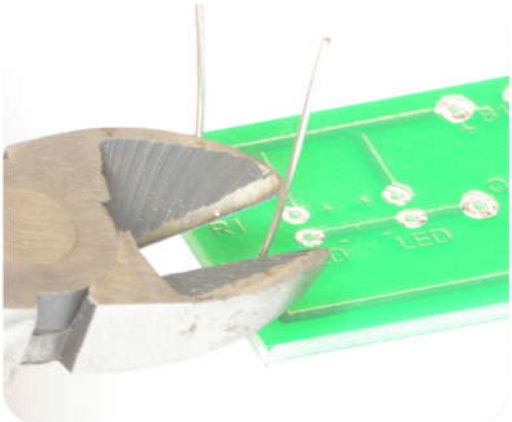
6 STOP SOLDERING

Remove the solder, then remove the soldering iron.



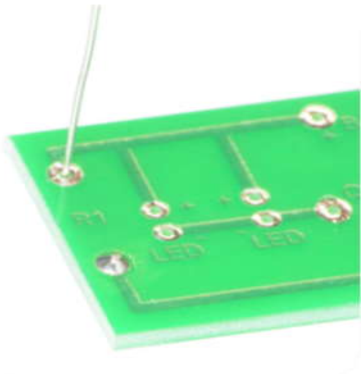
7 TRIM EXCESS

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

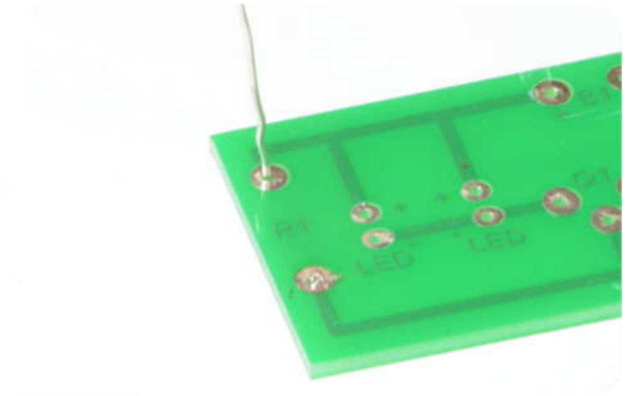
Heat the joint to be de-soldered with the soldering iron. Keep the tip of the solder sucker close to the joint, ready to use

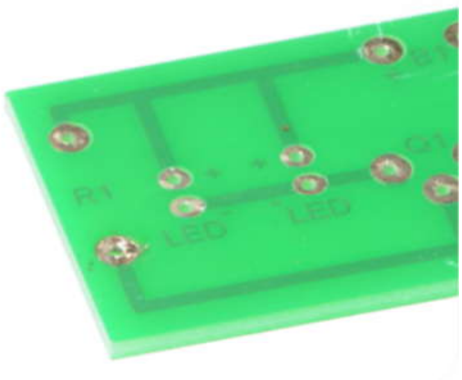
4 ACTIVATE EXTRACTOR

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.





Soldering Wire Connections

Some connections are made with stranded wire. It is usual to ‘tin’ wire to make it easier to place through the holes in the PCB, and to help it solder successfully.

1 STRIP WIRE

To tin wire firstly strip a small length of the insulation off.

2 TWIST WIRE

Then twist the strands together to form a single neat core.

3 APPLY HEAT

With the soldering iron in one hand, and solder in the other place the soldering iron tip at the end of the twisted core. This will heat the wire.

4 APPLY SOLDER

‘Wipe’ the end of the solder down the twists. This will melt when the wire is hot enough and apply a small amount of solder.

A well tinned wire only has a small amount of solder on it, just enough to hold the twist together. It should be possible to see the twisted strands through the solder.

Examples of Solder joints

The appearance of a solder joint tells a lot about how good it is. A good solder joint is shiny. This means that the solder has not been overheated and exhausted the flux.

1 IDEAL JOINT

This photo shows an ***ideal*** solder joint: there is enough solder to form a nice fillet, without excessive solder bulging out. The component leg is ideally in the centre of the joint.

