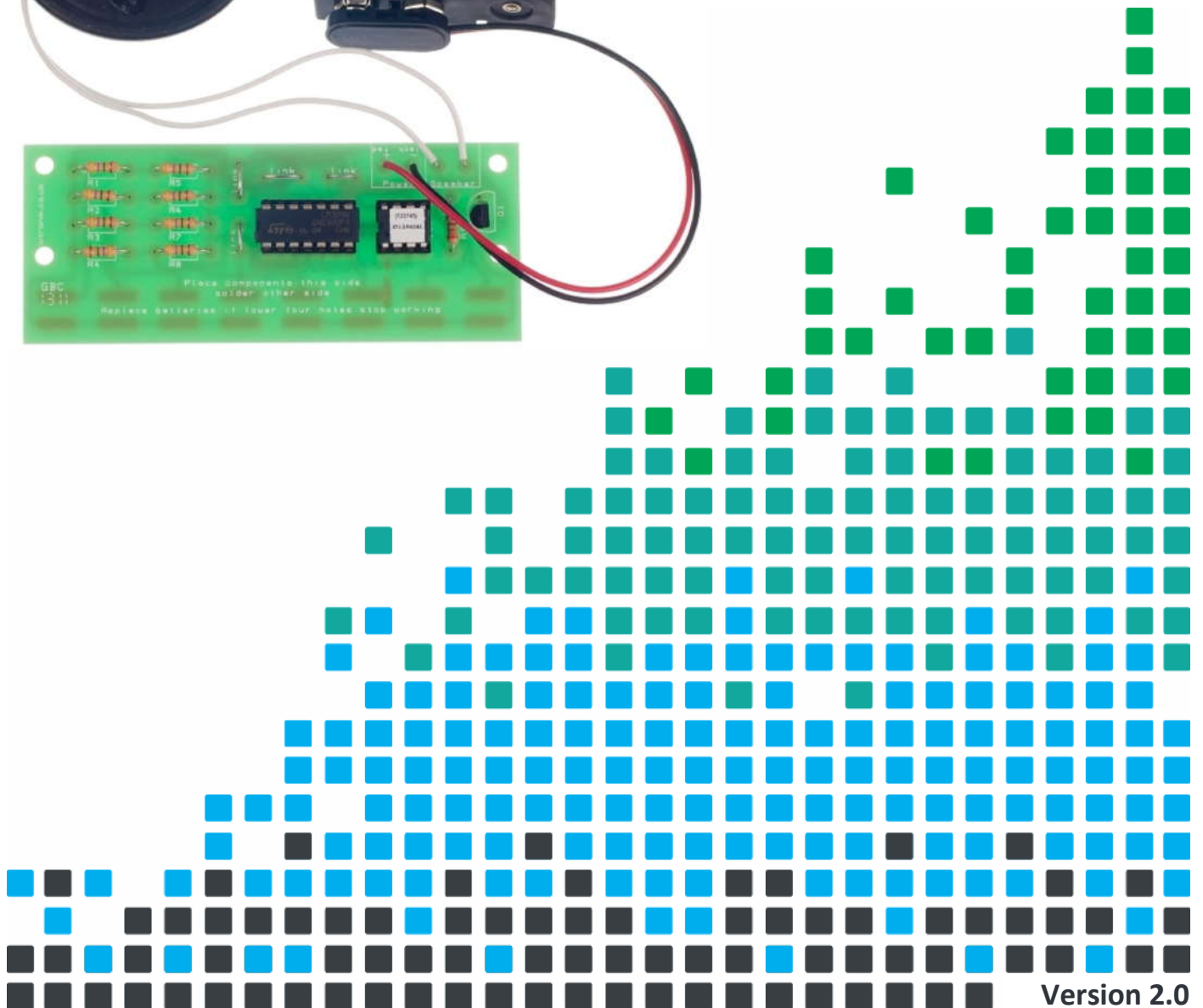
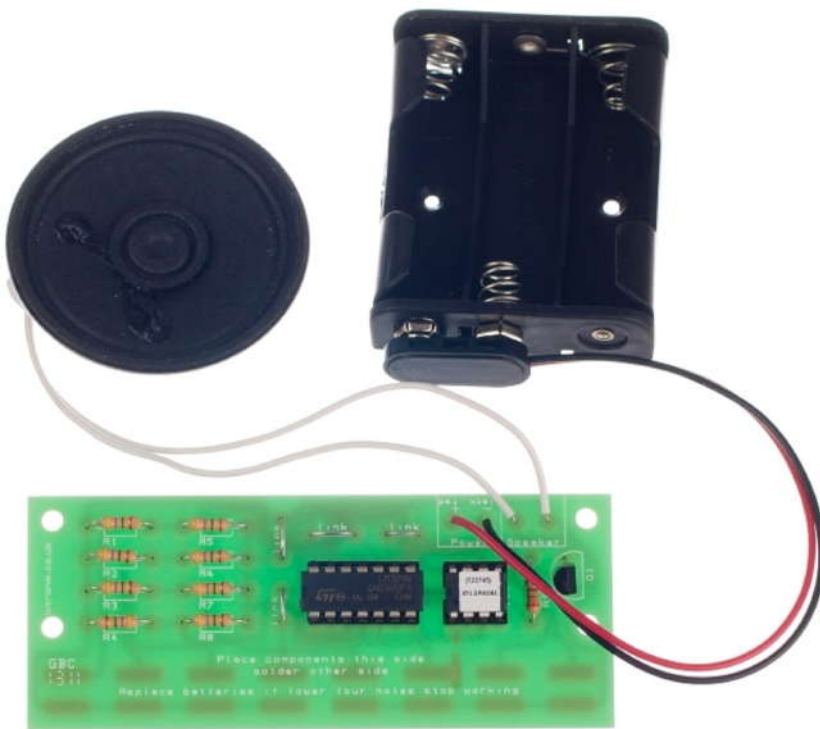


