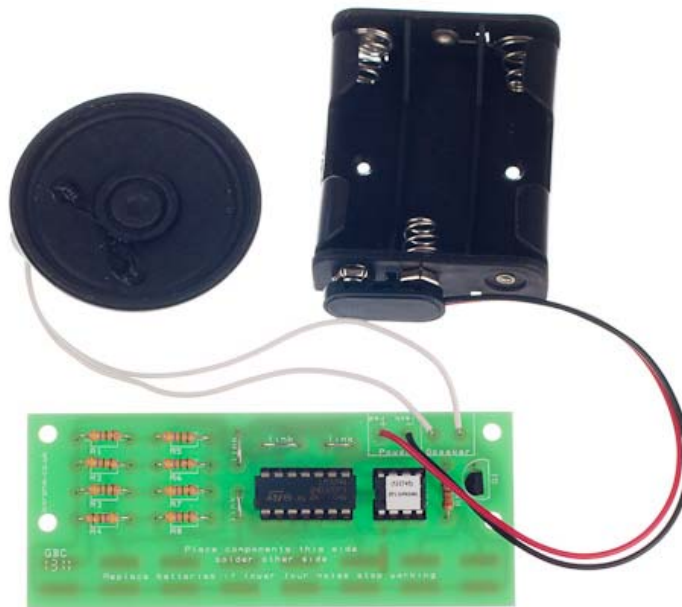




Xylophone



Teaching Notes

Issue 1.3

Product information: www.kitronik.co.uk/quicklinks/2105/

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Introduction

About the project kit

This project kit has been carefully designed for use by teachers in KS3/ KS4 design and technology. They are designed such that even teachers with a limited knowledge of electronics should have no trouble using them as basis around which to form a scheme of work.

The project kits can be used in two ways.

1. On their own as a way of introducing electronics and electronic construction to their students over a short number of lessons.
2. As part of a larger project involving all aspects of a product design, such as designing an enclosure for the electronics to fit into.

This booklet contains a wealth of material to aid the teacher in either case.

Using the booklet

This booklet is intended as an aid for teachers when planning and implementing their scheme of work.

The booklet is split into two sections. The first of these covers information specifically designed to support the teacher.

The second section contains information designed to form the basis around which lessons can be planned. The teacher can choose to use this in our suggested pre-planned way, or is free to 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. There are no page numbers in this booklet. This means you can feel free to pick and choose which sheets you use whilst still retaining a feeling of continuity.

Fault finding flow charts

Fault finding flow charts have been provided for use by both teacher and students. Please note that if there are multiple faults on a complete board these flow charts may not be able to accurately identify the causes.

Support and resources

You can also find 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

We have developed various schemes of work for which the project kits can be used. Included within the main scheme are the areas of the National Curriculum Program of Study that it fulfils. Equally, feel free to use the material as you see fit to develop your own schemes.

Before starting we would advise 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 that make these products suitable for this market.
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 the 'Designing the Enclosure' sheet. Develop a product design using the 'Design' sheet. <u>Homework:</u> 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 'How to solder' sheet demonstrate and get students to practice soldering. Start the 'Resistor' section. <u>Homework:</u> Complete any of the remaining resistor tasks.
Hour 6	Build the electronic kit using the 'Build Instructions'.
Hour 7	Complete the build of the electronic kit. Check the completed PCB and fault find if required using 'Checking Your Xylophone PCB' and fault finding flow charts. <u>Homework:</u> Read 'How the Xylophone Works' sheet.
Hour 8	Using cardboard get the students to model their enclosure design. Allow them to make alterations to there design if the model shows any areas that need changing.
Hour 9	Build the enclosure. <u>Homework:</u> Collect some examples of instruction manuals.
Hour 10	Build the enclosure. <u>Homework:</u> Read 'Instructions' sheet and start developing instructions for the student's Xylophone design.
Hour 11	Build the enclosure. <u>Homework:</u> Complete instructions for the student's Xylophone design.
Hour 12	Using the 'Evaluation and Improvement' sheet, get the students to evaluate their final product and identify where improvements can be made.