2 ACCPETABLE JOINT

The following illustrates an ***acceptable*** solder joint: the solder is shiny, but there is slightly more solder than required, and the component leg is off centre.

Learn to Solder Teaching Resources

www.kitronik.co.uk/2163

It can be tricky to add just the correct amount of solder when learning. The following photos show typical bad joints.

1 NOT ENOUGH SOLDER

2 SLIGHTLY TOO MUCH SOLDER

The PCB tracks are covered in a special paint called solder resist. This helps prevent the solder from flowing away from the joint. As more solder is added it builds into a blob, as shown in the next 2 photos:

3 TOO MUCH SOLDER

4 FAR TOO MUCH SOLDER

Too much solder on a joint can cause bridging to adjacent components, leading to a short circuit.

Solder contains flux to ensure the joints are sounds and not oxidised. The flux works by reacting with the oxides that are present, and converting them back to metals.

Overheating the joint, or taking too long can use all the available flux. This leads to the solder oxidising and what is known as a dry joint. The following joints are also 'Dry'. Note that a dry joint does not necessarily mean that it does not have enough solder, but refers to the solder not 'wetting' the component and the pad correctly to flow.

5 DRY JOINT

Notice the 'Orange Peel' roughness of the solder. This is caused by the metal in the solder turning to oxides.

6 TOO MUCH SOLDER & DRY

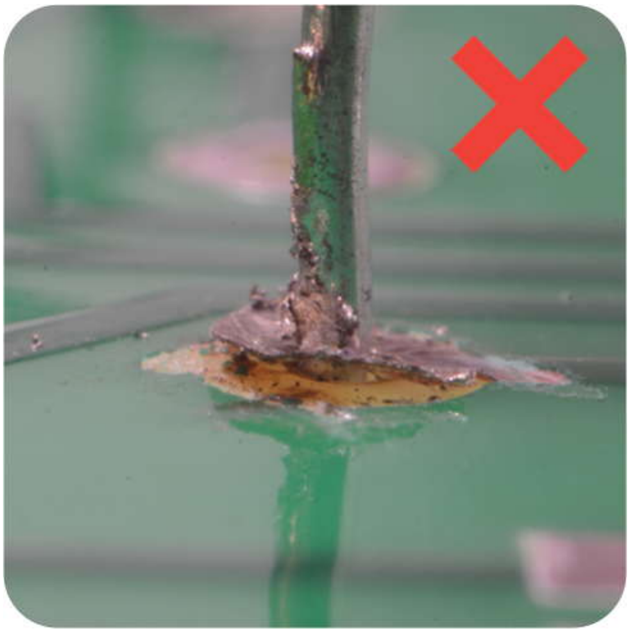
This joint, with too much solder, is also showing the symptoms of dry joints – notice the dull grey colour, and orange peel texture.

7 NOT ENOUGH SOLDER & DRY

Compare this dry joint with too little solder to the earlier one with too little solder – notice the comparatively dull appearance of the solder on the dry joint.

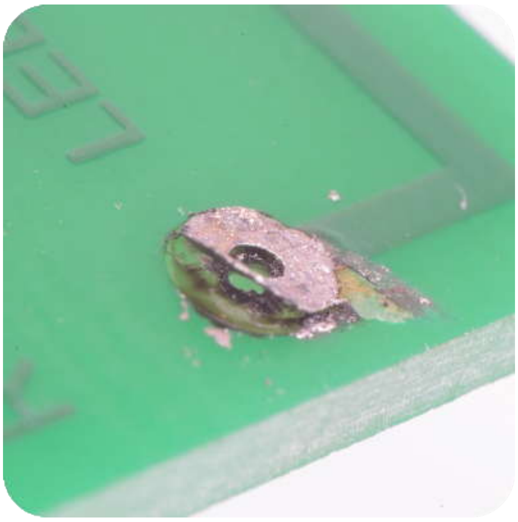
8 OVERHEATED

Overheating a solder pad on a PCB can also cause the copper layer to come away from the fibre glass that the board is made from. This can cause circuit failure when the track on the circuit board breaks, leading to an open circuit.