CREATE YOUR OWN ELECTRONIC MUSICAL INSTRUMENT WITH THIS

# XYLOPHONE KIT



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## 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](http://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. <u>Homework:</u> Collect examples of electronic products that are sold to the target market (e.g. keyboards etc.). 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. <u>Resource:</u> Sample of products designed for the target market. <u>Homework:</u> 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. <u>Homework:</u> 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 Ten Steps' sheet, demonstrate and get students to practice soldering. Start the 'Resistor Value' worksheet. <u>Homework:</u> 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 Xylophone PCB' section and the fault finding flow chart. <u>Homework:</u> Read 'How the Xylophone Works' sheet.
Hour 9	Build the enclosure. <u>Homework:</u> Collect some examples of instruction manuals.
Hour 10	Build the enclosure. <u>Homework:</u> Read 'Instruction Manual' sheet and start developing instructions for the xylophone.
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 Xylophone PCB' and fault finding flow chart.

## Answers

### Resistor questions

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

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

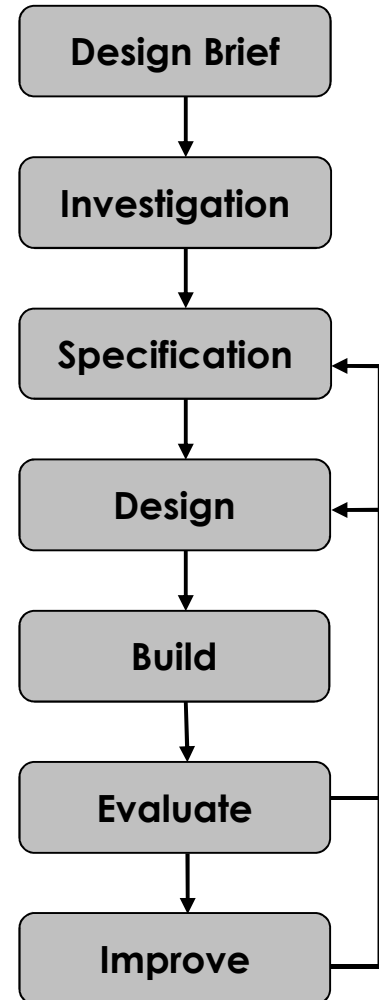
Build your design based upon the design that you have developed.

### **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.

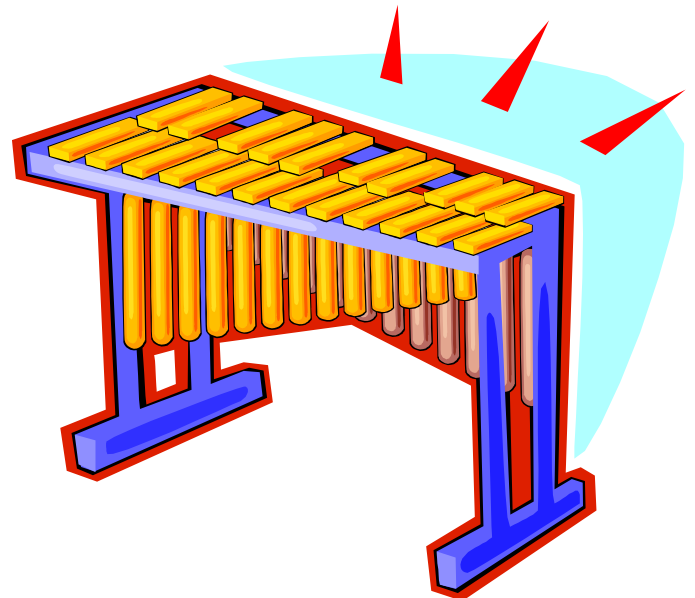


## The Design Brief

An electronics manufacturer has an idea for an electronic xylophone that is much smaller than the traditional style xylophone (see picture right). They believe that this will allow the product to be much more portable / convenient to transport.

The xylophone has been developed to a working prototype Printed Circuit Board (PCB) stage.

The manufacturer is unsure how the final product should look and feel. The manufacturer has asked you to develop the product for its target market, meeting all of the requirements for a product of this type.

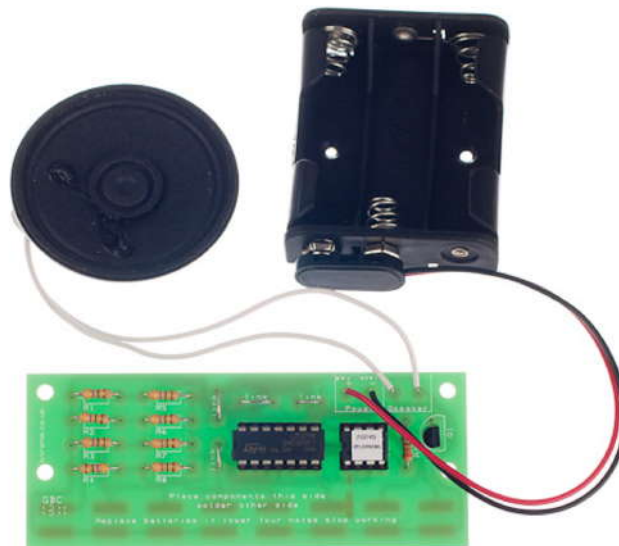


## Description of the Xylophone

The xylophone has eight specially designed keys, formed as part of the Printed Circuit Board. These are 'activated' by placing a finger over the chosen key. Each key, when pressed, plays a different note.