Additional Work

Package design for those who complete ahead of others.

National Curriculum fulfilment (England)

Designing and making 1.1: b, c.
Creativity 1.3: a, c.
Critical evaluation 1.4: a, b.
Key processes 2: a, b, c, d, e, f, g, h.
Range and content 3: a, b, e, j, l, m.
Curriculum opportunities 4: a, b, c.

Electronics only

Hour 1	Introduction to the kit demonstrating a built unit. Using the 'How to solder' sheet practice soldering.
Hour 2	Build the kit using the 'Build Instructions'.
Hour 3	Check completed PCB and fault find if required using 'Checking Your xylophone PCB' and fault finding flow charts.

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

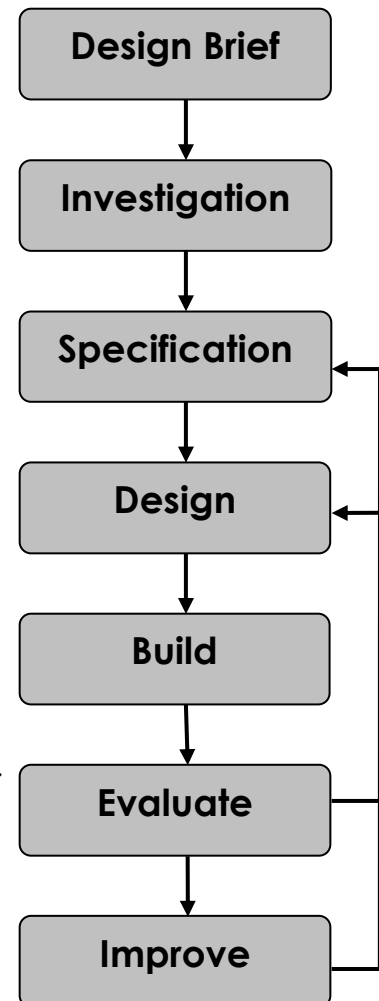
Build your design based upon the design that you have developed.

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.



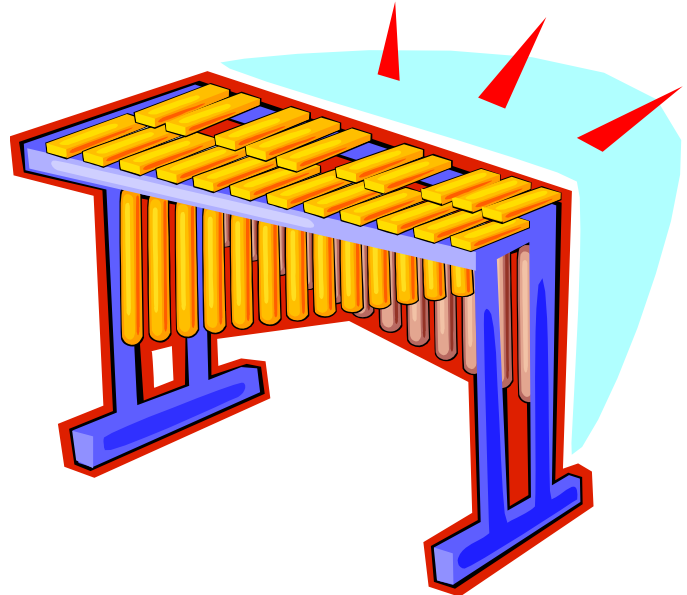


The Design Brief

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 the requirements for a product of this type.