Simple Circuit Board Repair

Printed Circuit Boards (PCB) are made from layers of fibre glass and copper, glued together.
Whilst the glues used are very heat resistant it is possible to overheat a PCB and damage it.
Kitronik PCB designs use large tracks and pads to help make this a rare problem, the larger amount of copper helps to dissipate the heat.

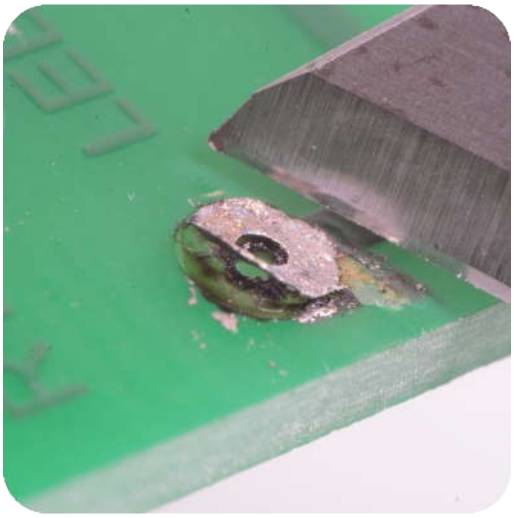


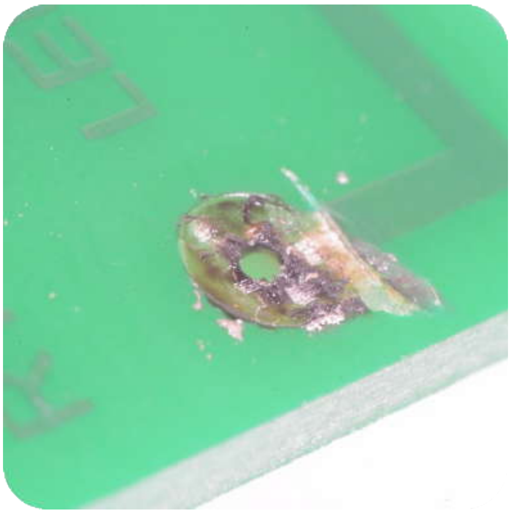
If a PCB is overheated the most likely outcome is that the copper layer will delaminate from the fibre glass board. This usually leads to broken joints and a non-working circuit.

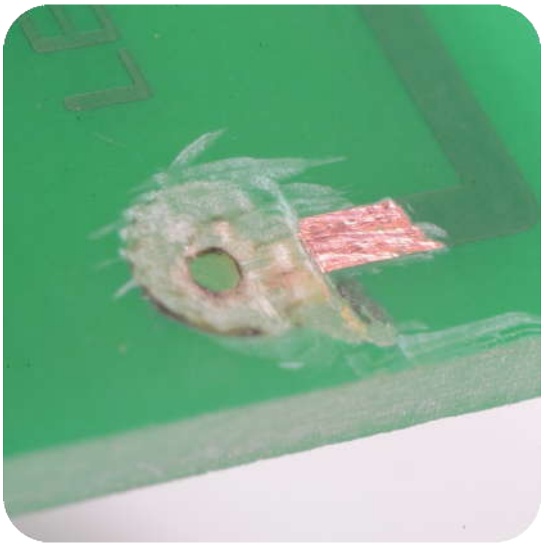
It is possible to repair some faults using adhesive copper tape and solder.

1 REMOVE DAMAGE

Remove as little of the damage as possible to get back to a sound track. Cutting through the damaged tracks with a sharp knife will help to limit additional damage during removal.