## 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 product must be light weight.	Example: To make it practical as a portable product.



## Design

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

Name.....

Class.....



## Design Review (group task)

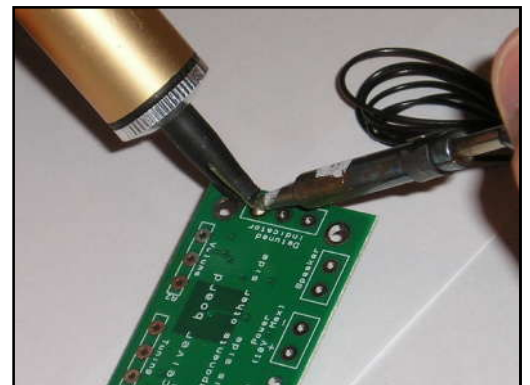
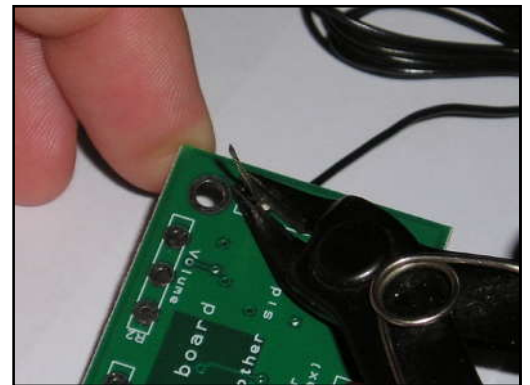
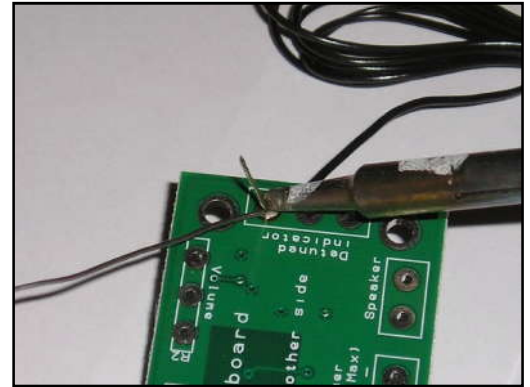
Split into groups of three or four. Take it in turns to review each person's design against the requirements of their specification. Also look to see if you can spot any additional aspects of each design that may cause problems with the final product. This will allow you to ensure that you have a good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

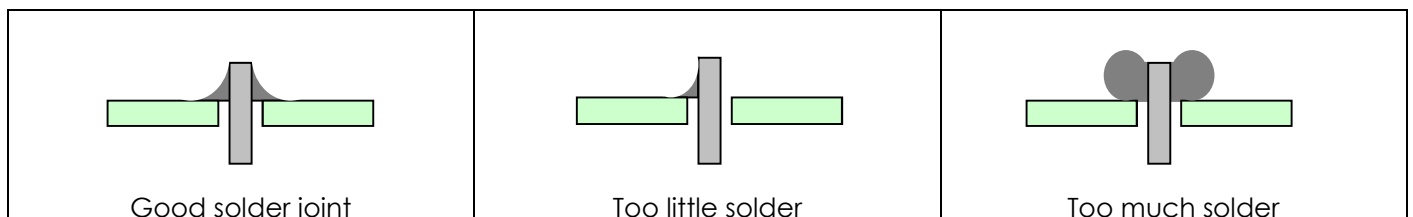


## Soldering in Ten Steps

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).



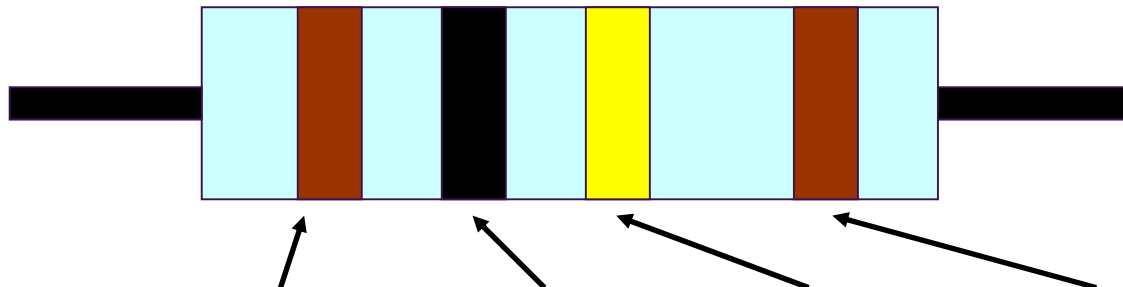
## Solder joints



## 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  $\Omega$  (ohms) and is often referred to as its 'resistance'.

### Identifying resistor values



Band Colour	1st Band	2nd Band	Multiplier x	Tolerance
Silver			$\div 100$	10%
Gold			$\div 10$	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:

$$\begin{aligned}
 &2 \text{ (Red)} \ 7 \text{ (Violet)} \times 1,000 \text{ (Orange)} &= 27 \times 1,000 \\
 &&= 27,000 \text{ with a 5% tolerance (gold)} \\
 &&= 27\text{K}\Omega
 \end{aligned}$$