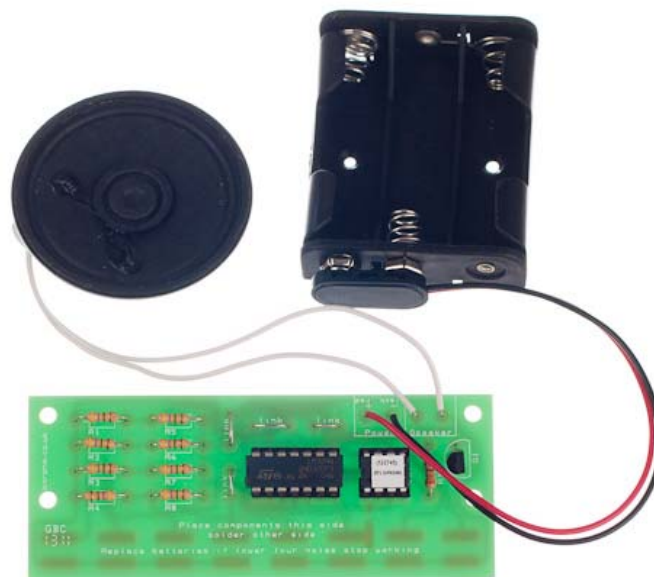


Description of the Xylophone

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 products that are already aimed at similar markets. 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.

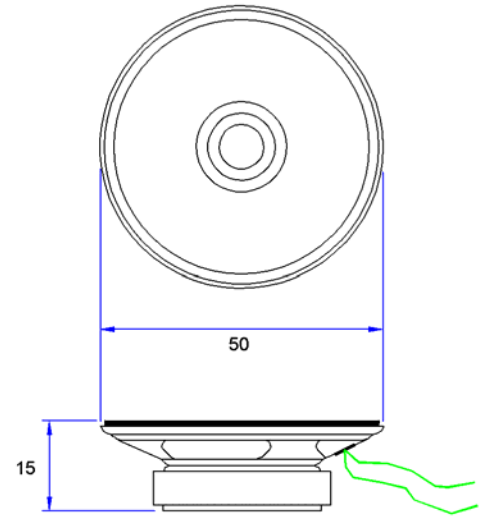
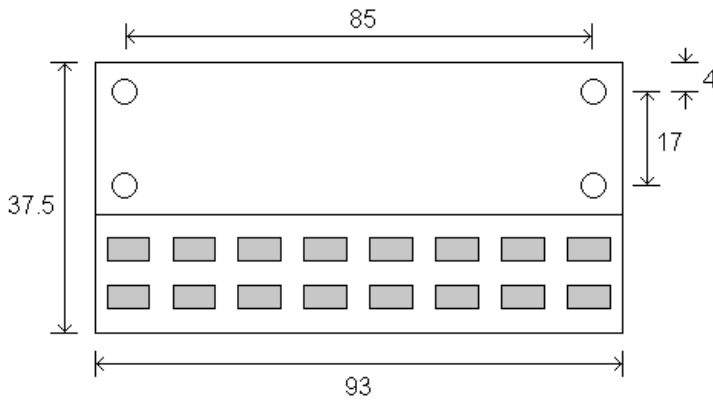
Name.....

Class.....

Requirement	Reason
Example: The product must be light weight.	Example: To make it practical as a portable product.



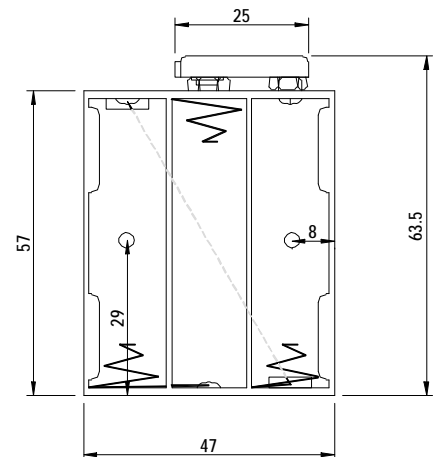
Designing the Enclosure



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

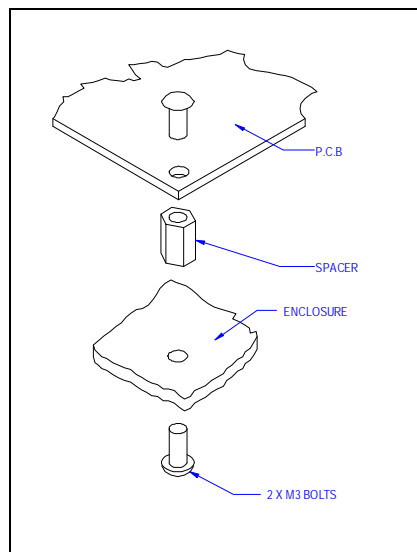
- The size of the PCB (above).
- Where and how accessible the keys will be.
- Where the speaker will be mounted (above right).
- Access to the batteries to allow them to be changed (right).