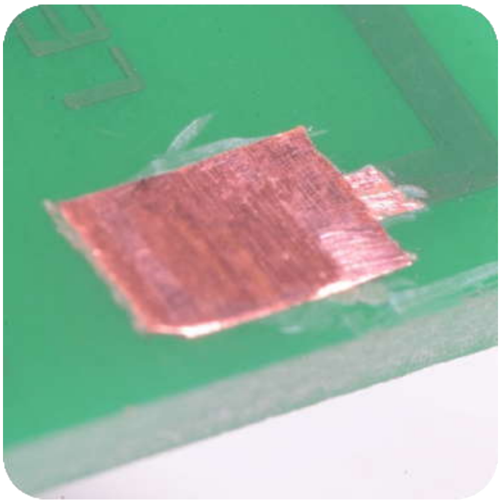


2 REMOVE SOLDER RESIST

Scrape a little of the solder resist off with a knife, sharp screwdriver, or fine sandpaper. Ensure that the exposed track is clean and shiny. It is also a good idea to clean any residual burnt PCB material off, to allow the tape to stick well.

3 ADD COPPER TAPE

Stick on some of the copper tape. Overlap the existing track very slightly.

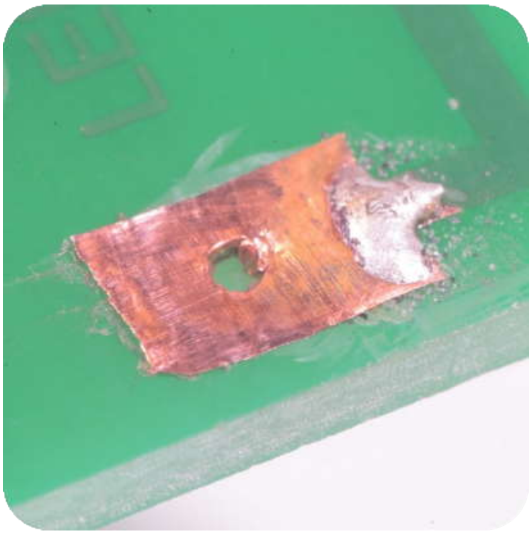


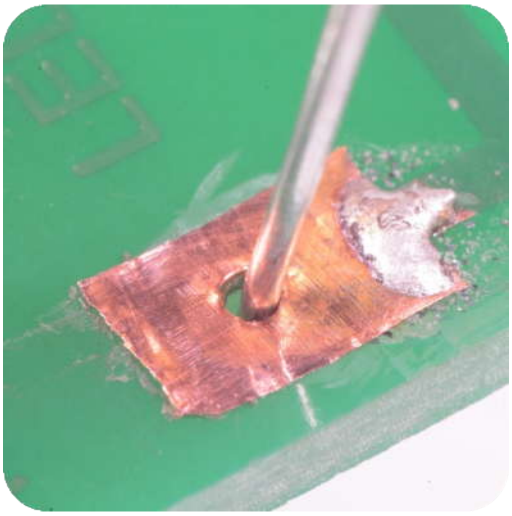
4 SOLDER JOINT

Carefully solder the joint(s) where the repair has taken place. Most copper tape adhesive melts at soldering temperatures, so be quick and use as little heat as possible. When the tape cools the adhesive will usually remain sticky.

5 PRESS TAPE HARD ONTO PAD

Rub over the pad area with a hard, rounded item, such as the none writing end of a biro. This will push the copper tape down over the pad area. The pad hole will show through the tape, and can then be pierced with a component lead, paperclip, or similar.



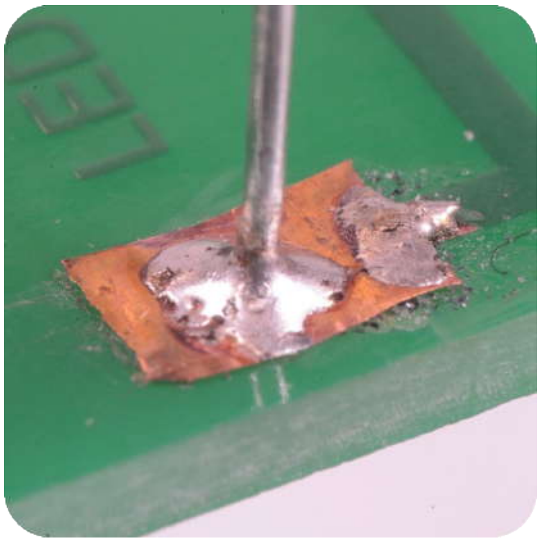


6 TRIM EXCESS (OPTIONAL)

The Copper tape can be cut to size with scissors, craft knife etc. Once a repair has been made it is also possible to trim the excess tape. If this is done exercise caution, as the repair is more fragile than the original PCB track, and may become unstuck again.