#### Too many zeros?

Kilo ohms and mega ohms can be used:

$$1,000\Omega = 1\text{K}$$

$$1,000\text{K} = 1\text{M}$$

### 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 $\Omega$			
3,900 $\Omega$			
47,000 (47K) $\Omega$			
1,000,000 (1M) $\Omega$			

## 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 ( $\pm 10\%$ )											
10	12	15	18	22	27	33	39	47	56	68	82

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



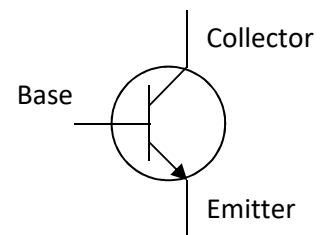
## Using a Transistor as a Switch

### Overview

A transistor in its simplest form is an electronic switch. It allows a small amount of current to switch a much larger amount of current either on or off. There are two types of transistors: NPN and PNP. The different order of the letters relate to the order of the N and P type material used to make the transistor. Both types are available in different power ratings, from signal transistors through to power transistors. The NPN transistor is the more common of the two and the one examined in this sheet.

### Schematic symbol

The symbol for an NPN type transistor is shown to the right along with the labelled pins.



### Operation

The transistor has three legs: the base, collector and the emitter. The emitter is usually connected to 0V and the electronics that is to be switched on is connected between the collector and the positive power supply (Fig A). A resistor is normally placed between the output of the Integrated Circuit (IC) and the base of the transistor to limit the current drawn through the IC output pin.

The base of the transistor is used to switch the transistor on and off. When the voltage on the base is less than 0.7V, it is switched off. If you imagine the transistor as a push to make switch, when the voltage on the base is less than 0.7V there is not enough force to close the switch and therefore no electricity can flow through it and the load (Fig B). When the voltage on the base is greater than 0.7V, this generates enough force to close the switch and turn it on. Electricity can now flow through it and the load (Fig C).

Fig A – Basic transistor circuit

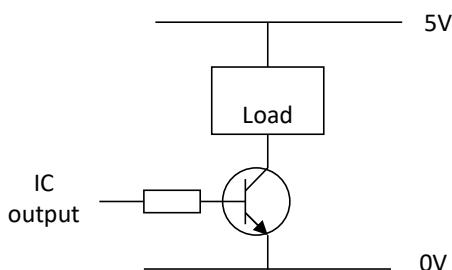


Fig B – Transistor turned off

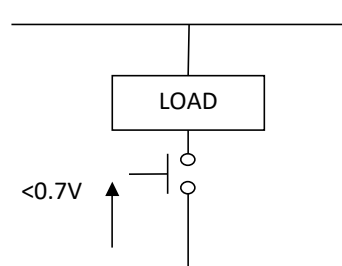
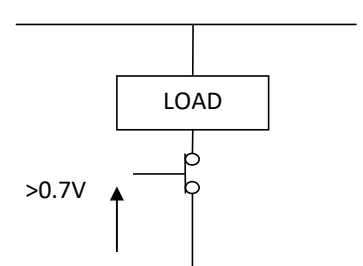
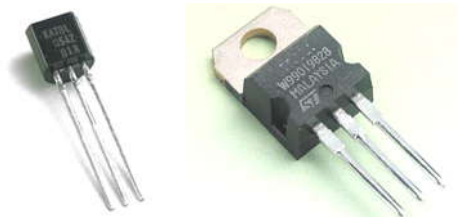


Fig C – Transistor turned on



### Current rating

Different transistors have different current ratings. The style of the package also changes as the current rating goes up. Low current transistors come in a 'D' shaped plastic package, whilst the higher current transistors 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 transistors are wired differently so they have to be looked up in a datasheet to find out which pin connects where.



## Instruction Manual

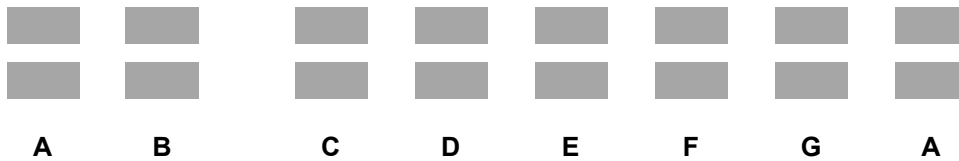
Your electronic xylophone is going to be supplied with some user instructions. Using the information below and anything else that you feel should be included. Write a set of instructions that will allow someone else to use your xylophone design. Try to make the instruction clear and easy to follow.

You may wish to collect a number of example instruction manuals. This will allow you to decide what style of instructions you feel are simple to follow.

### Using the xylophone

- To turn the xylophone on, connect the battery holder to the battery clip (unless you have added an on/off switch).
- When the xylophone is turned on the xylophone will produce a short bleep.
- The circuit will gradually flatten the battery even when it is not playing a note so the battery should be left unconnected when not in use.
- If half of the keys stop working, this will be because the batteries have become too flat.

The keyboard can be played by covering the pair of pads with a finger. If the xylophone makes a funny noise, you may be pressing the key too lightly or have your finger on two keys at the same time.