Technical drawings of these items are illustrated on this page, which should help you design your enclosure. All dimensions are in mm. x4 PCB mounting holes are 3.3 mm diameter.



Enclosure Prototype

Using cardboard, foam or anything else that is suitable, make a prototype of your enclosure design. This will give you the chance of changing any aspects of the design that do not work as well as expected.



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.

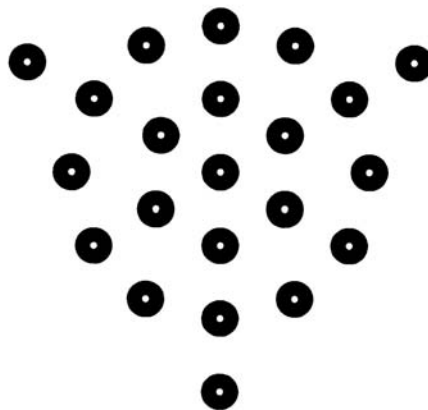
Your PCB has four mounting holes designed to take M3 bolts



Speaker Grill

The speaker grill pattern bellow 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.





Design

Develop your ideas to produce a number of sketched concept designs. Then choose one of these designs and develop it further, insuring it meets the requirements listed in the specification.

Name.....

Class.....



Design Review (group task)

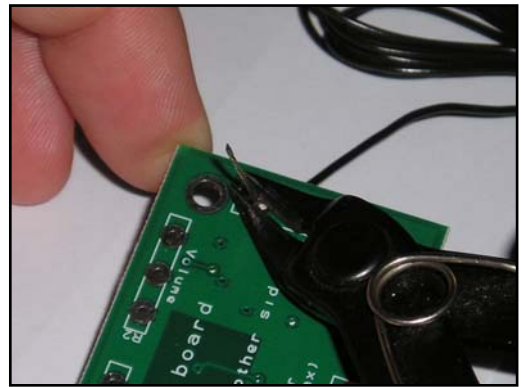
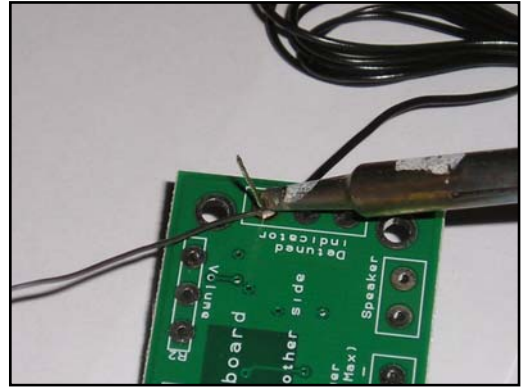
Split into groups of three or four. Take it in turns to review each person's design against the requirements of their specification. Also look to see if you can spot any additional aspects of their design that may cause problems with the final product. This will allow you to ensure you have a good design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

Comment	Reason for comment	Accept or Reject

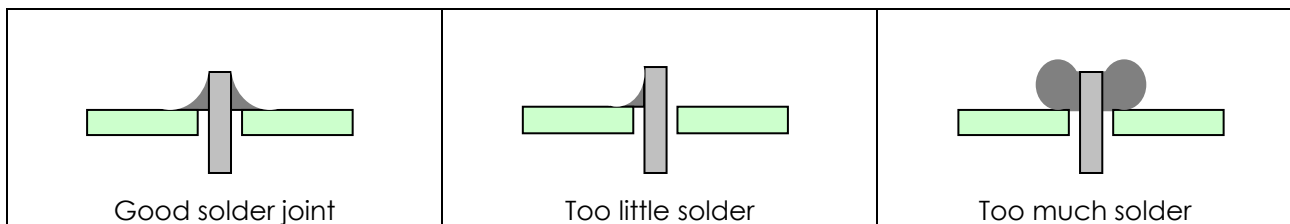


Soldering In Ten Steps

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 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 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