7 SOLDER COMPONENT

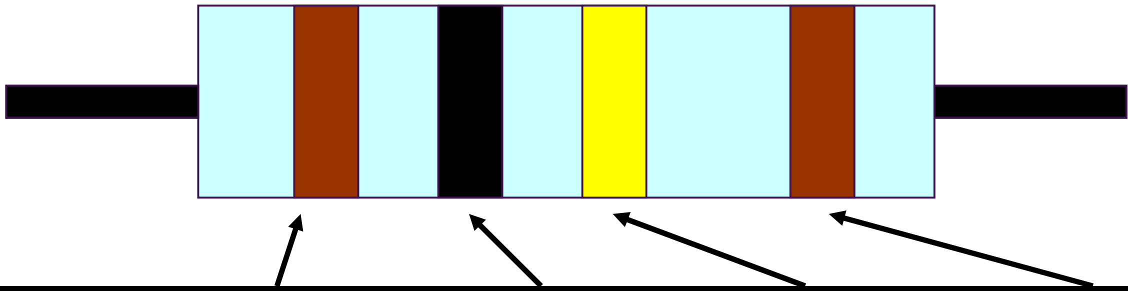
The component can then be fitted and soldered in the normal manner. Keep the heat input form the soldering as brief as possible, as the adhesive and the additional joint attaching the new pad are sensitive.



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

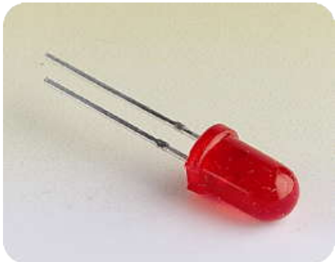
There are a number of different ranges of values for resistors. Two of the most popular are the E12 and E24. They take into account the manufacturing tolerance and are chosen such that there is a minimum overlap between the upper possible value of the first value in the series and the lowest possible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

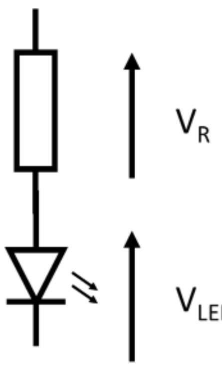
Ohms Law tells us that the flow of current (I) in a circuit is given by the voltage (V) across the circuit divided by the resistance (R) of the circuit.

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

Like diodes, LEDs drop some voltage across them: typically 1.8 volts for a standard LED.

The Learn to Solder kit is designed to runs off a 9 volt PP3 battery so there must be a total of 9 volts dropped across the LED (V_{LED}) and the resistor (V_R). As the LED manufacturer's datasheet tells us that there is 2.1 volts dropped across the LED, there must be 6.9 volts dropped across the resistor. ($V_{LED} + V_R = 2.1 + 6.9 = 9V$).

From the datasheet, this LED has a maximum current of 25mA. Since we know that the voltage across the current limit resistor is 6.9 volts and we know that the current flowing through it should be less than 0.025 amps the minimum resistor needed can be calculated.



Using Ohms Law in a slightly rearranged format:

$$R = \geq \frac{V}{I} = \frac{6.9}{0.025} \geq 276\Omega$$

Hence, we need at least 276Ω current limit resistor. Typically, an LED will operate at a good brightness with 10mA of current. That would give a current limit resistor of 690 Ω. In this kit, there are 4 100 Ω resistors, giving a current of 17.5mA.