When the Saints Go Marching is the following notes:

C E F G C E F G C E F G E C E D E E D C E G G F F E F G E C D C

### Example song

You may wish to include an example song in your user instructions. Use the boxes below to develop a song. Write down a key number in the required squares to show the sequence in which the keys should be played.






## 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.



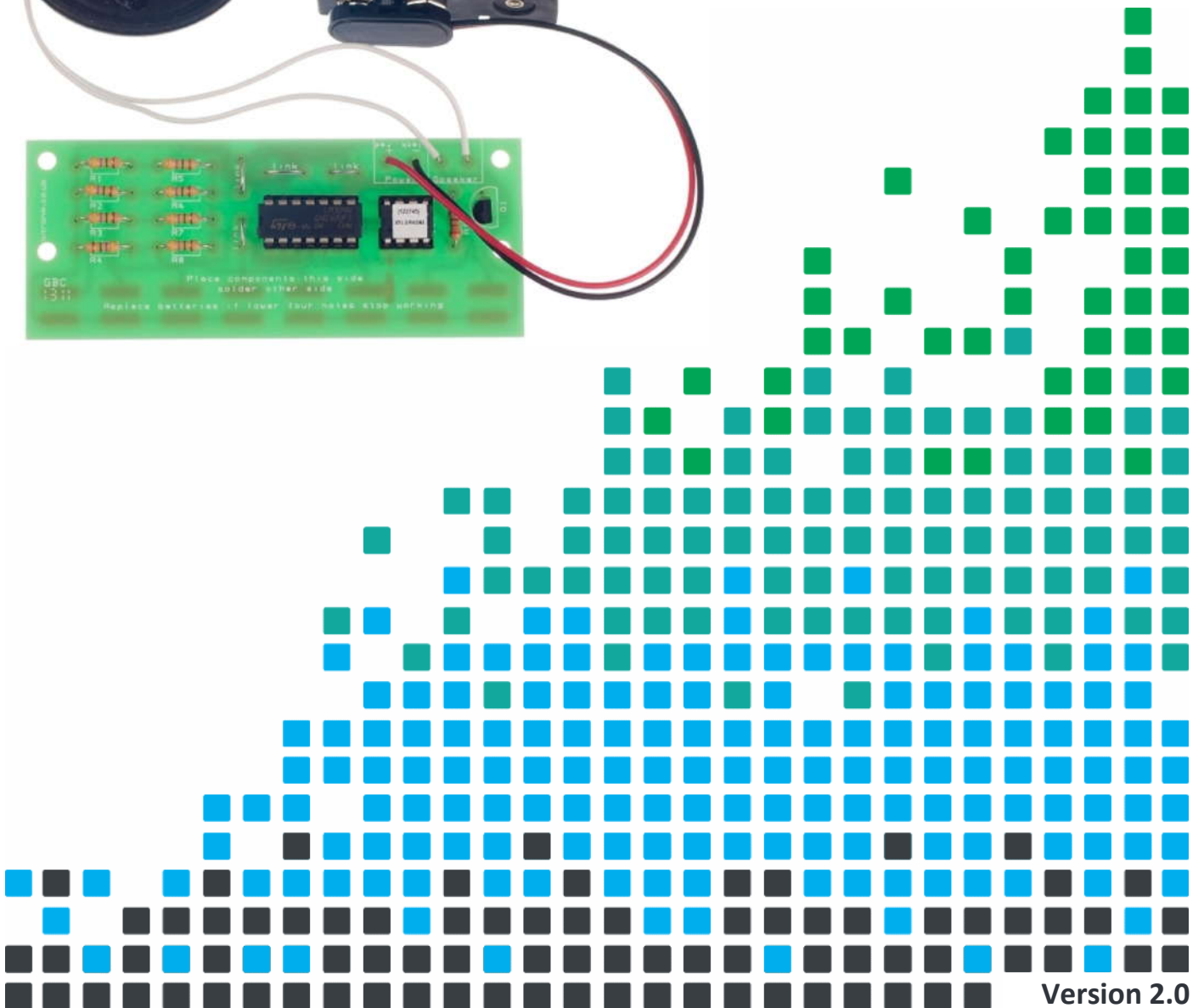
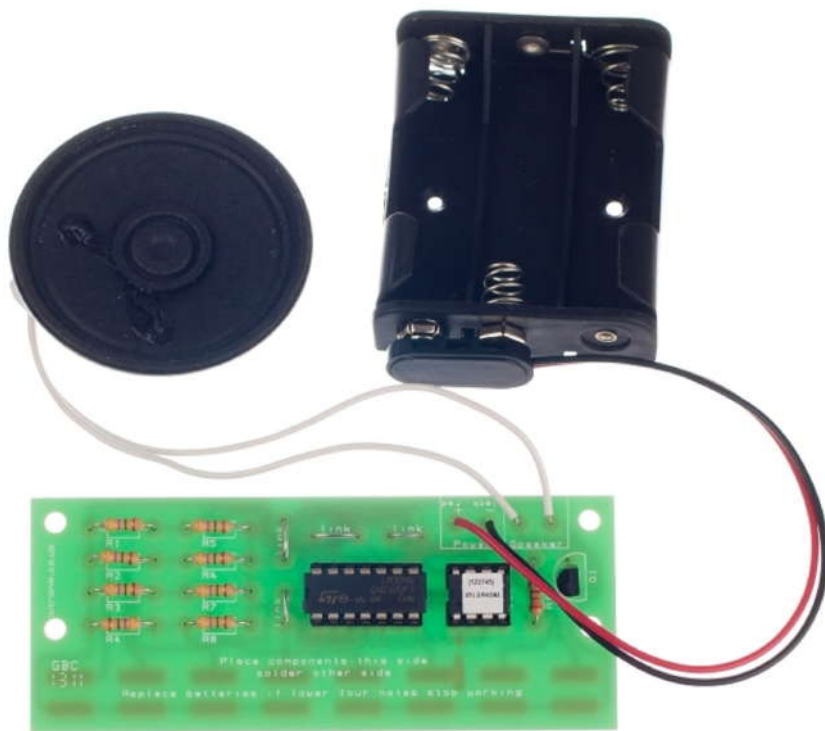