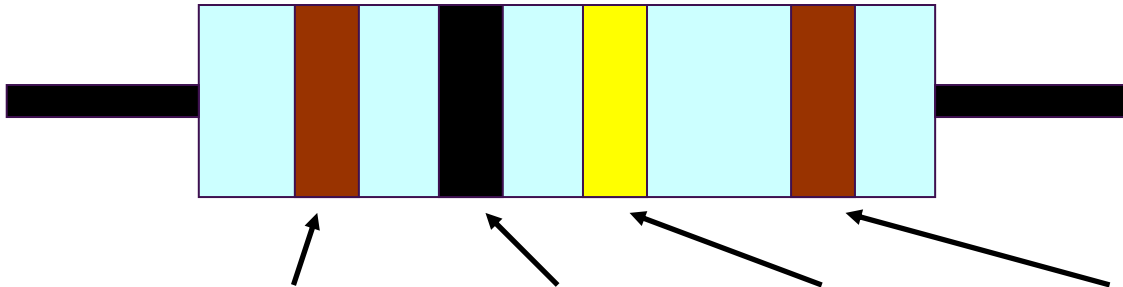




Resistors

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			$\div 100$	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:

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

Too many zeros?

Kilo ohms and mega ohms can be used:

$$1,000\Omega = 1K$$

$$1,000K = 1M$$

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 designs performance.

Preferred values

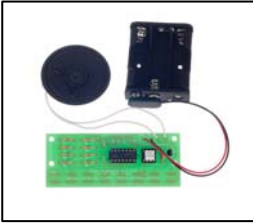
There are a number of different ranges of values for resistors. Two of the most popular are the E12 and E24. They take into account the manufacturing tolerance and are chosen such that there is a minimum overlap between the upper possible value of the first value in the series and the lowest possible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



Build Instructions



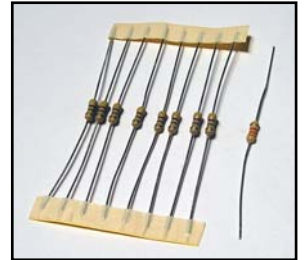
Before you put any components in the board or pick up the soldering iron, just take a look at the Printed Circuit Board (PCB). The components go in the side with the writing on and the solder goes on the side with the tracks and silver pads.

You will find it easiest to start with the small components and work up to the taller larger ones. If you've not soldered before get your soldering checked after you have done the first few joints.

Step 1

Start with the nine small resistors (shown right):
R1 to R8 are 4.7M Ω (Yellow, Violet, Green coloured bands).
R9 is 3.3k Ω (Orange, Orange, Red coloured bands).

The text on the board shows where R1, R2, etc go. Make sure that you put the resistors in the right place.



Step 2

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'.

Step 3

Solder the smallest Integrated Circuit (IC) holder in to 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.



Step 4

Solder the largest Integrated Circuit (IC) holder (shown left) in to 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.

Step 5

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.



Step 6

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.



Step 7

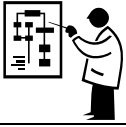
To connect the speaker to you need to cut two pieces of wire to the desired length. Strip both ends and solder them into 'Speaker' and the other end to the tabs on the speaker. The wires can go either way around.

Adding an on / off switch

- Solder one end of the power clip to the PCB, either black to '-' or red to '+'.
• Solder the other end of the power clip to the on / off switch.
• Using a piece of wire, solder the remaining terminal on the on / off switch to the remaining power connection on the PCB.

Step 8

The IC's can now be put into the holders ensuring the notch on the chips line up with the notch on the holders.