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 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

ESSENTIAL INFORMATION

BUILD INSTRUCIONS
HOW THE KIT WORKS

DEVELOP YOUR SOLDERING SKILLS WITH THIS

LEARN TO SOLDER CLASS PACK

Version 1.0

Learn to Solder

www.kitronik.co.uk/2163

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 resistor R1. The text on the PCB shows where R1 should go. It doesn't matter which way around the resistor goes into the board. Solder the resistor, remembering to trim the legs afterward.
Repeat with R2, R3 and R4.

PCB Ref	Value	Colour Bands
R1,R2, R3, R4	100Ω	Brown, black, brown

2 PLACE THE LED

Solder the LED. Ensure that the positive leg is inserted into the correct hole. The positive leg is the longer one. Use the PCB markings to help.

3 INSPECT YOUR WORK

Check there is a component in each place indicated on the PCB.

Check all the solder joints are good.

4 TEST YOUR WORK

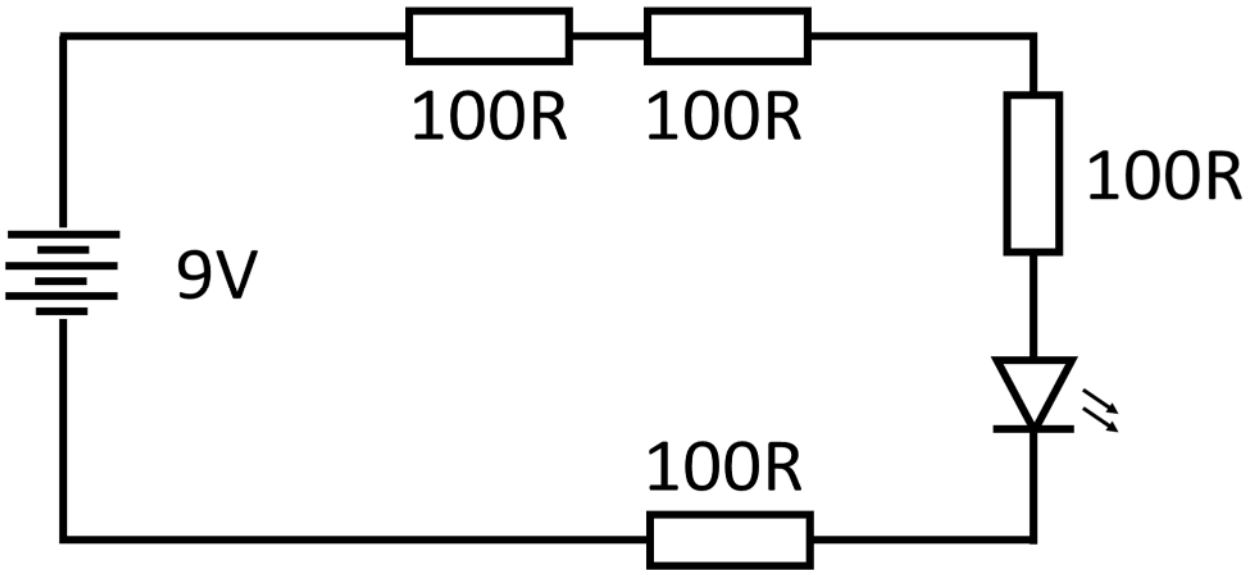
Place the PCB on a PP3 battery.

Check the LED lights up.

Checking Your Learn to Solder PCB

- Check the solder joints are all good.
- Is the LED correct way round?

How the Learn to Solder PCB Works



The circuit diagram for the Learn to Solder PCB is shown above. It is a very simple circuit. The 9V battery that powers the circuit is connected via the PCB pads.

LEDs can be damaged if the current through them is not limited.

With a 9V battery, and forward voltage drop of 2.1V on the LED, a 400 Ω current limiting resistor will give a current of 17.5mA. The LED specification is maximum current of 25mA, so the LED will light with good brightness.
The resistance has been split to give 8 solder joints to practice, rather than 2. The 4 100Ω resistors in series add up to 400 Ω.

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/2163

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

www.kitronik.co.uk/facebook

www.kitronik.co.uk/youtube

www.kitronik.co.uk/google