## ESSENTIAL INFORMATION

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

CREATE YOUR OWN ELECTRONIC MUSICAL INSTRUMENT WITH THIS

# XYLOPHONE KIT



Version 2.0

## 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 RESISTORS

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

PCB Ref	Value	Colour Bands
R1 to R8	4.7M $\Omega$	Yellow, violet, green
R9	3.3k $\Omega$	Orange, orange, red



### 2 CONNECT THE WIRES

Solder the four wire links into place. You will need to cut and strip the pieces to the correct size. The places that these need to go are indicated on the PCB by four solid white lines and the text 'link'.



### 3 SOLDER THE SMALLEST IC HOLDER

Solder the smallest Integrated Circuit (IC) holder into IC1. When putting this into the board, be sure to get it the right way around. The notch on the IC holder should line up with the notch on the lines marked on the PCB.



### 4 SOLDER THE LARGEST IC HOLDER

Solder the largest Integrated Circuit (IC) holder into IC2. When putting this into the board, be sure to get it the right way around. The notch on the IC holder should line up with the notch on the lines marked on the PCB.



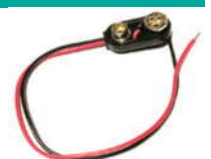
### 5 SOLDER THE TRANSISTOR

Solder the transistor into Q1. Take care to ensure that the 'D' shape of the transistor lines up with the 'D' shape on the PCB.



### 6 ATTACH THE BATTERY CLIP

The battery connector should be soldered into the 'Power' terminal. The red wire must go to the '+' terminal and the black wire must go to the '-' terminal.



## 7

### CONNECT THE SPEAKER

To connect the speaker to you need to cut two pieces of wire to the desired length. Strip both ends and solder them into 'Speaker' and the other end to the tabs on the speaker. The wires can go either way around.



## 8

### INSERT THE IC CHIP

The ICs can now be put into the holders, ensuring that the notch on the chips line up with the notch on the holders.

## Checking Your Xylophone PCB

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

### Check the top of the board to ensure that:

- The notch on both of the ICs and the IC holders are in the same orientation as the markings on the printed circuit board.
- The colour bands on R9 are Orange, orange and red.
- The red wire on the battery connector goes to the '+' terminal on the power terminals and the black wire goes to the '-' terminal.
- The 'D' shape of the transistor and the board marking line up.

## Testing the PCB

The software on the microcontroller has been specially designed to allow easy testing of the PCB.

When the batteries are inserted the xylophone will:


- Produce a short bleep.
  - If it does not beep use the fault finding flow chart to find the cause of the fault.
- Once the unit has finished its short bleep, test that all of the keys work correctly.
  - If it does not beep use the fault finding flow chart to find the cause of the fault.
- To turn the system off disconnect the batteries.



## Adding an On / Off Switch

If you wish to add a power switch, don't solder both ends of the battery clip directly into the board, instead:


1

Solder one end of the battery clip to the PCB, either black to '-' or red to '+'.  