Checking Your PCB

Check the following before you insert the batteries:

Check the bottom of the board to ensure that:

- All holes (except the 4 large 3 mm 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:

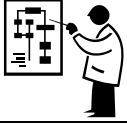
- The notch on both of the IC's and the IC holders are in the same orientation as the markings on the printed circuit board.
- The colour bands on R9 are Orange, Orange and Red.
- The red wire on the battery connector goes to the + terminal on the power terminals and the black wire goes to the – terminal.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

Testing the PCB

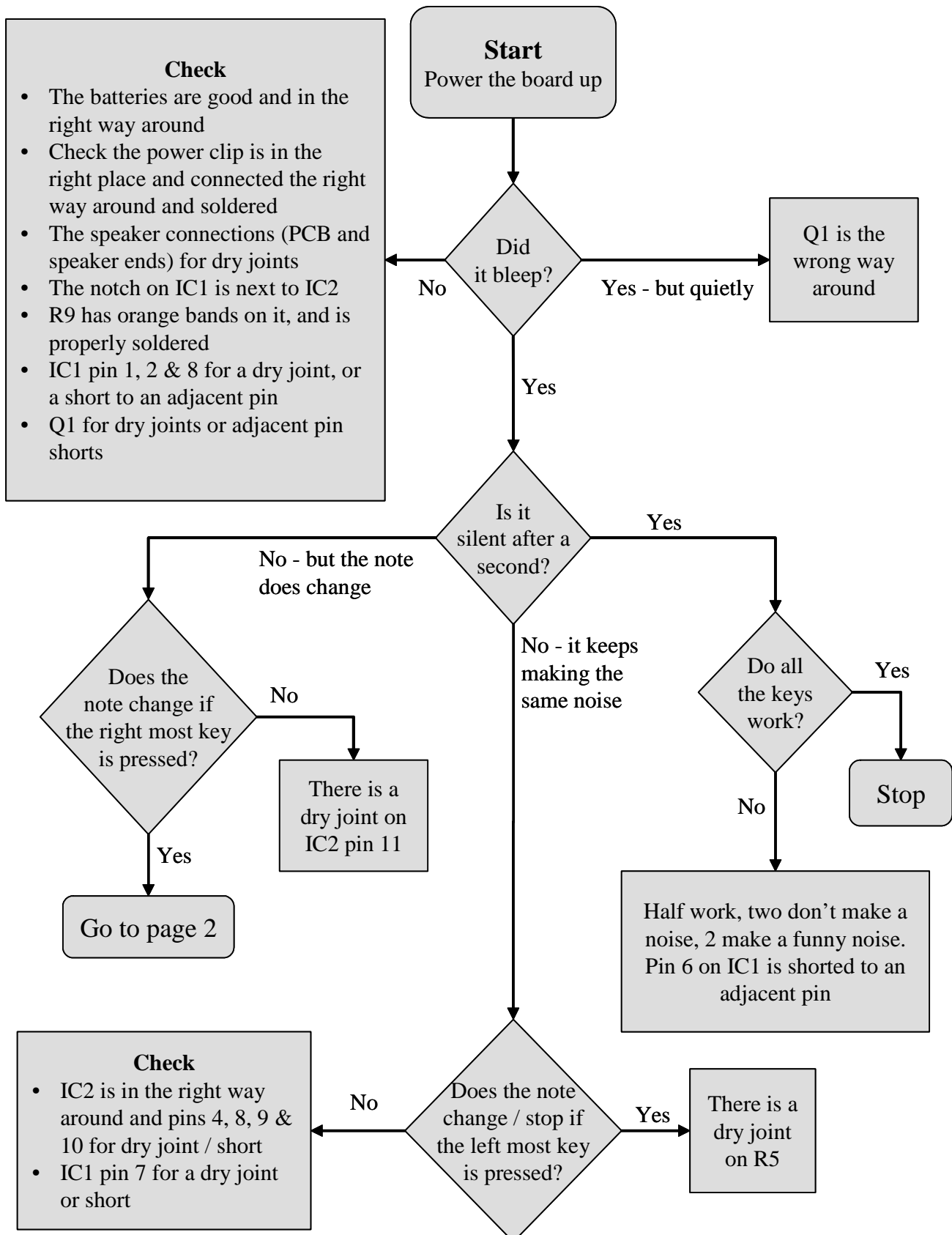
The software on the microcontroller has been specially designed to allow easy testing of the PCB.