2

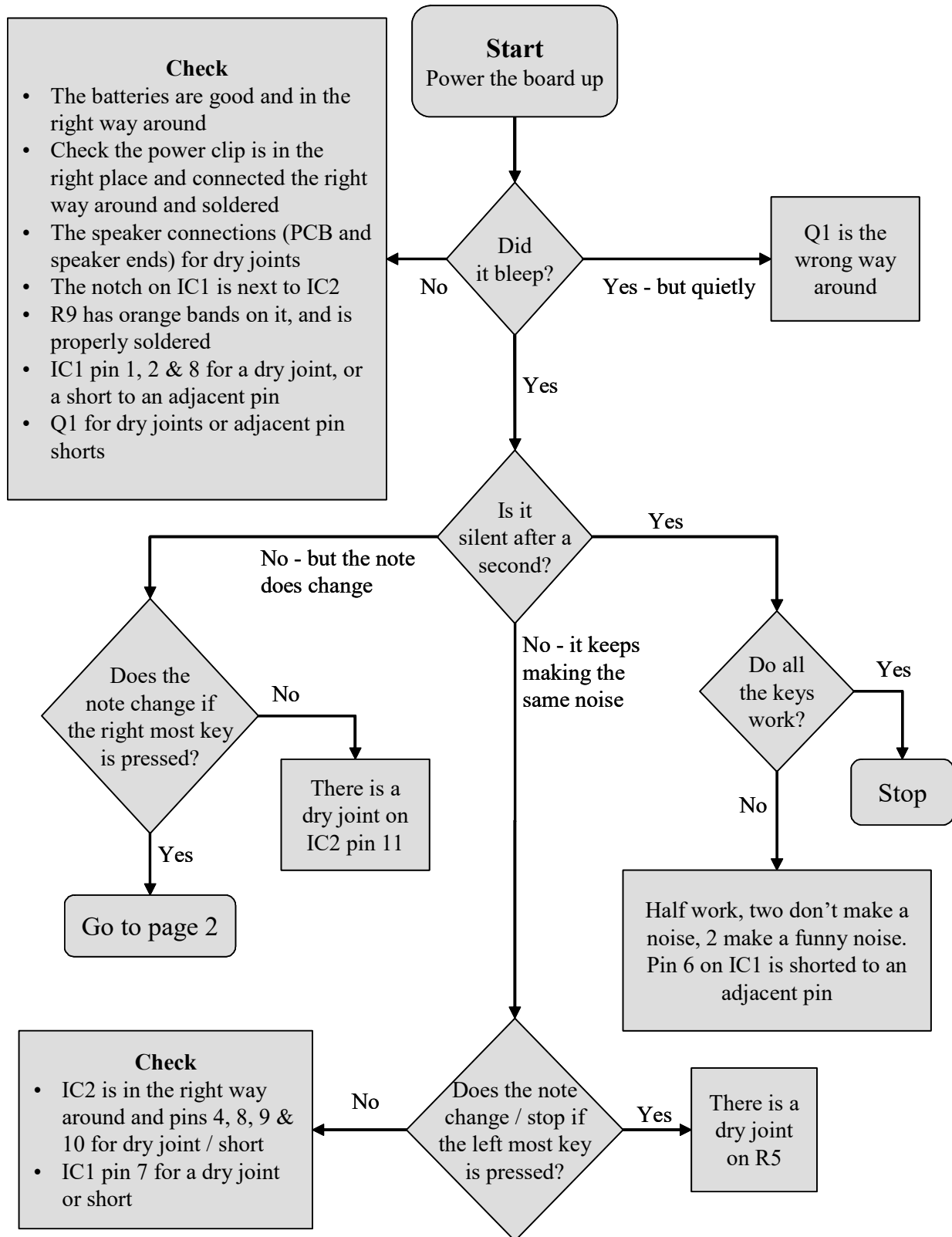
Solder the other end of the battery clip to the on / off switch.  


3

Using a piece of wire, solder the remaining terminal on the on / off switch to the remaining power connection on the PCB.  




## Fault finding flow chart



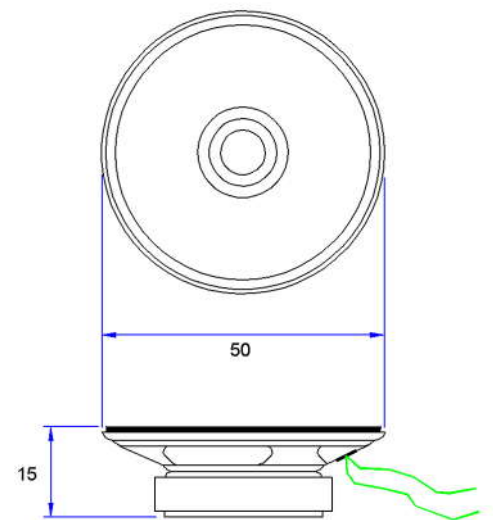
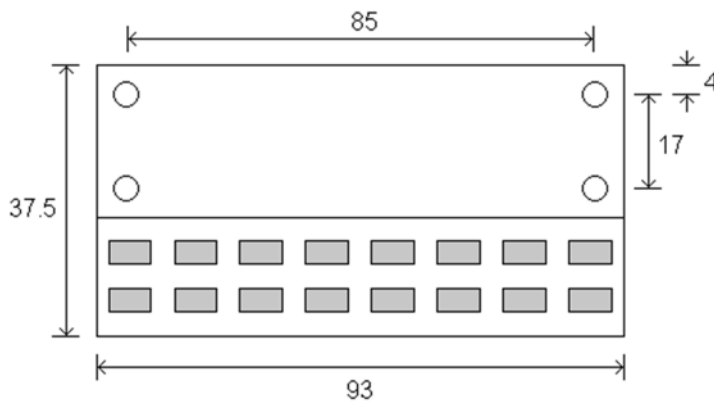
## Designing the Enclosure

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

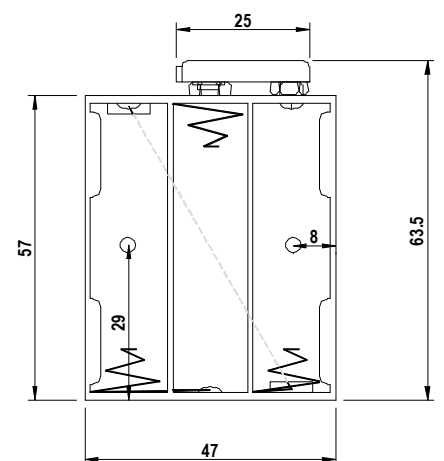
- The size of the PCB (below, top left).
- Where and how accessible the keys will be.
- Where the speaker will be mounted (top right).
- Access to the batteries to allow them to be changed (bottom right).

Technical drawings of these items are illustrated on this page, which should help you to design your enclosure. All dimensions are in mm.

x4 PCB mounting holes are 3.3mm diameter.



<p>P.C.B</p> <p>SPACER</p> <p>ENCLOSURE</p> <p>2 X M3 BOLTS</p>	<p><b>Mounting the PCB to the enclosure</b></p> <p>The drawing to the left shows how a hex spacer can be used with two bolts to fix the PCB to the enclosure.</p> <p><i>Your PCB has four mounting holes designed to take M3 bolts.</i></p>
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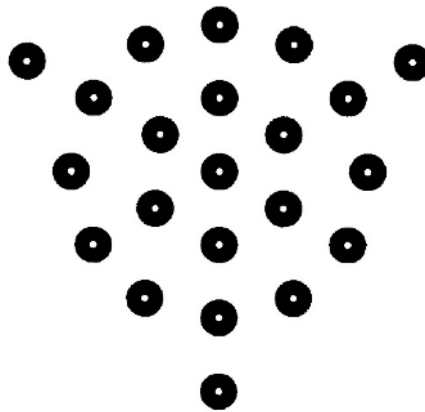




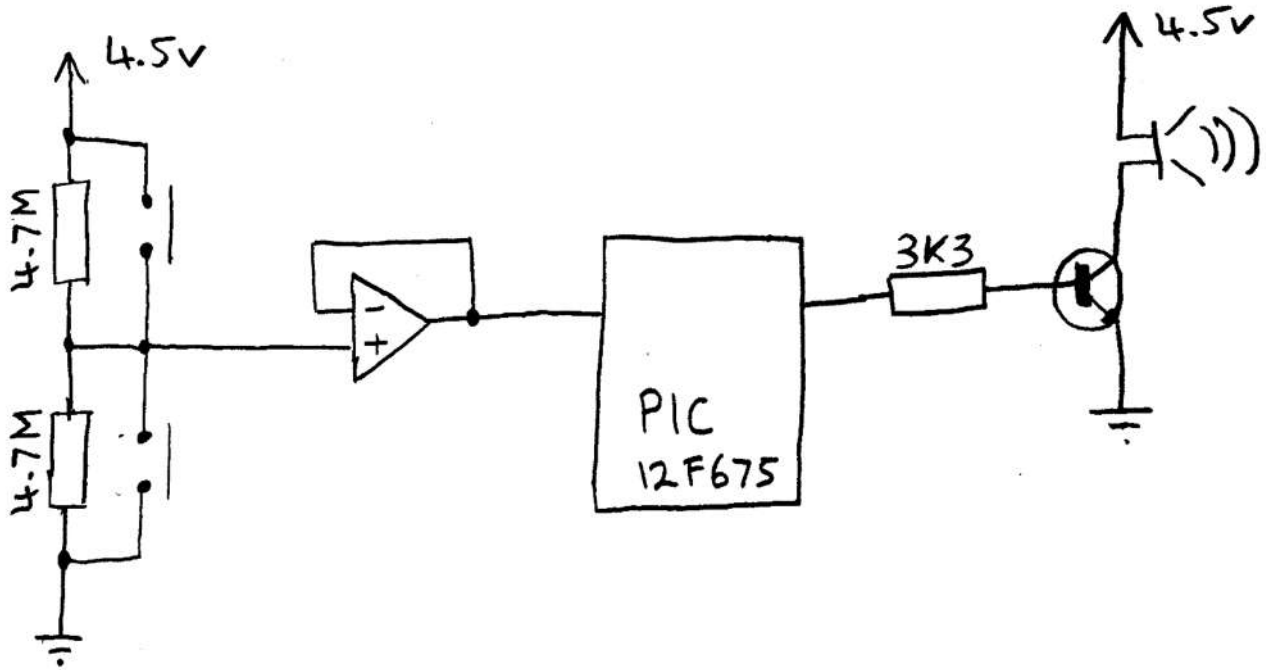
## Speaker Grill

The speaker grill pattern below has been designed for the speaker supplied. The three outer points have been designed as retaining points for holding the speaker in place.

The grill is printed to size and can be used when developing your enclosure design as well as for a template for drilling the holes when you are building your enclosure. The recommended drill size is 5mm, except for the three outer points which may need to be different depending upon how these are used to secure the speaker.



## How the Xylophone Works



The circuit (above) only shows two of the eight keys as the other six work in the same way. The switches used on the xylophone are formed from tracks on the PCB. These have been placed close together so that when a finger is placed on them, there is a resistance created between the pads. The typical resistance of a finger is around 2 - 8 M $\Omega$ . Two 4.7M $\Omega$  resistors are used to make a potential divider, the centre of which will have half the voltage of the power supply. The switches are placed across these resistors and cause the voltage at the centre of the potential divider to move up or down, depending on which switch is pressed. This voltage is fed into an operational amplifier (op amp) that has a unity gain. This means that the output of the op amp is the same as the input. Whilst this might sound a little pointless, the drive power of the input at 10 M $\Omega$  is very weak and not good enough to drive the microcontroller's inputs. What the op amp does is impedance match the switches so that they can be read by the microcontroller.

The microcontroller, which is like a small computer, reads the four channels (two keys per channel) and decides if the voltage has moved from the default centre position. If the voltage it reads is above or below the centre voltage, it sounds the appropriate note for the key that has been pressed. This is done by turning a transistor on and off very quickly, depending on which note is being sounded somewhere between 400 and 1000 times each second. The transistor acts as a switch to drive the speaker. This is needed because the microcontroller is not powerful enough to drive the speaker directly.



## 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/2105](http://www.kitronik.co.uk/2105)



This kit is designed and manufactured in the UK by Kitronik

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