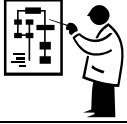
When the batteries are inserted the xylophone will:

- Produce a short beep.
 - 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 beep test that all 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.

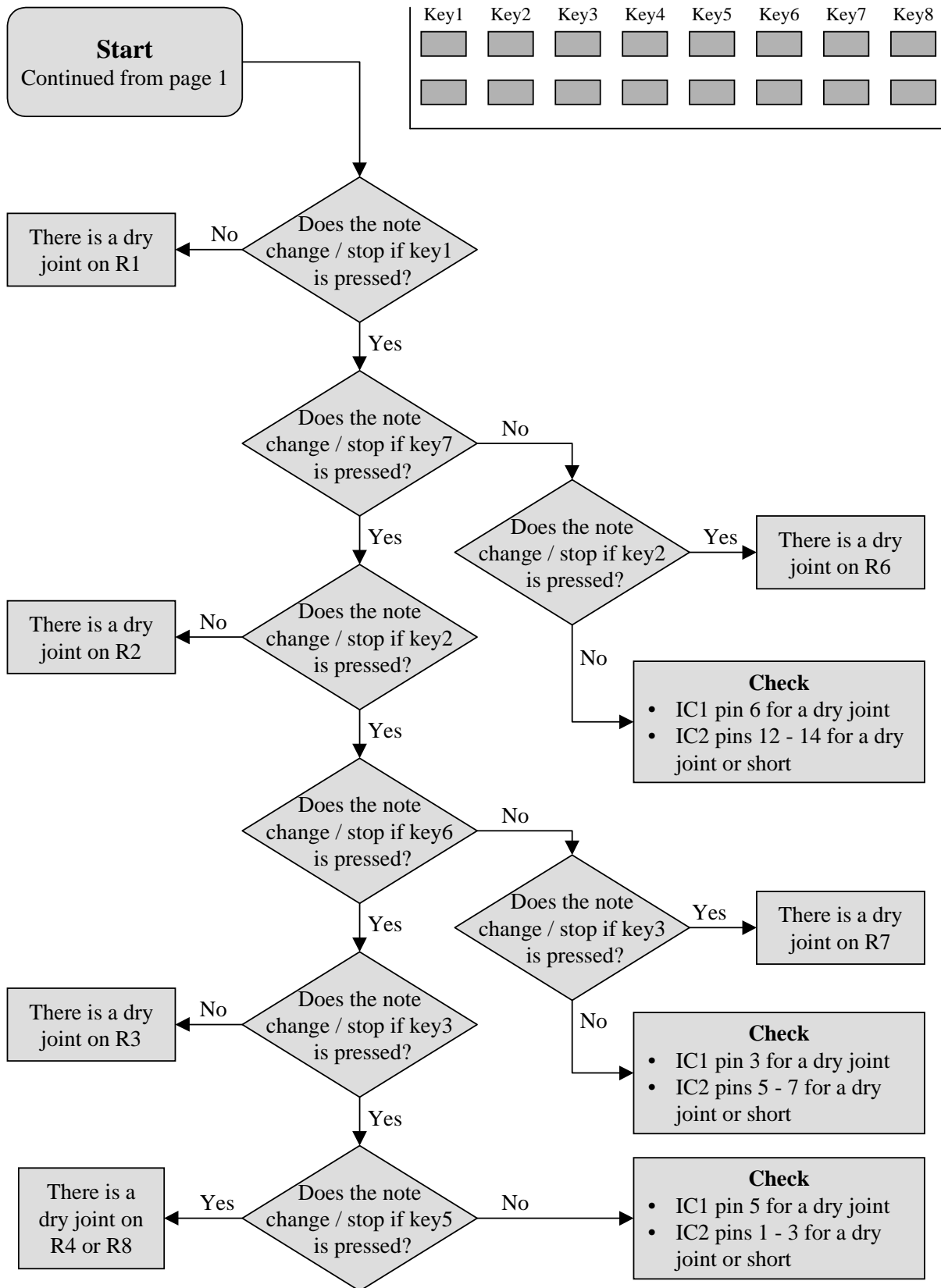


Fault finding flow chart



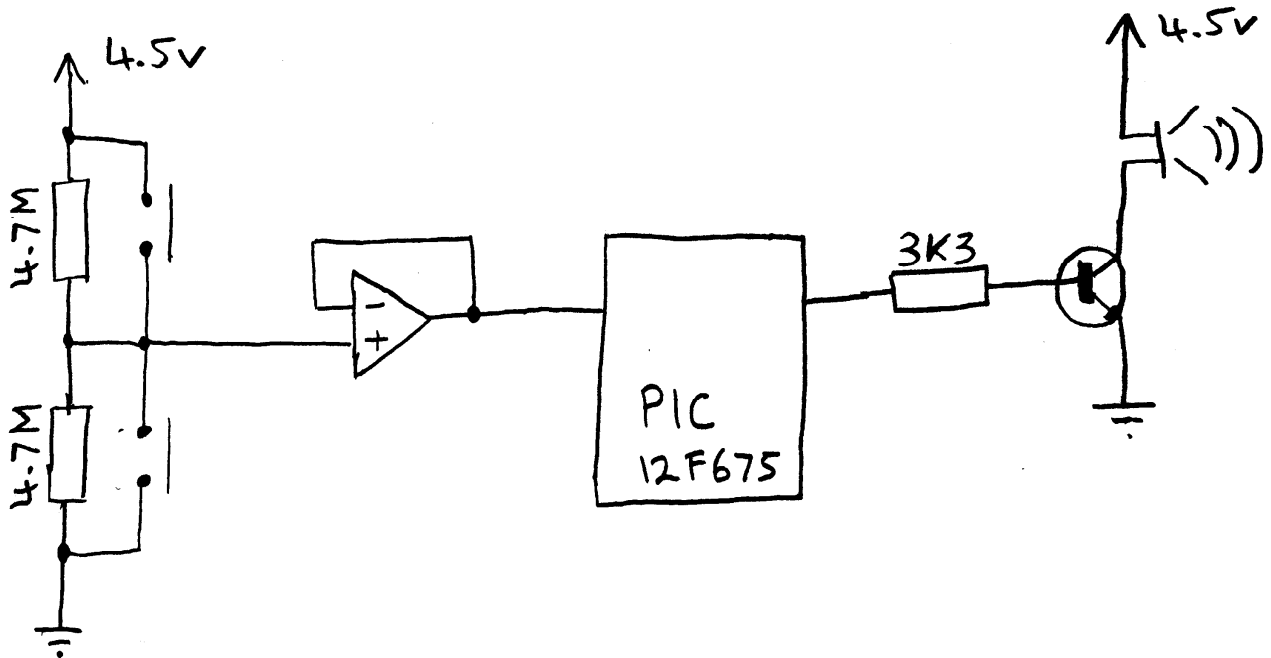


Fault finding flow chart - Page 2





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 Ω . Two 4.7M Ω 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 Ω is very weak and not good enough to drive the microcontrollers inputs. What the op amp does is impedance match the switches so 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 center 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.



Evaluation

It is always important to evaluate your design once it is complete. This will ensure that it has meet all the requirements defined in the specification. In turn this should ensure that the design fulfils the design brief.

Check your design meets all 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 list aspects of the design that 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 that 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 to the public through the high street shops 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.

Reordering information

<i>Description</i>	<i>Stock code</i>
Xylophone kit	2105

Sales

Phone: 0845 8380781
Fax: 0845 8380782
Email: sales@kitronik.co.uk

Technical support

Email: support@kitronik.co.uk
Phone: 0845 8380781

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